INTERIM SUMMARY REPORT

Asian Carp Monitoring and Response Plan

2017

Asian Carp Regional Coordinating Committee

U.S. Army Corps of Engineers

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 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 Workgroup, 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 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 23 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, 2015, and 2016. More specifically, it is intended to act as an update to the 2016 ISR that was developed in 2017. This 2017 ISR is intended to act as 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 2018 Asian Carp Monitoring and Response Plan (MRP), has also been completed by the MRWG. The 2018 MRP presents each project's plans for activities to be completed in 2018. Similar to the ISR, the MRP is intended to function as a living document, and will be updated at least annually. In conjunction, the 2018 MRP and 2017 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 2017 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 2017 results for 23 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 three general categories:

1) **Detection:** Determine the distribution and abundance of Asian carp to guide response and control actions.
2) **Manage and Control:** Prevent upstream passage of Asian carp towards Lake Michigan via use of barriers, mass removal, and understanding best methods for preventing passage.
3) **Response:** Establish comprehensive procedures for responding to changes in Asian carp population status, test these procedures through exercises, and implement if necessary.

A summary of the highlights of each project is presented below, intended to provide a brief snapshot of project accomplishments during 2017.

DETECTION PROJECTS

Seasonal Intensive Monitoring 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 2017.
- Estimated 990 person-hours were spent to complete 109.3 hours of electrofishing, set 139 km (86.5 mi) of trammel/gill net, 2.2 km (1.4 mi) of commercial seine, 8 Fyke nets, and 2 Great Lake Style Pound Nets (pound nets) in 2017

- Across all locations and gears in 2017, sampled 31,818 fish representing 58 species and 2 hybrid groups.
- Since 2010, an estimated 26,826 person-hours were spent to complete 1,086.7 hours of electrofishing, set 823.9 km (512 mi) of gill/trammel net and 11.1 km (6.9 mi) of commercial seine, tandem trap nets, hoop nets, Fyke nets, and pound nets.
- A total of 374,288 fish representing 73 species and six hybrid groups were sampled, including 2,020 Banded Killifish (state threatened species) from 2010-2017
- Examined 111,761 YOY Gizzard Shad since 2010 and found no Asian carp.
- Since 2010, 16 non-native species have been captured accounting for 15% of the total fish caught and 22% of the total species.
- From 2011-2016, no Bighead Carp or Silver Carp have been captured or observed. One Bighead Carp captured in Lake Calumet in 2010, and one Silver Carp was captured in Little Calumet River in 2017.
- 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 Sampling in the CAWS and Refining eDNA Interpretation 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 2017, resulting in 240 samples collected and analyzed.
- One additional eDNA sampling event took place in response to a live capture of a Silver Carp in June 2017, resulting in 280 samples collected and analyzed.
- Results: zero positive detection for both species of Asian carp DNA.

Below the Electric Dispersal Barrier Monitoring:

- Two eDNA sampling events took place in Dresden Island Pool of the Illinois Waterway in May and September of 2017.
- 276 samples were collected in May: 6 were positive for Silver Carp DNA and 2 were positive for both Silver and Bighead Carp DNA.
- 276 samples were collected in September: 13 were positive for Silver Carp DNA and 4 were positive for both Silver and Bighead Carp DNA.

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.

- 820 ichthyoplankton samples were collected from 10 sites across the length of the Illinois Waterway during April – October 2017, capturing over 113,000 larval fish, including

over 58,000 larval Asian carp. Additionally, over 38,000 Asian carp eggs were collected in ichthyoplankton samples in 2017.

- Asian carp eggs were collected in the LaGrange, Peoria, and Starved Rock pools during 2017. Asian carp larvae were only identified from the LaGrange and Peoria pools. These results further confirm observations made in 2015 – 2016 that Asian carp reproduction occurs in at least some years in the upper Illinois River. However, across 8 years of sampling, only a handful of 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 2017, with eggs and larvae collected from mid-May to late July. The early spawning activity appears to have been associated with periods of very high, but declining discharge, whereas later spawning events occurred during modest increases in the hydrograph.

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 the Starved Rock Lock and Dam during the 2017 field season, however, three individuals were caught in Peoria Pool near Henry, Illinois (RM 194).
- A total of 18 juvenile Asian carp (≤ 400 mm TL) were found in Starved Rock Pool and 118 in Peoria Pool during 2017 field sampling efforts. Most of these fish are likely age 2 and are smaller inividuals from the 2015 cohort.

Juvenile Asian Carp Telemetry in the Illinois River – The purpose of this project is to gain a greater understanding of juvenile Asian carp behavior and preferred habitats. The project implants juvenile Asian carp with tags and tracks their movements in the Illinois River and associated backwaters via the existing telemetry system.

- A total of 72 fish were tagged in 2017.
- The mean weekly movement distance was 943.7 m per week.
- Percent total residency was 39.4% in backwaters, 36.0% in the main channel, and 24.6% in the side channels.

Monitoring Efforts Downstream of the Electric Dispersal Barrier – This project includes monthly standardized monitoring with electrofishing gear, netting gear, and commercial fishermen 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.

- An estimated 21,488.5 person-hours expended sampling fixed, random, targeted, and additional sites downstream the Electric Dispersal Barrier (2010-2017).

- A total of 837.25 hours electrofishing, 1,431.2 km (889.3 miles) trammel/gill net, 1,700 hoop netting nights, and 676 mini-fyke netting nights (2010-2017).
- A total of 291,781 fish captured, representing 97 species and eight hybrid groups (2010-2017).
- No Bighead or Silver Carp have been captured in Lockport or Brandon Road pools in any year sampled, but have been collected in Dresden Island Pool totaling 3,868 (2010-2017). Historically, Rock Run Rookery, Mobil Bay and the downstream end of Treats Island within the Dresden Island Pool are locations where Asian carp have been known to congregate and are frequently sampled.
- The leading edge of the Asian carp population is 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 leading edge over the past 10 years.

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 28.2 million detections from 597 tagged fish.
- No live tagged fish have crossed the Electric Dispersal Barrier in the upstream direction.
- High percentage of unique tags in surrogate fish continue to be detected near the Electric Dispersal Barrier.
- Only 2 lock passages by Common Carp downstream from Lockport Pool to Brandon Road.
- 10 Common Carp moved through the Lockport Controlling Works Spillway into Brandon Road Pool in 2017.
- Asian carp continue to be detected throughout the Dresden Island Pool.
- A single detection of a Bighead Carp occurred at the Brandon Road Lock and Dam approach channel.
- The majority of Asian carp detections occur at Rock Run Rookery and near the Harborside Marina.
- Up to 50% unique transmitters detected within the Kankakee River but only accounted for 1.85% of the total detections in Dresden Island Pool.

Monitoring of Fish Abundance and Spatial Distribution near the Electric Dispersal Barrier and in Lockport, Brandon Road Pools – 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 System were observed during late summer. Fish density remained relatively high during fall surveys.
- Fish density was low during winter and spring.

- There were significantly greater mean total densities of fish observed immediately below the Electric Dispersal Barrier System during the summer than in spring or winter.

Analysis of Feral Grass Carp in the CAWS and Upper Illinois River – This project is intended 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.

- 61 feral Grass Carp were analyzed for ploidy and life history traits.
- 59% of the feral Grass Carp were diploid.
- 13 Grass Carp were captured within the CAWS, above the USACE's Electric Dispersal Barrier System, 6 of which were diploid.
- 1 fish has passed multiple lock and dams, passing downstream through Marseilles, Starved Rock and Peoria locks and dams

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.

- 34 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.
- 18 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.

Young-of-year and Juvenile Asian Carp Monitoring – Monitoring for small Asian carp is conducted during other sampling events, with 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 2017 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 2017. Mini-fykes caught the most Silver Carp <6 inches. Trawling captured more Silver Carp 6-12 inches.
- Completed 2,448 hours of electrofishing across all years and pools.
- Examined 466,955 Gizzard Shad <152 mm (6 inches) along the CAWS and Illinois Waterway during 2017, most of which were in the Marseilles Pool (~80%).
- High catches of small Asian carp in 2014, moderate in 2015 and 2017, 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 in 2017 was one Silver Carp (6-12 inches) in the Starved Rock Pool.
- Given that the numbers of small Asian carp sampled differ by orders of magnitude between years, it is recommended that monitoring of small Asian carp be continued to examine population fluctuations.

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 and eggs and larvae that may be transported to the CSSC via laterally flowing Des Plaines River floodwaters passing through the barrier fence.

- Collected 11,082 fish representing 58 species and 3 hybrid groups from 2011-2017 via electrofishing (57.69 hours) and gill netting (140 sets; 20,384 yards).
- No Bighead Carp or Silver Carp have been captured or observed through all years of sampling.
- Seven Grass Carp have been collected, of which six were submitted for ploidy analysis. All six were determined to be triploid.
- Three overtopping events since 2011 have resulted in several improvements to the barrier fence.

Comprehensive Removal Summary – This report presents an analysis of all efforts to remove Asian carp from the Illinois River below the Electric Dispersal Barrier. It summarizes the efforts of multiple removal projects, and analyzes trends in removal totals both over time and spatially, and also analyzes changes in species composition of removed Asian carp.

- Contracted commercial fishers and agency staff deployed 2,396.4 miles (3856.6 km) of gill/trammel net, 20 miles (32.1 km) of commercial seine, 230 pound net nights and

3,225.5 hoop net nights, 459 electrofishing hours, and 29.8 electrified paupier hours in the upper Illinois Waterway since 2010.

- A total of 90,469 Bighead Carp, 681,743 Silver Carp, and 4,668 Grass Carp were removed from 2010-2017. The total weight of Asian carp removed was 3,193.01 tons.

USGS Support for Implementation of MRP – This project focuses on developing tools to support the activities conducted by all other agencies in the effort to control Asian carp migration. Specifically, the project focuses on implementing and evaluating new strategies for monitoring, surveillance, risk assessment, control, and containment of bigheaded carp. This project also works to develop and evaluate databases and decision support tools to streamline the analysis of data collected by other projects.

- Two additional real-time telemetry recievers were deployed to inform contingency actions. One was deployed just upstream of Brandon Road Lock and Dam and the other was deployed just upstream of the electrical barrier.
- Significant progress in development of an online platform and tools for the Monitoring and Response Work Group (MRWG) database and telemetry database were made in FY2017. Both databases will be rolled out to the MRWG in useable formats by mid-FY2018.
- Near real-time satellite tags were successfully deployed for the first time on bigheaded carp in the Dresden Island pool.
- A telemetry study was initiated to better understand lateral habitat use in the Starved Rock pool to inform bigheaded carp removal efforts.
- Decision support tools to inform removal of adult bigheaded carp and mitigate for bigheaded carp egg/larvae entrainment moved toward completion.

MANAGE AND CONTROL PROJECTS

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.
- One 15 minute electrofishing run was 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 14 September 2017 and 27 September 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 2,056 miles (3,308.8km) of gill/trammel net, 20 miles (32.2km) of commercial seine, 162 pound net nights and 2,342 hoop net nights in the upper Illinois Waterway since 2010.
- A total of 88,159 Bighead Carp; 638,186 Silver Carp; and 4,558 Grass Carp were removed by contracted commercial fisherman from 2010-2017. The total weight of Asian carp removed was 3,078 tons.
- 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.

Barrier Defense 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.

- A total of 30,162 Asian carp (80.88 tons) were removed in 2016 and 2017 at a rate of 1.7 tons/day and 4.8 tons/day, respectively. The rise in harvest efficiency is likely due to increased payload capacity and mechanical improvements implemented in 2017.
- Asian carp comprised 91% of species captured by paupier in 2016–2017.
- In standardized paupier sampling, Silver Carp catch rates in Hanson Material Services East Pit were higher at night and in the summer season. These patterns were not observed in Hanson Material Services West Pit (a backwater with low connectivity and high exploitation pressure).

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 542 fish in Lockport Pool, Brandon Road Pool, Dresden Island Pool and Rock Run Rookery (Between March 14, 2017 and December 22, 2017).
- A total of 163 fish were recaptured in 2017 using pulsed DC-electrofishing, gill nets, trammel nets and 6-foot diameter hoop nets.
- A total of 126 recaptures had tags but showed no movement between barrier structures, 26 recaptures were observed due to fin clip but had no tag to show movement, and 11 recaptures showed movement through barrier structures and lock and dam structures .
- One Common Carp with a floy tag showed downstream movement through the Brandon Road Lock and Dam.

Assessing Spatiotemporal Changes in Asian Carp Abundance and Density to Target Management Actions and 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.

- Hydroacoustic surveys of Dresden Island and Marseilles pools helped inform contracted harvest and revealed different within-year (across months) patterns in density than were observed in 2016. Environmental data were collected concurrent with hydroacoustic surveys and will be analyzed to explore possible environmental predictors of Asian carp densities.
- Annual fall hydroacoustic surveys of the Illinois River (Dresden Island – Alton pools) were completed in October 2017. Asian carp mean density in Dresden Island Pool appears to have decreased by an estimated 93% from 2012 to 2017. This is a potential result of commercial harvest.
- Early generation bigheaded carp hybrids (e.g., F_1 and F_2 individuals) had lower condition than other bigheaded carp groups (parental species and more advanced hybrids [majority of alleles either Silver Carp of Bighead Carp]).
- Early generation bigheaded carp hybrids were uncommon (65 out of 1479 individuals) and composed a greater proportion of bigheaded carp sampled in the upper Illinois River (Dresden Island – Starved Rock pools). Bighead Carp and hybrids that had predominantly Bighead Carp genes also represented greater proportion of fish sampled in the upper Illinois River compared to lower river reaches.
- The movements and biological metrics examined for advanced generation hybrids were typically similar to whichever parental species they shared the majority of their genes with (i.e., Silver Carp of Bighead Carp). Therefore, management actions and models designed for Silver Carp or Bighead Carp are likely applicable to the majority of hybrids within the population.

Evaluation of Gear Efficiency and Asian Carp Detectability – This project assessed 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 age-0 Silver Carp were higher during 2017 than in 2015 and 2016, but lower than were observed during 2014. However, the majority of age-0 Silver Carp captured in 2017 were collected in a single mini-fyke net, highlighting the extremely patchy spatial distribution of juvenile Silver Carp during years of successful reproduction. No juvenile Bighead Carp were observed during 2017.
- During 2017, mini-fyke nets collected the highest total numbers of age-0 Silver Carp, similar to all other study years. Beach seines and dozer trawls captured very low numbers of age-0 Silver Carp. Pulsed-DC electrofishing only captured adult Silver Carp in 2017.
- The majority of age-0 Silver Carp were captured during summer sampling in 2017, whereas only 3 individuals were captured during fall sampling, similar to the pattern observed in 2014. In contrast, the majority of age-0 Silver Carp captured during 2015 and 2016 were collected during fall. These differences in capture rates among seasons suggest differences in spawning dates and survival rates of juvenile Silver Carp among years.
- Age-0 Silver Carp lengths were very similar during summer (22-41 mm) and fall (21-44 mm) sampling, suggesting that fish captured in the fall were the product of a different cohort than those captured in summer.

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 in support of mass removal events of Asian carp.
- Preliminary evaluation of alternate configurations of pound nets suggests perpendicular sets may catch more fishes, including Asian carp, than parallel sets. However, the sample sizes from current evaluations are insufficient to make robust conclusions. Additional sets are required to statistically compare configurations.

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 arrested the owner of a Kentucky fish farm who knowingly imported and stocked fish into multiple ponds throughout Illinois during the past 12 years without VHS import permits or a non-resident aquatic life dealer's license. The owner pled guilty in court and paid $5,000 in restitution to the IDNR.
- The ISU investigated a complaint of two college students who unlawfully released live largemouth bass and tilapia into an Urbana park district pond during a cultural/merit release ceremony. A records search of the Asian food market that sold the fish to the students identified the fish hauler. ISU set up surveillance on the store and inspected the fish truck when it arrived to deliver more fish. The fish hauler had been delivering fish for approximately 7 months without the required restricted species transportation permit or a VHS import permit. The delivery location of the Asian market was not listed as a delivery location on previous permits, and the hauler admitted he delivered non-VHS tested largemouth bass from a university in Indiana to the store. A total of 24 illegal deliveries were documented, and the owner agreed to plead guilty in court and pay $5,000 in restitution to the IDNR.
- The investigation into a Missouri tilapia fish farm revealed the company illegally sold 2,650 tilapia fingerlings to customers throughout Illinois in 2016 & 2017 without applying for the required restricted species transportation permit or purchasing a non-resident aquatic life dealer's license. The fish were shipped to customers via FedEx, and some were released into open waters. The owner of the company was brought into compliance and appropriate enforcement action was taken.
- The ISU cited a Texas company for illegally transporting a boat lift covered in zebra mussels from Texas to Lake Shelbyville in Illinois.
- The ISU discovered a golf course in Southern Illinois illegally stocked 1,000 tilapia in two separate ponds for vegetation control purposes. The fish were ordered on the Internet and shipped via FedEx. The facility manager was unaware it was illegal to stock them and cooperated with the investigation.

RESPONSE PROJECTS

Upper Illinois Waterway Contingency Response Plan Operation Silver Bullet Summary – This response project was conducted following the discovery of a single Silver Carp in the Little Calumet River, approximately 9 miles from Lake Michigan and above the Electric Dispersal Barrier. This discovery triggered two weeks of intensive sampling to assess whether additional Asian carp were present in the vicinity of the captured Silver Carp.

- Multiagency Response (IDNR, USFWS, USACE) utilized the Incident Command System (ISC) with guidelines set forth in the 2017 Monitoring Response Plan Upper Illinois Contingency Response Plan.

- Crews utilized electrofishing, trap (fyke) nets, pound nets, commercial netting, and electrified paupier sampling methods to collect a total of 22,156 fish over the two week sampling period. Fish captured represented 52 species and 6 hybrid groups. No Bighead or Silver Carp were capture or observed during the operation.

INTRODUCTION

The 2017 Interim Summary Report (ISR) presents a comprehensive accounting of project results from activities completed by the Asian carp Monitoring and Response Workgroup in 2017. 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 2017 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 fishermen 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 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.

DETECTION PROJECTS

Seasonal Intensive Monitoring in the CAWS

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

Introduction and Need:

Detections of Asian carp eDNA upstream of the Electric Dispersal Barrier in 2009 initiated the development of a monitoring plan using boat electrofishing and contracted commercial fishers to sample for Asian carp at five fixed sites upstream of the barrier. In addition, random area sampling began in 2012 in order to increase the chance of encountering Asian carp in the CAWS beyond the designated fixed sites. Based on the extensive sampling performed upstream of the Electric Dispersal Barrier from 2010 through 2013 (682 hours of electrofishing, 445.8 km (277 mi) of gill/trammel net, 2.2 km (1.4 mi) of commercial seine hauls) and only one Bighead Carp being collected in Lake Calumet in 2010, fixed site and random area sampling effort was reduced upstream of the barrier to two Seasonal Intensive Monitoring (SIM) events from 2014- 2017. The reduction of effort upstream of the Electric Dispersal Barrier will allow for increased monitoring efforts downstream of the barrier. The increase in sampling downstream of the Electric Dispersal Barrier will focus sampling efforts on the leading edge of the Asian carp population, which will serve to reduce their numbers in this area thus mitigating the risk of individuals moving upstream towards the Electric Dispersal Barrier and Lake Michigan by way of the CAWS. Results from SIM upstream of the Electric Dispersal Barrier will contribute to our understanding of Asian carp abundances in the CAWS and guide conventional gear or rotenone rapid response actions designed to remove Asian carp from areas where they have been captured or observed.

Objectives:

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

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

Project Highlights:

- Completed 2-two week SIM events with conventional gears in the CAWS upstream of the Electric Dispersal Barrier in 2017.

Seasonal Intensive Monitoring in the CAWS

- Estimated 990 person-hours were spent to complete 109.3 hours of electrofishing, set 139 km (86.5 mi) of trammel/gill net, 2.2 km (1.4 mi) of commercial seine, 8 Fyke nets, and 2 Great Lake Style Pound Nets (pound nets) in 2017
- Across all locations and gears in 2017, sampled 31,818 fish representing 58 species and 2 hybrid groups.
- Since 2010, an estimate 26,826 person-hours were spent to complete 1,086.7 hours of electrofishing, set 823.9 km (512 mi) of gill/trammel net and 11.1 km (6.9 mi) of commercial seine, tandem trap nets, hoop nets, Fyke nets, and pound nets.
- A total of 374,288 fish representing 73 species and six hybrid groups were sampled, including 2,020 Banded Killifish (state threatened species) from 2010-2017
- Examined 111,761 YOY Gizzard Shad since 2010 and found no Asian carp.
- Since 2010, 16 non-native species have been captured accounting for 15% of the total fish caught and 22% of the total species.
- From 2011-2016, no Bighead Carp or Silver Carp have been captured or observed. One Bighead Carp captured in Lake Calumet in 2010, and one Silver Carp was captured in Little Calumet River in 2017.
- 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, Fyke nets, commercial seine, and pound nets 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. Pound nets had a single 100.0 m (328.0 ft.) by 3.0 m (9.8 ft.) lead and two adjustable length wings 3.0 m (9.8 ft.) in depth, and a mesh cab, or catch area, 6.1 m long by 3.0 m wide by 3.0 m deep (19.6 x 9.8 x 9.8 ft.) square made from webbing. The cab had two, 3.0 m (9.8 ft.) long by 2.5 cm (1.0 in.) diameter steel pipes sewn to the bottom of the horizontal panels of the cab serving as weights and one 3.0 m (9.8 ft.) long by 7.6 cm (3.0 in.) diameter capped polyvinyl chloride pipe stitched to the top of the rear horizontal cab panel serving as a float. Fyke nets had a single 15.2 m (50.0 ft.) long by 1.4 m (4.5 ft.) deep lead. The frames of the net was constructed of two, 1.2 m (4.0 ft.) by 1.8 m (5.0 ft.) rectangular bars made of 8 mm (0.3 in.) black oil temper spring steel. Inner wings (vertical wall throats) of the frame extended from outer corners of the front rectangle to the middle of the rear rectangle. A 76.0 mm (3.0 in.) vertical gap existed on either side of lead between the wings and lead at middle of rear rectangle. A 1.2 m (4.0 ft.) webbing covered gap connected the cab and frame together. The cab

was constructed of six, 0.9 m (3.0 ft.) diameter spring steel hoops spaced 61 cm (24 in.) apart from each other. Cab and frame together were 6.0 m (20.0 ft.) in total length.

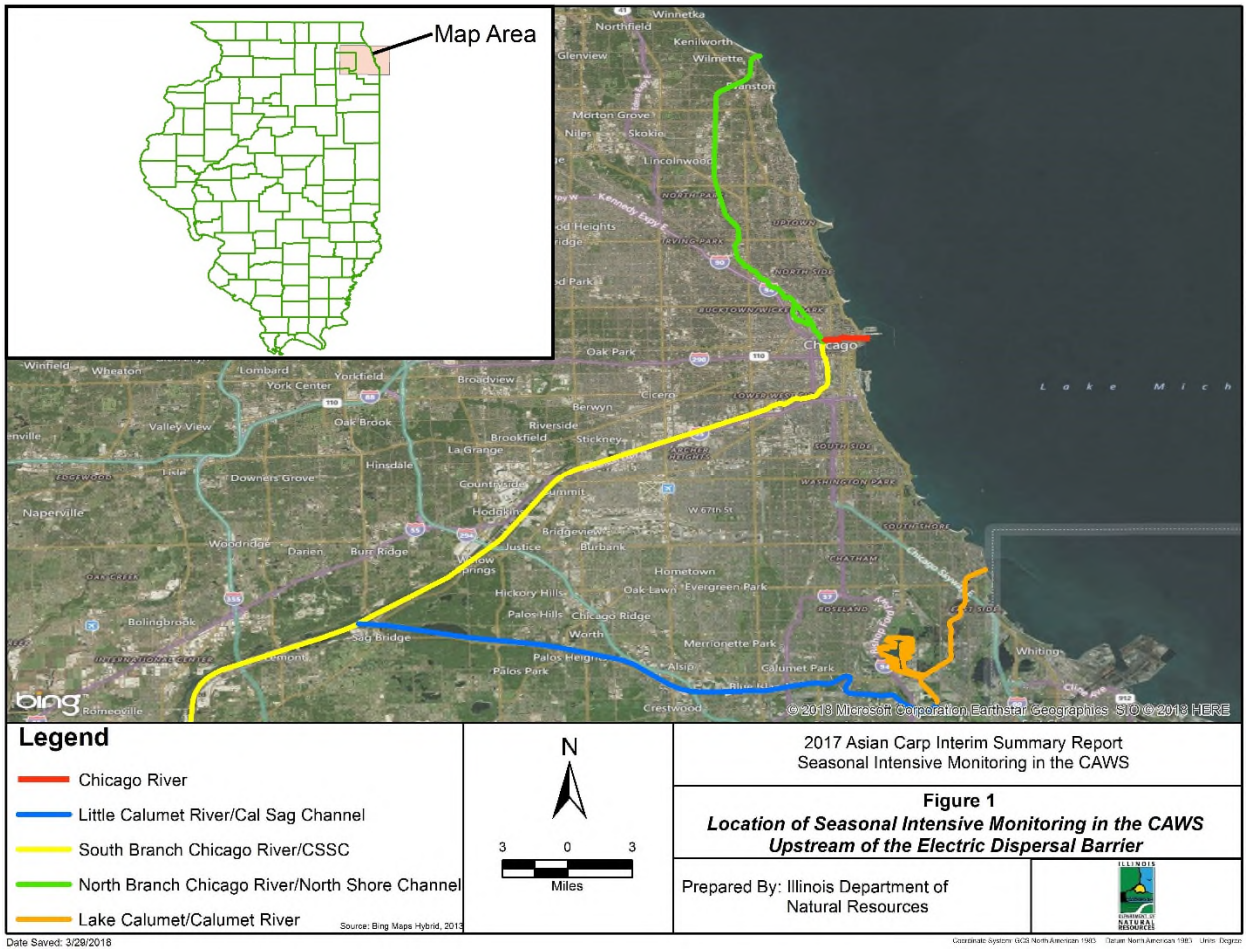

Figure 1. *Location of SIM in the CAWS upstream of the Electric Dispersal Barrier.*

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. Pound nets and Fyke nets were set by IDNR biologists and checked once every 2 net nights by IDNR biologists and commercial fishers.

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 12th, June 19th, September 18th and September 25th 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 2017 (Figure 2). Effort in 2017 was 109.3 hours of electrofishing (437 transects) with an estimated 990 person-hours, 139 km (86.5 mi) of trammel/gill netting (803sets) with an estimated 1,485 person hours, 2.9 km (1.8 mi) of commercial seine with an estimated 135 person hours, 2 pound nets fished for 8.9 net nights with an estimated 135 person hours, and 8 Fyke nets fished for 52.1 net nights with an estimated 135 person hours (Table 1.). Across all locations and gears, 31,818 fish representing 58 species and 2 hybrid groups were sampled in 2017 (Table 2.) Gizzard Shad and Common Carp were the predominant species, comprising 61% of all fish sampled. 11 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, Rainbow Trout, Silver Carp Non-native species made up 17% of the total species collected and 20% of the total fish in 2017. Two hundred and twenty-five (225) Banded Killifish, a state threatened species, were also collected. They were identified and returned to the water alive. In addition, we examined 6,240 young of the year (YOY) Gizzard Shad and found no YOY Asian carp. No Bighead Carp were captured or observed. One (1) Silver Carp was captured in a trammel net in Little Calumet River on June 22nd, 2017. This capture prompted

two weeks of intensive sampling in Lake Calumet, Calumet River, Calumet Harbor, and Little Calumet River. During this sampling event no Bighead or Silver Carp were captured or observed (**see Operation Silver Bullet report**).

Since 2010, an estimated 26,826 person-hours were expended monitoring fixed and random sites in the CAWS upstream of the Electric Dispersal Barrier. Total effort was 1,086.7 hours of electrofishing (4,330 transects), 823.9 km (512 mi) of gill/trammel net (4,441 sets), 11.1 km (6.9 mi) of commercial seine hauls and 105.3 net nights of hoop and Fyke nets from 2010-2017 (Table 3). The use of hoop nets was suspended after 2013 due to low gear efficiency. A total of 374,288 fish representing 73 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 81% 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 23% of the total species. Banded Killifish, a state threatened species, have been routinely collected during our monitoring efforts in the CAWS. To date, 2,020 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 (1) Bighead Carp was caught in a trammel net in Lake Calumet in 2010, and one (1) Silver Carp was captured in a trammel net in Little Calumet River on June 22nd, 2017. Furthermore, 111,761 YOY Gizzard Shad have been examined since 2010 with no YOY Asian carp being identified.

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.

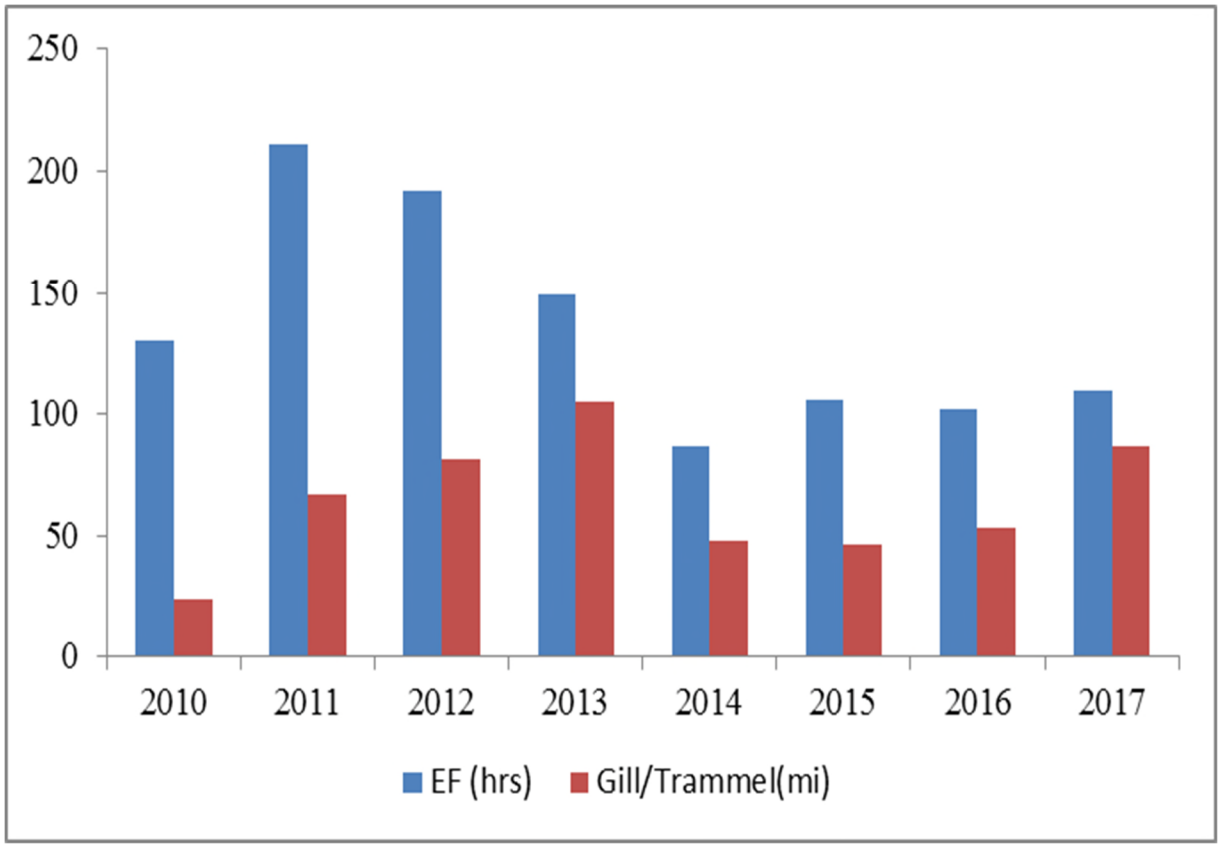

Figure 2. *Total electrofishing and trammel/gill netting effort at fixed and random sites in the CAWS upstream of the Electric Dispersal Barrier, 2010-2017.*

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 2017.*

	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	337.5	112.5	225.0	0.5	314.5	990
Samples (transects)	158	65	82	1	131	437
Electrofishing hours	39.5	16.3	20.5	0.3	32.8	109.3
Electrofishing Catch						
All fish (*N*)	8,598	4,493	5,301	36	7,770	26,198
Species (*N*)	43	37	29	4	38	58
Hybrids (*N*)	2	2	1	0	1	2
Bighead Carp (*N*)	0	0	0	0	0	0
Silver Carp (*N*)	0	0	0	0	0	0
CPUE (fish/hr)	217.7	275.6	258.6	120.0	236.8	240.0
Netting Effort						
Estimated person-hours	540	531	223	33.5	157	1,485
Samples (net sets)	242	267	140	13	141	803
Miles of net	26.6	30.0	15.6	0.7	13.5	86.5
Netting Catch						
All fish (*N*)	542	617	440	30	288	1,917
Species (*N*)	13	12	2	2	6	14
Hybrids (*N*)	0	1	1	0	1	1
Bighead Carp (*N*)	0	0	0	0	0	0
Silver Carp (*N*)	0	1	0	0	0	1
CPUE (fish/100 yds of net)	1.2	1.2	1.5	2.4	1.2	1.3
Seine Effort						
Estimated person-hours	135	-	-	-	-	135
Samples (seine hauls)	4	-	-	-	-	4
Miles of seine	1.8	-	-	-	-	1.8
Seine Catch						
All fish (*N*)	2,763	-	-	-	-	2,763
Species (*N*)	10	-	-	-	-	10
Hybrids (*N*)	0	-	-	-	-	0
Bighead Carp (*N*)	0	-	-	-	-	0
Silver Carp (*N*)	0	-	-	-	-	0
CPUE (fish/seine haul)	690.8	-	-	-	-	690.8

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
Fyke Net Effort						
Estimated person-hours	135	-	-	-	-	135
Net nights	52.1	-	-	-	-	16
Fyke Net						
All fish (*N*)	294	-	-	-	-	294
Species (*N*)	17	-	-	-	-	17
Hybrids (*N*)	1	-	-	-	-	1
Bighead Carp (*N*)	0	-	-	-	-	0
Silver Carp (*N*)	0	-	-	-	-	0
CPUE (fish/net night)	5.6	-	-	-	-	5.6
Pound Net Effort						
Estimated person-hours	135	-	-	-	-	135
Net nights	8.9	-	-	-	-	8.9
Pound Net						
All fish (*N*)	646	-	-	-	-	646
Species (*N*)	15	-	-	-	-	15
Hybrids (*N*)	0	-	-	-	-	0
Bighead Carp (*N*)	0	-	-	-	-	0
Silver Carp (*N*)	0	-	-	-	-	0
CPUE (fish/net night)	72.6	-	-	-	-	72.6

Table 2. *Total number of fish captured with electrofishing, trammel/gill nets, commercial seine, Fyke nets, and pound nets in the CAWS upstream of the Electric Dispersal Barrier during Seasonal Intensive Monitoring, 2017.*

	Chicago River		CSSC-S Branch			Lake Calumet-Cal River				Little Cal-Cal Sag		N Branch-N Shore		All Sites
Species	Elelctrofishing	Gill/Trammel	Elelctrofishing	Gill/Trammel	Comm Seine	Elelctrofishing	Gill/Trammel	Pound net	Fyke Ne	Elelctrofishing	Gill/Trammel	Elelctrofishing	Gill/Trammel	All Gears
Gizzard Shad < 6 in	8		1573		1570	587				1099		1403		6240
Gizzard shad	17		1461			990	1	89	10	1060		2365		5993
Common carp	8	29	1079	436	4	837	183	281	31	881	449	764	279	5261
Bluegill	1		312			707		22	100	124		531		1797
Largemouth bass			206		8	727	1	6	3	233	2	553		1739
Pumpkinseed			224			762		3	38	216		135		1378
Freshwater drum		1	2	3	835	46	199	34		46	92	1	2	1261
Yellow perch			1		190	877			15	50		25		1158
Golden shiner			118			143			1	36		573		871
White sucker			9			47				58		751		865
Bluntnose minnow			87			332				155		212		786
Emerald shiner	2		36			295				177		83		593
Rock bass						523				4		5		532
Channel catfish			37		134	47	10	182	53	24	8	28	4	527
Smallmouth bass					3	389	1			8		7		408
Black bullhead			6			361				7		21		395
Smallmouth buffalo						253	65	6	1	7	12	1		345
Banded killifish			1			118				96		10		225
Green sunfish			7			70				31		65		173
Goldfish			34			32				23	1	38	1	129
Spotfin shiner			36			6				18		56		116
Black buffalo						13	59				39			111
Round Goby			2			81				8		1		92
White bass			3		14	39	5		3	21		3		88
Brook silverside			2			20				43		3		68
Yellow bullhead			15			35			1	11	1	4		67
Brown bullhead						52			7		1			60
Alewife						37			8			6		51
Blackstripe topminnow			3							1		47		51
Bowfin						45				4				49
Black crappie			5			4		12	5	1		17		44
Spottail shiner						13				1		30		44
White perch						19			11	8		3		41
Quillback						37	1							38
Western mosquitofish			30											30
Bullhead minnow			4			15				3		2		24
Hybrid Sunfish			1			7			2	7		5		22
Bigmouth buffalo						2	8	1			7			18
Fathead minnow			2			6				2		7		17
Yellow bass										13				13
Flathead catfish							8	2	2					12
Northern pike			2			5		1				4		12
White crappie					2			3		7				12
Carp x goldfish hybrid				1		2				1	3		1	8
Orangespotted sunfish						2		2	3	1				8
Walleye					3	1		2				2		8
Creek chub										6		1		7
Oriental Weatherfish			2									5		7
River carpsucker						7								7
Grass carp						3	1				1			5
Central stoneroller						2								2
Central mudminnow										1				1
Chinook Salmon													1	1
Coho salmon						1								1
Common shiner												1		1
Longnose gar			1											1
Mimic shiner										1				1
Rainbow trout												1		1
Redear sunfish												1		1
Silver carp											1			1
Silver redhorse						1								1
Total Fish	36	30	5,301	440	2,763	8,598	542	646	294	4,493	617	7,770	288	31,818
Species *(N)*	4	2	29	2	10	43	13	15	17	37	12	38	6	58
Hybrids *(N)*	-	-	1	1	-	2	-	-	1	2	1	1	1	2

Table 3. *Summary of effort and catch data for all fixed and random site monitoring in the CAWS upstream of the Electric Dispersal Barrier, 2010-2017.*

	2010	2011	2012	2013	2014	2015	2016	2017	Total
Electrofishing Effort									
Estimated person-hours	1,280	2,180	4,330	1,528	945	990	990	990	13,233
Samples (transects)	519	844	765	588	348	422	407	437	4,330
EF (hrs)	130.0	211.0	192.0	149.3	87.1	106.0	102.0	109.3	1086.7
Electrofishing Catch									
All fish (*N*)	33,688	52,385	97,510	45,443	24,492	28,549	22,557	26,198	330,822
Species (*N*)	51	58	59	56	56	61	59	58	69
Hybrids (*N*)	3	3	3	2	2	2	2	2	6
Bighead Carp (*N*)	0	0	0	0	0	0	0	0	0
Silver Carp (*N*)	0	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	239.7	304.4
Netting Effort									
Estimated person-hours	885	1,725	3,188	1,932	1,125	1,125	1,125	1,485	12,590
Samples (net sets)	208	389	699	959	440	445	498	803	4,441
TRA/GIL (mi)	23.8	67.0	81.7	104.9	48.2	46.6	53.3	86.5	512.0
Netting Catch									
All fish (*N*)	2,439	4,923	3,060	4,195	1,461	1,062	1,283	1,917	20,340
Species (*N*)	17	20	20	30	18	13	18	14	32
Hybrids (*N*)	1	1	1	1	1	1	1	1	1
Bighead Carp (*N*)	1	0	0	0	0	0	0	0	1
Silver Carp (*N*)	0	0	0	0	0	0	0	1	1
CPUE (fish/100 yds of net)	5.8	4.2	2.1	2.3	1.7	1.3	1.4	1.3	2.3
Seine Effort									
Estimated person-hours	-	-	-	135	135	135	135	135	675
Samples (seine hauls)	-	-	-	3	2	3	3	4	15
Miles of seine	-	-	-	1.4	0.9	1.4	1.4	1.8	6.9
Seine Catch									
All fish (*N*)	-	-	-	7,577	1,725	5,989	3,765	2,763	21,819
Species (*N*)	-	-	-	15	11	14	15	10	16
Hybrids (*N*)	-	-	-	1	0	0	0	0	1
Bighead Carp (*N*)	-	-	-	0	0	0	0	0	0
Silver Carp (*N*)	-	-	-	0	0	0	0	0	0
CPUE (fish/seine haul)	-	-	-	2,525.7	862.5	1,996.3	1,255.0	690.8	1,454.6

Table 3. *Continued.*

	2010	2011	2012	2013	2014	2015	2016	2017	Total
Hoop/Trap Net/Fyke Net									
Estimated person-hours	-	-	-	-	-	30	28	135	193
Samples (sets)	-	-	-	11	-	4	3	8	34
Net nights	-	-	-	25.2	-	16	12	52.1	105.3
All fish (*N*)	-	-	-	93	-	172	102	294	661
Species (*N*)	-	-	-	17	-	17	15	17	17
Hybrids (*N*)	-	-	-	0	-	0	0	1	0
Bighead Carp (*N*)	-	-	-	0	-	0	0	0	0
Silver Carp (*N*)	-	-	-	0	-	0	0	0	0
CPUE (fish/net night)	-	-	-	3.7	-	10.8	8.5	5.6	6.3
Pound Net Effort									
Estimated person-hours		-	-	-	-	-	-	135	135
Net nights		-	-	-	-	-	-	8.9	8.9
Pound Net									
All fish (*N*)		-	-	-	-	-	-	646	646
Species (*N*)		-	-	-	-	-	-	15	15
Hybrids (*N*)		-	-	-	-	-	-	0	0
Bighead Carp (*N*)		-	-	-	-	-	-	0	0
Silver Carp (*N*)		-	-	-	-	-	-	0	0
CPUE (fish/net pull)		-	-	-	-	-	-	72.6	72.6

Strategy for eDNA Sampling in the CAWS and Refining eDNA Interpretation 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)

Introduction and Need:

Monitoring with multiple gears in the CAWS has been essential to determine the effectiveness of efforts to prevent self-sustaining populations of Asian carp from establishing in the Great Lakes. Environmental DNA (eDNA) has been used as a surveillance tool to monitor for genetic presence of Bighead Carp and Silver Carp in the Chicago Area Waterway System (CAWS) since 2009. To maintain vigilance above the Electric Dispersal Barrier, eDNA has been collected annually at four regular monitoring sites. In 2014, many of the projects, including use of eDNA moved work to below the Electric Dispersal Barrier to better describe the active invasive front. eDNA results were no longer consdidered a trigger for any kind of response for the Monitoring and Response Plan beginning in 2013.

Objectives:

(1) Sample Asian carp DNA in historical locations in the CAWS to maintain vigilance in areas above the Electric Dispersal Barrier, an area believed to be free of live Bighead Carp and Silver Carp.

(2) Improve the interpretation of eDNA results along an active invasion front by collecting eDNA samples in Dresden Island Pool of the Illinois Waterway below the Electric Dispersal Barrier. Dresden Island has an Asian carp gradient with few fish collected at the upper part of the pool and heavy harvest rates in the lower part of the pool, eDNA samples may reflect this carp gradient within a single pool.

Project Highlights:

CAWS Monitoring:

- One eDNA comprehensive sampling event took place in the CAWS at four regular monitoring sites in 2017, resulting in 240 samples collected and analyzed.
- One additional eDNA sampling event took place in response to a live capture of a Silver Carp in June 2017, resulting in 280 samples collected and analyzed.
- Results: zero positive detection for both species of Asian carp DNA.

Below the Electric Dispersal Barrier Monitoring:

- Two eDNA sampling events took place in Dresden Island Pool of the Illinois Waterway in May and September of 2017.
- 276 samples were collected in May: 6 were positive for Silver Carp DNA and 2 were positive for both Silver and Bighead Carp DNA.

- 276 samples were collected in September: 13 were positive for Silver Carp DNA and 4 were positive for both Silver and Bighead Carp DNA.

Methods:

The CAWS was sampled for eDNA of Bighead Carp and Silver Carp in June and September 2017. Both sampling events immediately preceded Seasonal Intensive Monitoring in the CAWS. eDNA sampling in Dresden Island Pool of the Illinois Waterway, below the Electric Dispersal Barrier, was conducted in May and September.

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).

In the June sampling of the CAWS, 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. In the September sampling of the CAWS, FWS crews collected 280 samples (including field blanks) in expanded reaches of the CAWS: 15 samples from the Chicago Sanitary and Ship Canal, 38 samples from South Branch of Chicago River, 13 samples from Chicago River, 21 samples from North Branch of Chicago River, 45 samples from North Shore Channel, 76 samples from Little Calumet River, 24 samples from Calumet River, and 48 samples from Lake Calumet. Additionally, FWS crews collected 276 samples (including blanks) in both May and September below the Electric Dispersal Barrier in Dresden Island Pool. 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 in the upper portion of Dresden Island Pool. Therefore samples were collected in a manner similar to early detection efforts, with each sample consisting of 250mL of water.

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:

Of the 240 eDNA samples (250 ml each) collected upstream of the Electric Dispersal Barrier in June, zero samples were positive for either Silver Carp or Bighead Carp DNA. Similarly, there were zero positive samples out of the 280 samples collected above the Electric Dispersal Barrier

in September. All eDNA results are available at: http://www.fws.gov/midwest/fisheries/eDNA/Results-chicago-area.html. These results are consistent with the results of previous years showing low to no detections in these areas. These low detection rates are 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. There was a live Silver Carp captured in the Little Calumet River below Thomas J. O'Brien Lock and Dam in June. eDNA samples were collected two weeks prior to this capture, however there were no positive eDNA detections in the vicinity of the capture location. A single Silver Carp represents a very low density, which may be undetectable by eDNA sampling. Also, the captured fish may have recently moved into the area and may not have been a resident of the Little Calumet River, but rather a transient rogue, which wouldn't allow for eDNA accumulation in the immediate area.

Below the Electric Dispersal Barrier:

A total of 552 samples (split between May and September) were collected below the Electric Dispersal Barrier in Dresden Island Pool, where Asian carp have been present in a gradient of high (lower pool) to low (upper pool) density (Figures 1-2). In May six samples were positive for Silver Carp DNA and two samples were positive for both Silver and Bighead Carp DNA. All positive samples occurred in the lower part of the pool, below the I-55 bridge. In September, 13 samples were positive for Silver Carp DNA and 4 were positive for both Silver and Bighead Carp DNA. All but two of the positive detections occurred below the I-55 bridge. Traditional gear data suggests that the upper portion of Dresden Island Pool (upstream of the I-55 bridge, excluding Rock Run Rookery) has lower carp density than the lower portion (2016 Asian Carp Monitoring and Response Plan Interim Summary Report). This is supported by the eDNA results from both 2017 events. Comparisons of the commercial catch data from the eDNA sampling dates show similar hotspots for Asian carp captures and positive eDNA detections (Illinois DNR unpublished data).

There was a noticeable shift in the locations of eDNA positive detections in the lower part of Dresden Island Pool between the May and September sampling events. During the May event, the marina and off-channel areas were the most positive (Figure 1), and in September most of the positive detections occurred on the main channel border (Figure 2). Commercial catch data from the months surrounding eDNA events also show that fewer fish were capture in the off-channel and marina areas in the lower pool in the fall versus spring (Illinois DNR unpublished data).

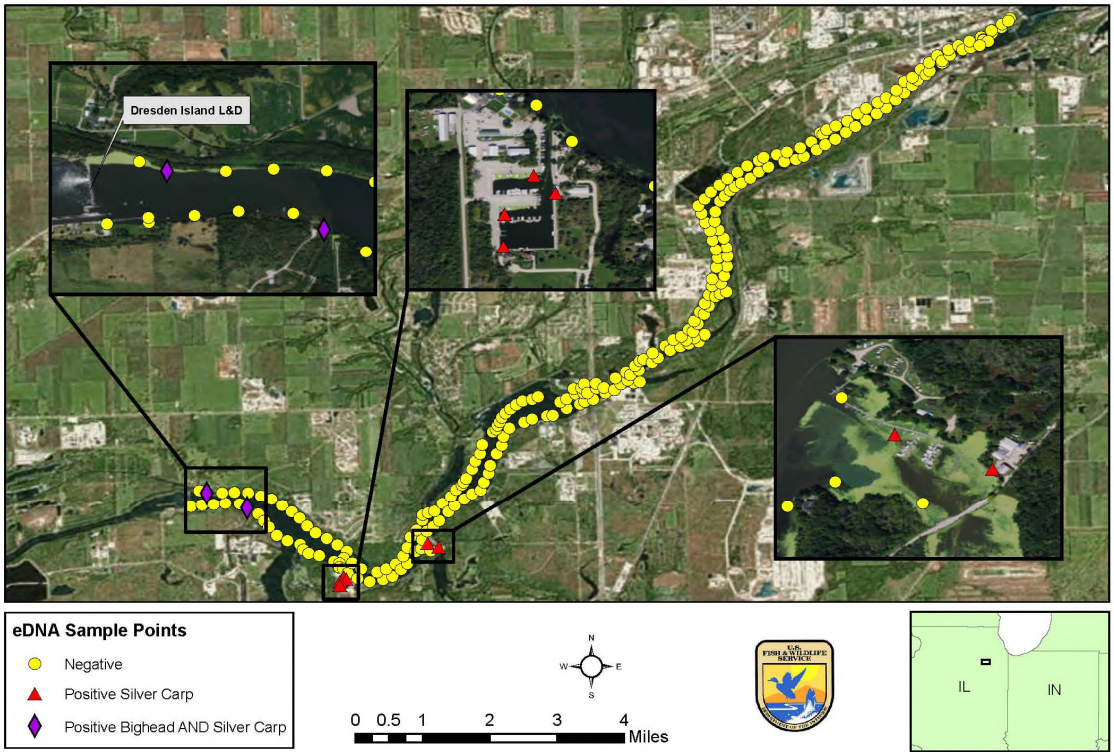

Figure 1. *Detection results for sites sampled for Silver Carp and Bighead Carp environmental DNA (eDNA) in Dresden Island Pool during May, 2017.*

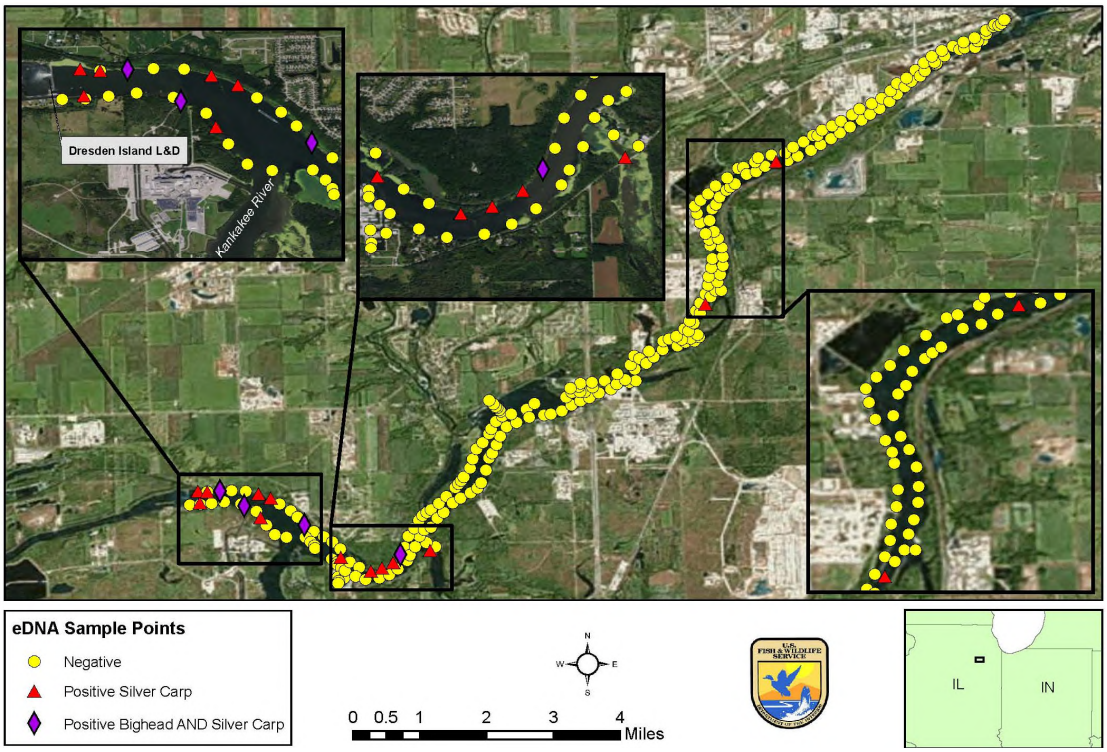

Figure 2. *Detection results for sites sampled for Silver Carp and Bighead Carp environmental DNA (eDNA) in Dresden Island Pool during September, 2017.*

Flow data for the two events show that the May and September events had similar flows on the two actual sampling days, however the flows over the 30 days prior to sampling differed (Figure 3). Flows during the May event were 2.6 times higher, on average per day, than the September event in the days leading up to the sampling events. Additionally, 30 days prior to the May sampling, there was a large rise in the hydrograph that receded. Based on telemetry data of Asian carp in the Upper Mississippi River, Asian carp are typically found in backwater and off-channel areas during this time of year prior to and in between large rises in the hydrograph (personal communication Kyle Mosel, USFWS). The positive detections along the main channel border in September also appear consistent with telemetered Asian carp movements in the Upper Mississippi River which show carp dispersing out of the off-channel areas during low water.

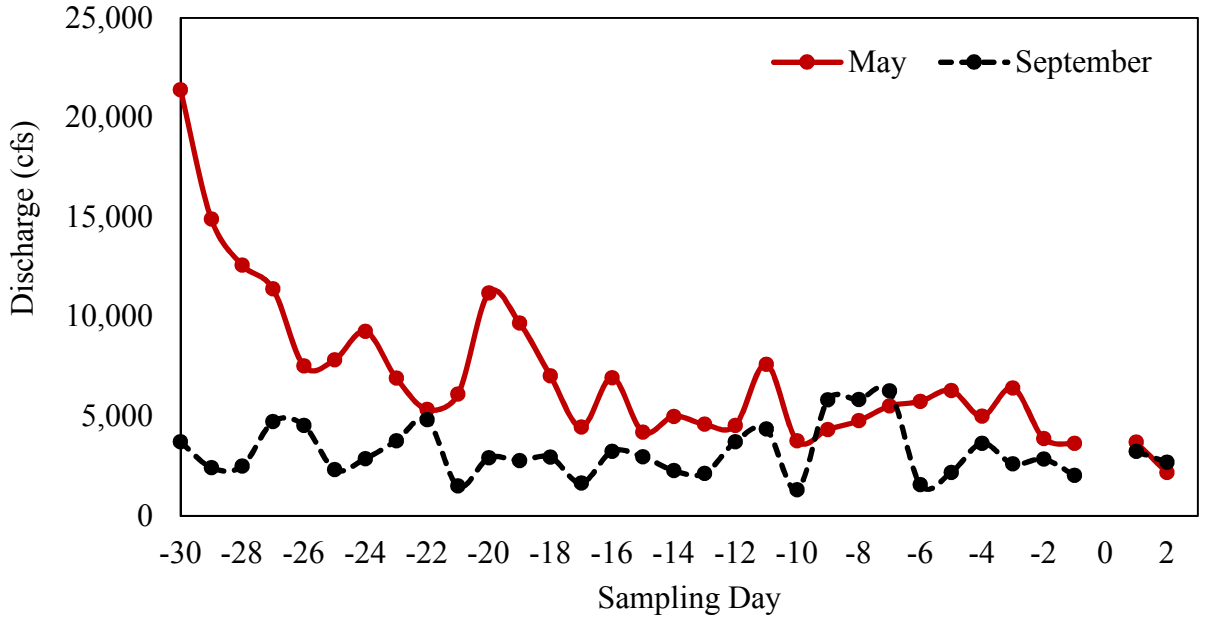

Figure 3. *Discharge (cubic feet per second) for the Des Plaines River at Joliet during the May and September eDNA sampling events (sampling days 1 and 2) and 30 days prior to each event (sampling days -30 through -1). Flow data were modified from USGS National Water Information System, Gage 05537980 Des Plaines River at Rout 53 at Joliet, IL, located in Brandon Road Pool of the Des Plaines River, which is directly upstream of the Dresden Island Pool (*https://waterdata.usgs.gov/il/nwis/uv?site_no=05537980*).*

Recommendation: In order to maintain vigilance within the CAWS, USFWS recommends continued eDNA sampling in the expanded target areas sampled in September 2017, which focused on slack-water areas, barge slips, marinas, near-shore habitats, etc. The goal of using eDNA in the CAWS is to apply a monitoring tool that has a much lower false negative (fail to detect eDNA that is present) rate than other monitoring methods, which can help provide a balanced and more complete monitoring program in the CAWS. To be clear, the rate of false negative results for eDNA monitoring is controlled by the sensitivity of the genetic assay, quality control measures employed, sample handling procedures, and sampling efficiency. The current FWS eDNA monitoring program has been critically evaluated by external reviewers and found

to employ more than adequate quality control measures to have low, or near zero false negative rates from method failure and methods have been experimentally and systematically modified since 2013 to improve sensitivity and sampling efficiency. Thus, eDNA surveillance with the current protocols can be considered to have low false negative rates. Current eDNA methods used by the FWS have some level of a false positive rate where the DNA detected could be from persistence of eDNA or from an alternate vector, but the methods employed are specific and use more than enough quality control measures to avoid false positive results from non-target species DNA or contamination. Thus, eDNA is only enhancing monitoring efforts in the CAWS. It is also recommend to increase the number of sampling events in the CAWS to four, with two events preceding the annual Seasonal Intensive Monitoring events (June and September), and two additional sampling events occurring at times to be determined based on flow, because additional events add power to detection probabilities of any sampling regime. Maintenance to the Electric Dispersal Barrier system will create a time zone in which the barrier will not provide protection for the CAWS, and increased eDNA monitoring below the system could provide early detection of changes in carp near the barrier. However, the channelized aspect of the river in Brandon Road and Lockport Pools does not create any areas where eDNA may accumulate, thus the next closest area is upper Dresden Island Pool. Thus, sampling will be combined with CAWS sampling but will be limited only to the upper portion of the pool due to the consistent positive detections in the lower portion of the pool. A similar sample density as used in 2017 will be replicated in 2018, but only in the portion above the I-55 bridge, so that efforts will act as early surveillance rather than confirming the known carp gradient in the pool. Care will be taken to avoid sampling during periods of high flows, since high flows likely push eDNA rapidly downstream.

Larval Fish Monitoring in the Illinois Waterway

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

Robert E. Colombo (Eastern Illinois University)

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

Introduction and Need:

Silver Carp and Bighead Carp are highly fecund, capable of producing hundreds of thousands of eggs that 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.

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

Project Highlights:

- 820 ichthyoplankton samples were collected from 10 sites across the length of the Illinois Waterway during April – October 2017, capturing over 113,000 larval fish, including over 58,000 larval Asian carp. Additionally, over 38,000 Asian carp eggs were collected in ichthyoplankton samples in 2017.
- Asian carp eggs were collected in the LaGrange, Peoria, and Starved Rock pools during 2017. Asian carp larvae were only identified from the LaGrange and Peoria pools. These results further confirm observations made in 2015 – 2016 that Asian carp

reproduction occurs in at least some years in the upper Illinois River. However, across 8 years of sampling, only a handful of 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 2017, with eggs and larvae collected from mid-May to late July. The early spawning activity appears to have been associated with periods of very high, but declining discharge, whereas later spawning events occurred during modest increases in the hydrograph.

Methods:

Larval fish sampling occurred at 10 sites throughout the Illinois Waterway during 2017 (Figure 1). Additional sampling took place in five tributary rivers (Kankakee, Fox, Mackinaw, Spoon, and Sangamon rivers). Sampling occurred weekly from April to early July, and biweekly from late July to October. At main channel 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 Services 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. 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 cubic meter of water sampled.

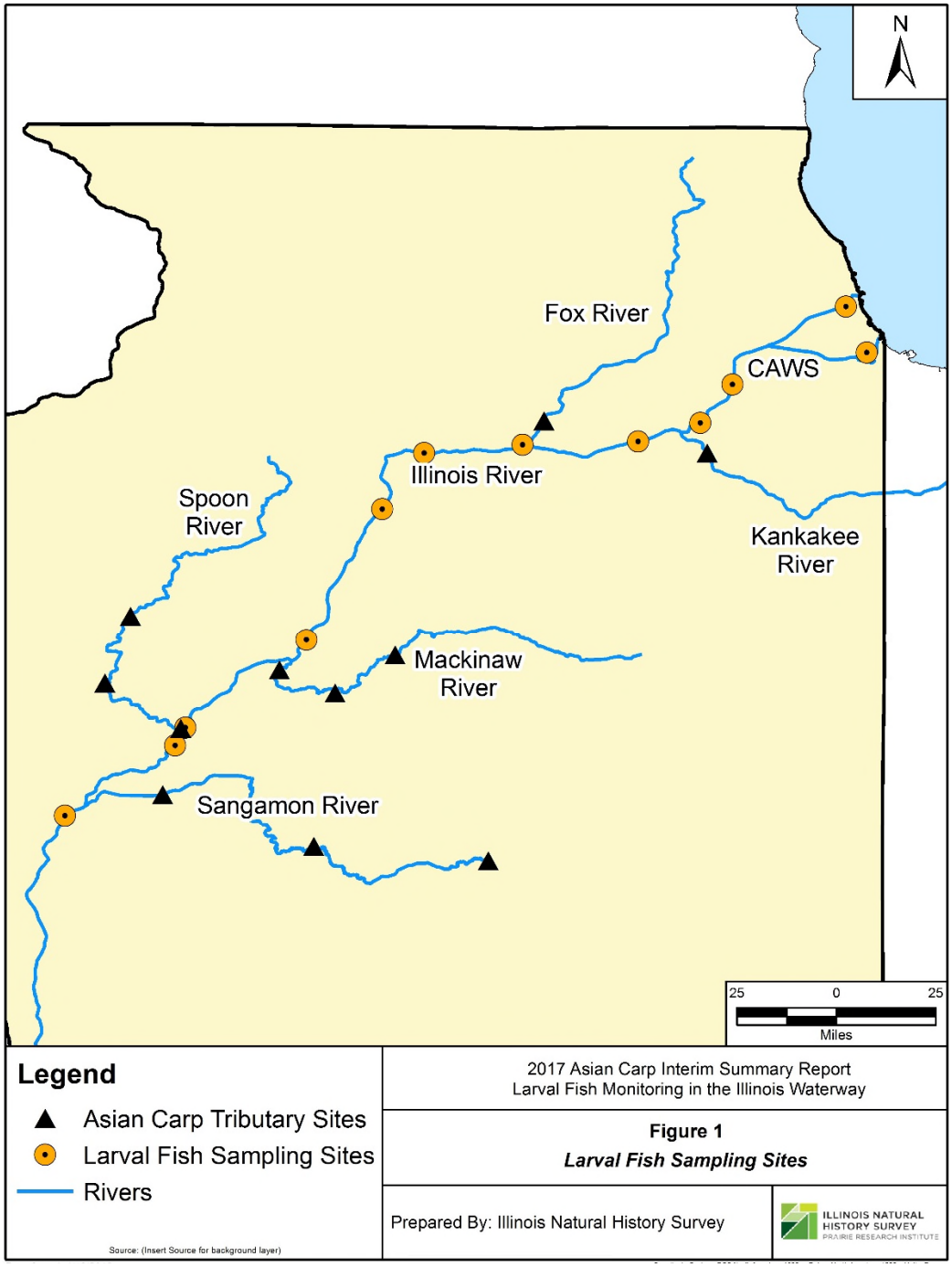

Figure 1. *Map of ichthyoplankton sampling sites in the Illinois Waterway. Sites on the main channel and backwaters of the Illinois Waterway are represented by circles. Sites in Illinois River tributaries are represented by triangles.*

Results and Discussion:

In 2017, a total of 820 ichthyoplankton samples were collected from main channel and backwater sites of the Illinois Waterway. From these, over 113,000 larval fish have been identified, including over 58,000 larval Asian carp. Additionally, over 38,000 Asian carp eggs

were collected in 2017. These numbers of Asian carp eggs and larvae are higher than those observed in any other study year except for 2015 (Table 1). As in some previous years, Asian carp appear to have had multiple spawning events in 2017, as indicated by the timing and location of eggs and larvae (Figure 2). Asian carp eggs and larvae were first observed at two sites in the LaGrange Pool during mid-May. These collections occurred once water temperatures rose above 20°C, during the descending limb of the hydrograph following a period of widespread flooding. No Asian carp eggs and larvae were observed at any site the following week, but small numbers of Asian carp eggs and larvae were collected at multiple sites in the LaGrange and Peoria Pools at the end of May into early June. Mid-June sampling did not detect Asian carp eggs or larvae at any site. However, late June samples detected very high densities of Asian carp eggs and larvae at multiple sites in the LaGrange and Peoria pools, with Asian carp eggs also collected in the Starved Rock Pool at this time. These late June collections occurred during a modest increase in discharge when water temperatures were consistently above 20°C (Figure 2). No Asian carp eggs or larvae were detected in early July, but considerable numbers of Asian carp eggs and larvae were again observed in the LaGrange and Peoria pools during late July, coinciding with a modest increase in discharge and consistently high water temperatures. No Asian carp eggs or larvae were collected at any site after July in 2017. No Asian carp eggs were collected upstream of the Starved Rock Pool, and no Asian carp larvae were collected upstream of the Peoria Pool during 2017. Over 300 ichthyoplankton samples were collected from Illinois River tributaries in 2017. No Asian carp eggs or larvae were collected in the Fox River or Kankakee River during 2017. Samples from other Illinois River tributaries are being processed and results will be reported once available.

Table 1. *Dates, effort, and number of larval fish captured during ichthyoplankton sampling activities on the Illinois Waterway during 2010 – 2017.*

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
2017	April 26 – Oct 18	820	113,516	58,541	38,805

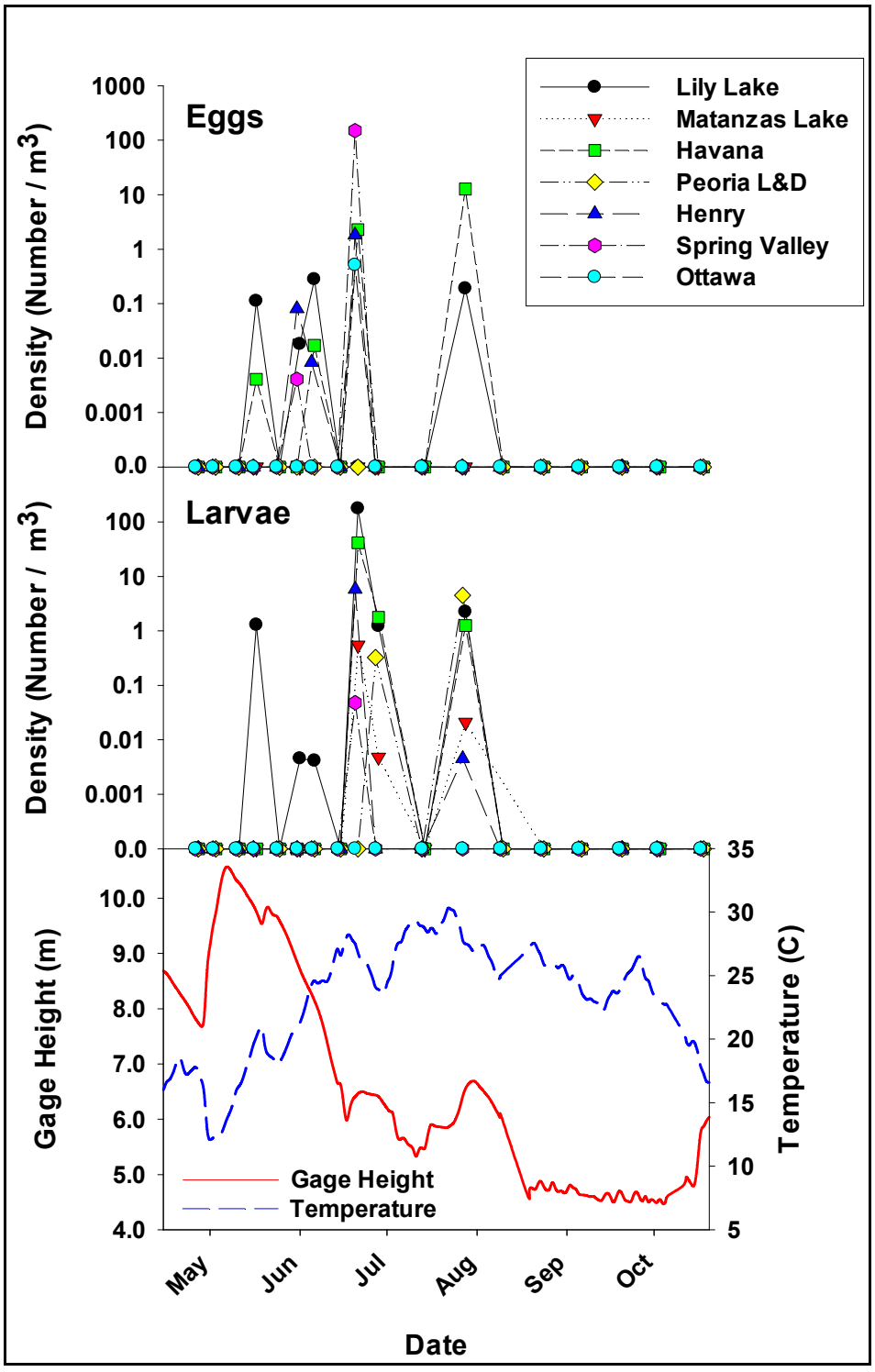

Figure 2. *Densities (number / m^3; note log scale) of Asian carp eggs (top panel) and larvae (middle panel) collected from sites throughout the Illinois Waterway during 2017. Mean daily gage height (m) and water temperature (° C) of the Illinois River during April – October 2017 (bottom panel) were obtained from USGS hydrograph 5586300 at Florence, IL.*

These data indicate that Asian carp successfully spawned in the Illinois River during 2017, producing large numbers of eggs and larvae, some of which recruited to juvenile stages (see Young-of-year and Juvenile Asian Carp Monitoring summary). 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. Environmental 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 – 2017 were associated with at least modest increases in discharge. However, many eggs and larvae observed during several study years, including in 2017, have been associated with steadily declining hydrographs. Asian carp spawning cues may be more complicated than currently understood and a detailed analysis of multiple years of sampling data, examining the relationships of temperature, water levels, and other environmental factors on 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 were not observed in the upper Illinois Waterway in any study year prior to 2015. The presence of Asian carp eggs in the Starved Rock and Marseilles pools during 2015 – 2017 confirms that some Asian carp reproduction takes place in the upper Illinois Waterway when conditions are conducive to spawning. However, across eight years of sampling, very few larvae have been collected upstream of the Starved Rock Lock and Dam. 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.

Recommendations:

Ichthyoplankton sampling should continue to monitor for Asian carp reproduction, particularly upstream of the Peoria Pool. Analyses examining relationships between environmental factors and Asian carp reproduction and recruitment are currently being conducted and will be reported during 2018. Additional analyses of Asian carp egg drift (FluEgg model) have been conducted with USGS partners, using a hydrodynamic model of the Illinois Waterway and a reverse-time

particle tracking algorithm to back-calculate the spawning locations of Asian carp eggs collected by ichthyoplankton sampling. These efforts should be further pursued to provide a robust understanding of Asian carp spawning locations throughout the Illinois River, and to understand where Asian carp larvae spawned in each navigation pool are likely to settle out of the drift under different flow conditions. 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.

Distribution and Movement of Small Asian Carp in the Illinois Waterway

Cory Anderson, Emily Pherigo, and Rebecca Neeley
(U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office
Wilmington Substation)

Participating Agencies: USFWS Columbia FWCO

Introduction and Need:

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

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

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

Distribution and Movement of Small Asian Carp in the Illinois Waterway

Objectives:

(1) Detect the presence of small Asian carp in the middle and upper IWW through intensive, targeted sampling.

(2) Determine the distribution and abundance of small Asian carp in the middle and upper IWW.

(3) 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 the Starved Rock Lock and Dam during the 2017 field season, however, three individuals were caught in Peoria Pool near Henry, Illinois (RM 194).
- A total of 18 juvenile Asian carp (≤ 400 mm TL) were found in Starved Rock Pool and 118 in Peoria Pool during 2017 field sampling efforts. Most of these fish are likely age 2 and are smaller inividuals from the 2015 cohort.

Methods:

Sampling sites were chosen at the discretion of crew leaders each day based on river conditions and most fishable areas. Each location was identified by generalized habitat strata: backwater, isolated pool, main channel, side channel, main channel, marina, or tributary. Physical characteristics and water quality measurements were made at each collection site and included: Secchi depth, depth, substrate type (i.e, boulder, cobble, gravel, sand, silt, and clay), temperature, specific conductivity, and dissolved oxygen. Water quality measurements were taken using a YSI Professional Series multi-meter. Additionally, GPS coordinates and time stamps were recorded at the start and end of each electrofishing event, trawl run, and mini-fyke net set.

All Bighead Carp, Silver Carp, Grass Carp (*Ctenopharyngodon idella*), and up to 10 Gizzard Shad (*Dorosoma cepedianum*) were measured for TL (mm) for each sample. Any other species were simply tallied and released to increase processing speed. Any fish not easily identified in the field were preserved in Excel Plus or 70% EtOH for laboratory identification to the lowest possible taxonomic level. Effort was quantified as net nights (mini-fykes) or minutes of electrofishing (boat electrofishing, dozer trawl, and paupier trawl).

Electrofishing – Pulsed DC daytime electrofishing conducted with perpendicular passes into shore, and 2 dippers, for 15 minute sampling 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 mini-fyke nets had a 24 foot lead and 1/8 inch mesh.

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

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

Results and Discussion:

During the 2017 field season, no small (≤153 mm TL) Asian carp were captured upstream of the Starved Rock Lock and Dam, however, three were caught in Peoria Pool near RM 194 (Henry, IL) (Table 1). One of the small Silver Carp was caught electrofishing in April, 2017 and the other two were captured in a single dozer trawl in September, 2017. Eighteen juvenile (≤400 mm TL) Silver Carp were caught in Starved Rock Pool in four locations: Heritage Harbor, Starved Rock Marina, Starved Rock Yacht Club, and near Delbridge Island (Table 1). Six of these juveniles were caught by the dozer trawl, and 12 by boat electrofishing. Additionally, 118 total juvenile Asian carp were captured in the Peoria Pool using dozer trawl (n = 74) and boat electrofishing (n = 47), mostly as part of the juvenile Asian carp telemetry efforts (n = 78). The majority of juvenile Asian carp were captured in backwater habitats (n = 59 juvenile Asian carp, 1 small Asian carp) and marinas (n = 59 juvenile Asian carp, 2 small Asian carp), however, these were also the areas fished the most, collectively (Table 2, Table 3).

Efforts during 2017 focused heavily on the Marseilles and Starved Rock pools as no small Asian carp were caught upstream of Starved Rock during 2016 (Table 4). Also, field crews were instructed to sample more main channels and side channels than prior years rather than solely sampling backwaters and marinas based on preliminary results of juvenile Asian carp telemetry. Less effort was put into Dresden Island, Brandon Road, and Lockport pools than during 2016. If juveniles or small Asian carp had been captured in Marseilles Pool, more effort would have been put into the upper pools. Also, more sampling was done in Peoria during 2017 than prior years as a result of the juvenile Asian carp telemetry project. Since goals of that project are to catch and tag small and juvenile Asian carp, efforts were combined with data from monitoring.

The most common species captured during all of 2017 sampling were: Gizzard Shad (*Dorosoma cepedianum*) (n = 15,568), Emerald Shiner (*Notropis atherinoides*) (n = 2,657), Silver Carp (n = 2,777, includes juveniles), Smallmouth Buffalo (*Ictiobus bubalus*) (n = 1,655), and Bluegill (*Lepomis macrochirus*) (n = 1,202) (Table 5). The large relative abundance of pelagic minnow

species and Gizzard Shad from 2017 sampling efforts indicates fishing is effective for these species despite the small relative numbers of juvenile Asian carp.

Recommendations:

Monitoring for the distribution (the leading edge) abundance of small Asian carp remains of critical importance based on the operational limitations of the electric barrier. Added knowledge of the life history and habitat usage of juvenile Asian carp remains important to improve capture efficiency and inform management efforts. Monitoring efforts for juvenile and small Asian carp will continue for 2018. The project design will change slightly to have a more standardized approach to selecting sampling sites and operating field equipment. Data from the juvenile Asian carp habitat usage and movement telemetry study, started by the Carterville FWCO in 2016, will be used to generate random and targeted sampling locations in Dresden Island, Marseilles, and Starved Rock pools. The main goal of this study will still be to detect and determine the location of juvenile Asian carp in the Illinois Waterway downstream of the electric dispersal barrier.

Table 1. *Small Silver carp (≤153mm) and Juvenile Silver carp (≤400mm) caught by pool in Starved Rock and Peoria pools.*

	Starved Rock juvenile AC	Peoria small AC	Peoria juvenile AC
Mean (mm)	362	113	327
n	18	3	118
Range (mm)	256-394	109-115	174-397
Gear	Dozer, Electrofishing	Dozer, Electrofishing	Dozer, Electrofishing

Table 2. *Total juvenile and small Asian carp by habitat area. Small Asian carp depicted in parentheses.*

	Backwater	**Marina**	**Main Channel**	**Side Channel**
Dozer Trawl	34	24(2)	16	7
Electrofishing	25(1)	27	1	2
Total	59(1)	51(2)	17	9

Table 3. *Total effort in number of sites and minutes (net nights for mini fykes) separated by gear type and habitat strata for all sampled pools.*

Gear type	Main channel	Side channel	Backwater	Marina	Tributary	Isolated
Electrofishing (minutes)	1164.73	648.28	909.50	1060.73	162.88	120.00
Electrofishing (n sites)	79	43	61	67	12	8
Dozer trawl (minutes)	260.17	33.55	228.95	191.18	42.67	3.50
Dozer trawl (n sites)	53	6	21	24	9	1
Paupier trawl (minutes)	45.43	53.56	38.17	5.75	20.42	0.00
Paupier trawl (n sites)	9	13	10	2	5	0
Mini fyke nets (n net nights)	5	14	40	0	4	0

Table 4. *Total 2017 sampling effort by river pools and gear type used. Effort is recorded in minutes unless otherwise noted.*

	Peoria		Starved Rock		Marseilles	
	Effort	Num. sites	Effort	Num. sites	Effort	Num. sites
Boat Electrofishing (mins)	418	28	1447	97	1797	121
Dozer Trawl	307	53	226	40	97	20
Paupier Trawl	34	11	62	14	54	11
Mini-Fyke (net nights)	-	13	-	50	-	7
	Dresden Island		**Brandon Road**		**Lockport**	
	Effort	Num. sites	Effort	Num. sites	Effort	Num. sites
Boat Electrofishing	435	29	188	14	105	7
Dozer Trawl	100	20	64	13	39	8
Paupier Trawl	14	3	-	-	-	-
Mini-Fyke (net nights)	-	-	-	-	-	-

Table 5. *Mean relative abundance, standard error, total fish count, and percent site occurrence of fifteen most common fish species combined from all of 2017 monitoring efforts.*

Species	Mean % Abundance	SE	n	Percent of sites found
Gizzard Shad	30.62	1.29	15568	77.63
Emerald Shiner	11.73	0.88	2657	55.84
Silver Carp	11.65	0.86	2777	49.42
Smallmouth Buffalo	8.41	0.52	1655	59.92
Bluegill Sunfish	3.89	0.42	1202	38.72
Bullhead Minnow	3.15	0.53	450	19.46
Freshwater Drum	2.28	0.23	438	34.05
Largemouth Bass	1.86	0.19	678	31.71
River Carpsucker	1.67	0.16	404	29.18
Common Carp	1.27	0.17	389	20.43

Juvenile Asian Carp Telemetry in the Illinois River

Cory Anderson and Rebecca Neeley
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Participating Agencies: USFWS Columbia FWCO

Introduction:

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

Objectives:

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

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

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

Project Highlights:

- A total of 72 fish were tagged in 2017.
- The mean weekly movement distance was 943.7 m per week.
- Percent total residency was 39.4% in backwaters, 36.0% in the main channel, and 24.6% in the side channels.

Methods:

Prior to the 2017 field season, the Peoria Pool was broken into four macrohabitat categories: main channel, side channel, backwater, and marinas. Areas of the river where the river is dredged to maintain 9 feet depth and commercial barge traffic is allowed to operate were termed, “main channels.” Parts of the river which had flowing current but were separated from the main

channel by land or very shallow areas (<1 foot depth at base flow) were termed, “side channels.” Any non-flowing water still connected to the river was termed, “backwater.” Finally, any non-flowing area connected to the river that had depth maintained for boat traffic through dredging was termed, “marina.” The proportion of available habitat (surface area) was calculated from digital raster graphic topographic maps from the Illinois State Geological Survey, ESRI ArcMap 10.2, and U.S. Army Corps of Engineers navigational maps.

Juvenile Asian carp to be tagged were captured using boat electrofishing and an electrified dozer trawl from the Illinois River near Henry, Illinois and Lacon, Illinois from June 2017 to September 2017. Fish collection focused on marinas, backwaters, and side channels due to the morphology of the river in these areas and gear effectiveness in this part of the river. Following tagging, fish were released in proximity to their capture location. Fish tags used were Vemco V5 ultrasonic transmitters (180 kHz, 0.38 g in water, Vemco Ltd.) and Lotek NTQ-4 radio transmitters (168 mHz, 0.65g in water, Lotek Wireless).

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

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

Acoustic telemetry equipment was deployed prior to tagging fish. A total of 26 Vemco VR2-W 180kHz (Vemco Ltd) hydrophone receivers were placed from Hennepin, IL to Chillicothe, IL. Fourteen receivers were initially placed along the main channel, seven receivers were placed in

backwaters, two receivers were placed in marinas, and three receivers were placed in the limited side channels available. Main channel receivers were typically deployed by attaching the hydrophone to a 5 foot section of 3/16 inch galvanized steel cable and attaching the assembly to navigational buoys. In some main channel areas and side channel sets, hydrophones were attached to 3/16 inch cable that dangled from a float, tethered to a concrete anchor. The anchor was then either tethered to a tree on shore and padlocked, or attached to a 800 lb holding force Danforth style river anchor. Similar deployment methods were used for backwater sets.

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

Active tracking was not conducted in 2017 due to time limitations with tagging fish and deploying the telemetry gear. In the future active tracking will be conducted periodically, at least every other month, by boat. Acoustic active tracking will be conducted using a Vemco VR100 (Vemco Ltd.) mobile telemetry receiver unit and 180 kHz underwater hydrophone, mounted to an aluminum pole and attached to the front of the boat. Radio tracking will be conducted using a Lotek SRX800M (Lotek Wireless) mobile radio telemetry receiver unit and a 4-element or 6-element fixed mast Yagi antenna mounted 12 feet above the boat on an aluminum pole, or a 3-element handheld Yagi antenna when fish are in close proximity. Tracking will be conducted by driving at 5 mph or less down the river channel and into each backwater lake, side channel, and marina area, while monitoring for fish detections. Active tracking data will primarily be used to inform field efforts of fish outside of the receiver deployment zone.

Results and Discussion:

A total of 72 juvenile Asian carp were tagged in the Peoria Pool of the Illinois River during 2017 (Table 1). Twelve of these fish were tagged using both acoustic V5 tags and NTQ radio tags. Mean total length of tagged fish was 320 mm and the smallest total length of a tagged Asian carp was 174 mm (Table 1).

Table 1. *2017 Juvenile Asian carp tagging events, mean TL (mm), mean wt (g), number of fish tagged.*

Date	n tagged	Mean TL (mm)	Mean wt (g)
6/28/2017	2	231.5	188.0
7/11/2017	5	317.0	334.4
7/12/2017	7	328.0	346.4
7/13/2017	13	320.5	349.9
7/24/2017	9	345.4	309.8
7/25/2017	3	325.7	267.7
7/26/2017	3	362.3	333.7
8/8/2017	10	320.7	253.4
9/14/2017	6	276.8	202.2
10/12/2017	9	367.0	461.1
10/31/2017	5	364.4	455.2
Total	**72**	**323.6**	**318.3**

Juvenile Asian carp occupied backwater habitat strata the greatest frequency of times (n = 1461 residencies) and spent the greatest mean time in these areas (10.55 hours), however there was no significant difference between backwater areas and main channels (Table 2). These results are similar to the preliminary data analyzed from telemetry in 2016, which indicated juvenile Asian carp were being detected in main channel habitats as often as in backwaters. Juvenile Asian carp had average residence times of 9.65 hours in main channels and stopped near receivers 982 times (minimum of 30 minutes) (Table 2).

Table 2. *Mean residence time and number of residences of telemetered juvenile Asian carp in the Peoria Reach of the Illinois River separated by habitat strata during 2017 acoustic telemetry.*

Receiver strata	Mean Residency (hours)	n residences
Backwater	10.55	1461
Main channel	9.65	982
Side channel	6.58	562

When mean residence times are plotted with river discharge, a trend emerges with moderate positive correlation (0.53) between discharge and residency near a receiver (Figure 1). This relationship may be caused by the smaller bodied Asian carp avoiding high river currents. There was no correlation between residence time and water temperature (-0.15).

Mean weekly movement distance (mean of 943.7 m per week) of juvenile Asian carp fluctuated greatly throughout the field season but was generally higher between June and September (Figure 2). Roughly half (52%, n = 395 movements) of movements recorded were fish moving between backwater and adjacent main channel areas, repeatedly. This is similar to what was analyzed based on residence times, with juvenile Asian carp stopping most frequently in backwater and main channel areas. Most other movements (42%) were fish moving up or downstream in the main channel between receivers. When movements were analyzed alongside river discharge there was no correlation (-0.28), despite current velocity being a trigger for adult Asian carp spawning activity (Figure 2). When mean weekly movement distances are plotted

with temperature, a weak positive correlation (0.41) can be seen; as temperature decreased, the movement distances of fish decreased (Figure 3). This would be expected based on the physiology of fish and the general decrease in activity during winter. Unfortunately, temperature data was only analyzed from September to December due to data being unavailable earlier in the year.

To date, the results of this study indicate that juvenile Asian carp reside in main channels nearly the same amount of time as backwater habitats. This is similar to what was seen during 2016 and is different from the common thought of where to find juvenile Asian carp. Juveniles may be schooling with adults even at a young age, potentially as soon as they are able to swim in the river current. Juvenile Asian carp had mean weekly movements averaging about 1 km throughout the year but decreasing during late fall and early winter. More data will be collected and further analysis conducted to determine the mean distance juvenile Asian carp swim upstream. Additionally, efforts will be made to sample other water quality parameters to test for correlations with movements and residencies. Results from this year will be used in 2018 to generate targeted sites in upper pools for monitoring juvenile Asian carp with the goal to increase capture efficiency.

Recommendations:

Telemetry will provide valuable knowledge on the habitat usage and movement characteristics of juvenile Asian carp. Based on data from the study to date, juvenile Asian carp are spending a large portion (over 50%) of residence times in main channel and side channel habitats. If this remains true, it will be important to tailor monitoring regimes in the upper pools of the Illinois River to reflect this habitat usage. Additionally, juvenile Asian carp averaged a movement distance of 800 meters per week in the main channel. Continued telemetry studies and more data will provide insight as to what drives these movement patterns. Because of the danger of juvenile Asian carp entering the Great Lakes through the Illinois Waterway and the relatively low success of catching small Asian carp in upper reaches, this project should continue for 2018 and at least one or two more years to best inform the monitoring in upper reaches.

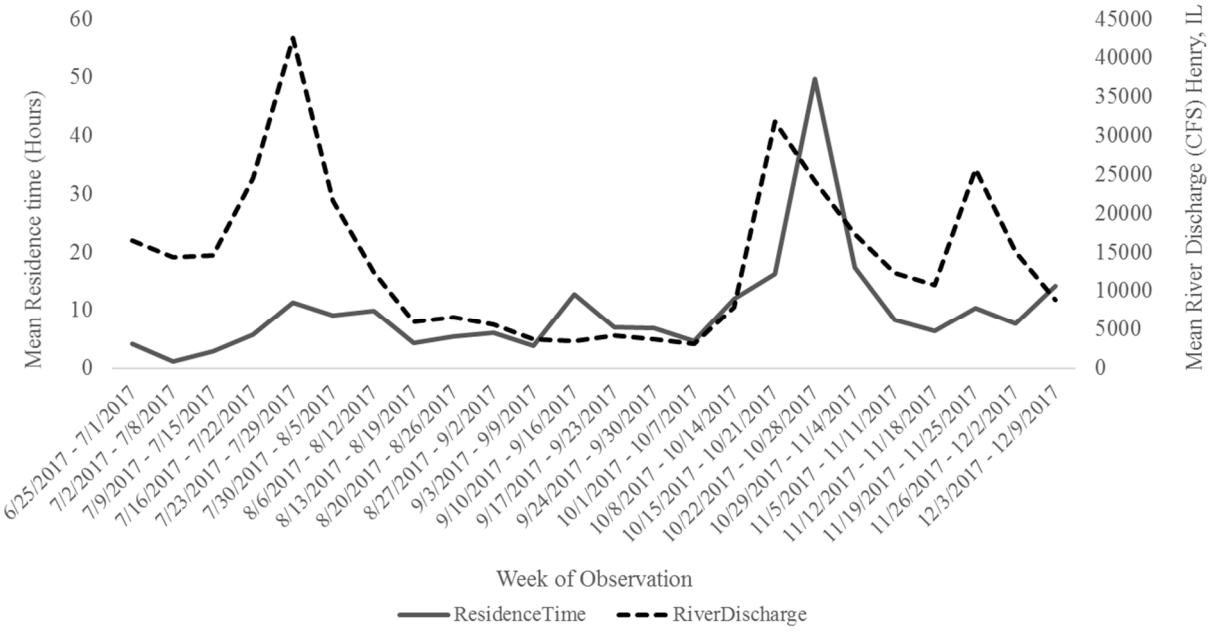

Figure 1. *Mean weekly residence time (hours, solid line) of hydroacoustic telemetered juvenile Asian carp in the Peoria reach of the Illinois River and mean weekly river discharge (CFS, dashed line) at the gauge in Henry, IL.*

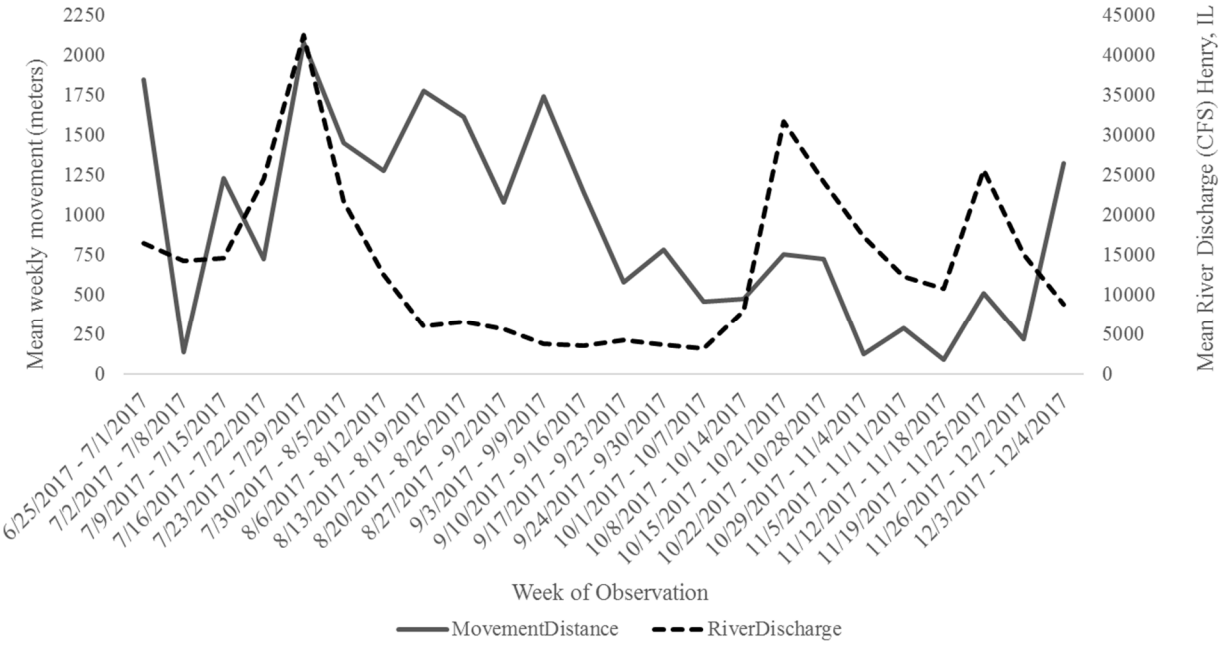

Figure 2. *Mean weekly movement distance (meters, solid line) of hydroacoustic telemetered juvenile Asian carp in the Peoria reach of the Illinois River and mean weekly river discharge (CFS, dashed line) at the gauge in Henry, IL.*

Juvenile Asian Carp Telemetry in the Illinois River

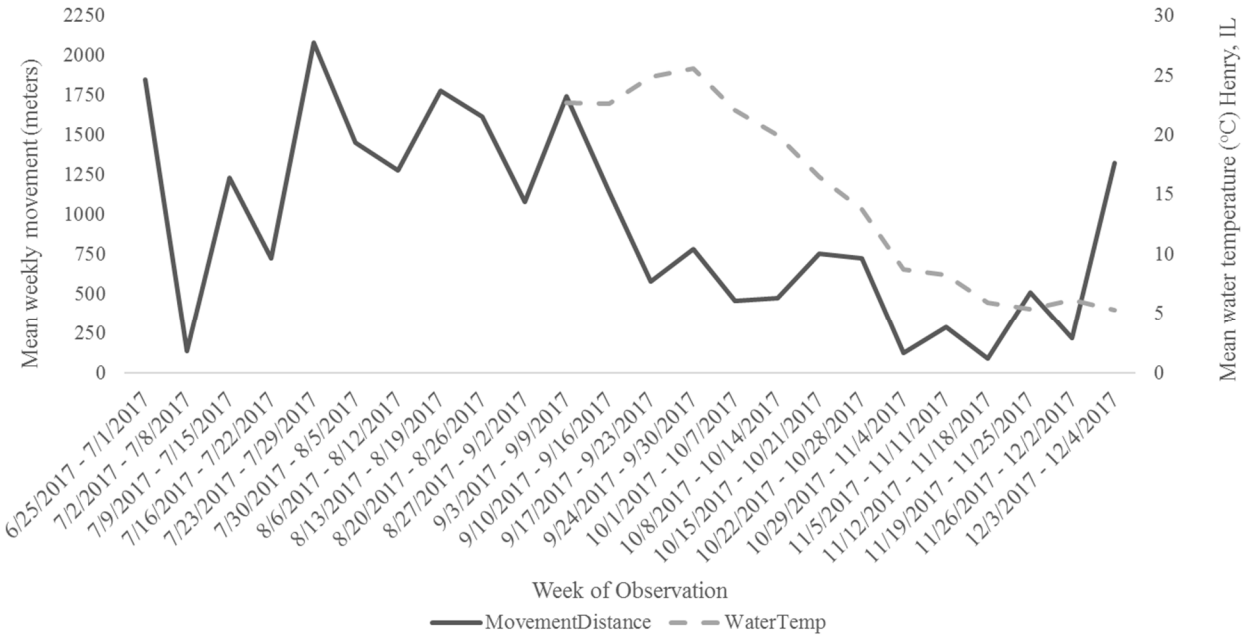

Figure 3. *Mean weekly movement distance (meters, solid line) of hydroacoustic telemetered juvenile Asian carp in the Peoria reach of the Illinois River and mean weekly river temperature (degrees Celsius, dashed line) at the gauge in Henry, IL.*

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 (Wilmington), Colombia, and La Crosse Fish and Wildlife Conservation Offices (field support); U.S. Army Corps of Engineers – Chicago District (field support)

Introduction and Need: Standardized sampling is essential to managers monitoring population growth and range expansion of aquatic invasive species. Information learned from consistent and long-term monitoring
(i.e., presence/absence, distribution, and abundance of target species) is imperative to understanding the threat of possible invasion upstream the Electric Dispersal Barrier. We use pulsed-DC boat electrofishing, hoop and mini-fyke netting, and contracted commercial fishers to sample for invasive Asian carp in the four reaches below the Electric Dispersal Barrier: Lockport, Brandon Road, Dresden Island, and Marseilles pools. These efforts are useful to monitor changes in the leading edge, distribution, and relative abundance of Asian carp in the Illinois Waterway over time. The 'leading edge' is defined as the farthest upstream location where multiple Bighead or Silver Carp have been captured in conventional sampling gears during a single trip or where individuals of either species have been caught in repeated sampling trips to a specific site. Our eight years of data (2010-2017) provide a working knowledge of Asian carp abundance and distribution downstream the Electric Dispersal Barrier and the potential threat of upstream movement to the CAWS.

Objectives:

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

(2) Determine relative abundance of Asian carp in locations and habitats where they are likely to congregate.

(3) Supplement Asian carp distribution data obtained through other projects (i.e., Asian Carp Barrier Defense project, Telemetry master plan).

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

Monitoring Efforts Downstream the Electric Dispersal Barrier

Project Highlights (Electrofishing, commercial netting, and hoop/mini fyke netting):

- An estimated 21,488.5 person-hours expended sampling fixed, random, targeted, and additional sites downstream the Electric Dispersal Barrier (2010-2017).
- A total of 837.25 hours electrofishing, 1,431.2 km (889.3 miles) trammel/gill net, 1,700 hoop netting nights, and 676 mini-fyke netting nights (2010-2017).
- A total of 291,781 fish captured, representing 97 species and eight hybrid groups (2010-2017).
- No Bighead or Silver Carp have been captured in Lockport or Brandon Road pools in any year sampled, but have been collected in Dresden Island Pool totaling 3,868 (2010-2017). Historically, Rock Run Rookery, Mobil Bay and the downstream end of Treats Island within the Dresden Island Pool are locations where Asian carp have been known to congregate and are frequently sampled (Figure 1).
- The leading edge of the Asian carp population is 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 leading edge over the past 10 years.

Methods:

As in previous years, the 2017 sampling design included pulsed-DC boat electrofishing, gill/trammel netting, and hoop/mini-fyke netting at fixed, random, and targeted sampling locations in pools downstream the Electric Dispersal Barrier: Lockport, Brandon Road, Dresden Island, and Marseilles pools. Commercial netting efforts were focused in Lockport, Brandon Road, and Dresden Island pools. The fixed sampling locations (four sites/pool sampled regularly since 2010) are primarily in the upper portions of each pool below lock and dam structures and in habitats where Asian carp are likely to congregate (backwaters and side channels habitats). Electrofishing random sites were computer generated for main channel sampling locations (112 computer generated sites per pool). Targeted commercial netting replaced random netting in 2015 allowing commercial fishers to choose their netting locations increasing the likelihood of capturing a Bighead or Silver Carp.

Electrofishing Protocol

Fixed and random electrofishing samples occurred bi-weekly from April to November 2017. All electrofishing used pulsed-DC current and included one or two netters (two netters were preferred). Electrofishing was conducted in a downstream direction in waterway channels (including following the shoreline into off-channel areas) or in a clockwise direction in backwater sloughs. Electrofishing runs were 15 minutes in length and generally parallel to shore. The operator was encouraged to switch the pedal on and off at times to prevent pushing fish in front of the boat and to increase the chances of catching an Asian carp. Common Carp were counted without capture, while all other fish were netted and placed in a tank to be identified and counted, after which they were returned live to the water (native fish only). Young-of-year

(YOY) Gizzard Shad were examined closely for the presence of Asian carp and counted to provide an assessment of any young Asian carp in the waterway. All field data were entered into a Microsoft Access Fish App database.

Gill and Trammel Netting Protocol

In 2017, IDNR contracted commercial fishers (3 fishers per week) deployed gill/trammel nets at fixed and targeted sampling locations downstream the Electric Dispersal Barrier in Lockport, Brandon Road and Dresden Island pools (including Rock Run Rookery) bi-weekly from March to December. An IDNR/INHS biologist was aboard each commercial netting boat to monitor operations, record data, check for ultrasonic- or jaw-tagged Bighead or Silver carp (left pelvic/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 site locations were selected based upon the discretion of commercial fishers. Deployed nets were attended at all times. Net sets were a short duration utilizing noise to drive fish into the nets (i.e., "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 yards) 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.

Hoop and Mini-Fyke Netting Protocol

In 2017, IDNR/INHS biologists conducted hoop and mini-fyke net sampling at fixed sites downstream the Electric Dispersal Barrier. Fixed site sampling took place 1 week per month from May to December in Lockport, Brandon Road, Dresden Island, and Marseilles pools. Additional hoop net sampling also took place in the Dresden Island Pool in June 2017 in response to a sustained high water event.

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 unharmed. 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 in 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.

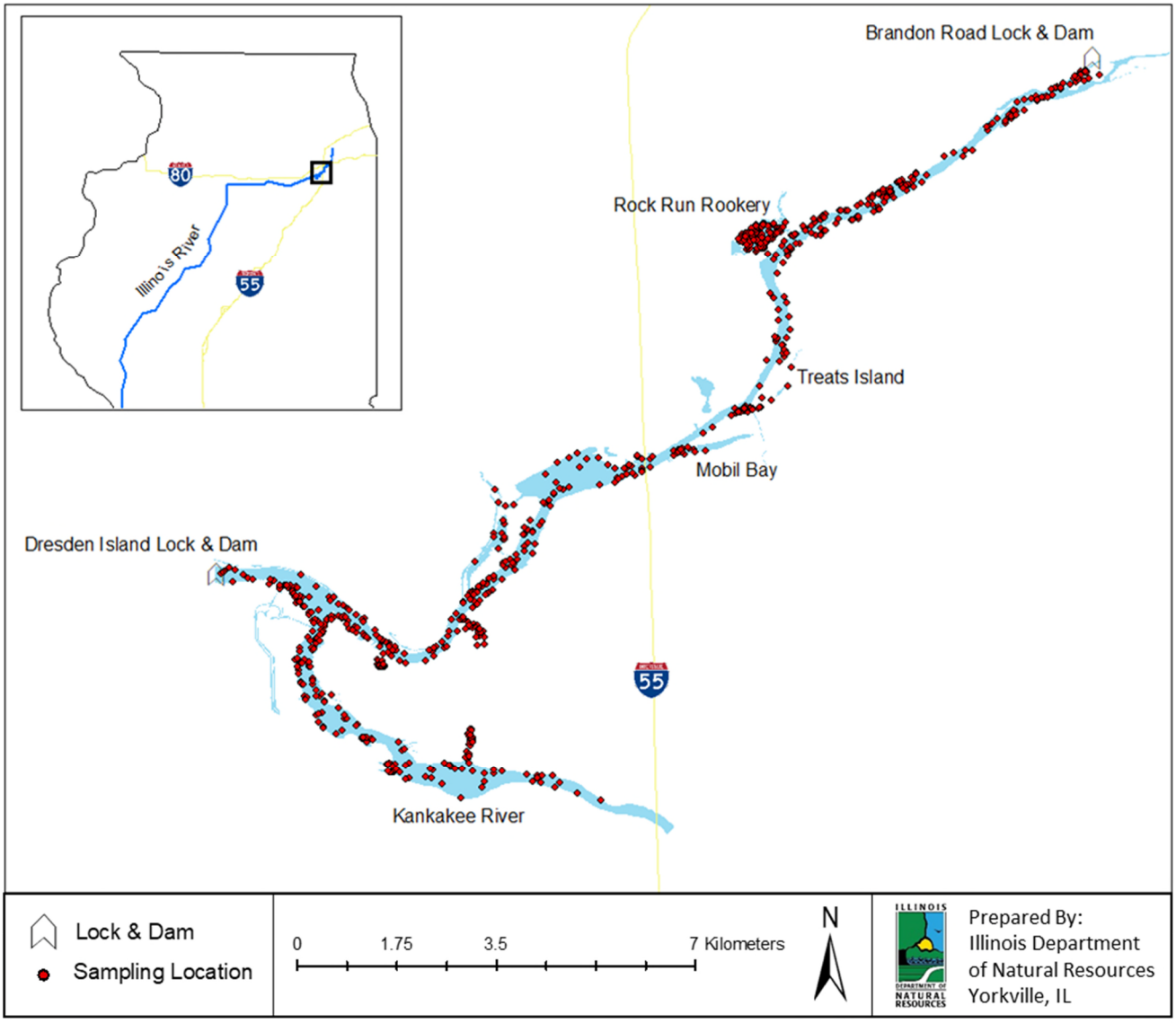

Figure 1. *Fixed, random, targeted, and additional sampling locations for all gear types (electrofishing, hoop/mini-fyke netting, and commercial netting) used to monitor Asian carp populations in Dresden Island Pool in 2017.*

Results and Discussion:

Electrofishing Effort and Catch

From 2010-2017, an estimated 7,397.5 person-hours were expended completing 837.25 hours of electrofishing. A total of 197,855 fish were sampled representing 97 species and seven hybrid groups at fixed and random electrofishing sites downstream the Electric Dispersal Barrier (Table 1). Fixed site catch-per-unit-effort (CPUE) in 2017 was 333.86 fish/hour, a slight decrease from

the 2016 fixed site CPUE (430 fish/hour; Table 2). Random site CPUE in 2017 was 235.12 fish/hour, a slight increase from the 2016 random site CPUE (200 fish/hour; Table 2). Decreases in fixed site CPUE in 2017 are likely attributed to a decrease in Gizzard Shad detection (n = 8,489 in 2017 compared to n = 17,423 in 2016). Increases in random site CPUE in 2017 are likely attributed to an increase in Gizzard Shad detection (n = 12,567 in 2017 compared to n = 10,906 in 2016) and Emerald Shiner detection (n = 2,051 in 2017 compared to n = 898 in 2016). Fixed site Asian carp CPUE was 4.75 fish/hour (7.18 fish/hour in 2016) and random site Asian carp CPUE was 2.70 fish/hour (5.47 fish/hour in 2016). Fixed sites were selected based on habitats where Asian carp are likely to congregate, thus Asian carp CPUE is higher at those sites than at random sites. Computer generated random sites were distributed on main channel borders resulting in lower Asian carp CPUE at those sites. No Bighead Carp or Silver Carp were sampled by electrofishing in Lockport or Brandon Road pools for any year sampled. In Dresden Island Pool, Asian carp fixed site CPUE was 0.32 fish/hour (0.6 fish/hour in 2016) and Asian carp random site CPUE was 0.96 fish/hour (0.66 fish/hour in 2016). In Marseilles Pool, Asian carp fixed site CPUE was 18.55 fish/hour (28.62 fish/hour in 2016) and Asian carp random site CPUE was 10.09 fish/hour (19.73 fish/hour in 2016). A total of 14,671 Gizzard Shad ≤ 152 mm (6 inches) were examined at fixed and random sites downstream the Electric Dispersal Barrier in 2017 with no Asian carp YOY detected. This has been consistent for all years sampled. In 2017, species with the greatest overall abundance were Gizzard Shad (57.7%), Emerald Shiner (9.8%), Bluegill (4.5%), Smallmouth Buffalo (3.9%), and Common Carp (3.7%) for random and fixed site electrofishing in all pools sampled (Table 2).

Gill and Trammel Netting Effort and Catch

From 2010-2017, 1,431.1 km (889.2 miles) of gill/trammel net were deployed at fixed, random, targeted and additional sampling locations downstream the Electric Dispersal Barrier. From 2010-2017, 10,358 person-hours were expended monitoring Asian carp; commercial netting yielded 31,733 fish representing 35 species and three hybrid groups. In 2017, 338.4 km (210.3 miles) of gill/trammel net were deployed at fixed and targeted sites in Lockport, Brandon Road, and Dresden Island pools. Commercial netting yielded 9,876 fish representing 27 species and two hybrid groups, of which Common Carp (22%) and Smallmouth Buffalo (57%) comprised 79% of the total catch and Bighead (3%) and Silver (5%) Carps comprised 8% of the total catch (Table 3). No live Asian carp were captured in Lockport or Brandon Road pools, but were captured at fixed and targeted sites in Dresden Island Pool (n = 799; Table 2). Catches of Bighead and Silver Carps in the Dresden Island pool were higher at fixed and targeted sites sampled in 2017 (n = 297 and n = 502, respectively) than from fixed and targeted sites sampled in 2016 (n = 230 and n = 236, respectively; Table 2). Differences in Asian carp catches may be attributed to an increase in effort in 2017 from 2016 (338.4 km compared to 304.6 km respectively). The increase in effort was the result of the Unified Fishing Method that occurred in Dresden Island Pool in October 2017 and the continued use of three commercial fishers. Gill/trammel netting CPUE (number of fish/100 yards of net) for all fish species was 2.9 fish/100 yards at targeted sites and 0.5 fish/100 yards at fixed sites in 2017 (Table 2), compared to 2.0

fish/100 yards at targeted sites and 3.6 fish/100 yards at fixed sites in 2016. CPUE of Bighead Carp was 0.09 fish/100 yards at targeted sites and 0.0 fish/100 yards at fixed sites in 2017 (Table 2), compared to 0.08 fish/100 yards at targeted sites and 0.003 fish/100 yards at fixed sites in 2016. CPUE of Silver Carp was 0.15 fish/100 yards at targeted sites and 0.003 fish/100 yards at fixed sites in 2017 (Table 2), compared to 0.08 fish/100 yards at targeted sites and 0.03 fish/100 yards at fixed sites in 2016.

Hoop and Mini-Fyke Netting Effort and Catch

From 2012 to 2017, an estimated 3,668 person hours were expended setting and running 856 hoop nets and 676 mini-fyke nets (1,700 hoop net nights and 524 mini-fyke net nights) downstream the Electric Dispersal Barrier. Hoop netting yielded 4,549 fish representing 24 species and two hybrid groups (Table 4). Smallmouth Buffalo comprised the largest proportion of the catch (45%; n = 2,029), followed by Channel Catfish (26%; n = 1,200) and Common Carp (12%; n = 563). Mini-fyke netting yielded 57,645 fish representing 66 species and one hybrid group (Table 5). Bluegill constituted the largest proportion of the catch (39%; n = 22,188) followed by Bluntnose Minnow (18%; n = 10,157) and Pumpkinseed (6.1%; n = 3,491).

In 2017, hoop netting yielded 2,245 fish representing 17 species and two hybrid groups, with Smallmouth Buffalo comprising most of the catch (53%; n = 1,192), followed by Channel Catfish (24%; n = 533), and Common Carp (8.3%; n = 187; Table 4). No Asian carp were captured in Lockport or Brandon Road pools, but were captured at fixed/additional sites in Dresden Island Pool (6 Bighead Carp, 1 Grass Carp, and 2 Silver Carp) and at fixed sites in Marseilles Pool (6 Bighead and 43 Silver Carp; Table 4). Catches of Bighead Carp were lower in 2017 (n = 12) compared to 2016 (n = 19), and catches of Silver Carp were also lower in 2017 (n = 45) than in 2016 (n = 47). Hoop netting CPUE (number of fish/net night) of all fish species was 4.2 at fixed/additional sites in 2017 (Table 2), compared with 0.83 at fixed sites in 2016. Bighead Carp hoop netting CPUE was 0.022 at fixed/additional sites in 2017, compared with 0.074 at fixed sites in 2016. Silver Carp hoop netting CPUE was 0.084 at fixed/additional sites in 2017, compared with 0.18 at fixed sites in 2016. It should be noted that despite additional Dresden Island pool hoop net sampling in response to high water events in June 2017, Asian carp catch rates were lower than in 2016.

In 2017, mini-fyke netting yielded 9,100 fish representing 49 species and one hybrid group. The majority of the catch was comprised of Bluntnose Minnow (35%; n = 3,199), followed by Bluegill (19%; n = 1,765), and Banded Killifish (11%; n = 969), which is a state threatened species (Table 5). Mini-fyke netting CPUE (number of fish/net night) of all species captured was 73 at fixed sites in 2017 (Table 2), much greater than in 2016 (CPUE = 55). No Asian carp were captured.

Monitoring Efforts Downstream the Electric Dispersal Barrier

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/trammel netting) and monitoring/removal projects (*see* Barrier Defense Removal report) add confidence to the finding that the relative abundance of Asian carp has 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/trammel netting using the same protocols as in 2017.

Monitoring Efforts Downstream the Electric Dispersal Barrier

Table 1. *Fixed and random electrofishing catch summary for 2017, including 2010-2017 in pools below the Electric Dispersal Barrier.*

	2017 Fixed Electrofishing						2017 Random Electrofishing						2010-2017	
	Pool						Pool							
Species	Lockport	Brandon	Dresden	Marseilles	No. Cap.	Percent	Lockport	Brandon	Dresden	Marseilles	No. Cap.	Percent	Captured	Percent
Alewife	27	2			29	0.20%		8			8	0.04%	47	0.02%
American eel			1		1	<0.01%							4	<0.01%
Banded darter													6	<0.01%
Banded killifish	205	26	9	32	272	1.85%	66	75	24	15	180	0.83%	760	0.38%
Bighead carp			1		1	<0.01%			1	3	4	0.02%	34	0.02%
Bigmouth buffalo			9	31	40	0.27%			9	11	20	0.09%	544	0.27%
Black buffalo			2		2	0.01%			1	1	2	<0.01%	196	0.10%
Black bullhead	2				2	0.01%		1			1	<0.01%	19	0.01%
Black crappie			12	8	20	0.14%			15	4	19	0.09%	175	0.09%
Black redhorse													16	<0.01%
Blacknose dace													2	<0.01%
Blackside darter													8	<0.01%
Blackstripe topminnow		1	2	2	5	0.03%			1	8	9	0.04%	73	0.04%
Blue catfish													1	<0.01%
Bluegill	17	31	370	178	596	4.06%	6	31	870	122	1,029	4.72%	10,917	5.52%
Bluegill x Green sunfish hybrid													30	0.02%
Bluntnose minnow	81	30	86	8	205	1.40%	28	49	303	14	394	1.81%	4,236	2.14%
Bowfin		1	2		3	0.02%		1	3	1	5	0.02%	40	0.02%
Brassy minnow													6	<0.01%
Brook silverside	7		2	12	21	0.14%			5	4	9	0.04%	278	0.14%
Brown bullhead													14	<0.01%
Bullhead minnow	1		9	28	38	0.26%			43	51	94	0.43%	1,241	0.63%
Carp x goldfish hybrid									2		2	<0.01%	59	0.03%
Central mudminnow								1			1	<0.01%	4	<0.01%
Central stoneroller		1	3		4	0.03%							11	<0.01%
Channel catfish	7	34	20	17	78	0.53%	2	21	64	59	146	0.67%	1,310	0.66%
Channel shiner				10	10	0.07%				39	39	0.18%	82	0.04%
Common carp	131	138	251	33	553	3.76%	64	74	574	79	791	3.63%	10,263	5.19%

Table 1. (*Continued*)

	2017 Fixed Electrofishing						2017 Random Electrofishing						2010-2017	
	Pool						Pool							
Species	Lockport	Brandon	Dresden	Marseilles	No. Cap.	Percent	Lockport	Brandon	Dresden	Marseilles	No. Cap.	Percent	Captured	Percent
Common shiner			1		1	<0.01%							30	0.02%
Creek chub	1				1	<0.01%				1	1	<0.01%	6	<0.01%
Emerald shiner	570	235	92	626	1,523	10.37%	310	364	294	1,083	2,051	9.41%	13,562	6.85%
Fathead minnow	6		1		7	0.05%	11	1	2		14	0.06%	41	0.02%
Flathead catfish				2	2	0.01%			5	5	10	0.05%	108	0.05%
Freshwater drum	3	12	53	70	138	0.94%	1	16	102	143	262	1.20%	1,912	0.97%
Gizzard shad	1,063	334	2,881	4,211	8,489	57.79%	1,036	780	3,571	7,180	12,567	57.63%	105,071	53.11%
Golden redhorse			24	51	75	0.51%			34	91	125	0.57%	1,399	0.71%
Golden shiner	40	2	64	12	118	0.80%	14	2	118	4	138	0.63%	850	0.43%
Goldeye									27		27	0.12%	30	0.02%
Goldfish	51	6	19	2	78	0.53%	8	33			41	0.19%	602	0.30%
Grass carp				3	3	0.02%		1	2	16	19	0.09%	99	0.05%
Grass pickerel	2	1	1		4	0.03%	1	1	1		3	0.01%	48	0.02%
Greater redhorse													5	<0.01%
Green sunfish	7		17	8	32	0.22%	9	2	33	17	61	0.28%	2,473	1.25%
Greenside darter													7	<0.01%
Highfin carpsucker				3	3	0.02%			1	1	2	<0.01%	48	0.02%
Hornyhead chub									1		1	<0.01%	3	<0.01%
Hybrid Sunfish			2		2	0.01%	1	2	3		6	0.03%	320	0.16%
Johnny darter													21	0.01%
King salmon													1	<0.01%
Largemouth bass	10	21	261	73	365	2.48%	9	54	565	61	689	3.16%	6,224	3.15%
Logperch			6	7	13	0.09%			13	25	38	0.17%	232	0.12%
Longear sunfish			2	1	3	0.02%			4	1	5	0.02%	58	0.03%
Longnose gar		1	21	66	88	0.60%	1	1	105	56	163	0.75%	1,264	0.64%
Mimic shiner									1		1	<0.01%	23	0.01%
Mooneye				1	1	<0.01%				1	1	<0.01%	11	<0.01%

Table 1. (*Continued)*

	2017 Fixed Electrofishing						2017 Random Electrofishing						2010-2017	
	Pool						Pool							
Species	Lockport	Brandon	Dresden	Marseilles	No. Cap.	Percent	Lockport	Brandon	Dresden	Marseilles	No. Cap.	Percent	Captured	Percent
Muskellunge									15	1	16	0.07%	18	<0.01%
Northern hog sucker				3	3	0.02%				1	1	<0.01%	81	0.04%
Northern pike		5	1	1	7	0.05%		1	8		9	0.04%	78	0.04%
Orangespotted sunfish				2	2	0.01%				6	6	0.03%	219	0.11%
Oriental weatherfish	11		1		12	0.08%	8				8	0.04%	230	0.12%
Paddlefish													1	<0.01%
Pumpkinseed	32	22	83	2	139	0.95%	12	38	109	1	160	0.73%	2,394	1.21%
Pumpkinseed x bluegill hybrid													15	<0.01%
Quillback			16	29	45	0.31%			10	20	30	0.14%	622	0.31%
Red shiner													3	<0.01%
Redear sunfish				2	2	0.01%							23	0.01%
River carpsucker			16	95	111	0.76%			38	104	142	0.65%	1,689	0.85%
River redhorse													13	<0.01%
River shiner									2		2	<0.01%	32	0.02%
Rock bass		1	6	3	10	0.07%		1	7		8	0.04%	122	0.06%
Round Goby		4	4		8	0.05%		6	3	1	10	0.05%	173	0.09%
Sand shiner			1		1	<0.01%				1	1	<0.01%	274	0.14%
Sauger				5	5	0.03%	1	1	1	8	11	0.05%	53	0.03%
Shorthead redhorse			38	42	80	0.54%			68	19	87	0.40%	580	0.29%
Shortnose gar				16	16	0.11%				4	4	0.02%	125	0.06%
Silver carp			4	204	208	1.42%			27	219	246	1.13%	2,296	1.16%
Silver chub													2	<0.01%
Silver redhorse			9	15	24	0.16%			30	25	55	0.25%	271	0.14%
Skipjack herring			2	1	3	0.02%		1	2	2	5	0.02%	63	0.03%
Slenderhead darter													7	<0.01%
Smallmouth bass	1	81	57	75	214	1.46%	9	56	105	125	295	1.35%	2,315	1.17%
Smallmouth buffalo			148	214	362	2.46%			416	633	1,049	4.81%	8,298	4.19%

Table 1. (*Continued*)

	2017 Fixed Electrofishing						2017 Random Electrofishing						2010-2017	
	Pool						Pool							
Species	Lockport	Brandon	Dresden	Marseilles	No. Cap.	Percent	Lockport	Brandon	Dresden	Marseilles	No. Cap.	Percent	Captured	Percent
Spotfin shiner	4		10	25	39	0.27%			10	92	102	0.47%	3,235	1.64%
Spottail shiner	13	13	122	31	179	1.22%		9	203	11	223	1.02%	1,743	0.88%
Spotted gar									1		1	<0.01%	8	<0.01%
Spotted sucker			3		3	0.02%			3		3	0.01%	45	0.02%
Stonecat													1	<0.01%
Striped bass x white bass hybrid		1			1	<0.01%				2	2	<0.01%	36	0.02%
Striped shiner									1		1	<0.01%	3	<0.01%
Suckermouth minnow				1	1	<0.01%							4	<0.01%
Tadpole madtom													4	<0.01%
Threadfin shad	20	51	5	113	189	1.29%	44	71	3	5	123	0.56%	5,706	2.88%
Trout perch									2		2	<0.01%	7	<0.01%
Unidentified Catostomid (suckers)													44	0.02%
Unidentified Cyprinid			1		1	<0.01%							5	<0.01%
Unidentified Moronid													3	<0.01%
Unidentified Percid													1	<0.01%
Walleye			3	2	5	0.03%				1	1	<0.01%	72	0.04%
Walleye x Sauger hybrid													1	<0.01%
Warmouth								1			1	<0.01%	17	<0.01%
Western mosquitofish	31				31	0.21%							78	0.04%
White bass			12	54	66	0.45%			2	73	75	0.34%	682	0.34%
White crappie			4	12	16	0.11%			15	2	17	0.08%	116	0.06%
White perch									3		3	0.01%	34	0.02%
White perch hybrid													1	<0.01%
White sucker		20	25	2	47	0.32%	2	57	27	1	87	0.40%	541	0.27%
Yellow bass				3	3	0.02%			2	1	3	0.01%	59	0.03%
Yellow bullhead	8	3	9		20	0.14%	9	5	23		37	0.17%	559	0.28%
Yellow perch	6	5			11	0.07%			2	1	3	0.01%	29	0.01%

Monitoring Efforts Downstream the Electric Dispersal Barrier

Table 1. (*Continued)*

	2017 Fixed Electrofishing						2017 Random Electrofishing						2010-2017	
	Pool						Pool							
Species	Lockport	Brandon	Dresden	Marseilles	No. Cap.	Percent	Lockport	Brandon	Dresden	Marseilles	No. Cap.	Percent	Captured	Percent
Total Caught	2,357	1,082	4,804	6,447	14,690	100%	1,652	1,765	7,935	10,455	21,807	100%	197,855	100%
Species	28	27	52	51	69		22	32	60	54	74			
Hybrid Groups	0	1	1	0	2		1	1	2	1	3			

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Monitoring Efforts Downstream the Electric Dispersal Barrier

Table 2. *Fixed and random electrofishing, fixed and targeted gill and trammel netting, and fixed and additional hoop and mini-fyke netting efforts with catch summaries for 2017 in pools below the Electric Dispersal Barrier.*

Fixed Electrofishing Effort-2017

	Pool				
	Lockport	Brandon	Dresden	Marseilles	Total
Sample Dates	3 April - 30 November				
Estimated person-hours	90	82.5	157.5	110	440
Electrofishing hours	9	8.25	15.75	11	44
Samples (transects)	36	33	63	44	176
All Fish (*N*)	2,357	1,082	4,804	6,447	14,690
Species (*N*)	28	27	52	51	69
Hybrids (*N*)	0	1	1	0	2
Bighead Carp (*N*)	0	0	1	0	1
Silver Carp (*N*)	0	0	4	204	208
CPUE (fish/hour)	261.89	131.15	305.02	586.09	333.86

Random Electrofishing Effort-2017

	Pool				
	Lockport	Brandon	Dresden	Marseilles	Total
Sample Dates	3 April - 30 November				
Estimated person-hours	205	210	292.5	220	927.5
Electrofishing hours	20.5	21	29.25	22	92.75
Samples (transects)	82	84	117	88	371
All Fish (*N*)	1,652	1,765	7,935	10,455	21,807
Species (*N*)	22	32	60	54	74
Hybrids (*N*)	1	1	2	1	3
Bighead Carp (*N*)	0	0	1	3	4
Silver Carp (*N*)	0	0	27	219	246
CPUE (fish/hour)	80.59	84.05	271.28	475.22	235.12

Fixed Gill and Trammel Netting Effort - 2017

	Pool				
	Lockport	Brandon	Dresden	Marseilles	Total
Sample dates	14 March - 30 November				
Estimated person-hours	55	55	54	0	164
Samples (net sets)	55	55	54	0	164
Total miles of net	6.3	6.5	6.6	0	19.4
All Fish (N)	44	18	123	0	185
Species (N)	2	3	9	0	10
Hybrids (N)	1	0	1	0	1
Bighead Carp (N)	0	0	0	0	0
Silver Carp (N)	0	0	1	0	1
CPUE (No. fish/100 yards of net)	0.40	0.16	1.06	0.00	0.54

Targeted Gill and Trammel Netting Effort - 2017

	Pool				
	Lockport	Brandon	Dresden	Marseilles	Total
Sample dates	14 March - 30 November				
Estimated person-hours	414	451	611	0	1,476
Samples (net sets)	414	451	611	0	1,476
Total miles of net	46.5	53	91.4	0	190.9
All Fish (N)	83	441	9,166	0	9,690
Species (N)	4	6	27	0	27
Hybrids (N)	1	1	2	0	2
Bighead Carp (N)	0	0	297	0	297
Silver Carp (N)	0	0	501	0	501
CPUE (No. fish/100 yards of net)	0.10	0.47	5.70	0.00	2.88

Hoop Netting Effort - 2017

	Pool				
	Lockport	Brandon	Dresden	Marseilles	Total
Sample Dates	22 May - 8 December				
Estimated person-hours	80	80	440	70	670
Net nights	64	64	352	56	536
Samples (net sets)	32	32	176	28	268
All Fish (*N*)	52	66	1,994	133	2,245
Species (*N*)	3	5	16	9	17
Hybrids (*N*)	0	0	2	0	2
Bighead Carp (*N*)	0	0	6	6	12
Silver Carp (*N*)	0	0	2	43	45
CPUE (No. fish/net night)	0.81	1.03	5.66	2.38	4.19

Mini Fyke Netting Effort - 2017

	Pool				
	Lockport	Brandon	Dresden	Marseilles	Total
Sample Dates	22 May - 8 December				
Estimated person-hours	80	80	80	70	310
Net nights	32	32	32	28	124
Samples (net sets)	32	32	32	28	124
All Fish (*N*)	3,287	2,257	3,239	317	9,100
Species (*N*)	27	23	30	26	49
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)	102.72	70.53	101.22	11.32	73.39

Monitoring Efforts Downstream the Electric Dispersal Barrier

Table 3. *Fixed and targeted contracted commercial netting catch summary for 2017, including 2010-2017 in pools below the Electric Dispersal Barrier.*

	Fixed Gill and Trammel Netting Catch - 2017					Targeted Gill and Trammel Netting Catch - 2017					2010-2017	
	Pool					Pool						
Species	Lockport	Brandon	Dresden	No. Captured	Percent	Lockport	Brandon	Dresden	No. Captured	Percent	No. Captured	Percent
Bighead Carp								297	297	3.06%	2,219	6.99%
Bigmouth Buffalo			8	8	4.32%			615	615	6.35%	1,631	5.14%
Black Buffalo							1	65	66	0.68%	392	1.24%
Black Bullhead								1	1	0.01%	1	0.00%
Black Crappie								1	1	0.01%	1	0.00%
Bluegill											1	0.00%
Bowfin									1	0.01%	2	0.01%
Channel Catfish	1	1	6	8	4.32%	4	11	124	139	1.43%	599	1.89%
Common Carp	39	16	42	97	52.43%	74	392	1,650	2,116	21.83%	11,302	35.62%
Common Carp x Goldfish Hybrid	4		2	6	3.24%	2	1	6	9	0.09%	142	0.45%
Flathead Catfish			1	1	0.54%			24	24	0.25%	93	0.29%
Freshwater Drum			5	5	2.70%		13	140	153	1.58%	505	1.59%
Gizzard Shad								6	6	0.06%	11	0.03%
Goldeye											3	0.01%
Golden Redhorse								3	3	0.03%	3	0.01%
Goldfish		1		1	0.54%		7	6	13	0.13%	63	0.20%
Grass Carp								22	22	0.23%	96	0.30%
Largemouth Bass								6	6	0.06%	31	0.10%
Longnose Gar			2	2	1.08%	1		35	36	0.37%	154	0.49%
Muskellunge											2	0.01%
Northern Pike								2	2	0.02%	12	0.04%
Quillback								2	2	0.02%	49	0.15%
River Carpsucker			1	1	0.54%			40	40	0.41%	212	0.67%
Sauger											1	0.00%
Shorthead Redhorse								2	2	0.02%	2	0.01%
Shortnose Gar								1	1	0.01%	2	0.01%
Silver Carp			1	1	0.54%			501	501	5.17%	1,047	3.30%
Silver Carp x Bighead carp Hybrid								1	1	0.01%	1	0.00%
Silver Redhorse								3	3	0.03%	6	0.02%
Skipjack Herring											4	0.01%
Smallmouth Buffalo			55	55	29.73%	2	16	5,609	5,627	58.06%	13,117	41.34%
Spotted Gar								1	1	0.01%	8	0.03%
Striped Bass x White Bass Hybrid											5	0.02%
Unidentified Catostomid											4	0.01%
White Bass								1	1	0.01%	2	0.01%
Walleye								1	1	0.01%	4	0.01%
White Crappie											1	0.00%
White Sucker								1	1	0.01%	1	0.00%
Yellow Bullhead											4	0.01%
Total Captured	44	18	123	185	100%	83	441	9,166	9,691	100%	31,733	100%
No. Species	2	3	9			4	6	27			35	
No. Hybrid Groups	1		1			1	1	2			3	

Table 4. *Fixed and additional hoop netting catch summary for 2017, including 2010-2017 in pools below the Electric Dispersal Barrier.*

	Hoop Netting Catch - 2017						2012-2017	
	Pool							
Species	Lockport	Brandon	Dresden	Marseilles	No. Captured	Percent	No. Captured	Percent
Bighead Carp			6	6	12	0.53%	172	3.78%
Bigmouth Buffalo			14	1	15	0.67%	16	0.35%
Black Buffalo			6		6	0.27%	13	0.29%
Black Crappie			6		6	0.27%	8	0.18%
Channel Catfish	12	55	451	15	533	23.74%	1,200	26.38%
Common Carp	30	6	132	19	187	8.33%	563	12.38%
Common Carp x Goldfish Hybrid			1		1	0.04%	5	0.11%
Flathead Catfish			58	8	66	2.94%	110	2.42%
Freshwater Drum	10	2	126	14	152	6.77%	193	4.24%
Gizard Shad					0	0.00%	1	0.02%
Golden Redhorse			1		1	0.04%	4	0.09%
Goldfish					0	0.00%	4	0.09%
Grass Carp			1		1	0.04%	3	0.07%
Largemouth Bass					0	0.00%	1	0.02%
Longnose Gar					0	0.00%	1	0.02%
Quillback					0	0.00%	2	0.04%
River Carpsucker			18	2	20	0.89%	52	1.14%
Shorthead Redhorse			1		1	0.04%	2	0.04%
Silver Carp			2	43	45	2.00%	152	3.34%
Silver Redhorse			3		3	0.13%	4	0.09%
Smallmouth Bass		2			2	0.09%	3	0.07%
Smallmouth Buffalo		1	1,166	25	1,192	53.10%	2,029	44.60%
Striped Bass x White Bass Hybrid			1		1	0.04%	3	0.07%
Walleye			1		1	0.04%	1	0.02%
White Bass					0	0.00%	4	0.09%
White Crappie					0	0.00%	3	0.07%
Total Captured	52	66	1,994	133	2,245	100.0%	4,549	100.0%
No. Species	3	5	16	9	17		24	
No. Hybrid Groups	0	0	2	0	2		2	

Table 5. *Minnow fyke netting catch summary for 2017, including 2010-2017 in pools below the Electric Dispersal Barrier.*

	Minnow Fyke Netting Catch - 2017						2012-2017	
	Pool							
Species	Lockport	Brandon	Dresden	Marseilles	No. Captured	Percent	No. Captured	Percent
Banded Darter				1	1	0.0%	1	0.0%
Banded Killifish	880	33	53	3	969	10.6%	1,929	3.3%
Black Buffalo					0	0.0%	1	0.0%
Black Bullhead			1		1	0.0%	7	0.0%
Black Crappie		4	1	1	6	0.1%	37	0.1%
Blackstripe Topminnow		3	4	3	10	0.1%	327	0.6%
Bluegill	225	390	1,058	92	1,765	19.4%	22,188	38.5%
Bluntnose Minnow	587	1,368	1,226	18	3,199	35.2%	10,157	17.6%
Bowfin					0	0.0%	1	0.0%
Brook Silverside			9	2	11	0.1%	46	0.1%
Brown Bullhead					0	0.0%	1	0.0%
Bullhead Minnow				2	2	0.0%	365	0.6%
Central Mudminnow	2				2	0.0%	6	0.0%
Channel Catfish		1			1	0.0%	92	0.2%
Channel Shiner			1	13	14	0.2%	14	0.0%
Common Carp	353	1	4		358	3.9%	1,125	2.0%
Common Shiner	1	2			3	0.0%	7	0.0%
Creek Chub	10		5	1	16	0.2%	21	0.0%
Emerald Shiner	66	9	16	52	143	1.6%	780	1.4%
Fathead Minnow					0	0.0%	4	0.0%
Flathead Catfish			4		4	0.0%	6	0.0%
Freshwater Drum			1		1	0.0%	7	0.0%
Gizzard Shad	15			8	23	0.3%	757	1.3%
Gizzard Shad < 6"	15	178	560		753	8.3%	753	1.3%
Glass Shrimp	37				37	0.4%	37	0.1%
Golden Shiner	57	2	8		67	0.7%	172	0.3%
Goldfish					0	0.0%	21	0.0%
Grass Pickerel	2				2	0.0%	5	0.0%
Green Sunfish	113	10	36	5	164	1.8%	3,126	5.4%
Hybrid Sunfish	51	1	8		60	0.7%	313	0.5%
Johnny Darter				1	1	0.0%	24	0.0%
Largemouth Bass	1	54	62	1	118	1.3%	415	0.7%
Logperch					0	0.0%	14	0.0%
Longear Sunfish			2		2	0.0%	9	0.0%

Table 5. (*Continued)*

Species	Minnow Fyke Netting Catch - 2017						2012-2017	
	Pool				No. Captured	Percent	No. Captured	Percent
	Lockport	Brandon	Dresden	Marseilles				
Longnose Gar			2	1	3	0.0%	18	0.0%
Northern Pike					0	0.0%	2	0.0%
Orangespotted Sunfish		3	1	4	8	0.1%	1,178	2.0%
Oriental Weatherfish	119	4			123	1.4%	318	0.6%
Pumpkinseed	97	43	21		161	1.8%	3,491	6.1%
River Shiner					0	0.0%	24	0.0%
Rock Bass		3	3	1	7	0.1%	43	0.1%
Round Goby	67	57	12	5	141	1.5%	1,550	2.7%
Sand Shiner	1	7		52	60	0.7%	641	1.1%
Sauger		1			1	0.0%	15	0.0%
Shorthead Redhorse					0	0.0%	2	0.0%
Shortnose Gar			1		1	0.0%	11	0.0%
Silver Chub		1	10		11	0.1%	11	0.0%
Skipjack Herring					0	0.0%	1	0.0%
Slenderhead Darter					0	0.0%	1	0.0%
Smallmouth Bass	1				1	0.0%	16	0.0%
Smallmouth Buffalo				1	1	0.0%	8	0.0%
Spotfin Shiner	2		8	12	22	0.2%	3,463	6.0%
Spottail Shiner		75	110	33	218	2.4%	831	1.4%
Stonecat					0	0.0%	1	0.0%
Striped Shiner					0	0.0%	3	0.0%
Suckermouth Minnow					0	0.0%	1	0.0%
Tadpole Madtom	4	4	3		11	0.1%	98	0.2%
Threadfin Shad					0	0.0%	6	0.0%
Unidentified Catostomid					0	0.0%	15	0.0%
Unidentified Centrarchid					0	0.0%	50	0.1%
Unidentified Cyprinid					0	0.0%	10	0.0%
Unidentified Darter					0	0.0%	1	0.0%
Unidentified Ictiobus	3				3	0.0%	3	0.0%
Unidentified Moronid					0	0.0%	1	0.0%
Unidentified Notropis					0	0.0%	35	0.1%
Walleye					0	0.0%	1	0.0%
Warmouth	10				10	0.1%	28	0.0%

Table 5. (*Continued)*

Species	Minnow Fyke Netting Catch - 2017						2012-2017	
	Pool				No. Captured	Percent	No. Captured	Percent
	Lockport	Brandon	Dresden	Marseilles				
Western Mosquitofish	139		1	2	142	1.6%	1,842	3.2%
White Bass	4				4	0.0%	6	0.0%
White Crappie	2		2		4	0.0%	52	0.1%
White Perch				2	2	0.0%	13	0.0%
White Sucker					0	0.0%	45	0.1%
Yellow Bass				1	1	0.0%	34	0.1%
Yellow Bullhead	421	3	6		430	4.7%	998	1.7%
Yellow Perch	2				2	0.0%	10	0.0%
Total Captured	3,287	2,257	3,239	317	9,100	100%	57,645	100.0%
No. Species	27	23	30	26	49		66	
No. Hybrid Groups	1	1	1	0	1		1	

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).

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

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

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

- **Objective:** Monitor the movements of tagged fish at Dresden Island, Brandon Road, and Lockport Locks and Dams using stationary receivers (n = 8) placed above and below and within each lock.
- **Objective:** Review and compare standard operating protocols and vessel lockage statistics for Lockport, Brandon Road and Dresden Island Locks.

Telemetry Interim Summary Report

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

- **Objective:** Determine if the leading edge of the 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 Bighead and Silver Carp have been captured and relay information to the population reduction program undertaken by IDNR and commercial fishermen.

Additional objectives of the telemetry monitoring plan:

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

Project Highlights:

- To date, USACE has acquired 28.2 million detections from 597 tagged fish.
- No live tagged fish have crossed the Electric Dispersal Barrier in the upstream direction.
- High percentage of unique tags in surrogate fish continue to be detected near the Electric Dispersal Barrier.
- Only 2 lock passages by Common Carp downstream from Lockport Pool to Brandon Road.
- 10 Common Carp moved through the Lockport Controlling Works Spill way into Brandon Road Pool in 2017.
- Asian carp continue to be detected throughout the Dresden Island Pool.
- A single detection of a Bighead Carp occurred at the Brandon Road Lock and Dam approach channel.
- The majority of Asian carp detections occur at Rock Run Rookery and near the Harborside Marina.
- Up to 50% unique transmitters detected within the Kankakee River but only accounted for 1.85% of the total detections in Dresden Island Pool.

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 2016 season there were approximately 94 tagged fishes (V16 Vemco transmitters) that remained active and 23 of these transmitters were scheduled to expire within calendar year 2017. 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; 69 kHz) were implanted into surrogate species in 2017 to maintain adequate transmitter saturation within the Lower Lockport Pool and downstream of the electric dispersal barrier system. An additional 4 Silver Carp and 4 Bighead Carp were implanted with transmitters within the Dresden Island Pool (V13; 69 kHz). These transmitters were outfitted with a temperature and pressure sensor to monitor environmental and habitat use data along with each detection. This increased the number of transmitters to 127 that were active for at least a portion of calendar year 2017. A combination of prioritized response activities, reduced staffing resources, and delayed funding prevented additional transmitter implementation.

Tagged surrogate fishes have been released both above and below the Electric 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. 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 also used at the Electric Dispersal Barrier System and has been found to increase barrier approaches. Table 1 identifies all fishes containing active transmitters within the winter of 2016 and the field season of 2017 along with their release point within the system.

Table 1: *Active Fishes and Release Points within the Study Area in 2017*

Release Location	Species Implanted	Number of Fish Implanted
Between Barriers	Common Carp	1
Lower Lockport Pool (Downstream of Barriers)	Common Carp	50
Lower Lockport sub-total		**51**
Brandon Rd Pool	Common Carp	20
Brandon Road sub-total		**20**
Dresden Island Pool	Bighead Carp	39
	Silver Carp	17
Dresden Island sub-total		**56**
Total		**127**

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 downloading stationary receivers and supplementing with mobile tracking techniques as necessary. 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 2016 were redeployed in March 2017 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 decreased from sixteen in 2016 to fourteen in 2017. Receiver coverage was reduced within the Dresden Island pool within the Kankakee River upstream of the Wilmington Dam (n = 2). The revised study area was covered by 31 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 Brandon Road Lock and Dam. A VR2C cabled receiver (Vemco) was installed at the end of the season within the canal and connected to a shoreline modem. The receiver will upload detections to a USGS maintained website providing real-time results. This real-time receiver is in addition to a receiver previously installed by USGS for USACE upstream of the Electric Dispersal Barrier System and part of a larger inter-agency effort to strategically cover the Illinois Waterway with this new data transmission technique.

The Dresden Island Pool was also included within the telemetry receiver networks for concurrent studies led by USFWS, USGS, SIU and USFWS. USGS maintained 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 maintained three stationary receivers within the upper pool in proximity to the lock and dam. One receiver was located 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 maintained four stationary receivers within the Dresden Island Pool and one receiver within the Brandon Road Pool. The USFWS receivers in the Dresden Island Pool were focused on the backwater areas of Treats Island, and the Brandon Road Pool receiver was 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 three.

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 January 1, 2017, there were a total of 26 tagged surrogate fish (Common Carp) active within the Lower Lockport Pool (mean ± SD; 625 ± 77 mm). In order to maintain a similar number of tagged fish within the Lower Lockport pool across years, an additional 25 Common Carp (607 ± 98 mm) were tagged and released in 2017 to increase transmitter density bringing the total to 51. 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 (n=14) and Lower (n=11) Lockport Pool and released at the Cargill boat launch within the Lower Lockport Pool downstream of the Electric Dispersal Barrier System. Fish captured above and released below the barriers increase the likelihood of barrier interaction as they attempt to return to their point of capture.

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 representing spring, June to August representing summer, and September to November representing 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 were 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.

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.

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 were collected at that location by SIUC which were 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.

Asian carp Movement Analysis – A total of 56 USACE tagged Asian carp (Bighead and Silver Carp) 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 2017 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 (December – February), spring (March – May), summer (June – August) and fall (September – November). 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 2017. 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 2017, 28.2 million detections from 590 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 2017 sampling season in which 127 transmitters were detected system wide for a total of 3.9 million data points from November 21, 2016 through November 30, 2017.

Goal 1: Determine if fish approach and/or penetrate the Electric Dispersal Barrier System (Barrier Efficacy)

There were a total of 51 tagged surrogate fishes with batteries still active in 2017 between Lockport Lock and the Electric Dispersal Barrier System. Seven stationary receivers (VR2W) detected movement on all of the tagged surrogate fishes throughout the pool in 2017. There were a total of just over 3 million detections within Lower Lockport Pool and zero detections in the Upper Lockport Pool indicating no tagged fish passage through the barriers.

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 generally lower in straight channel sections of the canal with deep water which best characterizes stations LL02 and LL03a. Residency time increased in areas with shallow water habitat (LL03, LL04, and LL05) or at barriers to movement such as the Electric Dispersal Barrier System (EDBS, LL01) and the Lockport Lock (LL06). Detections at the EDBS were highest in the summer months when fish were most active. Alternatively, detections increased in the lower pool near the lock during the winter months. It should be noted that even during the winter months there were still active fish approaching the barriers and that there were only two receivers deployed during the winter months of this period of analysis.

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) which follows similar observed patterns of fish movement in previous years. Seventy percent of all tagged fish were still observed to approach the barrier during the winter months but did not spend much time in that detection range when they appeared.

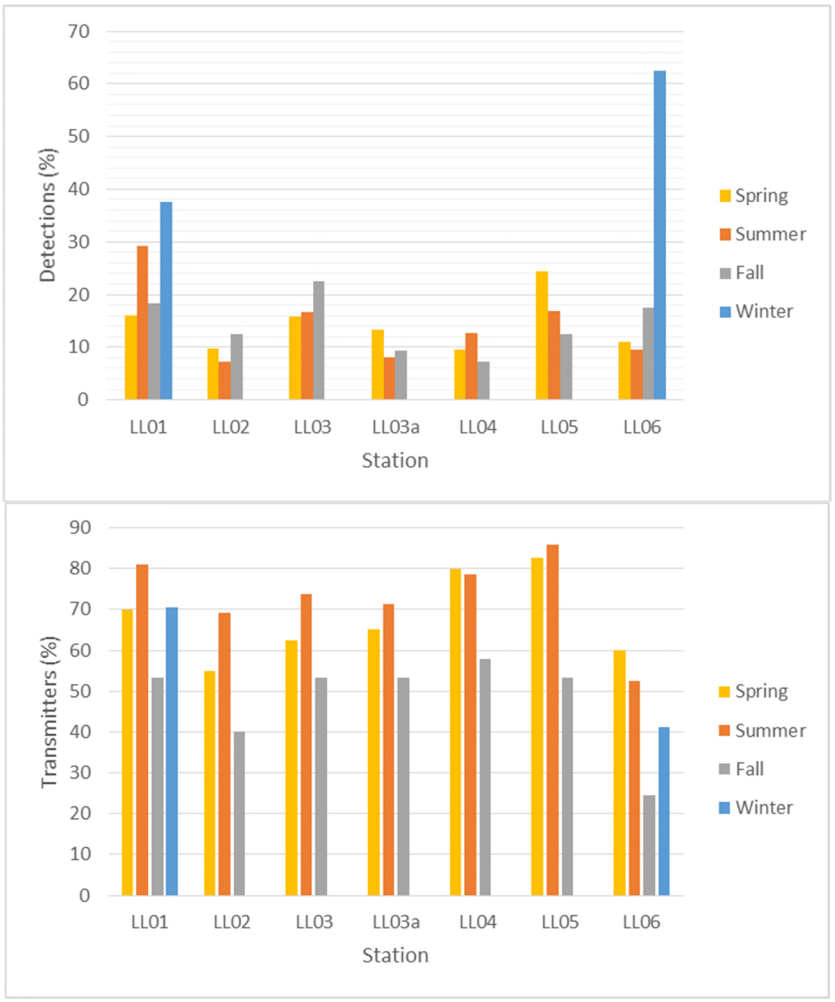

Figure 1: *Graphs depicting the percentage of total detections (top) and unique transmitters detected (bottom) within the Lower Lockport Pool from December 1, 2016 to November 29, 2017 categorized by station and season.*

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

There were twelve occurrences of inter-pool movement by tagged fishes in calendar year 2017. All 12 movements consisted of tagged Common Carp moving from Lockport Pool to Brandon Road Pool. Ten of the twelve fish to move between pools all moved from Lockport Pool to Brandon Road Pool through the Lockport Controlling Works spillway. The time frame between when fish are last detected at a receiver near the Controlling Works and then detected in Brandon Road Pool fluctuates. It is hypothesized that high flows at the spillway force fish into the Des Plaines River and the fish ultimately end up in Brandon Road Pool. The remaining 2 fish moved downstream through the Lockport Lock. The first instance occurred between April 30th and May 5th, 2017. The fish was last detected on the receiver at Lockport Lock on April 30th and then detected in Brandon Road Pool on May 5th five days later. During this time a total of 15 downstream lockages and 16 upstream lockages occurred. Based on the delay in detections, it is not possible to determine exactly when the fish locked through and downstream into Brandon

Road pool. The second instance occurred on May 2nd, 2017. Differences in detection from a receiver upstream of Lockport Lock and a detection downstream in Brandon Road Pool was approximately 11.5 hours in the same day. During the 11.5 hourr difference in detection time, only one 40 minute downstream lockage occurred and the fish likely made it through during that time period.

From 2010 to 2017, there have been 65 occurrences of tagged fish moving downstream and 32 occurrences of upstream movement between navigation pools by a total of 81 individual tagged fish (Table 2). Inter-pool movement was greatest between the Lockport and Brandon Road pools accounting for 57% (n = 56) of all inter-pool movements (upstream n = 32; downstream n = 65). The majority of downstream movement into the Brandon Road Pool occurred through the Lockport Controlling Works spillway approximately two miles upstream of the lock (46%; n = 30). 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 2017. Downstream is defined as DS and upstream is defined as US.*

Interpool Movement Data			
	US	DS	Total
Lockport	13	13	26
Lockport Spillway	0	30	30
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 28 out of 56 USACE tagged Asian Carp were detected within the Dresden Island Pool throughout 2017 resulting in a 50% detection of tagged fish. The 28 tagged Asian carp consisted of 20 Bighead Carp (Mean TL ± SD; 925 ± 91 mm), 7 Silver Carp (782 ± 82 mm), and 1 hybrid (878 mm). In addition, 8 active tags from SIU were detected throughout Dresden Islan Pool and used within this analysis.

In total, the receivers placed in Dresden Island Pool and the adjacent tributaries collected 692,632 detections from a total of 36 tagged Asian carp and two Common Carp. The percent of total detections at each receiver ranged from 0 to 77% (Figure 2). The stations that had the greatest percent of total detections included DI09a (77%), RR01 (8%), DI10 (7%), and KR01 (2%). While typically a large number of tagged fish are not detected at the Kankakee River

confluence, KR01 had more detections during 2017 and accounted for 2% of all detections. This is not surprising as Asian carp are consistently captured by contracted commercial fishermen in this area. The station at Rock Run Rookery (RR01) 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. Station DI10 is located upstream of the Dresden Island Lock. The placement of DI09a was a new placement in 2016 and once again had the majority of the detections within Dresden Island Pool. As indicated in the 2016 Interim Summary Report, a myriad of habitat types within and adjacent to station DI09a combined with the constriction point in the river 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 River or upstream before returning to the area.

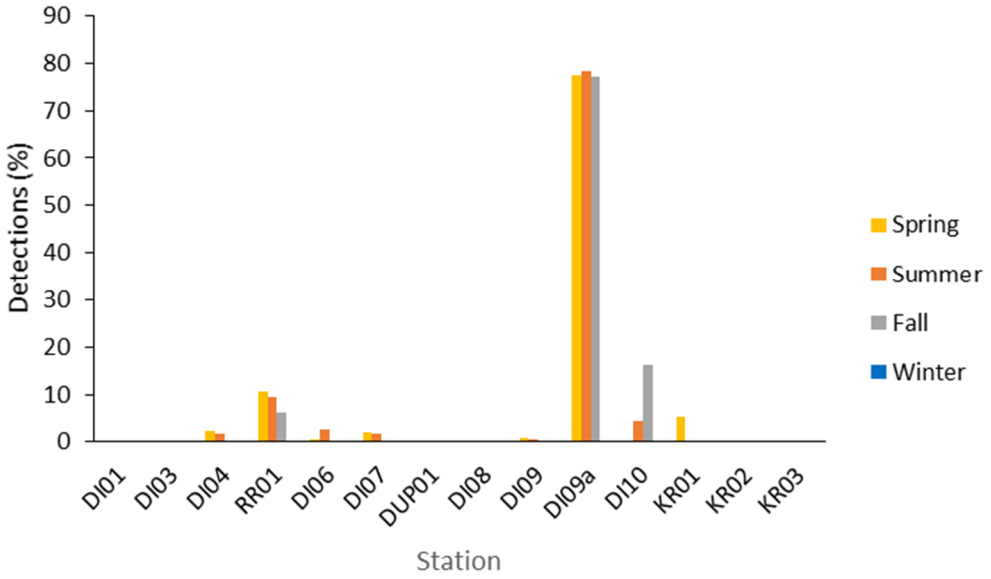

Figure 2: *Percent of total detections from each station within the Dresden Island Pool and the connecting tributaries across seasons.*

Total 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 71% throughout the Dresden Island Pool (Figure 3). 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. In summer and fall, DI09a had the greatest percent of total detections followed by RR01

(Figure 3). Conversely, the greatest number of unique tags detected in spring occurred at RR01 followed by DI09a. As expected, increases in detections and percent of active tags detected increased during the spring and summer while fish are most active. A total of 85% of the active tags were detected in spring with 71% of the detections occurring at DI09a and 10% at RR01. Similarly, 76% of the active tags were detected during summer with 78% of the detections occurring at DI09a and 9% at RR01. Finally, 83% of active tags were detected in fall with 52% of the detections occurring at DI09a, 40% detections at DI10, and 38% of the detections occurring at RR01. These data continue to support the importance of DI09a as potential habitat and potential transition zones for Asian carp movement between Kankakee River and the upper portions of the pool.

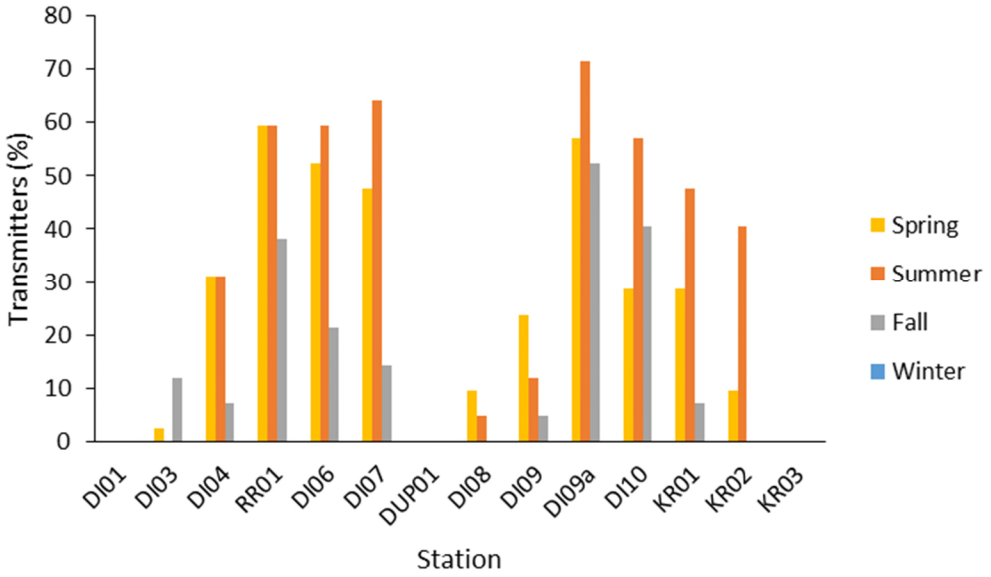

Figure 3: *Percentage of unique active tags detected by each station across seasons within the Dresden Island Pool and connecting tributaries.*

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 August 9, 2016 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 August 10, 2016. The Bighead Carp then stages within the approach channel for close to 7 hours again before returning downstream. Another Bighead Carp had a single detection at the lock in 2017 on September 3rd at around 02:00. The fish was previously detected on DI04 and RR01 but was last detected at DI03. Due to the single detection, the fish likely moved back downstream to an area that is not covered by the telemetry network. A download in March of 2018 will be investigated to determine the location of this fish.

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 2018. The number of Asian carp currently tagged within Dresden Island Pool should also be maintained using supplemental and replacement transmitters for these species. 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 throughout the Upper Illinois River and the Chicago Area Waterway System.

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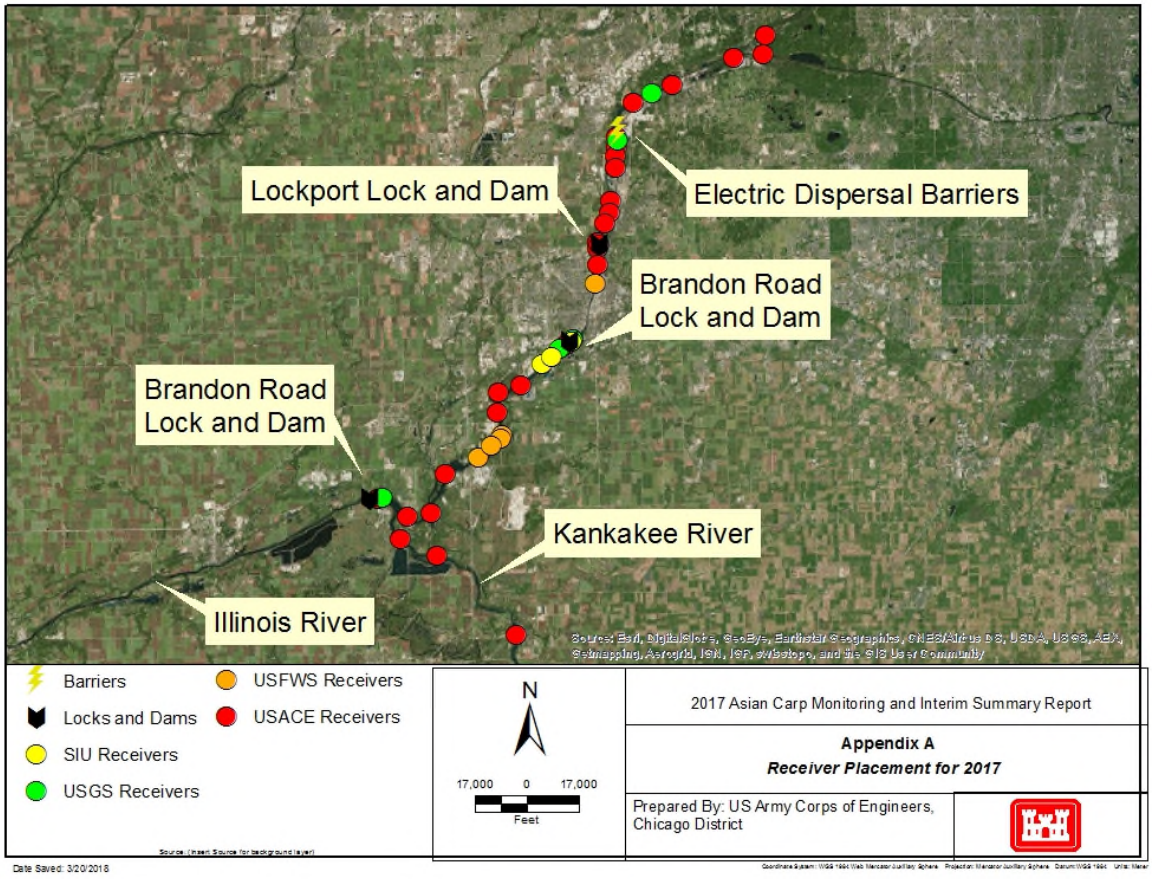
Lockport Lock and Dam
Electric Dispersal Barriers
Brandon Road
Lock and Dam
Brandon Road
Lock and Dam
Kankakee River
Illinois River
Barriers
Locks and Dams
SIU Receivers
USGS Receivers
USFWS Receivers
USACE Receivers
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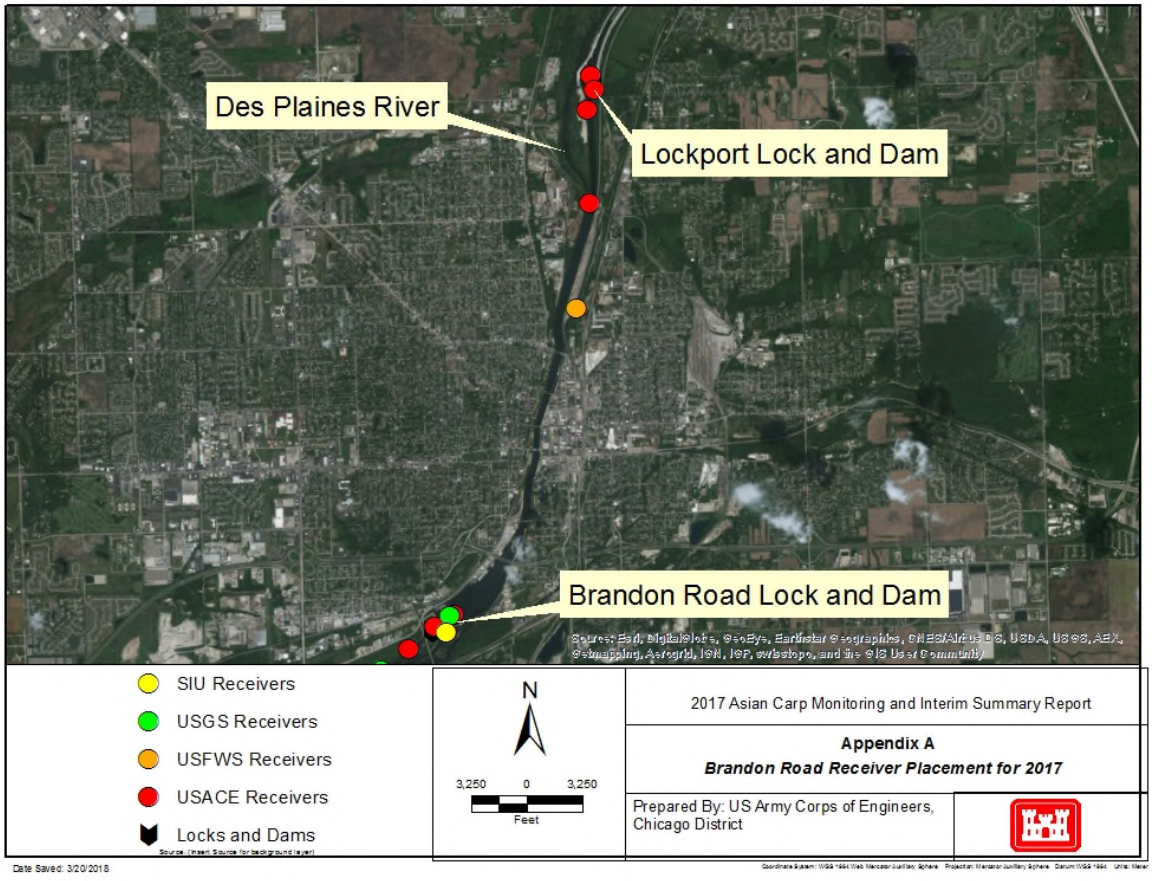
Feet
2017 Asian Carp Monitoring and Interim Summary Report
Appendix A
Receiver Placement for 2017
Prepared By: US Army Corps of Engineers,
Chicago District
Date Saved: 3/20/2018


Des Plaines River
Lockport Lock and Dam
Brandon Road Lock and Dam
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
SIU Receivers
USGS Receivers
USFWS Receivers
USACE Receivers
Locks and Dams
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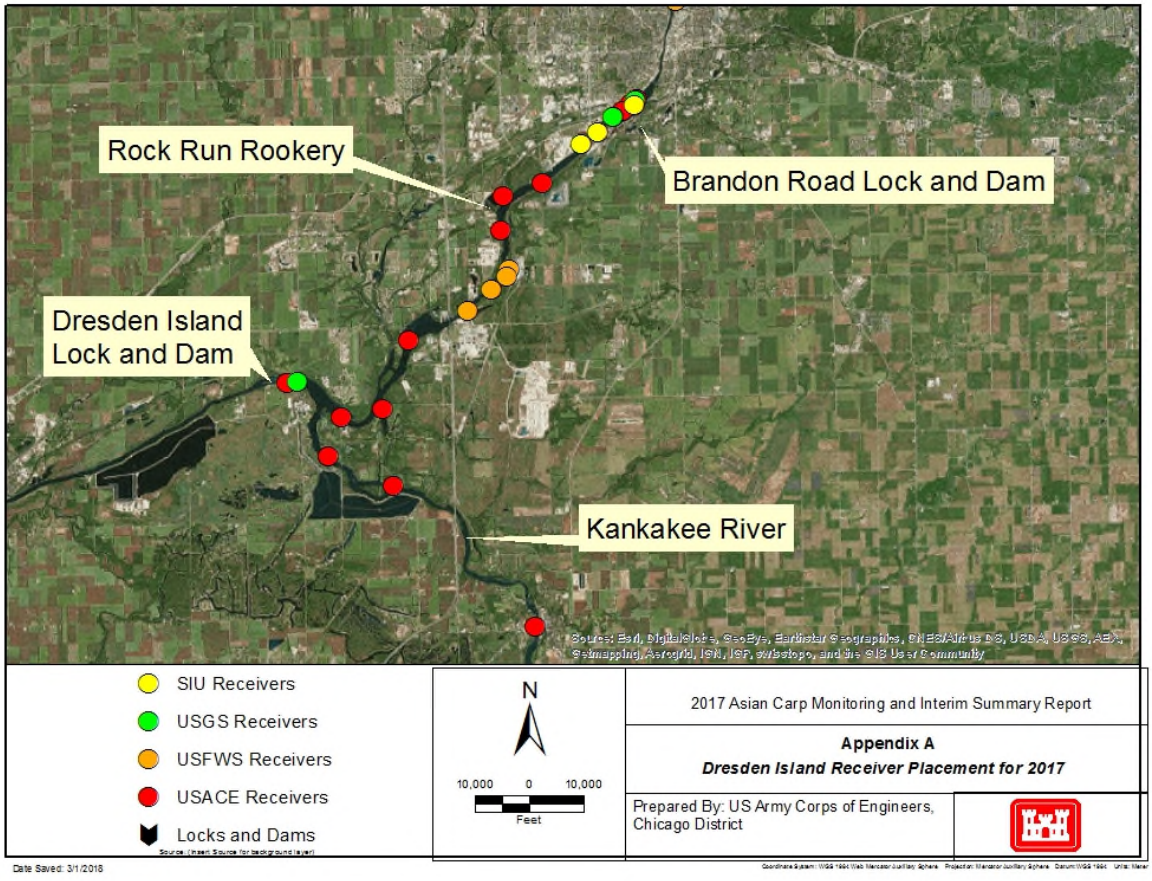
2017 Asian Carp Monitoring and Interim Summary Report
Appendix A
Brandon Road Receiver Placement for 2017
Prepared By: US Army Corps of Engineers, Chicago District


Rock Run Rookery
Brandon Road Lock and Dam
Dresden Island
Lock and Dam
Kankakee River
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
SIU Receivers
USGS Receivers
USFWS Receivers
USACE Receivers
Locks and Dams
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2017 Asian Carp Monitoring and Interim Summary Report
Appendix A
Dresden Island Receiver Placement for 2017
Prepared By: US Army Corps of Engineers, Chicago District

Monitoring of Fish Abundance and Spatial Distribution near the Electric Dispersal Barrier and in Lockport, Brandon Road Pools

Jeremiah J. Davis, Andrew W. Peters, and Rebecca N. Neeley
(U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office, Wilmington Substation)

Participating Agencies: U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office, Wilmington Substation (lead agency); USACE-Chicago District (field/logistical support)

Introduction and Need:

The Electric Dispersal Barrier System 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 Electric Dispersal Barrier System at different times throughout the year, primarily during the summer and fall (Parker et al. 2015). How fish interact with the Electric Dispersal Barrier System 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 Electric Dispersal Barrier System 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 2017. Additionally, split-beam hydroacoustic surveys of the Lockport and Brandon Road navigation pools were undertaken in the upper Illinois Waterway during spring, summer, and fall in 2014, 2015, 2016, and 2017. This work allowed for a greater understanding of the changes in fish densities and 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 Electric Dispersal Barrier System 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.

Objectives:

1) Evaluate the density and size structure of the fish community directly below the Electric Dispersal Barrier System throughout the year.
2) Determine the density and distribution of fish in upper navigation pools within the Illinois Waterway throughout the year.
3) Evaluate size structure of fish in the study reaches and quantify seasonal changes.
4) Identify large fish targets in the study pools suspected of being Asian carp to direct targeted sampling efforts at these fish for removal.

Monitoring of Fish Abundance and Spatial Distribution near the Electric Dispersal Barrier and in Lockport, Brandon Road Pools

Project Highlights:

- Peak fish densities near the Electric Dispersal Barrier System were observed during late summer. Fish density remained relatively high during fall surveys.
- Fish density was low during winter and spring
- There were significantly greater mean total densities of fish observed immediately below the Electric Dispersal Barrier System during the summer than in spring or winter.

Methods:

Acoustic Fish Surveys below the Electric Dispersal Barrier

A series of side-looking split-beam hydroacoustic surveys were conducted below the CSSC Electric Dispersal Barrier System to assess fish density and distribution patterns near the barrier on a fine temporal scale. Surveys below the Electric Dispersal Barrier System took place between January and December 2017 on a bi-weekly to monthly basis. Survey transects began approximately 500 m below the Electric Dispersal Barrier System 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 Electric Dispersal Barrier System, 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 -9.6˚ below parallel from the water surface. Split beam acoustic data was collected using Visual Acquisition v.6® from 1.15 – 50 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 hydroacoustic data were post-processed in Echoview® v. 8.0. 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 > -70 dB 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 Electric Dispersal Barrier System 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 and Brandon Road navigation pools seasonally between 2013 and 2017. 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 (approximately 50 m) several concentric transects were conducted.

Results and Discussion:

Fish Surveys below the Electric Dispersal Barrier

Results from acoustic surveys conducted directly below the Electric Dispersal Barrier System during 2017 suggested that fish density during late winter was very low (mean = 0.10 fish/1000 m^3, SD = 0.09, n = 3). During the spring, fish density below the Electric Dispersal Barrier System remained low (mean = 0.11 fish/1000 m^3, SD = 0.02, n = 2). During the summer, fish density below the Electric Dispersal Barrier System increased significantly ((F = 9.34, df =3, P < 0.0001) (mean = 0.80 fish/1000 m^3, SD = 0.56, n = 3). During the fall, fish density decreased from levels observed during summer and showed no significant difference between winter or

spring densities (mean = 0.34 fish/1000 m^3, SD = 0.35, n = 3) (Figure 1). The fish targets ensonified during the surveys were estimated to be primarily < 150 mm. However, several larger fish targets were observed during the surveys. These results follow trends that were previously observed in the Lockport Pool near the Electric Dispersal Barrier System during 2015 and 2016; however, densities were lower across all seasons during 2017 than were observed during 2016 (Asian Carp Regional Coordinating Committee Monitoring and Rapid Response Workgroup, 2016). Increased fish density during the summer was likely driven by an influx of young of year fishes into the community.

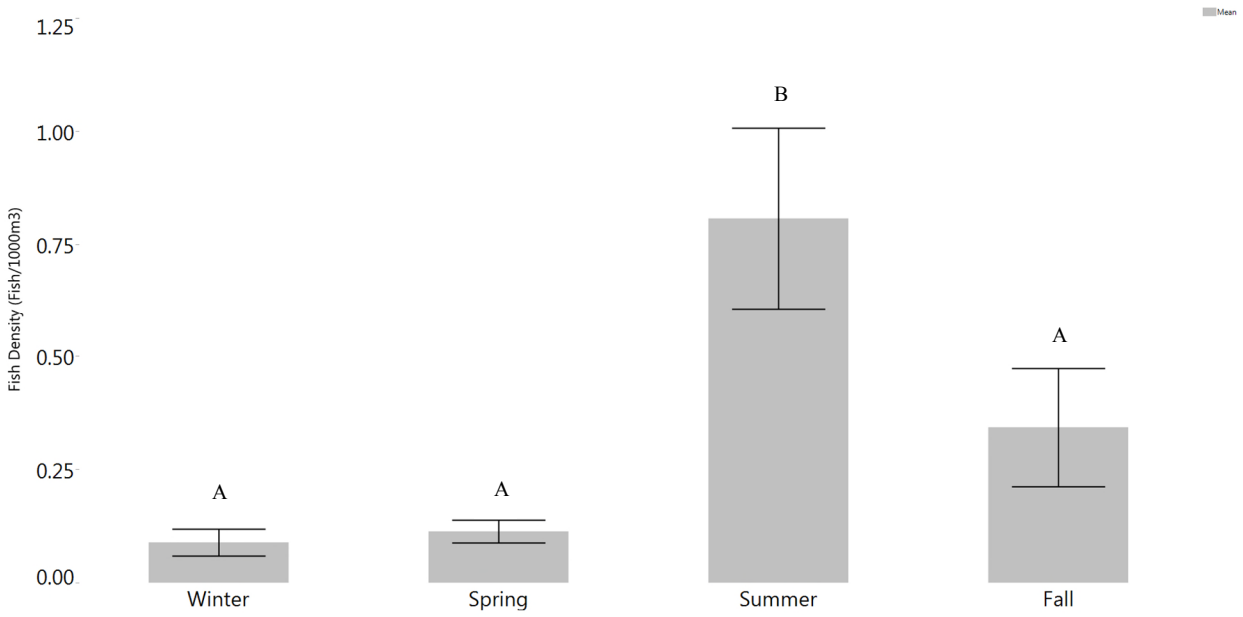

Figure 1. *Mean fish density (# / 1000m^3) observed from the downstream edge of the barrier IIA parasitic structure to 500 m below) during split-beam hydroacoustic surveys conducted during 2017 . Error bars denote S.E. Different letters denote significant differences.*

Illinois River Pool Surveys

Results from the hydroacoustic surveys conducted in the Lockport and Brandon Road Pool in 2017 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 declines as fall progressed in Lockport Pool. Results from the 2017 surveys suggested that during the late winter and spring, total fish density was greater in the Brandon Road Pool (winter = 0.12 fish/1000 m^3 and spring = 0.11 fish/1000 m^3) than in the Lockport Pool (winter = 0.08 fish/1000 m^3 and spring = 0.08 fish/1000 m^3). During summer, fish density increased in both study pools. The greatest fish density during summer was observed in Lockport Pool (0.73 fish/1000 m^3). The majority of the increases in fish density appeared to be driven by young of year recruitment as was confirmed by survey gear during the summer.

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.

Table 1. *Fish densities observed during seasonal hydroacoustic surveys in the Lockport and Brandon Road navigation pools.*

Season	Survey Date	Pool	Fish Density
Winter	3/15/2017	Lockport	0.08
Winter	3/16/2017	Brandon Road	0.12
Spring	4/26/2017	Lockport	0.08
Spring	4/28/2017	Brandon Road	0.11
Summer	9/7/2017	Lockport	0.73
Summer	9/7/2017	Brandon Road	0.16
Fall	11/14/2017	Lockport	0.41
Fall	11/14/2017	Brandon Road	0.82

Recommendations:

(1) Continue monitoring abundance 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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Analysis of Feral Grass Carp in the CAWS and Upper Illinois River

Kevin Haupt, Brandon Falish, and Rebecca Neeley
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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).

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 around 4-5 years old, 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 assess 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 goals of this project were to analyze Grass Carp within the IWW and CAWS to determine life history traits, population dynamics, individual reproductive viability through ploidy testing and movement patterns with acoustic telemetry. Historic capture data of Grass Carp was analyzed to identify potential areas of higher densities, which was then used to identify areas to begin targeted sampling.

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

Due to the interest in Grass Carp movement, Grass Carp captured below the U.S. Army Corps of Engineers (USACE) Electric Dispersal Barrier System were implanted with Vemco acoustic telemetry tags and monitored for movement patterns 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) Evaluate within pool movement patterns and identify lock and dame passage events of Grass Carp below the USACE's Electric Dispersal Barrier System.

Project Highlights:

- 61 feral Grass Carp were analyzed for ploidy and life history traits.
- 59% of the feral Grass Carp were diploid.
- 13 Grass Carp were captured within the CAWS, above the USACE's Electric Dispersal Barrier System, 6 of which were diploid.
- 1 fish has passed multiple lock and dams, passing downstream through Marseilles, Starved Rock and Peoria locks and dams

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). These data were also including in appropriate tables and discussion to garner the best depiction of the current status of the grass carp population.

Incidental Grass Carp Collection

During the 2016 and 2017 field seasons, any Grass Carp captured in the Upper IWW and CAWS by USFWS and partner agencies were analyzed for ploidy determination using eyeballs. 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.

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 Electric Dispersal Barrier System were targeted using pulsed DC electrofishing, and additional areas were added as sampling expanded in 2017. Sampling occurred in Brandon Road, Dresden Island and Marseilles pools. In total, catch rates were below 0.5 fish per hour in all pools (Table 2). The majority of captures and sightings occurred in high flow areas in close proximity to the outflow from a lock and dam.

Ploidy Determination

To determine ploidy for Grass Carp collected during targeted sampling, 1-2 mLs of blood were collected 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, stored in saline solution, and shipped cold to the FHC for ploidy analysis using methods for vitreous humor cell analysis (Jenkins and Thomas 2007).

Grass Carp Telemetry

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 the Electric Dispersal Barrier System 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).

Initial efforts to collect Grass Carp to evaluate movement and potential lock and dam passage began in the Dresden Island Pool and expanded to include the Brandon Road Pool and Marseilles Pool. 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 at point of capture. 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. Information on tagged individuals and movements are described in Table 3.

Results and Discussion:

Grass Carp Collection and Ploidy Analysis

During the 2016 and 2017 field season, 67 Grass Carp were captured, 13 from the CAWS, 2 from Brandon Road Pool, 24 from Dresden Island Pool, 23 from Marseilles Pool and 5 from Starved Rock Pool (Table 1). Of the 67 fish captured, 61 samples were submitted for ploidy analysis. Twenty four fish were collected during targeted sampling and implanted with Vemco transmitters for telemetry purposes and could only be analyzed for ploidy via a blood sample. Ploidy analysis indicated that 36 of the 61 Grass Carp (59%) were diploid (Table 1). Both triploid fish and diploid fish were observed in the CAWS, Brandon Road, Dresden Island, and Marseilles pools, while only diploid fish were sampled in Starved Rock Pool (Table 1). Ploidy results in Figure 4 depict the process for ploidy determination. Of interest was the difference in the percentage of fish that were diploid in comparing fish from Dresden Island Pool to Marseilles Pool. Thirty percent of fish in Dresden Island Pool were diploid, while 86.4% of fish in Marseilles Pool were diploid (Table 1). These results are from a sample size that may not fully represent the current population within each pool and may change with increased sample size. Continuing the ploidy testing program may be warranted if ploidy determination of Grass Carp in the Upper IWW is deemed desirable by partner agencies.

Grass Carp Telemetry

Targeted sampling with the intention of catching Grass Carp for telemetry was primarily focused in Dresden Island Pool. A total of 53.08 hours of electrofishing effort yielded 18 of the total 24 tagged fish (Table 2). Much of the Dresden Island Pool was targeted, specifically presumed high density areas (Figure 2). However, most of the implanted fish were captured on the spillway side below the Brandon Road Lock and Dam and subsequently released at RM 285.2. Sampling in Brandon Road Pool captured an additional 2 fish in 2017, while 4 fish were tagged in Marseilles Pool. Of the 24 fish, only 1 fish passed through a lock and dam into a new pool, doing so on 3 occasions. This fish traveled downstream into Marseilles, Starved Rock and Peoria pools after being captured in Dresden Island Pool. Two fish have not been detected by the telemetry array while the remaining 21 fish have been detected making small, within-pool movements (Table 3).

Based on data from a real-time receiver managed by the USGS at RM 285.6, most of the fish tagged in Dresden Island Pool are using habitat around the approach channel at 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 utilized by the telemetered fish.

Targeted sampling for Grass Carp was effective around areas of high velocity and in close proximity to lock and dams. Current telemetry data suggest that movement within pools occurs frequently and successful downstream passage of lock and dams can occur. Two fish were located in the lock chamber of Brandon Road Lock and Dam but did not progress upstream into Brandon Road Pool. These two occurrences are the closest to an upstream passage event

occurring to date. Given the short time span and limited number of tagged fish in the system, detailed evaluation of movement and the potential upstream passage events is unobtainable at this time. Fish movement data will continue to be collected and will constitute a more robust data set for which detailed evaluation and assessment about Grass Carp movement within these pools can be made. Initial findings suggest that backwater utilization in Dresden Island Pool is limited. This does not indicate that slow velocity or off channel habitats are not utilized, as telemetry receivers in slow water areas adjacent to the main channel appear to be areas of high occupancy. One fish (originally tagged in Dresden Island Pool) passed through the Marseilles, Starved Rock, and Peoria locks and dams, with the most upstream detections occurring inside the lock chamber of Brandon Road Lock and Dam. After spending the first 5 months in Dresden Pool, it was detected in Marseilles Pool for 2 days, then detected moving downstream through the Starved Rock Pool, and picked up in the Peoria Pool the following day. This one example depicts that downstream movement is achievable, that many river miles can be traveled in a short time period, these events can occur during the winter months, and that the lock chamber is being used for downstream passage.

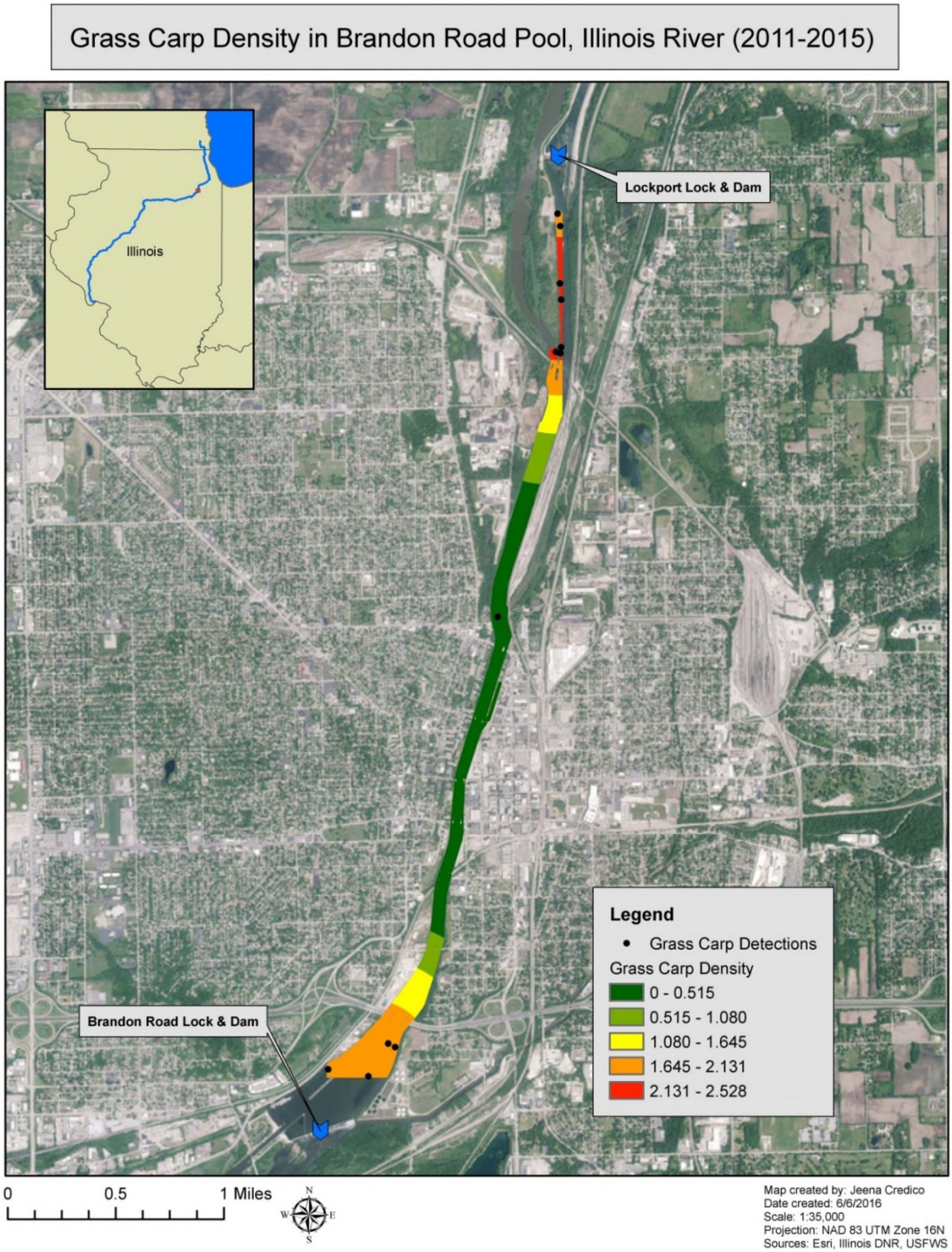

Figure 1. *Kernel density of Grass Carp for Brandon Road Pool based on capture data from 2011-2015.*

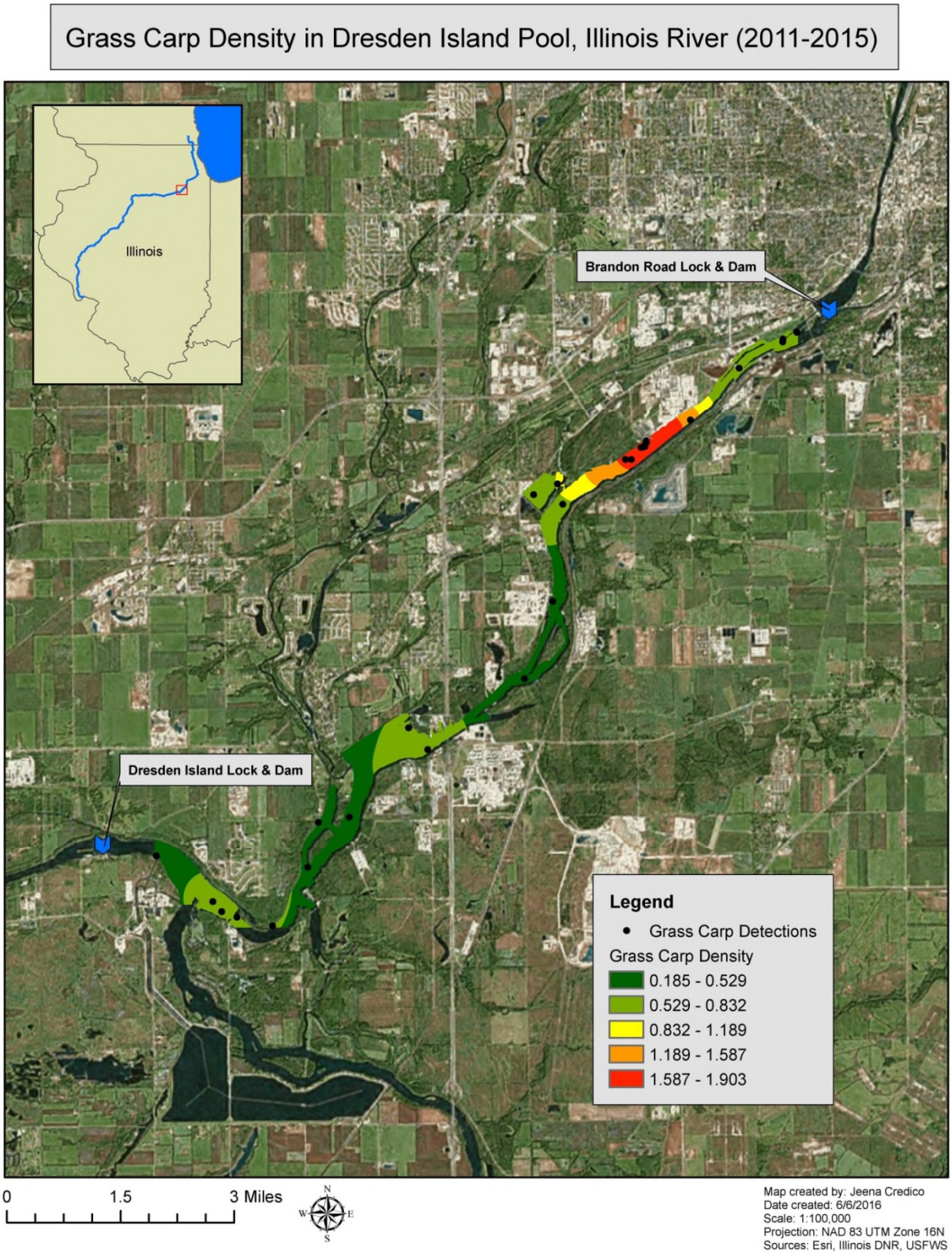

Figure 2. *Kernel density of Grass Carp for Dresden Island Pool based on capture data from 2011-2015.*

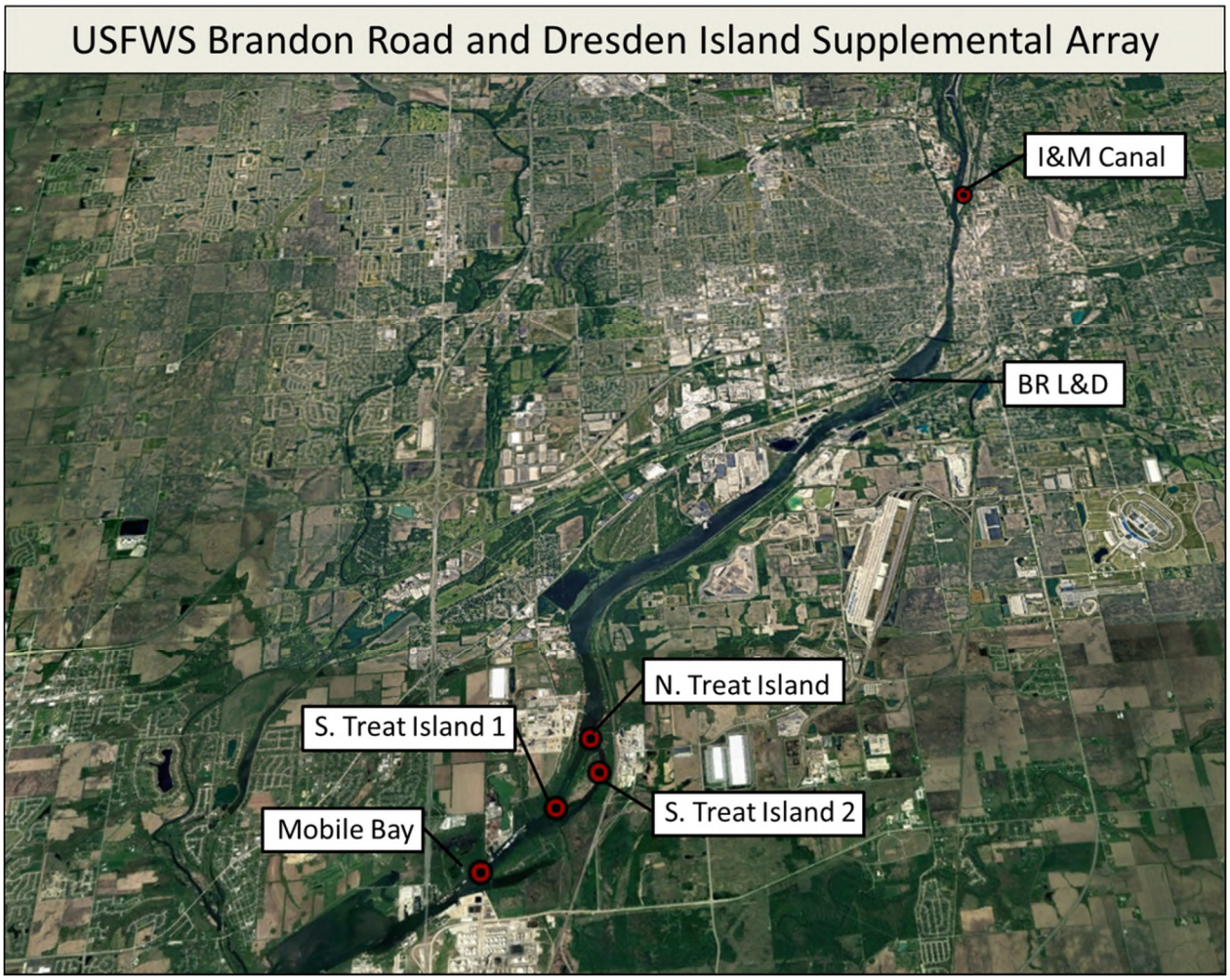

Figure 3. *VR2W receiver locations for Brandon Road and Dresden Island, which were used in conjunction with the current telemetry array within the IWW.*

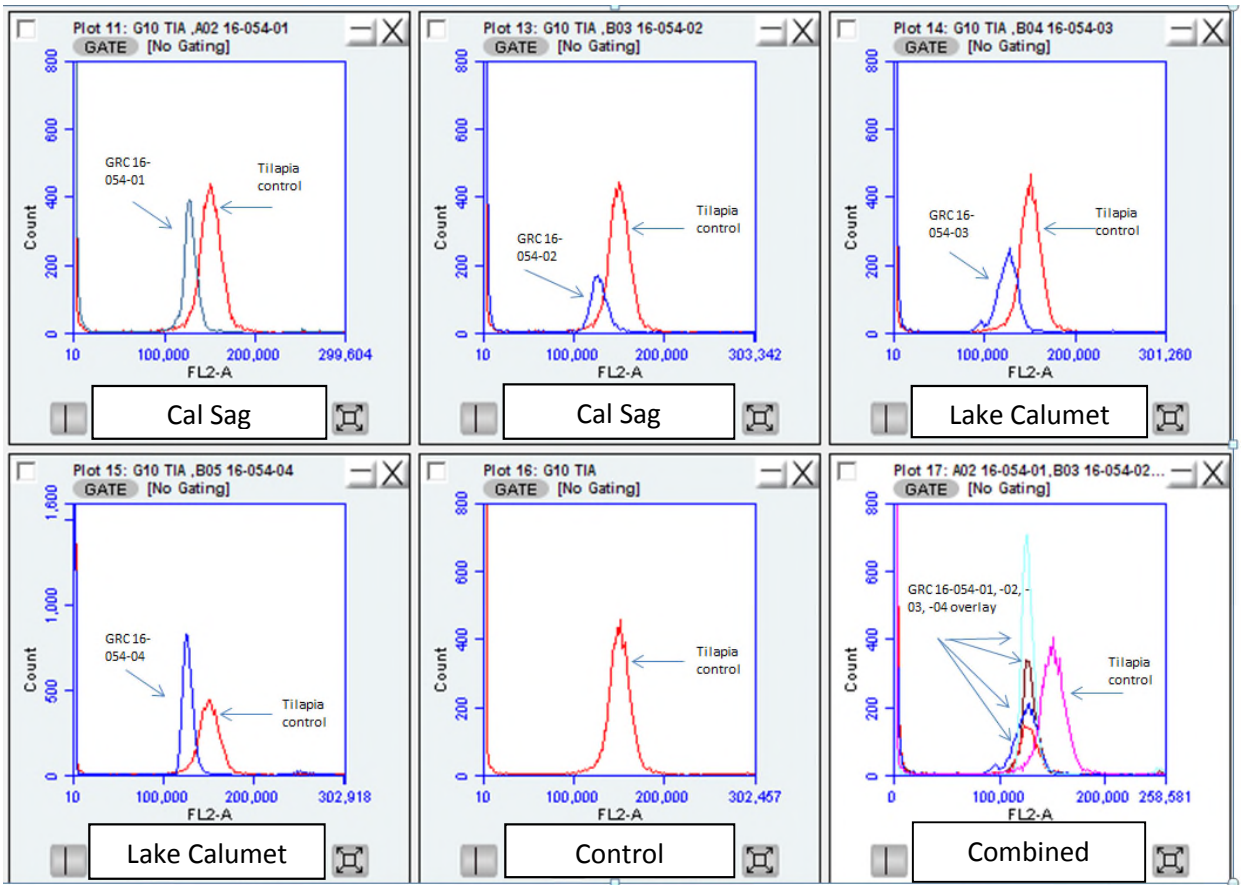

Figure 4. *Ploidy results of the four Grass Carp captured within the CAWS during the 2016 field season. Spikes to the left of the control are indicative of a diploid specimen.*

Table 1. *Grass Carp captures and ploidy results from the CAWS and pools within the IWW for the 2016 and 2017 field season.*

Pool	n	% Diploid	Avg. Length (mm)	Avg. Weight (g)
CAWS	13	46.1	1019	13821
Brandon Road	2	50	848.5	8250
Dresden Island	24	30	969.3	12013
Marseilles	23	86.4	923.4	10306
Starved Rock	5	100	666.2	3924
Total	67	59	937.1	10843.6

Table 2. *Effort and total catch of Grass Carp during targeted sampling for telemetry tagging based on pool during the 2016 and 2017 field season.*

Pool	Brandon Road	Dresden Island	Marseilles
Effort (hrs)	8.04	53.08	9.03
Grass Carp	1	21	4
CPUE (fish/hr)	0.12	0.39	0.44

Table 3. *Upstream and downstream extent and range of Grass Carp from stationary receivers.*

Fish Tag #	RM Release	↑ RM Detection	↓ RM Detection	Range (miles)
17344	284.5	285.9	276.8	9.1
17345	285.5	285.7	280.9	4.8
17346	285.2	285.7	282.8	2.9
17347	285.2	285.9	208.5	77.4
17348	285.2	285.7	282.8	2.9
17349	285.2	285.7	285.7	0
17350	263.5	271.1	262	9.1
17351	270.5	271.5	271.1	0.4
17352	270.5	271.1	271.1	0
17353	285.2	285.7	271.6	14.1
17354	285.2	285.7	285.5	0.2
17356	285.2	285.5	282.8	2.7
17357	285.2	285.5	280.9	4.6
17359	274.4	279.4	271.6	7.8
17360	271.1	-	-	NA
17361	289.7	-	-	NA
17362	283	285.5	283.2	2.3
17364	285.2	285.5	285.5	0
17366	285.2	285.5	285.5	0
17368	285.2	285.5	285.5	0
17370	285.5	285.5	282.8	2.7
17372	285.5	285.5	283.2	2.3
17373	285.7	283.2	283.2	0

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Alternative Pathway Surveillance in Illinois – Urban Pond Monitoring

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

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 Lake Michigan or the CAWS upstream of the Electric Dispersal Barrier. Ponds in Gompers Park, Jackson Park, and Lincoln Park are the exceptions. The Lincoln Park South and Jackson Park lagoons are no longer potential sources of Bighead Carp because they were rehabilitated with piscicide in 2008 and 2015, respectively. Gompers Park never had a report of Asian carp, nor have any been captured or observed during past sampling events. Nevertheless, examining all urban fishing ponds close to the CAWS or Lake Michigan 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 were 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 using conventional gears (electrofishing and trammel/gill nets) for the presence of Asian carp.

Project Highlights:

- 34 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.
- 18 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.

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 43 Bighead Carp and one Silver Carp have been removed from nine ponds (Table 1). Fifty-seven hours of electrofishing and 12 miles of gill/trammel net were utilized to sample 24 Chicago area fishing ponds, resulting in 34 Bighead Carp removed from five ponds since 2011. Additionally, eight Bighead Carp and one Silver Carp killed by either natural die-off or pond rehabilitation with piscicide have been removed since 2008. Lastly, one Bighead Carp was incidentally caught by a fisherman in 2016. The lagoons at Garfield and Humboldt Park have 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. 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.

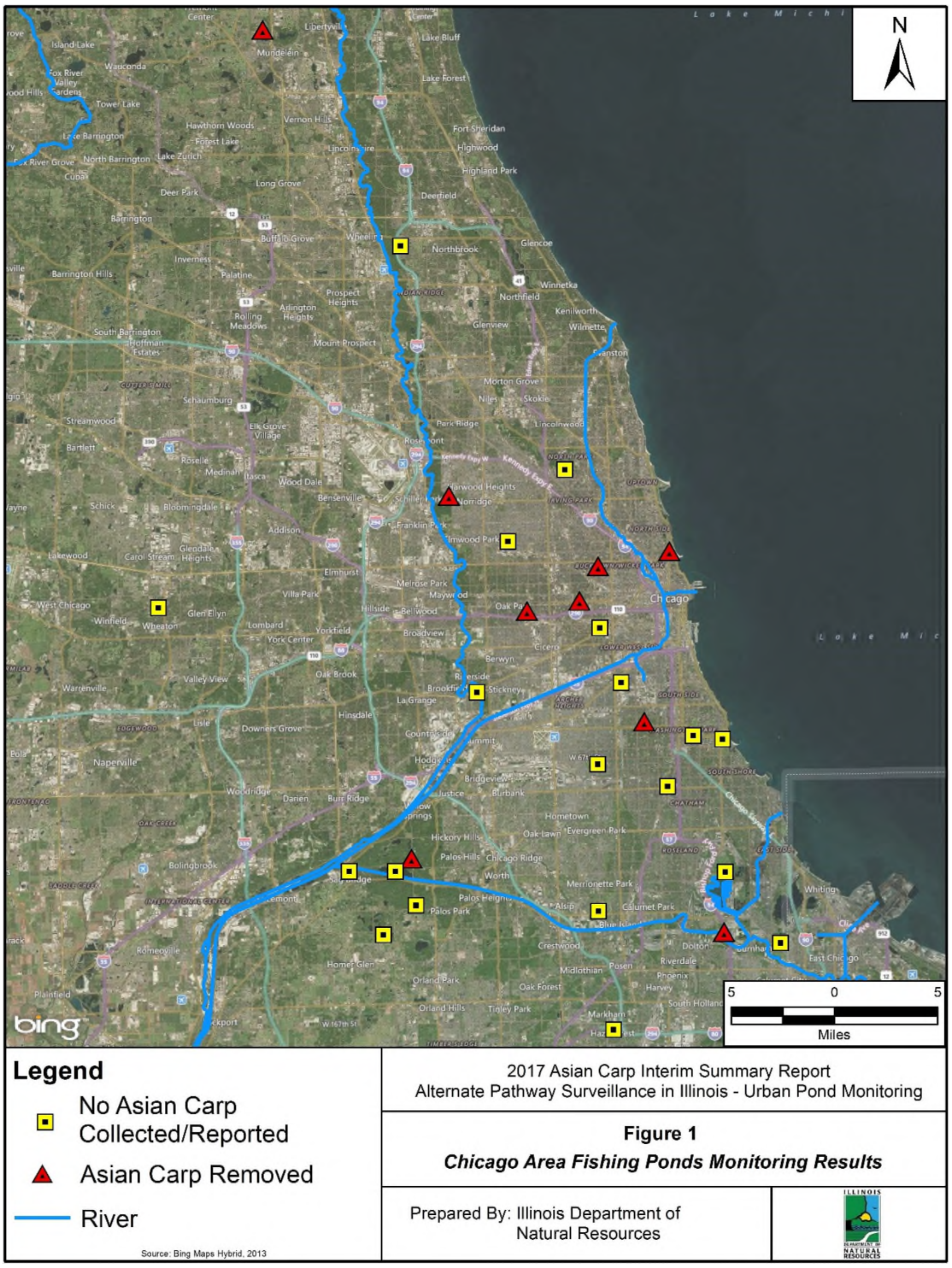

Figure 1. *Chicago area fishing ponds from which Asian carp have been removed (red) and those from which no Asian carp have been collected or reported (yellow).*

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 µmol/mol; within 50-150 microns of the otolith center) to lower values (range 400-650 µmol/mol) toward the edge of the otolith (mean 618

µmol/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 strictly on photographic evidence or reports from credible sources.

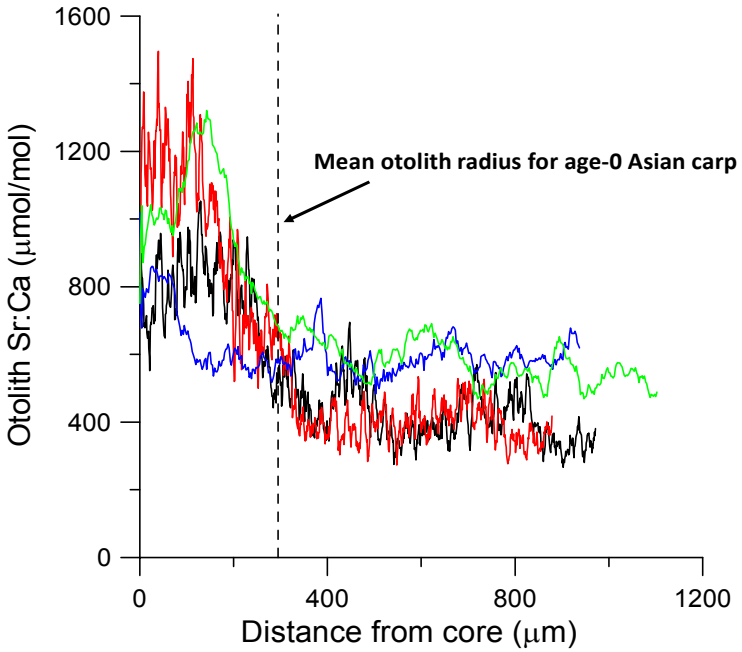

Figure 2. *Example of laser ablation transects for four Chicago pond Bighead Carp otoliths. The dashed line represents the mean otolith radius for age-0 Asian carp taken from nearby rivers.*

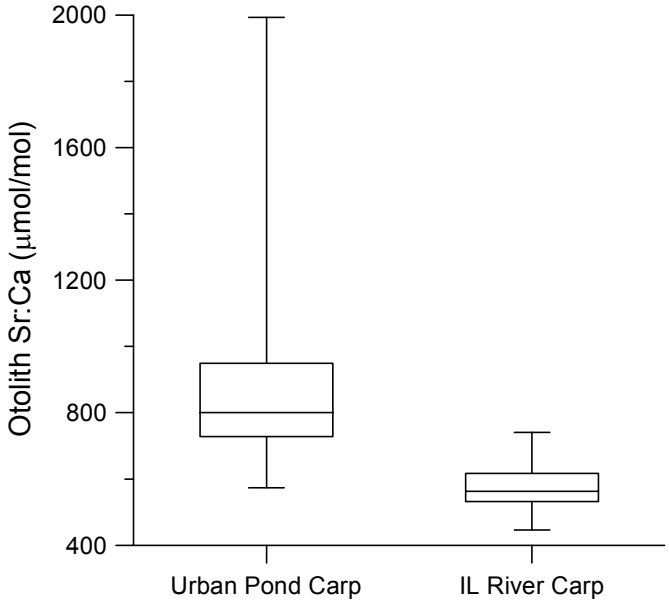

Figure 3. *Boxplots of otolith core Sr:Ca for Chicago pond (N = 24) and Illinois River (N = 81) Asian Carp. The minimum value for urban pond carp represents the Silver Carp collected from Sherman Park.*

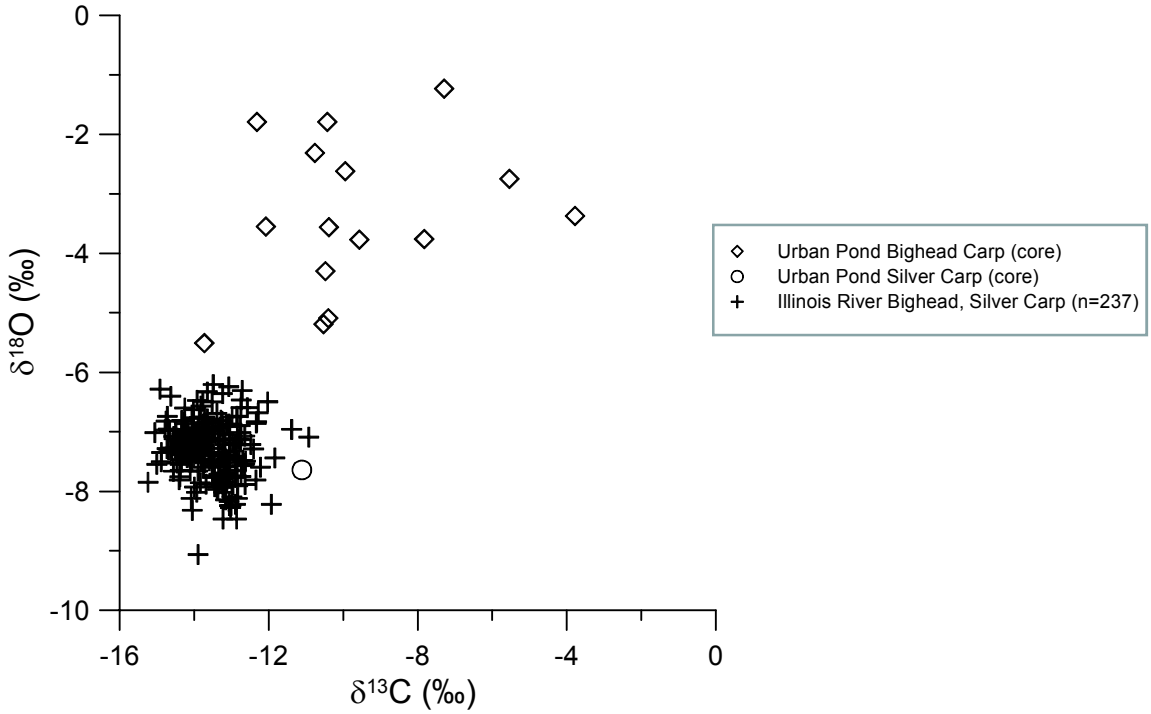

Figure 4. *Otolith Core $\delta^{18}O$ and $\delta^{13}C$ comparing Urban Pond and Illinois River Bighead and Silver Carps.*

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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]	20.0	3.6	7	20	-	-
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	57.2	12.1	34	34	0	10

Young-of-year and Juvenile Asian Carp Monitoring

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

Introduction:

Bighead Carp and Silver Carp are known to spawn successfully in large river systems where rising water levels and suitable temperatures (18 – 30ºC) initiate reproduction and continuous flows and moderate current velocities transport their semi-buoyant eggs during early development. Successful reproduction and recruitment is crucial to the establishment and long-term viability of Asian carp populations in the Mississippi River and its tributaries. Currently, large numbers of Asian carp inhabit the Illinois River, which is hydrologically connected to Lake Michigan. The risk that Asian carp invade and establish viable populations in Lake Michigan and other Great Lakes increases as Asian carp advance further up the Illinois River and its connected waterways. Successful spawning events pose a critical threat because larval fish may recruit to juvenile life stages and potentially challenge the Electric Dispersal Barrier. Despite no current evidence of successful Asian carp reproduction in the CAWS, Des Plaines River, or uppermost Illinois River, targeting young-of-year and juvenile Asian carp in monitoring efforts is needed to monitor the spatial and temporal changes in the numbers of small Asian carp and their potential advancement through the Illinois River towards the Great Lakes.

Objectives:

Multiple gears suitable for sampling small fish were used to:

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

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

Project Highlights:

- Sampled for young Asian carp from 2010 to 2017 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 2017. Mini-fykes caught the most Silver Carp <6 inches. Trawling captured more Silver Carp 6-12 inches.
- Completed 2,448 hours of electrofishing across all years and pools.

Young-of-year and Juvenile Asian Carp Monitoring

- Examined 466,955 Gizzard Shad <152 mm (6 inches) along the CAWS and Illinois Waterway during 2017, most of which were in the Marseilles Pool (~80%).
- High catches of small Asian carp in 2014, moderate in 2015 and 2017, 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 in 2017 was one Silver Carp (6-12 inches) in the Starved Rock Pool.
- Given the numbers of small Asian carp sampled differ by orders of magnitude between years, it is recommended that monitoring of small Asian carp be continued to examine population fluctuations.

Methods:

As in the past, 2017 sampling for young-of-year and juvenile Asian carp took place through other projects of the MRRP. See individual project summary reports and the 2017 MRRP for sampling locations and specifics of gears involved. Please refer to specific project summary reports for detailed sampling methods and protocols.

Sampling of small Asian carp consisted of a combination of active and passive gears. Effort was reported for each gear. Because effort varies by gear type, values are reported in terms of time (hours sampled), net night deployments, or seine-hauls. Trawling (e.g., Paupier, dozer), pulsed-DC electrofishing, seining hauls, and mini fyke nets were the principal gears used to monitor for young Asian carp throughout the Illinois Waterway during 2017. Counts of small Gizzard Shad < 152 mm (6 inches) are included to track the relative abundance of other planktivores across pools and through time. The intensive monitoring effort was the product of sampling by multiple agencies (IDNR, INHS, USFWS), and a summation of all catch and sampling effort from 2010-2017 is presented here.

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, six gears in 2016, and six gears in 2017. Sampling during 2017 included both active gears, (trawling, electrofishing, beach seining) and a passive gear (mini-fyke nets). In 2017, only Silver Carp were sampled, 99% of which were collected in the LaGrange Pool (n =2,967; Table 7). The remaining 1% were in the Peoria Pool (n = 25) and the Starved Rock Pool (n = 1). Notably, no small Bighead Carp were captured during 2017. In previous years (2015, 2016) a few small Asian carp were sampled in the Marseilles Pool (Tables 5, 6). However, in 2017, no small Asian carp were detected in this pool by any agency. The farthest upstream pool where small Asian carp were detected was in the Starved Rock Pool (n = 1, 6-12 inches). The greatest numbers of young-of-year (<6 inches)

Silver Carp were collected in mini-fyke nets (n = 2,855), followed by Paupier trawls (n = 98), dozer trawls (n = 22) and with low catches for other gears. Active sampling including trawling and electrofishing captured the most Silver Carp 6 – 12 inches, whereas mini-fyke nets only captured Silver Carp <6 inches. A total of 466,955 Gizzard Shad <152 mm (6 inches) were collected along the Illinois River (Table 7). Numbers of Gizzard Shad were greater than in the preceding years (Tables 1-6).

During 2017, approximately 501 hours of active sampling effort was conducted across all pools to sample small Asian carp. DC electrofishing accounted for 431 hours and trawling accounted for 70.25 hours in all pools. Mini-fyke nets fished for a total of 238 net-nights and 41 seine hauls were conducted (Table 7). Overall, sampling effort varied among pools and among gears, but adequately covered the CAWS upstream of the Electric Dispersal Barrier and all pools downstream. Sampling effort was consistent, albeit slightly higher, than previous years, suggesting differences in Asian carp numbers reflect changes to population dynamics.

Over the duration of this project, stark inter-annual differences in the numbers of small Asian carp have been observed, often differing by orders of magnitude. No juvenile Asian carp <12 inches were captured in 2010 (note: LaGrange, 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. However, this pattern did not carry over to the following years, as the total numbers of small Asian carp were considerably lower during 2015 and 2016, but higher when compared to 2010-2013. Total numbers of small Asian carp sampled in 2017 were orders of magnitude lower when compared to 2014, but slightly higher than 2010-2016. Notably, a large percentage of Silver Carp were small (<6 inches) and collected within a single gear type (mini-fyke nets). Yet, no 6-12 inches Silver Carp were collected in mini-fyke nets. Fortunately, these sizes are captured by trawls that sample habitats further away from the shoreline.

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 2010-2017. In 2017, catch of Asian carp was exclusively Silver Carp. Numbers of Silver Carp captured in 2017 were substantially lower than 2014 catches. Sampling detected one small (6 – 12 inches) Asian carp in the Starved Rock Pool, similar to past segments, but total numbers were lower than in previous years. Moreover, no small Asian carp were captured in the Marseilles Pool. This is notable, as several small Asian carp were collected in the Marseilles Pool in 2015 and 2016. Although 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 the catches and distribution of young Asian carp from researchers and management biologists. 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						
Year, location, (river mile)	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.
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 Continued

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 Continued

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

Table 7. *Number of juvenile Bighead Carp, Silver Carp, and Gizzard Shad sampled with various gears in the CAWS and Illinois Waterway during 2017.*

Location	Gear	Effort	Number Collected				
			Bighead Carp <6 in.	Bighead Carp 6-12 in.	Silver Carp <6 in.	Silver Carp 6-12 in.	Gizzard Shad
CAWS	Electrofishing (hours)	203.9	0	0	0	0	15022
Brandon Road	Electrofishing (hours)	32.5	0	0	0	0	2089
	Mini Fyke (net nights)	29.4	0	0	0	0	178
	Dozer Trawl (hours)	1.1	0	0	0	0	27
	Paupier Trawl (hours)	0	0	0	0	0	0
Lockport	Electrofishing (hours)	31.3	0	0	0	0	2451
	Mini Fyke (net nights)	28.4	0	0	0	0	30
	Dozer Trawl (hours)	0.65	0	0	0	0	0
	Paupier Trawl (hours)	0	0	0	0	0	0
Dresden Island	Electrofishing (hours)	54.5	0	0	0	0	8972
	Mini-fyke (night sets)	34.8	0	0	0	0	560
	Dozer Trawl (hours)	1.7	0	0	0	0	269
	Paupier Trawl (hours)	0.2	0	0	0	0	322
	Push Trawl (hours)	0	0	0	0	0	0
	Surface Trawl (hours)	0	0	0	0	0	0
	5/8" mesh seine (pulls)	4	0	0	0	0	1557
	Bottom Electrified Trawls (pulls)	0	0	0	0	0	0
Marseilles	Electrofishing (hours)	70	0	0	0	0	18966
	Mini-fyke (night sets)	41	0	0	0	0	10
	Dozer Trawl (hours)	8.5	0	0	0	0	28891
	Paupier Trawl (hours)	23.5	0	0	0	0	278339
	Push Trawl (hours)	0	0	0	0	0	0
	Surface Trawl (hours)	0	0	0	0	0	0
	5/8" mesh seine (pulls)	5	0	0	0	0	52453
	Bottom Electrified Trawls (pulls)	0	0	0	0	0	0

Table 7 Continued

Starved Rock	Electrofishing (hours)	24	0	0	0	1	3044
	Mini-fyke (night sets)	50	0	0	0	0	38
	Dozer Trawl (hours)	3.7	0	0	0	0	1419
	Paupier Trawl (hours)	2.9	0	0	0	0	728
	Push Trawl (hours)	0	0	0	0	0	0
	Surface Trawl (hours)	0	0	0	0	0	0
	Bottom Electrified Trawls (pulls)	0	0	0	0	0	0
Peoria	Electrofishing (hours)	7	0	0	3	11	123
	Mini-fyke (night sets)	13	0	0	0	0	1
	Dozer Trawl (hours)	5.1	0	0	0	11	87
	Paupier Trawl (hours)	0.5	0	0	0	0	25
	Push Trawl (hours)	0	0	0	0	0	0
	Surface Trawl (hours)	0	0	0	0	0	0
	Bottom Electrified Trawls (pulls)	0	0	0	0	0	0
La Grange	Electrofishing (hours)	7.7	0	0	0	0	1190
	Mini Fyke (net nights)	42	0	0	2855	0	0
	Dozer Trawl (hours)	13.9	0	0	6	5	14059
	Paupier Trawl (hours)	8.5	0	0	28	70	36105
	Push Trawl (hours)	0	0	0	0	0	0
	Surface Trawl (hours)	0	0	0	0	0	0
	Cast Net (sets)	0	0	0	0	0	0
	Purse Seine (sets)	0	0	0	0	0	0
	1/8" Mesh Seine (Pulls)	32	0	0	3	0	0
	Small Mesh Gill Nets (hours)	0	0	0	0	0	0
	Bottom Electrified Trawls (pulls)	0	0	0	0	0	0

Des Plaines River and Overflow Monitoring

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

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 Lockport Lock and Dam. Asian carp have been observed in this pool up to the confluence with the Des Plaines River, and have free access to enter the upper Des Plaines River. In 2010 and 2011, Asian carp eDNA was detected in the upper Des Plaines River (no samples were taken in 2012 – 2017). 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. One low-lying area was reinforced with a large berm. It is important to understand the Asian carp population status, monitor for any potential spawning events, and determine effectiveness of the physical barrier to help inform management decisions, evaluate risk during overtopping events, and direct removal actions.

Objectives:

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

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

Project Highlights:

- Collected 11,082 fish representing 58 species and 3 hybrid groups from 2011-2017 via electrofishing (57.69 hours) and gill netting (140 sets; 20,384 yards).

- No Bighead Carp or Silver Carp have been captured or observed through all years of sampling.
- Seven Grass Carp have been collected, of which six were submitted for ploidy analysis. All six were determined to be triploid.
- Three overtopping events since 2011 have resulted in several improvements to the barrier fence.

Methods:

In 2017, sampling was conducted in the upper Des Plaines River from the confluence near Crest Hill, Illinois upstream to near Lyons, Illinois (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 completed. 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 backwaters and channel habitat that was accessible near launch locations using gill nets and electrofishing gear. All fish were identified and released.

Potential overtopping events were investigated to determine if surface water was reaching the CSSC, to locate any breaches, and to sample for fish/eggs/larvae that have passed the barrier fence. Crews drove or walked along the fence and inspected areas where water reached the fence. Ichthyoplankton samples were collected when overtopping events occurred at water temperatures conducive to spawning (>18° C) (Kolar et al. 2007). Icthyoplankton samples were taken at three locations: Willow Springs Road via bridge, at the confluence with the CSSC via boat, and above the confluence in the CSSC via boat. Samples were collected using 500 µm mesh and a 0.5 m diameter hoop. At each site, three replicate samples were collected for five minutes each. Samples were taken just beneath the surface, stationary from the bridge or towed slowly upstream from the boat. Samples were transferred to 95% ethanol and later processed in a laboratory where larval fish were identified to family and genus and eggs were identified as Asian carp or non-Asian carp.

Results and Discussion:

During the seven years of sampling (2011-2017), 57.69 hours of electrofishing and 140 sets covering 20,384 yards of gill net resulted in a total catch of 11,082 fish. Fifty-eight species and three hybrid groups have been collected. Common Carp have been the most commonly collected species, followed by Bluegill and Gizzard Shad. In 2017, 6.40 hours of electrofishing resulted in 1055 fish representing 37 species and one hybrid group. Six gill net sets totaling 2800 yards resulted in 331 fish representing nine species and one hybrid group. 2017 sampling yielded 39 species and one hybrid group overall. No Bighead Carp or Silver Carp have been collected or observed throughout all years of sampling.

No Grass Carp were collected in 2017. To date, six Grass Carp have been tested for ploidy out of seven total collections (Figure 2). All six tested were determined to be triploid, or sterile. Therefore, it is likely that Grass Carp captured in the upper Des Plaines River 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 within the upper Des Plaines River.

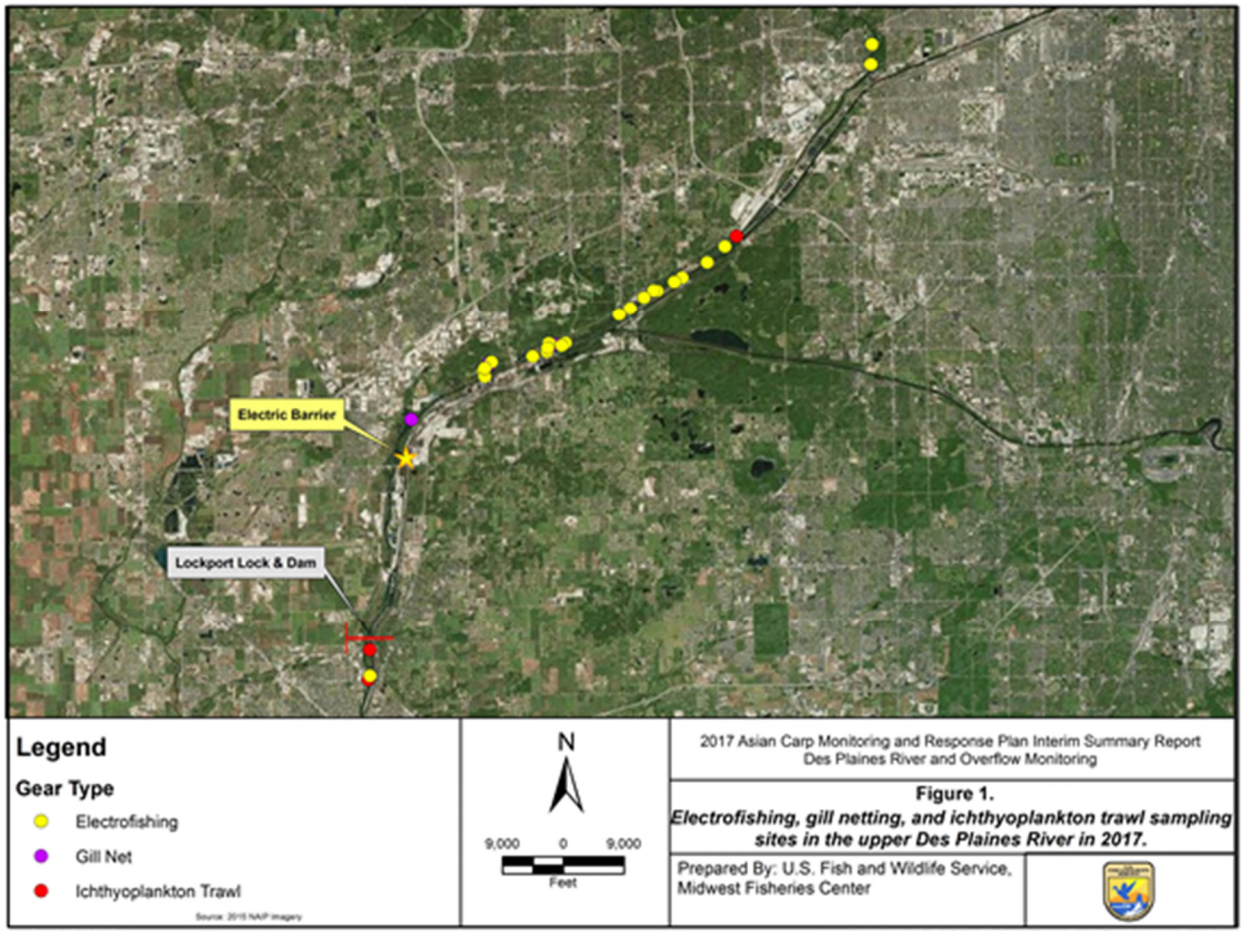

Figure 1: *Electrofishing and gill netting sampling sites in the upper Des Plaines River in 2017.*

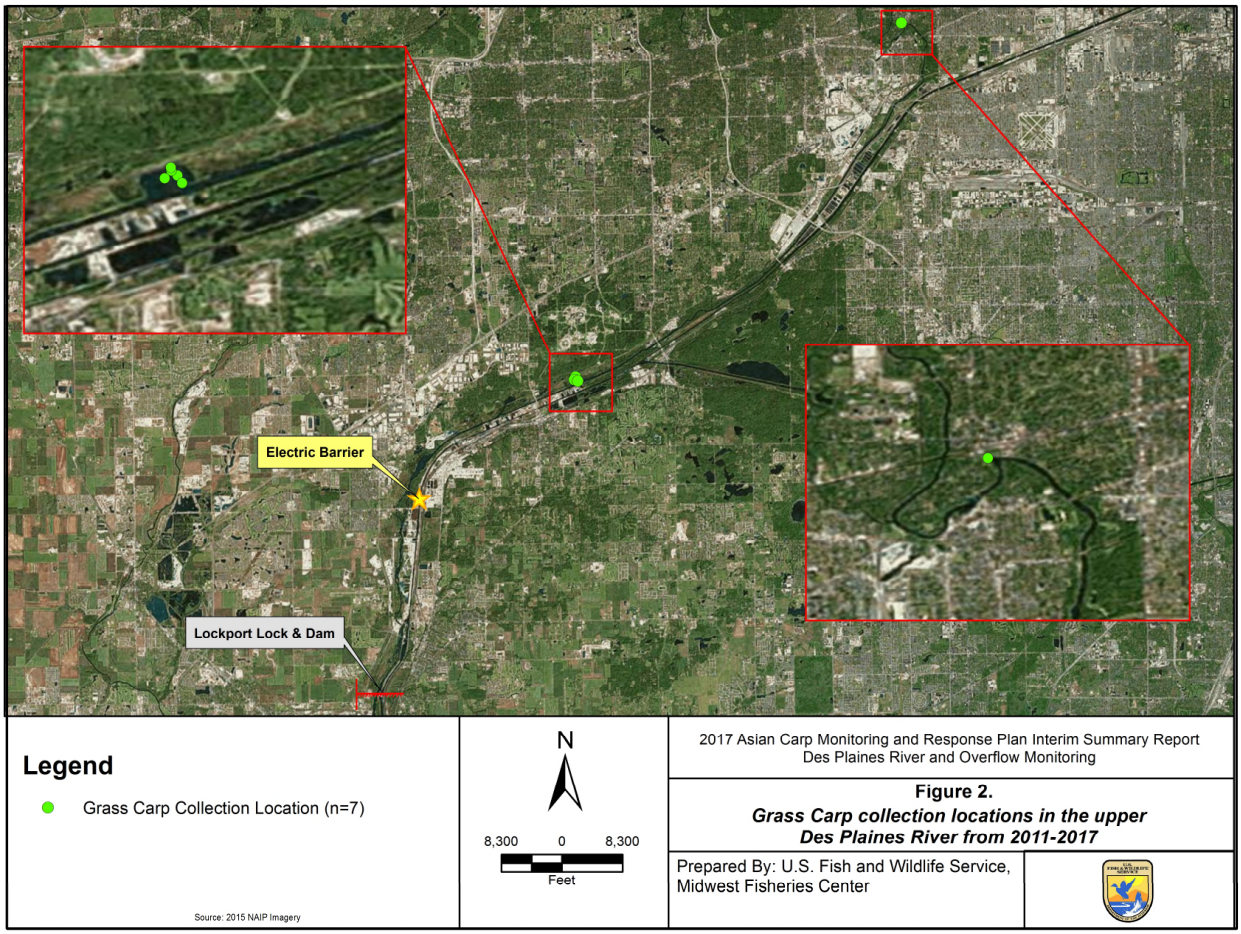

Figure 2: *Grass Carp collection locations in the upper Des Plaines River from 2011-2017.*

Three investigations of potential overtopping events took place in 2017. On May 2, 2017, the USGS stream gauge at Lemont recorded a crest of 11.05 feet. The entire length of the barrier fence was monitored with USACE personnel and no surface water was found to be transferring from the Des Plaines River to the CSSC. Water had passed through the fence at one location (41.71619; -87.91419), but a newly constructed berm prevented surface water from reaching the CSSC. Ichthyoplankton trawl samples were collected at three locations (Figure 1). No Asian carp were identified among the 12 larval fish and 14 eggs that were collected. On July 18, 2017, USFWS received a request to investigate surface water running over Canal Bank Road near Lemont Road. Investigators traced the water back to the source and determined it to be ground water. On October 15, 2017, the USGS stream gauge at Lemont recorded a crest of 12.44 feet. FWS personnel accompanied USACE personnel on October 16, 2017. Surface water reached the fence in several areas but no surface water was found draining into the CSSC. Several holes in the fence were located near Willow Springs, Illinois. However, no water reached the holes. Repairs are underway.

Des Plaines River and Overflow Monitoring

Recommendation:

Continue gill netting and electrofishing for adult and juvenile Bighead Carp and Silver Carp in the upper Des Plaines River with emphasis on backwater habitat. Continue to monitor Des Plaines River stage during heavy rainfall events and conduct investigations of the physical barrier, as needed, in areas where overflow has occurred. Collect icthyoplankton samples during potential overflow events when temperatures are conducive for reproduction.

References:

Kolar, C.S., D.C. Chapman, W.R. Courtenay, 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.

Comprehensive Asian Carp Removal Summary

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

Introduction:

This is a comprehensive summary of all Asian carp removal that has occurred during the Asian carp program in the upper Illinois and lower Des Plaines rivers downstream of the Electric Dispersal Barriers from 2010 to present (Figure 1). Additional details about Asian carp removal can be found in the IDNR Barrier Defense Project, USFWS Barrier Defense Project and Monitoring Efforts Downstream of the Electric Dispersal Barrier sections of this report.

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.

(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 and agency staff deployed 2,396.4 miles (3856.6 km) of gill/trammel net, 20 miles (32.1 km) of commercial seine, 230 pound net nights and 3,225.5 hoop net nights, 459 electrofishing hours, and 29.8 electrified paupier hours in the upper Illinois Waterway since 2010.
- A total of 90,469 Bighead Carp, 681,743 Silver Carp, and 4,668 Grass Carp were removed from 2010-2017. The total weight of Asian carp removed was 3,193.01 tons.

Methods:

Further details about Asian Carp removal methods can be found in the IDNR Barrier Defense Project, USFWS Barrier Defense Project and Monitoring Efforts Downstream of the Electric Dispersal Barrier sections of this report.

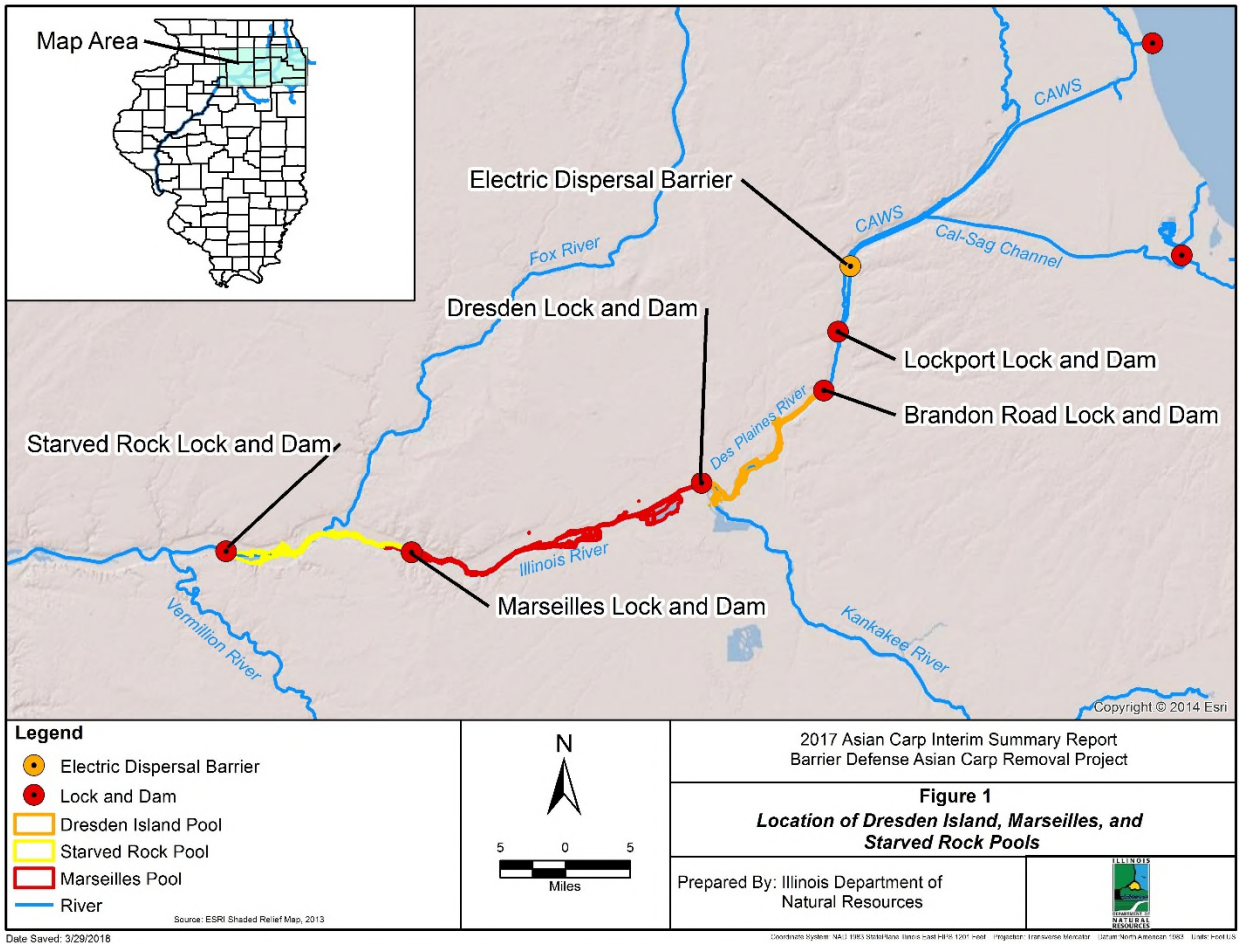

Figure 1. *Location of Barrier Defense downstream of the Electric Dispersal Barrier.*

Results and Discussion:

A total of 2,396.4 miles (3856.6 km) of gill/trammel net, 20 miles (32.1 km) of commercial seine, 230 pound net nights and 3,225.5 hoop net nights, 459 electrofishing hours, and 29.8 electrified paupier hours were deployed in the upper Illinois Waterway since 2010 (Table 1). The total weight of Asian carp caught and removed from 2010-2017 was 6,386,020 pounds (3,193.01 tons) (Table 1). Silver Carp, Bighead Carp, and Grass Carp accounted for 69.1%, 24.7%, and 6.2% of the total tons harvested since 2010, respectively.

The combined catch of Asian carp (Bighead Carp, Silver Carp, and Grass Carp) since 2010 was 776,880 individuals (Table 1). The total harvest of Asian carp 2010-2017 consisted of 87.8% Silver Carp, 11.6% Bighead Carp, and 0.6% Grass Carp.

Gill/Trammel nets yielded 83.3% of the Asian carp removed since 2010, followed by seines (8.1%), paupier (3.9%), hoop nets (3.6%), pound nets (0.7%), and electrofishing (0.4%) (Figure 2).

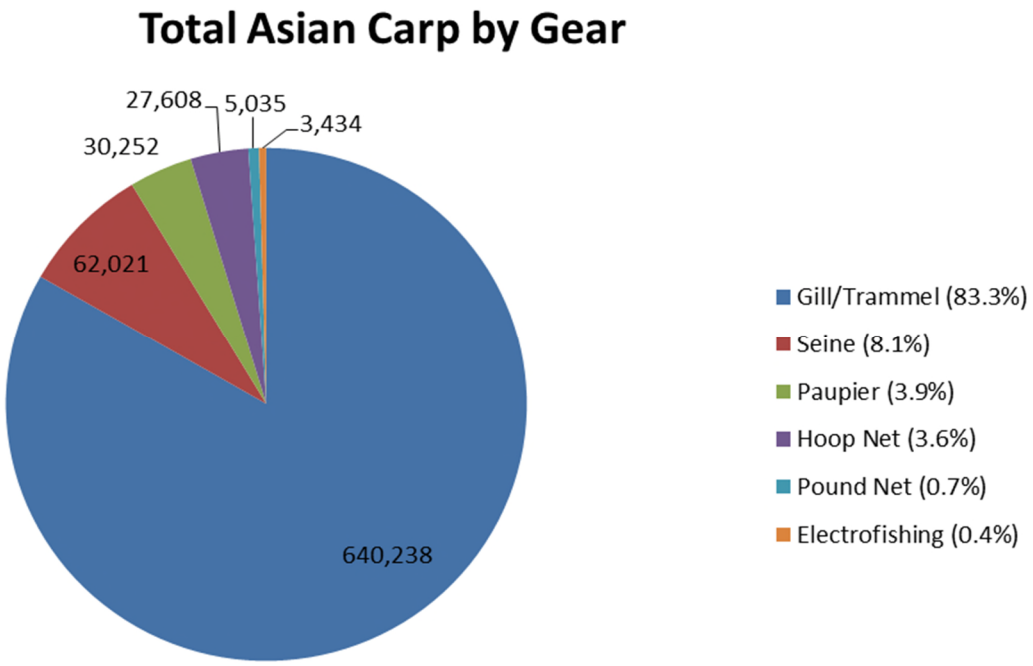

Figure 2. *Total Asian carp removal 2010-2017 by gear type.*

Gill/Trammel nets yielded 85.6% of the Asian carp tonnage removed since 2010, followed by seines (8%), hoop nets (2.9%), paupier (2.5%), pound nets (0.6%), and electrofishing (0.4%) (Figure 3).

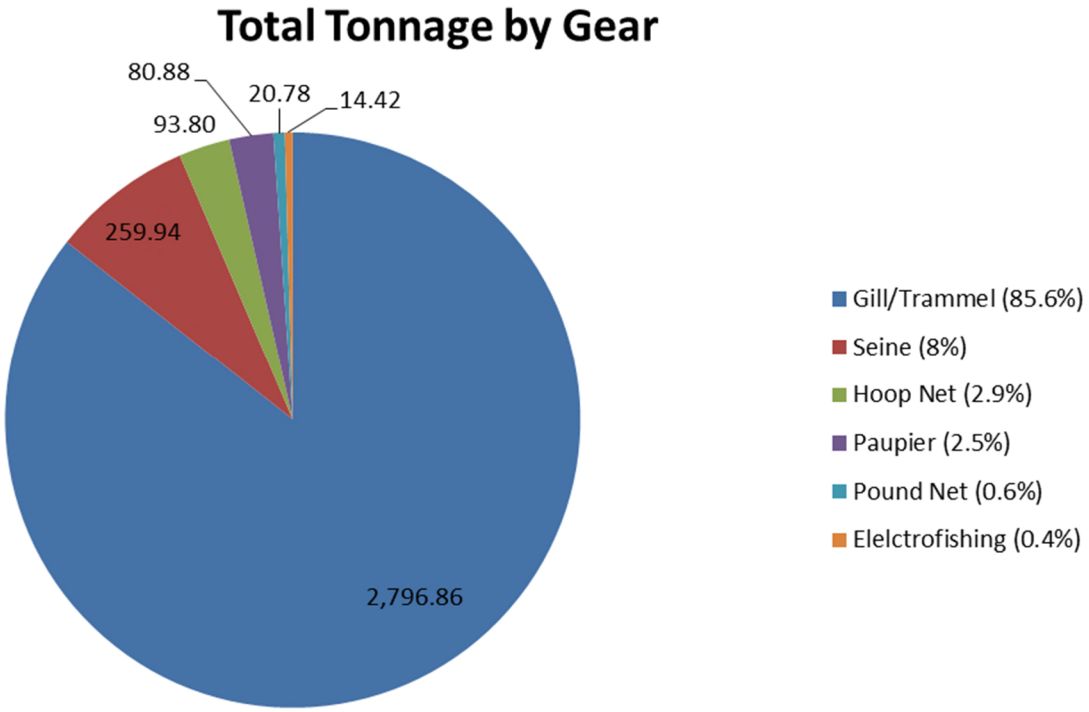

Figure 3. *Total Asian carp tonnage removal 2010-2017 by gear type.*

Comprehensive Asian Carp Removal Summary

Catch of Asian carp within Pools –

Dresden Island Pool:

A total of 340.7 miles of gill/trammel net, 620 hoop net nights, 4 pound net nights, and 242 electrofishing hours were deployed in the Dresden Island Pool since 2010. A total of 2,140 Bighead Carp; 1,104 Silver Carp; and 78 Grass Carp were harvested since 2010 (Table 1).

Marseilles Pool:

A total of 1,468.3 miles of gill/trammel net, 15 miles of commercial seine, 420.9 hoop net nights, 226 pound net nights, 217 electrofishing hours, and 0.4 paupier hours were deployed in the Marseilles Pool since 2010. A total of 67,070 Bighead Carp; 232,900 Silver Carp; and 1,042 Grass Carp were harvested since 2010 (Table 1).

Starved Rock Pool:

A total of 587 miles of gill/trammel net; 4 miles of commercial seine; 2,184.6 hoop net nights; and 29.4 paupier hours were deployed in the Starved Rock Pool since 2010. A total of 21,259 Bighead Carp; 447,739 Silver Carp; and 3,548 Grass Carp were harvested since 2010 (Table 1).

Comprehensive Asian Carp Removal Summary

Table 1: Total *Asian carp removal effort and harvest of Asian carps from Dresden Island, Marseilles and Starved Rock pools during 2010-2017.*

	Effort						Harvest							
Year and River Pool	Miles of Net	Electrofishing Hrs	Miles of Seine	Hoop net Nights	Pound Net Nights	Paupier Hrs	Bighead Carp (*N*)	Silver Carp (*N*)	Grass Carp (*N*)	Total (*N*)	Bighead Carp (tons)	Silver Carp (tons)	Grass Carp (tons)	Total (tons)
2010														
Dresden	1.8	6					2			2	0.01			0.01
Marseilles	75.5	6					4,894	1,139		6,033	53.11	8.11		61.22
Starved Rock														
All pools	77.3	12					4,896	1,139		6,035	53.12	8.11		61.23
2011														
Dresden	4.8	9					8			8	0.06			0.06
Marseilles	219.2	9					20,087	7,023	34	27,144	229.39	46.00	0.16	275.55
Starved Rock	44.6						2,964	10,730	132	13,826	21.36	53.32	0.65	75.33
All pools	268.6	18					23,059	17,753	166	40,978	250.81	99.32	0.81	350.94
2012														
Dresden	9.8	9		32.0			120	36	3	159	0.87	0.04	0.28	1.20
Marseilles	235.6	9	0.9	32.0			13,971	11,074	160	25,205	126.07	64.39	0.67	191.13
Starved Rock	67.3						3,994	20,589	243	24,826	22.42	99.98	1.39	123.79
All pools	312.7	18	0.9	64.0			18,085	31,699	406	50,190	149.36	164.41	2.34	316.12
2013														
Dresden	16.4	32		56.0			1,095	93	13	1,201	13.50	0.17	0.73	14.40
Marseilles	237.8	32	0.9	48.0			7,746	11,747	378	19,871	74.05	59.38	2.67	136.10
Starved Rock	104.1						3,938	38,666	369	42,973	21.93	1.97	168.14	192.04
All pools	358.2	64	0.9	104.0			12,779	50,506	760	64,045	109.48	61.52	171.54	342.54
2014														
Dresden	52.3	47		64.0			104	25	5	134	1.04	0.07	0.20	1.30
Marseilles	216.0	50	1.1	64.0			7,553	27,903	108	35,564	69.33	112.29	0.05	181.67
Starved Rock	91.0		0.2	421.7			4,220	63,132	416	67,768	19.74	222.73	0.72	243.19
All pools	359.3	97	1.3	549.7			11,877	91,060	529	103,466	90.11	335.09	0.97	426.16
2015														
Dresden	77.9	39		116.0			272	150	11	433	2.36	0.15	0.96	3.47
Marseilles	141.2	39	1.6	86.5	24		5,387	69,105	216	74,708	38.90	236.00	1.20	276.10
Starved Rock	78.3		0.5	141.2			2,908	68,681	641	72,230	13.20	198.10	3.70	215.00
All Pools	297.4	78	2.2	343.7	24		8,567	137,936	868	147,371	54.46	434.25	5.86	494.57
2016														
Dresden	79.8	55					232	263	21	516	2.31	0.28	1.46	4.05
Marseilles	203.1	39	8.1	85.7	128	0.4	5,943	62,565	76	68,584	46.86	251.40	0.40	298.66
Starved Rock	88.3		2.1	683.1		15.4	2,065	94,486	613	97,164	9.65	259.88	3.50	273.02
All Pools	371.2	94	10.2	768.8	128	15.8	8,240	157,314	710	166,264	58.81	511.55	5.36	575.73
2017														
Dresden	98.0	45.0		352.0	4.0		307	537	25	869	5.28	0.33	4.25	9.86
Marseilles	139.9	33.0	2.8	104.7	74.0		1,489	42,344	70	43,903	13.56	176.70	0.30	190.56
Starved Rock	113.7		1.3	938.6		14.0	1,170	151,455	1,134	153,759	4.90	413.90	6.50	425.30
All Pools	351.7	78.0	4.1	1,395.3	78.0	14.0	2,966	194,336	1,229	198,531	23.74	590.93	11.05	625.72
2010-2017														
Dresden	340.7	242.0		620.0	4.0		2,140	1,104	78	3,322	25.42	1.03	7.89	34.34
Marseilles	1,468.3	217.0	15.4	420.9	226.0	0.4	67,070	232,900	1,042	301,012	651.27	954.27	5.45	1610.99
Starved Rock	587.4		4.2	2,184.6		29.4	21,259	447,739	3,548	472,546	113.20	1249.88	184.60	1547.67
All pools	2,396.4	459.0	19.6	3,225.5	230.0	29.8	90,469	681,743	4,668	776,880	789.89	2205.17	197.94	3193.01

USGS Support for Implementation of MRP

Brent Knights, Marybeth K. Brey, J.C. Nelson (U.S. Geological Survey, Upper Midwest Environmental Sciences Center)
James Duncker, Elizabeth Murphy (U.S. Geological Survey, Central Midwest Water Science Center)
James Lamer (Western Illinois University)
Greg Whitledge (Southern Illinois University)

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

Introduction and Need:

Intensified surveillance of Bighead carp and Silver carp (i.e., bigheaded carp) in the Upper Illinois River between the Starved Rock Lock and Dam and the Chicago waterway's electrical barriers using advanced and traditional telemetry methods (e.g., transmitting data from passive receivers in near real-time, enhanced acoustic arrays, manual tracking, and satellite-capable transmitters) will provide a greater understanding of the movements, habitats, and behaviors of bigheaded carp in areas of intense management. This new information will allow for better application of control and containment tools. An abundance of data have been and are currently being collected in the Upper Illinois River. However, limited effort has been made to bring this information together to support management objectives, and to inform further research and data collection. There is a need to develop databases, decision support tools, and targeted analyses of existing data to provide information for adaptive and integrated management of bigheaded carp in the intensive management zone.

Objectives:

(1) Implement and evaluate new strategies for monitoring, surveillance, risk assessment, control and containment of bigheaded carp.

(2) Develop and evaluate of databases and decision support tools in support of bigheaded carp control.

Project Highlights:

- Two additional real-time telemetry recievers were deployed to inform contingency actions. One was deployed just upstream of Brandon Road Lock and Dam and the other was deployed just upstream of the electrical barrier.
- Significant progress in development of an online platform and tools for the Monitoring and Response Work Group (MRWG) database and telemetry database were made in FY2017. Both databases will be rolled out to the MRWG in useable formats by mid-FY2018.

- Near real-time satellite tags were successfully deployed for the first time on bigheaded carp in the Dresden Island pool.
- A telemetry study was initiated to better understand lateral habitat use in the Starved Rock pool to inform bigheaded carp removal efforts.
- Decision support tools to inform removal of adult bigheaded carp and mitigate for bigheaded carp egg/larvae entrainment moved toward completion.

Methods:

1) Telemetry, and telemetry database and visualization tool to inform removal and contingency actions:

   a. *Real-time telemetry receivers:* Deploy real-time telemetry receivers in the Upper Illinois River at some of the following sites to inform removal efforts and contingency actions for bigheaded carp: Wilmington Dam on Kankakee River, downstream of the electric barrier, in Dresden Island Pool upstream of Rock Run Rookery, upstream of Brandon Road Lock and Dam, in Rock Run Rookery in Dresden Island Pool, or in Hansen Material Pit in Marseilles Pool. Provide access to the data from these new real-time receivers to the Fish Telemetry website (http://il.water.usgs.gov/data/Fish_Tracks_Real_Time/). Incorporate the data stream from the additional real-time receivers into the telemetry database and visualization tool (see Telemetry database section below). Work with management agencies to identify additional sites for placement of automated realtime receivers to inform removal efforts above Starved Rock Lock and Dam. Continue email summaries of real-time telemetry detections at key locations on the Illinois River to inform removal and contingency actions. Finalize the real-time telemetry alert system that notifies management agencies and partners via email or text of significant detetections.

   b. *Telemetry database and visualization tool*: Transfer the database and visualization tool to the Upper Midwest Environmental Sciences Center (UMESC) from the USGS Western Ecological Science Center. Change platforms for the database and visualization tool to a more user- and developer-friendly one. Develop data upload/download and issue reporting tools. Continue development of the data sharing agreements. Release another version of the telemetry database and visualization tool to collaborating management and research agencies (https://my-beta.usgs.gov/fishtracks/index) for final testing.

   c. *Testing real-time GPS satellite tags:* Complete field testing of satellite-capable geotags for tracking bigheaded carp to inform removal efforts in Dresden Island Pool. In collaboration with USGS, Western Illinois University will deploy seven real-time GPS satellite tags in Dresden Island pool in the upper Illinois River. Develop protocols for sharing real-time data with fish removal crews.

   d. *Lateral habitat use to inform removal:* Conduct field work on telemetry study to assess lateral habitat use of bigheaded carp in Starved Rock Pool. USGS and Southern Illinois

University are collaborating on a telemetry project to investigate the use of lateral habitats by bigheaded carps in the Starved Rock Pool, including a better understanding of the timing and environmental conditions that influence lateral habitat use. The ultimate goal of this study is to inform removal efforts via predictions of lateral habitat use based on environmental condition. This model will be incorporated into a computer dashboard or phone application that removal crews can use to target bigheaded carp in this reach.

2) Database and decision support tools actions:

   a. *MRWG database:* Continue the development of a database to host monitoring and evaluation data (exclusive of telemetry data) collected by the MRWG for the Upper Illinois River. Transfer the existing data from IL DNR to the UMESC. Begin to develop upload/download, query, report generation, quality assurance-quality control, visualization and issue reporting tools for authorized users.

   b. *Decision support for bigheaded egg/larvae entrainment:* Continue the development of a decision support tool that incorporates FluEgg to inform mitigation measures to minimize the entrainment of bigheaded carp eggs and larvae by barge traffic.

   c. *Decision support tool based on adult bigheaded carp habitat:* Initiate the development of a decision support tool based on a habitat suitability model for predicting bigheaded carp locations from 2D hydrologic and water quality data.

   d. *Support MRWG contingency planning:* Provide support, as requested, for the development of annual and contingency monitoring and response plans for the Illinois River including tabletop exercises.

Results and Discussion:

1) Telemetry, and telemetry database and visualization tool to inform removal and contingency actions:

   a. *Real-time telemetry receivers:* Two new real-time telemetry receivers were deployed in 2017, one at Chicago Sanitary and Ship Canal-Lemont gage (upstream of the fish barrier) at River Mile (RM) 302 and a second in the Des Plaines River at Rockdale (upstream side of Brandon Rd. Lock and Dam) at RM 286. The data from these real-time receivers are downloaded to the USGS server, and available to managers at https://il.water.usgs.gov/data/Fish_Tracks_Real_Time/. Information from these receivers are now included in the updates and alerts that go out in near real-time and weekly to relevant managers. Range testing of deployed real-time receivers was conducted. Based on results from range testing, some modifications to receiver deployment will be implemented in FY2018.

   b. *Telemetry database and visualization tool (FishTracks):* The database was transferred from the USGS Western Ecological Science Center to UMESC. In addition, we have

completed structuring the database for small memory usage with fast queries. The database is connected to web applications, which can upload data directly and is protected by authorized account logins (until the data can be made public). The FishTracks visualization tool includes a filtered table for querying data by receiver, location, time period, and more. It also includes a rudimentary spatial report tool that shows fish movements, and receiver and gage locations. Tools were also developed for automating the U.S. Army Corps of Engineers real-time receiver data and USGS's National Water Information System gage data web scraping. A new version of the database and FishTracks will be available by June 2018.

c. *Testing real-time GPS satellite tags:* Five male Silver Carp and two female Bighead Carp ranging in size from 712 mm to 970 mm were tagged with satellite tags. A total of 173 usable data points were collected from these tags at variable deployment times and durations. Location information from six of the fish coroborated general patterns observed from active tracking of acoustically tagged fish that were manually tracked during the last two years. As the data were collected, it was shared with fisheries biologists and commercial fishermen responsible for removing bigheaded carp from this pool. Protocols and phone applications to effectively share real-time data are being developed. This study demonstrated that real-time GPS satellite tags can be used to monitor bigheaded carp in a riverine system. Tag modifications are being suggested to manufacturer to increase battery life and reduce the time needed to transmit. The tags have only been tested during the late fall when surfacing by bigheaded carp are presumed to be less frequent. Therefore, this spring and summer additional tags will be deployed to assess their performance during this period of more frequent surfacing by bigheaded carp.

d. *Lateral habitat use to inform removal:* Beginning in fall 2016, USGS and Southern Illinois University began a project to investigate the use of lateral habitats by bigheaded carps as well as the timing and environmental conditions that influence lateral habitat use. Stationary telemetry receivers were arranged during fall of 2016 to monitor movement among select lateral habitats and main channel habitat. Additional stationary receivers were added in spring 2017. All stationary receivers were range tested in the summer of 2017 to get individual receiver detection range and detection probability. Fifty acoustic telemetry transmitters were surgically implanted into bigheaded carps in April 2017 (distributed among lateral habitats). Water temperatures were monitored over the entire study via temperature loggers on a subset of the stationary receivers. To attempt to link lateral habitat use by bigheaded carps to environmental conditions, weekly measurements of temperature, discharge, dissolved oxygen, turbidity, blue-green algae, and chlorophyll *a* were measured in each lateral habitat (5 measurements/week) and the main channel (10 measurements/week) when conditions allowed from April 2017 through September 2017. The zooplankton was also sampled in each lateral habitat and the main channel once in June 2017 and once in August 2017. For 2018, the collection of data continues using the

passive acoustic telemetry array in place in Starved Rock Pool and data collection will continue through fall 2018.

2) Database and decision support tools:

   a. *MRWG database:* The MRWG database was transferred from the IL DNR to UMESC. In addition, we have completed structuring the database for small memory usage with fast queries. The database is connected to a web application which allows the upload of data directly to the database and is protected by authorized account logins (until the data can be made public). In addition, the web applications can query data in the database using filter criteria including fishing gear, pool name, and time period. The MRWG application includes report generation capabilities to, for example, summarize catch and catch per unit of effort data by date and pool. The reports include interactive graphics, for example, pie, stacked bar, line, and spatial. The MRWG application also includes an in-browser QAQC feature.

   b. *Decision support tool for bigheaded carp egg/larvae entrainment:* We completed modeling of the downstream movement of simulated egg plumes (using the leading edge, mean distance, and trailing edge results) under each flow scenario provided by the Central Midwest Water Science Center in Champaign, IL. These plume scenarios were run at various temperatures (spanning the known range of spawning temperatures for both species) for one particular spawning location (just below Marseilles Lock & Dam in this instance). We created a series of visualizations that show the modeled range of the egg plume in relation to the lock and dam locations where entrainment might occur.

   c. *Decision support tool based on adult bigheaded carp habitat:* Work on the Removal Decision Support Tool has focused on building of an online habitat modeling framework and data mining tool for previously published data. Data generated by the Upper Mississippi River Restoration Program's Long Term Resource Monitoring element and from Stainbrook et al. 2007 have been converted to Web Mapping Services format, added to the online framework, and updated to meet USGS metadata compliance. (Stainbrook, Karen M.; Dettmers, John M.; Trudeau, Thomas N. 2007. GIS data for predicting suitable Asian carp habitat in the Illinois waterway using geographic information systems. Champaign, IL: Illinois Natural History Survey)

   d. *Support MRWG contingency planning:* USGS participated in the MRWG Tabletop Exercise for the contingency response plans for the Illinois River in February of 2017.

MANAGE AND CONTROL PROJECTS

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, Barrier 2A, and Barrier 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 (approximately 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 in 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 Barrier 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 assess risk for the presence of Asian carp and clear fish as deemed necessary by the MRWG 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 Barrier 2A. This would allow fish present just downstream to move up to Barrier 2B. If Barrier 2A were to then come back online, those fish that moved below Barrier 2B would then be trapped between the barriers. If an outage is then experienced at Barrier 2B, the fish trapped between the barriers would then be able to move past into the area between Barrier 2B and the Demonstration Barrier or into upper Lockport pool if the Demonstration Barrier 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 Barrier 2B before maintenance operations are initiated at Barrier 2B or after maintenance is completed at Barrier 2A by collecting or driving fish into nets from the area with mechanical technologies (surface noise, surface pulsed-DC electrofishing and surface to bottom gill nets) or, if needed, a small-scale rotenone action.

(2) Assess fish assemblage <300 mm (12 inches) in total length between Barrier 2A and Barrier 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 Barrier 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.

Barrier Maintenance Fish Suppression

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.
- One 15 minute electrofishing run was 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 14 September 2017 and 27 September 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 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 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 of 2016 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.

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 2017 Barrier 2A was the primary barrier to fish passage in the upstream direction within the Electric Dispersal Barrier System. Barrier 2A experienced a loss of power in water at both arrays for an extended duration (minimum = 9 minutes; maximum = 17 days and 21 hours) a total of 11 times (Table 1). Barrier 2B was operational during each of Barrier 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 three 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.

The three monitoring actions performed at the Electric Dispersal Barrier System utilized either DC electrofishing or hydroacoustic sonar scans. The first monitoring responses were conducted by USFWS Wilmington sub-office. They completed a sonar scan between the barriers (September 14). Results from these scans indicated fish abundance was low between the barriers and no large fish were observed. USFWS completed another sonar scan of the area between the barriers on September 27, 2017. While these scans were not specifically requested by the MRWG it helped further assess the risk for fish presence between Barriers 2A and 2B following the outages in late August and early September. Results from these scans indicated no large fish and low abundance of small fish between Barriers 2A and 2B. The other monitoring response occurred November 27. USACE completed one 15 minute electrofishing run to help assess the risk for Asian carp presence. No fish were observed or captured.

In addition to the outages reported in the 2017 calendar year, USACE coordinated with the MRWG on a planned outage event at Barriers 2A and 2B in March and April of 2018. A concurrent shutdown of Barrier 2A and 2B was needed to support dive operations and inspection and replacement 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 November 21, 2017 to discuss the risk for Asian carp presence and the need for clearing actions. It was determined that USACE would complete a download of data from 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). USFWS will perform bi-weekly sonar scans 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.

Barrier Maintenance Fish Suppression

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	16-Jan-17	9h
IIA	21-Jan-17	6h
IIA	22-Jan-17	11h
IIA	23-Jan-17	6h
IIA	27-Jan-17	1h
IIA	24-Jul-17	9 min
IIA	11-Aug-17	22 min
IIA	14-Aug-17	24 d 16h
IIA	12-Dec-17	6 d 1 h 58 min
IIA	21-Dec-17	7h 27 min
IIA	22-Dec-17	17 d 21 h 10 min

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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Seth Love (Illinois Natural History Survey)

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

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 nine 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.

(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 2,056 miles (3,308.8km) of gill/trammel net, 20 miles (32.2km) of commercial seine, 162 pound net nights and 2,342 hoop net nights in the upper Illinois Waterway since 2010.
- A total of 88,159 Bighead Carp; 638,186 Silver Carp; and 4,558 Grass Carp were removed by contracted commercial fisherman from 2010-2017. The total weight of Asian carp removed was 3,078 tons.
- 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 10, 24 and 51 river miles downstream of the Electric Dispersal Barrier, respectively (Figure 1). 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*. As a result, 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, March – December 2016, and February – December 2017. 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).

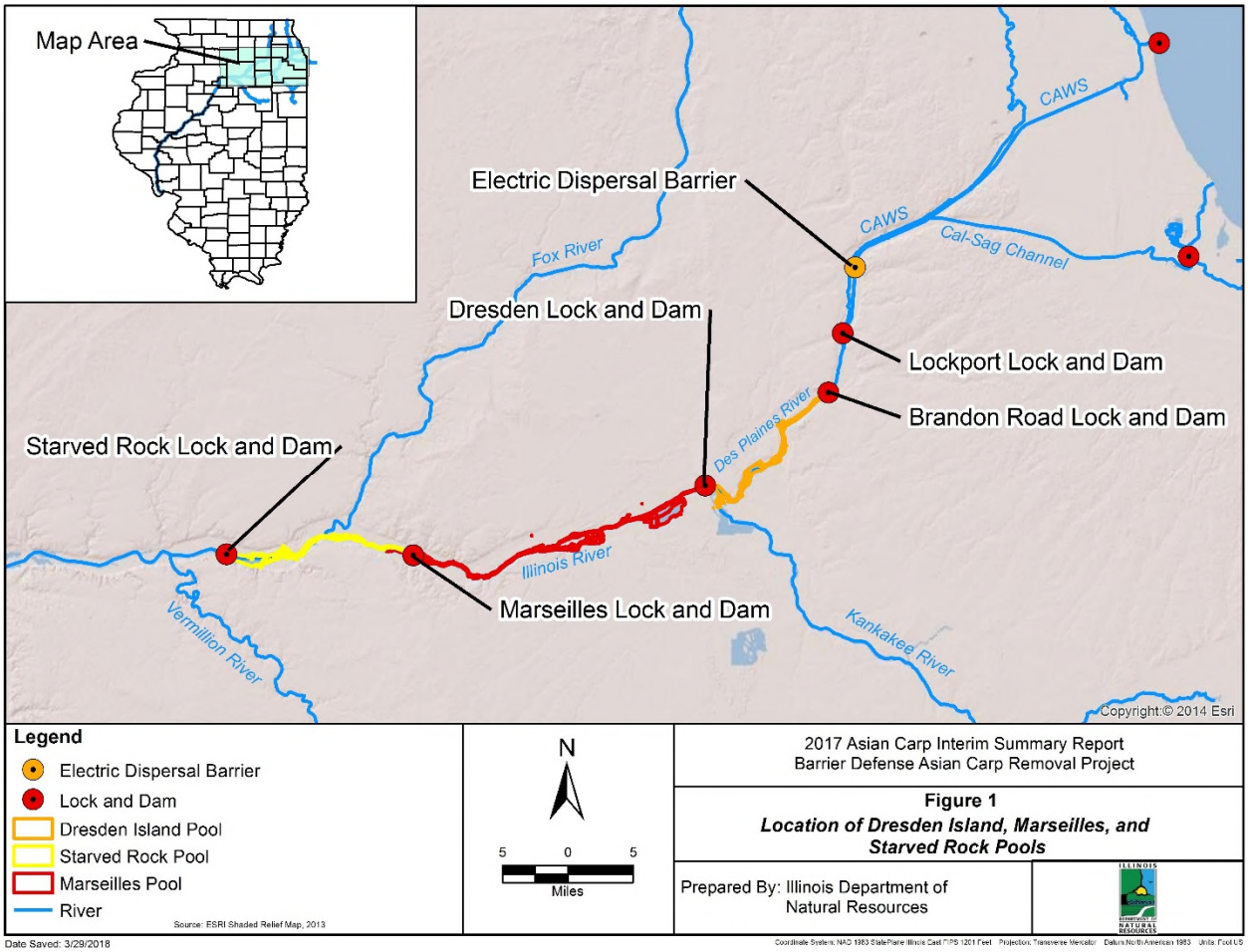

Figure 1. *Location of Barrier Defense downstream of the Electric Dispersal Barrier.*

Five to six commercial fishing crews per week fished four days of each scheduled week. Fishing weeks were scheduled to encompass 1-3 weeks during each month of 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 [63.5 -127 mm]) 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 [0.27-0.73 km] 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 utilized for non-consumptive purposes (e.g., converted to liquid fertilizer, chum, etc.). 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; 10,980 person-hours in 2016; and 10,463 person-hours in 2017 have been spent netting Asian carp during barrier defense removal efforts. A total of 2,056 miles (3,308.8 km) of gill/trammel net, 20 miles (32.2 km) of commercial seine, 162 pound net nights and 2,342 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 2010-2017 was 6,156,000 pounds (3,078 tons) (Table 1). Silver Carp, Bighead Carp, and Grass Carp accounted for 87.3%, 12.1%, and 0.6% of the total tons harvested since 2010, respectively.

The combined catch of Asian carp (Bighead Carp, Silver Carp, and Grass Carp) since 2010 was 730,903 individuals (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; 5.2% in 2016; and 1.6% in 2017. 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; 94.4% in 2016; and 97.7% in 2017. 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; 0.6% in 2015; 0.4% in 2016; and 0.7% in

2017. The total harvest of Asian carp from 2010-2017 consisted of 87.3% Silver Carp, 12.1% Bighead Carp, and 0.6% Grass Carp.

The annual gill/trammel catch per unit effort for Asian carp (CPUE; number of fish/1,000 yards of net) of all pools combined in 2017 was the highest to date at 338.3. CPUEs observed in other years include: 306.3 in 2016; 316.9 in 2015; 121.7 in 2014; 97.0 in 2013; 87.6 in 2012; and 86.9 in 2011. Monthly gill/trammel CPUE for all pools combined demonstrates an increasing trend since 2011 (Figure 2).

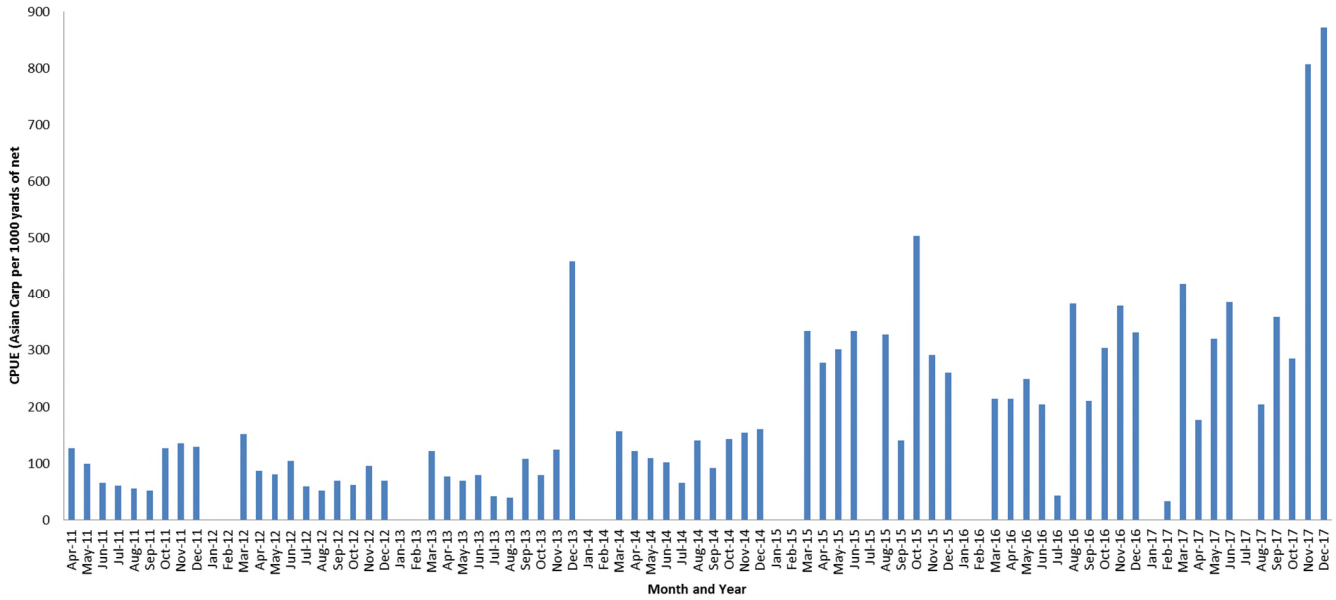

Figure 2. *Monthly catch per unit effort (CPUE; number of Asian carp per 1,000 yards of gill/trammel net) for all pools combined in 2011- 2017.*

Catch of Asian carp within Pools

Dresden Island Pool:

The Dresden Island Pool was not fished as part of the Barrier Defense Project in 2017 due to increased effort in the Fixed Site Monitoring Downstream of the Dispersal Barrier project. A total of 840 Asian carp (8.7 tons) were removed from the Dresden Island Pool (including Rock Run Rookery) by the Fixed Site Monitoring Downstream of the Dispersal Barrier project in 2017. 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 February through December in 2017. A total of 246,260 yards (225.2 km) of gill/trammel net, 2.8 miles (4.5 km) of commercial seine and 48.7 hoop net nights were deployed in 2017. A total of 41,775 Silver Carp; 1,486 Bighead Carp; and 51 Grass Carp were harvested in 2017 (Table 1). The commercial seine hauls yielded 1,248 Silver Carp and 47 Bighead Carp. Hoop nets caught 295 Silver Carp and 27 Bighead Carp. Silver Carp dominated the catch in 2017 (96.5%), 2016 (91.2%), 2015

(92.6%), 2014(78.2%), and 2013 (58.5%). Prior to 2013, Bighead Carp was the dominant species caught in the Marseilles Pool (Table 1). The annual CPUE of Asian carp from gill/trammel nets in Marseilles Pool was 166 Asian carp per 1,000 yards of net. Monthly gill/trammel CPUE for Asian carp captured in Marseilles Pool from 2014-2017 can be found in Figure 3.

Starved Rock Pool:

Commercial fisherman removed Asian carp in Starved Rock Pool from March through December in 2017. A total of 200,200 yards (183.1 km) of gill/trammel net, 1.3 miles (2.1km) of commercial seine, and 938.6 hoop net nights were deployed in 2017. A total of 121,264 Silver Carp; 1,151 Bighead Carp; and 1,128 Grass Carp were harvested in 2017 (Table 1). Hoop nets accounted for 13,308 Silver Carp; 95 Bighead Carp; and 28 Grass Carp in 2017. Silver Carp were the dominant species harvested in 2017 (98.2%). 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. The CPUE decreased in 2014 to 205.6, then increased to 441.5 in 2015, 476.1 in 2016, and 549.8 in 2017. Monthly gill/trammel CPUE for Asian carp captured in Starved Rock Pool from 2014-2017 can be found in Figure 3.

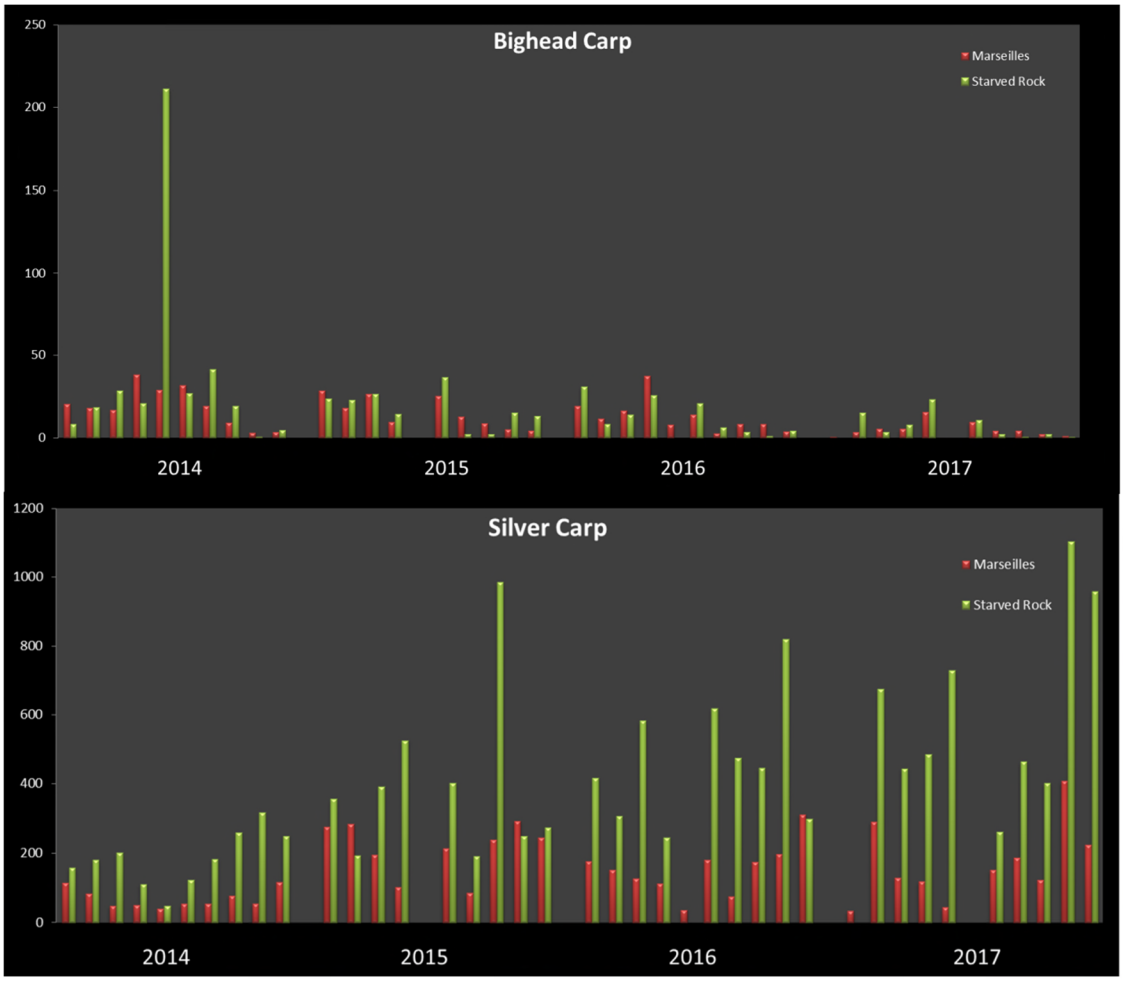

Figure 3. *Yearly trends in Catch per unit effort (CPUE; Asian carp/1000 yards of gill/trammel net) in 2013-2016.*

Catch of Bycatch Species

Gill and Trammel nets:

A total of 181,048 fish representing 35 species and 2 hybrid groups were caught in gill\trammel nets during the 2017 Asian carp removal effort (Table 2). Asian carp (Bighead Carp, Silver Carp, and Grass Carp) made up 82.8% of the catch while *Ictiobus* spp. (Bigmouth Buffalo, Smallmouth Buffalo, and Black Buffalo) along with Common Carp made up an additional 15.4% of the total catch. A total of 638 fish from 10 species and 1 hybrid species made up the game fish species captured in 2017. Game fish represented 0.4 % of the total catch in 2017. Similar to previous years, Flathead, Blue, and Channel Catfish were the most dominant game fish species captured in 2017 accounting for 83.9 % of the game fish captured.

Hoop Nets:

A total of 15,826 fish representing 17 species were caught in hoop nets in 2017. Asian carp (Bighead Carp, Silver Carp, and Grass Carp) made up 86.9% of the catch while Flathead and Channel Catfish made up an additional 5.4% of the total catch.

Commercial Seine:

A total of 8,598 fish representing 17 species were caught in commercial seines in 2017. Asian carp (Bighead Carp, Silver Carp, and Grass Carp) made up 15.5% of the catch while Freshwater Drum made up an additional 30.3% of the total catch. Game fish represented 9.9% of the catch with *Moronidae* spp. making up 31.1% of the game fish captured.

Great Lakes Pound Net:

A total of 11,931 fish representing 28 species were caught in pound nets in 2017. Asian carp (Bighead Carp, Silver Carp) made up 5.4% of the catch, while Freshwater drum made up an additional 53.1%. Game fish represented 13.2% of the catch with *Moronidae* spp. making up 60.5% of the game fish captured.

Recommendation:

We recommend increased Asian carp removal in the upper Illinois Waterway to reduce Asian 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 Marseilles and Starved Rock pools during 2010-2017 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	235.6	2	0.9			13,962	11,018	160	25,140	126.07	64.39	0.67	191.13
Starved Rock	198	67.3					3,994	20,589	243	24,826	22.42	99.98	1.39	123.79
All pools	797	302.9	2	0.9			17,956	31,607	403	49,966	148.49	164.37	2.06	314.92
2013														
Marseilles	457	237.8	2	0.9			7,742	11,633	378	19,753	74.05	59.38	2.67	136.10
Starved Rock	236	104.07					3,938	38,666	369	42,973	21.93	1.97	168.14	192.04
All pools	693	341.87	2	0.9			11,680	50,299	747	62,726	95.98	61.35	170.81	328.14
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	236.00	1.23	276.13
Starved Rock	225	78.3	4	0.53	141.2		2,908	68,681	641	72,230	13.20	198.10	3.64	214.94
All Pools	645	219.5	18	2.15	163.7	24	8206	137,485	857	146,548	52.10	434.10	4.86	491.06
2016														
Marseilles	553	203.1	37	8.1	85.7	64	5,924	62,490	76	68,490	46.86	251.30	0.43	298.59
Starved Rock	291	88.3	14	2.1	683.1		2,048	83,790	606	86,444	9.60	232.03	3.44	245.06
All Pools	844	291.434	51	10.2	768.8	64	7,972	146,280	682	154,934	56.46	483.33	3.87	543.65
2017														
Marseilles	488	139.9	12	2.8	48.7	74	1,486	41,775	51	43,312	13.56	176.70	0.29	190.55
Starved Rock	442	113.7	3	1.3	938.6		1,151	121,264	1,128	123,543	4.80	361.09	6.40	372.28
All Pools	930	253.7	15	4.1	987.3	74	2,637	163,039	1,179	166,855	18.36	537.78	6.69	562.83
2010-2017														
Marseilles	5,631	1,468	70	15	157	162	66,936	231,334	1,023	299,293	651	954	5	1,611
Starved Rock	1,894	587	22	4	2,185		21,223	406,852	3,535	431,610	113	1,169	184	1,467
All pools	7,525	2,056	92	20	2,342	162	88,159	638,186	4,558	730,903	764	2,123	190	3,078

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 2011-2017. All species other than Asian carp and Common Carp were returned to the river immediately after capture.*

	2011		2012		2013		2014		2015		2016		2017	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Species	Captured	%	Captured	%	Captured	%	Captured	%	Captured	%	Captured	%	Captured	%
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%	2,402	1.33%
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%	147,472	81.45%
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%	22,349	12.34%
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%	3,292	1.82%
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%	2,119	1.17%
Grass Carp	171	0.32%	299	0.51%	303	0.40%	524	0.55%	823	0.53%	681	0.31%	1,150	0.64%
Freshwater Drum	573	1.08%	689	1.18%	1,055	1.40%	1,091	1.15%	1,510	0.97%	11,685	5.31%	736	0.41%
River Carpsucker	61	0.12%	26	0.04%	105	0.14%	229	0.24%	467	0.30%	2,028	0.92%	616	0.34%
Channel Catfish	201	0.38%	137	0.23%	321	0.43%	430	0.45%	616	0.40%	1,679	0.76%	307	0.17%
Flathead Catfish	313	0.59%	299	0.51%	417	0.55%	301	0.32%	233	0.15%	331	0.15%	225	0.12%
Black Buffalo	188	0.36%	262	0.45%	432	0.57%	318	0.33%	133	0.09%	81	0.04%	110	0.06%
Largemouth Bass	28	0.05%	22	0.04%	28	0.04%	26	0.03%	34	0.02%	61	0.03%	33	0.02%
Silver Redhorse							1	< 0.01%	3	0.00%	8	<0.01%	33	0.02%
Quillback	37	0.07%	46	0.08%	49	0.07%	84	0.09%	134	0.09%	497	0.23%	31	0.02%
Walleye	9	0.02%	12	0.02%	7	0.01%	5	0.01%	15	0.01%	35	0.02%	25	0.01%
Longnose Gar	11	0.02%	25	0.04%	68	0.09%	91	0.10%	40	0.03%	110	0.05%	23	0.01%
Shortnose Gar	16	0.03%	37	0.06%	44	0.06%	13	0.01%	29	0.02%	36	0.02%	15	0.01%
Golden Redhorse			2	< 0.01%	6	0.01%	30	0.03%	5	< 0.01%	30	0.01%	14	0.01%
Sauger	19	0.04%	31	0.05%	12	0.02%	11	0.01%	31	0.02%	65	0.03%	13	0.01%
White Bass	13	0.02%	11	0.02%	40	0.05%	23	0.02%	14	0.01%	505	0.23%	13	0.01%
Gizzard Shad	6	0.01%	22	0.04%	5	0.01%	3	< 0.01%	4	< 0.01%	2,193	1.00%	12	0.01%
Paddlefish	78	0.15%	51	0.09%	37	0.05%	37	0.04%	31	0.02%	27	0.01%	9	<0.01%
Shorthead Redhorse		< 0.01%	1	< 0.01%			4	< 0.01%	1	< 0.01%	15	0.01%	9	<0.01%
White Crappie	1	< 0.01%	2	< 0.01%	1	< 0.01%	4	< 0.01%	7	< 0.01%	65	0.03%	8	<0.01%
Blue sucker													5	<0.01%
Black Crappie	1	< 0.01%	1	< 0.01%	2	< 0.01%	4	< 0.01%	7	< 0.01%	133	0.06%	4	<0.01%
Northern Pike	1	< 0.01%	1	< 0.01%	2	< 0.01%			1	< 0.01%	5	<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%	3	<0.01%
Hybrid Striped Bass	2	< 0.01%	7	0.01%	2	< 0.01%	5	0.01%	12	0.01%	12	0.01%	3	<0.01%
Yellow Bass	3	0.01%	5	0.01%	9	0.01%	9	0.01%	4	< 0.01%	157	0.07%	3	<0.01%
Common Carp x Gold	1	< 0.01%	4	0.01%	2	< 0.01%					2	<0.01%	2	<0.01%
Highfin Carpsucker											2	<0.01%	2	<0.01%
Skipjack Herring	9	0.02%	14	0.02%			6	0.01%	6	< 0.01%	39	0.02%	2	<0.01%
Alligator Gar													1	<0.01%
Bowfin					4	0.01%			3	< 0.01%	5	<0.01%	1	<0.01%
Greater redhorse													1	<0.01%
Mooneye			6	0.01%	3	< 0.01%	1	< 0.01%	8	0.01%	3	<0.01%	1	<0.01%
American Brook Lamprey											1	<0.01%		
Black Bullhead											2	<0.01%		
Bluegill			1	< 0.01%			1	< 0.01%	1	< 0.01%	10	<0.01%		
Gizzard Shad < 6 in											375	0.17%		
Goldeye	1	< 0.01%							3	< 0.01%				
Goldfish					20	0.03%			2	< 0.01%				
Green Sunfish x Bluegill Hybrid											8	<0.01%		
Muskellunge	1	< 0.01%			2	< 0.01%	1	< 0.01%	2	< 0.01%				
River Redhorse	1	< 0.01%					1	< 0.01%	1	< 0.01%	4	<0.01%		
Rock Bass			1	< 0.01%										
Smallmouth bass											11	0.01%		
Unidentified Buffalo Species					137	0.18%					3,446	1.57%		
Unidentified Carpsucker											470	0.21%		
Unidentified Catostomidae											2,062	0.94%		
Unidentified Moronidae											865	0.39%		
White Perch					1	< 0.01%					4	<0.01%		
White Sucker											1	<0.01%		
Total All Species	52,924		58,391		75,145		95,268		155,896		219,936		181,048	

Barrier Defense Using Novel Gear

Josey Ridgway and Emily Pherigo (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)

Introduction and Need:

Barrier Defense was initiated in 2010 to reduce the number of Asian carp downstream of the Electric Dispersal Barrier and thereby decrease risk of invasion into the Great Lakes (Bushman et al. 2015 [ISR]). In 2015, the Columbia Fish and Wildlife Conservation Office (FWCO) tested the efficacy of a variety of novel trawls including an electrified butterfly frame-trawl (paupier) in removing Asian carp from the upper and lower Illinois River (Doyle et. al 2015 [ISR]). Those results indicated that the paupier was effective in catching a wide range of Asian carp sizes (24 – 1,000 mm) from a variety of habitats, including those with flowing water which are traditionally difficult to sample. The paupier was officially incorporated into Barrier Defense in 2016 and complemented the effort by removing >11,000 Silver Carp ranging from 183 to 850 mm (Ridgway et al. 2016 [ISR]). In 2017, the paupier continued to be used in mass removal efforts and as part of a study investigating an optimal time period (season and time of day) to catch Asian carp. These two objectives had distinct protocols and goals and are therefore presented independently.

Objectives:

(1) Support ILDNR coordinated Barrier Defense to remove adult and juvenile Asian carp from the upper Illinois River with the paupier.

(2) Increase paupier harvest by assessing and addressing efficiency limitations.

(3) Determine optimal period (time of day and season) for Asian carp capture to inform future Barrier Defense efforts with the paupier.

Project Highlights:

- A total of 30,162 Asian carp (80.88 tons) were removed in 2016 and 2017 at a rate of 1.7 tons/day and 4.8 tons/day, respectively. The rise in harvest efficiency is likely due to increased payload capacity and mechanical improvements implemented in 2017.
- Asian carp comprised 91% of species captured by paupier in 2016–2017.
- In standardized paupier sampling, Silver Carp catch rates in Hanson Material Services East Pit were higher at night and in the summer season. These patterns were not observed in Hanson Material Services West Pit (a backwater with low connectivity and high exploitation pressure).

Barrier Defense Using Novel Gear

PART 1: ASIAN CARP MASS REMOVAL

Background:

The Columbia FWCO has deployed the paupier to remove several tons of invasive carp from the upper Illinois River to assist efforts to alleviate propagule pressure to the Electric Dispersal Barrier. Paupier field operations are continuously assessed and adapted to increase daily removal of Asian carp and further evaluate the optimal settings and timeframe for mass removal efforts using the paupier.

Objectives:

(1) Support ILDNR coordinated Barrier Defense to remove adult and juvenile Asian carp from the upper Illinois River with the paupier.

(2) Increase paupier harvest by assessing and addressing efficiency limitations.

Methods:

Gear, 2016–2017

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. Anodes were powered with a 72-amp or 82-amp ETS box. Anode droppers were affixed to booms 3 – 4 m in front of the frames. In addition, a hemisphere anode was suspended in each paupier frame approximately 1 m back from the net opening (Figure 1). The frames act as the cathodes, concentrating the electric field between the boom anodes, the frame, and the hemisphere anodes inside the net. The boom anodes initially immobilize fish to drift in the net and the hemisphere anodes maintain captured fish. Duty cycle and frequency (pulses/second) were 15% and 30 hertz, respectively. Power output was adjusted based on ambient conductivity and observed immobilization of Silver Carp.

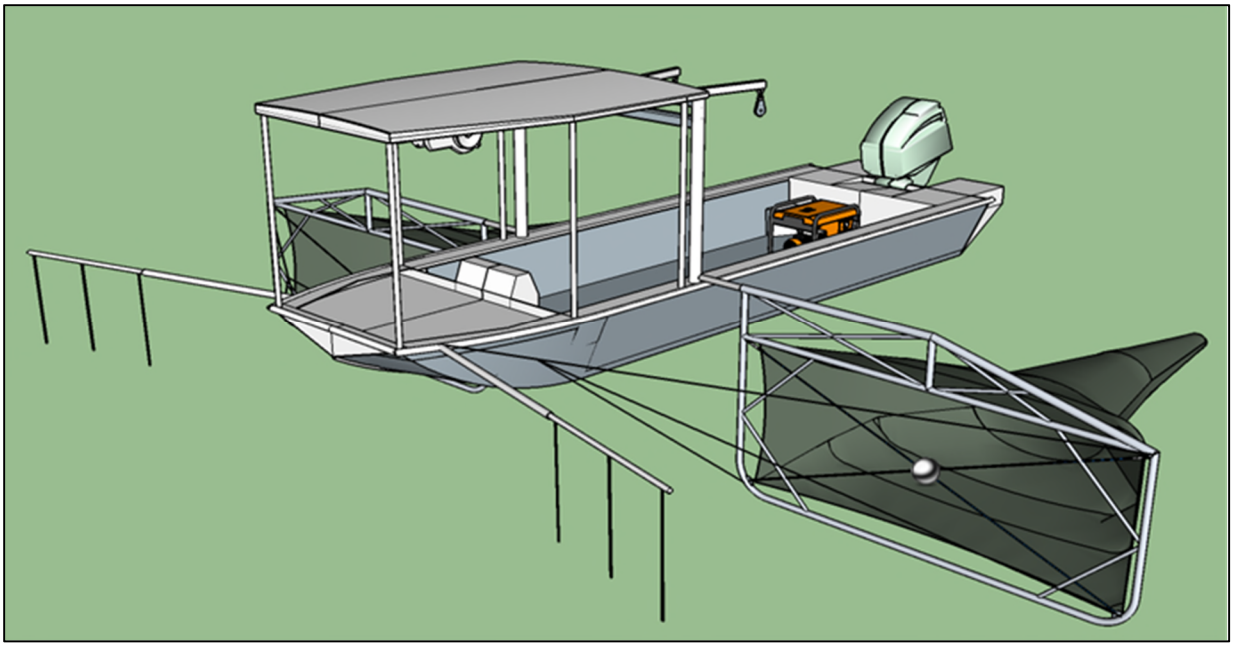

Figure 1. *Electrified paupier boat illustration used in Barrier Defense depicting booms attached to each corner of the bow with cable dropper anodes, a hemisphere anode visible in the port-side frame, and conical nets.*

Data Collection, 2016

In 2016, mass removal efforts took place in the Marseilles Pool in September (1/4 of a day, summer), and in the Starved Rock Pool in May (5 days, spring), June (2 days, summer), August (2 days, summer), September (1.75 days, summer), October (2 days, fall), and November (3 days, fall). Crews consisted of 3 – 4 staff and one paupier boat. Using commercially available fish finders (i.e., Humminbird 1100 Series, and Humminbird 360ssi) and local knowledge, aggregations of Asian carp were located in a variety of habitat types (slack or backwater and flowing habitats) and targeted during variable length transects. Transects were 2 to 20 minutes depending on habitat availability or net capacity. Asian carp were held and transported in the paupier boat to the processing-disposal station. Payload capacity was 2 tons.

Data Collection, 2017

In 2017, mass removal efforts took place in August (3 days, summer), September (3 days, summer), October (2 days, fall), and November (3 days, fall) in the Starved Rock Pool of the upper Illinois River (Figure 2). Since flowing habitats had less bycatch and higher percent Silver Carp catch compared to backwaters (Ridgway et al 2016 [ISR]), Asian carp aggregations were located in flowing habitats (i.e., tributary, side channel, and channel borders) using commercially available fish finders (i.e., Humminbird 1100 Series, and Humminbird 360ssi) and targeted during variable length transects. Transects were 2 to 20 minutes depending on habitat availability or net capacity.

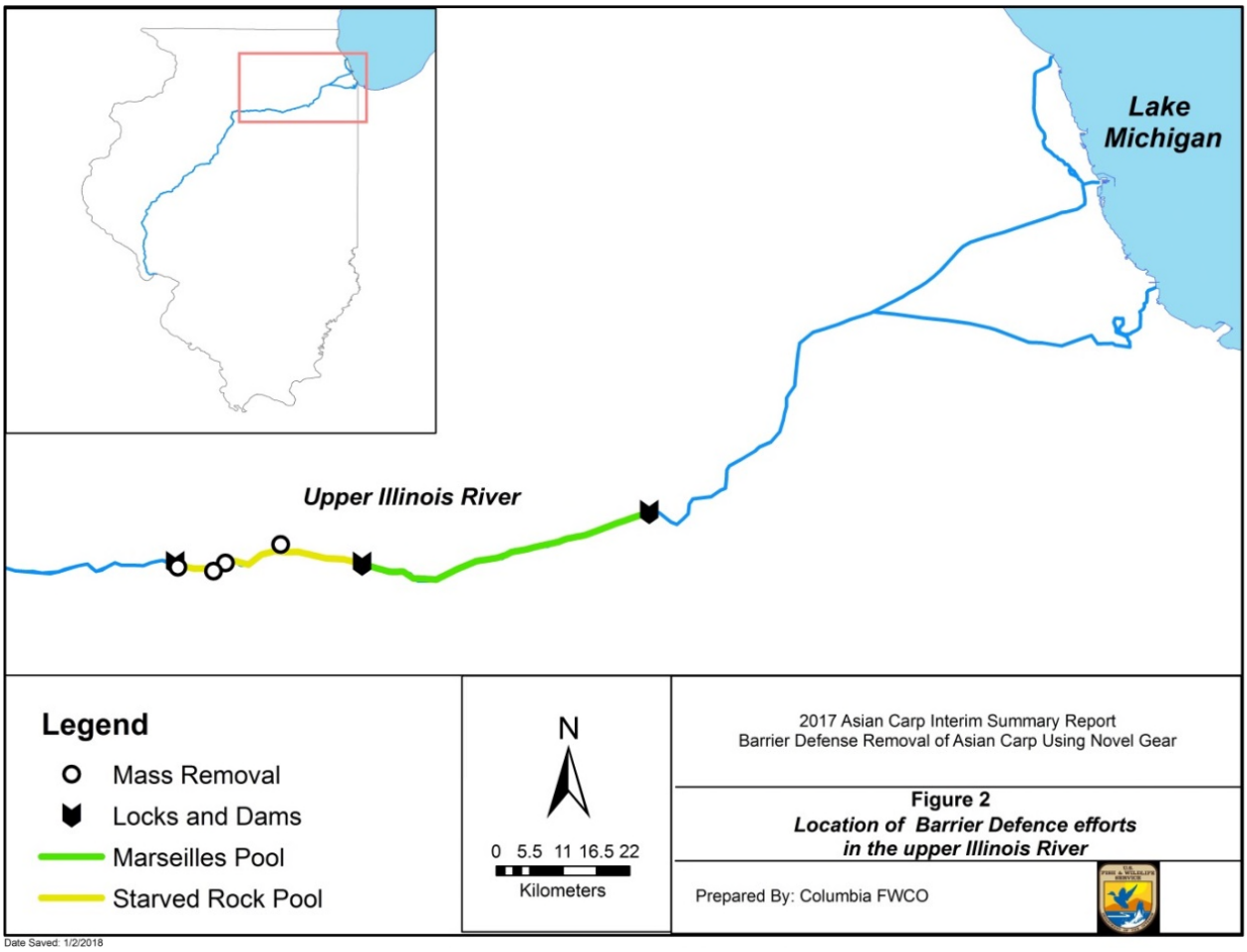

Figure 2. *Targeted locations during Barrier Defense using the electrified paupier in the Starved Rock Pool of the upper Illinois River, 2017.*

Mechanized winches, a tender boat, and a fish hauling trailer were added in 2017 (Figure 3). The winches lifted paupier nets with heavy loads of Asian carp into a tender boat, an all welded aluminum john boat, measuring 7.3 m long, 183 cm wide at floor width, and 63.5 cm deep. Native fish were identified to species, enumerated, and immediately released. When the tender boat was full, Asian carp were transported to a trailer with large plastic totes (1.1 m by 1.2 m by 0.9 m) stationed at the nearest boat ramp. At that time, all Asian carp were enumerated by species, and Silver Carp were distributed evenly into totes throughout the day. While the tender boat offloaded carp into the trailer, the paupier crew continued to fish, loading and processing catches. At the end of a day's effort, Asian carp were hauled to the ILDNR processing-disposal station. Total payload capacity was 9 tons (trailer = 5 tons; tender boat = 2 tons; paupier = 2 tons). At the processing-disposal station, total length (mm) and weight (g) were collected for a 10% subsample of Silver Carp selected at random and for all Bighead and Grass carp to assess size structure and calculate biomass.

Figure 3. *(1) Mechanized winches on the paupier, (2) a tender boat, and (3) a hauling trailer with totes were used in Barrier Defense operations in the Starved Rock Pool of the upper Illinois River, 2017.*

In an effort to identify variables that could be improved to potentially increase harvest, time expended during paupier field operations was logged. Field operation time started when the paupier launched from the trailer and stopped when the paupier returned to the boat ramp at the end of the day. Operational components included set-up/takedown, electrotrawl, emptying nets, next deployment, gear repair, health breaks, and travel and communications (Table 1).

Table 1. *Timed components of paupier operations used in Barrier Defense in the Starved Rock and Marseilles pools of the upper Illinois River, 2017.*

Operational Components	Description
Set-up/Takedown	Paupier set-up and takedown at start and end of removal: three people connecting the electrofishing box to the generator, attaching anodes, and bridling net frames
Electrotrawl	Active electrotrawling
Emptying Nets	Period between electrotrawl and when nets are emptied and loaded onto tender boat
Next Deployment	Typically takes five minutes to align paupier on next transect, therefore five minutes were assumed between each deployment
Gear Repair	Mending torn nets and troubleshooting generator and electrofishing box
Health Breaks	Time given for crew to refresh
Travel and Communications	Boat travel from site to site and crew communications.

Results and Discussion:

Paupier Summary, 2016–2017

Sixteen days and 290 labor-hours were expended in 2016 and 11 days and 392 labor hours were expended in 2017 targeting and removing Asian carp with the paupier during Barrier Defense efforts (Table 2). Nearly 30 hours of electrotrawling were deployed in the Starved Rock and Marseilles pools since 2016 (Table 2). The weight of Asian carp removed in those efforts totaled 161,760 lbs (80.88 tons; Table 2). Silver Carp, Bighead Carp, and Grass Carp accounted for > 99.999%, < 0.001%, and < 0.001% of the total tons of Asian carp harvested since 2016, respectively.

Table 2. *Summary of electrified paupier effort and Asian carp captured during Barrier Defense in the Starved Rock (SR) and Marseilles (MA) pools of the upper Illinois River, 2016–2017. Labor-hour was defined as crew-time spent on the water targeting Asian carp.*

	Effort			Harvest						
Year and Pool	Days (*N*)	Electrotrawl Hours	Labor Hours*	Bighead Carp (*N*)	Silver Carp (*N*)	Grass Carp (*N*)	Bighead Carp (tons)	Silver Carp (tons)	Grass Carp (tons)	Total Asian Carp (tons)
2016										
Marseilles	0.25	0.4	4.0		28			0.10		0.10
Starved Rock	15.75	15.4	286.0	17	11,075	8	0.05	27.85	0.03	27.93
2017										
Starved Rock	11.00	14.0	392.2	2	19,116	6	0.01	52.80	0.03	52.84

*Daily crew size in 2016 was 3 or 4 people, while in 2017 was 6 people.

Paupier Efficiency, 2016–2017

Silver Carp catch rate was 707 Silver Carp per electrotrawl hour in 2016 and 1,369 Silver Carp per electrotrawl hour in 2017. Silver Carp were harvested at a rate of 193 pounds per labor hour in 2016 and 269 pounds per labor hour in 2017. In terms of daily removal, Silver Carp were harvested at a rate of 1.7 tons/day in 2016 and 4.8 tons/day in 2017. Many factors may have contributed to increased daily harvest; however, the addition of a tender boat and crew, mechanical improvements, and fish hauling trailer were likely major factors. With only the paupier in 2016, payload capacity was limited to 2 tons per day. Thus when catch rates were high and the paupier reached capacity, removal halted for the day. In contrast, payload capacity in 2017 was 9 tons per day allowing for more harvest. In addition to increased capacity, the tender boat crew processed catches (removing bycatch and loading Asian carp into the hauling trailer) which allowed for more electrotrawling time. Additionally, improvements in mechanical winches reduced crew fatigue and the physical stress of handling several tons of carp.

Paupier Catch, 2017

Asian carp (Silver Carp, Bighead Carp, Grass Carp) accounted for 91% of fish captured. Non-targeted fish included suckers (buffalofishes, carpsuckers, redhorses, hogsuckers [5%]), Gizzard Shad (3%), sport fish (catfishes, temperate basses, Walleye, Sauger, black basses, [< 1%]), and other species (Bowfin, Common Carp, Emerald Shiner, Freshwater Drum, mooneyes [1%]).

Silver Carp total length ranged from 444 to 828 mm (n = 2,042; mean = 602 mm; SE = 1.009; Figure 5) with few Silver Carp measuring < 500 mm. The two Bighead Carp captured were 644 and 827 mm in total length. Grass Carp total length ranged from 668 to 811 mm (n = 5; mean = 736; SE = 26.583).

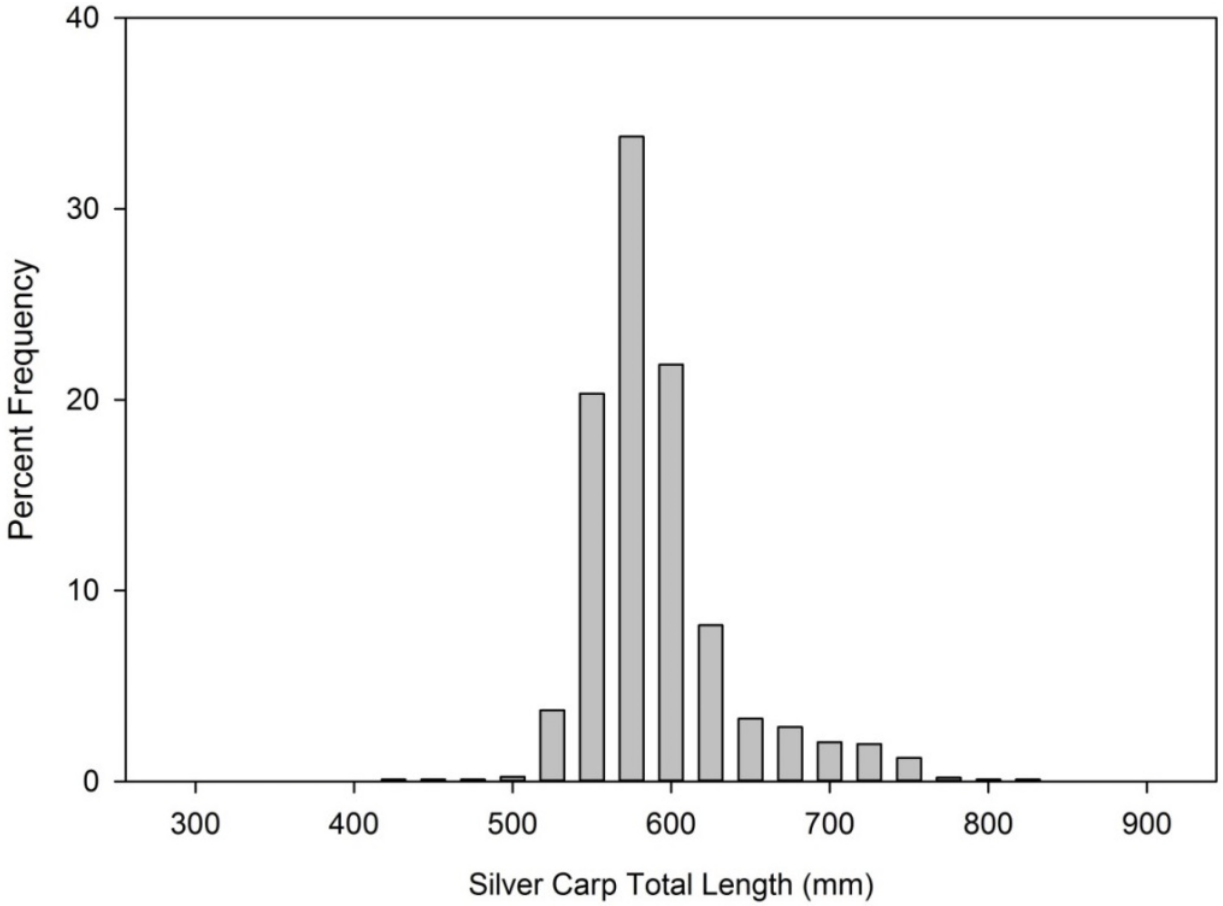

Figure 5. *Length frequency histogram of Silver Carp subsample (n = 2,042) captured with electrified paupier during Barrier Defense in the Starved Rock Pool of the upper Illinois River, 2017.*

Paupier Operation Components, 2017

In 11 days, a total of 65.3 hours were expended on the water targeting Asian carp. Over 20% of that time was spent electrotrawling (Figure 4). However, the time spent emptying the paupier nets accounted for the largest component of field operations (> 25%) as loads up to 900 Silver Carp (sum of both port and starboard nets) are fundamentally heavy and time-consuming to handle. Setting-gear in the morning and taking it down in the afternoon, making minor repairs, and health breaks each accounted for less than 10% of field operations (Figure 4). Minor mechanical and net adjustments could further reduce time expended handling fish and reallocate more time towards electrotrawling and catching Asian carp. Travel and communications accounted for 20% of time spent in the field (Figure 4) which may be addressed with crew experience and improved methods of targeting carp aggregations (knowledge gained, hydroacoustics, telemetry, and/or fish finders).

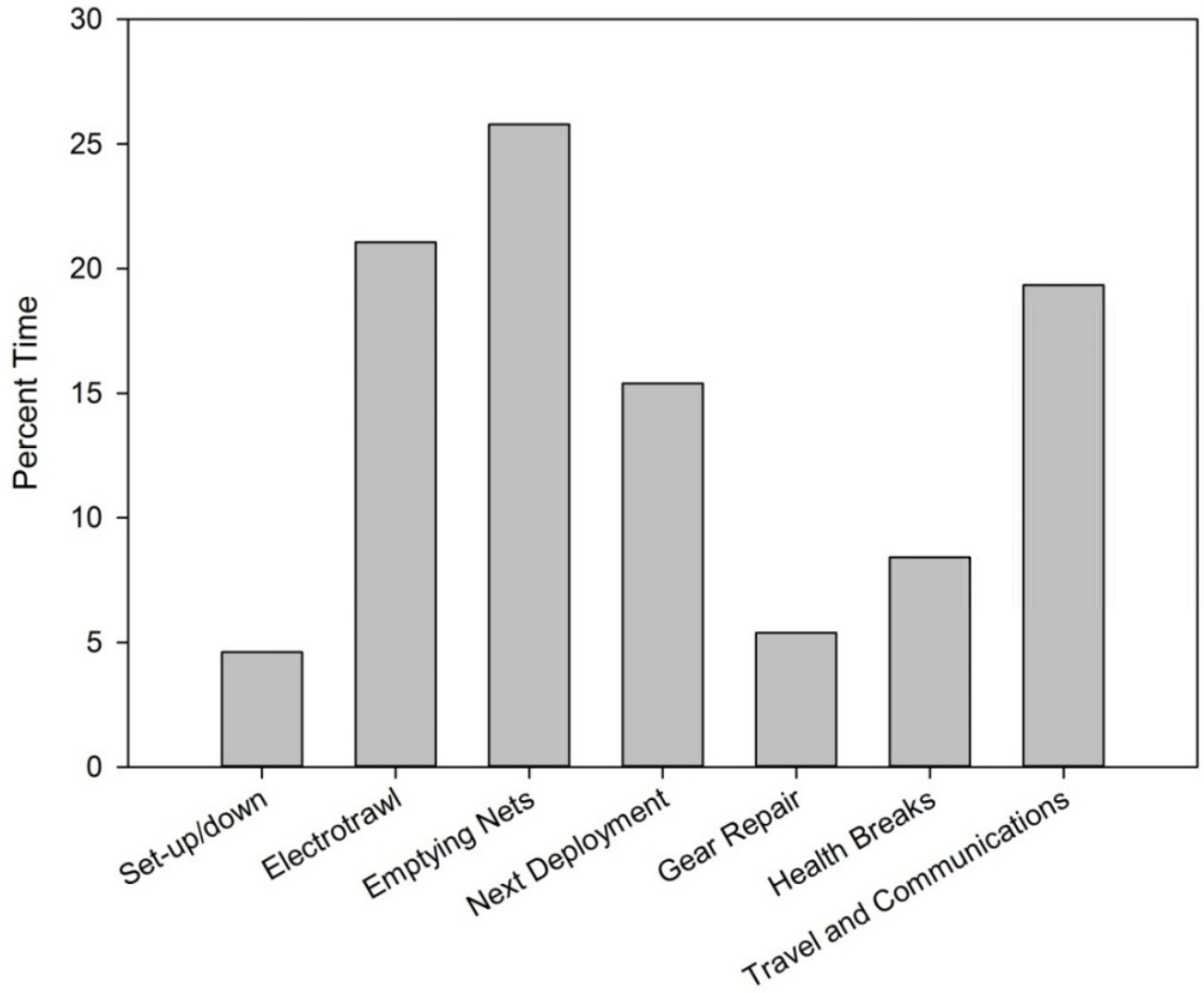

Figure 4. *Percent of total time (65.3 hours) spent on Barrier Defense operation components in the Starved Rock Pool of the upper Illinois River, 2017.*

PART 2: NIGHTTIME SAMPLING STUDY

Background:

Nighttime sampling has the potential to increase Asian carp capture efficiency and harvest with surface trawling gears such as the paupier. Telemetered Bighead Carp in the Illinois River frequented the water's surface at higher rates during nighttime hours (J. Lamar, University of Western Illinois, Macomb, IL, personal communication). Additionally, Silver Carp catch rates with the paupier were drastically higher during nighttime electrotrawling on Kentucky Lake (J. Hammen, US Fish and Wildlife Service, Columbia MO, unpubl. data).

In an effort to determine if these observations could increase removals through future Barrier Defense efforts, the paupier was deployed in Hanson Material Services (Hanson Material Services) East and West pits during nighttime periods and Silver Carp catch rates were assessed by time of day (daytime and nighttime) and seasons (spring, summer, and fall), 2017.

Barrier Defense Using Novel Gear

Objective:

(1) Determine optimal period (time of day and season) for adult Asian carp capture to inform future Barrier Defense efforts with the paupier.

Methods:

Data Collection

Paupier frames were fitted with nets (3/4 inch bar mesh body and cod) able to capture young-of-year Asian carp if present. Sampling was conducted in two backwater lakes (Hanson Material Services East and West pits) in the Marseilles Pool of the Illinois River (**Figure 6**). One week each in May (spring), August (summer), and November (fall) were sampled to test seasonal influences. Five minute transects were conducted in the three hours before and the five hours after sunset to test daytime influences. Transect location and direction were random, generated using ArcGIS.

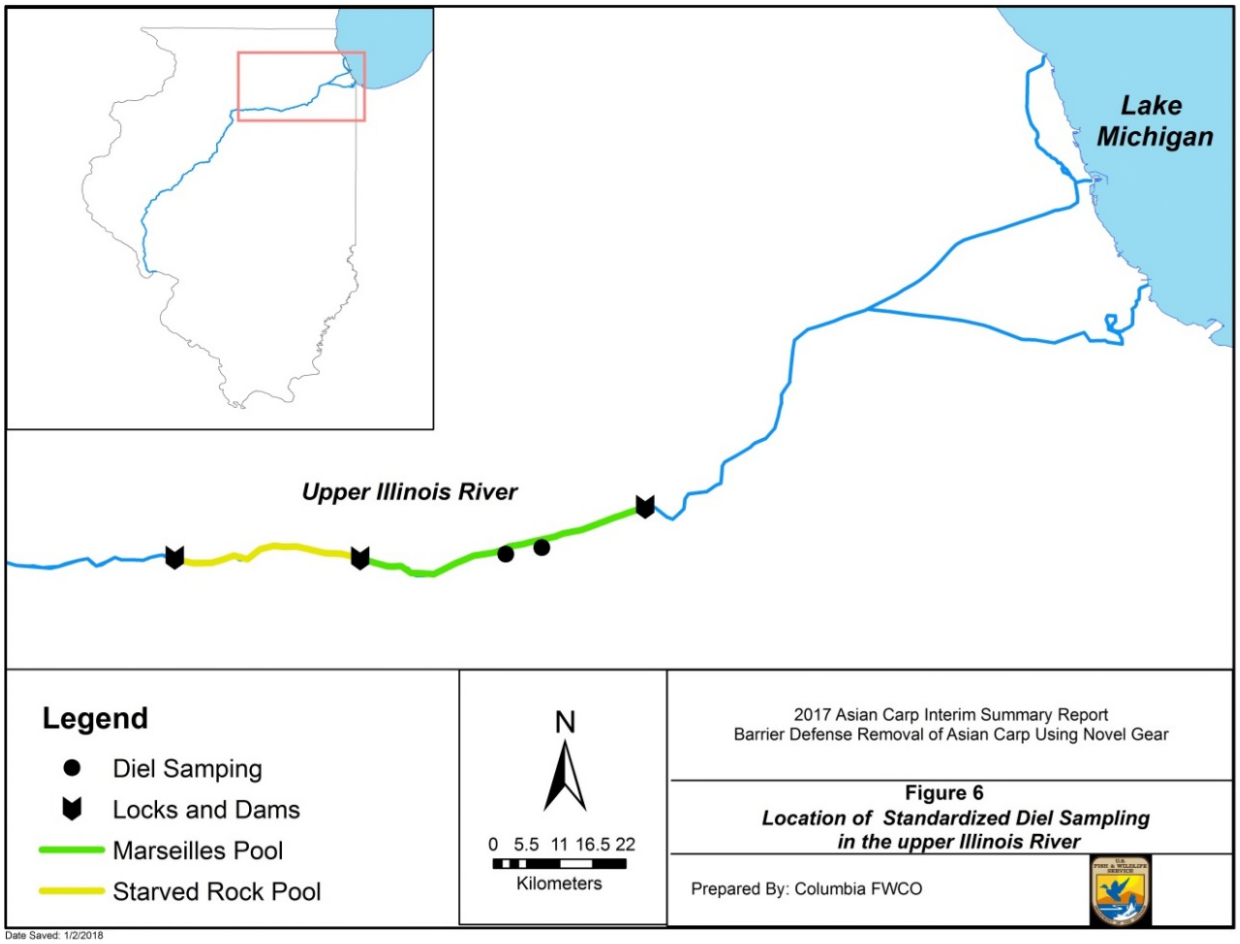

Figure 6. *Sample locations for a nighttime sampling study using the electrified paupier in the Hanson Material Services [Hanson Material Services] East and West pits of the Marseilles pool in the upper Illinois River, 2017.*

Data Analysis

Catch rates were calculated as the number of Silver Carp per 5 minute transect, and $\log_{10}$ transformed to meet the assumption of normality. A two-way analysis of variance (ANOVA) was used to determine seasonal (i.e., spring, summer, fall) and time of day (day or night) effects on catch rates. Hanson Material Services East and West pits were tested seperately to avoid site effects. Statistical tests were declared significant at $\alpha = 0.05$.

Results and Discussion:

The interaction of time of day and season was not significant in Hanson Material Services East pit or West pit (Two Way ANOVA; $P > 0.330$). Therefore, we analyzed main effects (time of day and season) independently. In Hanson Material Services East Pit, Silver Carp catch rates were higher at night compared to day (Two Way ANOVA; $P = 0.031$; Figure 7, panel 1). Additionally, catch rates were different among seasons (Two Way ANOVA; $P < 0.001$; Figure 7, panel 2) with Silver Carp catch rates highest in summer (Holm-Sidak method; $P < 0.001$), and similar in spring and fall (Holm-Sidak method; $P = 0.566$; Figure 7, panel 2). In Hanson Material Services West Pit, where the unified method removed several tons of Silver Carp in March 2017 (refer to Unified Method ISR) and connectivity with mainstem Illinois River is reduced, Silver Carp catch rates were not statistically different between day and night (Two Way ANOVA; $P = 0.327$) or among seasons (Two Way ANOVA; $P = 0.063$; Figure 7, panels 3 and 4). Overall, catch rates in Hanson Material Services West Pit were low— nearly half (46%) of the samples captured zero Silver Carp. Although the reason is unclear, these findings may indicate Silver Carp populations exhibit different daily and seasonal behaviors depending on exploitation pressure, connection to the mainstem river, and/or population density.

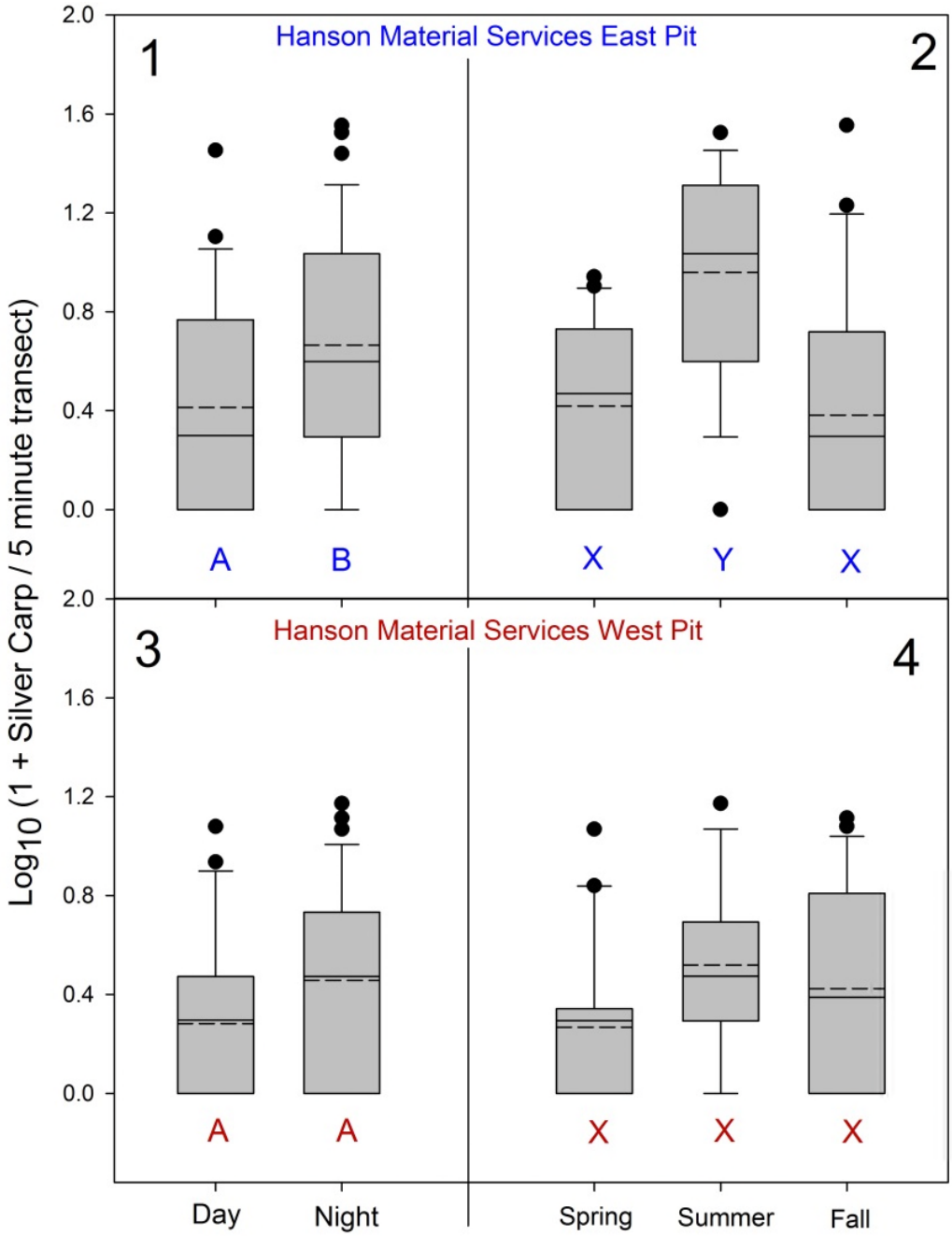

Figure 7. *Silver Carp catch per five minute transects (log_{10} transformed) compared between day and night and among seasons in the Hanson Material Services East (panels 1 & 2) and West (panels 3 & 4) pits, Marseilles Pool, 2017. The horizontal dashed lines in the plot represent the means while the horizontal solid lines represent the 10th, 25th, median, 75th, and 90th percentiles. East Pit (panels 1 & 2) and West Pit (panels 3 & 4) were tested independently using 2-way analysis of variance and different letters ("A", "B" and "X", "Y") represent significant differences between day/night and among seasons.*

Overall Recommendations:

- The paupier can serve as a mass removal tool and provides unique abilities to actively capture virtually all sizes of carp from a variety of habitat types.

- To maximize paupier harvest of Asian carp in the upper Illinois River, removal efforts can be focused in the summer season (June–September) during daylight hours. Nighttime sampling may be preferred based on objectives, location, and where safety and logistics allow.
- Increase daily electrotrawling time and Asian carp capture by addressing gear and logistical limitations. Improving mechanization, tender boat capacity, and/or net modifications would further reduce time expended handling carp. A process-disposal station adjacent to Starved Rock Pool would reduce time expended hauling carp.
- Target mass removal efforts on aggregations of carp detected by knowledge gained, hydroacoustics, telemetry, and/or fish finders.

Overall Literature Cited:

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Doyle, W., E. Pherigo, A. Masters, S. Schlick, and K. Drews. 2015. Exploratory gear development project. Asian Carp Monitoring and Response Plan Interim Summary Reports 201-217. Illinois Natural History Survey, Champaign-Urbana, IL.

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Understanding Surrogate Fish Movement with Barriers

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Nick Bloomfield and Rebecca Neeley (US Fish and Wildlife Service – Carterville Fish and Wildlife Conservation Office)

Mathew Shanks and 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 furthest upstream an Asian carp has been caught or observed is in Dresden Island Pool near river mile 278, which is 18 river miles downstream of the Electric Dispersal Barrier. Given the close proximity, Asian carp pose a real threat to the Electric Dispersal Barrier. The goal of this project is to use surrogate species to assess the potential risk of Asian carp movement through barriers (i.e. lock chambers and the Electric Dispersal Barrier). In addition, recapture rates of surrogate species will be used to determine sampling efficiency in the area between the Electric Dispersal Barrier and the Dresden Island Lock and Dam. In order to test the potential risk of Asian carp movement through barriers, surrogate species will be tagged in 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 Buffalo) make good surrogates due to their migration pattern and large body sizes (Becker 1983).

Understanding Surrogate Fish Movement with Barriers

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.
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 542 fish in Lockport Pool, Brandon Road Pool, Dresden Island Pool and Rock Run Rookery (Between March 14, 2017 and December 22, 2017).
- A total of 163 fish were recaptured in 2017 using pulsed DC-electrofishing, gill nets, trammel nets and 6-foot diameter hoop nets.
- A total of 126 recaptures had tags but showed no movement between barrier structures, 26 recaptures were observed due to fin clip but had no tag to show movement, and 11 recaptures showed movement through barrier structures and lock and dam structures.
- One Common Carp with a floy tag showed downstream movement through the Brandon Road Lock and Dam.

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 2017). The sample design includes electrofishing at four fixed sites and twelve random sites in each of the three pools below the Electric Dispersal Barrier. Contracted commercial netting will include four fixed sites in each pool along with targeted sampling determined by the commercial fisherman in Brandon Road Pool, Lockport Pools and Dresden Island Pool each week sampled. Contracted commercial netting will also include targeted sampling in Rock Run Rookery each week sampling is conducted 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 targeted contracted commercial fishing sites occur throughout each pool, including the lower portions of each pool as well as in the Kankakee River, from the Des Plaines Fish and Wildlife Area boat launch downstream to the confluence with the Des Plaines River.

Floy tagging and external marking procedure

Floy tags will be anchored to all Common Carp, Bigmouth Buffalo, Smallmouth Buffalo and Black Buffalo collected. The length of each fish will be recorded in millimeters along with date, location, coordinates and an individual tag reference number. Floy tags will be anchored by inserting the tag gun needle into a fleshy area below the dorsal fin on the left side of the fish. The needle should be inserted at an acute angle to the body, angling the needle towards the anterior portion of the fish to allow the tag to lie along the side of the fish. The needle should pass the midline of the body but not penetrate the opposite side of the fish. If the T-bar is only held in by the fish's skin, the tag will be removed and the fish will be retagged. A secondary mark on the dorsal fin will be given to all fish collected in case of a Floy tag malfunction. A fin clip will be given to all fish on the dorsal 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 14, 2017 and December 22, 2017, a total of 542 Common Carp, Smallmouth Buffalo, Bigmouth Buffalo, Black Buffalo and Common Carp x Goldfish hybrids were tagged in Lockport Pool, Brandon Road Pool, Dresden Island Pool and Rock Run Rookery. Of the total 6,262 fish tagged in 2014, 2015, 2016 and 2017, 532 were recaptured which gave a recapture percentage of 10.2% (Table 1). Recapture percentages by gear type in Lockport Pool, Brandon Road Pool and Dresden Pool where 2.1%, 3.3% and 1.8% for gill and trammel nets and 2.2%, 1.2% and 0.3% for electrofishing, respectively (Figure 2). Individual recapture percentages from 2014 to 2017 for Lockport Pool, Brandon Road Pool, Dresden Island Pool and Rock Run Rookery were 7.3%, 7.0%, 5.2% and 21.3%, respectively (Table 1). Recapture percentages for Common carp from 2014 to 2017 for Lockport Pool, Brandon Road Pool, Dresden Island Pool and Rock Run Rookery were 7.3%, 6.8%, 3.4% and 11.5%, respectively (Figure 1). Recapture percentages for *Ictiobus* spp. (Smallmouth, Bigmouth, and Black) from 2014 to 2017 for Lockport Pool, Brandon Road Pool, Dresden Island Pool and Rock Run Rookery were 0.0%, 16.7%, 9.8% and 22.3%, respectively (Figure 1). Of the 163 recaptures in 2017, 11 showed movement from the original pool from which they were captured (Table 2). One Common Carp (592mm) was initially captured and tagged in Brandon Road Pool on October 14, 2015 and was recaptured on June 5, 2017, in Dresden Island Pool. This fish travelled 14.6 miles downstream from the tagging location through the Brandon Lock and Dam. This surrogate fish demonstrated the ability for movement downstream through the Brandon Road Lock and Dam. Ten of the 11 recaptured that travelled through a barrier structure travelled through the Dresden Island Pool and Rock Run Rookery connection. Of these 10 recaptures, 3 of the recaptured fish moved from Rock Run Rookery into Dresden Island Pool, 6 of the recaptured fish moved from Dresden Island Pool into Rock Run Rookery, and 1 of the recaptured fish moved from Rock Run Rookery

into Dresden Island Pool and then back into Rock Run Rookery where it was recaptured (Table 2). With the 137 recaptured tagged fish in 2017, we feel Floy tag retention has met expectations.

Recommendations: With the collected 4 years of continuous surrogate fish tagging, we feel we have sufficient data to evaluate our sampling effectiveness and a better understanding on surrogate fish movement through barrier structures. With this assessment, we feel no further tagging of surrogate fish is necessary.

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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.

Dettmers, J. M. and S. M. Creque. 2004. Field assessment of an electric dispersal barrier to protect sport fishes from invasive exotic fishes. Annual Report to the Division of Fisheries, Illinois Department of Natural Resources, Illinois Natural History Survey, Center for Aquatic Ecology and Conservation.

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

Table 1. *Number of Fish Floy Tagged and Recaptured from 2014 to 2017.*

	Total Tagged Fish				Total Recaptured Fish				
	2014	2015	2016	2017	2014	2015	2016	2017	Recapture %
Lockport Pool									
Common carp	177	130	205	39	3	10	24	4	
Smallmouth buffalo	1								
Bigmouth buffalo									
Black Buffalo									
Common X Goldfish hyb.	2	4	1						
Total	180	134	206	39	3	10	24	4	7.3%
Brandon Pool									
Common carp	276	440	292	59	7	48	13	6	
Smallmouth buffalo	4	14	9	3		4	1		
Bigmouth buffalo									
Black Buffalo									
Common X Goldfish hyb.	5	17	4						
Total	285	471	305	62	7	52	14	6	7.0%
Dresden Pool									
Common carp	466	510	240	105	1	24	10	10	
Smallmouth buffalo	565	737	586	133	4	28	46	47	
Bigmouth buffalo	24	20	45	12	1	2	2	3	
Black Buffalo	16	29	11	2		1	1	3	
Common X Goldfish hyb.	1	14		1					
Total	1072	1310	882	253	6	55	59	63	5.2%
Rock Run Rookery									
Common carp	9	26	45	23		4	2	6	
Smallmouth buffalo	86	261	279	131	2	28	73	65	
Bigmouth buffalo	21	53	62	32		5	14	16	
Black Buffalo	1	18	14	1		3	5	3	
Common X Goldfish hyb.				1					
Total	117	358	400	188	2	40	94	90	21.3%
Marseilles Pool									
Smallmouth Buffalo					1		1		
Total					1		1		
Starved Rock Pool									
Common Carp						1			
Total						1			
Overall Total	1654	2273	1793	542	19	158	192	163	10.2%

Table 2. *Distance Fish Travelled Through a Barrier System Before Recaptured 2017.*

Downstream Movement	Species	Date Captured	Date Recaptured	Distance Travelled (miles)
Dresden Pool to Rock Run Rookery	Smallmouth Buffalo	4/16/2015	5/25/2017	4.2
	Smallmouth Buffalo	7/22/2014	4/28/2017	9.3
	Smallmouth Buffalo	4/2/2015	9/8/2017	8.4
	Smallmouth Buffalo	7/7/2016	4/28/2017	5.6
	Bigmouth Buffalo	10/30/2015	9/1/2017	9.8
	Smallmouth Buffalo	7/12/2016	11/3/2017	1.0
	Smallmouth Buffalo*	4/4/2017	5/25/2017	1.3
Rock Run Rookery to Dresden Pool	Bigmouth Buffalo	10/31/2014	11/29/2017	0.3
	Smallmouth Buffalo*	10/16/2015	4/4/2017	1.4
	Bigmouth Buffalo	6/10/2016	8/29/2017	0.7
	Smallmouth Buffalo	4/7/2017	10/19/2017	12.3
Brandon Pool to Dresden Pool	Common Carp	10/14/2015	6/5/2017	14.6

*** - Same Fish**

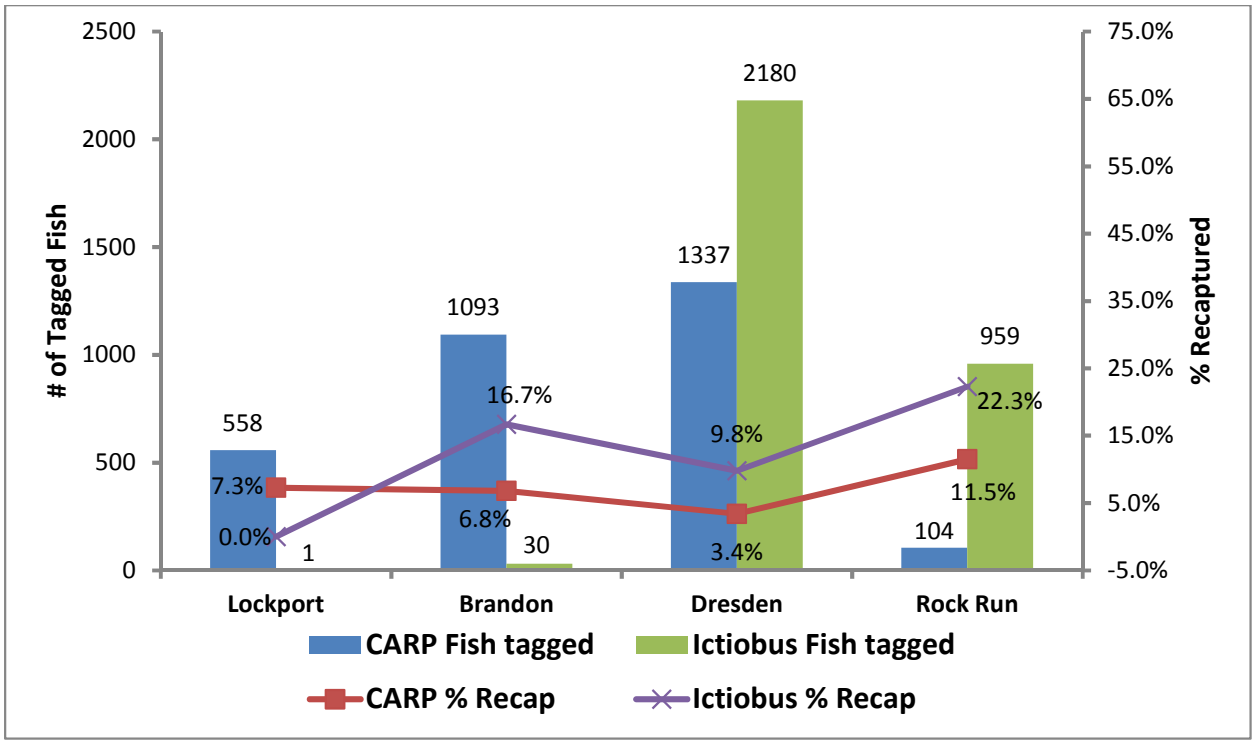

Figure 1. *Number of Fish Floy Tagged and Recaptured Percentages from 2014 to 2017.*

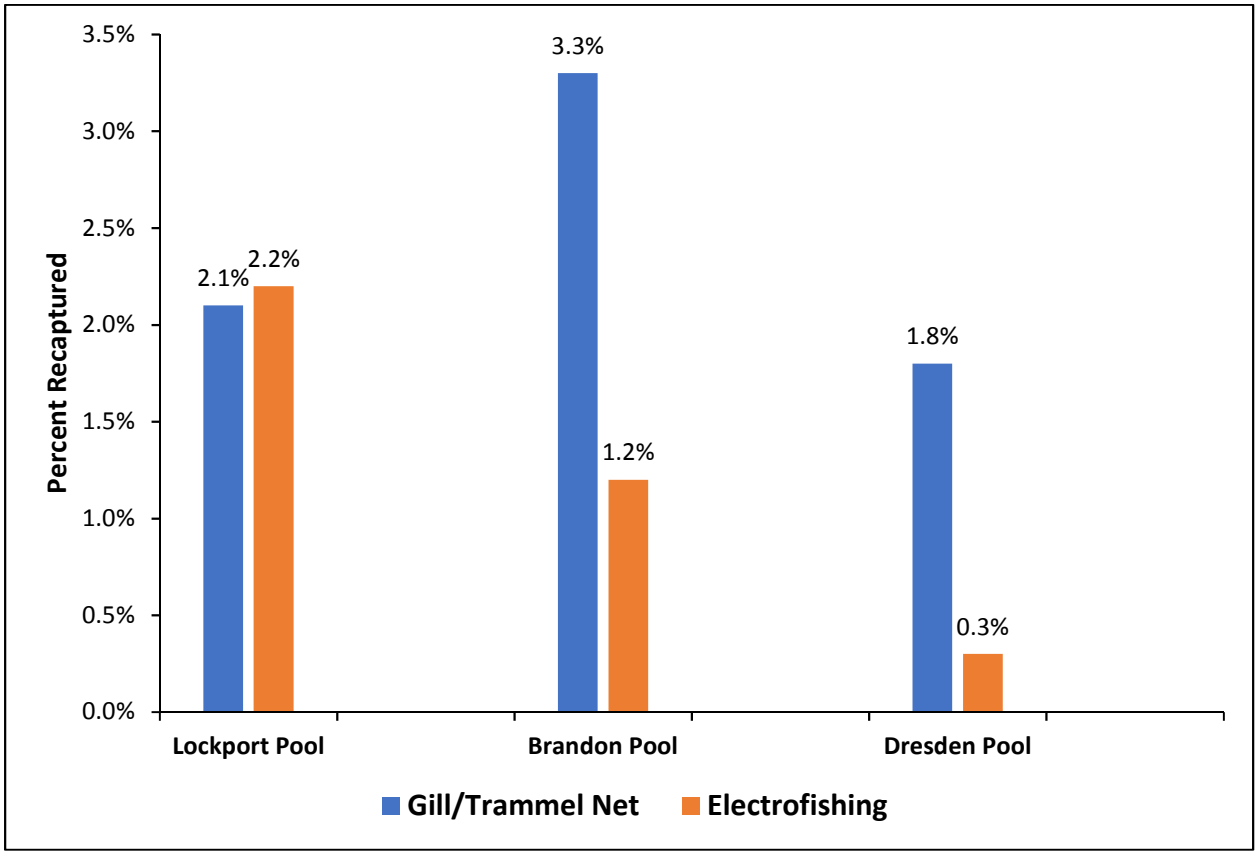

Figure 2. *Recapture Rates of Gill-Trammel Nets and Electrofishing Per Pool from 2014 to 2017.*

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

Alison Coulter, David Coulter, Morgan Michael, Greg Whitledge, Jim Garvey
(Southern Illinois University)

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

Introduction and Need:

As Asian carp continue to advance upstream through the Illinois River towards the Laurentian Great Lakes, slowing their upstream dispersal has become a management priority. Limiting propagule pressure may be the best way to prevent expansion of the population front. Currently, propagule pressure is controlled via the Electric Dispersal Barriers in the Chicago Area Waterway System (CAWS) and decreased by contracted removal of Asian carp in the upper river reaches and commercial harvest in the lower reaches. Therefore, assessments of Asian carp population characteristics, abundance, and movements, coupled with repeated estimates of abundance along the population front, can help to both refine and plan control and management efforts.

Dresden Island Pool represents the current population front for the adult Asian carp invasion in the Illinois River, whereas Marseilles Pool is the most upstream pool where young-of-year Asian carp have been found. Annual density estimates obtained by Southern Illinois University (SIU) indicate that densities have been lower in these reaches and are comprised of larger individuals, with higher proportions of Bighead Carp, than in other reaches of the Illinois River (Alton, LaGrange, Peoria, and Starved Rock pools; Coulter et al. 2016c, MacNamara et al. 2016). Contracted harvest has also been successful at reducing densities at specific sites, and reach-wide density estimates in Marseilles and Dresden Island pools appear related to contracted removal efforts (Coulter et al. 2016c, MacNamara et al. 2016). Annual density estimates are essential for understanding trends in abundance throughout the river and for evaluating whether these patterns are related to commercial (lower river) or contracted (upper river) removal. However, more frequent density estimates, especially in Marseilles and Dresden Island pools, would better direct harvest efforts by identifying locations where Silver Carp and Bighead Carp densities are highest, determining if spatial distributions change throughout a year, and comparing characteristics (e.g., size structure, condition) of Silver Carp and Bighead Carp among sites and through time.

Frequent estimates of fish densities also allow for the elucidation of the environmental factors that influence Asian carp density which can potentially lead to predictions of spatial distributions and better target harvest efforts. For example, Asian carp abundances have previously been linked to chlorophyll-a levels (Calkins et al. 2012); therefore, by mapping or monitoring chlorophyll-a concentrations, among other variables, it may be possible to predict when and where Asian carp abundances may be higher. These types of data could also be used to target

early detection efforts (e.g., eDNA) to areas where Asian carp are most likely to occur. By coupling Asian carp densities obtained during hydroacoustic surveys with environmental variables monitored simultaneously, it may be possible to predict Asian carp distributions and densities in the upper reaches of the Illinois River, as well as other river ecosystems these fishes may invade in the future.

Southern Illinois University has been monitoring Illinois River Asian carp population characteristics, densities, and movements since 2012 and have been collecting fin clips to determine hybrid status since 2013. Movement data from Asian carps have previously provided insight into the movement patterns of these species and led to management recommendations to further reduce upstream dispersal in the Illinois River. Since 2013, the majority of Asian carp from which movement data have been collected have been tested to determine their hybrid status. Hybrid Asian carp may be different biologically or behaviorally from Bighead or Silver Carp (Liss et al. 2016) and, therefore, may require additional management actions (Lamer et al. 2010; Lamer et al. 2015). Sufficient data have now been collected to provide evaluations of possible differences in demographics and movement of hybrids and the parental Asian carp species.

While habitat matching of hydroacoustic Asian carp densities with environmental conditions are ongoing, densities from repeated hydroacoustic surveys in Marseilles and Dresden Island pools, surveys from before and after the unified fishing event in Marseilles Pool in early 2017, and differences in the biology and movements among Silver Carp, Bighead Carp, and their hybrids are presented.

Objectives:

(1) Assess spatial and temporal variation of Asian carp densities in Marseilles and Dresden Island pools and match densities to environmental values.

(2) Estimate density of Asian carp in the Illinois River in fall 2017.

(3) Compare movements between parental Asian carp species (Silver Carp and Bighead Carp) and their hybrids throughout the Illinois River using acoustic telemetry data.

Project Highlights:

- Hydroacoustic surveys of Dresden Island and Marseilles pools helped inform contracted harvest and revealed different within-year (across months) patterns in density than were observed in 2016. Environmental data were collected concurrent with hydroacoustic surveys and will be analyzed to explore possible environmental predictors of Asian carp densities.

- Standardized fall hydroacoustic surveys of the Illinois River (Dresden Island – Alton pools) revealed densities were similar in 2017 compared to 2016 in all pools (Alton – Marseilles) except Dresden Island Pool. Dresden Island Pool fall density in 2017 was lower than densities in all previous years since fall densities have been assessed (since 2012).
- Early generation bigheaded carp hybrids (e.g., F_1 and F_2 individuals) had lower condition than other bigheaded carp groups (parental species and more advanced hybrids [majority of alleles either Silver Carp of Bighead Carp]).
- Early generation bigheaded carp hybrids were uncommon (65 out of 1479 individuals) and composed a greater proportion of bigheaded carp sampled in the upper Illinois River (Dresden Island – Starved Rock pools). Bighead Carp and hybrids that had predominantly Bighead Carp genes also represented greater proportion of fish sampled in the upper Illinois River compared to lower river reaches.
- The movements and biological metrics examined for advanced generation hybrids were typically similar to whichever parental species they shared the majority of their genes with (i.e., Silver Carp of Bighead Carp). Therefore, management actions and models designed for Silver Carp or Bighead Carp are likely applicable to the majority of hybrids within the population.

Methods:

Hydroacoustic Surveys

Repeated hydroacoustic surveys in the upper Illinois River in 2017 were completed in March (20-March), early June (5-June), and late July (24-July). Final 2017 surveys in these reaches and throughout other Illinois River reaches (Starved Rock – Alton pools) were completed in October. Two October surveys were conducted in Dresden Island Pool - before and after the Unified Method harvest to both inform and evaluate the event. Water quality data (temperature, dissolved oxygen, conductivity, chlorophyll-*a* concentration) were also continuously sampled during all surveys. All hydroacoustic sampling methods, designs, and analyses followed those outlined in MacNamara et al. (2016).

Unified Method – Hydroacoustic Surveys

Hydroacoustic surveys were completed before and after each of the two unified events that occurred in 2017: Hanson Material Services West Pit in March and Dresden Island Pool in October. Results from the Hanson Material Services West Pit are included in this report while the Dresden Island Pool surveys are being processed.

Hybrid Asian Carp Movements

From 2013 – 2016, fin clips from bigheaded carp, either collected in the lower Illinois River (Alton – Peoria pools) in August of each year or from various Illinois River reaches in different years and implanted with acoustic telemetry tags, were collected and analyzed for hybrid status.

In total, hybrid information was collected from 1,479 individuals (909 individuals in fall sampling – length, weight, age data collected; 570 individuals with telemetry tags – length, movement data collected). Individuals were placed into five groups based on the numbers of single nucleotide polymorphisms (SNPs) that were from Silver Carp and Bighead Carp. These groups were: Silver Carp – 100% SNPs Silver Carp; Bighead Carp – 100% SNPs Bighead Carp; early generation hybrid bigheaded carp – F_1 and F_2 individuals or those with ~ 50% SNPs from each species; advanced generation hybrid Silver Carp – more than 50% of SNPs from Silver Carp but < 100%; advanced generation hybrid Bighead Carp – more than 50% but < 100% of SNPs from Bighead Carp.

Using only fish collected in the fall of 2013 (the only collection year when all hybrid groups were represented), length-frequency distributions (KS tests, holm-bonferroni corrected p-values), length-weight regressions (analysis of covariance [ANCOVA], holm-bonferroni corrected p-values) and condition (Fulton's Condition Factor; Kruskal-Wallis test) were compared among the five bigheaded carp groups.

Within a bigheaded carp population, some individuals may be highly mobile while others are more stationary (Prechtel et al. 2018). To assess the prevalence of highly mobile individuals within each bigheaded carp group, annual range (maximum displacement: upstream to downstream extent over which each individual occurred; Prechtel et al. 2018) and numbers of dam passages through each dam type (i.e., wicket or gated) were compared among the bigheaded carp groups. Mean ranges were compared among bigheaded carp groups with a Kruskal-Wallis test. The highest 25% of mean yearly ranges in each bigheaded carp group (the most mobile individuals) were also compared with a Kruskal-Wallis test. The proportions of each bigheaded carp group that successfully passed upstream though each type of dam (gated – upper Illinois River, wicket – lower Illinois River) or did not pass through any dam were compared using a Fisher's exact test. Proportions of each bigheaded carp group that passed downstream through dams were similarly compared.

Telemetry data were used to evaluate differences in the patterns and environmental drivers of movement across the hybrid groups. Movements and behaviors of bigheaded carps have commonly been related to temperature, river discharge, and changes in temperature and discharge (DeGrandchamp et al. 2008; Coulter et al. 2016a; Coulter et al. 2016b; Coulter et al. 2017; Lubejko et al. 2017). Therefore, mean temperature (from HOBO temperature loggers operated by SIU) and discharge (from USGS river gages) as well as derived variables quantifying changes in these metrics were evaluated for their influence on the movement of different bigheaded carp groups. Derived variables were 24 hour change in temperature and discharge and change in weekly mean temperature and discharge. All variables were reach-specific except where no discharge data were available (Starved Rock and Dresden Island pools) and, in these cases, data from the next pool downstream were used. The six environmental variables related to temperature and discharge were checked for correlations (Pearson correlations) prior to inclusion in the models. Mean daily discharge and change in weekly

discharge were moderately correlated ($r = 0.46$), so only mean daily discharge was included in analyses. Other environmental variables were not correlated with each other (all correlations: $-0.04 < r < 0.26$).

Possible environmental drivers of movement distances (net and total) were examined for each hybrid group or parental species using generalized linear mixed-effects models (Bates et al. 2015). The full models included fixed effects of fish total length, mean water temperature, change in water temperature over 24 hours, change in weekly water temperature, mean discharge, and change in discharge over 24 hours. The full model also included random effects of individual fish and month nested within year. The full model and all possible combinations of fixed effects (including single variables) were run and evaluated using Akaike's Information Criterion corrected for small sample size (AICc; Barton 2016). Models with ΔAICc values ≤ 2 were averaged (conditional averaging; Barton 2016) so that the coefficient and significance of each included environmental variable could be determined for each hybrid group.

Results and Discussion:

Hydroacoustic Surveys

Observed Asian carp (Silver Carp and Bighead Carp combined) densities in Dresden Island Pool remained constant from March to June and decreased slightly from June to July. This was due to a decrease in observed Silver Carp density and a marginal decrease in observed Bighead Carp density (Figure 1). Within Dresden Island Pool, Asian carp densities were highest in the Treats Island side-channel and Mobil Bay backwater, although densities at Treats Island were highly variable (Figures 2). At other locations in Dresden Island Pool, densities were high in the main channel adjacent to the Rock Run Rookery backwater, just upstream from Rock Run Rookery, near the mouth of the Kankakee River, and within the power plant effluents near the Kankakee River. Many of these locations also had the highest abundance in consecutive surveys.

Asian carp densities in late July within the Marseilles Pool were higher in July than June (Figure 1) but were comparable to densities observed in March. This was due to an increase in observed Silver Carp density from June levels. Asian carp densities remained similar to the previous survey in the Hanson Material Services East Pit backwater lake and the main channel but increased in the Sugar Island side-channel and Hanson Material Services West Pit backwater lake (Figure 2). Within the main channel, locations with high densities were mostly downstream, towards the Marseilles Lock & Dam. Densities in the Hanson Material Services East Pit were highest in the northeast cove, along the eastern shoreline, and in the north-central bay. Asian carp densities in the West Pit were moderate along most of the shoreline but were elevated in the west end of the lake, along the north-central shoreline, and in the northeastern cove.

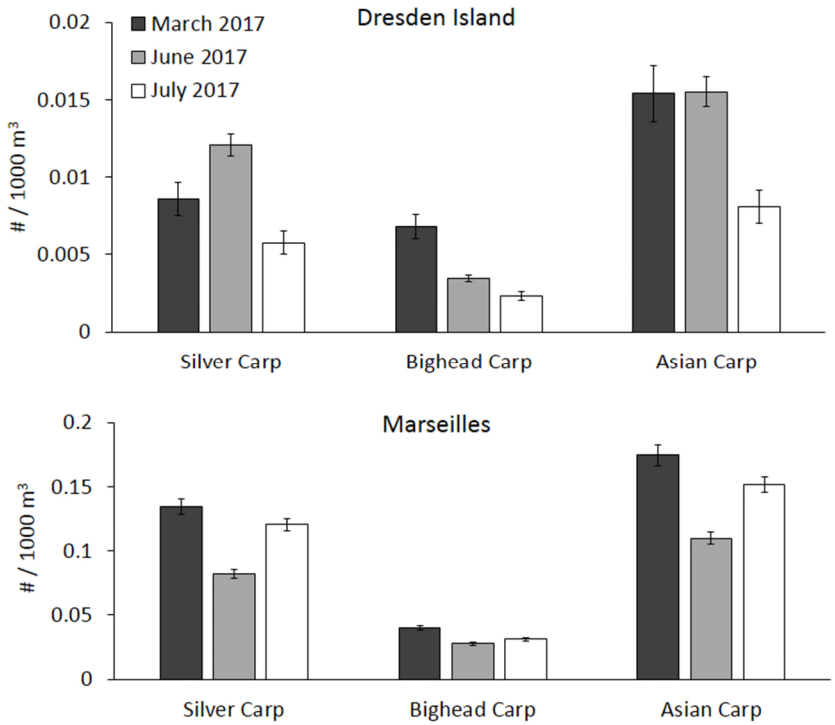

Figure 1. *Mean (SE) reach-wide Silver Carp, Bighead Carp, and Asian carp (Bighead and Silver Carp combined) densities observed from mobile hydroacoustic surveys in the Dresden Island and Marseilles reaches in 2017. Note differences in scale between panels.*

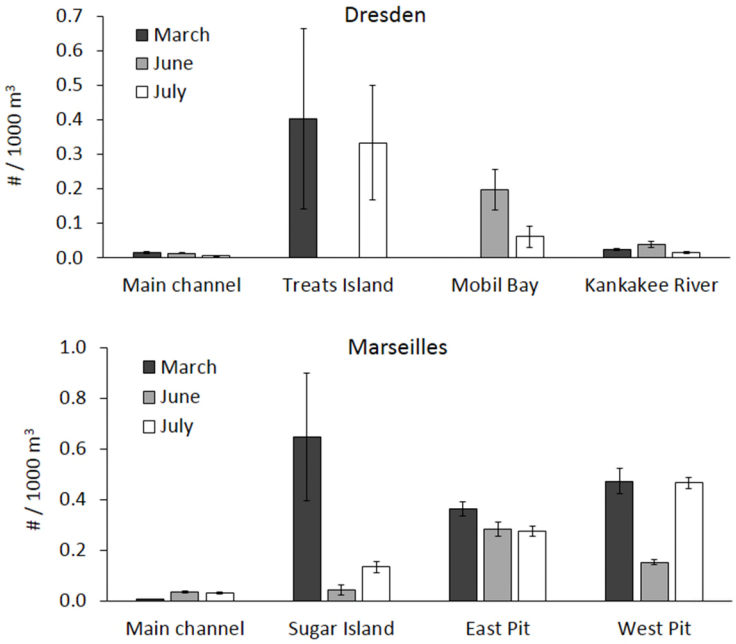

Figure 2. *Mean (SE) site-specific Silver Carp, Bighead Carp, and Asian carp (Bighead and Silver Carp combined) densities observed from mobile hydroacoustic surveys in the Dresden Island and Marseilles reaches in 2017. Note differences in scale between panels.*

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

Fall (October) hydroacoustic surveys were performed from Alton – Dresden Island pools to assess long-term trends in density. Density estimates in the three lower river pools were similar between 2017 and 2016 (Figure 3). In the upper river, Starved Rock and Marseilles pools also had similar densities in 2017 compared to 2016. Fall density in Dresden Island Pool was lower in 2017 compared to all previous years since fall densities have been assessed in this pool (Figure 3; Figure 4). Densities throughout 2017 in Dresden Island Pool were relatively low compared to fall estimates from previous years (Figure 4).

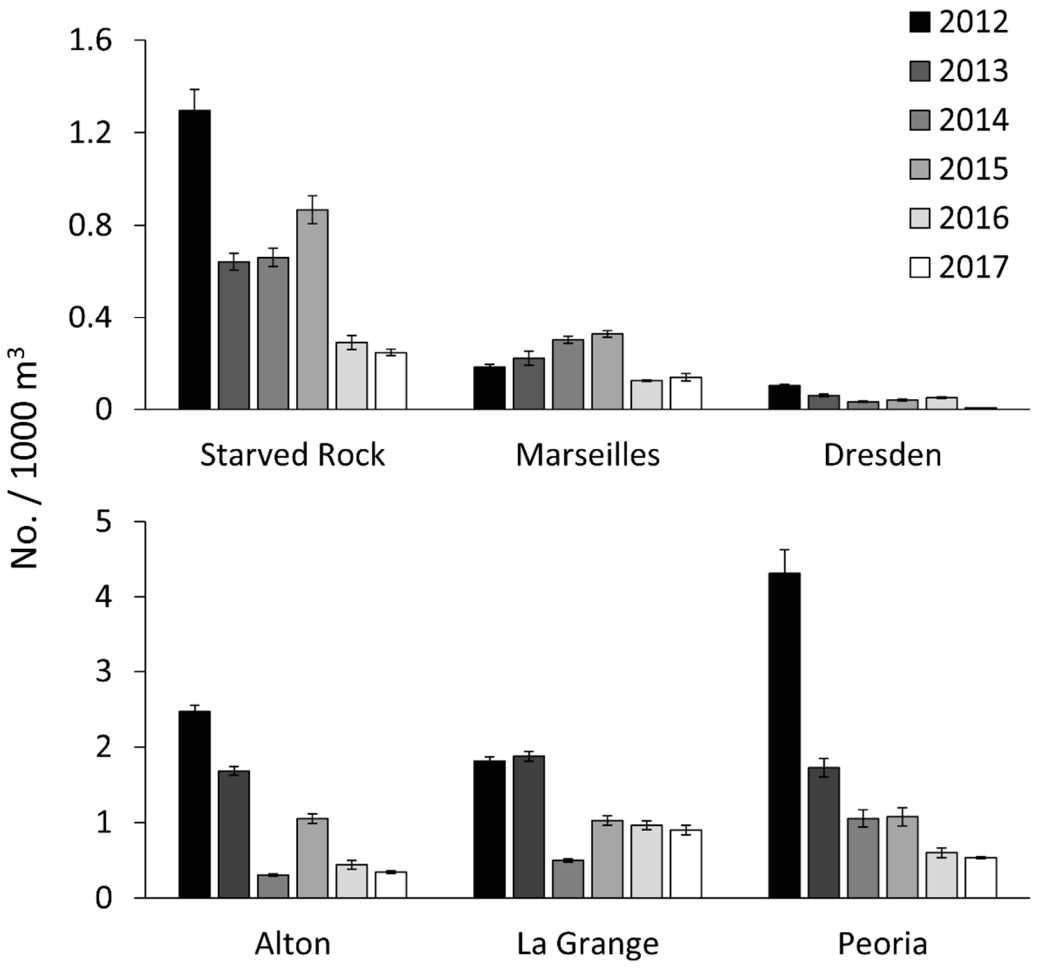

Figure 3. *Mean (SE) Asian carp (Bighead Carp and Silver Carp combined) densities estimated from fall hydroacoustic surveys conducted at standardized locations in each pool. Note differences in y-axis scale between upper river pools (top panel) and lower river pools (bottom panel).*

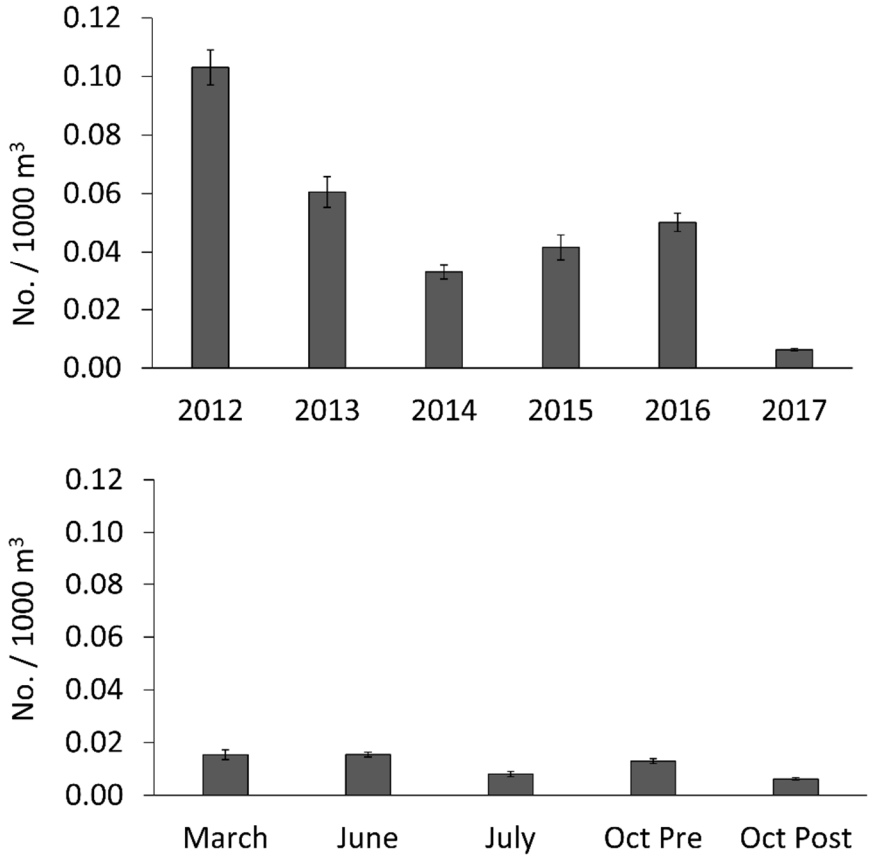

Figure 4. *Mean (SE) Asian carp (Bighead Carp and Silver Carp combined) densities in the Dresden Island Pool from fall standardized surveys among years (top panel) and repeated sampling approximately every other month during 2017 (bottom panel). Oct Pre and Oct Post: densities sampled before and after the October Unified Method conducted in the Dresden Island Pool, respectively.*

Unified Method – Hydroacoustic Surveys

Pre- and post-unified surveys of Hanson Material Services West Pit occurred on February 25, 2017 and March 23, 2017 respectively. Pre-unified distributions of Asian carps were similar to 2016 and were provided to agencies prior to the Unified Method to assist with netting efforts. Pre-unified densities were significantly lower than pre-harvest densities before the Unified Method event in the Hanson Material Services West Pit in spring 2016. Bighead Carp and Silver Carp densities significantly decreased following the Unified Method harvest (Figure 5).

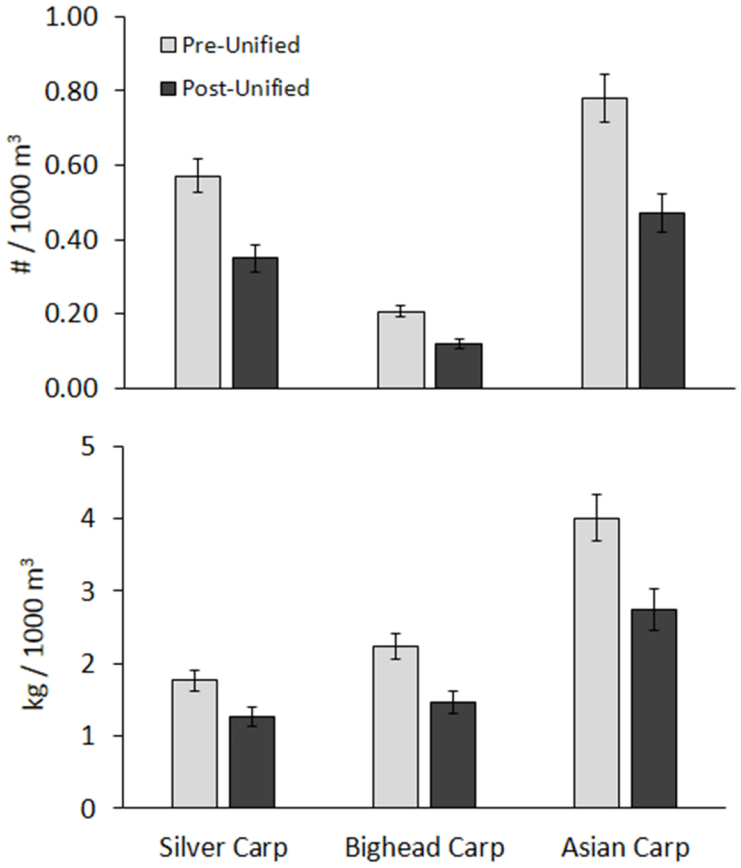

Figure 5. *Mean (SE) Silver Carp, Bighead Carp, and Asian carp (Silver Carp and Bighead Carp combined) before and after the Unified Method event in the Hanson Material Services West Pit in spring 2017.*

Hybrid Asian Carp

Early generation hybrids were extremely rare (65 of 1,479 individuals), a similar result to previous evaluations of bigheaded carp hybrid abundance (e.g., Lamer et al. 2015). Additionally, Bighead Carp (n = 90) and advanced generation Bighead Carp hybrids (n = 93) were also uncommon compared to Silver Carp (n = 632) and advanced generation Silver Carp hybrids (n = 597). Early generation hybrids, Bighead Carp and advanced generation Bighead Carp hybrids were all more common in upper Illinois River reaches (i.e., above Starved Rock Lock and Dam) than in the lower Illinois River.

Length-frequency distributions and length-weight regressions of advanced generation hybrids were similar to whichever parental bigheaded carp species they shared the most SNPs with, but Silver Carp and advanced hybrid Silver Carp were different from Bighead Carp and advanced hybrid Bighead Carp. Early generation hybrids were not different from the other bigheaded carp groups in length-frequency or length-weight regressions. This finding potentially results from early bighead carp hybrids displaying intermediate traits to the two parental species or being

highly variable among the two parental species. Additionally, the rarity of early hybrids in the dataset means there was a small sample size of these individuals which may have affected results.

Body condition was different among bigheaded carp groups (Figure 6). Condition of the advanced generation Silver Carp hybrids was greater than that of the early generation hybrids but less than Silver Carp. Advanced generation Silver Carp hybrid condition was not different from Bighead Carp condition. Early generation hybrids had a significantly lower condition than Silver Carp but were not different from Bighead Carp.

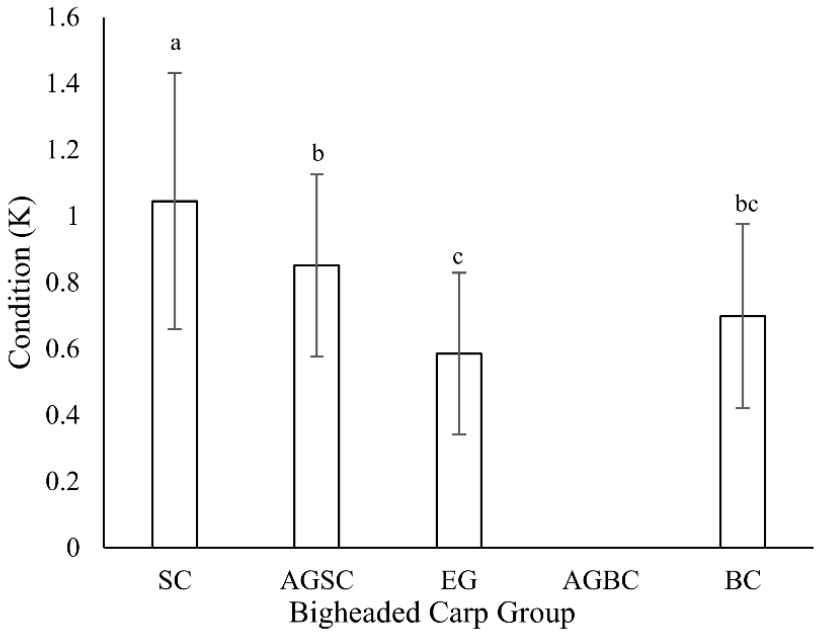

Figure 6. *Fulton's condition factor (K, mean ± se) of bigheaded carp hybrid groups. Individuals were collected from the Illinois River in fall 2013. Abbreviations for bigheaded carp hybrid groups: Silver Carp (PSC), advanced generation Silver Carp hybrids (AGSC), early generation hybrids (EG), advanced generation Bighead Carp hybrids (AGBC), Bighead Carp (PBC). Condition was not available for any AGBC. Letters indicate significant differences.*

Overall, comparisons among bigheaded carp hybrids and parental species indicate that, for most traits examined, hybrids with a majority of SNPs from one parental species were similar to that parental species (e.g., advanced generation Silver Carp similar to Silver Carp. Body condition was reduced in hybrid groups compared to parental species and early generation hybrids had the lowest condition observed. Previous studies have found that hybrid bigheaded carps may have reduced nutritional performance compared to parental species (Liss et al. 2016) and our results support this. Additionally, it appears that early generation hybrids may be inferior to advanced generation hybrids as indicated by their reduced condition. However, numbers of early generation hybrids were low which may have influenced comparisons.

Annual ranges travelled by each individual over the entire study were not different among hybrid groups. The most mobile individuals in each group were significantly different from each other. Bighead Carp mean distance (rkm) moved per year of the most mobile individuals was not different from other groups upon *post hoc* testing; however, other groups (advanced generation Silver Carp and Bighead Carp hybrids and Silver Carp) were all different from each other. The most mobile Silver Carp covered a greater annual range than advanced generation Silver Carp hybrids which both had a greater annual range than advanced generation Bighead Carp hybrids. Upstream passages were different among bigheaded carp groups with early hybrids having proportionately more upstream passages through gated dams than all other groups, but no other comparisons were significant (Figure 7). Downstream passages were not different among bigheaded carp groups.

Averaged models evaluating the total distance travelled for Silver Carp and advanced generation Silver Carp hybrids both contained average daily discharge as significant predictors while Bighead Carp and advanced generation Bighead Carp hybrids both contained 24 hr change in temperature as significant predictors. The Bighead Carp averaged total distance model also contained significant variables of total length and average daily temperature. No evaluated variables were significant in the early generation hybrid total movement averaged model.

The averaged model evaluating net distances travelled by Silver Carp contained no significant predictors; however, mean daily discharge was significant in the model for advanced generation Silver Carp hybrids. 24 hour change in temperature was significant in the averaged model for advanced generation Bighead Carp while 24 hour change in discharge and average temperature were significant in the Bighead Carp net movement averaged model. None of the evaluated variables were included in the averaged model of net movement for early generation hybrids.

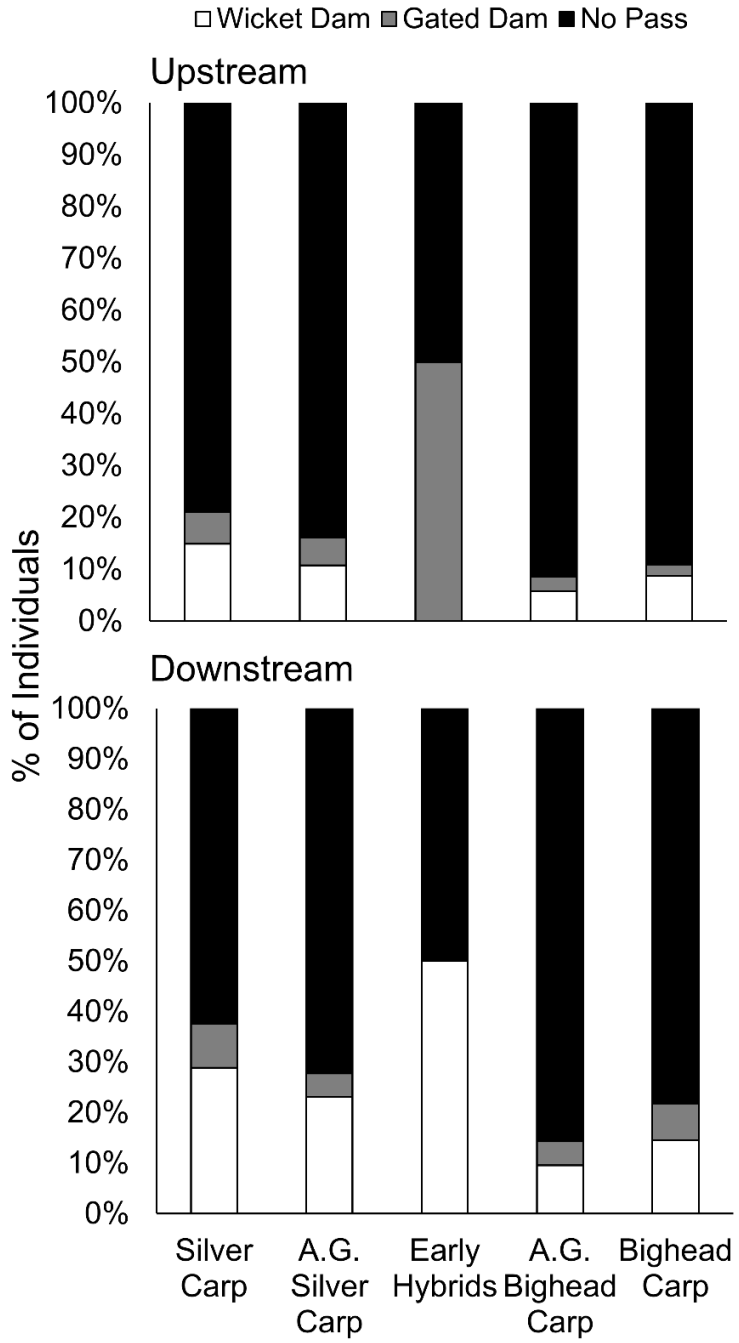

Figure 7. *Percent of individuals in each bigheaded carp group that passed at least once upstream (upper panel) or downstream (lower panel) through an Illinois River Dam. Passages are divided by dam type (wicket – La Grange Lock and Dam, Peoria Lock and Dam; gated – Starved Rock Lock and Dam, Marseilles Lock and Dam, Dresden Island Lock and Dam). The No Pass group is number of individuals that did not pass through either type of dam. Silver Carp, advanced generation Silver Carp hybrids (A.G. Silver Carp), early generation hybrid bigheaded carps (Early Hybrids), advanced generation Bighead Carp hybrids (A. G. Bighead Carp), and Bighead Carp.*

Movements of bigheaded carp groups were related to environmental conditions or fish length, but the strongest environmental predictor varied among the groups. In general, the distances (total and net) traveled by Bighead Carp and advanced generation Bighead Carp hybrids were related to recent temperatures (daily means and change over 24 hour), while distances traveled by Silver Carp and advanced generation Silver Carp were typically related to river discharge. Similar responses were previously observed in Bighead Carp and Silver Carp movements between a backwater and main channel habitat wherein Bighead Carp movement between habitats was related to water temperature and Silver Carp habitat use was related to river discharge (Coulter et al. 2017). Early generation hybrid movement distances were not significantly related to any of the environmental variables examined or with fish length. Since the two parental species appear to respond to different environmental conditions, early generation hybrids, as a mixture of the two species, may have a weaker or intermediate response to environmental conditions. Additionally, the comparatively small number of early generation hybrids for which data were available could have limited our ability to detect relationships due to the high individual variability in movements observed in other bigheaded carp studies (Prechtel et al. 2017). Therefore, future research should focus on monitoring more early generation hybrids or investigating additional environmental cues for movement.

Recommendations:

Hydroacoustic surveys are needed to inform (via spatial distribution maps) and evaluate Unified Method events and contracted harvest in the upper river. Differences in densities and spatial distributions from repeated surveys in Dresden Island Pool between 2016 and 2017 indicate that seasonal patterns are highly variable among years. Therefore, repeated surveys in the upper river will help direct contracted harvest. Additional management actions targeting early generation hybrids are likely not necessary due to their rarity and likely competitive inferiority to Silver Carp, Bighead Carp, and advanced generation bigheaded carp hybrids (based on condition and nutrition performance [Liss et al. 2016]). However, rare early generation hybrids may drive the upstream spread of bigheaded carps. Conclusions related to this finding require further data collection due to the low sample sizes of early generation hybrids. Other metrics examined indicate that, in most aspects, advanced generation hybrids were similar to whichever parental species from which they had the majority of SNPs. However, differences in growth among parental species and advanced hybrids may lead to the maintenance of hybrids in the population and the potential need for additional management of advanced generation hybrids (especially as related to their higher growth rates at small sizes). Management actions taken based on the movements and habitat use of Silver Carp or Bighead Carp will likely affect advanced generation hybrids as they respond to similar environmental cues.

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Evaluation of Gear Efficiency and Asian Carp Detectability

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

Participating Agencies: Illinois Natural History Survey (lead)

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.

(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 age-0 Silver Carp were higher during 2017 than in 2015 and 2016, but lower than were observed during 2014. However, the majority of age-0 Silver Carp captured in 2017 were collected in a single mini-fyke net, highlighting the extremely patchy spatial distribution of juvenile Silver Carp during years of successful reproduction. No juvenile Bighead Carp were observed during 2017.

- During 2017, mini-fyke nets collected the highest total numbers of age-0 Silver Carp, similar to all other study years. Beach seines and dozer trawls captured very low numbers of age-0 Silver Carp. Pulsed-DC electrofishing only captured adult Silver Carp in 2017.
- The majority of age-0 Silver Carp were captured during summer sampling in 2017, whereas only 3 individuals were captured during fall sampling, similar to the pattern observed in 2014. In contrast, the majority of age-0 Silver Carp captured during 2015 and 2016 were collected during fall. These differences in capture rates among seasons suggest differences in spawning dates and survival rates of juvenile Silver Carp among years.
- Age-0 Silver Carp lengths were very similar during summer (22-41 mm) and fall (21-44 mm) sampling, suggesting that fish captured in the fall were the product of a different cohort than those captured in summer.

Methods:

Following the detection of larval Asian carp by ichthyoplankton sampling during May – July (see Larval Fish Monitoring Summary), gears were deployed to sample for juvenile Asian carp during summer (July) and fall (late September) at paired main channel and backwater sites within the LaGrange Pool of the Illinois River (Figure 1). Both summer and fall sampling were conducted concurrently with USFWS trawling efforts in the LaGrange Pool to allow for comparisons among gears (see Gear Evaluation for Removal and Monitoring of Asian Carp Species Summary).

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 located at river kilometer 186.7 for the backwater lake (Matanzas Lake) and river kilometer 193.1 for main channel habitats (Havana). Gears used in 2017 were determined from experimental comparisons of multiple gears conducted in previous study years (Collins et al. 2017). All fish captured in 2017 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 2017 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)
- Dozer trawl (1 m x 2 m frame, 4 m long net, 3 mm mesh)

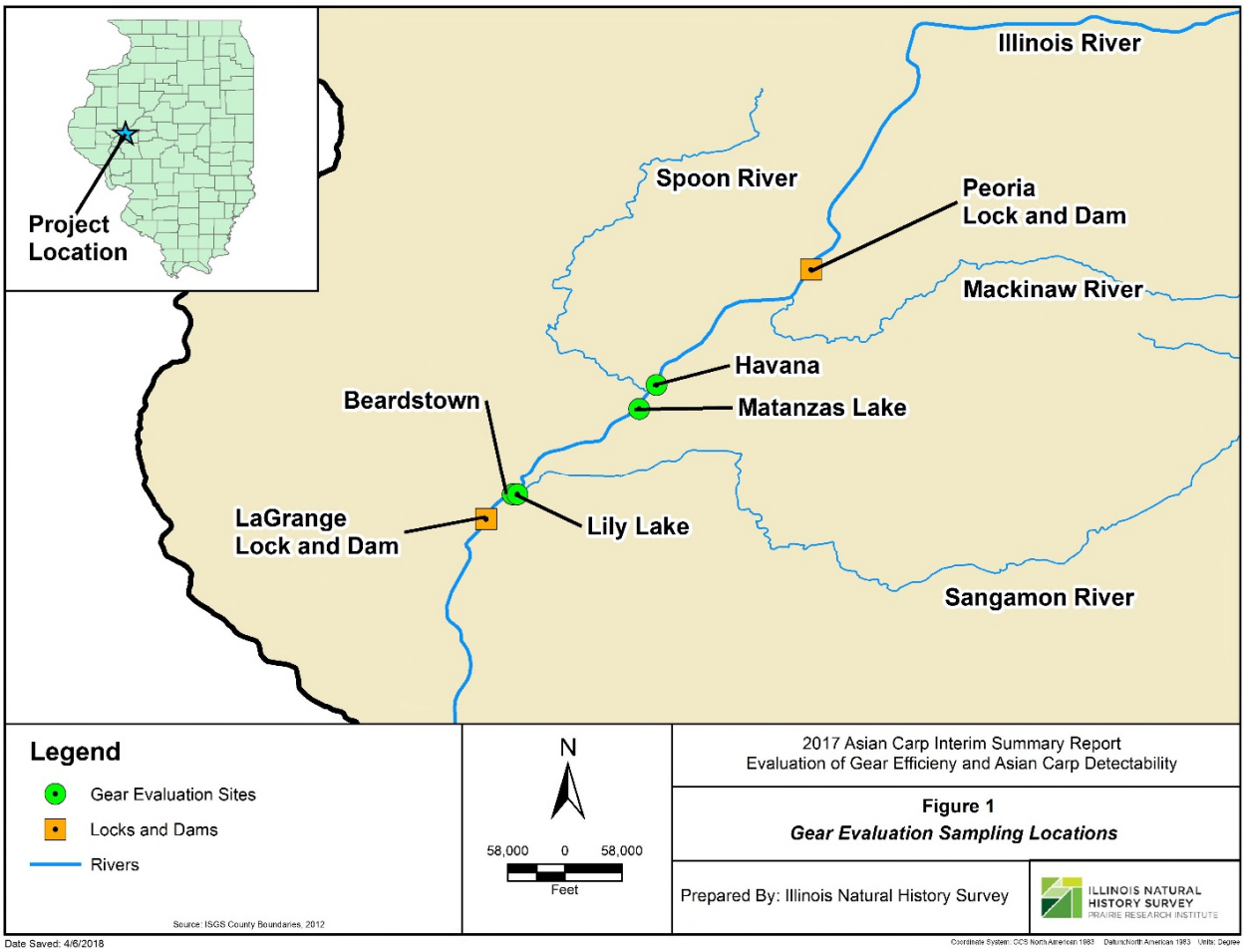

Figure 1. *Map of 2017 gear evaluation sampling locations in the LaGrange Reach of the Illinois Waterway. Navigation dams are represented by squares. Sampling sites are represented by circles.*

Results and Discussion:

Evaluation of sampling gears targeting juvenile Asian carp during 2017 resulted in the capture of 19,444 fish, including 2,861 age-0 Silver Carp. Mini-fyke nets captured the highest numbers of all fish (July: n = 6,419; September: n = 4,036), and the most age-0 Silver Carp (July: n = 2,852; September: n = 3) during both sampling periods. However, the majority of age-0 Silver Carp were captured in a single mini-fyke net during the July sampling event (n = 2,817), highlighting the patchy spatial distribution of age-0 Silver Carp when they are present. Beach seines (n = 4,226) and dozer trawls (n = 3,791) captured lower numbers of fishes and only a small number of age-0 Silver Carp (beach seines: n = 3; dozer trawls: n = 3). Pulsed-DC electrofishing captured 972 total fish, but only produced adult Silver Carp.

Although extremely high numbers of Asian carp eggs and larvae were collected in 2017 (see Larval Fish Monitoring Summary), recruitment to juvenile stages appears to have been moderate compared to previous sampling years. The total numbers of age-0 Silver Carp captured in 2017 were higher than in 2015 (n = 115) or 2016 (n = 336), but substantially lower than in 2014 (n =

67,881). Additionally, higher numbers of age-0 Silver Carp were captured in fall sampling in 2015 and 2016, whereas the vast majority of age-0 Silver Carp in 2017 were captured during summer sampling. These differences in catches indicate wide variation in recruitment to juvenile stages among years, as well as potential differences in spawning dates and survival rates of juvenile Asian carp.

Silver Carp body lengths were very similar between summer (22-41 mm) and fall (21-44 mm) sampling, suggesting that fish captured in the fall were the product of a different cohort than those captured in summer. Indeed, multiple bouts of Asian carp spawning were observed during 2017 (see Larval Fish Monitoring Summary), which may have produced early and late cohorts of juveniles. Because of the small numbers of age-0 Silver carp captured by beach seines and dozer trawls in 2017, confident comparisons among gear types could not be made. Assessments of sampling gears in previous years have suggested that some differences in size selectivity for juvenile Asian carp exists among gear types, with beach seines typically capturing the smallest size groups of age-0 Silver Carp, and other gear types collecting broader length ranges. Additionally, larger size groups of age-0 and age-1 Asian carp do not appear to be vulnerable to nearshore sampling gears such as mini-fyke nets and beach seines, suggesting that a habitat shift occurs as these fishes increase in size, and that alternate offshore sampling gears may be necessary to target these larger juvenile size classes.

Despite below average catch rates, mini-fyke nets consistently captured age-0 Silver Carp in both main channel and backwater habitats during 2017. Mini-fyke nets have produced higher catch rates of age-0 Silver Carp than any other sampling gear in every year of this study, and appear to be among the most effective tools for targeting these fishes in near-shore habitats. Earlier years of this study suggested that beach seines may have some value for juvenile Asian carp sampling. However, this gear type has produced very low and inconsistent capture rates of age-0 Asian carp in more recent years, bringing its utility into question. Boat electrofishing has also been found to perform poorly for capturing juvenile Asian carp. Although this gear is widely employed by a number of agencies for Asian carp monitoring, the results of this study suggest that it is not an effective tool for monitoring juvenile size classes. Because immobilization of fish by electric fields is related to body size, smaller Asian carp may not be very vulnerable to the waveforms used by many agencies. Further assessment of electrofishing settings or alternative electrofishing configurations for targeting juvenile Asian carp may be warranted.

No juvenile Bighead Carp were captured during 2017. Over the past four years (2014-2017), only a very few juvenile Bighead Carp have been collected. Bighead Carp reproduction and recruitment may have been low in recent years, 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.

Evaluation of Gear Efficiency and Asian Carp Detectability

Recommendations:

Evaluation of sampling gears targeting juvenile Asian carp was possible during both 2014 and 2017 due to successful reproduction and subsequent recruitment to juvenile stages. Mini-fyke nets appear to consistently capture higher numbers of Silver Carp than all other gear types (Collins et al. 2017), and are recommended for monitoring juvenile Asian carp in near-shore environments. However, some evidence indicates that larger age-0 and age-1 Asian carp are unlikely to inhabit nearshore habitats. Monitoring these larger individuals in offshore areas thus requires differing gears that sample deeper water. Continued comparison of existing gears targeting juvenile Asian carp with various trawling methods (see Gear Evaluation for Removal and Monitoring of Asian Carp Species Summary) is warranted to better understand methods for increasing catch rates and enhancing detection of juvenile Asian carp, and for better targeting larger size groups of juvenile Asian carp in offshore habitats. 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. Modelling efforts examining detection probabilities and sample size requirements for both juvenile and adult Asian carp, and for several native fish species, are currently under development and will be reported during 2018. Results of this future research will be reported as they become available to allow for adaptation of monitoring and control activities.

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Unconventional Gear Development

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(Illinois Natural History Survey)

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

Introduction:

Traditional sampling gears vary widely in their ability to capture Asian carp. Many conventional gears used to sample large rivers may have limited effectiveness for capturing and removing large quantities of Asian carp. In recent years, there has been a concerted effort by fisheries agencies to explore novel means of removing large numbers of invasive Asian carps, which has required the evaluation of unconventional fisheries gears. Catch rates and size selectivity of new gears and deployment strategies are being evaluated and compared with select traditional gears to determine the utility of unconventional techniques for monitoring and capturing large numbers of Asian carp.

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.
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 in support of mass removal events of Asian carp.
- Preliminary evaluation of alternate configurations of pound nets suggests perpendicular sets may catch more fishes, including Asian carp, than parallel sets. However, the sample sizes from current evaluations are insufficient to make robust conclusions. Additional sets are required to statistically compare configurations.

Methods:

In 2017, unconventional gear efforts focused on the use of Great Lakes trap (pound) nets as part of an ongoing collaboration with IDNR and USGS partners to achieve various monitoring and research objectives. Previously, 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 in a way where the two wings from the net were angled to opposite banks, blocking the entirety of the waterway. In larger floodplain lakes, blocking from

bank to bank is not possible. During 2017, INHS explored multiple locations in the Illinois Waterway to test alternate pound net configurations, and examined alternate pound net deployments at the Hanson Material Services pit near Morris, Illinois (Marseilles Pool). INHS staff set one pound net perpendicular to shore and another parallel to shore to compare catch rates and species composition between these alignments. Pound nets were set on August 14 and fished until August 18, totaling 8 net nights, 4 per configuration. Nets were fished for 24 hour sets and were attended daily, at which time all fishes were removed, measured, and weighed.

In collaboration with USGS efforts to test the effectiveness of feeding attractants and mass removal events, INHS provided technical assistance, assisting and training USGS field crews on how to deploy and maintain pound net sets.

Results and Discussion:

INHS explored multiple locations in the Illinois Waterway to test alternative configurations for Great Lakes trap (pound) nets. Pound net sets require large floodplain habitats with reduced flows to reduce the likelihood of being damaged by flowing debris. Moreover, sites needed to be large enough to permit the perpendicular or parallel deployment configurations. Several sites in the Peoria Pool were examined during summer 2017 to determine if they had sufficient area and depth for pound net operation. Based on these surveys, water depths during summer were insufficient to deploy the pound nets. Pound nets require approximately 2 meters of water in order to fish properly. All sites were determined to be too shallow during summer flows. Based on this overview, in future years INHS will attempt to deploy pound nets at appropriate locations during spring when water levels are higher.

During tests of alternative pound net configurations at the Hanson Material Services area, overall catch rates were very low compared to previous years' pound net efforts at this same location. A total of 81 fish were captured, including 6 Asian carp (3 Bighead Carp, 2 Silver Carp, 1 Grass Carp). Previous pound netting efforts found that daily catches of Silver Carp and Bighead Carp averaged 30 and 13 fish per net night, respectively. The low 2017 catch rates are potentially due to the extensive Asian carp removal efforts that have been conducted throughout the year in the Hanson Material Services backwater. More fish were captured in the perpendicular set than in the parallel set ($n = 48$ vs $n = 33$), including all of the Bighead Carp and Silver Carp. These preliminary findings indicate that pound nets do catch Asian carp in at least one alternate deployment configuration. Additional deployments will be required to adequately evaluate alternative pound net configurations, particularly in areas where Asian carp densities are higher. However, low water levels prohibited testing pound nets at other potential study sites during 2017. Further trials will be conducted once water levels in select backwaters that are known to contain Asian carp are suitable for deployment of pound nets.

Unconventional Gear Development

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). Low water conditions can prohibit effective deployment of pound nets in backwater habitats of the Illinois River. Managers seeking new deployment locations should consider river stage, and consider deploying pound nets earlier in the field season when water levels are more suitable.

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.

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:

When the IDNR Invasive Species Unit (ISU) was formed in 2012, it had limited experience dealing with the complex issues of aquatic invasive species (AIS). The experience and knowledge of the ISU within the AIS field has grown significantly since its inception. While our partners work diligently to prevent the spread of invasive species through natural pathways, our efforts focus on detecting and preventing intentional or unintentional activities within human pathways that threaten our environment. The ISU previously caught a commercial fisherman in an undercover operation who was selling live Asian carp to boost his profits. Another covert operation led to the arrest of an out-of-state bait dealer who illegally sold live rusty crayfish in violation of Illinois laws. Numerous fish haulers and bait dealers have been caught and fined for ignoring the rules Illinois put in place to protect our waterways. Aquaculture inspections have led to the discovery of illegal facilities operating under the radar, and customers who purchased restricted species and stocked them into open waters. The ISU investigated its first case of a cultural/merit release which identified an unlicensed food market and a fish hauler illegally selling and delivering live fish. Food markets inspections revealed the high demand for and presence of live aquatic species being shipped from Asia and other regions into our State. Some of those species are not approved for importation or possession in Illinois, and there is no guarantee they will be used for food after customers leave the store with them. The ISU arrested a fish broker who falsified a restricted species transportation application and illegally stocked hundreds of Grass Carp in ponds and lakes throughout northern Illinois. Internet investigations confirm those involved with pet and aquarium trade want unusual and exotic species for their collections and are willing to go to extreme measures to get them. A click of a mouse can get something shipped from almost anywhere in the world and delivered overnight to the doorstep of the buyer. There was no shortage of activity within the ISU during this project period, but experience and training throughout the years has helped shape the ISU into what it is today. A capable and willing adversary to anyone risking the overall mission to prevent the spread of invasive species.

Objectives:

(1) Continue to educate and assist Conservation Police Officers regarding invasive species regulations and enforcement techniques.

(2) Monitor the Internet for advertisements of illegal invasive species.

(3) Look for illegal sales or importation of invasive species within the bait industry.

(4) Use the portable environmental DNA testing machines to detect any traces of Asian carp during bait shop and bait truck inspections.

(5) Conduct surveillance operations and random checks of live fish markets.

(6) Carry out fish truck inspections for all live shipments we encounter.

(7) Enforce importation regulations of live aquatic life coming into Illinois.

(8) Complete training relevant towards invasive species investigations.

(9) Represent our agency and the ISU at relevant conferences and joint operations related to invasive species issues.

Project Highlights:

- The ISU arrested the owner of a Kentucky fish farm who knowingly imported and stocked fish into multiple ponds throughout Illinois during the past 12 years without VHS import permits or a non-resident aquatic life dealer's license. The owner pled guilty in court and paid $5,000 in restitution to the IDNR.
- The ISU investigated a complaint of two college students who unlawfully released live largemouth bass and tilapia into an Urbana park district pond during a cultural/merit release ceremony. A records search of the Asian food market that sold the fish to the students identified the fish hauler. ISU set up surveillance on the store and inspected the fish truck when it arrived to deliver more fish. The fish hauler had been delivering fish for approximately 7 months without the required restricted species transportation permit or a VHS import permit. The delivery location of the Asian market was not listed as a delivery location on previous permits, and the hauler admitted he delivered non-VHS tested largemouth bass from a university in Indiana to the store. A total of 24 illegal deliveries were documented, and the owner agreed to plead guilty in court and pay $5,000 in restitution to the IDNR.
- The investigation into a Missouri tilapia fish farm revealed the company illegally sold 2,650 tilapia fingerlings to customers throughout Illinois in 2016 & 2017 without applying for the required restricted species transportation permit or purchasing a non-resident aquatic life dealer's license. The fish were shipped to customers via FedEx, and some were released into open waters. The owner of the company was brought into compliance and appropriate enforcement action was taken.
- The ISU cited a Texas company for illegally transporting a boat lift covered in zebra mussels from Texas to Lake Shelbyville in Illinois.
- The ISU discovered a golf course in Southern Illinois illegally stocked 1,000 tilapia in two separate ponds for vegetation control purposes. The fish were ordered on the Internet and shipped via FedEx. The facility manager was unaware it was illegal to stock them and cooperated with the investigation.

Alternate Pathway Surveillance in Illinois - Law Enforcement

Methods:

The ISU generated enforcement activity based upon public complaints and tips, surveillance operations, on-site facility inspections, fish truck inspections, record audits, permit reviews, Internet investigations and working with other agencies.

Results and Discussion:

- The ISU incorporated uniformed Conservation Police Officers into some investigations and facility inspections to help familiarize them with AIS enforcement techniques and provide hands on experience.
- Internet searches for the sale of invasive species mostly located advertisements for Illinois injurious plants, but some advertisements for restricted species like tilapia were also found. The searches did not find any advertisements for live Asian carps. The Internet pathway is of high concern because almost anything can be sold from anywhere in the world and shipped to customers overnight through the mail or a delivery service. Neither the shipper nor customer may have any idea of Illinois regulations, and it can be difficult to detect and prevent these types of transactions. Sellers who are aware of importation laws sometimes alter the name of the product they are illegally selling, so it is harder for officials to find. The ISU actively participated in the Great Lakes Commission's GLDIATR project which is a web monitoring system to identify AIS species for sale and their suppliers.
- The ISU did not identify any instances of the illegal importation of bait within the bait industry. Two retail bait shops were discovered to be operating without the required minnow dealer's license. Those businesses were brought into compliance and a search of their records revealed their bait suppliers had the proper permits and licenses.
- The ISU utilized the portable environmental DNA testing machines in bait shops and open water bodies throughout Northeast Illinois. The testing did not identify any samples that showed a positive result for Asian carp eDNA. The ISU provided feedback to USGS to help improve the deployment of the newly developed technology. The filters became clogged from open water sources before an appropriate amount of water could be run through them. Also, the initial amount of Asian carp eDNA sent in the positive control tubes didn't contain enough liquid to run positive control tests. The technology is suitable for testing relatively clear water in bait shops or bait trucks, but a modification to the filter process is necessary to test ponds and lakes.
- Surveillance operations yielded detailed information on two separate fish haulers illegally delivering live fish to fish markets. None of the information indicates the fish are Asian carp, but future operations are planned to apprehend these individuals. A surveillance operation in Central Illinois resulted in the arrest and guilty plea in court of a fish hauler for attempting to conceal a delivery of live non-tested largemouth bass to a food market. A random inspection detail of live fish markets in Chinatown found two stores that were illegally importing live American eels from New York and selling them.

Alternate Pathway Surveillance in Illinois - Law Enforcement

- All the fish truck inspections conducted for this objective period were random inspections. None of the inspections located any live Bighead or Silver Carp. One inspection of a fish hauler who transports restricted species (barramundi, tilapia, grass carp) found the hauler had an expired restricted species transportation permit. Fish truck inspections have created a positive impact within the fish transportation industry. There is a dramatic increase in compliance with Illinois regulations because the word has spread that fish deliveries are being actively inspected.
- $31,982.00 in restitution was awarded to the IDNR during this objective period because of the ISU taking enforcement action against individuals or companies that violated Illinois importation laws for live aquatic life. ISU made it a priority to educate those who were unaware their actions were illegal, and seek appropriate penalties for the those who knowingly disregarded the law for personal gains.
- The ISU attended training on the following topics: Use of drones in law enforcement; Lacey Act court ruling and the impact on Interstate transportation of AIS; Invasive species identification and reporting; Early detection and distribution mapping system for AIS; Great Lakes Basin aquatic invasive species of concern; Management and prevention options with AIS; Investigation techniques using social networking sites.
- The ISU attended and represented Illinois and the IDNR at the Great Lakes Law Enforcement Committee meetings in Ypsilanti, Michigan and Sault Ste. Marie Ontario. The ISU attended quarterly Environment Crimes Task Force meetings. The ISU assisted the Illinois-Indiana Sea Grant AIS Team with four AIS Pet Take Back events. The ISU and the Kentucky Fish and Wildlife Department cooperated in a joint investigation of a Kentucky Fish Farm that was violating laws in both states.

Recommendations:

The success in preventing the spread of invasive species through human pathways depends upon the ability to communicate and coordinate with multiple agencies and personnel. The ISU should allocate the appropriate amount of time for networking with other agency personnel involved with similar objectives, and assist all relevant requests for assistance from outside agencies. The ISU needs to constantly stay updated with technology advances and trends within the AIS field.

RESPONSE PROJECTS

Upper Illinois Waterway Contingency Response Plan
Operation Silver Bullet Summary

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).

Introduction and Need:

The Illinois Department of Natural Resources and the Asian Carp Regional Coordinating Committee (ACRCC) announced the finding of one Silver Carp in the Illinois Waterway below T.J. O'Brien Lock and Dam, approximately nine miles away from Lake Michigan. The Silver Carp was captured in the Marine Services Corp. Marina at River Mile 324.2 at CAWS Fixed Site #4. The fish was captured with a 3.5-inch gill net by a contracted commercial fisher at 9:45am June 22, 2017 as part of the ACRCC Monitoring Response Work Group's Seasonal Intensive Monitoring project.

The Silver Carp capture triggered two additional weeks of intense sampling in the area, as outlined in the ACRCC's 2017 Contingency Response Plan beginning June 26, 2017 and ending July 7, 2017. It is important to note that this Silver Carp capture does not confirm that a reproducing population of Asian Carp currently exists above the Electric Dispersal Barriers or within the Great Lakes. In eight consecutive years of intensive monitoring and fish sampling in the Chicago Area Waterway System, this is the second time a Bighead or Silver Carp has been found above the Electric Dispersal Barriers. A Bighead Carp was found in Lake Calumet in 2010.

Objectives:

(1) Remove Asian carp from the CAWS upstream of the Electric Dispersal Barrier focusing on the Calumet River, Little Calumet River and Lake Calumet area.

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

Project Highlights:

- Multiagency Response (IDNR, USFWS, USACE) utilized the Incident Command System (ISC) with guidelines set forth in the 2017 Monitoring Response Plan Upper Illinois Contingency Response Plan.

Upper Illinois Waterway Contingency Response Plan
Operation Silver Bullet Summary

Electrofishing:

- Crews from IDNR, USACE and USFWS completed 378 electrofishing runs at target and random sites (94.25 hours total).
- Electrofishing collected 19,876 fish consisting of 51 species and 5 hybrid groups.

Trap (Fyke) Nets:

- Crews from IDNR set seven trap nets in Lake Calumet, totaling 51.9 net nights of effort.
- Trap netting collected 200 fish of 15 species and 1 hybrid group.

Pound Net:

- Crews from IDNR set one-pound net in Lake Calumet, totaling 9 net nights of effort.
- The pound net collected 62 fish of 7 species.

Commercial Netting:

- Contracted commercial fishers along with assisting IDNR biologists set 46.0 miles of gill net (388 sets) at target and random sites.
- Commercial netters collected 1,572 fish of consisting of 23 species and 1 hybrid group.

Electrified Paupier:

- The electrified paupier sampled open-water habitats targeting adult size fish. The nets had 2 inch bar mesh in the body tapering to ¾ inch bar mesh in the cod.
- The electrified paupier conducted 32 sampling sites transects consisting of 15.3 miles of river which equated to over 6 hours of shock time.
- The electrified paupier collected 456 fish representing 14 species.

Summary:

- A total of 22,156 fish representing 52 species and 6 hybrid groups were collected in all gear types combined. (Six Grass Carp were collected and removed).
- Operation Silver Bullet was successful and conducted safely.
- No Bighead or Silver Carp were captured or observed during the operation.

Methods:

As a result of the Silver Carp capture on June 22, 2017, response actions were implemented within the guidelines of the Upper Illinois Waterway Contingency Response Plan contained in the 2017 Monitoring and Response Plan.

The Contingency Response Plan describes specific response actions within the five navigation pools of the Upper Illinois Waterway (IWW) - Lockport, Brandon Road, Dresden Island, Marseilles, and Starved Rock pools (river miles 231 to 327). In the event a change is detected in the status of Asian carp in those pools indicating an increase in risk level, this plan will be

implemented to carry out response actions. This contingency plan allows for deployment of aggressive monitoring or control tools deemed most appropriate by the MRWG, the ACRCC, and the governmental agency holding locational or operational jurisdictional authority.

Command and control of this Asian Carp response in the IWW was implemented under the MRWG. The Incident Command System (ICS) is a management system designed to enable effective and efficient incident management by integrating a combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure. The MRWG utilized the ICS to manage response operations to maximize efficiency and ensure a standard approach across all participating agencies. A Unified Command was maintained to determine the overarching response objectives and in implementing individual tactics necessary to accomplish each objective.

An Incident Action Plan (IAP) is a standard means of documenting and communicating objectives, strategies, and tactics used to address issues resulting from an incident. At the core of a functional IAP are well-written objectives. The standard acronym is "SMART" objectives—objectives that are (1) Specific, (2) Measurable, (3) Achievable, (4) Realistic, and (5) Task-oriented. Objectives can then be inserted into an IAP template. Each response is unique, but the basic concepts of operations and objectives can be the building blocks for a solid IAP that communicates, internally and externally, the jurisdiction's plans for managing an incident. An IAP was created for each week of Operation Silver Bullet.

Description of Gears and Protocols Implemented for Response:
Pulsed DC-electrofishing, trammel and gill nets, deep water gill nets, fyke nets, electrified paupier, and pound nets were used during Operation Silver Bullet to detect any Asian carp in the area of interest which consisted of Lake Calumet, the Calumet River, and the Little Calumet River (Figure 1). Trammel and gill nets were 3 m (10 feet) deep x 91.4 m (300 feet) long in bar mesh sizes ranging from 88.9-108 mm (3.5-4.25 inches). Deep water gill nets were 9.1 m (30 feet) deep x 91.4 m (300 feet) long with bar mesh sizes ranging from 69.9-88.9 mm (2.75-3.5 inches). Pound nets had a single 100.0 m (328.0 feet) by 3.0 m (9.8 feet) lead and two adjustable length wings 3.0 m (9.8 feet) in depth, and a mesh cab, or catch area, 6.1 m long by 3.0 m wide by 3.0 m deep (19.6 x 9.8 x 9.8 feet) square made from webbing. The cab had two, 3.0 m (9.8 feet) long by 2.5 cm (1.0 inch) diameter steel pipes sewn to the bottom of the horizontal panels of the cab serving as weights and one 3.0 m (9.8 feet) long by 7.6 cm (3.0 inches) diameter capped polyvinyl chloride pipe stitched to the top of the rear horizontal cab panel serving as a float. Fyke nets had a single 15.2 m (50.0 feet) long by 1.4 m (4.5 feet) deep lead. The frames of the net were constructed of two, 1.2 m (4.0 feet) by 1.8 m (5.0 feet) rectangular bars made of 8 mm (0.3 inch) black oil temper spring steel. Inner wings (vertical wall throats) of the frame extended from outer corners of the front rectangle to the middle of the rear rectangle. A 76.0 mm (3.0 inches) vertical gap existed on either side of lead between the wings and lead at middle of rear rectangle. A 1.2 m (4.0 feet) webbing covered gap connected the cab and frame together.

The cab was constructed of six, 0.9 m (3.0 feet) diameter spring steel hoops spaced 61 cm (24 inches) apart from each other. Cab and frame together were 6.0 m (20.0 feet) in total length.

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 returned live to the water. Due to similarities in appearance and habitat use, young-of-year (YOY) Gizzard Shad < 152.4 mm (6 inches) 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). Locations for each net set were located and identified with GPS coordinates. Captured fish were identified to species, enumerated and released. Pound nets and Trap "Fyke" nets were set by IDNR biologists and checked once every 24 hours by IDNR biologists and commercial fishers.

Electrified Paupier Protocol – Modeled after shrimp trawlers in the Gulf of Mexico, the paupier has metal frames measuring 3.7 m wide by 1.5 m tall extending off the port and starboard with 52 mm bar mesh nets attached to the frames tapering back approximately 7 m towards the stern to a 20 mm bar mesh cod end. Anodes were powered with a 72-amp or 82-amp ETS box. Anode droppers were affixed to booms 3 – 4 m in front of the frames. In addition, a hemisphere anode was suspended in each paupier frame approximately 1 m back from the net opening. The frames act as the cathodes, concentrating the electric field between the boom anodes, the frame, and the hemisphere anodes inside the net. The boom anodes initially immobilize fish to drift in the net and the hemisphere anodes maintain captured fish. Duty cycle and frequency (pulses/second) were 15% and 30 hertz, respectively. Power output was adjusted based on ambient conductivity and observed immobilization of Silver Carp.

Random and Targeted Site Protocol- Prior to the response, random sampling sites for electrofishing and gill/trammel netting were computer-generated using a Geographic Information System (GIS) software. While in the field, agency biologist or contract fisherman also identified targeted site locations if habitat and safety criteria were met to deploy gear. GPS coordinates (decimal degrees) were recorded at all sampling sites during the response.

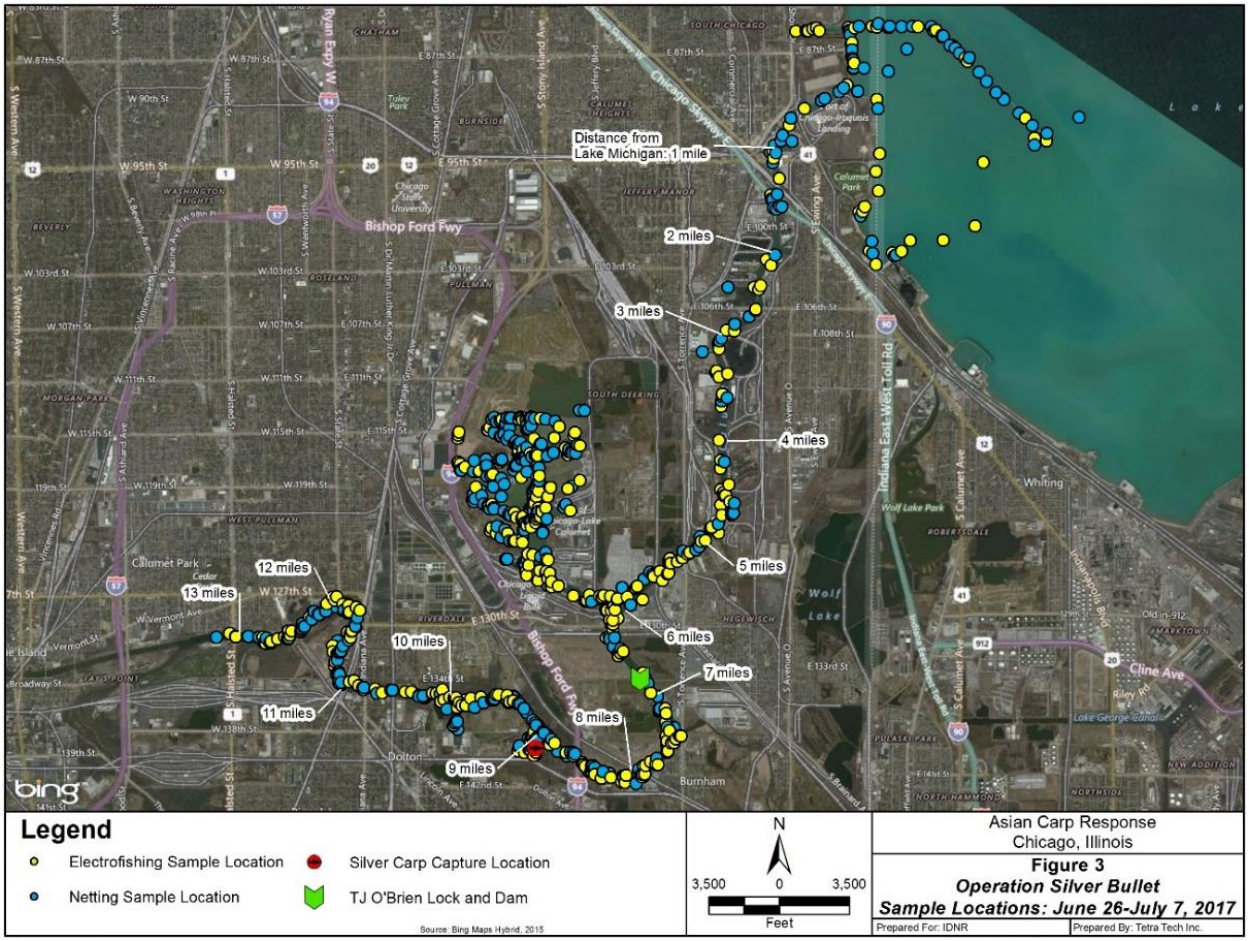

Figure 1. *Location of Operation Silver Bullet evet and sites sampled.*

Results and Discussion:

Operation Silver Bullet took place during the weeks of June 26 and July 3, 2017 upstream of the Electric Dispersal Barrier. **No Bighead or Silver Carp were captured or observed during Operation Silver Bullet**. Effort for this response consisted of 95.25 hours of electrofishing (378 transects) with an estimated 950 person-hours, 74 km (46 miles) of trammel/gill netting (388 sets) with an estimated 900-person hours, 1-pound net fished for 9 net nights with an estimated 45-person hours, and 7 Trap (Fyke) nets fished for 51.9 net nights with an estimated 135-person hours (Table 1.). The electrified paupier expended 24-person hours with 6 hours of sampling effort (32 transects, 15 miles) (Table 3). An estimated 2,054-person hours were allocated for the field operations of this event.

Across all locations and gears, 22,156 fish representing 52 species and 6 hybrid groups were sampled (Table 2 and 3). Gizzard Shad and Common Carp were the predominant species, comprising 32% of all fish sampled. Eleven nonnative species were also sampled, which included Common Carp and hybrids, Round Goby, Alewife, Goldfish, White Perch and hybrids,

Grass Carp, Chinook Salmon and Rainbow Trout. Non-native species made up 13% of the total species collected during the operation. Six hundred and thirty-one (631) Banded Killifish, a state threatened species, were also collected. They were identified and returned to the water alive. In addition, we examined 2,416 young of year (YOY) Gizzard Shad and found no YOY Asian carp.

Recommendation:

Operation Silver Bullet was the first response utilizing the Upper Illinois Waterway Contingecy Response Plan, and as a result, many lessons were learned. The Incident Command System used during this operation proved to be a great asset in tracking resources and promoting communication throughout the event. Constant refinement of the contigency response plan is needed as work continues to further our understanding of the Asian carp habits, our knowledge of the upper Illinois Waterway, and incorporate addional resources for future responses. Continued yearly table top exercises conducted by the Monitoring and Response Workgroup will prove to be benefiecial in the planning and execution of response events.

Upper Illinois Waterway Contingency Response Plan
Operation Silver Bullet Summary

Table 1. *Summary of effort and catch data for Operation Silver Bullet in the CAWS upstream of the Electric Dispersal Barrier 2017*

	Cal Harbor/Lake MI	Lake Calumet-Cal River	Little Cal-Cal Sag	
Electrofishing (EF)				**Total**
Estimated person-hours	270	360	320	950
Samples (transects)	105	152	121	378
EF (hrs)	26	38	30.25	94.25
All fish (*N*)	354	8,767	10,755	19,876
Species (*N*)	15	40	40	51
Hybrids (*N*)	0	5	4	5
Bighead Carp (*N*)	0	0	0	0
Silver Carp (*N*)	0	0	0	0
CPUE (fish/hr)	13.6	230.7	355.5	199.9
Gill/Trammel				
Estimated person-hours	_	540	360	900
Samples (net sets)	_	220	168	388
TRA/GIL (mi)	_	27	19	46
All fish (*N*)	_	788	784	1572
Species (*N*)	_	21	13	23
Hybrids (*N*)	_	1	1	2
Bighead Carp (*N*)	_	0	0	0
Silver Carp (*N*)	_	0	0	0
CPUE (fish/100 yds of net)	_	1.6	2.3	1.95
Fyke Net				
Estimated person-hours	_	135	_	135
Samples (sets)	_	16	_	16
Net nights	_	51.9	_	51.9
All fish (*N*)	_	200	_	200
Species (*N*)	_	15	_	15
Hybrids (*N*)	_	1	_	1
Bighead Carp (*N*)	_	0	_	0
Silver Carp (*N*)	_	0	_	0
CPUE (fish/net night)	_	3.9	_	3.9
Pound Net				
Estimated person-hours	_	45	_	45
Samples	_	3	_	3
Net nights	_	3.9	_	3.9
All fish (*N*)	_	62	_	62
Species (*N*)	_	7	_	7
Hybrids (*N*)	_	0	_	0
Bighead Carp (*N*)	_	0	_	0
Silver Carp (*N*)	_	0	_	0
CPUE (fish/net night)	_	20.7	_	20.7

Upper Illinois Waterway Contingency Response Plan
Operation Silver Bullet Summary

Table 2. *Total number of fish captured with electrofishing, trammel/gill nets, commercial seine, Fyke nets, and pound nets in the CAWS upstream of the Electric Dispersal Barrier during Operation Silver Bullet, 2017*

	Cal Harbor/Lake MI	Lake Calumet-Cal River	Little Cal-Cal Sag	Lake Calumet-Cal River	Little Cal-Cal Sag	Lake Calumet-Cal River	Lake Calumet-Cal River	
Species	Elelctrofishing	Elelctrofishing	Elelctrofishing	Gill/Trammel	Gill/Trammel	Pound net	Trap "Fyke" net	All Sites
Common carp	13	567	1063	293	467	5	9	2417
Gizzard Shad < 6 in		197	2219					2416
Gizzard shad	104	691	1552	17	21	11	6	2402
Pumpkinseed	5	875	1400			5	65	2350
Yellow perch	2	1408	132				22	1564
Emerald shiner		514	903					1417
Bluegill		749	340			27	67	1183
Largemouth bass		489	637					1126
Rock bass	20	853	41					914
Bluntnose minnow		227	637					864
Banded killifish		228	403					631
Freshwater drum	1	55	99	243	194		1	593
Smallmouth bass	76	383	12	3	1			475
Brown bullhead		372	1		2		2	377
Golden shiner		31	260				1	292
Black bullhead		233	34	1			2	270
Black buffalo	4	36	29	113	69			251
Green sunfish		130	117					247
White sucker		70	168					238
Round Goby	38	128	50					216
Spotfin shiner		28	125					153
Channel catfish		52	21	53	6	9	2	143
Brook silverside		25	103					128
Smallmouth buffalo	1	80	13	26	4			124
Alewife	73	20	7					100
Bullhead minnow		39	59					98
White perch		23	59		1		6	89
White bass		34	49	2		2	1	88
Goldfish		9	67	1	4			81
Bowfin		70	4					74
Yellow bullhead		32	14	1	1			48
Spottail shiner		12	20					32
Fathead minnow			31					31
Sand shiner			28					28
Black crappie		5	13			3	5	26
Carp x goldfish hybrid			3	12	8			23
Bigmouth buffalo	1	12	3	5	2			23
Yellow bass		14	3					17
Quillback		11		2	3			16
White Bass x White Perch		1	13					14
Shorthead redhorse	13							13
Orangespotted sunfish			12					12
Unidentified Morone (temperate basses)		2					8	10
White crappie		3	3				1	7
River carpsucker		4		3				7
Walleye		1		5				6
Grass carp		4		2				6
Silver redhorse			2	2				4
Northern pike		2		1				3
Rainbow trout	2							2
White perch x yellow bass hybrid		1	1					2
Central mudminnow			1					1
Chinook Salmon				1				1
Flathead catfish				1				1
Golden redhorse	1							1
Longnose gar							1	1
Unidentified Catostomidae (suckers)		1						1
Western mosquitofish	1							1
Bluegill x longear sunfish hybrid		28						28
Hybrid Sunfish		16	4				1	21
Striped bass x white bass hybrid		2						2
Total Fish	355	8,767	10,755	787	784	62	200	21,710
Species *(N)*	15	40	40	21	13	7	15	52
Hybrids *(N)*	0	5	4	1	1	0	1	6

Upper Illinois Waterway Contingency Response Plan
Operation Silver Bullet Summary

Table 3. *Total effort and number of fish captured with electrified paupier in the CAWS upstream of the Electric Dispersal Barrier during Operation Silver Bullet, 2017*

	Calumet River
Electrified Paupier	
Estimated person-hours	24
Samples (transects)	32
Miles	15
EF (hrs)	6
All fish (*N*)	456
Species (*N*)	14
Hybrids (*N*)	0
Bighead Carp (*N*)	0
Silver Carp (*N*)	0
CPUE (fish/hr)	76
Species	
Gizzard Shad	418
White Bass	15
Common Carp	6
Goldfish	4
Emeral Shiner	3
White Sucker	2
Alewife	1
Black Buffalo	1
Brook Silverside	1
Channel Catfish	1
Freshwater Drum	1
Golden Shiner	1
Largemouth Bass	1
Pumpkinseed	1

APPENDICES

Appendix A:
USGS Integration of New Science and Technology

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Introduction and Need:

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

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

New deterrents, monitoring, surveillance, and decision support tools to increase the efficacy of these two primary tactics (i.e., Electric Dispersal Barrier and targeted removal) in the IMZ would further minimize the risk of introducing Asian carp propagules into the Great Lakes. Redundant deterrent technologies like sound or CO_2 might work better than a single technology because the efficacy of individual technologies is known to vary with environmental conditions and life stage requirements of Asian carp. Tandem and redundant operations allow for protection across a greater range of conditions and life stages, and allow for backup in the case of failure of a single

deterrent technology. For example, few Asian carp have been detected upstream of Brandon Road Lock and Dam, located in the upstream portion of the IMZ. Studies at this location are being conducted to deter Asian carp movement upstream towards the Electric Dispersal Barrier, thereby providing a buffer for the Electric Dispersal Barrier. Additionally, deployment of CO_2 or sound at locks and dams between Brandon Road Lock and Dam and Starved Rock Lock and Dam might limit passage of Asian carp to upstream reaches, allowing fishing to reduce Asian carp abundances in that stretch of river in the short term and may act in a cumulative fashion to reduce propagule pressure at the Electric Dispersal Barrier over time. As well, deterrents (e.g., CO_2, and sound) and algal attractants might be integrated with targeted removal, and eventually other control technologies like piscicide-laced microparticles, to further reduce Asian carp abundance in the IMZ. Greater understanding of the movements, habitats, and behaviors of Asian carp in areas of intense management and elsewhere will allow for better application of existing control and containment tools, and inform development of new tools.

Objectives:

(1) Implement and evaluate new tools for monitoring, surveillance, risk assessment, control, and containment.

(2) Conduct studies on movements, habitats, and behaviors of Asian carp to inform existing and new tools for control and containment.

Project Highlights:

- A chemical control that has some selectivity to Asian carp has been identified and two successful field trials using microparticles were completed, one in Missouri and the second in Indiana.
- A second and third deployment of the Chinese Unified Fishing Method (method of slowly driving fish to areas where they are more easily captured) to remove Asian carp were performed, with approximately 60,000 pounds of fish removed by IDNR in the Hanson Material Services pit in the Marseilles Pool of the Illinois River, and 240,000 pounds of fish by USGS and partners at Creve Coeur Lake in Missouri.
- A thesis on native predators of young-of-year Asian carp in the LaGrange Pool was completed and a manuscript for publication is being drafted.
- A manuscript on natal sources of Asian carp for an emerging population has been drafted.

Methods:

The USGS and its partners including IDNR, SIU, WIU, USFWS, USACE, and others will test new technologies (e.g., underwater sound, CO_2, and feeding attractants) to develop behavioral

information, and conduct life history studies to inform targeted removal and minimize immigration of Asian carp into the upper Illinois River to protect the Great Lakes.

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

a. *Acoustic deterrent*: Coordinate and collaborate with state and federal natural resource agencies to deploy acoustic deterrents at strategic locations in the greater Mississippi River Basin to accomplish management and research objectives. Evaluate the habituation potential of Bighead and Silver Carp to the 100 hp boat motor sound. Evaluate the hearing ability (using Auditory Evoked Potentials; AEPs) of Bighead and Silver carp to provide information to refine sounds useful for carp deterrence.

b. *CO_2 deterrent*: Continue planning for the application of carbon dioxide (CO_2) at a lock chamber in the Upper Mississippi River.

c. *Acoustic stimuli as a potential herding tool*: The removal of bigheaded carps using traditional fishing gear alone is difficult due to their complex behaviors. Therefore, methods that can enhance harvest efficiency may help managers remove carps with gears they already possess or can easily obtain. USGS has conducted a series of field tests evaluating the use of sound for enhancing capture and removal of bigheaded carps. To achieve this, underwater speakers are mounted to boats and the boats are directed in various patterns in order to manipulate fish movement into harvest gears for removal.

d. *Microparticle application:* Coordinate and collaborate with state and federal natural resource management agencies to deploy antimycin-laden microparticles in a field setting to kill Asian carp to accomplish a specific management objective. Evaluate the potential use of microparticles as a passive and unique fish marker for differentiation of discrete fish populations.

e. *Advanced monitoring techniques:* Use genetic tools to verify the identity of morphometrically identified bigheaded carp eggs and larvae collected in standardized monitoring in the upper Illinois River. Finalize and disseminate protocols to use genetic tools (i.e., Next Generation Sequencing and quantitative Polymerase Chain Reaction (qPCR) to efficiently screen ichthyoplankton tows for the presence of Asian carp eggs and larvae.

f. *Assessments of Unified Method:* Prepare and submit manuscript describing the Chinese Unified Method and its potential use in the United States, and work with IDNR to perform second trial of the method, and perform a third trial in Creve Coeur Lake in Missouri. Complete analysis and report on telemetry study during the application of the Unified Method in Hanson Material Services pit in the Marseilles Pool of the Illinois River. Deploy sound as a driving mechanism in the conduct of the Unified Fishing method in Hanson Material Services pit in the Marseilles Pool of the Illinois River, and in

Creve Coeur Lake in Missouri. Analyze the effects of driving and innovative harvest methods at the Creve Coeur location.

g. *Algal attractants:* For this year and moving into 2019, the next phase of chemical attractant research will focus on screening other potential attractants for all four Asian carp species using an electro-olfactogram. Attractants that elicit an electrical response will be further tested to evaluate the species' behavioral response to the stimulus. If a strong behavioral response is observed, field tests will be conducted to determine whether the stimulus can effectively concentrate carp for more efficient removal. When techniques for concentrating carp are shown to be effective, those methods will be shared with interested management agencies so that Asian carp can be harvested more efficiently.

(2) Conduct studies on movements, habitats, and behaviors of Asian carp to inform existing and new tools for control and containment.

a. Complete analysis and reports on field and pond studies assessing native predators to control Asian carp.

b. Continue/initiate studies on otolith microchemistry to determine fish movements through strategic dams and sources of recruitment to emerging and established populations of Asian carp.

c. Develop an Integral Projection Model to evaluate alternate management strategies, namely use of YY-males, for Asian carps.

Results and Discussion:

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

a. *Acoustic deterrent:*

- Habituation to a 100hp boat motor recording was evaluated for Silver and Bighead Carp in UMESC ponds. Data are being processed. A manuscript is expected in 2019.
- Habituation of motivated fish to a 100hp boat motor recording was evaluated for Silver and Bighead Carp in CERC ponds. A manuscript is currently in review
- Hearing tests (i.e., audio evoked potentials) were completed for Silver and Bighead Carp in collaboration with the Univeristy of Minnesota Duluth. For both species, hearing range was higher than previously reported, and hearing sensitivity was lower than previously described. The data were published in Vetter BJ, Brey MK, Mensinger AF (2018) Reexamining the frequency range of hearing in silver (Hypophthalmichthys molitrix) and bighead (H. nobilis) carp. PLoS ONE 13(3): e0192561.

- USGS worked closely with the USACE and the Engineer Research and Development Center to develop an acoustic propegation model and recommend a deterrent array for the Brandon Road lock approach. Data processing is ongoing and will be completed in 2018. A full report is expected in 2019.

b. *CO_2 deterrent*:

- Obtained approval from USACE Rock Island District to conduct CO_2 trials at an auxiliary lock near Lock and Dam 14 on the Upper Mississippi River.
- Completed dye study to characterize mixing within the auxiliary lock test site.
- Completed engineering project with the University of Wisconsin-Platteville to design piping systems for the auxiliary lock.
- Permits to conduct research have been submitted. Several permits have been obtained with the remainder currently in review.

c. *Acoustic stimuli as a potential herding tool:* To date, the use of sound to enhance capture using traditional gears including gill and trammel nets has been evaluated in a tributary and backwater to the Illinois River. Current goals are to test the effectiveness of different sounds and harvest gears for herding and capturing fish. A specific challenge that must be addressed is how to move carps out of deeper holes and large woody debris, areas they typically will not leave. A report is currently being drafted.

d. *Microparticle application*: Two field trials were completed with microparticles. The first trial was conducted in a backwater to the Missouri River near Columbia, Missouri. This study was designed to use a passive marker so that consumption of the microparticle by non-target fishes could be identified. The second trial was conducted in a backwater to the Wabash River near Lafayette, Indiana. The goal of this trial was to evaluate the effectiveness of antimycin-laden microparticles to selectivey kill Silver Carp. Results from these trials have been presented at the International Conference on Aquatic Invasive Species in Fort Lauderdale in October 2017. A manuscript is currently in development and will be submitted during spring of 2018. Additionally, a fungicide that has selectivity to Grass Carp has been identified and a formulation for a Grass Carp bait has been developed.

e. *Advanced monitoring techniques:* A rapid screening protocol for using molecular tools to prioritize ichthyoplankton tows is nearly complete. Preliminary results suggest that a method to sample and analyze ethanol drawn from the preservative of an ichthyoplankton tow sample rather than the eggs or larvae in that sample is a viable option to screen samples that may contain an Asian carp egg and/or larvae.

f. *Assessments of Unified Method:* Complex sound was deployed as a driving mechanism in the conduct of the Unified Fishing method in Hanson Material Services pit in the Marseilles Pool of the Illinois River and at Creve Coeur Lake in Missouri. Approximately 60,000 pounds of fish were captured by IDNR. A report on telemetry study during the

application of the Unified Method in Hanson Material Services pit in the Marseilles Pool of the Illinois River was provided at a meeting of managers. The Creve Coeur Lake effort was completed by USGS in February 2018. Multiple methodologies were employed (including two forms of hydroacoustics, a mark-recapture effort, telemetry, and quantitative environmental DNA) to evaluate untested driving (i.e., sound and electrofishing) and harvesting techniques. In this effort 240,000 pounds of Bighead and Silver Carp were captured. Post-harvest abundance assessments will be completed soon. Analysis of data to evaluate different driving and harvesting techniques is just beginning.

g. *Algal attractants and complex sound to aid in removal efforts:* Studies are currently focused on testing the effectiveness of an algal attractant for concentration of bigheaded carps in the field. Preliminary field tests have been conducted at several sites on the Missouri River, in backwaters of the Illinois River, and at Mallard Lake near St. Louis, utilizing either manual application or automated feeding platforms. More in-depth studies are planned to further test carp attraction to the algal stimulus using automated platforms in habitats with low flow and stable water level. The algal attractant has also been used for the delivery of a poisoned microparticle, to facilitate ingestion by Asian carp. Field applications testing the ingestion of microparticles using the algal stimulus are currently ongoing. Studies evaluating the use of the algal stimulus to enhance capture rates of bigheaded carps using passive capture gears are also ongoing. To date, pound nets have been tested and future studies will further evaluate capture efficiency of pound nets and other passive harvest gears at different locations. Preliminary field studies in 2016 have shown that pound nets paired with a food attractant have the potential to increase harvest. Another goal for this research is to identify habitat types where these techniques and gears are most effective.

2. Conduct studies on movements, habitats, and behaviors of Asian carp to inform existing and new tools for control and containment.

   a. In collaboration with WIU field studies were conducted in the Illinois and Upper Mississippi Rivers to determine the propensity of native predators to consume young-of-year (YOY) Asian carp in areas with established (LaGrange Pool) and emerging (Pool 19) populations. Numerous native species were found to consume YOY Asian carp in both locations. Over 2,000 individual predator diets were examined. A thesis has been completed on the LaGrange Pool study (Anderson, C.A., Diet analysis of native predatory fish to investigate predation of juvenile Asian carp. 2016. A thesis presented to the faculty of the school of graduate studies of Western Illinois University in partial fulfillment of the requirements for the degree Master of Science) and a corresponding manuscript for publication in peer reviewed journal is in preparation. A thesis and manuscript is anticipated in 2019 for the ongoing Pool 19 predation study.

   b. In collaboration with state partners, other otolith microchemistry studies are underway on Asian carp in the Upper Mississippi River. An initial study there is complete, a draft

manuscript has been prepared and is expected to be published in 2018. This study examined over 120 adult Asian carp from Pools 19 and 20 to determine natal sources of recruitment for this emerging population. A second study in collaboration with SIU and WIU is underway to look at microchemistry of Asian carp in the reach between Lock and Dam 19 and Lock and Dam 16 in the Upper Mississippi River to more broadly assess natal sources to this emerging population. A thesis and manuscript from this study is expected in 2019. In collaboration with SIU and IL DNR, a fin ray microchemistry study is underway on native species in the Des Plaines River to assess movement through Brandon Road Lock and Dam. The first field season to establish feasibility of the fin ray microchemistry approach is complete. Native fishes including channel catfish (*Ictalurus punctatus*), buffaloes (*Ictiobus spp.*), carpsuckers (*Carpoides spp.*), black basses (*Micropterus spp.*), and redhorses (*Moxostoma spp.*) were sampled from the Des Plaines, Kankakee, and Illinois rivers. Water samples from the Des Plaines, Kankakee, and Illinois rivers were sampled to establish if unique chemical signatures were present. The 2018 field work will focus on increasing sample sizes of fishes that showed promise from the 2017 feasibility work and are most management relevant. This study is expected to be complete and published in a thesis and peer-reviewed journal in 2019.

c. Develop an Integral Projection Model to evaluate alternate management strategies, namely use of YY-males, for Asian carps. A model to evaluate the use of YY-males to control Grass Carp has been developed. A manuscript has been accepted by a peer-reviewed journal. This model suggests that life history traits of the Grass Carp make control by YY-male technologies unlikely.