2020
INTERIM SUMMARY REPORT
Asian Carp Monitoring and Response Plan

EXECUTIVE SUMMARY

This Asian Carp Interim Summary Report (ISR) was prepared by the Monitoring and Response Work Group (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 21 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 2020 and provides recommendations for next steps for each project.

This ISR builds upon prior plans developed annually since 2011. This 2020 ISR serves as a record of activities and accomplishments by MRWG agencies during 2020. The MRWG has also completed a companion document, the 2021 Asian Carp Monitoring and Response Plan (MRP). The 2021 MRP presents each project's plans for activities to be completed in 2021. The MRP is intended to function as a living document and will be updated at least annually. In conjunction, the 2021 MRP and 2020 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.

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*). For the purpose of this ISR, the term 'Asian carp' refers to Bighead Carp and Silver Carp, exclusive of other Asian carp species such as Grass Carp and Black Carp. 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 2020 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 2020 results for 21 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) **Management 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 2020.

DETECTION PROJECTS

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

- Completed two, 2-week SIM events with conventional gears in the CAWS upstream of the EDBS in 2020.
- No Silver Carp or Bighead Carp were captured or observed in 2020. One Bighead Carp was captured in Lake Calumet in 2010, and one Silver Carp was captured in the Little Calumet River in 2017 with no other captures or observations in any other year.
- An estimated 195 person-hours were spent completing 28.7 hours of electrofishing, setting 222.4 km (138.2 mi) of gill net, and 2.9 km (1.8 mi) of commercial seine in 2020.

- Across all locations and gears, 10,087 fish were sampled representing 44 species and 2 hybrid groups in 2020.
- An estimated 34,919 person-hours have been spent to complete 1,321.6 hours of electrofishing and set 1,297.9 km (806.5 mi) of gill/trammel net, 19.2 km (11.9 mi) of commercial seine, and 114.2 net nights of tandem trap nets, hoop nets, fyke nets, and pound nets since 2010.
- From 2010-2020, a total of 482,675 fish representing 86 species and 8 hybrid groups were sampled, including 2,949 Banded Killifish (state threatened species).
- Young-of-year (YOY) Gizzard Shad (*n*=125,874) were examined and no YOY Asian carp have been found since 2010.
- Non-native species (*n*=17) have been captured accounting for 16 percent of the total number of fish caught and 20 percent of the total species since 2010.
- Recommend continued use of SIM in the CAWS upstream of the EDBS for localized detection and removal of Asian carp. Further recommend continued assessment of experimental gears during SIM as an alternative means for capturing Asian carp.

***Strategy for eDNA Sampling in the CAWS* –** This project continues environmental DNA (eDNA) monitoring in strategic locations in the CAWS that will be used to provide information on the location of Asian carp.

- No regular eDNA sampling events were conducted in 2020 due to COVID-19 and the travel restrictions put in place by the Department of the Interior Region 3 Fisheries Program.
- In February 2020, USFWS conducted sampling of the main sewer lines coming into the Racine Avenue Pumping Station, resulting in positive Asian carp eDNA detection in all four lines.

***Telemetry Monitoring Plan* –** This project uses ultrasonically tagged Asian carp and surrogate species to assess if fish are able to challenge and/or penetrate the EDBS or pass through navigation locks. Sampling Season was abbreviated this year due to constraints imposed by the pandemic.

- To date, the U.S. Army Corps of Engineers (USACE) has acquired 35 million detections from 686 tagged fish.
- No live tagged fish have crossed the EDBS in the upstream direction.
- A high percentage of tagged surrogate fish in the Lower Lockport Pool continue to be detected near the EDBS.
- There were no upstream and three downstream passages of Common Carp between the Brandon Road and Lockport Pools.
- Asian carp continue to be detected throughout the Dresden Island Pool with the majority of detections occurring near the Harborside Marina and Dresden Island Lock.

- Up to 50% of the detected transmitters within Dresden Island Pool were detected near the Dresden Island Lock within a given season. This location registered approximately 75% of all the detections in the pool for the year.

***USGS Telemetry Project* –** This project uses real-time acoustic telemetry receivers for detecting Asian carp and surrogate fish, deployed at strategic locations in the upper Illinois Waterway (IWW). Location information of tagged bigheaded carp (Silver Carp and Bighead Carp) from real-time detections are available online to biologists directing day-to-day fish removal efforts, and as email alerts to managers responsible for executing monitoring and contingency actions.

- Seven real-time receivers were deployed and maintained in the upper Illinois Waterway System in 2020.
- Maintained a system to alert key MRWG personnel of detections of bigheaded carp in areas of concern.
- Completed the quality assurance of the dataset to include data for the years 2012 through 2019. This expanded dataset was compiled from multiple agencies and cooperators through FishTracks data repository.
- Made several advances to the multistate movement model previously developed for invasive carp in this system.

***Monitoring of Fish Abundance and Spatial Distribution near the EDBS and in Lockport, Brandon Road, and Dresden Island Pools* –** This project uses numerous monitoring tools to assess fish populations near the EDBS in an attempt to identify seasonal and temporal trends for fish abundance near the barrier.

- Fish abundances both within and directly downstream of the EDBS were similar across 2020 hydroacoustic surveys conducted from January – March.
- Fish abundances within the EDBS were low with a mean of 0.75 large fish targets detected per survey (min = 0, max = 2 individual large fish targets).
- Fish abundances directly downstream of the EDBS were releativly low with a mean of 1.8 large fish targets detected per survey (min = 0, max = 3 individual large fish targets).
- Large fish density was greatest in Dresen Island Pool (1.1 fish / 100,000 m^3), and similar in Brandon Road and Lockport pools (0.4 fish / 100,000 m^3) during March 2020. Fish densities across all three pools were fairly low and similar to Fall 2019 survey results.
- Fish density was greater in Dresden Island Pool during the summer surveys relative to the densities in Brandon Road and Lockport pools. The greatest fish density was observed during the August survey of Dresden Island Pool. The lowest fish density was observed in during the September survey of Dresden Island Pool. Overall fish density was similar among the three pool during the fall surveys. *Results are from 2019 and March 2020; remaining monthly scheduled surveys canceled due to COVID-19.*

***Distribution and Movement of Small Silver Carp and Bighead Carp in the IWW* –** 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. USFWS limited field crews to two or fewer people to prioritize staff safety during the COVID-19 pandemic. This crew-size limitation restricted small-bodied Asian carp monitoring in 2020.

- In 2020, 51 sites in three Illinois River pools (Starved Rock, Marseilles, and Dresden) were sampled for small-bodied Asian carp, providing 8.03 hours of combined boat electrofishing and dozer trawl effort. This effort yielded no small-bodied Asian carp but yielded 194 large-bodied (greater than 350 mm TL) Asian carp.
- USFWS recommends concluding this study and incorporating the lessons learned from this study into the EDM program.

Larval Fish Monitoring in the IWW **–** 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.

- 404 ichthyoplankton samples were collected from seven sites from the Brandon Road to LaGrange navigation pools of the IWW during May – September 2020, capturing 1,947 Asian carp larvae and 465 Asian carp eggs. The majority of these specimens were collected during the last week in May, with low numbers of eggs and larvae present throughout June. Eggs were collected as far upstream as the Marseilles Pool, and three Asian carp larvae were collected from the Starved Rock Pool during 2020. Overall, numbers of Asian carp eggs and larvae observed during 2020 were very low compared to other recent study years.
- 297 ichthyoplankton samples were collected from Illinois River tributaries during 2020. No evidence of Asian carp reproduction was observed in the Kankakee, Fox, or Mackinaw rivers, but a single Asian carp larvae was collected from the Spoon River, and Asian carp eggs were collected from the Sangamon River in 2020.

Movement and Density of Bigheaded Carp in the Illinois River – Bigheaded carp (Silver Carp and Bighead Carp) spatial distributions vary both seasonally and annually; therefore, quantifying how spatial distributions change through time will help direct contracted harvest efforts to high-density locations in order to maximize removal efficiency. Density hotspots, though, shift throughout the year and vary among years. Thus, assessments of bigheaded carp spatial distributions in Dresden Island and Marseilles pools will allow contracted removal to maintain high harvest rates. Monitoring of bigheaded carp densities via hydroacoustic sampling throughout the Illinois River (Alton to Dresden Island pools) by Southern Illinois University (SIU) has been ongoing since 2012 and is a useful metric to evaluate long-term changes in bigheaded carp abundance. Broad-scale density estimates also help inform management actions in the upper river near the invasion front.

- Repeated hydroacoustic surveys in Dresden Island and Marseilles pools identified areas of high bigheaded carp density and how these locations change through time. These data helped direct contracted removal efforts throughout 2020.
- The ninth year of standardized monitoring of bigheaded carp densities was completed in 2020 from Alton – Dresden Island pools. These data allow for long-term assessments and comparisons of density trends across space and through time.

- Tagging of 188 adult bigheaded carp took place in Alton, LaGrange, and Starved Rock pools to maintain sufficient surveillance to detect adult movements among pools and towards the invasion front.
- Preliminary analysis of movement data indicates that Common Carp respond to similar environmental conditions as bigheaded carp, supporting the use of Common Carp as a surrogate for understanding bigheaded carp movement behavior.
- Bigheaded carp densities in Starved Rock, Marseilles, and Dresden Island pools were not completed due to COVID-related delay in processing capture data.
- Bigheaded carp densities in Alton pool during fall 2020 were similar to past years. La Grange and Peoria pool bigheaded carp densities in fall 2020 were slightly lower than previous years, excluding 2019, which was a flood year.
- Bigheaded carp spatial distributions change through time and are not consistent across years, necessitating repeated surveys in Dresden Island and Marseilles pools in order to direct harvest efforts to appropriate locations. Standardized fall hydroacoustic surveys from Alton–Dresden Island pools are also needed to monitor long-term population trends that act as an additional surveillance tool and can assist in making management decisions.

***Habitat Use and Movement of Juvenile Silver Carp in the Illinois River Using Telemetry* –** Laboratory tests have indicated the EDBS is sufficient for stopping large-bodied fish passage but tests on small Bighead Carp (51-76mm total length) have indicated that the operational capabilities of the EDBS may be insufficient to block passage of small-bodied fishes. Acoustic and radio telemetry provide a means to directly evaluate habitat use and movement patterns of young life-stage Silver Carp and their risk of breaching the EDBS. Additionally, information on juvenile Silver Carp habitat preferences can be exploited by monitoring agencies to improve both the effectiveness and efficiency of juvenile Silver Carp early detection monitoring.

- 37 juvenile Silver Carp were tagged in 2019
- Due to insufficient data (low detection of telemetered fish), mean weekly movement distance of telemetered juvenile Silver Carp could not be calculated for 2019 or 2020.
- Due to insufficient data, mean residence times by habitat area for telemetered juvenile Silver Carp could not be calculated for 2019 or 2020 (no tag detections met the criteria of a residence events; see methods for criteria).

***Des Plaines River and Overflow Monitoring* –** In 2020, sampling was conducted in the upper Des Plaines River from E Romeo Rd (Romeoville, Illinois) to Columbia Woods (Willow Springs, Illinois). Sampling was performed using pulsed-DC boat electrofishing and short term (1 – 2 hours) surface to bottom gill net sets. No Bighead Carp or Silver Carp have been captured or observed through all years of sampling (2011-2018).

- Collected 13,882 fish representing 67 species and 4 hybrid groups from 2011 – 2020 via electrofishing (81.5 hours) and gill netting (153 sets; 23,684 yards [21,656.7 m]).
- No Bighead Carp or Silver Carp have been captured or observed through all years of sampling.
- Ten Grass Carp have been collected since 2011. No Grass Carp collected in 2020.

- Four overtopping events since 2011 have resulted in several improvements to the barrier fence. One overtopping event occurred in 2020.

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.

- 44 Bighead Carp and one Silver Carp have been removed from 10 ponds.
- Eight Bighead Carp and one Silver Carp killed by either natural die-off or pond rehabilitation with piscicide have been removed from Chicago area ponds since 2008.
- 18 of the 21 IDNR Chicago Urban Fishing Program ponds have been sampled with nets and electrofishing.

Multiple Agency Monitoring of the Illinois River for Decision Making – This project uses standardized methodology to monitor Bighead Carp, Black Carp, Grass Carp, and Silver Carp populations in pools below the EDBS. This monitoring is necessary to understand their upstream progression and minimize the risk of establishment above the EDBS. Extensive monitoring also provides managers the ability to evaluate the impacts of management actions (e.g., contracted removal) and collect data to assist other projects (e.g., Spatially Explicit Asian Carp population [SEACarP] model). Data collected from a standardized multiple gear sampling approach have been used to create accurate and comparable relative abundance estimates of specific species and detect the presence of previously unrecorded invasive species.

- In 2020, an estimated 7,845 person-hours were expended sampling fixed and random sites downstream the EDBS including 169 hours of electrofishing, 1,353.46 hoop netting net nights, 440.01 minnow fyke netting net nights, and 91.64 fyke netting net nights.
- A total of 252,911 fish representing 107 species and 13 hybrid groups were captured in 2020.
- No Asian carp (large or small) were captured in Lockport or Brandon Road pools in 2020.
- The leading edge of the Bighead Carp and Silver Carp populations remained around river mile 281 (north of I-55 Bridge within the Dresden Island Pool near the Rock Run Rookery) in 2020.
- Small Silver Carp and Bighead Carp (< 6 inches/152.4 millimeters [mm]) were captured Peoria Pool (river mile 216; ~108 miles from Lake Michigan) in 2020. 14 miles further upriver than 2019.
- Data from projects outside of the MRWG MRP were incorporated because of standardization, creating a comprehensive synthesis of each Asian carp species' status across the entire Illinois River Waterway below the EDBS in 2020.

MANAGE AND CONTROL PROJECTS

USGS Illinois River Monitoring and Evaluation – This project incorporates all data from removal and monitoring efforts into a centralized database. This centralized database facilitates data standardization, accessibility, sharing, and analysis to aid in Asian carp removal efforts, evaluations of management actions, and population modeling.

- Completed validation of hydroacoustic survey data (e.g., multi-beam and sidescan sonar), collected in priority management areas throughout the Illinois River and processed into a suite of benthic data layers.
- Completed tracking and activity data from boats and gear deployments into animated visualization overviews of Unified Method fishing events for several Dresden Island Unified Method events.
- Continued development of an online, interactive mapping tool as a centralized access point for existing Asian carp-related data layers.

Contracted Commercial Fishing Below the EDBS – This project uses contracted commercial fishers to reduce Asian carp (Bighead Carp, Black Carp, Grass Carp and Silver Carp) abundance and monitor for changes in range in the Des Plaines River and upper Illinois River, downstream of the EDBS. By decreasing Asian carp abundance, we anticipate reduced migration pressure towards the EDBS, lessening the chances of Asian carp gaining access to upstream waters in the CAWS and Lake Michigan.

- Since 2010, contracted commercial fishers effort in the upper IWW below the dispersal barrier includes 4,317 miles (6,947km) of gill/trammel net, 20 miles (31 km) of commercial seine, 245 Great Lakes pound net nights, and 4,369 hoop net nights.
- In total, 101,579 Bighead Carp, 1,157,698 Silver Carp, and 10,461 Grass Carp were removed by contracted fishers from 2010-2020. The total estimated weight of Asian carp removed is 5147.5 tons (10,295,000 lbs.).
- No Asian carp have been collected in Lockport or Brandon Road Pools since the inception of this project in 2010.
- The leading edge of the Asian carp population remains near Rock Run Rookery in Dresden Island Pool (~river mile 281; 46 miles from Lake Michigan). No appreciable change has been found in the leading edge over the past 10 years.
- Since 2010, this program has been successful at managing the Asian carp population in the upper Illinois River. Continued implementation of this project will provide the most current data on Asian carp populations at their leading edge and reduce pressure on the EDBS.

Asian Carp Population Modeling to Support an Adaptive Management Framework **–** This project involves the creation and refining/updating of the SEACarP model. This model is used to predict Asian carp population density and movement amongst pools in the Illinois River. The model can be used to simulate different management and control actions to assist managers in prioritizing these actions.

- Updated demographic parameters for Silver Carp and Bighead Carp across the Illinois River with an additional 13,000 fish from 2018 and 2019.

- Solicited critical feedback from quantitative experts including feedback on model assumptions, design, and analysis to promote model-based tool development and improvements and incorporated feedback and rerun model simulations.
- Model predictions indicated that additional lower pool mortality was a more effective long-term control strategy than additional upper pool mortality. Similarly, model results from scenarios that focused on upstream movement deterrence indicated that reduced passage immediately upstream of source populations was more effective than alternative sites located further upstream. Further, model simulations provide evidence that the most effective long-term strategy to manage Silver Carp is by using a combination of control methods. Larger reductions in Silver carp relative abundance were realized by combining upstream movement deterrence with additional mortality in lower and upper pools.
- Continued to work closely with MRWG technical workgroups to prioritize future data collections and research using population model assumptions and limitations as a decision support tool.

***Telemetry Support for the SEACarP Model* –** This project supports the SEACarP model by providing additional monitoring of Asian carp via telemetry. Movement is the backbone of the SEACarP model and is the primary source of information about how researchers expect the population to respond to management strategies. Therefore, the model functions as an important tool that can be used by fisheries managers to inform harvest and control of adult Asian carp (Silver Carp and Bighead Carp) in the IWW. Because harvest effects such as changes in fish density and size distributions are likely impact movement and will thus influence our ability to predict population responses, continued monitoring of Asian carp movement in the IWW is necessary. This research provides an improved understanding of Asian carp movement in the IWW and its effects on population dynamics.

- Due to safety concerns surrounding the COVID-19 pandemic, USFWS did not implant acoustic transmitters in any Asian carp in 2020.
- Data from the five 69 kHz acoustic receivers were collected, processed, and provided to the Telemetry Work Group.
- 150 V-9 acoustic transmitters were ordered with delivery rescheduled for March 2021.

***Asian Carp Demographics* –** This project focuses on building a more robust understanding of Asian carp population demographics throughout the Illinois River, including establishing/ refining consensus metrics for identification, sexing, and age determination of Asian carp.

- Collected over 4,500 Silver Carp from six pools of the Illinois River during 2018 - 2020 and processed nearly 700 aging structures. 1,307 Silver Carp were collected from the lower three pools of the Illinois River during fall 2020 with the electrified dozer trawl.
- Contributed to the comprehensive Asian carp dataset using Silver Carp captured from three pools of the Illinois River with the electrified dozer trawl. Standardized data collections included length, age, sex, and relative abundance.
- Provided data useful to measure population responses to changes in management strategies.

- Coordinated with the MRWG Monitoring Work Group to share age and maturity determination procedures.
- Coordinated with the Illinois Natural History Survey (INHS) to provide recommendations on precision and accuracy of Asian carp ageing structures.
- Confirmed the electrified dozer trawl as an effective standardized method for demographic data collection.

Evaluation of a Modular Electric Barrier – This project focuses on testing and evaluating the use of a modular, transportable electric barrier to prevent the passage of Asian carp. Electric barriers have been used to impede or direct the movements of fishes for many years. However, almost all electric barriers used by fisheries agencies are constructed at fixed locations and are therefore stationary. Stationary electrical barriers currently serve as a line of defense in blocking the expansion of Asian carp into the Laurentian Great Lakes. Although useful for specific control purposes, such designs lack spatial flexibility and thus the capacity for adaptive management applications. Modular electric barriers may provide managers with the option to deploy control measures in a variety of locations to achieve various management objectives.

- A modular electric deterrent barrier system has been procured by INHS. Because this barrier system is modular, it can be transported and deployed at a variety of locations. This system consists of a series of pulsers, generators, and winch-housed electrode cables that can be scaled to produce an electric field capable of deterring fishes across a range of waterbody conductivities and channel dimensions.
- A field deployment of the modular electric barrier in 2020 determined that sufficient voltage gradients for deterring the movements of Asian carp were produced at and near the electrodes when the barrier was operated at recommended settings. The field produced by the modular barrier system is therefore suitable for the purposes of controlling movements of Asian carp.
- INHS has produced deployment guidelines that should provide a thorough overview of the considerations, planning, and procedures that are required to operate the modular barrier system. The modular electric barrier system should be available to partner agencies for use at locations where preventing passage of Asian carp or other invasive fishes has been determined to be a high priority, and where other deterrent measures are not sufficient or readily available to achieve desired objectives.

Alternate Pathway Surveillance in Illinois – Law Enforcement – The IDNR Invasive Species Unit (ISU) was created in 2012 as a special law enforcement component to the overall Asian carp project.

- The owner of a Missouri fish farm previously charged with selling and shipping live tilapia to Illinois customers, which is in violation of fish importation regulations, entered into a deferred prosecution agreement with the Illinois Attorney General's Office and was ordered to pay $8,000 in restitution to the State of Illinois.

- A New Mexico fish farmer charged with multiple counts of shipping live tilapia to unapproved aquaculture facilities and without the required permits pled guilty to all counts and paid the designated fines.
- ISU investigated an anonymous complaint of a bait shop illegally selling frozen shad and Asian carp parts as bait. The investigation revealed the shad were illegally harvested from a prohibited area and the Asian carp bait violated Viral Hemorrhagic Septicemia regulations. The business was brought into compliance with all regulations.

Asian Carp Enhanced Contract Removal Program – This project focuses on enhancing Asian carp removal in strategic locations, as determined by modeling efforts, including the SEACarP model. The project provides an economic incentive to commercial fisherman that remove Asian carp from targeted locations. Removal efforts currently focus on Peoria Pool.

- Removed more than 3,300,000 pounds under this program from the Peoria Pool of the Illinois River.
- Entered into thirty-one contracts with Illinois-licensed commercial fishers targeting the Peoria Pool.
- Processed more than $330,000 in payments to fisherman.
- Selected a firm/team to create a Branding & Marketing Strategy and created a new name and logo for Asian carp. Preparation toward a launch event is well under way.

RESPONSE PROJECTS

Contingency Response Plan Actions – No response actions were necessary during 2020. As part of the Contingency Response Plan, barrier maintenance fish suppression is conducted to support USACE during maintenance operations at the EDBS. This process 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 EDBS at each primary barrier loss of power to water.
- Two 15-minute electrofishing run were completed between Barriers 2A and 2B to supplement existing data in support of the MRWG clearing decision.
- Split-beam hydroacoustics and side-scan sonar assessed the risk of large fish presence between the barriers on a bi-weekly basis, both below and within the EDBS indicating fish over 300 mm, but in low abundance.
- In 2020, hydroacoustic scans at the barriers did not occur. COVID-19 restrictions prevented USFWS from safely conducting the scans and traditional monitoring in Lockport was used to assess risk.
- No Asian carp were captured or observed during fish suppression operations.

INTRODUCTION

The 2020 Interim Summary Report (ISR) presents a comprehensive accounting of project results from activities completed by the Asian Carp Monitoring and Response Work Group (MRWG) in 2020. 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 nine 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 2019 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.

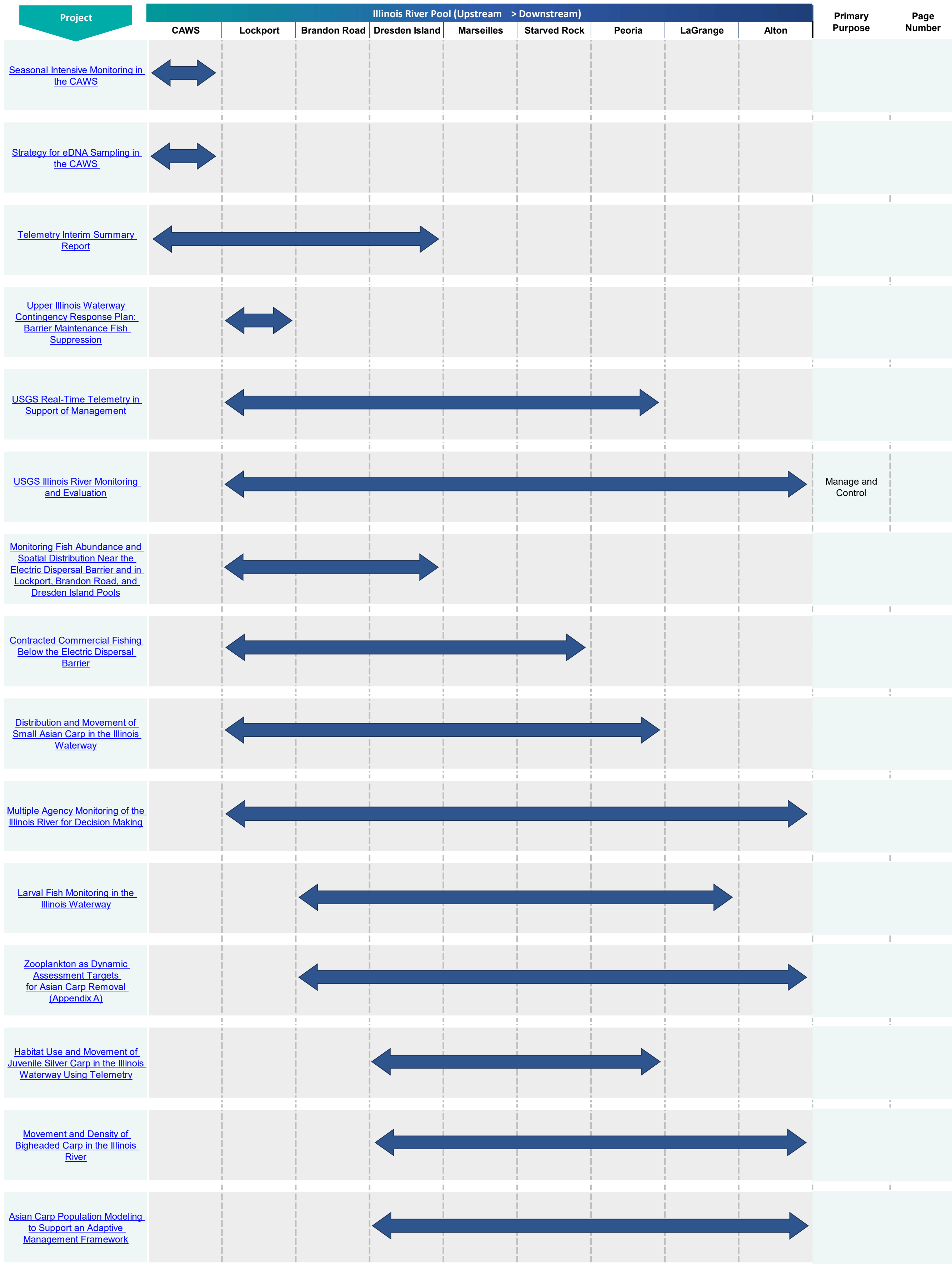
Flooding events during the 1980s and 1990s allowed Asian carp to greatly expand their range in natural river systems. Asian carp are currently wide spread in the Mississippi River basin, including the Ohio River, Missouri River, and Illinois River. Areas with large populations of Asian carp have seen 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.

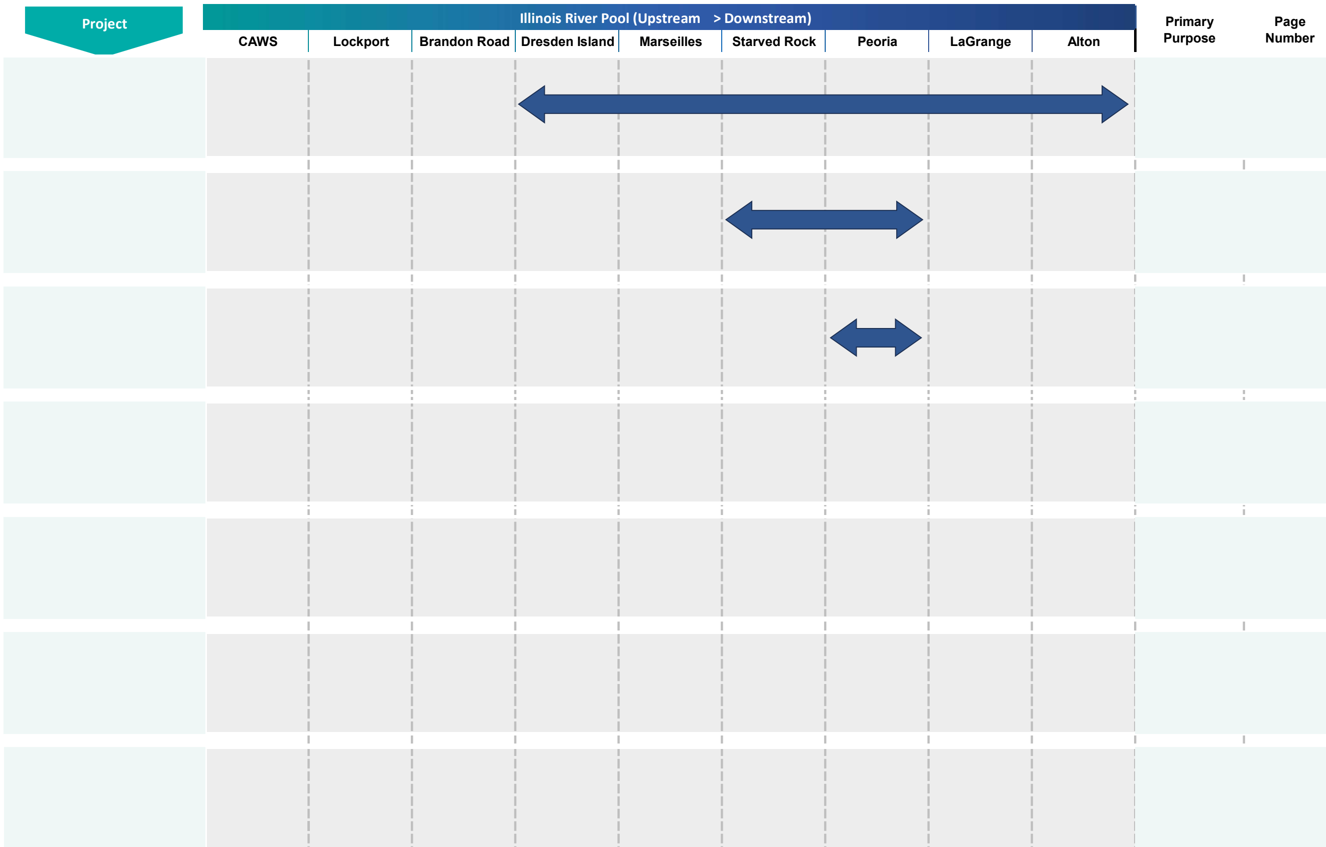
The expansion of Asian carp populations throughout the central U.S. has had enormous impacts on local ecosystems and economies. Where Asian carp are present, the native ecosystems have been altered, resulting in changes to the populations and community structure of aquatic organisms. The trademark leaping 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 (ACRCC) and the Asian Carp MRWG 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.

PROJECT LOCATIONS

In an effort to more clearly depict the geospatial scale and focus of the projects included in the Monitoring and Response Plan (MRP), the MRWG has prepared a project location cross-walk. This cross-walk is intended to be used as a tool to allow readers to quickly understand where a specific project focuses its efforts, and also to quickly discern all projects that are operating in a specific portion of the Illinois Waterway. The project cross-walk tool includes links to specific project ISRs for readers using a digital version of the ISR, and page numbers for readers using a physical version. In that sense, it can also function as an additional table of contents for the document. The project cross-walk tool is presented below.


Project
Illinois River Pool (Upstream > Downstream)
CAWS
Lockport
Brandon Road
Dresden Island
Marseilles
Starved Rock
Peoria
LaGrange
Alton
Primary Purpose
Page Number
Seasonal Intensive Monitoring in the CAWS
Strategy for eDNA Sampling in the CAWS
Telemetry Interim Summary Report
Upper Illinois Waterway Contingency Response Plan: Barrier Maintenance Fish Suppression
USGS Real-Time Telemetry in Support of Management
USGS Illinois River Monitoring and Evaluation
Manage and Control
Monitoring Fish Abundance and Spatial Distribution Near the Electric Dispersal Barrier and in Lockport, Brandon Road, and Dresden Island Pools
Contracted Commercial Fishing Below the Electric Dispersal Barrier
Distribution and Movement of Small Asian Carp in the Illinois Waterway
Multiple Agency Monitoring of the Illinois River for Decision Making
Larval Fish Monitoring in the Illinois Waterway
Zooplankton as Dynamic Assessment Targets for Asian Carp Removal (Appendix A)
Habitat Use and Movement of Juvenile Silver Carp in the Illinois Waterway Using Telemetry
Movement and Density of Bigheaded Carp in the Illinois River
Asian Carp Population Modeling to Support an Adaptive Management Framework


Project
Illinois River Pool (Upstream > Downstream)
CAWS
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DETECTION PROJECTS

Seasonal Intensive Monitoring in the CAWS

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

Pools Involved: Chicago Area Waterway System (CAWS)

Introduction and Need:

Detections of Asian carp (Silver Carp and Bighead Carp) environmental deoxyribonucleic acid (eDNA) upstream of the Electric Dispersal Barrier System (EDBS) in 2009 initiated the development of a monitoring plan that utilized boat electrofishing and contracted commercial fishers to sample for Asian carp at five fixed sites upstream of the barrier. Random area sampling began in 2012 in order to increase the chance of detecting Asian carp in the CAWS beyond the designated fixed sites. Extensive sampling performed upstream of the EDBS from 2010 through 2013 (682 hours of electrofishing, 445.8 kilometers (km) (277 miles [mi]) of gill/trammel net, and 2.2 km (1.4 mi) of commercial seine hauls) resulted in one Bighead Carp being collected in Lake Calumet in 2010. Fixed site and random area sampling effort was then reduced upstream of the barrier to two Seasonal Intensive Monitoring (SIM) events from 2014-2020. Following effort reduction, one Silver Carp was collected in the Little Calumet River in 2017, resulting in a rapid, interagency contingency response effort. Effort reduction upstream of the EDBS allows for increased monitoring efforts downstream of the barrier. Increased sampling downstream of the EDBS focuses sampling effort at the leading edge (Dresden Island Pool) of the Asian carp population, which serves to reduce their numbers in that area, reducing the risk of individuals moving upstream towards the EDBS and Lake Michigan by way of the CAWS. Results from SIM upstream of the EDBS will contribute to our understanding of Asian carp abundance in the CAWS and guide actions designed to remove Asian carp from areas where they have been captured or observed.

Objectives:

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

(2) Remove Asian carp from the CAWS upstream of the EDBS when warranted.

Project Highlights:

- Completed two, 2-week SIM events with conventional gears in the CAWS upstream of the EDBS in 2020.
- No Silver Carp or Bighead Carp were captured or observed in 2020. One Bighead Carp was captured in Lake Calumet in 2010, and one Silver Carp was captured in the Little Calumet River in 2017 with no other captures or observations in any other year.
- An estimated 195 person-hours were spent completing 28.7 hours of electrofishing, setting 222.4 km (138.2 mi) of gill net, and 2.9 km (1.8 mi) of commercial seine in 2020.
- Across all locations and gears, 10,087 fish were sampled representing 44 species and 2 hybrid groups in 2020.
- An estimated 34,919 person-hours have been spent to complete 1,321.6 hours of electrofishing and set 1,297.9 km (806.5 mi) of gill/trammel net, 19.2 km (11.9 mi) of commercial seine, and 114.2 net nights of tandem trap nets, hoop nets, fyke nets, and pound nets since 2010.
- From 2010-2020, a total of 482,675 fish representing 86 species and 8 hybrid groups were sampled, including 2,949 Banded Killifish (state threatened species).
- Young-of-year (YOY) Gizzard Shad (*n*=125,874) were examined and no YOY Asian carp have been found since 2010.
- Non-native species (*n*=17) have been captured accounting for 16 percent of the total number of fish caught and 20 percent of the total species since 2010.

Methods:

Pulsed DC-electrofishing, gill and trammel 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 EDBS (Figure 1). Gill and trammel nets were 3 meters (m) (10 feet [ft.]) deep x 91.4 m (300 ft.) long in bar mesh sizes ranging from 88.9-108 millimeters (mm) (3.5-4.25 in). Deep water gill nets were 9.1 m (30 ft.) deep by 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 by 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 centimeter (cm) (1.0 inch [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 frame of the net was constructed of two, 1.2 m (4.0 ft.) by 1.8 m (5.0 ft.) rectangular bars made of 8 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.

Intensive electrofishing and netting took place at five fixed site areas and four random site sampling areas. Random sites were generated with GIS software from shape files of designated random site areas. For a more detailed description of fixed and random sampling areas, see the 2020 Monitoring and Response Plan (MRP).

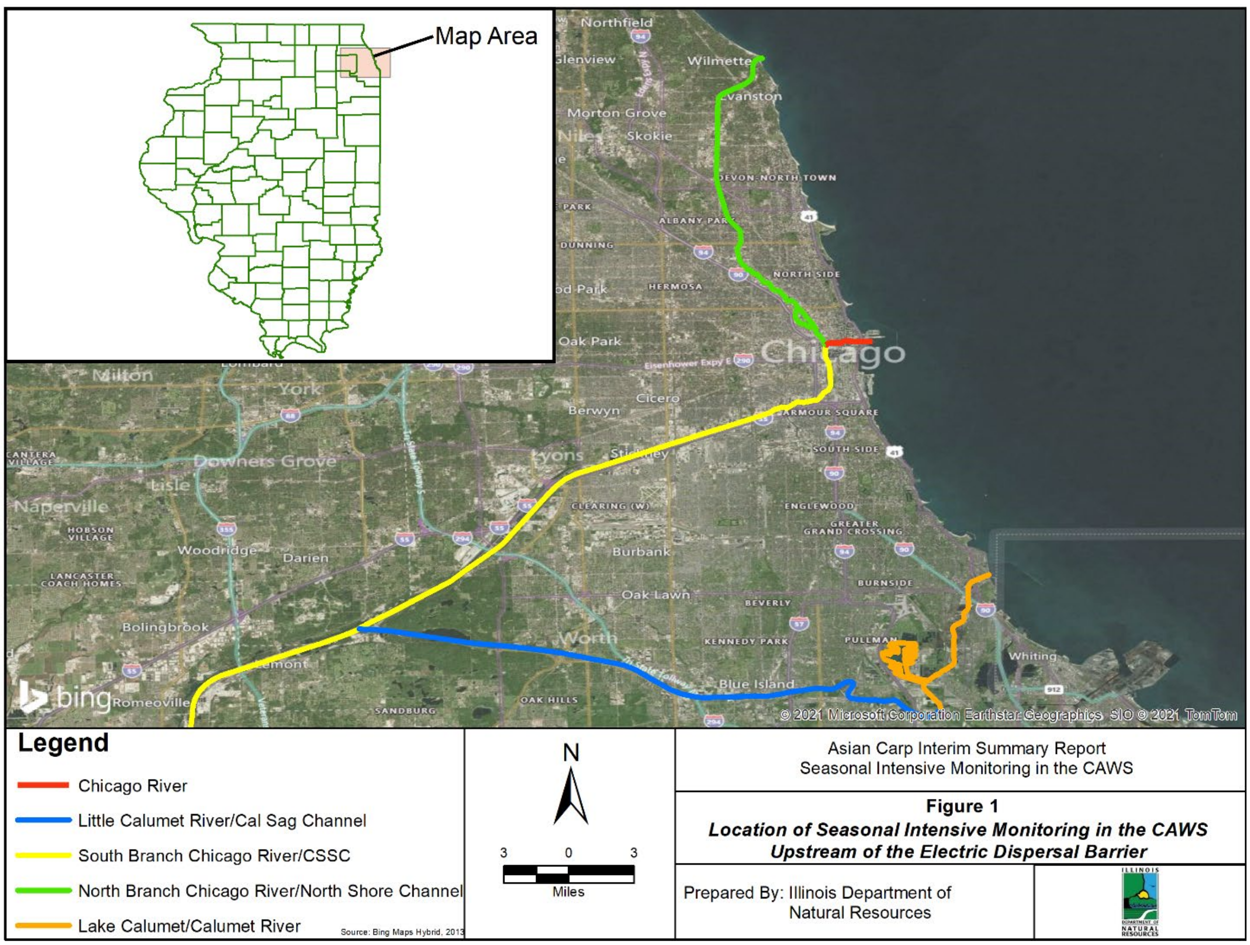


Figure 1. *Location of SIM in the CAWS upstream of the Electric Dispersal Barrier.*

Seasonal Intensive Monitoring in the CAWS

Decontamination Protocol

Consistent with findings from the 2013 eDNA Calibration Study, the potential for Asian carp genetic material in eDNA samples exists as the result of residual material on sampling equipment (boats, netting gear, etc.). In response to these findings, the Monitoring and Response Work Group (MRWG) developed a Hazard Analysis and Critical Control Points 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 percent solution) of boats and potentially contaminated equipment for all agency boats participating in the SIM (MRWG 2020; Appendix C). Additionally, all nets used are site-specific to the CAWS and are only used for monitoring efforts upstream of the EDBS.

COVID-19 Specific Guidelines

Due to an unforeseen global pandemic, the makeup of agency contribution was modified in 2020 as IDNR and USACE were the only two agencies that were able to participate. Social distancing guidelines set by the Center for Disease Control were enforced and disinfecting procedures were utilized during both SIM events in the CAWS.

Electrofishing Protocol

Each boat used pulsed DC-electrofishing at fixed and random sites with two dip-netters to collect stunned fish. The 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 the 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 while all other fish were netted and placed in a holding tank, identified, and counted, and returned live to the water. Due to similarities in appearance and habitat use YOY Gizzard Shad less than 152.4 mm (6 in.) long were examined closely for the presence of YOY Asian carp and enumerated.

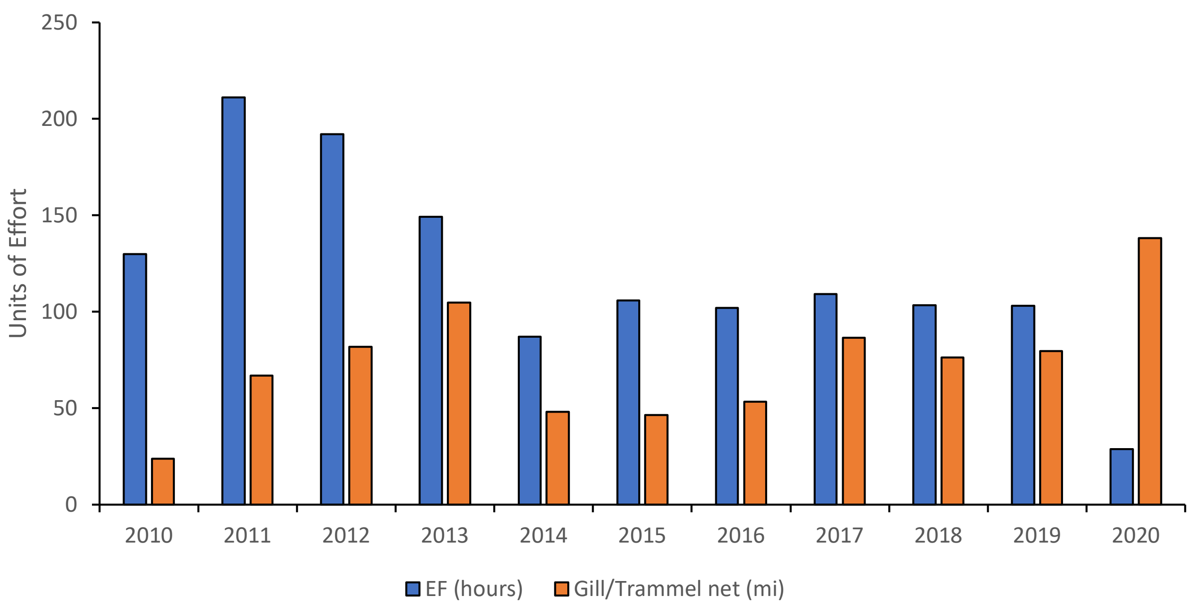
Netting Protocol

Contracted commercial fishers set gill at fixed and random sites. Sets were of short duration (~15 minutes) 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) increasing detection probability (Butler et al. 2018). In Lake Calumet, a 731.5 m (2,400 ft.) commercial seine was also used. 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 agency biologists and checked once every two net nights.

Results and Discussion:

SIM took place during the weeks of June 8th, June 15th, September 14th, and September 21st in 2020. Sampling for Bighead Carp and Silver Carp eDNA did not proceed SIM in the spring and the fall event due to COVID-19 (see Strategy for eDNA Monitoring in the CAWS interim summary). Notable changes from the 2020 MRP-designed SIM event included transitioning from electrofishing and netting to nearly all netting (with doubled netting effort) and efforts was reduced to two, 2-week sampling events due to agency capabilities during COVID-19 (Figure 2). Effort in 2020 was 28.7 hours of electrofishing (127 transects) requiring an estimated 195 person-hours, 222.4 km (138.2 mi) of gill netting (1,252 sets) utilizing an estimated 2,655 person hours, and 2.9 km (1.8 mi) of commercial seine with an estimated 180 person hours (Table 1). Fyke nets were not deployed in 2020 due to high water levels and observed native species mortality in 2018. Fyke net use should be evaluated based on conditions in the future. Pound nets and trammel nets were similarly not deployed in 2020.

Figure 2. *Total electrofishing and trammel/gill netting effort at fixed and random sites in the CAWS upstream of the Electric Dispersal Barrier System, 2010-2020.*



Across all locations and gears, 10,087 fish representing 44 species and 2 hybrid groups were sampled in 2020 (Table 2). Netting was predominately used versus electrofishing in 2020. Alternation in individual gear effort may have biased the abundance/species composition collected compared to prior years. Gizzard Shad and Common Carp were the predominant species, comprising 57 percent of all fish sampled. Seven non-native species were sampled, which included Common Carp and hybrids, Round Goby, Alewife, Goldfish, White Perch, Oriental Weatherfish, and Grass Carp. Non-native species made up 16 percent of the total species collected and 42 percent of the total fish by count in 2020. All species collected in 2020 had been detected in prior years. In addition, 934 YOY Gizzard Shad were examined, and none found to be YOY Asian carp. No Bighead Carp or Silver Carp were captured or observed.

An estimated 34,919 person-hours were expended monitoring fixed and random sites upstream of the EDBS since 2010. Total effort was 1,321.6 hours of electrofishing (5,283 transects), 1,297.9 km (806.5 mi) of gill/trammel net (7,114 sets), 19.2 km (11.9 mi) of commercial seine hauls and 114.2 net nights of hoop, pound and fyke nets from 2010-2020 (Table 3). Hoop net use was suspended after 2013 due to low gear efficiency. A total of 482,675 fish representing 86 species and 8 hybrid groups have been sampled since 2010 (Table 3). Gizzard Shad, Common Carp, Bluegill, Largemouth Bass, Bluntnose Minnow, and Pumpkinseed were the predominant species sampled, accounting for 77 percent of all fish collected. Since 2010, 17 non-native species have been caught, which include Alewife, Bighead Carp, Brown Trout, Chinook Salmon, Coho Salmon, Common Carp and hybrids, Goldfish, Grass Carp, Oriental Weatherfish, Rainbow Smelt, Rainbow Trout, Round Goby, Silver Arrowana, Silver Carp, Threespine Stickleback, Tilapia, and White Perch. Non-native species constitute 16 percent of the total number of fish caught and 20 percent of the total species. One Bighead Carp was caught in a trammel net in Lake Calumet in 2010, and one Silver Carp was captured in a trammel net in the Little Calumet River on June 22, 2017 with no other captures or observations in other years. Furthermore, 125,874 YOY Gizzard Shad have been examined since 2010 with no YOY Asian carp being identified.

Recommendation:

We recommend continued use of SIM upstream of the EDBS. 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. We plan to implement similar levels of electrofishing as in 2016-2019, due to the impacts on species richness and total catch of the reduced effort in response to COVID. Furthermore, we recommend continued assessment of experimental gears during SIM as an alternative means for capturing Asian carp.

References:

Asian Carp Monitoring and Response Working Group (MRWG). 2020. 2020 Monitoring and Response Plan for Asian Carp in the Upper Illinois River and Chicago Area Waterway System. Illinois, Chicago.

Seasonal Intensive Monitoring in the CAWS

Kevin Irons, Justin Widloe, Nathan Lederman, Eli Lampo, Charmayne Anderson, Claire Snyder (Illinois Department of Natural Resources), Andrew Mathis, Allison Lenaerts, Dan Roth, Jehnsen Lebsock (Illinois Natural History Survey)

Table 1. *Summary of effort and catch data for Seasonal Intensive Monitoring in the CAWS upstream of the Electric Dispersal Barrier System, 2020.*

Locations of Efforts	**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	60	45	15	30	45	195
Samples (transects)	52	38	11	2	24	127
Electrofishing hours	13	9.5	2.28	0.15	3.78	28.7
Electrofishing Catch						
All fish (*N*)	1,574	3,198	175	0	297	5,244
Species (*N*)	28	28	9	0	17	38
Hybrids (*N*)	1	0	0	0	1	1
Bighead Carp (*N*)	0	0	0	0	0	0
Silver Carp (*N*)	0	0	0	0	0	0
CPUE (fish/hr)	121.1	336.6	76.8	0	78.6	182.7
Netting Effort						
Estimated person-hours	795	810	510	45	495	2,655
Samples (net sets)	357	371	269	4	251	1,252
Miles of net	39.2	39.5	29.5	0.45	29.5	138.2
Netting Catch						
All fish (*N*)	655	351	639	1	318	1,964
Species (*N*)	13	8	3	1	4	15
Hybrids (*N*)	0	1	0	0	1	1
Bighead Carp (*N*)	0	0	0	0	0	0
Silver Carp (*N*)	0	0	0	0	0	0
CPUE (fish/100 yds of net)	0.95	0.51	1.2	0.13	0.61	0.81
Seine Effort						
Estimated person-hours	135	--	--	--	--	135
Samples (seine hauls)	4	--	--	--	--	4
Miles of seine	1.8	--	--	--	--	1.8
Seine Catch						
All fish (*N*)	2879	--	--	--	--	2,879
Species (*N*)	11	--	--	--	--	11
Hybrids (*N*)	0	--	--	--	--	0
Bighead Carp (*N*)	0	--	--	--	--	0
Silver Carp (*N*)	0	--	--	--	--	0
CPUE (fish/seine haul)	719.8	--	--	--	--	719.8

Seasonal Intensive Monitoring in the CAWS

Table 2. *Total number of fish captured with electrofishing (EF), trammel/gill nets (Nets), and commercial seine (Seine) in the CAWS upstream of the Electric Dispersal Barrier during SIM, 2020.*

	Chicago River		**CSSC-S Branch**		**Lake Calumet-Cal River**			**Little Cal-Cal Sag**		**N Branch-N Shore**		**All Sites**
Species	EF	Nets	EF	Nets	EF	Nets	Seine	EF	Nets	EF	Nets	All Gears
Alewife*			1		27			2				30
Banded killifish					10			92		5		107
Bigmouth buffalo						14	4		4			22
Black buffalo						40			8			48
Black bullhead					9			6		1		16
Black crappie					3							3
Brook silverside					39			1				40
Brown bullhead						1						1
Bluegill			3		198			44		22		267
Bluntnose minnow			15		20			38		16		89
Blackstripe topminnow										1		1
Bowfin					15			2				17
Carp x goldfish*									2		1	3
Common carp*		1	59	626	219	157	5	364	283	13	310	2037
Creek chub										1		1
Channel catfish				10	2	7	466	20	18		4	527
Emerald shiner			9					182				191
Fathead minnow								3				3
Flathead catfish						8						8
Freshwater drum					8	238	1141	48	27		2	1464
Goldfish*					1			7		1	1	10
Golden redhorse					1							1
Golden shiner					12			26		13		51
Grass carp*						2			1			3
Green sunfish					9							9
Gizzard shad			25	2	35	4	1234	1424		50		2774
Gizzard shad < 6 in			43	1	12			770		108		934
Largemouth bass			5		370		9	84		24		492
Northern pike					1							1
Oriental Weatherfish*								2				2
Pumpkinseed			2		169			44		6		221
Pumpkinseed x bluegill					1					3		4
Round goby*					9					1		10
Rock bass					96			3		1		100
River carpsucker					1	1	1					3
Spotfin shiner			13					4		4		21
Smallmouth buffalo					32	177	15	5	6			235
Smallmouth bass					47	3						50
Spottail shiner								2		1		3
Threadfin shad					2							2
Unidentified Catostomidae						1						1
Walleye						2						2
White bass					6		2	2				10
White perch*								2				2
White sucker								13		26		39
Yellow bullhead					6		1	3	2			12
Yellow bass								1				1
Yellow perch					214		1	4				219
Total Fish (N)		1	175	639	1574	655	2879	3198	351	297	318	10087
Total Species (N)		1	9	3	28	13	11	28	8	17	4	44
Total Hybrids (N)					1				1	1	1	2

*: non-native species

Seasonal Intensive Monitoring in the CAWS

Table 3. *Summary of effort and catch data for all fixed and random site monitoring in the CAWS upstream of the Electric Dispersal Barrier, 2010-2020.*

Type of Effort	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Electrofishing Effort												
Estimated person-hours	1,280	2,180	4,330	1,528	945	990	990	990	990	1,118	195	**15,536**
Samples (transects)	519	844	765	588	348	422	407	437	414	412	127	**5,283**
EF (hrs)	130	211	192	149.3	87.1	106	102	109	103.5	103	28.7	**1,321.60**
Electrofishing Catch												
All fish (N)	33,688	52,385	97,510	45,443	24,492	28,549	22,557	26,198	26,944	18,247	5,244	**381,257**
Species (N)	51	58	59	56	56	61	59	58	60	48	39	**83**
Hybrids (N)	3	3	3	2	2	2	2	2	2	2	1	**8**
Bighead Carp (N)	0	0	0	0	0	0	0	0	0	0	0	**0**
Silver Carp (N)	0	0	0	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	260.3	177.2	182.7	**288.5**
Gill/Trammel Netting Effort												
Estimated person-hours	885	1,725	3,188	1,932	1,125	1,125	1,125	1,485	1,148	1,440	2,655	**17,833**
Samples (net sets)	208	389	699	959	440	445	498	803	710	711	1252	**7,114**
Miles of net	23.8	67	81.7	104.9	48.2	46.6	53.3	86.5	76.6	79.7	138.2	**806.5**
Netting Catch												
All fish (N)	2,439	4,923	3,060	4,195	1,461	1,062	1,283	1,917	1,174	1,622	1,964	**25,100**
Species (N)	17	20	20	30	18	13	18	14	23	19	18	**41**
Hybrids (N)	1	1	1	1	1	1	1	1	1	1	1	**2**
Bighead Carp (N)	1	0	0	0	0	0	0	0	0	0	0	**1**
Silver Carp (N)	0	0	0	0	0	0	0	1	0	0	0	**1**
CPUE (fish/100 yds of net)	5.8	4.2	2.1	2.3	1.7	1.3	1.4	1.3	0.9	1.2	0.81	**1.8**
Seine Effort												
Estimated person-hours	-	-	-	135	135	135	135	135	135	135	135	**1,087**
Samples (seine hauls)	-	-	-	3	2	3	3	4	3	4	4	**26**
Miles of seine	-	-	-	1.4	0.9	1.4	1.4	1.8	1.4	1.8	1.8	**11.9**
Seine Catch												
All fish (N)	-	-	-	7,577	1,725	5,989	3,765	2,763	3,110	7,457	2,879	**35,265**
Species (N)	-	-	-	15	11	14	15	10	10	16	11	**26**
Hybrids (N)	-	-	-	1	0	0	0	0	0	0	0	**1**
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/seine haul)	-	-	-	2,525.7	862.5	1,996.3	1,255.0	690.8	1,036.70	1,864.3	719.8	**1,356.3**
Hoop/Trap Net/ Tandem Trap Net												
Estimated person-hours	-	-	-	-	-	30	28	135	135	-	-	**328**
Samples (sets)	-	-	-	11	-	4	3	8	7	-	-	**33**
Net-days	-	-	-	25.2	-	16	12	52.1	43	-	-	**148.3**
Catch												
All fish (N)	-	-	-	93	-	172	102	294	693	-	-	**1,354**
Species (N)	-	-	-	17	-	17	15	17	19	-	-	**34**
Hybrids (N)	-	-	-	0	-	0	-	1	1	-	-	**2**
Bighead Carp (N)	-	-	-	0	-	0	-	0	0	-	-	**0**
Silver Carp (N)	-	-	-	0	-	0	-	0	0	-	-	**0**
CPUE (fish/net-day)	-	-	-	3.7	-	10.75	8.5	5.6	16.1	-	-	**9.1**
Pound Net Effort												
Estimated person-hours	-	-	-	-	-	-	-	135	-	-	-	**135**
Net-days	-	-	-	-	-	-	-	8.9	-	-	-	**8.9**
Pound Net catch												
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-day)	-	-	-	-	-	-	-	72.6	-	-	-	**72.6**

Strategy for eDNA Sampling in the CAWS

Jenna Bloomfield (U.S. Fish and Wildlife Service, La Crosse FWCO)

Participating Agencies: U.S. Fish and Wildlife Service (USFWS)

Pools Involved: CAWS

Introduction and Need:

Monitoring with multiple gears in the Chicago Area Waterway System (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 deoxyribonucleic acid (eDNA) sampling has been conducted annually as a surveillance tool to monitor for genetic presence of Bighead Carp and Silver Carp in the CAWS and maintain vigilance above the Electric Dispersal Barrier System (EDBS) since 2009. Beginning in 2013, eDNA results no longer automatically triggered response action through the Monitoring and Response Plan. Since the implementation of dedicated sampling gears for all efforts above the EDBS, and the application of refined DNA markers during sample processing, a low, baseline level of Asian carp DNA signal has been consistently detected in the CAWS and attributed to a combination of vectors. This consistent level of minimal or zero positive eDNA detections annually, along with limited captures of live Asian carp by traditional sampling gears above the EDBS, supports the assumption that there is not a self-sustaining, reproductive Asian carp population above the barrier. An abnormally high number of positive eDNA detections in Bubbly Creek in October 2019 spurred the need for futher investigation into the potential for the Racine Avenue Pumping Station (RAPS) to contribure Asian carp DNA material into the waterway during occasional discharges of untreated sewer water, known as Combined Sewer Overflow (CSO) events.

Objectives:

(1) Sample for Bighead Carp and Silver Carp DNA in targeted areas of the CAWS to maintain vigilence and complement other ongoing monitoring efforts above the EDBS.

(2) Sample for Bighead Carp and Silver Carp DNA in the municipal sewer sysem connected to the RAPS.

Strategy for eDNA Sampling in the CAWS

Project Highlights:

- No regular eDNA sampling events were conducted in 2020 due to COVID-19 and the travel restrictions put in place by the Department of the Interior Region 3 Fisheries Program.
- In February 2020, USFWS conducted sampling of the main sewer lines coming into the RAPS, resulting in positive Asian carp eDNA detection in all four lines.

Methods:

In coordination with the Metropolitan Water Reclamation District of Greater Chicago, USFWS collected eDNA water samples from four main sewer lines leading to the RAPS. Forty-five samples were collected from each of the four sites across two separate time points in the day: morning and mid-day. Each sample consisted of one 250 milliliter (mL) centrifuge tube. Blank samples were also utilized for quality control. All samples were put on ice and kept in a dark cooler immediately after collection. All samples were returned to the Whitney Genetics Lab or processing. To expedite the analysis process, a subset of samples including five samples from each site and time point (n = 40) were analyzed for Asian carp DNA presence.

Results and Discussion:

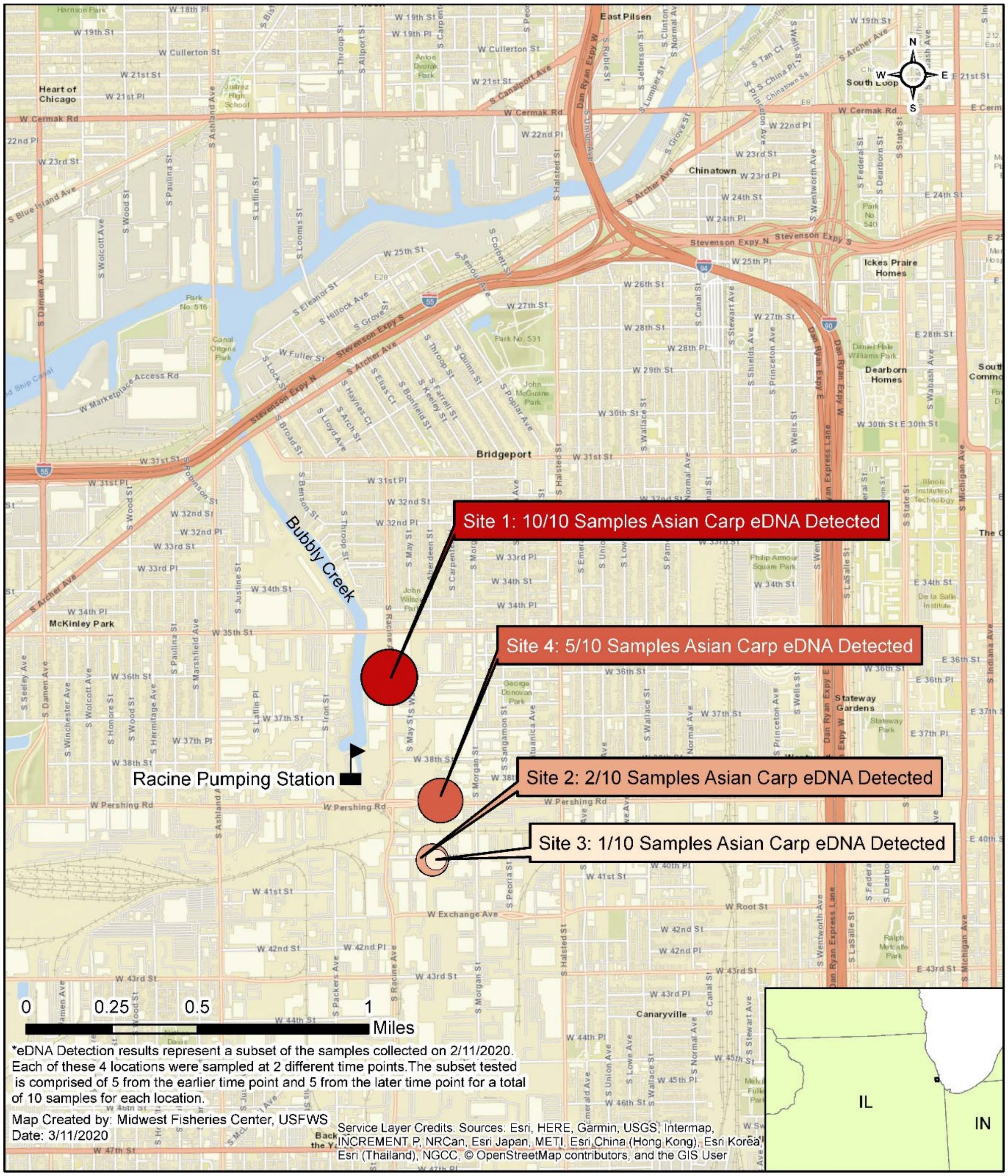
Of the 40 water samples analyzed from the larger group of 180 collected from the four sewer interceptors, at least one positive detection occurred at each interceptor (Figure 1). Of the four sites, the furthest north site had the greatest detection of Asian carp DNA with all 10 of the subset samples being positive. Overall positivity of the sample subsets decreased as interceptor location moved southward.

Given the presence of Asian carp eDNA in all four interceptors that lead directly into the RAPS and subsequently dump untreated water into Bubbly Creek during CSO events, it is likely that the large number of detections in Bubbly Creek in the fall of 2019 came from sewer water discharged from the RAPS.

Recommendation:

With the knowledge that the RAPS has a great potential to influence Asian carp eDNA detections, USFWS will no longer sample Bubbly Creek or the surrounding sections of the Chicago Sanitary and Ship Canal or South Branch of the Chicago River. Taking into consideration the potential influence of CSO activity in general, any future sampling will not be conducted within seven days of a confirmed CSO event that may affect the targeted sampling area.

Figure 1. *Sampling locations and detection proportion of a subset of Asian carp eDNA water samples collected from four sewer interceptors leading to the Racine Avenue Pumping Station near Chicago, Illinois in February 2020.*



Telemetry Monitoring Plan

John Belcik, Nicholas Barkowski, (US Army Corps of Engineers – Chicago District)

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

Pools Involved: Lockport, Brandon Road, and Dresden Island

Introduction:

Acoustic telemetry has been identified within the Asian Carp Regional Coordinating Committee (ACRCC) Asian Carp Plan as one of the primary tools to assess the efficacy of the electric dispersal barrier system (EDBS). The following report summarizes methods and results from implementing a network of acoustic receivers to track the movement of Bighead Carp, *Hypopthalmichthys nobilis*, and Silver Carp, *H. 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 EDBS in the Upper Illinois Waterway (IWW). This network was installed and is maintained through a partnership between the USACE and other participating agencies as part of the Monitoring and Response Work Group's (MRWG) monitoring plan (MRWG 2019).

The purpose of the telemetry program is to assess the effect and efficacy of the EDBS 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 EDBS using receivers placed immediately upstream and downstream of the EDBS.
- **Objective** Support EDBS 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=6) placed above and below each lock.

- **Objective** Review and compare standard operating protocols and vessel lockage statistics for Lockport, Brandon Road and Dresden Island Locks.

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

- Sampling season was abbreviated this year due to constraints imposed by the pandemic
- To date, USACE has acquired 35 million detections from 686 tagged fish.
- No live tagged fish have crossed the EDBS in the upstream direction.
- A high percentage of tagged surrogate fish in the Lower Lockport Pool continue to be detected near the EDBS.
- There were no upstream and three downstream passages of Common Carp between the Brandon Road and Lockport Pools.
- Asian carp continue to be detected throughout the Dresden Island Pool with most detections occurring near the Dresden Island Lock.
- Up to 50% of the detected transmitters within Dresden Island Pool were detected near the Dresden Island Lock within a given season. This location registered approximately 75% of all the detections in the pool for the year.

Telemetry Monitoring Plan

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 2019 season there were approximately 140 tags (V16 Vemco transmitters) that remained active and 11 of these transmitters were scheduled to expire within calendar year 2020. During 2020, there were also nine fish that appeared to have experienced mortality. Further reducing the number of active tagged fish to 120 by the end of 2020. Additional tagging would normally be required to sustain the recommended levels of the target sampling size as battery life expired and mortalities occurred in previously tagged fish. However, due to the COVID-19 pandemic, field operations were severely limited during the 2020 season and no tagging operations were conducted.

Tagged surrogate fishes have been previously released below the EDBS, but no tagged Asian carp were previously 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. Fish captured in Dresden Island Pool were released at or near the point of capture only after they were deemed viable and able to swim under their own power. It has been observed that displaced fishes exhibit site fidelity and attempt to return to their original capture location. As such, to induce more approaches to the EDBS, all the surrogate fishes released within Lower Lockport Pool were originally captured from the Upper Lockport Pool. Table 1 identifies all fishes containing active transmitters between November of 2019 and November of 2020 along with their release point within the system.

Table 1. *Active Fishes and Release Points within the Study Area in 2020*

Release Location	Species Implanted	Number of Fish Implanted
Lower Lockport Pool (Downstream of EDBS)	Common Carp	69
Lower Lockport sub-total		**69**
Brandon Road Pool	Common Carp	0
Brandon Road sub-total		**0**
Dresden Island Pool	Bighead Carp	8
	Silver Carp	43
Dresden Island sub-total		51
Total		**120**

Methods for stationary receiver deployment and downloads as well as mobile tracking were maintained from previous year's effort. After deployment, data retrieval occurred bi-monthly throughout the season by downloading stationary receivers. A detailed description of methods can be found in the MRP Interim Summary Report (2012). Those stationary receivers removed for winter in November 2019 were redeployed at the end of May 2020. The layout of receiver positions within the study remained almost the same as the previous year (MRP 2019 Interim Summary Report 2021). One additional receiver was placed on the Des Plaines River in the backwater pool directly below Lockport Control Works. The revised study area was covered by 28 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 for either pool or tributary location (e.g. LL for Lower Lockport or RR for Rock Run Rookery) 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, there are five real-time receivers that have been installed in previous years by USGS in the area of coverage. One located above and below Brandon Road Lock and Dam, one upstream and downstream of the EDBS, and one upstream of Dresden Island Lock and Dam. The receivers upload detections to a USGS maintained website, providing real-time results and are part of a larger inter-agency effort to strategically cover the Illinois Waterway with this new data transmission technique.

Barrier Efficacy

Barrier efficacy was assessed through a system of eleven stationary receivers with four upstream and seven downstream of the EDBS within the Lockport Pool. Receivers were placed at the lock entrance, in areas offering shallow habitat, in proximity to the EDBS 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 EDBS. Additionally, data were analyzed to assess temporal and spatial distribution patterns within the Lower Lockport Pool. All detections were recorded and compiled into the detection data set.

Detections on each receiver in the network 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 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.

Detection data were compiled for all stations by the number of detections for all transmitters and the total number of transmitters detected. The total number of detections were calculated for each of the seven stations from the EDBS to the Lockport Lock for the full year and by season. Seasons were defined by monthly data with December to February representing winter, March to May for spring, June to August for summer, and September to November for fall. Each station detection sub-total was then summed across the pool to calculate the total number of detections in 2020 and then further detailed by season. Similarly, the total number of transmitters were recorded for each station independently. Detection data for all stations combined was also reviewed to determine the total number of transmitters detected annually. This process was repeated for each season to obtain total number of detections by station and totaled for the entire pool.

The total annual detections and total seasonal detections across the pools 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 transmitters detected at each station and across the pool for both the full year and within each season. Percentage metrics were calculated for 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 EDBS. 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. Lower Lockport Pool is characterized by the area downstream of the EDBS and upstream of Lockport Lock and Dam, while Upper Lockport consists of the area upstream of the EDBS to the CSSC and Cal-Sag Channel. The remaining pools include the Brandon Road Pool of the Des Plaines River 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, data was collected within the pool by SIU and USGS which was shared with USACE. VR2W receivers were placed above and below each lock and dam as well as any other potential transfer pathways between pools. Data from the VR2W receivers was 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 reviewed for each passage where a specific time of occurrence could be determined.

Asian carp Movement Analysis

A total of 64 USACE tagged Asian carp (Bighead Carp and Silver Carp) were within the Dresden Island Pool at the beginning of 2020 with 10 transmitters expiring in March of that year. Movement of individual fish were tracked via Vemco VR2W stationary receivers (Appendix A) strategically placed throughout the Des Plaines and Kankakee Rivers. VR2W detections were then uploaded into Vemco VUE. Each station's detection sub-total was then summed across the pool to calculate the percent of total detections in 2020 and then further detailed by season. Detections of tags were recorded, and percent of tags detected at each station was calculated for each season of winter (Dec- Feb), spring (Mar-May), summer (June-Aug) and fall (Sept-Nov).

Total tags and total detections at each receiver by season were used to observe any movement patterns. Detections for each tag detected were individually analyzed to determine if any fish potentially died during 2020. Fish that demonstrated only downstream movement 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 November 2020, 35 million detections from 686 USACE tagged fish have been recorded within the study area since the telemetry monitoring system was established in 2010. While no tagged fish have been released upstream of the EDBS for several years, the Chicago District continues to maintain receivers upstream of the EDBS to monitor for transit of fish from below the barrier. Results to date have shown that zero live fish have crossed the EDBS in the upstream (northward) direction. The following sections provide new results from data collected in the 2020 sampling season in which 66 transmitters were detected system wide for a total of 1.3 million data points from 21 November 2019 through 18 November 2020.

Goal 1: Monitor the EDBS for upstream passage of large fishes and assess risk of Bighead Carp and Silver Carp presence (Barrier Efficacy).

There was a total of 69 tagged surrogate fishes with batteries still active in 2020 that were released between Lockport Lock and the EDBS. Seven stationary receivers (VR2W) detected movement of 29 tagged surrogate fish throughout the pool in 2019. There was a total of 858,115 detections within Lower Lockport Pool and zero detections in the Upper Lockport Pool indicating no passage of tagged fish through the EDBS.

The percentage of detections at each receiver across seasons (Figure 1) and the percentage of a station's total detections that occurred within a given season were used to compare residency time and habitat use across the pool (Figure 2). The percentage of transmitters within the pool detected at each station provided an indication of relative movement patterns within the pool by the population of tagged fishes (Figure 3). 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.

The number of detections was lowest in straight channel sections of the canal with deep water which best characterizes station LL03a (~2.2% of annual Lower Lockport detections). The areas with the highest number of detections were the shallow water barge slip (LL03) just downstream of the EDBS and the shallow backwater area at LL05 with 26% and 44% respectively. Approximately 9.1% of the detections in Lower Lockport were just below the barrier. Due to the later start of the field season, USACE biologists could not access the telemetry network until the end of May or start of June. As a result, the batteries of many of the receivers were critically low, and the receiver below the barrier (LL01) did no record any detections between April 12 and

June 1. At the EDBS, the number of detections was highest in the winter months (37% of total receiver detections). This varied from previous years when the highest number of detections was typically in the summer and winter having the fewest detections (USACE 2021). Likewise, LL03 (1 mile downstream) experienced an increase in winter with 30% of the station's detections occurring in this season, similar to previous years (USACE 2021) (Figure 2). However, relatively few detections were found to be at LL02, the station between the barrier and the barge slip, during the winter months. Only 5% of the detections at LL02 were recorded during the winter. Many of the fish that were detected during this time were likely overwintering at or near the EDBS. Common Carp often overwinter in deeper areas of a water body, such as what is found in the main channel of the canal at the EDBS or in parts of the barge slip where LL03 is located (Bajer and Sorenson 2009; Penne and Pierce 2008). During the winter there were 12 fish detected at the EDBS, six of them were detected on LL02 and LL03. Indicating that at least some of the fish were actively moving in the system and approaching the EDBS during the winter season.

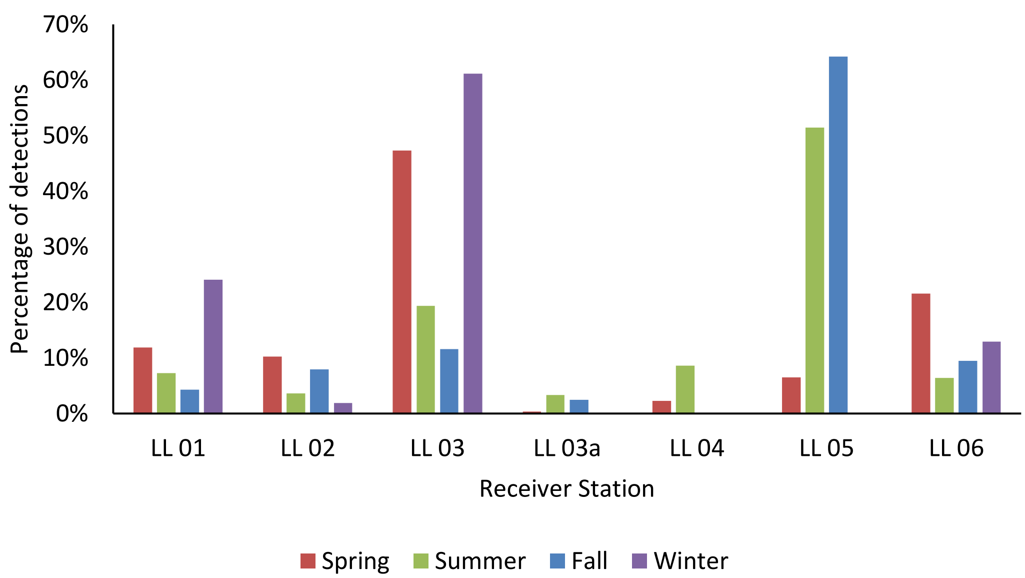


Figure 1. *Percentage of the Lockport Pool's total seasonal detections shown across receivers in 2020***.**

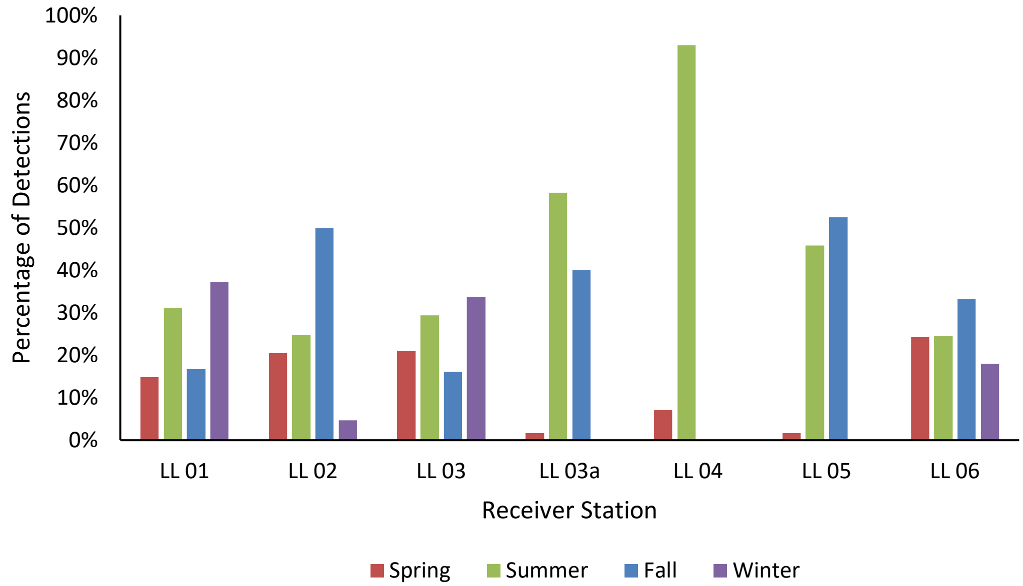


Figure 2. *Percentage of total number of detections per individual receiver across seasons within the Lockport Pool in 2020.*

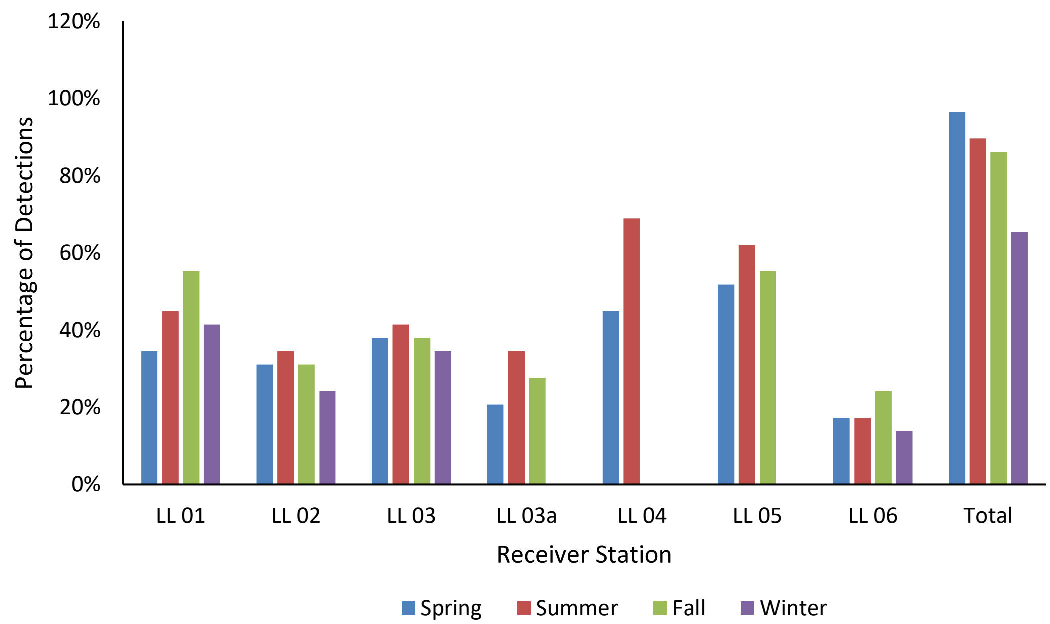


Figure 3. *Percentage of the total number of tags in Lockport Pool detected on a receiver in a season and in total for 2019.*

Table 2. *Number of detections within the Lower Lockport Pool during 2020. *Values do not indicate a lack of fish, but rather that the receiver was removed from the water during that time. **Indicates a loss of functionality in the receiver at some point, likely a dead battery.*

	Fall	Spring	Summer	Winter	Total
LL 01	*13,023*	*11,552***	*2,4332*	*29,163*	*78,070*
LL 02	*24,338*	*9987*	*12,045*	*2,295*	*48,665*
LL 03	*35,445*	*4,6163*	*64,723*	*74,221*	*220,552*
LL 03a	*7,536*	*317*	*10,975*	*0**	*18,828*
LL 04	*0***	*2194*	*28,769*	*0**	*30,963*
LL 05	*196,177*	*6345*	*171,534*	*0**	*374,056*
LL 06	*28,940*	*21,088*	*21,313*	*15,640*	*86,981*
Total	*305,459*	*97,646*	*333,691*	*121,319*	*858,115*

Table 3. *Number of tags detected at a station during 2019. *Does not indicate a lack of fish, but rather that the receiver was removed from the system during that time. **Indicates a loss of functionality in the receiver at some point, likely a dead battery.*

	Spring	Summer	Fall	Winter	Total
LL 01	10	13	16	12**	19
LL 02	9	10	9	7	12
LL 03	11	12	11	10	14
LL 03A	6	10	8	0*	11
LL 04	13**	20	0*	0*	20
LL 05	15	18	16	0*	18
LL 06	5	5	7	4	9
TOTAL	28	26	25	19	29

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

There were seven occurrences of inter-pool movement by five tagged fishes between November 2019 and November 2020. Four of the movements between USACE monitored pools were by three Common Carp, two moved from the Lockport Pool to the Brandon Road pool and one from the Lockport Pool to the Brandon Road Pool to the Dresden Island Pool then as far as the

LaGrange Pool. All these fish were caught upstream of the EDBS and released below the EDBS; two in 2019 and one in the 2017 season.

For those two fish that transferred just between the Lockport and Brandon Road Pools, one transited through the Lockport Lock. The other likely traveled through Bear Trap Dam Control Works when the gates were opened either on April 28-29 or May 15-19. During those two periods the gates were open for several hours where a range of 1,255 to 4,697 cubic feet/sec of water per day went through the gates (Table 4). Photo 1 and Photo 2 show conditions on the Des Plaines River at the control works when the majority of the gates are fully open. These images show similar water levels on each side of the Bear Trap Dam Control Works Structure, which may have allowed fish to move through this area. While we have suspected that upstream movement through Bear Trap Dam Water Control Works was possible, this is the first time we have likely evidence of this occurring. The fish that used the lock did so between February 21 and March 1st. There were multiple detections on the upstream and downstream side of the lock, an indication that the fish was likely trapped inside the lock and detected when the doors were opened during any of the multiple lockage events during that time. Ultimately moving from the Lockport Pool to the Brandon Road Pool.

There was one Common Carp that made a downstream transit between multiple pools (A69-9001-8693). At the end of the 2019 season this fish was last detected at the Lockport Control Works on November 13, 2019 when the receiver was removed for the winter. Due to the pandemic, receivers were not deployed until May/June of 2020. At the end of April before receivers were deployed, the control works were opened in response to heavy rain events that likely brought this fish through the gates at that time as it was next detected at the Brandon Road Lock on April 30 and 3:38 A.M.. The receiver below Brandon Road Lock broke free of its mooring some time before a download could take place and any data that could have shown when this fish transited between the Brandon Road and Dresden Island pools was lost. However, on May 1 at 7:02 A.M. this fish was detected at Dresden Island Lock where it transited to the Marseilles Pool and was detected in Marseilles at 8:23 P.M. on May 1st. This fish was then detected 33 miles downstream on May 2 at 8:36 P.M. in the Starved Rock Pool where it was detected for several days traveling up and downstream between several locations before being detected at river mile 208.5 in the Peoria Pool on May 18 at 2:04 P.M.. Lastly, it made the transit to the LaGrange Pool where it was first detected on May 23 and 9:04 A.M. and last detected at river mile 120.9 on May 23 shortly after its first detection. This fish was presumed to be alive for its transit at least through the Starved Rock Pool given that it was traveling multiple miles in the up and down stream directions. It is presumed to still be in the Peoria Pool. Between the end of April and the end of May, the region experienced several large rain events, causing flood conditions and increased flow rates throughout much of the Illinois River for several days. These events coincide with this fish's movements and are likely responsible for assisting in the 170-mile transit over the 23 days of detections.

Table 4. *Number of hours each gate was open at the Lockport Control Works and the average daily cubic feet per second of water that went through the gates between November 2019 and November 2020.*

Lockport CW Gate Openings (Hours) 11/1/2019-11/30/2020								
Date	Gate 1	Gate 2	Gate 3	Gate 4	Gate 5	Gate 6	Gate 7	Avg. Daily CFS
4/29/2020	5.25	5.25	5.50	5.50	6.75	5.50	6.75	1,255.00
4/30/2020	21.5	21.50	21.50	21.75	21.75	21.75	21.75	4,697.00
5/15/2020	6.75	0.00	6.75	7.00	8.75	8.75	8.75	1,441.00
5/17/2020	22	0.00	20.50	20.25	20.25	21.00	21.00	3,808.00
5/18/2020	24	0.00	24.00	24.00	24.00	24.00	24.00	4,440.00
5/19/2020	19.5	0.00	19.25	19.00	18.75	18.50	18.50	3,501.00
10/2/2020	0	0.00	5.00	0.00	0.00	0.00	0.00	152.00
10/7/2020	0.25	0.25	0.25	0.25	0.25	0.25	0.25	54.00
10/11/2020	1.5	0.00	0.00	0.00	0.00	0.00	0.00	48.00
10/12/2020	13.75	0.00	0.00	0.00	0.00	0.00	0.00	441.00
10/13/2020	8.5	0.00	0.00	0.00	0.00	0.00	0.00	272.00
10/30/2020	0.25	0.25	0	0	0	0	0	16.00
11/5/2020	0	0	0	0	0	0.25	0.25	15.00
11/10/2020	0	0.00	0.25	0.50	0.00	0.00	0.00	23.00

Photo 1. *Picture of Bear Trap Dam Control Works. Picture was taken May 18, 2020 from the entrance of the low water crossing to get to Cargill Boat Ramp looking East-Northeast. Water levels appear to be very similar between the water bodies.*

There were no other fish that had migrated between the Brandon Road Pool and the Dresden Island Pool during 2020.

There were two instances of fish moving from the Dresden Island Pool into the Marseilles Pool. One was by a Bighead Carp on June 28 and the other was by a Silver Carp between December 18^{th} and 20^{th}. This is a continued indication that Asian carp have been and are able to transit between pools by utilizing lockage events. To date very few tagged Asian carp have been documented approaching the Brandon Road Lock chamber. However, given their ability to use a lockage event to transit between navigation pools it remains a possibility for them to transit between Dresden Island Pool and Brandon Road Pool if favorable conditions occur. During 2020 however, only two Grass Carp were detected in the vicinity of Brandon Road Lock throughout the year. No Asian carp were detected at the lock.

Photo 2. *Picture of water flowing over the low water crossing road on the way to the Cargill boat ramp. The picture was taken May 18th, 2020 looking south-southeast.*

Overall, from 2010 to 2019, there have been 90 occurrences of tagged fish moving downstream and 45 occurrences of upstream movement between navigation pools by a total of 102 individual tagged fish (Table 5). Inter-pool movement was greatest between the Lockport and Brandon Road Pools accounting for 58% (n=80) of all inter-pool movements (upstream n=22; downstream n=58). The majority of downstream movement into the Brandon Road Pool occurred through the Bear Trap Dam Control Works spillway approximately two miles upstream of Lockport Lock and Dam (n=35). Movement between the Dresden Island and Marseilles Pools comprised 32% (n=45) of all inter-pool movement (upstream n=20; downstream n=22). The lowest inter-pool movement occurred through the Brandon Road Lock and Dam accounting for 10% (n=14) of the total. Upstream movement through the Brandon Road Lock has occurred in the past by Common Carp originally captured within the Brandon Road Pool and released within the Dresden Island Pool. This method of capture in one pool and release in a different pool 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. The same capture and release technique is used to encourage fish to challenge the EDBS by capturing them in the Upper Lockport Pool and releasing them into the Lower Lockport Pool.

Table 5. *Tagged fish inter-pool movement from 2010 to 2020. Downstream is defined as DS, upstream is defined as US, total indicates the total number of interpool transfers seen.*

Interpool Movement Data			
	Up	Down	Total
Lockport Lock	21	23	44
Control Works	1	35	36
Brandon Road Lock	5	9	14
Dresden Island Lock	20	25	45

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

Due to the limitations in field activities imposed this season by the ongoing pandemic, the only appropriate dataset that can be analyzed for meaningful patterns would be the data collected during the summer and fall seasons.

Throughout 2020 there were 64 USACE tagged Asian carp within the Illinois Waterways. A total of 26 fish were detected within the Dresden Island Pool throughout 2020. Out of those 26 fish that were detected within the Dresden Island Pool, 13 were released by USACE (11 Asian Carp, 2 Common Carp), 10 by WIU-USGS, and three by USFWS. The 11 USACE tagged Asian carp consisted of one Bighead Carp (1100 mm) and 10 Silver Carp (781 ± 57.7 mm). All were tagged between 2016 and October of 2019.

In total, the receivers placed in Dresden Island Pool and the adjacent tributaries collected 163,311 detections from a total of 21 tagged Asian carp, three Grass Carp, and two Common Carp. The percent of the pool's total detections attributed to each receiver ranged from 0.04 to 30.6%. The station that had the greatest percent of total detections was DI10 with 30.6% in winter, 13.2% in the fall. This receiver had the highest percentage of detections for the summer and fall period with 22.8% and the whole year, recording 74.7% of all the detections in the pool. This is likely due to it being the only receiver in the pool that was deployed for the whole year. Whereas the other receivers in the pool were not deployed until the first week of June. Figure 6 and Figure 7 show the percentage of the pool's total number of detections that occurred within a season and the percentage of a receiver's total number of detections that occurred within a season respectively for Dresden Island Pool.

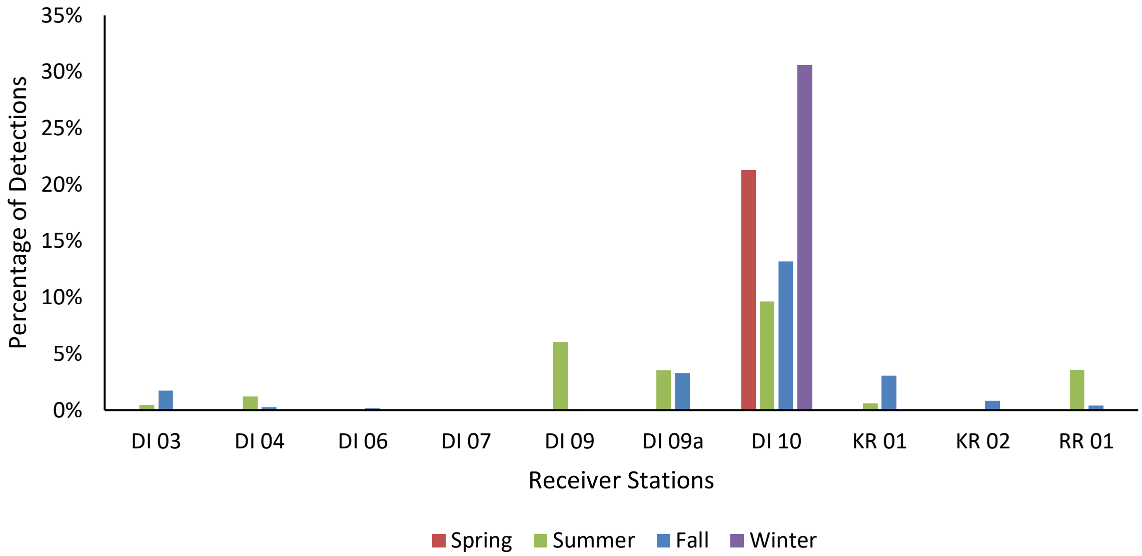


Figure 4. *Percentage of the Dresden Island Pool's total seasonal detections shown across receivers in 2020. Most locations experienced a small number of detections during the year. * under 100 detections for whole year.*

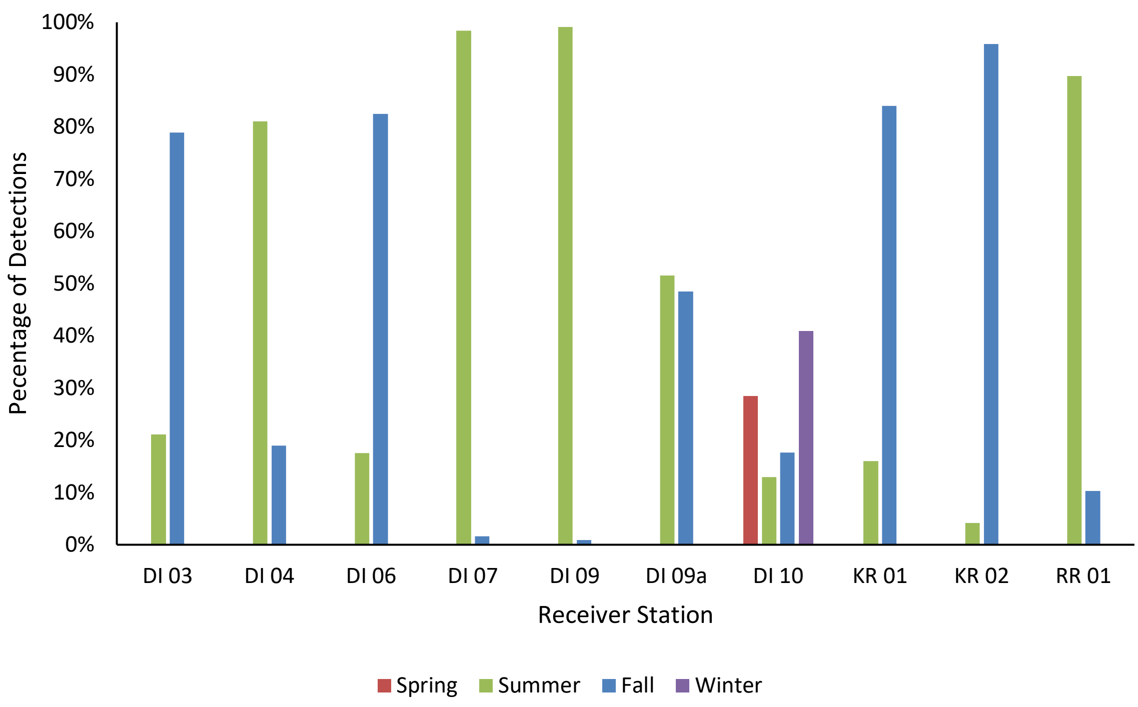


Figure 5. *Percentage of a receiver's total number of detections that occurred within a given season within the Dresden Island Pool in 2020.*

The DI10 station is located just downstream of the confluence of the Des Plaines and Kankakee Rivers. In previous years, the confluence area has been the site of the most detections in the pool (USACE 2017; USACE 2018, USACE 2019). This area encompasses one of the narrowest locations in the pool and has several different habitat types within its vicinity. Additionally, as shown in previous years, this location, the area just upstream of the confluence (DI09a), and Kankakee River (KR01) detect a high number of the total tags in the pool throughout the year (Figure 8). The area around the confluence is likely serving as a congregation location for fish to reside in throughout the year. Up to 73% of the fish that were detected in the Dresden Island Pool throughout the year were detected at the lock. The greatest number of stationary or resident fish (fish only detected on one receiver) were found at DI10. In summer, 60% of the fish that were identified as stationary in the pool were found on this receiver, with fall having 27% of the tags in the pool being residents at this location (Figure 9). The spring and winter seasons could not be analyzed for residency due to DI10 being the only receiver that was detecting during those seasons.

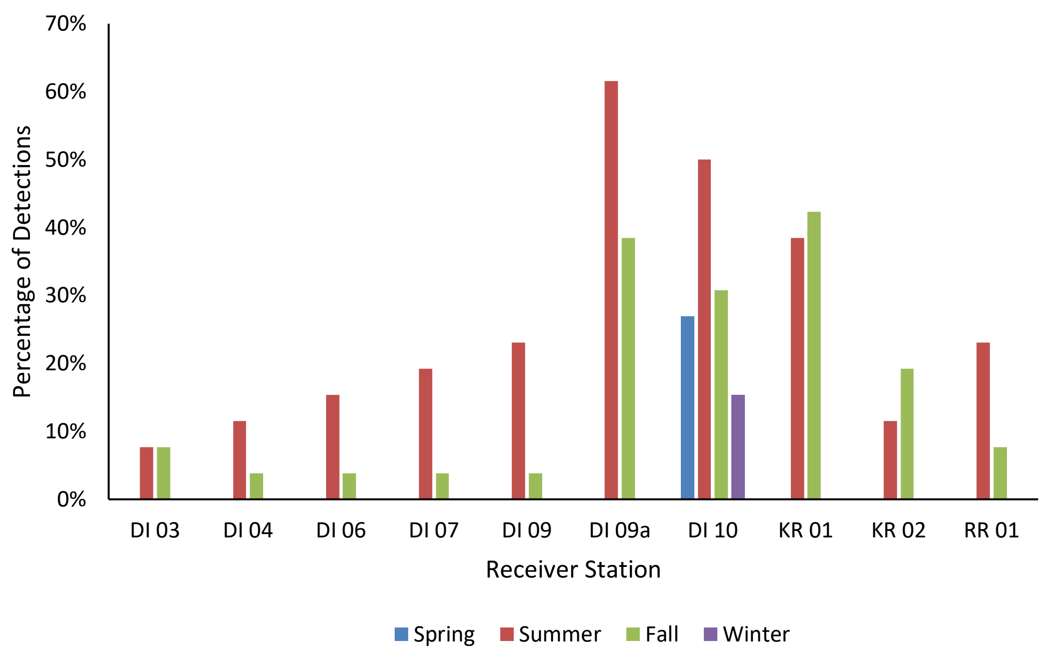


Figure 6. *Percentage of Dresden Island Pool's total tags detected at a given station during the 2020 season.*

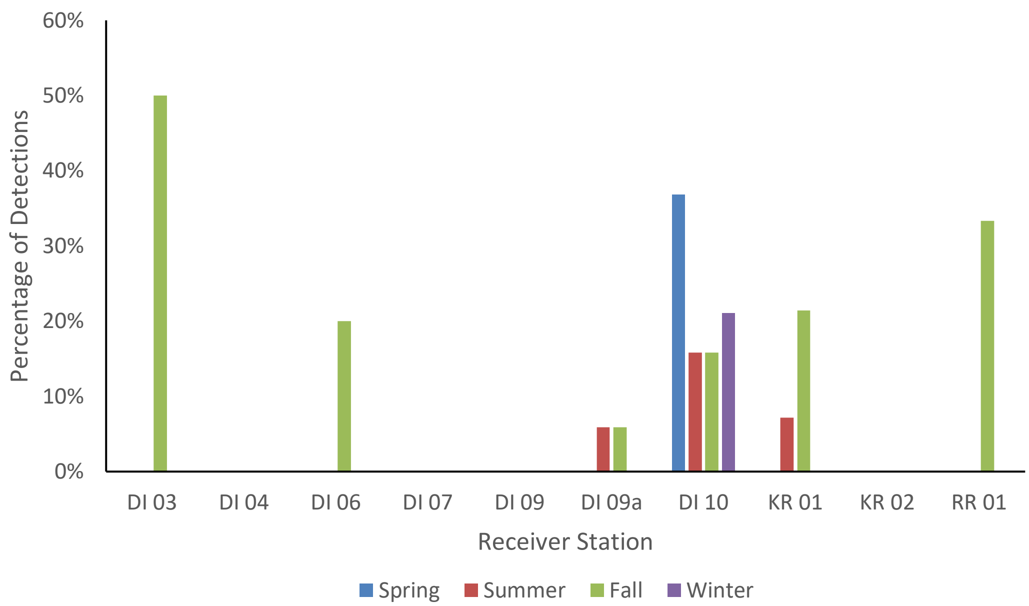


Figure 7. *Percentage of tags detected on a receiver that are considered residents (were not detected on a second receiver) during a season in 2020.*

Percent of the total active tags detected at each receiver and the percent of total detections were used in conjunction to acquire inferences of summer and fall fish movement within the Dresden Island Pool. Percent of active Asian carp tags detected seasonally ranged from 4 to 62% throughout the Dresden Island Pool (Figure 8) (8-73% overall). In summer, and fall, DI10 had the greatest percent of total detections (9.6& and 13.1% respectively). This was followed by DI09 in summer at 6% and DI09a with 3.5%. In fall, DI09a had 3.3% of the total and KR01 had 3.1 (Figure 6). Similarly, 61.5% and 38.5% of the active tags were detected during summer and fall at DI09a with 38.5% and 42.3% at KR01 (Figure 8). These data continue to support the importance of using the three receivers at the confluence (DI09a, DI10 and KR01) to monitor habitat use and movement of Asian carp through several habitat types and between the Kankakee River and the upper portions of the pool.

There are two additional locations of interest in the Dresden Island Pool. The first one being the Brandon Road Lock and Dam (DI03). This location normally has a receiver present in the approach channel throughout the year to detect any approaching, tagged fish. At some point between the November 2019 and June 2020 downloads this receiver broke free of its mooring and was lost. However, there is a real-time receiver station just downstream of this location that serves as a backup which was functional during the missing period. During the first half of the year and after a new USACE receiver was deployed, two grass carp were detected as being within detection range of the lock. No tagged Asian carp were detected approaching Brandon Road Lock in the 2020 sampling season. The other location is KR03 which is approximately 0.5 mile downstream of Wilmington Dam. This location did not detect any fish during the 2020 season.

Telemetry Monitoring Plan

Asian carp typically prefer side channels during times of low flow and have shown a preference for avoiding static areas (DeGrandchamp et al. 2008; Calkins et al. 2012). Due to these habitat preferences both the approach channel and Wilmington Dam locations are not considered to be ideal habitat for Asian Carp. The approach channel is narrow and deep with engineered sides and much of the time it experiences little to no flow. To get to the Wilmington Dam location, a fish would need to go through approximately 5.5 miles of shallow, rocky water between KR02 and KR03. This area often has a consistent flow of water, but will experience occasional flood pulses, which were largely absent in the later half of 2020. In previous years, fish have utilized these periods of increased flows and have traveled upstream to the dam. This absence of flood pulses in 2020 and combination of low tag density likely explains why no fish were present at this location on the Kankakee River in 2020.

Given these low levels of detections of both this year and past years, Asian carp are likely not drawn to either location in large numbers under normal conditions as they would be for areas such as backwaters or low flow side channels. A total of seven out of the 26 detected transmitters in the Dresden Island Pool were detected at KR02, which is located at the start of the rocky section leading to KR03, at some point during the year. During the 2019 season, the majority of the detections at this location were in the spring, and in this year (2020) the majority (84%) of the detections at this receiver were in fall. There does not appear to be a clear pattern as to when Asian carp are coming to this area or why and when present they do not consistently press further past it during ordinary conditions. It should be noted that because of the rocky habitat and the additional noise from the movement of water over those rocks, there may be enough background noise to mask transmitter pings and therefore limit detections or range that fish can be detected. As a result, the amount of detections here might not accurately depict the number of tagged fish congregating in this area. USACE is exploring other receiver placement options for the 2021 season that can give the desired detection coverage to monitor for fish that may be approaching Wilmington Dam.

Recommendations:

USACE recommends continuation of the telemetry program and maintaining the target level of surrogate species tags within the system by replacing expired tags throughout all three pools below the EDBS in early 2021. USACE will be maintaining its new receiver on the Des Plaines River the Bear Trap Dam Control Works facility to better understand potential transport of tagged fishes between Lockport Pool and the Des Plaines River. USACE will continue to collaborate with MRWG partners to maximize our understanding of Asian carp movement and biology within the Dresden Island Pool. USACE recommends continued collaboration with SIU to perform comparisons of surrogate species to Bighead and Silver Carp. Understanding of how well Common Carp and other surrogates represent the behavior of Bighead Carps is important in determining the usefulness of the data collected from those surrogate species near the EDBS. USACE will also continue to investigate the large expanse of data collected over the last 11 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 the collaboration with partner agencies performing parallel studies will be ongoing. Collaboration with MRWG partners has helped fill in receiver coverage in areas that are lacking in the USACE network. 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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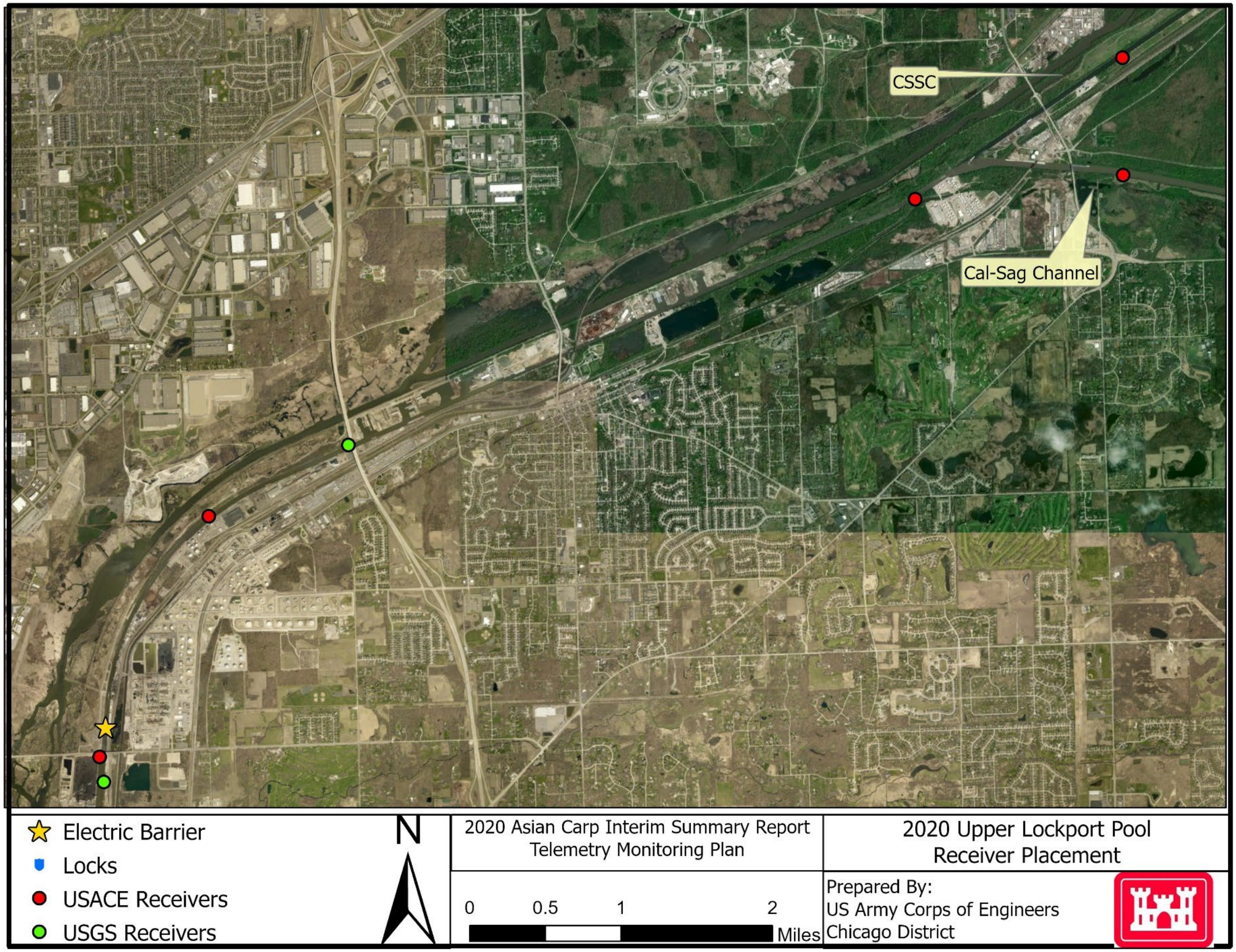
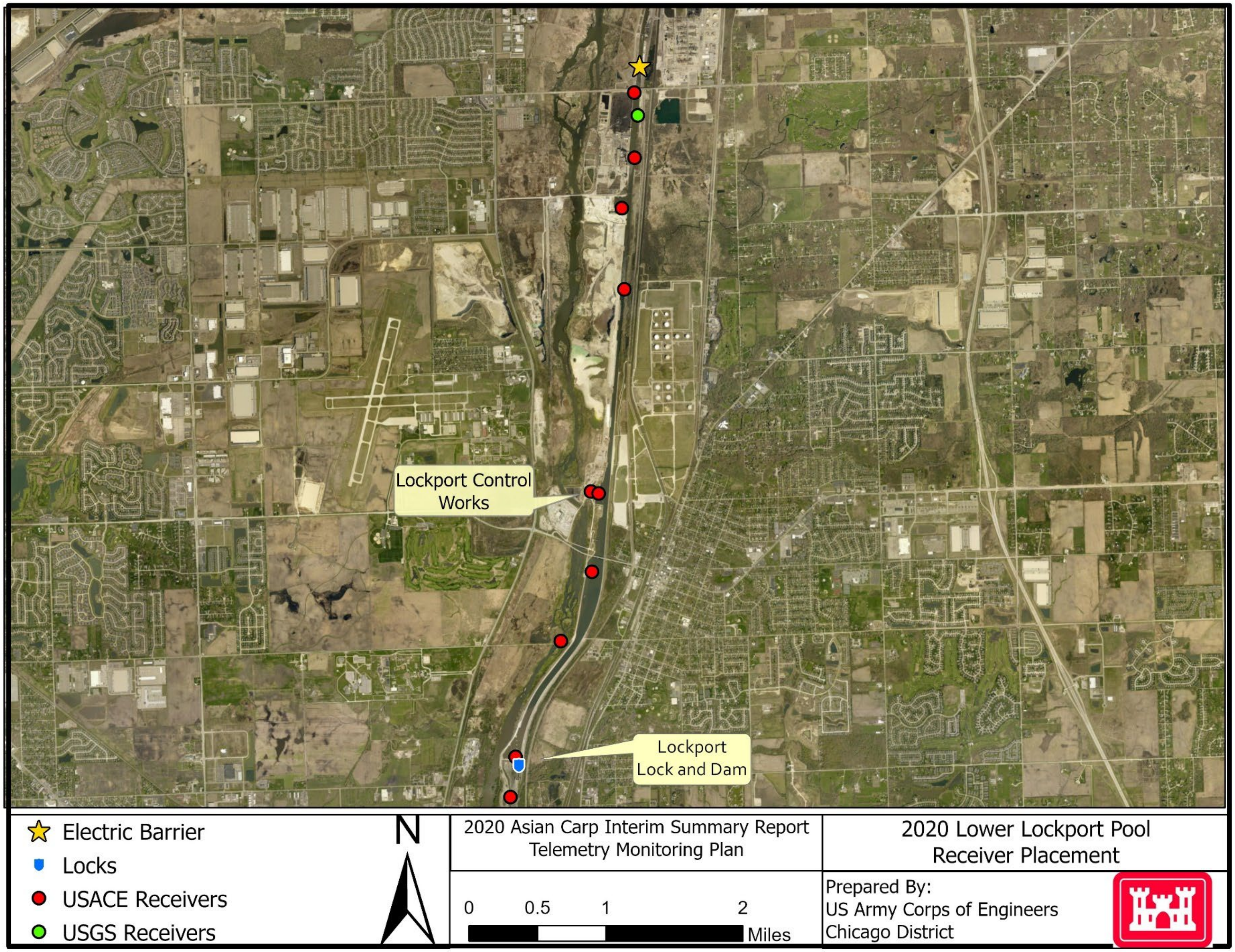
Telemetry Monitoring Plan

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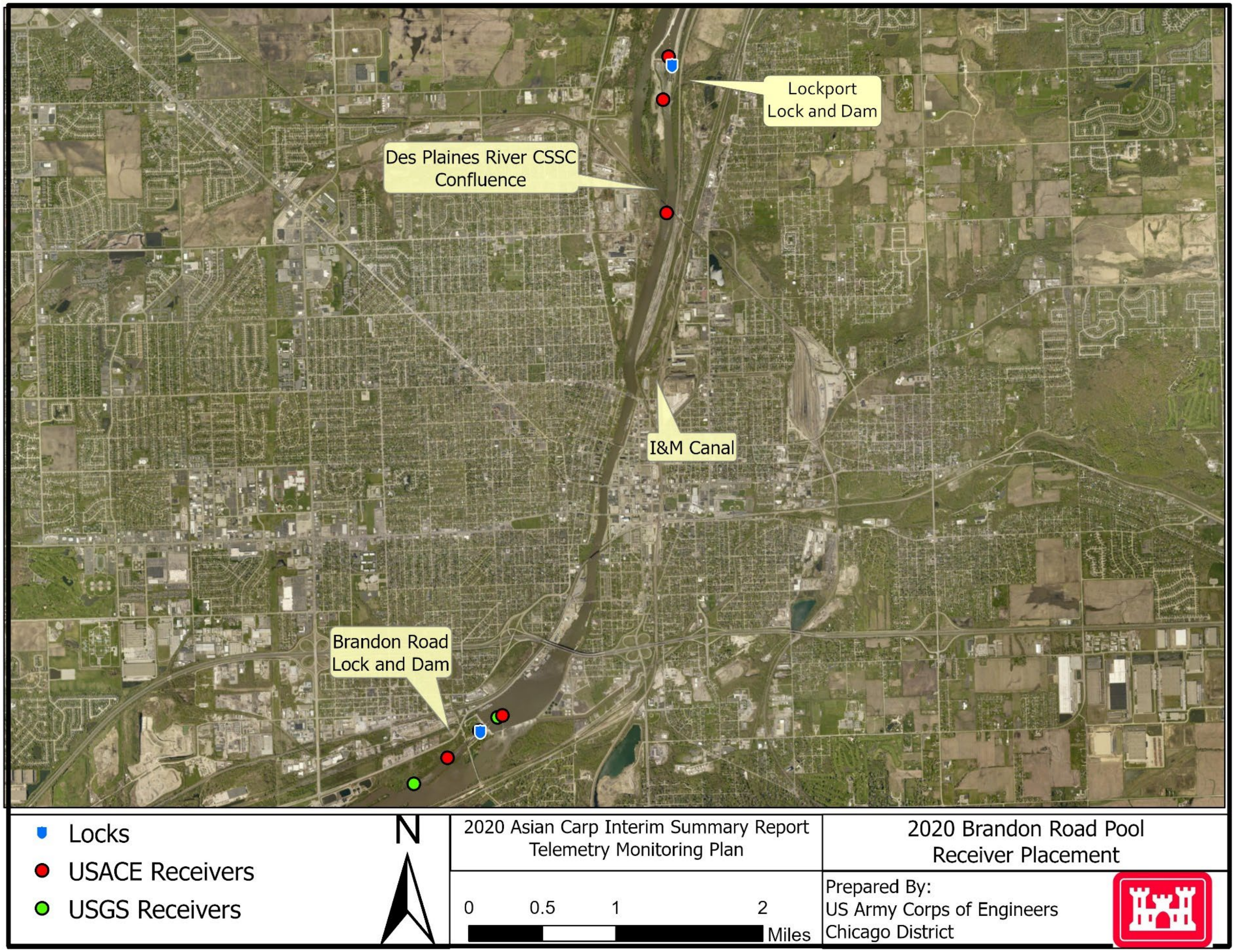
Receiver Placement
Prepared By:
US Army Corps of Engineers
Chicago District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Receiver Placement
Prepared By:
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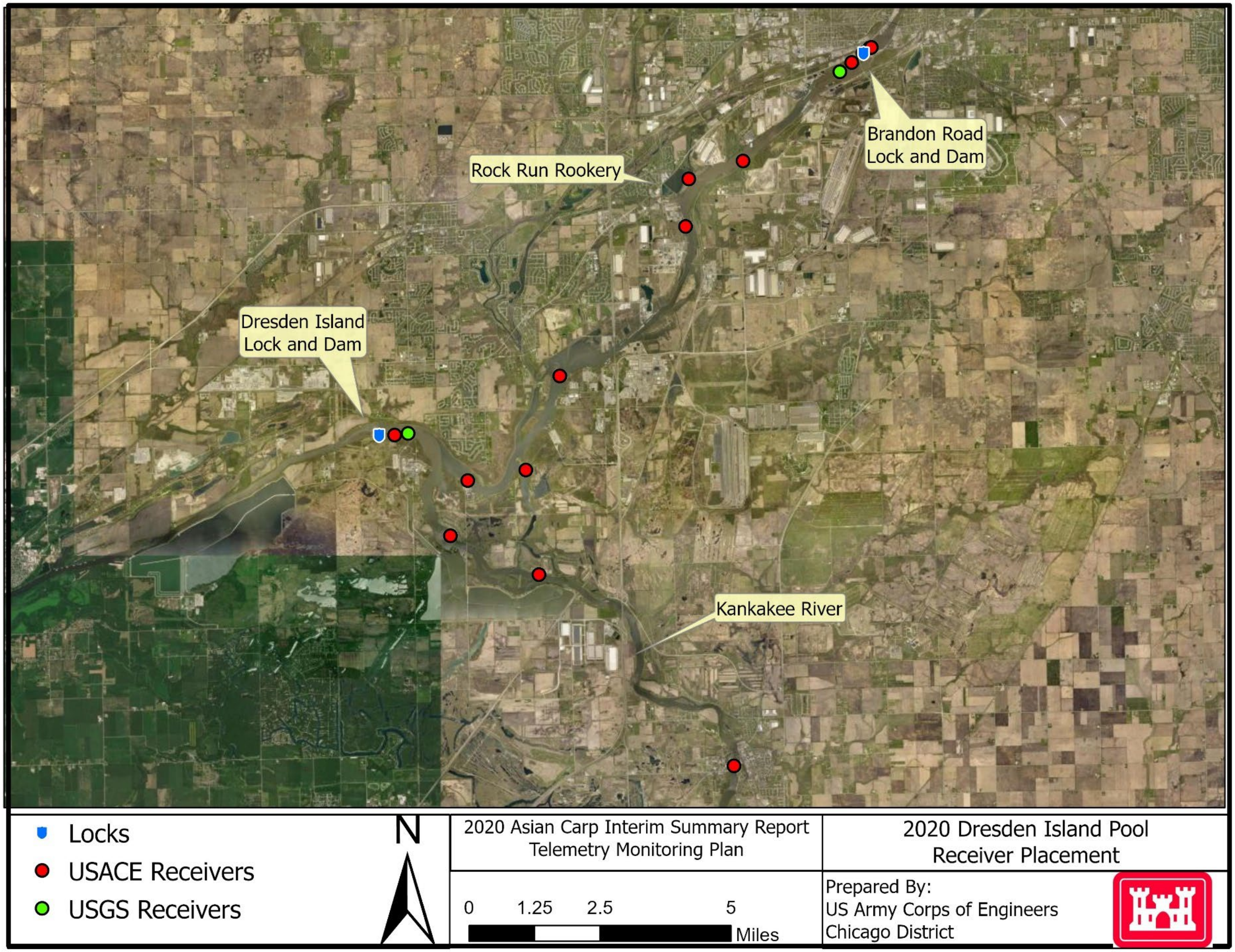
Chicago District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Telemetry Monitoring Plan
2020 Dresden Island Pool
Receiver Placement
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Prepared By:
US Army Corps of Engineers
Chicago District

USGS Telemetry Project

Brent Knights, Marybeth Brey, Jessica Stanton, Travis Harrison, Doug Appel, and Enrika Hlavacek (U.S. Geological Survey, Upper Midwest Environmental Sciences Center); Jim Duncker (U.S. Geological Survey, Central Midwest Water Science Center)

Participating Agencies: U.S.Geological Survey (USGS), Southern Illinois University, U.S. Army Corps of Engineers, Illinois Department of Natural Resources, U.S. Fish and Wildlife Service, Western Illinois University, Illinois Natural History Survey

Pools Involved: All Illinois River Navigation Pools and upper Illinois Waterway Systems

Introduction and Need:

Telemetry of acoustically tagged bigheaded carp (i.e., Bighead Carp *Hypophthalmichthys nobilis* and Silver Carp *H. molitrix*) and surrogate fish species has become an invaluable tool in management for these species in the upper Illinois Waterway (ISystem (i.e., upper Illinois River, lower Des Plaines River, and Chicago Area Waterway System [CAWS]). For example, movement probabilities between adjacent navigation pools need to be estimated to parameterize the Spatially Explicit Asian Carp Population (SEACarP) Model. SEACarP is a population model used in scenario planning by the Monitoring and Response Work Group (MRWG) to evaluate alternative management actions. These movement probabilities are estimated from the telemetry data obtained from a longitudinal network of strategically placed receivers that detect bigheaded carp implanted with acoustic transmitters. In addition, fish removal by contracted fishers has become the primary method of controlling bigheaded carp in the upper Illinois and lower Des Plaines Rivers. Variable patterns in bigheaded carp distribution, habitat, and movement, influenced by seasonal and environmental conditions, make targeting bigheaded carp for removal and containment challenging and costly. Understanding these movement patterns for bigheaded carp through modeling and real-time telemetry applications informs removal efforts and facilitates monitoring and contingency actions based on fish movements.

To develop a better understanding of fish movement dynamics to meet management objectives, an existing network of real-time and data-logging acoustic receivers in the upper Illinois Waterway Systems is collaboratively managed by a multi-agency team (see Participating Agencies section above). A Telemetry Workgroup has been established by the MRWG to ensure that the multi-agency telemetry efforts are coordinated to efficiently and effectively meet the MRWG goals. This workgroup plans and executes the placement of receivers, tagging of bigheaded carp with acoustic tags, and management of the telemetry data. Three primary objectives to meet MRWG goals identified by the Telemetry Workgroup included (1) development of a common standardized telemetry database with visualization and analysis tools, (2) transitioning from Program MARK (http://www.phidot.org/software/mark/) to a custom Bayesian multi-state model for estimating movement probabilities needed for SEACarP and

(3) deploying, maintaining, and serving data from real-time acoustic receivers to inform contingency planning and fish removal.

A telemetry database and visualization tools (FishTracks) will facilitate standardization, archiving, sharing, quality assurance, visualization and analysis of the telemetry data needed for management. Modifications and additions to FishTracks will facilitate more problem-free use of the database and associated applications, as well as useful extraction of information to meet management goals. The transition to a custom Bayesian multi-state model to estimate movement probabilities will support more efficient, effective, and robust population modeling with SEACarP by overcoming short comings of Program MARK for this purpose. These shortcomings include lack of customizability and extensibility, problems of singularities and poor-convergence, software crashes, parameter exclusion from models, an inability to consistently generate estimates of movement probability, and a lack of uncertainty estimates for movement probabilities. A real-time receiver network that is maintained and tested annually will ensure reliability and accuracy of the real-time alerts to bigheaded carp movements that can be used by management to plan contingency actions.

Objectives:

(1) *Database*: Maintenance and development of FishTracks telemetry database and associated tools.

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

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

Project Highlights:

Database

Several updates to improve FishTracks functionality and ease of use included (1) a visualization tool for active receivers to facilitate multi-agency coordination, (2) webpages for searching transmitter and receiver inventory, (3) an application programming interface (API) for alternative access, and (4) program code in R statistical software for querying, summarizing and analyzing telemetry data via the API.

Movement Model

Quality assurance of the 2012-2019 telemetry data from FishTracks being used in the new multi-state movement probability model was completed. An additional parameter was added to the movement model to directly account for variable numbers of receivers deployed in each river reach to improve estimates of detection probability. The new movement model was successfully run on the full dataset of tagged Silver Carp and Bighead Carp in the Illinois River and results will be (1) incorporated into planning efforts by the Telemetry Workgroup for receiver deployment and fish tagging to continue monitoring of this vital population dynamic (i.e., movement) and (2) shared with the MRWG Modeling Workgroup to be used in parameterizing the SEACarP model for further scenario planning to inform control of bigheaded carp in the Illinois River and associated Waterway Systems.

Real-time Receiver Network and Alert System

Seven real-time receivers were deployed and maintained in the upper Illinois Waterway System in 2020. The systems that share FishTracks telemetry data online with partners and alert key MRWG personnel of detections of bigheaded carp in areas of management concern were continued in 2020.

Methods:

Database

FishTracks, a Microsoft SQL Server application, was actively maintained at the USGS Upper Midwest Environmental Sciences Center (UMESC). Maintenance involves routine data backups, performance of internal consistency checks, and rebuilding indexes as needed to keep the application online and available to users. New telemetry data was uploaded into FishTracks by UMESC personnel after it was collected, quality assured, and submitted by partner agencies via an upload application. Further quality assurance was conducted at UMESC by a database manager to screen for missing data or potentially aberrant values. Information on missing data and potentially aberrant values was then sent to partners for validation or correction. FishTracks functionality was modified or added based on partner recommendations and needs (e.g., modeling efforts) identified through quarterly meetings of the Telemetry Workgroup and other interactions with partners. Application updates, new version releases, and data requests were communicated to contributing partner agencies via the Telemetry Workgroup.

Movement Model

The USGS in collaboration with the Telemetry Workgroup and Population Modelling Workgroup of the MRWG developed a multi-state model to estimate interpool movement probabilities needed for SEACarP. The "states" represented in these multi-state models are the navigation pools in the Illinois and Des Plaines Rivers and upper Illinois Waterway Systems. Specifically, Bayesian statistical methods were used to create a model syntax that maximizes user customizability and extensibility, while avoiding the problems of singularities and poor-convergence inherent to the rival frequentist Program MARK. For example, previous multi-state modeling with Program MARK has been fraught with difficulties (e.g., computer crashes, automatically excluding parameters from the model, and not providing estimates) thought to be related to model complexity including the number of model parameters derived from the number of states, recapture periods, random effects to account for individual fish, and allowance for spatial and temporal heterogeneity. In addition, Program MARK does not provide uncertainty estimates for the parameters, and these are desired in the context of scenerio planning with the SEACarP model. Hierarchical models performed in a Bayesian framework provide a direct expression of uncertainty for parameters to use in the SEACarP model. USGS further reviewed the historical telemetry data in FishTracks for completeness and aberrant values prior to using it in the multi-state model.

Real-time Receiver Network

A network of seven real-time receivers was redeployed, maintained, and tested in the Upper Illinois Waterway System by USGS crews in spring and summer 2020. Data access for these receivers was maintained online. Real-time alerts were provided to key personnel via email as requested by partner agencies.

Results:

Database

The latest version of the FishTracks telemetry database and visualization tool includes new features for managing the multi-agency telemetry efforts and analysis. The Receiver Activity Map provides a view of the active receivers for any period of interest. The active receiver view facilitates interagency coordination of receiver deployment to maximize efficiency in the multi-agency telemetry network. Additionally, new data summary and visualization tools were created to support the auditing and coordination of data management in FishTracks. To improve data accessibility and inspection, webpages were added to FishTracks website to provide for searches of transmitter and receiver information. Further steps were taken to improve data access by publishing and documenting the API which provides easy access to the data via R software. We also developed R code that uses this API to provide users with the ability to directly access the data from an analytic environment (i.e., R statistical software). One of the latest features of FishTracks website is the Detection Stream tool which animates daily fish movements to allow users to audit receiver and transmitter information, as well as, quickly view fish movements.

Movement Model

Understanding the movement and dispersal characteristics of invasive Bighead Carp and Silver Carp is an important aspect of their management and control on the Illinois River. Summarizing movement rates within and between basins will aid in informing decisions for efficient management and control of these species. In FY 2020, we completed the quality assurance of the dataset to include data for the years 2012 through 2019. This expanded dataset was compiled from multiple agencies and cooperators through FishTracks data repository.

We also made several advances to the multistate movement model previously developed for invasive carps in this system. The primary advancement was to parameterize the model to directly account for variable numbers of receivers deployed in each river reach throughout the duration of the study. Adjusting the model in this way allows for more robust estimates of detection probability within the model. These detection probability curves also provide a means to evaluate how the current number and arrangement of receivers in each pool are doing at detecting the tagged fish in that pool.

These new models were successfully run on the full dataset of tagged Silver Carp and Bighead Carp in the Illinois River. We are currently working on preparing a manuscript to describe the results of this effort to date. The results will be provided to the MRWG Modeling Workgroup to be used in parameterizing the SEACarP model for further scenario planning to inform control of bigheaded carp in the Illinois River and associated Waterway Systems. We are also working with the SEACarP modeling team to begin work to explore possible modeling approaches to determine the effects of fish density and size on pool-to-pool movement rates. Understanding these effects would be useful to further improve the movement models for informing bigheaded carp removal or deterrence in this system.

Real-time Receiver Network

USGS personnel monitored, downloaded and maintained data from seven real-time receivers in the upper Illinois Waterway System in 2020. Locations of the seven real-time receivers in the upper Illinois Waterway System included (1) Chicago Sanitary and Ship Canal (CSSC) near Lemont, Illinois, (2) CSSC below Fish Barrier at Romeoville, Illinois, (3) Des Plaines River above Brandon Road Lock and Dam at Rockdale, Illinois, (4) Des Plaines River below Brandon Road Lock and Dam at Rockdale, Illinois, (5) Illinois River above Dresden Island Lock and Dam near Minooka, Illinois, (6) HMS West Pit at culvert near Morris, Illinois, and (7) Illinois River below Starved Rock Lock and Dam at Utica, Illinois.

Each receiver was programmed to alert partner agencies when acoustically tagged bigheaded carp are detected. Four real-time receivers are in areas of management concern (upstream of the bigheaded carp invasion front in upper Dresden Island Pool; receiver locations 1 – 4 above), and these receivers did not detect a bigheaded carp in 2020. The three real-time receivers outside of these areas of concern contribute to the broader telemetry network objectives to provide important information on seasonal bigheaded carp movements. All the receivers were accessed remotely, and the data made available online. Detection data and summaries were shared with partners throughout the year.

Modifications to the real-time receivers in 2020 included the repositioning of the receiver at the Romeoville site below electric fish barrier (receiver location 2 above) to increase protection from barges while still providing a large detection area. A sentinel tag was also deployed at the Lemont site above the electric fish barrier (receiver 1 above). This location (approximately 5 miles above the electric dispersal barrier) does not generally detect tagged fish, so the sentinel tag provides an indication that the receiver is functioning properly in this area of high management concern.

USGS Telemetry Project

COVID travel restrictions in 2020 prevented us from completing the annual range tests for these receivers. Results from 2019 receiver range testing and detection summaries have been shared in workgroup meetings and are included in a draft USGS open-file report that is currently under review. Range testing and continued operation of the real-time receivers and alert system is planned for FY21.

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

Michael A. Glubzinski and Nathan T. Evans (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); U.S. Army Corps of Engineers-Chicago District (field/logistical support)

Pools Involved: Lockport, Brandon Road, and Dresden Island

Introduction and Need:

The Electric Dispersal Barrier System (EDBS) located within the Chicago Sanitary and Ship Canal (CSSC) operates with the purpose of preventing inter-basin transfer of invasive fishes between the Mississippi and Great Lakes basins. Observational evidence from previous studies suggests that fish may congregate below the EDBS at different times throughout the year, primarily during the summer and fall (Parker & Finney, 2013); however, ultimately, fish interaction with the EDBS is not predictable or well understood. Having a greater understanding of the spatial and temporal patterns of fish density within and below the EDBS is important to barrier management, as it allows operational and maintenance decisions to be made in sync with an understanding of potential risk. To determine these periods of elevated risk, split-beam hydroacoustic surveys were planned to be performed within and below the EDBS on a bi-weekly basis throughout 2020. Monthly split-beam hydroacoustic surveys of the Lockport, Brandon Road, and Dresden Island navigation pools of the upper Illinois Waterway (IWW) were also scheduled to evaluate the potential for increased pressure on the EDBS from fish moving from the pools immediately downriver. However, due to the COVID-19 pandemic, both of these projects were suspended beginning in mid-March. Results from the first two months of sampling (January – early March) nonetheless provide some insight into the dynamics of fish densities and distributions in the upper pools of the IWW, when few other sampling events occur. Understanding fish assemblage dynamics throughout the upper IWW allows the findings from a range of other research activities at the EDBS to be put into a system-wide context, enabling more refined interpretations of results and allowing managers to make informed decisions.

Objectives:

(1) Evaluate the abundance of fishes within and directly below the EDBS bi-weekly throughout the year.

(2) Determine the density of fishes in the three upper navigation pools within the IWW monthly throughout the year.

(3) Identify changes in large fish abundance that could indicate risk of further Asian carp invasion.

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

Project Highlights:

- Fish abundances both within and directly downstream of the EDBS were similar across 2020 hydroacoustic surveys conducted from January – March.
- Fish abundances within the EDBS were low with a mean of 0.75 large fish targets detected per survey (min = 0, max = 2 individual large fish targets).
- Fish abundances directly downstream of the EDBS were releativly low with a mean of 1.8 large fish targets detected per survey (min = 0, max = 3 individual large fish targets).
- Large fish density was greatest in Dresen Island Pool (1.1 fish / 100,000 m^3), and similar in Brandon Road and Lockport pools (0.4 fish / 100,000 m^3) during March 2020. Fish densities across all three pools were fairly low and similar to Fall 2019 survey results.

Methods:

Acoustic Fish Surveys at the Electric Dispersal Barrier System

Horizontal, split-beam hydroacoustic and side-scan sonar surveys were conducted biweekly-to-monthly below the CSSC EDBS from January – March 2020 to assess fish density and distribution patterns near the barrier on a fine temporal scale. Survey transects began approximately 1.2 km below the EDBS at 41°37'46.2756" N, -88°3'41.9724" W. The survey vessel followed a path close to the west wall traveling north with the side-looking hydroacoustic transducers aimed towards the east wall. Each transect continued through the EDBS, paused briefly to allow bubbles and wake to disperse, turned south, and then traveled closely along the east wall back to 41°37'46.2756" N. Three consecutive replicate hydroacoustic samples took place on each survey date.

Survey equipment consisted of a pair of Biosonics® 200 kHz split-beam transducers and a 4125 Edge Tech ultra-high-resolution side scan unit. The two split-beam transducers were mounted in parallel on the starboard side of the research vessel 0.28 m below the water surface on a dual axis mechanical rotator. The side scan unit was attached to a port-side davit and lowered <1 m into the water. Transducer sampling angles were set to -3.2˚ and -9.6˚ below the water surface to maximize coverage and minimize beam overlap. When necessary, due to boat movement, the rotators were manually repositioned to maintain these angles. Split beam acoustic data was collected using Visual Acquisition v.6® from 1 to 50 m from the transducer face, at a ping rate of 5 pings per second, and a 0.4 ms pulse duration. Data collection was set to begin at 1 m from the transducer face 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, water temperature was measured and input into Visual Acquisition v.6® prior to all data collections. The on-axis calibration of the split-beam acoustic transducers were confirmed with a tungsten carbide calibration sphere before sampling following Foote et al. (1987).

Split-beam hydroacoustic data were post-processed in Echoview® v. 9.0. Data was loaded into a mobile survey template. The mobile survey template was used to identify and estimate the size and location of single fish targets based on angular position and target strength (TS). Data post-processing followed standard methods (Glover et al. unpublished data). Data that were collected outside of the analysis bounds (between 41°37'46.2756" 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 the "single target detection – split-beam (method 2)" algorithm within the Echoview Fish Tracking Module®, and single target TS was converted from dB to target length using equations derived from Love (1977). Large fish targets were classified as those with TS ≥ -28.7 (≥ 12 inches [30.5 cm]) total length based on the true side-aspect TS of a fish. Each individual fish track was also spatially located within the water column using the split-beam transducers capabilities and assigned X, Y, and Z positional coordinates. Methods for processing the side-scan sonar data to supplement the hydroacoustic results are currently being developed. Side-scan sonar results will be presented in the future.

Illinois Waterway Pool Surveys

To quantify the density and spatial distribution of the fish community in the upper IWW, hydroacoustic surveys were conducted throughout the Lockport, Brandon Road, and Dresden Island navigation pools in March of 2020. The surveys were conducted using the same equipment, collection techniques, and analysis methods as were employed during the hydroacoustic surveys at the EDBS. Within each navigation pool, upstream and downstream transects were sampled near the channel margin, with transducers facing outwards towards the middle of the channel. In areas where the navigation channel was wider than the range of the survey equipment (Dresden Island Pool), a second set of mirrored transects were conducted near the extent of the range of the first transects' beams (approximately 50 m).

Results and Discussion:

Fish Surveys within and below the Electric Dispersal Barrier

Results from the hydroacoustic surveys conducted within the EDBS indicate low fish abundance within the EDBS from January – March 2020 (mean = 0.75 large fish targets detected per survey; range = 0 to 2 individual large fish targets) (Figure 1). Zero large fish targets were detected within the EDBS during 2 of the 4 sampling periods. Additionally, results from the portion of the hydroacoustic surveys conducted immediatley downstream of the EDBS also suggested low fish abundance downstream of the EDBS from January – March 2020 (mean = 1.8 large fish targets detected per survey; range = 0 to 3 individual large fish targets). At least one large fish target was detected below the EDBS during each sampling period. While observed abundance was consistently low both within and below the EDBS, restricted sampling due to

COVID-19 may not have captured spikes in abundance that have been witnessed in the past during summer and fall (Parker & Finney, 2013).

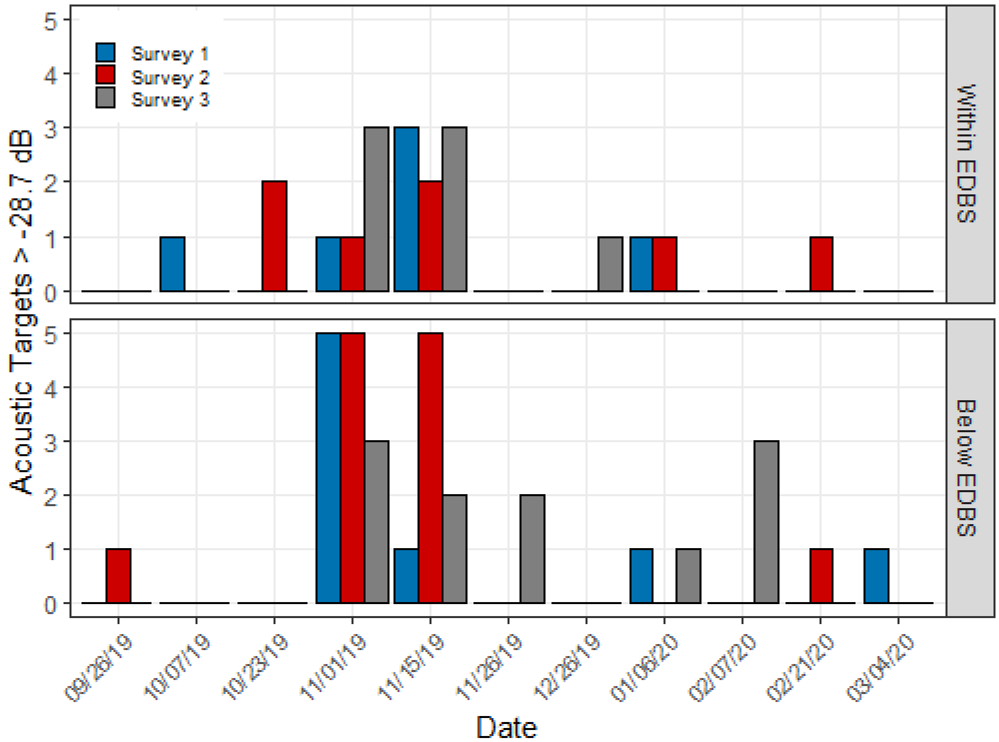

Figure 1. *Number of large fish targets (≥ -28.7 dB) observed within and immediately downstream of the EDBS during split-beam hydroacoustic surveys conducted from September 2019 – March 2020.*

Illinois River Pool Surveys

Results from March 2020 hydroacoustic surveys conducted in Dresden Island, Brandon Road, and Lockport pools illustrate greater large fish densities in Dresden Island Pool (1.1 fish > 10”/100,000 m^3), and similar densities Brandon Road and Lockport pools (0.4 fish > 10”/100,000 m^3). Densities observed during March 2020 were similar to those collected in Fall 2019 (Figure 2), suggesting overall large fish abundance in these pools did not change over winter.

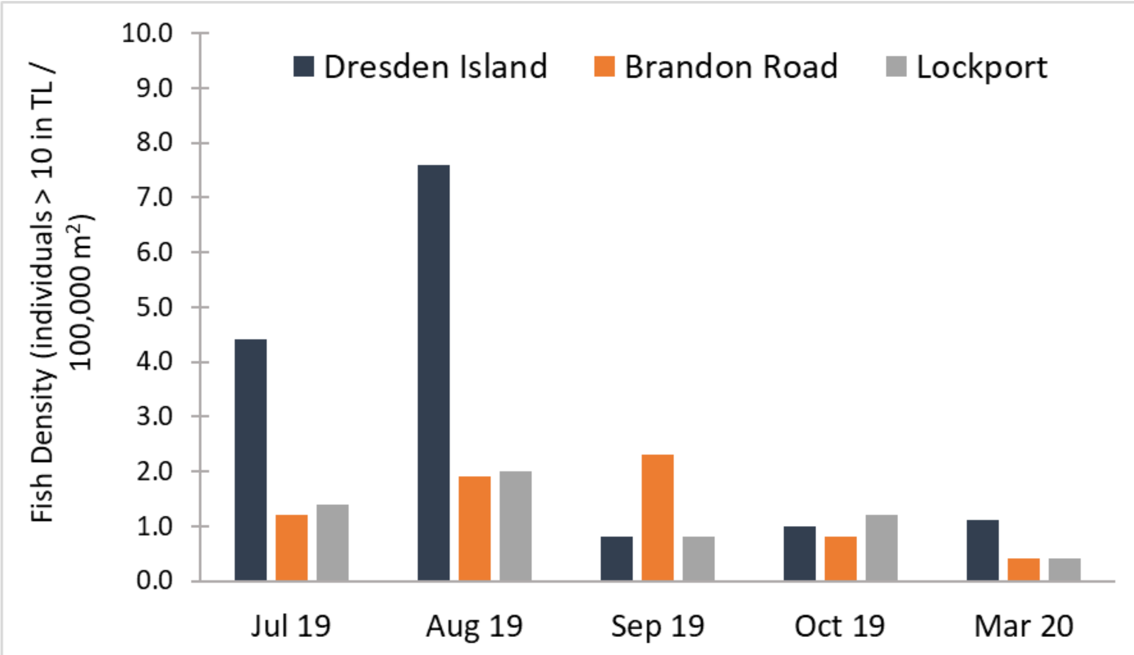

Figure 2. *Mean fish density (individuals/100,000 m^3) observed from split-beam hydroacoustic surveys conducted in Dresden Island, Brandon Road, and Lockport Pools from summer 2019 – March 2020. Remaining scheduled monthly surveys for 2020 were cancelled due to the COVID-19 pandemic. Results indicate no observed change in large fish abundance between fall of 2019 and early spring of 2020.*

Conclusion

While limited in scope in 2020 due to the COVID-19 pandemic, these studies nonetheless continued to provide insight into the dynamics of fish assemblages near the EDBS that are unattainable using traditional fisheries sampling gears, and enabled documentation of fish density trends at the invasion front and uninvaded ranges of bigheaded carps in the upper IWW. Insights from these monitoring efforts are valuable for identifying risk and informing management actions.

Recommendations:

(1) Continue monitoring the spatial and temporal patterns of large fish within the upper IWW to detect changes in biomass or habitat utilization that could be indicative of changes in assemblage structure.

(2) Continue monitoring and rapid reporting of survey data to inform management agencies of suspected Asian carp observations or changes in large fish abundance.

(3) Increase the spatial and temporal coverage of paired physical capture sampling, and explore other alternative techniques, to provide species inferences from hydroacoustics data.

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Distribution and Movement of Small Asian Carp in the Illinois Waterway

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Participating Agencies: U.S. Fish and Wildlife Service (USFWS) Carterville FWCO – Wilmington, IL Substation

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

Introduction and Need:

Invasive Silver Carp and Bighead Carp (*Hypophthalmichtys molitrix* and *H. nobilis*; hereafter collectively called "Asian carp") populations have expanded upstream in the Mississippi River basin since the 1970s and are now established in the Illinois River (Chick & Pegg, 2001; Sass et al., 2010). The Chicago Area Waterway System (CAWS) is a network of manmade canals that connect the Illinois River to Lake Michigan and is the most probable invasion pathway for Asian carp to enter Lake Michigan (Kolar et al., 2007). If Asian carp were to reach Lake Michigan, they would likely spread throughout the Laurentian Great Lakes, be impossible to eradicate, and would endanger ecosystems and industries (Cooke & Hill, 2010). To block Illinois River Asian carp from reaching Lake Michigan, the U.S. Army Corps of Engineers constructed an Electric Dispersal Barrier System (EDBS) in the CAWS near Romeoville, IL (ACRCC, 2014).

The EDBS appears to be effective at preventing passage of large-bodied (greater than 6 inch total length [TL], 153 millimeters [mm] TL) fish, but its effectiveness against small (less than or equal to 6 inch, 153 mm TL) fish is unclear (Holliman, 2011). Field tests have shown that smaller native fishes have passed through the EDBS by being trapped and swept (i.e., entrained) upstream in the gaps between northbound river-going cargo barges (Davis et al., 2016). Laboratory tests also indicate that smaller fishes can be transported through the EDBS by water currents created during southbound barge movements (Bryant et al., 2018). Together, these studies demonstrate that small-bodied Asian carp could plausibly pass upstream of the EDBS, which would leave no further barriers to prevent them from entering the Great Lakes.

To manage the risk that Asian carp present for the Great Lakes, a large-scale program (Early Detection Monitoring, or EDM) monitors for Asian carp above and below the EDBS in the main channels of the upper Illinois River and CAWS. This monitoring has proven effective for catching large-bodied Asian carp but may be insufficient for catching small-bodied Asian carp as they tend to congregate in side-channels and backwaters (Koel et al., 2000). These behavioral tendencies increase the potential for monitoring efforts to erroneously conclude that small-bodied Asian carp are absent in targeted survey locations in the upper Illinois Waterway (IWW).

The need to monitor specifically for small-bodied Asian carp in the upper Illinois River and CAWS is underscored by the vulnerability of the EDBS to small fish, and the general focus of the EDM on detection of large-bodied Asian carp. High spatial- and temporal-resolution monitoring targeting small-bodied Asian carp will yield data to track the geographic distribution and relative abundance of these fish. These data can then be used to estimate how far upstream Asian carp have progressed in the upper Illinois River, which could indicate spawning or range expansion.

Objectives:

The goal of this study was to determine the spatial distribution of small-bodied Asian carp in the upper Illinois River through intensive, targeted sampling.

(1) Detect the furthest upstream location of small-bodied Silver Carp and Bighead Carp.

(2) Determine the distribution and abundance of small-bodied Silver Carp and Bighead Carp in the upper Illinois River.

(3) Use distribution and abundance data to characterize the risk of small-bodied Silver Carp and Bighead Carp entry into the Great Lakes via the CAWS.

Project Highlights:

- 2020:
  - 193 adult (greater than 350 mm TL) Silver Carp and one adult Bighead Carp were captured in Starved Rock and Marseilles pools. No small-bodied Asian carp were captured.

- Cumulative 2012-2020:
  - The furthest upstream location at which small-bodied Asian carp were collected within this project is the Marseilles Pool. In total, three juvenile Asian carp (less than 350 mm) were captured at this location. Two were captured on Oct 22, 2015 (168 mm TL and 171 mm TL; boat electrofishing; GPS: 41.32510°N, -88.54901°W) and one was captured on Oct 4, 2016 (295 mm TL; boat electrofishing; GPS: 41.32767°N, -88.74625°W).
  - A total of 2,385 small-bodied Asian carp have been collected through this project (1,114 "small" individuals less than or equal to 153 mm TL; 1,271 "juvenile" individuals between 154 and 350 mm TL).
  - This project recorded 480 net nights and 420 hours of electrofishing effort targeting capture of small-bodied Asian carp.
  - In this study, dozer trawls delivered relatively high catch-per-unit-effort (CPUE) and were the most effective gear for catching small-bodied Asian carp.

Methods:

COVID-19 Statement

USFWS limited field crews to two or fewer people to prioritize staff safety during the COVID-19 pandemic. This crew-size limitation restricted small-bodied Asian carp monitoring in 2020.

Sampling

Two size classes of small-bodied Asian carp were tracked: (1) “small” and (2) “juvenile”. “Small” Asian carp were defined as individuals less than or equal to 153 mm TL and “juvenile” Asian carp were defined as individuals between 154 and 350 mm TL. This size distinction is critical because Asian carp less than or equal to 153 mm TL and in the vicinity of the EDBS would be an immediate threat to the EDBS (Holliman, 2011), whereas 154 to 350 mm TL Asian carp are less likely to be an immediate threat to the EDBS but may have been a threat during the sampling year due to the fast growth rate of Asian carp (Gibson-Reinemer et al., 2017).

Sampling targeted small-bodied Asian carp in marinas, backwaters, and side-channels because small-bodied Asian carp prefer low-flow habitat (Koel et al., 2000). Specific sampling locations were chosen in these low-flow habitats at the crew leaders’ discretion based on gear efficacy, water conditions, historical small-bodied Asian carp capture rates, and experience gained from the previous USFWS juvenile Silver Carp telemetry project in the Peoria Pool. GPS coordinates and time stamps were recorded at the start and end of each electrofishing event and trawl run.

2020 Sampling

In 2020, all fishes were collected by two-person boat electrofishing and electrified dozer trawls (see *Sampling Gear Descriptions*), identified to species, and enumerated. Sampling was conducted between August 3 and August 13, 2020 in the Starved Rock, Marseilles, and Dresden Island pools because these pools are the presumed leading-edge of Asian carp expansion. Asian carp were weighed (g) and measured (mm, total length, TL). Any fish not easily identified to species was preserved in Excel Plus or 70% ethanol for laboratory identification to the lowest possible taxonomic level. Boat electrofishing and electrified dozer trawl sampling effort was quantified in hours. Sampling catch per unit effort was quantified as number of Asian carp caught per hour of electrofishing.

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.

Sampling Gear Descriptions

Electrofishing

Pulsed DC daytime electrofishing conducted from a motorboat. Electrofishing was performed in repeated passes perpendicular to and toward shore. Shocked fish were collected by one crewmate, by hand with a dip net. Electrofishing was conducted in 15-minute sampling periods.

Dozer Trawl

Pulsed DC daytime electrofishing conducted from a motorboat. Electrofishing was performed in continuous passes parallel to shore. Shocked fish were collected in a 4 mm mesh net at bow of the boat. The mesh net was held open by a 2 m by 1 m rigid frame mechanically raised and lowered to depths <1 m. The mesh net extended approximately 2.5 m toward the boat's stern as it was pulled forward and was tied closed at its cod end. Distance and duration of dozer trawls depended on site characteristics.

Results

In 2020, 51 sites in three Illinois River pools (Starved Rock, Marseilles, and Dresden) were sampled for small-bodied Asian carp, providing 8.03 hours of combined boat electrofishing and dozer trawl effort (Table 1). This effort yielded no small-bodied Asian carp but yielded 194 large-bodied (greater than 350 mm TL) Asian carp.

Table 1. *USFWS 2020 targeted small-bodied Silver Carp and Bighead Carp sampling effort in Starved Rock, Marseilles, and Dresden pools.*
Pools are organized left-to-right in this table to indicate furthest-from to nearest-to the EDBS. Effort is the total within-pool sampling time (in hours, h) for each gear type (electrofishing or dozer trawl). The number of sampling sites (n sites) is the total number of sites sampled with each gear type in each pool. This sampling effort was applied over two crew weeks between 3 August 2020, and 13 August 2020.

	Starved Rock		**Marseilles**		**Dresden**	
	Effort (h)	n sites	Effort (h)	n sites	Effort (h)	n sites
Boat Electrofishing	-	-	5	20	0.75	3
Dozer Trawl	2.28	28	-	-	-	-

Cumulative Sampling From 2012-2020

This project recorded 480 net nights and 420 hours of electrofishing effort dedicated to sampling for small-bodied Asian carp from 2012 through 2020 (Table 2). Additionally, some surveys were conducted without effort being recorded (see Table 2: Percent of sites with recorded effort). This means that the actual fishing effort expended in this project was often higher than the fishing effort reported in Table 2.

Catch per unit effort (CPUE) of small-bodied Asian carp was higher for electrified gears (CPUE measured in fish per hour) than for passive gears (CPUE measured in fish per net night; Table 3).

Maximum CPUE, 61.056 fish/h, was achieved in 2015 by electrified Paupier Trawl. Dozer Trawl CPUE averaged 5.623 fish/h for 2015 through 2019, which was consistently high compared to other gears.

Upstream pools, like Marseilles, had the lowest catch (Figure 1a, Table 2) and catch-per-unit-effort (Figure 1b, Table 3) of small and juvenile Asian carp. Conversely, downstream pools, like LaGrange and Peoria, had the highest catch (Figure 1a, Table 2) and highest catch-per-unit-effort (Figure 1b, Table 3) of small and juvenile Asian carp. This trend suggests that abundance of small and juvenile Asian carp is higher further downstream, which is consistent with literature on this subject (Kolar et al., 2007).

Results and Discussion:

Objective 1: Detect the furthest upstream location of juvenile Silver Carp and Bighead Carp.

This study's furthest upstream live small-bodied Asian carp were collected in Marseilles pool. Three juvenile ($154 \leq TL \leq 350$ mm) individuals were collected in Marseilles pool in 2015 and 2016. Since these fish are the furthest upstream live small-bodied Asian carp to be collected by this project, it is possible that these fish indicate the leading edge of Asian carp spawning in the Illinois River is in or upstream of Marseilles pool. While detecting these small-bodied Asian carp in Marseilles pool is clearly important, the rarity of these catches is also noteworthy. Specifically, no additional small-bodied Asian carp were caught in or upstream of Marseilles pool since 2016, which suggests the captures in Marseilles may be aberrations.

Objective 2: Determine the distribution and abundance of small Silver Carp and Bighead Carp in the upper Illinois River.

The highest numbers of small-bodied Asian carp were caught in downstream pools with known Asian carp spawning, like Peoria pool (Song et al., 2017). Small-bodied Asian carp were relatively rare in upstream pools where Asian carp spawning is unverified or absent, like Marseilles pool (Song et al., 2017). When combined, this evidence suggests either that A) small-bodied Asian carp are absent from upstream pools or B) small-bodied Asian carp are present in upstream pools and we did not expend enough effort to detect them. It is impossible to distinguish between these possibilities without additional fishing effort.

Objective 3: Use distribution and abundance data to characterize the risk of small Silver Carp and Bighead Carp entry into the Great Lakes via the CAWS.

A formal risk assessment would be required to determine the risk of small-bodied Silver Carp or Bighead Carp entering the Great Lakes via the CAWS. Such a risk assessment is outside the scope of this project because the effort applied by this project to detect small-bodied Asian carp near the EDBS falls short of the effort-threshold required to definitively conclude that a rare species is *absent* from a sampling area (Hoffman et al., 2011). For example, this project's furthest upstream Asian carp were found in Marseilles Pool, but other projects have predicted

Asian carp spawning (Zhu et al., 2018) and collected larval Asian carp (ACRCC, 2016) upstream of Marseilles Pool. Therefore, our project cannot conclude that small-bodied Asian carp are *absent* from pools near the EDBS, which would be required to assess invasion risk. Since it remains plausible that small-bodied Asian carp are in the vicinity of the EDBS, more monitoring should be conducted to determine their presence or absence.

Limitations and Lessons Learned

The observed increase in small-bodied Asian carp CPUE from 2012 to 2014 vs. 2015 to 2019 (Table 3, Figure 1b) was likely from increasing efficiency in targeting small-bodied Asian carp, not increasing small-bodied Asian carp abundance. To determine a change in abundance, effort would need to be randomized, stratified, and/or otherwise standardized. This project's sampling specifically targeted small-bodied Asian carp and was not standardized in time nor space so we cannot determine changes in abundance. Moreover, we made a point to test which habitats and gears were most efficient at catching small-bodied Asian carp.

We found that habitat and gear selection were critical for successfully capturing small-bodied Asian carp. Specifically, our findings substantiate evidence that small-bodied Asian carp favor side-channels and backwaters (Kolar et al., 2007) and that dozer trawls can be effective at catching these fish in these habitats (Hammen et al., 2019).

Recommendations

USFWS recommends concluding this study and incorporating the lessons learned from this study into the EDM program. Incorporating these lessons into EDM will maximize the certainty around determining the presence or absence of small-bodied Asian carp in the vicinity of the EDBS, which is critical, given the potential vulnerability of the EDBS to small-bodied fishes (Holliman, 2011).

Supplemental Information

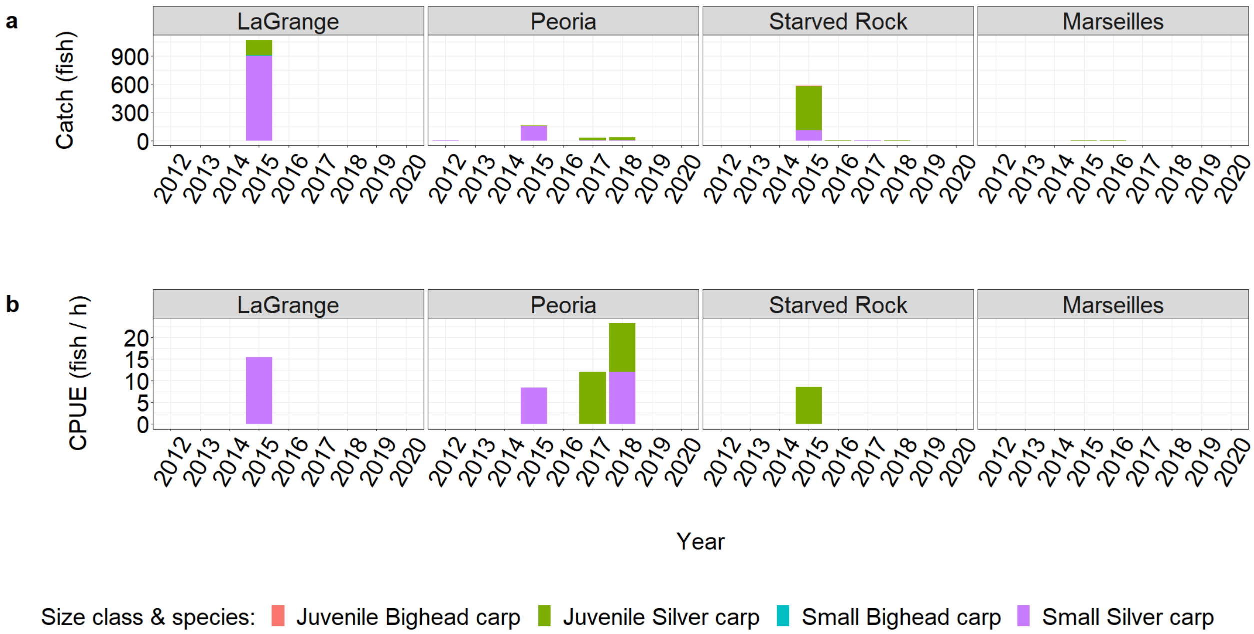

Figure 1. *Small and juvenile Asian carp catch and catch-per-unit-effort (CPUE) for 2012 through 2020 in four Illinois River pools.*
Pools are organized from furthest-from to nearest-to the EDBS (left to right). ***a)*** *Catch (count of individual fish collected with any gear type) of small and juvenile Asian carp.* ***b)*** *Catch-per-unit-effort (fish collected per hour of dozer trawl) of small and juvenile Asian carp.*

Table 2. *Fishing effort (measured in net nights or hours) applied by USFWS from 2012 through 2020 for small-bodied Asian carp surveys from LaGrange pool to the CAWS.*
"Net nights" has been abbreviated as "nn" in this table. These effort numbers are conservative estimates of total effort because effort was not recorded at all sites.

Year	Fyke Net (nn)	Mini-Fyke Net (nn)	Push Trawl (h)	Paupier Trawl (h)	Tow Trawl (h)	Electrofishing (h)	Dozer Trawl (h)
2012	29.5	93.6	3.2	-	-	2.3	-
2013	5.2	38.5	3.4	-	-	14.8	-
2014	-	35.6	*	-	-	13.7	-
2015	-	232	10.4	28.4	12.7	48.7	12.9
2016	-	9.1	-	-	4.8	86.6	0.3
2017	-	31.8	-	2.7	-	70.4	10
2018	-	*	-	-	-	64	5.6
2019	-	*	-	-	-	11.4	5.6
2020	-	-	-	-	-	5.5	2.3
% of sites with recorded effort	82.4	68.3	58.9	99	85.8	81.2	90.9

* = Gear was deployed in this year, but no effort was recorded

- = No gear was deployed in this year

Table 3. *Catch-per-unit-effort of small-bodied Asian carp captured between 2012 and 2020 from LaGrange pool to the CAWS.*
"Net nights" has been abbreviated as "nn" in this table.

Year	Fyke Net (fish/nn)	Mini-Fyke Net (fish/nn)	Push Trawl (fish/h)	Paupier Trawl (fish/h)	Tow Trawl (fish/h)	Electrofishing (fish/h)	Dozer Trawl (fish/h)
2012	0.034	0.032	0	-	-	0	-
2013	0	0	0	-	-	0	-
2014	-	0	0	-	-	0	-
2015	-	1.027	0.700	61.056	37.356	0.581	12.539
2016	-	0	-	-	0	0.024	0
2017	-	0	-	0	-	0.329	0.855
2018	-	0	-	-	-	0.016	6.400
2019	-	0	-	-	-	0	8.324
2020	-	-	-	-	-	0	0

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Larval Fish Monitoring in the Illinois Waterway

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

Pools Involved: Brandon Road, Dresden Island, Marseilles, Starved Rock, Peoria, and LaGrange pools and major tributaries [Kankakee River (Dresden Island), Fox River (Starved Rock), Mackinaw River (LaGrange), Spoon River (LaGrange), and Sangamon River (LaGrange)]

Introduction and Need:

Understanding the spatial and temporal dynamics of reproduction by invasive fishes can offer insight into the risk of further population expansion, factors influencing recruitment to the population, and the success of control measures. An evaluation of Asian carp reproduction and the distribution of early life stages in different sections of the Illinois Waterway (IWW) and its tributaries is needed to monitor for changes in the reproductive front of Asian carp populations in this system and to better understand the impacts of removal efforts on the reproductive potential of these populations. These data are used as an early detection system for monitoring the upstream expansion of Asian carp populations, potential reproduction by the newly expanding Black Carp population in Illinois, and to quantify the relationship between Asian carp stock density and reproductive output to assess the level of removal needed to degrade the ability of Asian carp to perpetuate themselves through reproduction.

Reproduction and recruitment of Asian carp in the IWW have been highly variable across years and multiyear efforts are necessary to assess the extent, location, and timing of invasive carp reproduction in the IWW, evaluate conditions affecting reproduction, and monitor for changes in the Asian carp reproductive front. Observations of eggs, larvae, and juveniles in the upper Illinois River indicate that some reproduction and potential recruitment occurs above Starved Rock Lock and Dam in some years. Due to egg and larval drift, reproduction in upper river pools may be an important source for recruits in downstream pools, particularly the Peoria Pool. Monitoring for any changes to these patterns can help to evaluate the risk for further population growth in the upper Illinois River. Asian carp spawning also appears to occur in some years in smaller tributary rivers. These systems may provide sources of recruits to basin-wide Asian carp populations and may offer insight into the suitability of Great Lakes tributaries for Asian carp establishment in the event of Asian carp expansion into Lake Michigan. Complementary annual assessments of Asian carp reproduction and stock density also provide data needed to quantify stock-reproduction relationships and evaluate the impact of Asian carp removal efforts on the reproductive potential of these populations. Simple relationships between stock abundance and reproductive potential of fish populations are often lacking, in part because of density-dependent processes and spatial and temporal variability in spawning conditions, stock composition, and first-year survival. Quantifying the relationship between adult stock density and reproductive productivity, and between reproductive output and recruitment strength will help to refine our understanding of the conditions and level of removal that reduce population growth rate of Asian carp in the IWW.

Objectives:

Fish eggs and larvae are being sampled in the IWW and its tributaries to:

(1) Monitor for potential changes in the reproductive front of Asian carp populations.

(2) Monitor for Black Carp reproduction in the IWW.

(3) Quantify the relationship between Asian carp stock density and reproductive output.

Project Highlights:

- 404 ichthyoplankton samples were collected from seven sites from the Brandon Road to La Grange navigation pools of the IWW during May – September 2020, capturing 1,947 Asian carp larvae and 465 Asian carp eggs. The majority of these specimens were collected during the last week in May, with low numbers of eggs and larvae present throughout June. Eggs were collected as far upstream as the Marseilles Pool, and three Asian carp larvae were collected from the Starved Rock Pool during 2020. Overall, numbers of Asian carp eggs and larvae observed during 2020 were very low compared to other recent study years.
- 297 ichthyoplankton samples were collected from Illinois River tributaries during 2020. No evidence of Asian carp reproduction was observed in the Kankakee, Fox, or Mackinaw rivers, but a single Asian carp larvae was collected from the Spoon River, and Asian carp eggs were collected from the Sangamon River in 2020. Although reproductive output was low during 2020, the magnitude of reproduction in tributaries in some years suggests that tributary rivers may be important sources of Asian carp egg and larval drift to the Illinois River under certain conditions.
- Adult Asian carp density and environmental conditions during the May/June period was found to influence spatiotemporal variation in the magnitude of Asian carp reproduction in the IWW across years. The relationship between total annual egg drift and adult density suggests that Asian carp exhibit density-dependent reproduction in the IWW. Annual magnitude of larval Asian carp drift in the IWW was also positively correlated with total annual drift of Asian carp eggs.
- The quantitative PCR methodology developed by Fritts et al. (2019) as a genetic screening tool to identify samples with Asian carp eggs or larvae was field tested with a subset of samples collected during the 2020 field season. Initial analyses demonstrated a highly significant relationship between the number of DNA copies present in the exchanged preservative of samples and is the presence of Asian carp eggs or larvae in a sample. This

methodology will be used in subsequent years to rapidly screen samples for Asian carp eggs and larvae in order to rapidly communicate the occurrence of spawning events.

Methods:

Larval fish sampling occurred at seven sites in the Illinois and Des Plaines rivers downstream of the Electric Dispersal Barrier during 2020 (Figure 1). Additional sampling took place in five tributary rivers (Kankakee, Fox, Mackinaw, Spoon, and Sangamon rivers). Sampling occurred weekly from May to the end of June and biweekly from July to the end of September. 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 navigation channel, parallel to the bank, at both upstream and downstream locations within each study site. Samples were collected using a 0.5 m diameter ichthyoplankton push-net with 500 µm 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. Three samples (one mid-channel and one on each side of the channel) were taken at each tributary site on each sampling date. The Kankakee and Fox rivers were sampled at sites below the furthest downstream dam on each river. Upstream and downstream sites were sampled on the Mackinaw, Spoon, and Sangamon rivers. Downstream tributary locations were sampled with the same boat-mounted push-net method used for main-channel sites, and all tributary sites were also 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 3.5 mm being identified as potential Asian carp eggs and retained for later genetic confirmation of identity. Larval fish and egg densities were calculated as the number of individuals per cubic meter of water sampled.

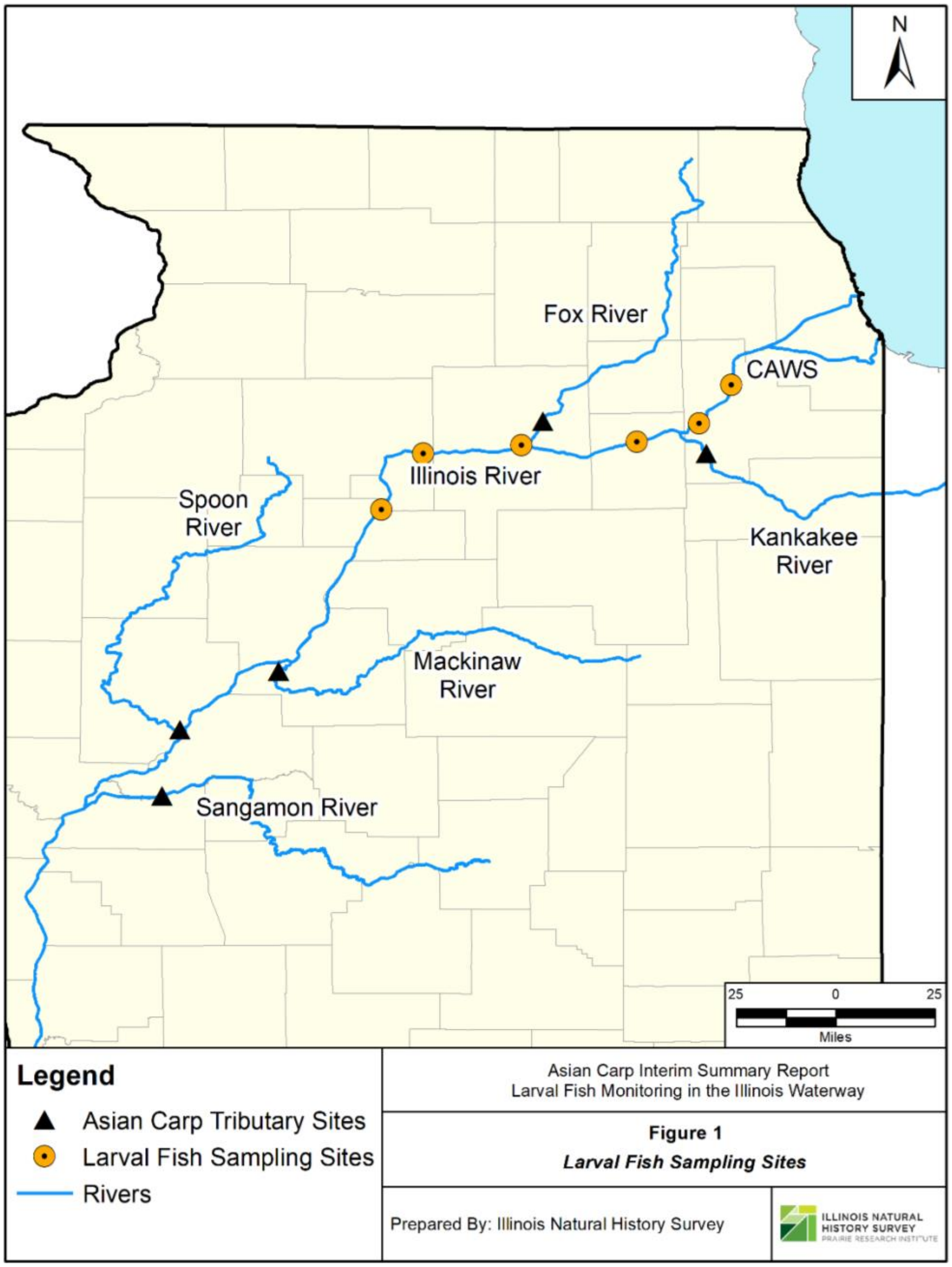


Figure 1. *Map of ichthyoplankton sampling sites in the IWW (circles) and in tributary rivers (triangles).*

Densities of Asian carp eggs and larvae were summarized by sampling location through time and compared to water temperature and river discharge to examine spatial patterns in Asian carp reproduction, identify conditions associated with spawning, and assess long-term trends in Asian carp reproductive output. Updated analyses examining the influence of adult spawning stock density and environmental factors on Asian carp reproductive output were conducted to assess the potential for Asian carp removal efforts to diminish the reproductive potential of Asian carp populations in targeted navigation pools. Previous analyses used peak densities of Asian carp eggs, but revised analyses estimated total egg and larval numbers drifting through each sampling site by multiplying ichthyoplankton density by discharge in order to standardize ichthyoplankton abundances observed under varying discharge conditions and summed these estimates across sampling dates in order to generate a relative annual index of egg and larval drift for each site. Previous analyses also used fall estimates of adult Asian carp density as an index of potential spawner density in each navigation pool during the following spring, but examination of Asian carp harvest trends suggested that use of fall stock density estimates were better used to represent potential spawner density during the preceding spring (i.e., the same year as the adult density estimate). Based on probable spawning locations identified by FluEgg model analysis of Asian carp egg collections (Zhu et al. 2018), egg densities in each navigation pool were related to the combined density of adult Asian carp within that pool and the next upstream pool. Mixed-model methodology with a repeated measures framework was used to model annual egg totals as a function of adult density and spring warming and discharge variables (May-June period). The first stage of this analysis tested if the relationship between adult density and standardized annual egg totals collected at each site was best described by a linear, quadratic, or logistic form. The next stage of the analysis assessed if the addition of spring warming and discharge patterns to the most supported adult density-total egg relationship improved the fit of the model to observed annual totals of Asian carp eggs at each site. To facilitate comparison of empirical support for each model, AIC corrected for small sample size (AIC_c), AIC_c weights, and evidence ratios were computed for each model. A null model (i.e., intercept only) was also included for comparison to assess whether there was meaningful support for any of the models in the set.

A subset of IWW ichthyoplankton samples were assessed for the presence of species-specific Asian carp DNA derived from eggs or larvae in order to further evaluate the potential for quantitative PCR (qPCR) screening (Fritts et al. 2019) to identify samples containing eggs or larvae prior to full processing and microscopic identification of specimens. Sample ethanol was exchanged with fresh molecular-grade ethanol and samples were gently inverted in the refreshed ethanol. Aliquots of sample preservative were then removed to screen for the presence of Asian carp DNA. Due to the potential for organic matter present within the samples to potentially bind to DNA and influence the probability of false positives, organic matter volume, wet mass, and dry mass was also measured for each sample. Following DNA extraction, DNA assays for the four taxa of invasive carps were run in multiplex reactions, following qPCR methodology. Samples were run in triplicate with a dilution series and no-template controls. The relationship between presence or absence of Asian carp eggs or larvae and DNA copy numbers, and the potential influence of organic matter content on this relationship was assessed with logistic regression models.

Larval Fish Monitoring in the Illinois Waterway

Results and Discussion:

During 2020, ichthyoplankton monitoring on the IWW collected 404 samples, capturing 1,947 Asian carp larvae and 465 Asian carp eggs. The vast majority of these specimens were collected during the last week in May, following water temperatures rising above 18°C for the first time that year and the largest increase in water level that occurred during the sampling period (Figure 2). Water levels declined sharply after this week and remained low and stable for the remainder of the 2020 season. However, low numbers of Asian carp eggs and larvae continued to be observed throughout June. Eggs were collected as far upstream as the Marseilles Pool during 2020. Of particular note, 3 Asian carp larvae were collected from the Starved Rock Pool during the last week in May. These early yolk-sac larvae are the furthest upstream that larvae have been observed since the three Silver Carp larvae collected in the Dresden Island Pool in 2015. Stage data from these specimens is being used by collaborators at the U.S. Geological Survey Central Midwest Water Science Center to estimate the location where these larvae were spawned based on temperature and flow conditions prior to the time of collection, and further information on these larvae will be provided as soon as it is available. Overall, numbers of Asian carp eggs and larvae observed in the main channel of the IWW during 2020 were very low compared to other recent study years, suggesting that conditions during 2020 were not generally conducive to Asian carp reproduction for much of the year.

An additional 297 ichthyoplankton samples were collected from tributary rivers during 2020. No Asian carp eggs or larvae were observed in the Kankakee, Fox, or Mackinaw rivers during 2020, but a single larvae was collected from the Spoon River at the beginning of June, and Asian carp eggs were collected from the Sangamon River during late May to mid-June. Peak densities of Asian carp eggs collected from the Sangamon River occurred on the first sampling date in May, which coincided with the highest river discharge during the 2020 sampling period (Figure 3). COVID-19 restrictions delayed the beginning of tributary sampling during 2020, however earlier spawning events were unlikely due to low water temperatures. Much lower discharge in the Spoon and Mackinaw rivers over the same time period may have contributed to a lack of detectable Asian carp reproductive activity in these tributaries during 2020. Asian carp eggs continued to be present in the Sangamon River in lower densities through mid-June despite declining discharge (Figure 3). River discharge declined considerably at the end of May in all tributary rivers and remained relatively stable throughout the typical spawning period from June through early July. As in the Illinois River main channel, the lack of any appreciable increase in water levels during this time likely created suboptimal conditions for Asian carp reproduction in Illinois River tributaries during 2020. Densities of larval Asian carp observed in the tributaries in 2020 were much lower than in earlier study years, particularly in the Sangamon River.

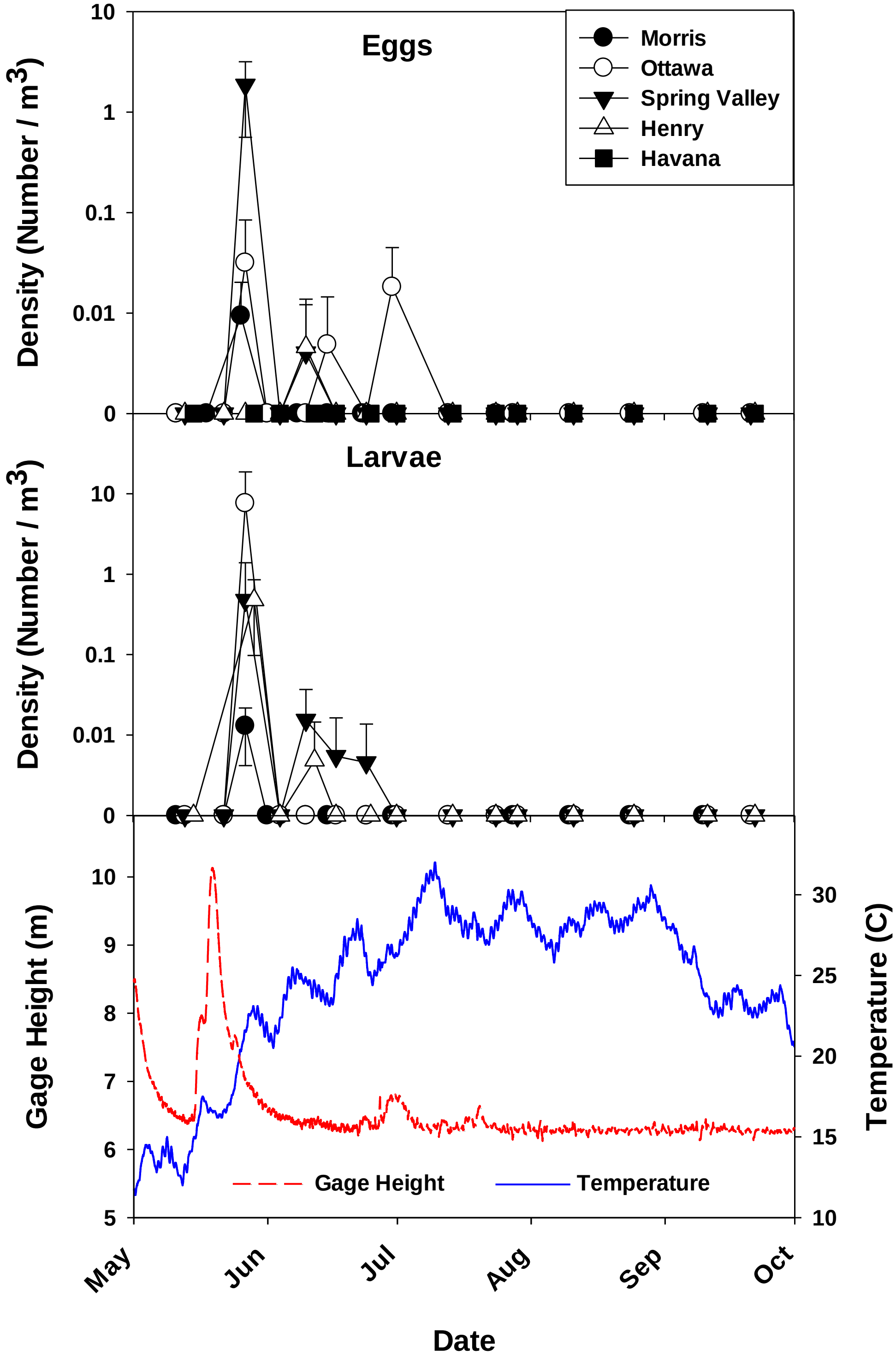


Figure 2. *Densities (number / m^3; note log scale) of Asian carp eggs (top panel) and larvae (middle panel) collected from main channel sites of the IWW during 2020. Mean daily gage height (m) and water temperature (° C) of the Illinois River during May – September 2020 (bottom panel) were obtained from USGS gage 5543010 at Seneca, IL.*

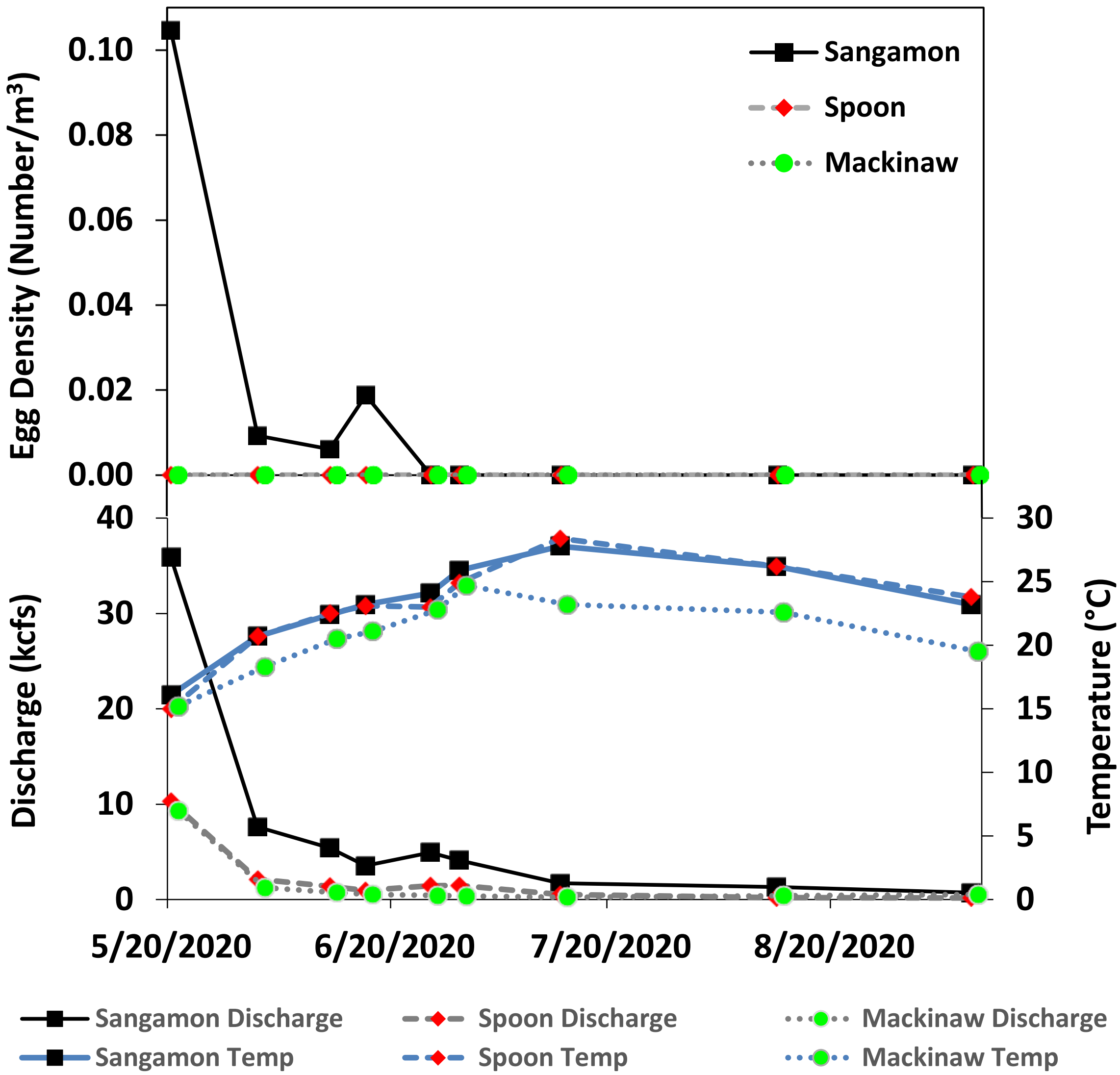


Figure 3. *Density (number / m^3) of Asian carp eggs (top panel) collected from downstream sites on three tributaries of the Illinois River (Sangamon, Spoon, and Mackinaw rivers) during May – September 2020. Water temperature (° C) was measured at each sampling event and mean daily discharge (thousand cubic feet/second) was obtained from USGS gages (Sangamon River: 5583000; Spoon River: 5570000; Mackinaw River: 5568000).*

Previous studies have noted that Asian carp spawning tends to be associated with a rising hydrograph when water temperatures are above 18°C (Kolar et al. 2007, Lohmeyer and Garvey 2009, Larson et al. 2017). The low and stable water levels during and after June 2020 likely did not provide adequate stimulus to synchronize reproduction by the majority of Asian carp in both the IWW and its tributaries. Small numbers of Asian carp eggs and larvae have been observed during 2020 and previous years under conditions considered atypical for Asian carp reproduction (i.e., low or declining water levels), suggesting that at least a small proportion of the spawning stock may attempt to spawn each year even under suboptimal conditions. Other studies have suggested that Asian carp display greater flexibility in spawning traits than is often recognized (Coulter et al. 2013, Deters et al. 2013). However, observations from both the IWW, its tributaries, as well as other systems (Lohmeyer & Garvey 2009, Coulter et al. 2016, Larson et al. 2017) indicate that mass spawning events that produce the highest densities of eggs and larvae do appear to largely coincide with increases in river discharge. Asian carp appear to be batch spawners, capable of spawning multiple times across a protracted time period (Papoulias et al. 2006, Tucker et al. 2020). During years with fluctuating hydrological conditions, low-magnitude spawning events may provide some reproductive success for individuals that delay spawning due to earlier suboptimal conditions or allow individuals that are energetically capable to produce additional offspring following a primary spawning event.

Across multiple years of monitoring, adult Asian carp density and environmental conditions during the May/June period was found to influence spatiotemporal variation in the magnitude of Asian carp reproduction in the IWW. The relationship between total annual egg drift and adult density was best described by a quadratic function compared to linear and logistic relationships, supporting a density-dependent relationship between Asian carp adult density and reproduction in the IWW (Figure 4). The most supported model combined the quadratic relationship with adult density with cumulative degree days by the end of June, and discharge coefficient of variation (CV). This four-factor model provided a reasonable fit to observed annual egg drift (adjusted R^2 = 0.61) and had thirteen times as much support (i.e., evidence ration of 13) as the model with the next lowest AIC_c score (quadratic adult density + discharge CV). Annual magnitude of larval Asian carp drift in the IWW was also positively correlated with total annual drift of Asian carp eggs ($r = +0.87$, $P = 0.02$).

The diminished reproductive output at low adult densities provides insight into one of the pathways through which sufficient levels of harvest may facilitate achieving the management goal of substantially reducing Asian carp in the IWW through recruitment overfishing. Reproductive output was either absent or too low to detect once the combined density of adult Asian carp in the Marseilles and Dresden Island pools were ≤ 0.268 adult carp/2000 m^3. While the relationship between the densities of the earliest life stages (i.e., embryos and larvae) and recruited individuals is not currently known, successful reproduction is a prerequisite for successful recruitment, and therefore, management that can disrupt reproduction may help attain the goals of the Asian carp harvest program. Conversely, the density-dependent relationship between annual egg and adult abundance documented in the IWW implies that there is the potential for compensatory reproductive output if insufficient numbers of adults are removed.

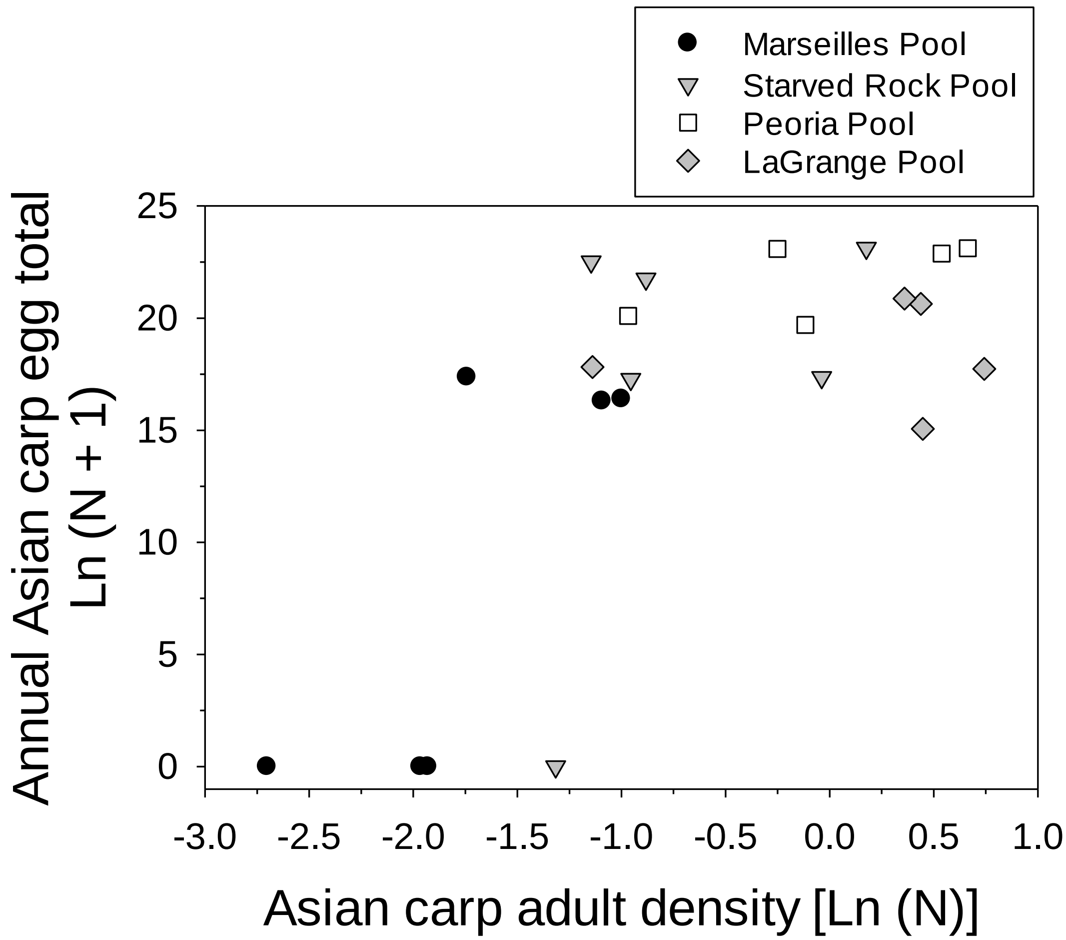
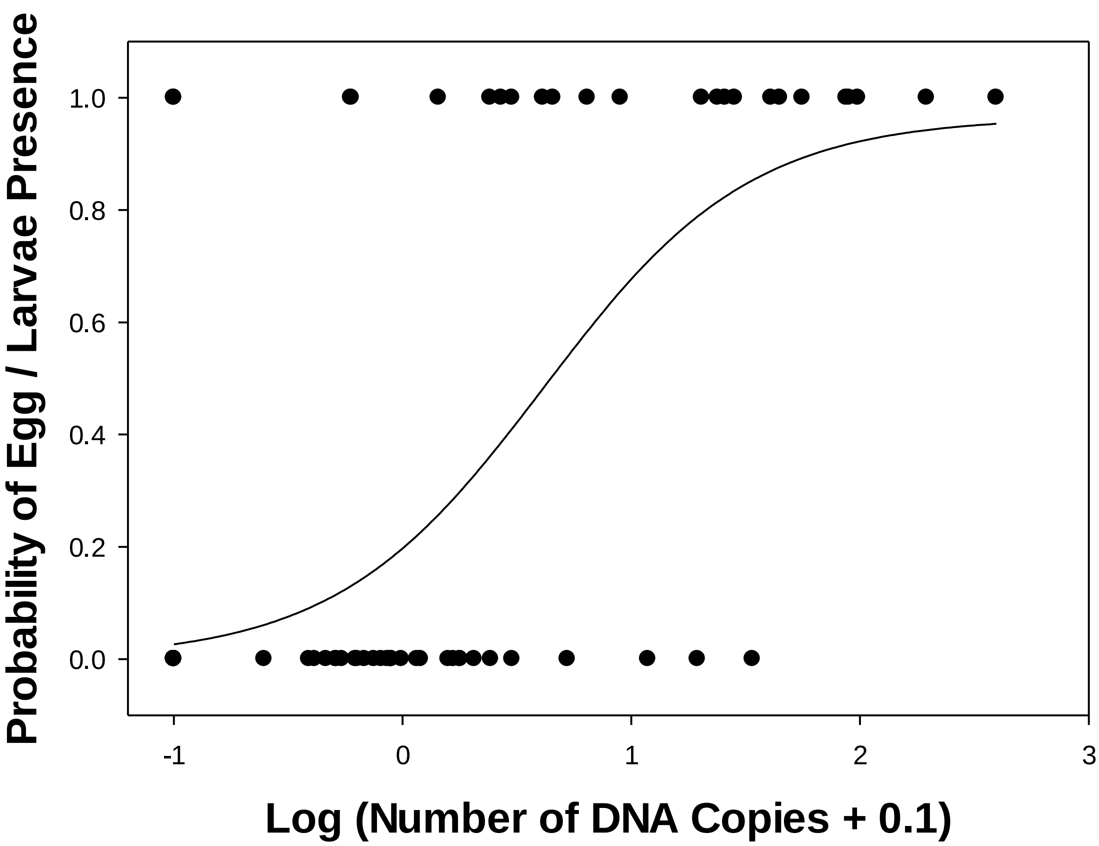


Figure 4. *Observed index of total annual Asian carp egg drift measured at sites within each navigation pool (coded by symbol) and associated adult Asian carp density. Index of total egg drift was estimated by summing observed egg densities standardized by site-specific discharge and scaled up over 24-hr intervals. Adult Asian carp density was estimated with autumn (late September – early November) hydroacoustic surveys.*

Reduced functional connectivity between navigation pools in the upper IWW (Coulter et al. 2018) may contribute to a lack of compensatory reproductive response at low stock densities, thereby increasing the effectiveness of removal efforts of these more isolated Asian carp populations. However, immigration may complicate removal efforts downstream of Starved Rock Lock and Dam, where movement rates between navigation pools are likely much higher (Coulter et al. 2018). Density-dependent reproductive output of Asian carp detectable through the larval stage also implies that any variation in stock-recruitment patterns for these species needs to be interpreted cautiously before being ascribed to environmental factors affecting survival from hatching to juvenile stages.

Quantitative PCR analyses demonstrated that the number of DNA copies present in a sample is a highly significant predictor of the presence of Asian carp eggs or larvae in the sample (logistic regression, $P < 0.0001$; Figure 5). The addition of variables representing the quantity of organic debris in a sample did not improve model fit, and organic matter content did not significantly alter the relationship between the number of DNA copies and the presence/absence of Asian carp eggs or larvae in a sample. This screening methodology therefore may have great potential to more quickly identify the presence of Asian carp early life stages in different areas of the IWW than is possible with traditional processing methods. Microscopy-based identification of eggs and larvae can take weeks to months to complete, whereas qPCR methods may be able to identify reproductive events within days of sample collection. COVID-19 related disruptions to laboratory operations limited the ability of qPCR screening to identify samples containing Asian carp eggs or larvae in a timely manner during 2020. In subsequent years, this methodology will be used to rapidly identify samples containing Asian carp early life stages so that the likely locations of Asian carp spawning can be quickly communicated and response actions can be initiated in a timely manner if warranted.

Figure 5. *The relationship between the number of copies of Asian carp DNA (summed across Asian carp species) and the presence of Asian carp eggs or larvae in ichthyoplankton samples collected from the IWW during 2020.*



Recommendations:

Ichthyoplankton sampling should continue to monitor for Asian carp reproduction in the upper IWW to evaluate any changes in the Asian carp reproductive front and assess the effects of Asian carp harvest activities on the reproductive potential of these populations. Relationships between reproductive output and recruitment should be investigated further to provide a more complete understanding of recruitment mechanisms and evaluate potential compensatory responses among different life stages to Asian carp harvest efforts. Further FluEgg modelling is needed to determine the consistency of Asian carp spawning locations in the IWW and provide information to better understand the relevant adult spawner density for assessment of stock - reproductive productivity relationships. Ichthyoplankton monitoring in tributary rivers should evaluate the relative contribution of these systems as sources of eggs and larvae to the main channel of the Illinois River and assess the potential for similar rivers in the Great Lakes region to serve as spawning tributaries. Quantitative PCR screening of ichthyoplankton samples should be expedited in order to rapidly identify samples containing Asian carp early life stages and communicate the occurrence of spawning events quickly enough to implement response actions.

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Movement and Density of Bigheaded Carp in the Illinois River

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Participating Agencies: Southern Illinois University – Carbondale (SIU, lead), Illinois Department of Natural Resources (IDNR, support), U.S. Fish and Wildlife Services (USFWS, support), U.S. Army Corps of Engineers Chicago Districut (USACE, support), U.S. Geological Survey (USGS, support), Illinois Natural History Survey (INHS, support), Western Illinois University (WIU, support)

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

Introduction and Need:

Management goals for bigheaded carp (Silver Carp and Bighead Carp) in the Illinois River focus on limiting upstream dispersal through monitoring, assessing movement barriers, and reducing abundance through contracted harvest. Bigheaded carp spatial distributions vary both seasonally and annually; therefore, quantifying how spatial distributions change through time will help target contracted harvest to maximize removal efforts and minimize costs. Additionally, long-term information on bigheaded carp population characteristics, distributions, and movements, especially along the population front in the upper Illinois River, can provide data to parameterize population models. These models simulate the effects of various management actions (e.g., harvest scenarios, locations of enhanced deterrent technologies) to determine which options are most likely to achieve management goals.

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

Monitoring Bigheaded Carp Movement and Density in the Illinois River

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

The Spatially Explicit Asian Carp Population (SEACarP) model of bigheaded carp in the Illinois River assesses how bigheaded carp populations respond to a variety of management actions (e.g., location and intensity of harvest; location and effectiveness of deterrent technologies). This model draws on a wide variety of data collected by different agencies including bigheaded carp densities and movement data collected by SIU. Collaborations between the Monitoring and Response Work Group (MRWG) modeling, telemetry, and hydroacoustic working groups have identified several additional data needs in addition to maintenance of current monitoring efforts. SIU's contribution to continued model support and development includes continued maintenance of the Illinois River stationary telemetry array to document inter-pool movements, deployment of additional acoustic telemetry tags in bigheaded carp (numbers set based on telemetry working group determinations), and continued hydroacoustic monitoring of bigheaded carp densities throughout the Illinois River. Additionally, telemetry working group partners have also identified the need to better understand the meaning of telemetry data collected from surrogate fishes by comparing movements of surrogate species in relation to those of bigheaded carp. To this end, SIU partnered with USACE to exploit SIU's existing acoustic telemetry tags in bigheaded carp near Starved Rock Pool and their stationary receiver array.

Objectives:

(1) Quantify Asian carp densities every other month in Dresden Island and Marseilles pools in 2020 using mobile hydroacoustic surveys to pinpoint high density areas that can be targeted during contracted removal. Surveys will also document how distributions of bigheaded carp change through time which can better inform targeted removal.

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

(3) Maintain SIU's extensive acoustic telemetry array currently in place in the Illinois River used to collect movement and dam passage information. Share collected data with telemetry working group and those working on the SEACarP population model.

(4) Collaborate with USACE to compare the movements of surrogate fish species (i.e., Common Carp) to the movements of bigheaded carps. This will help interpret movement

information of surrogate fish species from Dresden Island Pool to the CAWS, as it pertains to hypothetical bigheaded carps in those areas.

Project Highlights:

- Repeated hydroacoustic surveys in Dresden Island and Marseilles pools identified areas of high bigheaded carp density and how these locations change through time. These data helped direct contracted removal efforts throughout 2020.
- The ninth year of standardized monitoring of bigheaded carp densities was completed in 2020 from Alton – Dresden Island pools. These data allow for long-term assessments and comparisons of density trends across space and through time.
- Tagging of 188 adult bigheaded carp took place in Alton, LaGrange, and Starved Rock pools to maintain sufficient surveillance to detect adult movements among pools and towards the invasion front.
- Preliminary analysis of movement data indicates that Common Carp respond to similar environmental conditions as bigheaded carp, supporting the use of Common Carp as a surrogate for understanding bigheaded carp movement behavior.

Methods:

Hydroacoustic Surveys – Bi-monthly Heat Maps and Fall Standardized Surveys

Repeated hydroacoustic surveys in the upper Illinois River (Dresden Island and Marseilles pools) in 2020 were completed in March, June, and August. Final 2020 surveys in these pools and throughout other Illinois River (Starved Rock – Alton) pools were completed in fall of 2020. All hydroacoustic sampling methods, designs, and analyses followed those outlined in MacNamara et al. (2016). We also completed surveys before Unified Method events in Dresden Island Pool and the HMS Pits in Marseilles Pool to inform harvest crews on density hotspots prior to harvest. Fall hydroacoustic sampling for monitoring long-term bigheaded carp density trends occurred in October 2020 at standardized sites (including main channel, side channel, and backwater sites) following standardized sampling methods used in previous years (since 2012).

Movement and Dam Passage

Utilizing an array of 51 Vemco 69 kHz stationary receivers maintained by SIU (Coulter et al. 2018; Abeln 2018) as well as stationary receviers maintained by partner agencies (USGS, USACE, USFWS, MDC), the movements of Silver Carp and Bighead Carp implanted by SIU with internal transmitters (Vemco V16 transmitters) were monitored from Alton Pool upstream through Dresden Island Pool. One new stationary receiver was deployed throughout the river to replace a lost receiver and to support the surrogate fish project, resulting in a total of 51 stationary receivers operating throughout the river in 2020. Receiver totals (excluding those removed from lock chambers due to year-long lock maintenance) deployed within pools by SIU were as follows: Dresden Island-3, Marseilles-6, Starved Rock-20, Peoria-9, La Grange-6, Alton-7). Additional stationary receivers are deployed by other agencies in the Telemetry Working Group. Additionally, other fish species implanted with 69 kHZ transmitters by other members of the Telemetry Working Group can be detected by this array. Stationary receivers were downloaded on two occasions in 2020, with data initially checked to remove false detections and analyzed to identify upstream and downstream passages through lock and dam structures in the study area (e.g., Lubejko et al. 2017*)*. Additional acoustic telemetry tags were deployed to replace expiring tags in Alton (50 tags), LaGrange (98 tags), and Starved Rock (40 tags) pools. Statewide travel restrictions prevented these additional tags from being implanted into bigheaded carp until October of 2020.

Surrogate Fish Movements

In collaboration with USACE, this project utilizes SIU's extensive array of stationary receivers (25+) around Starved Rock Lock and Dam (upper Peoria Pool) and within Starved Rock Pool to monitor the movements of bigheaded carp and Common Carp (surrogate species). In 2020, 31 Common Carp and 40 bigheaded carp were tagged in Starved Rock Pool, in addition to the 50 Common Carp tagged in 2019 in and around Starved Rock Lock and Dam. Additionally, monthly active tracking (June – October) of tagged Common Carp and Silver Carp in Starved Rock and upper Peoria pools was conducted to collect habitat use data, including: general habitat use (main channel, channel border, side channel, backwater, tributary), sediment (sand, silt, rock) in occupied habitats, and water quality (water temperature, dissolved oxygen, and chlorophyll-*a* concentration). Active tracking consisted of a boat with an omnidirectional hydrophone travelling at idle speed downstream through main channel and lateral habitats. When a tagged fish was located, the directional hydrophone was used until a minimum decibel strength of the tag was achieved to determine fish location, at which point habitat information was recorded. A comparison of the timing of lock and dam passages between species is ongoing. However, species comparisons of additional movement indices was completed. Two movement metrics (movement and movement rate) were assessed for each species using data from the stationary receiver array to determine whether movements were related to similar environmental conditions. 'Movement' represented a binary response variable, where an individual was considered to have moved (i.e., Movement = 1) if it was detected on two or more stationary receivers within a week. Movement rate was quantified as the total river miles (rm) traveled per week based on stationary receiver detections. Four environmental conditions were used as predictor variables in species-specific models explaining movement and movement rate: mean weekly temperature °C (USGS station 5543010); change in weekly mean temperature °C; weekly mean discharge (ft^3/s; USGS station 05543500); change in weekly mean discharge (ft^3/s). We used a logistic mixed effects model to predict fish movement and a linear mixed effects model to predict fish movement rate using Akaike's Information Criterion with small sample size correction (AICc). Active tracking data collected over summer 2019, fall 2019 and summer 2020 also allowed for a habitat selection index (Manly selection ratio index; $\hat{W}_i$) to be calculated for each habitat type for each species.

Monitoring Bigheaded Carp Movement and Density in the Illinois River

Results and Discussion:

Hydroacoustic Surveys – Bimonthly Heat Maps and Fall Standardized Surveys

Mobile hydroacoustic surveys conducted every other month in Dresden Island and Marseilles pools identified locations where bigheaded carp aggregated and determined how these locations changed throughout the year. Density maps (Figure 1) were provided to MRWG members which helped inform contracted harvest efforts throughout the year. Hydroacoustic sampling and density heatmaps were also provided to removal crews prior to Unified Method events in Marseilles and Dresden Island pools.

Mobile hydroacoustic sampling was successfully completed in October 2020 from Alton – Dresden Island pools. Final bigheaded carp density estimates were calculated from Alton – Peoria pools, whereas final analysis of densities from Starved Rock – Dresden Island pools were not completed due to a Covid-related delay in processing electrofishing capture data from MRWG member agencies. Fall 2020 bigheaded carp estimated densities in Alton Pool were similar to past years, being intermediate between 2015 and 2016-2017 densities (Figure 2). In contrast, LaGrange and Peoria pool fall 2020 bigheaded carp densities were slightly lower than previous years, excluding 2019 which was a flood year.

Movement and Dam Passage

SIU stationary receivers were deployed and downloaded from Dresden Island Pool downstream through Alton Pool. One new stationary receiver was deployed in the river to replace a lost receiver, resulting in a total of 51 stationary receivers operating throughout the river in 2020. Receiver totals (not including those removed from lock chambers during 2020 lock maintenance) deployed within pools by SIU were as follows: Dresden Island-3, Marseilles-6, Starved Rock-20, Peoria-9, La Grange-6, Alton-7). Additional stationary receivers are deployed by other agencies in the Telemetry Working Group, including USGS, USACE, USFWS, and INHS.

New acoustic transmitters for 2020 were deployed in Alton (50 tags), LaGrange (98 tags), and Starved Rock (40 tags) pools. Due to statewide Covid-related travel restrictions, tagging was delayed until October. All detection data downloaded from stationary receivers throughout the year have been submitted for inclusion in the USGS-managed FishTracks telemetry database. Detections of upstream passages were documented at LaGrange and Peoria dams (3 passages each). Dam passages throughout the river were low compared to previous years likely because stationary receivers were removed from locks for most of 2020 due to lock maintenance, and new transmitter tags replacing expired tags were not able to be added to fish throughout the river until October.

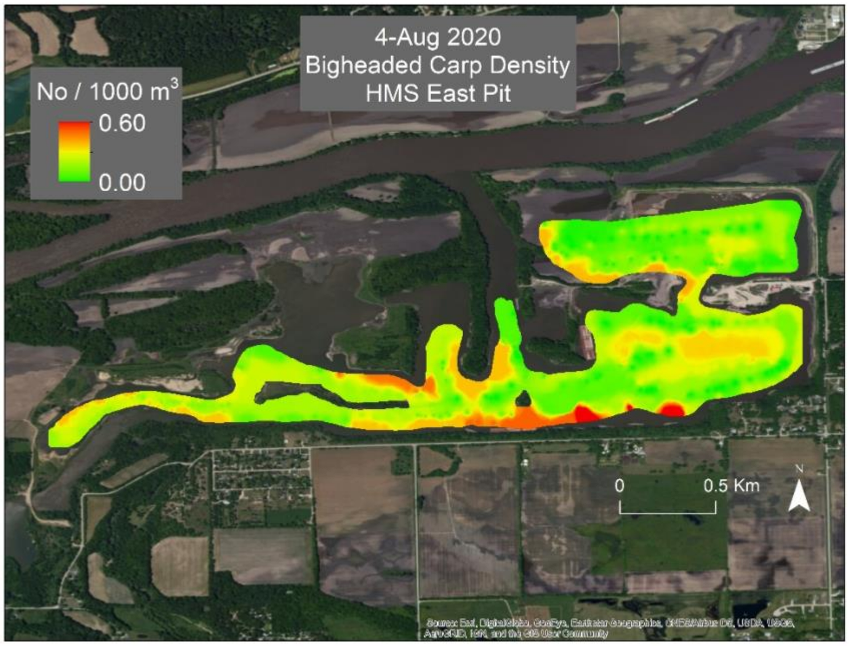

Figure 1. *Example heatmap displaying bigheaded carp spatial distributions in the HMS East Pit in the Marseilles pool sampled in August 2020 with mobile hydroacoustic sampling. Densities were observed using mobile hydroacoustic surveys.*

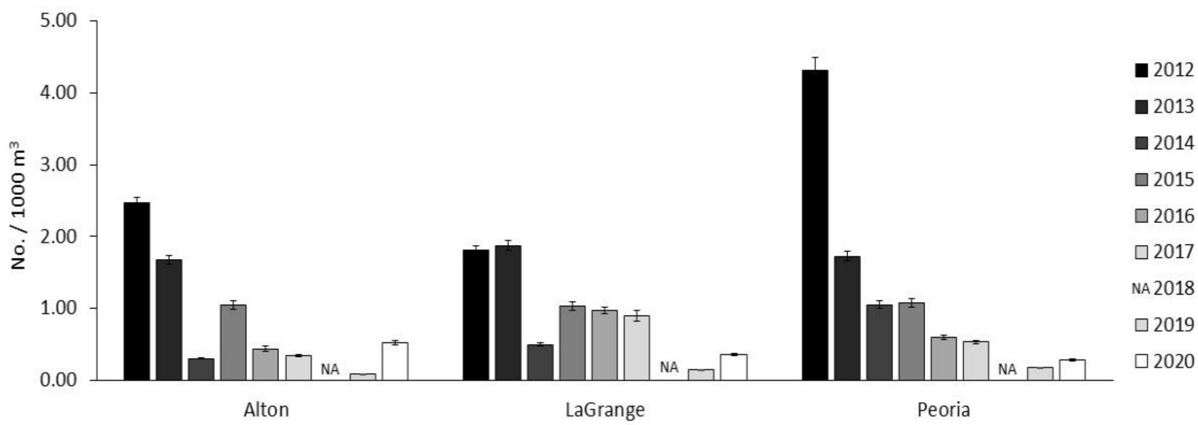

Figure 2. *Long-term mean (SE) bigheaded carp (Bighead Carp and Silver Carp combined) densities from mobile hydroacoustic sampling in the lower Illinois River during Fall of each year.*

Surrogate Fish Movement

The response variable 'movement' was related to environmental conditions separately for each species. Five candidate models were within ΔAIC of 2 for Common Carp (Table 1) and four candidate models were assessed for bigheaded carp (Table 1). Weekly mean discharge was found to be the only significant predictor of both Common Carp and bigheaded carp movement (Table 2). When assessing drivers of movement rates (rm week^{-1}), three candidate models were evaluated for Common Carp, and one model was sufficient for bigheaded carp (Table 3). Change in water temperature was a significant predictor of Common Carp movement rate, whereas bigheaded carp movement rates were explained by weekly mean discharge and change in weekly mean discharge (Table 2).

Based on habitat selectivity index determined from active tracking data, bigheaded carp selected heavily for backwater habitats ($\hat{W}_i > 3$) and side channel habitats ($\hat{W}_i > 1$), while showing generally no selection or selection against channel border habitat. No bigheaded carp or Common Carp were found in tributaries during the entirety of this study, and no bigheaded carp were found in main channel habitats during fall 2019 or summer 2020. Common Carp displayed more of a generalized habitat selection, exhibiting mostly no selection or selection for most habitats (Figure 3). Analyses of home range (using kernel density), substrate use, and dam passage are ongoing. Continuation of this work through 2021 (final data analysis) will provide better insight into the use of Common Carp as a movement surrogate for bigheaded carp.

Table 1. *Results of model selection predicting movement (detected on >1 telemetry receiver in a week) of bigheaded carp and Common Carp from environmental conditions. Temp: water temperature.*

Bigheaded Carp	AICc	ΔAIC
Intercept + Weekly Mean Discharge	586.65	0
Intercept + Weekly Mean Discharge+ Weekly Mean Temp	587.71	1.06
Intercept + Change in Temp + Weekly Mean Discharge	588.08	1.42
Intercept + Change in Discharge + Weekly Mean Discharge	588.64	1.99
Common Carp		
Intercept + Weekly Mean Discharge	1062.81	0
Intercept + Weekly Mean Discharge + Weekly Mean Temp	1063.37	0.56
Intercept + Change in Temp + Weekly Mean Discharge	1063.55	0.74
Intercept + Change in Temp + Weekly Mean Discharge + Weekly Mean Temp	1064.31	1.5
Intercept + Change in Discharge + Weekly Mean Discharge	1064.40	1.59

Table 2. *Averaged model coefficients (p-value) from all models with ΔAIC <2 for Common Carp (CC) and bigheaded carp (BH). Movement: move = 1, stationary =0. Variables included in the model: weekly mean water temperature (°C); change in weekly mean temperature (°C); weekly mean discharge; change in weekly mean discharge. Individual fish and week were included as random effects.*

	Movement		Movement Rate	
Variable	CC	BH	CC	BH
Weekly Mean Temperature	0.04 (0.45)	0.04 (0.71)	-0.09 (0.76)	-2.54 (0.57)
Change in Temperature	0.03 (0.47)	0.02 (0.78)	1.10 (0.01)	2.05 (0.41)
Weekly Mean Discharge	0.36 (<0.001)	0.34 (0.001)		-5.16 (0.02)
Change in Discharge	-0.01 (0.69)	0.00 (0.94)	-0.46 (0.15)	8.71 (0.0002)

Table 3. *Results of model selection predicting movement rates (rm week^{-1}) of bigheaded carp and Common Carp from environmental conditions. Temp: water temperature.*

Bigheaded Carp	AICc	ΔAIC
Intercept + Change in Discharge + Change in Temp + Weekly Mean Discharge + Weekly Mean Temp	1199.64	0
Common Carp		
Intercept + Change in Discharge + Change in Temp	1489.34	0
Intercept + Change in Discharge + Change in Temp + Weekly Mean Discharge	1490.66	1.32
Intercept + Change in Temp	1491.25	1.91

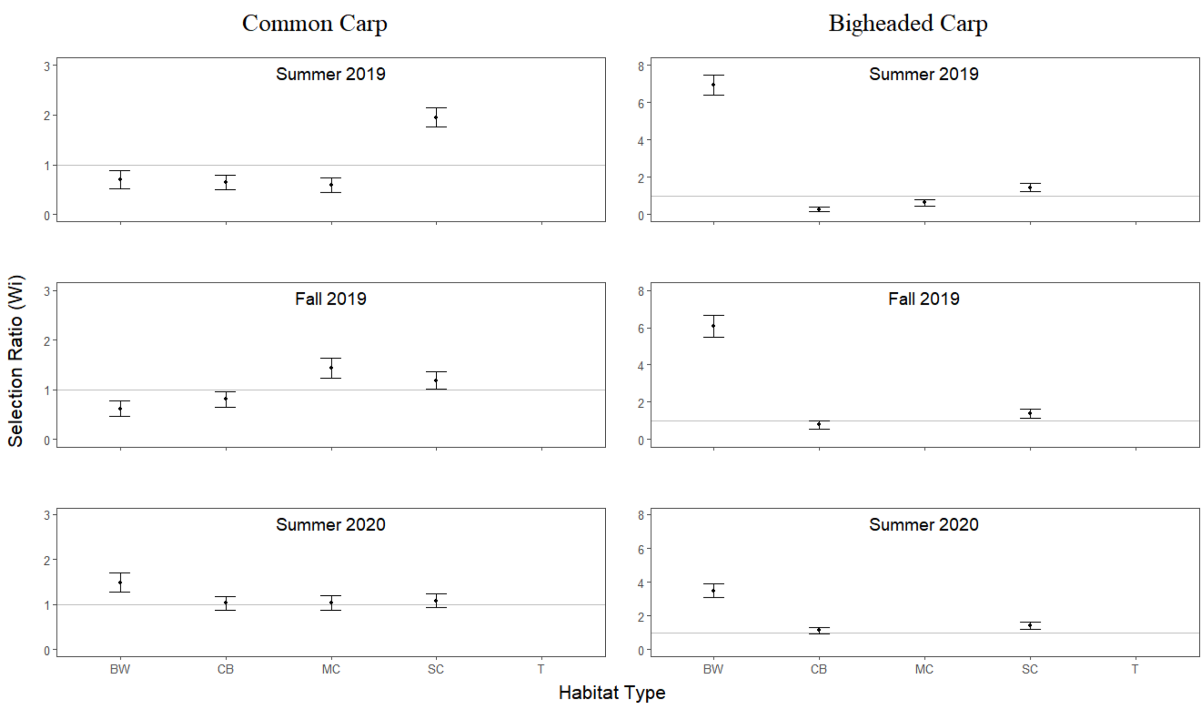

Figure 3. *Resource selection index values (Wi) and 95% confidence intervals for acoustically tagged Common Carp and bigheaded carp in the Illinois River. Confidence intervals overlapping 1 indicate neutral selection for a habitat, values <1 indicate avoidance, and values >1 indicate selection. Missing values represent no fish detected in a habitat. BW: backwater; CB: main channel border; MC: main channel; SC: side channel; T: tributary.*

Recommendations:

Hydroacoustic surveys are needed to inform (via spatial distribution maps) contracted removal and Unified Method events in the upper Illinois River pools, as the resulting data can increase harvest efficiency. Bigheaded carp spatial distributions change through time and are not consistent across years, necessitating repeated surveys in Dresden Island and Marseilles pools in order to direct harvest efforts to appropriate locations. Standardized fall hydroacoustic surveys from Alton–Dresden Island pools are also needed to monitor long-term population trends that act as an additional surveillance tool and can assist in making management decisions.

Telemetry data demonstrated that dam passage events continue to be highly variable annually, and continued collection of these data will serve to maintain sufficient adult surveillance efforts for detecting movement among pools, including toward the invasion front. Movement data will also be needed to improve dispersal models used in the SEACarp model. It will also be important to continue to assess annual variation in dam passages and how passage rates vary as densities of bigheaded carp change throughout the Illinois River (e.g., due to removal efforts and reproduction in lower river pools).

Monitoring Bigheaded Carp Movement and Density in the Illinois River

Preliminary analysis of movement data indicates that Common Carp respond to similar environmental conditions as bigheaded carp, supporting the use of Common Carp as a surrogate for understanding bigheaded carp movement behavior.

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

Cory A. Anderson and Nathan T. Evans (U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office, Wilmington Substation)

Participating Agencies: U.S. Fish and Wildlife Service (USFWS), Carterville Fish and Wildlife Conservation Office, Wilmington Substation

Pools Involved: Peoria

Introduction and Need:

Asian carp populations in the Illinois River have been progressively expanding upstream towards the Great Lakes since their introduction and establishment in the Mississippi River basin in the 1970s (Chick and Pegg 2001). To address the threat of invasive fish species moving into or out of the Great Lakes through the Chicago Sanitary and Ship Canal (CSSC) pathway, the U.S. Army Corps of Engineers (USACE) constructed an Electric Dispersal Barrier System (EDBS) near Joliet, IL in the Lockport Pool of the Illinois Waterway (Moy et al. 2010). The EDBS has been shown to be effective at stopping large-bodied fish from passing either upstream or downstream based on its electrical operational parameters and through acoustic telemetry (Sparks et al. 2011). The effectiveness of electricity to stun fish is size dependent and testing of operational parameters using small Bighead Carp (51 to 76 mm total length) revealed these parameters may be inadequate for blocking small fish passage at the EDBS (Holliman 2011). Additionally, research conducted by the U.S. Fish and Wildlife Service (USFWS) indicated that Golden Shiners, Notemigonus crysoleucas can be entrained in barge junction gaps and transported upstream through the electric barrier. This research provides evidence that barges may have the potential to transport young-of-year Silver Carp or Bighead Carp upstream (Davis et al. 2016). The potential for damage to the fishery in the Great Lakes coupled with the potential vulnerability of the EDBS and lack of information surrounding young life stages of Silver Carp and Bighead Carp have led to multiple state and federal agencies devoting resources to sampling the upper IWW to study demographics, upstream-most detections, and habitat use of these fishes.

Telemetry has a long history of use for understanding fish movements, home ranges, migration patterns, and spawning behaviors. Multiple studies are being conducted by agencies in the Asian Carp Regional Coordinating Committee on adult Silver Carp and Bighead Carp in relation to longitudinal movement, habitat use, and dam passage. These studies have helped to shed light on spawning behaviors, upstream migration, and habitat use of adult Silver Carp and Bighead Carp to better inform management actions for these fish. Despite the large amount of effort being undertaken to study adult Silver Carp and Bighead Carp, little information exists about habitat use and movement of juveniles.

This study was designed to: (1) quantify the broad scale habitat use of juvenile Silver Carp across four macro-habitat types (main channel, side channel, backwaters, and marinas) within the

Illinois River, (2) evaluate the movement potential of juvenile Silver Carp within the Illinois River, and (3) determine if juvenile Silver Carp movement correlates with Illinois River discharge and water temperature..

Objectives:

(1) Quantify movement frequency and distance of juvenile Silver Carp.

(2) Determine macro-habitat selection based on periods of residency of juvenile Silver Carp.

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

Project Highlights:

- 37 juvenile Silver Carp were tagged in 2019
- Due to insufficient data (low detection of telemetered fish), mean weekly movement distance of telemetered juvenile Silver Carp could not be calculated for 2019 or 2020.
- Due to insufficient data, mean residence times by habitat area for telemetered juvenile Silver Carp could not be calculated for 2019 or 2020 (no tag detections met the criteria of a residence events; see methods for criteria).

Methods:

Study Location

This study took place in the Peoria reach of the Illinois River bounded by the Peoria Lock and Dam (downstream) and the Starved Rock Lock and Dam (upstream). Prior to beginning the study, the Peoria reach was broken into four macro-habitat categories roughly following those established in the Long Term Resource Monitoring Program of the Upper Mississippi Basin Fish component: main channels, side channels, backwaters, and marinas (Ratcliff et al. 2014). Main channel habitats were defined as zones of the river and their shorelines that are continuously dredged to maintain a nine-foot depth. Side channels were defined as flowing water areas in the river that are separated from the main channel by land. Backwaters were defined as non-flowing water areas that are connected to the river during flat pool conditions. Marinas were defined as any other non-flowing areas that are presently or historically dredged to maintain depth for the purpose of mooring boats.

Telemetry Equipment and Fish Tagging

Acoustic telemetry equipment was deployed prior to fish tagging in April 2017. A total of 26 Vemco VR2-W 180kHz (Amerix systems-Vemco) hydroacoustic receivers were placed in the

Peoria reach of the Illinois River from Hennepin, IL to Chilicothe, IL. Receivers were placed in tandem sets on either side of the navigational channel at strategic narrow points in the river. Radio telemetry equipment was deployed in September 2017. A total of 10 passive monitoring stations were set up from the Peoria Lock and Dam at the downstream end to Hennepin, IL at the upstream end. Receivers were placed at key constriction points and entrances to backwaters or side channels similar to the placement of acoustic receivers. Since multiple antennas could be used for one site, typically one antenna would point downstream into the main channel and a second antenna would point into the backwater or side channel. Throughout the study, we attempted to download receiver data no less than every two months. During receiver checks, mounting hardware and peripheral supporting equipment was checked for integrity and replaced as needed. Batteries in acoustic receivers were replaced yearly; batteries for radio telemetry receivers were replaced as needed.

Juvenile Silver Carp were captured via boat electrofishing or electrified dozer trawl between Henry, IL and Peoria, IL from the Peoria Pool of the Illinois River. Fish collection focused on marinas, backwaters, and side channels due to the river morphology and gear effectiveness in this part of the river. Only individuals between 100mm - 400mm were retained for tagging. Larger sizes of Silver Carp and Bighead Carp were measured and enumerated then either retained for use in a separate telemetry study or destroyed. Only Silver Carp longer than 100mm in total length were considered for tagging. Smaller individuals were captured, however they were not suitable for use due to the inability to make an incision and close the wound properly. Additionally, weight of individuals smaller than 100mm was below the size threshold to maintain a tag-to-body weight ratio of 2% (75 g body weight minimum). Any other species captured as bycatch were identified, enumerated, and released.

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 ventral side up into a modified foam board (fish-shape cut out to provide proper support for surgery). Surgery crews sterilized equipment and wore gloves during all fish handling to prevent infection. Acoustic tags (V5 ultrasonic transmitters, Amerix Systems-Vemco Ltd.) and Radio tags (NTF-3-2 radio transmitters, Lotek Wireless LLC.) were surgically implanted into juvenile Silver Carp on the left ventral side of the body (just behind the pelvic fins). Three non-absorbable antibacterial nylon sutures were used to close the incision site for acoustic tags and a fourth suture was placed around the base of where the antenna exited the wound for radio tags to secure it. Following wound closure, the fish was placed in an aerated holding tank for recovery. Once the fish re-established equilibrium, it was released into the river. Total holding time for fish was generally less than four hours.

Data Analysis

Telemetry field data was offloaded using VUE software (Amerix Systems-Vemco Ltd.) for acoustic receivers and SRX800-Host software (Lotek Wireless LLC.) for radio receivers. VUE was used to generate text comma delimited files for detection data and remove detection errors from each receiver download. Windows Command Shell was used to combine these files into a single composite file for analysis in R. The R package V-Track and its dependencies were used to summarize detection data, run residency calculation, and movement distance calculations. Pearson correlation was used to test for correlation between residencies in each habitat strata and river conditions and between movement distance and river conditions.

Residence time for each fish was calculated with a residence event being triggered if a fish was detected at a single receiver for at least 10 tag pings within one hour. As ping rate was set at roughly 90s (60s-120s variability), a completely stationary individual could trigger a residence evident within 30 minutes. Residence events timed out if a fish was picked up on another receiver or was not detected for one hour. Residence events and durations for each fish were recorded based on habitat strata of the receiver location and averaged over all tagged fish for comparison. Residence events were plotted with river discharge (cubic feet per second) and water temperature (Celsius) logged at the U.S. Geological Survey stream gauge in Henry, IL.

Movement events were calculated in the event a tagged fish was detected on a given telemetry receiver and subsequently on a separate receiver. In the case of tandem receiver sets in the main channel, these sets were treated as one receiver to prevent false movements from being recorded by a fish being detected on both receivers. Movement data was summarized into weekly movement for each fish and averaged for each year of data. Mean weekly movements were also plotted with river discharge (cubic feet per second) and water temperature (Celsius).

Results and Discussion:

Tagging efforts resulted in 37 Silver Carp with a mean total length of 183mm being tagged in 2019. However, due to receiver loss and a low number of active tags within the system, an insufficient number of tag detections (only three fish at two locations) were collected during 2019 and 2020 to calculated residence times for the 2019 or 2020 timeframes. Similarly, for the same reasons as residence analysis, no tag detections meeting the criteria for a residence event were collected during 2019 and 2020. Therefore, mean weekly movement distances could not be calculated for the 2019 or 2020 timeframes.

Conclusions:

This project concluded in 2020. All active telemetry equipment was removed from the system in fall 2020. Few active telemetered fish remained after January 2020 and receivers were not able to be maintained due to spring flooding and harsh early winter conditions in 2019 followed by the Covid-19 pandemic resulted in crews being unable to conduct maintenance or recovery of acoustic receivers until fall of 2020. Ultimately, only two receivers were recovered during those efforts thus limiting data analyses for the 2019 and 2020 timeframes.

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

A final report with the full results of the habitat use and movement of juvenile Silver Carp in the Illinois River is currently in preparation. Ultimately, this work demonstrated the ability to successfully tag young-of-year Silver Carp (minimum total length 100mm) using telemetry tags. Additionally, results indicated different habitat use and movement patterns from mature Silver Carp.

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Des Plaines River and Overflow Monitoring

Jen-Luc Abeln and Nathan T. Evans (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 (USFWS, lead) and U.S. Army Corps of Engineers (USACE, field support)

Pools Involved: Not applicable

Introduction and Need:

The upper Des Plaines River originates in southeast Wisconsin and joins the Chicago Sanitary and Shipping Canal (CSSC) in the Brandon Road Pool immediately downstream of Lockport Lock and Dam. Silver Carp, Bighead Carp, and Grass 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 environmental deoxyribonucleic acid (eDNA) was detected in the upper Des Plaines River (no samples were taken in 2012 – 2020). If present in the upper Des Plaines River, Asian carp have the potential to bypass the Electric Dispersal Barrier System (EDBS) during flooding events (overtopping) that allow water to flow laterally between the upper Des Plaines River and the CSSC. To reduce the likelihood of Asian carp transfer between the two rivers, the USACE completed the construction of a physical barrier in 2010. The physical barrier consists of concrete barriers and 0.25-inch (6.35 millimeter [mm]) mesh fencing installed along 13.5 miles (21.7 kilometers [km]) of the upper Des Plaines River where it runs adjacent to the CSSC. This structure is designed to prevent adult and juvenile Asian carp from entering 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 that provided the potential for fish passage. An overtopping event in 2017 allowed water to breach the fence, but not connect to the CSSC. These locations 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. Due to the upper Des Plaines River's proximity to the CSSC and its potential to function as a bypass to the EDBS, it is important to understand the risks associated with overtopping events as well as Asian carp distribution and spawning within the river. Likewise, it is critical to determine and understand the effectiveness of the physical barrier at blocking Asian carp movement between the Des Plaines River and the CSSC.

Des Plaines River and Overflow Monitoring

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) Monitor for eggs and larvae around the physical barrier during high flow events when water moves laterally from the Des Plaines River into the CSSC.

(3) Monitor the effectiveness of the barrier against fishes during high flow events when water moves laterally from the Des Plaines River into the CSSC.

Project Highlights:

- Collected 13,882 fish representing 67 species and 4 hybrid groups from 2011 – 2020 via electrofishing (81.5 hours) and gill netting (153 sets; 23,684 yards [21,656.7 m]).
- No Bighead Carp or Silver Carp have been captured or observed through all years of sampling.
- Ten Grass Carp have been collected since 2011. No Grass Carp collected in 2020.
- Four overtopping events since 2011 have resulted in several improvements to the barrier fence. One overtopping event occurred in 2020.

Methods:

In 2020, sampling was conducted in the upper Des Plaines River from E. Romeo Road (Romeoville, IL) to Columbia Woods (Willow Springs, IL; Figure 1). Two sampling periods were completed from August 17-20 and from October 28-30 using pulsed-DC boat electrofishing. Electrofishing runs included one dipper (designated netter) and proceeded for 15 minutes. Only one dipper (rather than two dippers as in prior years) was used during 2020 sampling due to the COVID-19 pandemic. Sampling was performed in both backwater and main channel habitats that were accessible to sampling boats. All individual fishes were identified to species then released.

Results and Discussion:

During the ten years of sampling (2011-2020), 81.5 hours of electrofishing and 153 net sets covering 23,684 yards (21,656.7 m) of gill net resulted in a total catch of 13,882 fishes. Sixty-seven species and four hybrid groups have been collected. Common Carp have been the most commonly collected species, followed by Gizzard Shad, then Bluegill. In 2020, 8.5 hours of electrofishing resulted in 1,106 fish representing 31 species and 3 hybrid groups. No Bighead Carp or Silver Carp have been collected or observed throughout all years of sampling. Ten Grass Carp have been collected since 2011. No Grass Carp were collected in 2020.

Des Plaines River and Overflow Monitoring

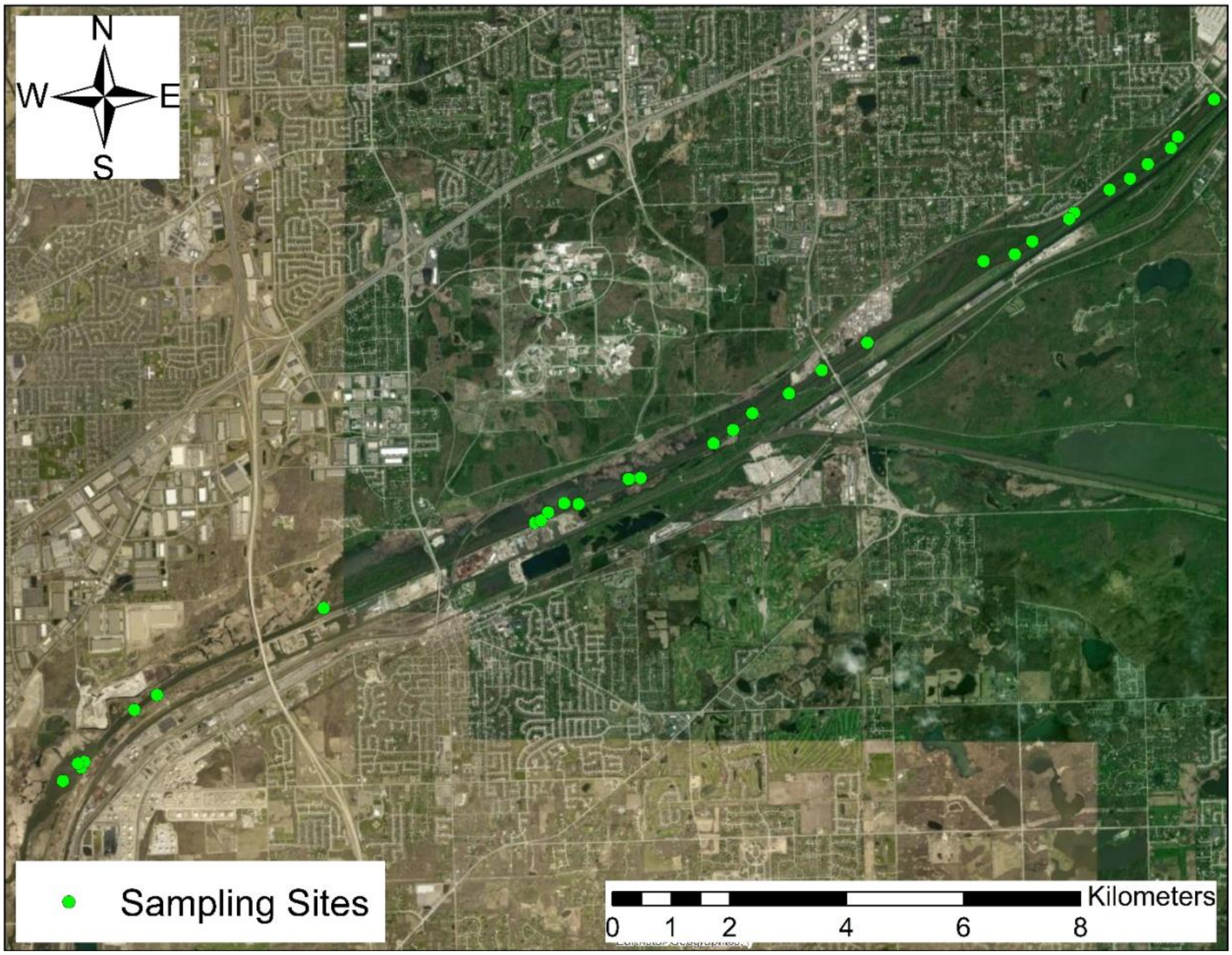

Figure 1. *2020 Sampling sites in the upper Des Plaines River.*

An overtopping event occurred during 2020, with the Des Plaines River cresting at a record high of 13.26 feet (ft.) on May 18th. This allowed for a few inches of water to pass from the Des Plaines River to the CSSC. It was the decision of the USFWS not to respond to the event due to precautions in place for the ongoing COVID-19 pandemic. It was felt that the safety of responding staff would not be able to be maintained given the pandemic. However, staff from USACE was able to respond to close the turtle gates before water started to pass through the barrier fence and monitor the integrity of the barrier fence. Six panels of fence were found to have scour holes that could have allowed for eggs and larvae to pass from the Des Plaines River to the CSSC. USACE staff deployed a seine at areas where passage was possible; however, high flow made the gear difficult to operate and no fish were captured during these attempts. Work is ongoing to repair the scour holes. Overtopping events may be reduced into the future due to the McCook Reservoir, which provides 3.5 billion gallons (13.2 billion liters) of flood water storage to the Chicago area, including the Des Plaines River.

Des Plaines River and Overflow Monitoring

Recommendations:

- Continue seasonal monitoring for adult and juvenile Bighead Carp and Silver Carp in the upper Des Plaines River with emphasis on backwater habitat.
- Improve monitoring for all life stages of Asian carp by including additional gear types (e.g., mini-fyke nets and experimental multi-panel gill nets) and effort expended towards early detection).
- Monitor Des Plaines River stage during heavy rainfall events and conduct investigations of the physical barrier, as needed, in areas where overflow has occurred.
- Sample icthyoplankton to monitor for egg and larvae drift during overflow events, especially when temperatures are conducive for reproduction.

Table 1. *Fish species collected (number of individuals) from the upper Des Plaines River between 2011 – 2020. Fishes were sampled via boat-mounted electrofishing and gill netting.*

Species	No. Captured 2020	No. Captured 2011-2019	Totals All Years
Banded Killifish	-	4	4
Bigmouth Buffalo	-	22	22
Black Buffalo	-	7	7
Black Bullhead	-	42	42
Black Crappie	29	315	344
Blackside Darter	1	14	15
Blackstripe Topminnow	9	68	77
Bluegill	64	1072	1,136
Bluntnose Minnow	76	779	855
Bowfin	28	145	173
Brown Bullhead	-	1	1
Bullhead Minnow	-	88	88
Carp x Goldfish Hybrid	24	32	56
Central Mudminnow	-	3	3
Central Stoneroller	-	9	9
Channel Catfish	14	420	434
Channel Shiner	-	2	2
Common Carp	92	3452	3,544
Creek Chub	-	39	39
Emerald Shiner	22	229	251
Fathead Minnow	-	43	43
Flathead Catfish	-	4	4
Freshwater Drum	-	7	7
Gizzard Shad	182	1,528	1,710
Golden Shiner	75	175	250
Goldfish	3	115	118
Grass Carp	-	10	10
Grass Pickerel	-	6	6
Green Sunfish	7	160	167
Highfin Carpsucker	-	1	1
Hornyhead Chub	27	14	41
Hybrid Striped Bass	-	1	1
Hybrid Sunfish	8	1	9
Johnny Darter	-	2	2
Largemouth Bass	155	978	1,133
Logperch	3	4	7
Longear Sunfish	-	1	1

Des Plaines River and Overflow Monitoring

Table 1. *continued*

Species	No. Captured 2020	No. Captured 2011-2019	Totals All Years
Longnose Gar	1	71	72
Mimic Shiner	-	1	1
Muskellunge	-	2	2
Northern Pike	20	232	252
Orangespotted Sunfish	-	115	115
Oriental Weatherfish	-	2	2
Pumpkinseed	40	143	183
Quillback	-	19	19
Redear Sunfish	-	1	1
River Carpsucker	-	23	23
River Shiner	2	8	10
Rock Bass	11	53	64
Rosyface Shiner	1	13	14
Round Goby	6	34	40
Sand Shiner	7	164	171
Sauger	14	69	83
Sauger x Walleye Hybrid	5	-	5
Smallmouth Bass	43	159	202
Smallmouth Buffalo	-	32	32
Spotfin Shiner	13	925	938
Spottail Shiner	77	401	478
Spotted Sucker	3	29	32
Suckermouth Minnow	-	1	1
Tadpole Madtom	-	1	1
Walleye	-	10	10
Warmouth	-	6	6
Western Mosquitofish	-	2	2
White Bass	-	1	1
White Crappie	-	3	3
White Perch	-	1	1
White Sucker	38	410	448
Yellow Bass	-	2	2
Yellow Bullhead	6	44	50
Yellow Perch	-	6	6
Sum No. Captured	1,106	12,776	13,882
Species Richness (Hybrids)	31(3)	67(3)	67(4)

Alternative Pathway Surveillance in Illinois – Urban Pond Monitoring

Justin Widloe, Nate Lederman, Eli Lampo, Claire Snyder, Charmayne Anderson, Kevin Irons (Illinois Department of Natural Resources), Allison Lenaerts, Dan Roth, Andrew Mathis, Jehnsen Lebsock (Illinois Natural History Survey), and Dr. Greg Whitledge (Southern Illinois University at Carbondale).

Participating Agencies: Illinois Department of Natural Resources (IDNR, lead), Southern Illinois University Carbondale (SIU, otolith chemistry analysis)

Pools Involved:

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

Introduction and Need:

IDNR fields many public reports of observed or captured Asian carp. All reports are taken seriously and investigated through phone/email correspondence with individuals making a report, requesting and viewing pictures of suspect fish, and visiting locations where fish are being held or reported to have been observed. In most instances, reports of Asian carp prove to be native Gizzard Shad or stocked non-natives, such as trout, salmon, or Grass Carp. Reports of Bighead Carp or Silver Carp from valid sources and locations where these species are not known to previously exist elicit a sampling response with boat electrofishing and trammel or gill nets. Typically, no Bighead Carp or Silver Carp are captured during sampling responses. However, this pattern changed in 2011 when 20 Bighead Carp (> 21.8 kg [48 lbs]) were captured by electrofishing and netting in Flatfoot Lake and Schiller Pond, both fishing ponds located in Cook County once supported by the IDNR Urban Fishing Program.

As a further response to the Bighead Carp in Flatfoot Lake and Schiller Pond, IDNR reviewed Asian carp captures in all fishing ponds included in the IDNR Urban Fishing Program located in the Chicago Metropolitan area. To date, 10 of the 21 urban fishing ponds in the program have verified captures of Asian carp either from sampling, pond rehabilitation with piscicide, natural die offs or incidental take. One pond had reported sightings of Asian carp that were not confirmed by sampling (McKinley Park). The distance from Chicago area fishing ponds to Lake Michigan ranges from 0.2 to 41.4 km (0.1 to 25.7 mi). The distance from these ponds to the Chicago Area Waterway System (CAWS) upstream of the Electric Dispersal Barrier System (EDBS) ranges from 0.02 to 23.3 km (0.01 to 14.5 mi). Although some ponds are located near Lake Michigan or the CAWS, most are isolated and have no surface water connection to the Lake or CAWS upstream of EDBS. Ponds in Gompers Park, Jackson Park, and Lincoln Park are the exceptions. The Lincoln Park South and Jackson Park lagoons are no longer potential sources of Bighead Carp because they were rehabilitated with piscicide in 2008 and 2015, respectively.

Gompers Park never had a report of Asian carp, nor have any been captured or observed during past sampling events. Nevertheless, examining all urban fishing ponds close to the CAWS or Lake Michigan continues to be of importance due to the potential of human transfer of Asian carp between waters within close proximity to one another, the CAWs, and Lake Michigan.

In addition to Chicago area ponds once supported by the IDNR Urban Fishing Program, ponds with positive detections for Asian carp eDNA were also reviewed. Eight of the 40 ponds sampled for eDNA by the University of Notre Dame resulted in positive detections for Asian carp, two of which are also IDNR urban fishing ponds (Jackson Park and Flatfoot Lake). Asian carp have been captured and removed from two of the eight ponds yielding positive eDNA detections. The distance from ponds with positive eDNA detections to Lake Michigan ranges from 4.8 to 31.4 km (3 to 19.5 mi). The distance from these ponds to the CAWS upstream of the EDBS ranges from 0.05 to 7.6 km (0.03 to 4.7 miles). The lake at Harborside International Golf Course has surface water connectivity to the CAWS. However, no Asian carp have been reported, observed, or captured. Though positive eDNA detections do not necessarily represent the presence of live fish (e.g., may represent live or dead fish, or result from sources other than live fish, such as DNA from the guano of piscivorous birds) all ponds with positive detections were examined for the presence of live Asian carp given the proximity to the CAWS.

Objectives:

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

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

Project Highlights:

- 44 Bighead Carp and one Silver Carp have been removed from 10 ponds.
- Eight Bighead Carp and one Silver Carp killed by either natural die-off or pond rehabilitation with piscicide have been removed from Chicago area ponds since 2008.
- 18 of the 21 IDNR Chicago Urban Fishing Program ponds have been sampled with nets and electrofishing.
- During 2020 sampling efforts were mitigated due to Covid-19. One call was reported to our agency. A report of a leaping fish within the pond behind the Cancer of Center of America (42.449339 -87.828856) was made on April 4, 2020. A fisher at the park indicated to that it was ‘a carp’. With the stay-at-home order that was put in place by the Governor of Illinois, the agency did not directly respond to this report with a site visit. The system was assessed remotely to the best of our abilities and reported the findings. The pond was about one mile from Lake Michigan, but did not directly connect to Lake Michigan, the Des Plaines River, or the DuPage River. A ~65 ft change in elevation exited between Lake Michigan and the pond so direct connection through a flood is

highly unlikely. It was felt that there was an extremely low chance of potential transfer into Lake Michigan if the sighting was an Asian carp. Access to the lake has yet to secured but is being worked on. If access is able to be gained, a response will occur.

Methods:

Sampling Protocol

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

Otolith Microchemistry and Aging

Asian carp captured in urban fishing ponds will have head, vertebrae, and post-cleithra removed and sent to SIU for otolith microchemistry analysis and age estimation.

Results and Discussion:

This project began in 2011 and is on-going. A total of 44 Bighead Carp and one Silver Carp have been removed from 10 ponds. 58 hours of electrofishing and 13 miles of gill/trammel net were utilized to sample 24 Chicago area fishing ponds, resulting in 35 Bighead Carp removed from five ponds since 2011. Additionally, eight Bighead Carp and one Silver Carp killed by either natural die-off or pond rehabilitation with piscicide have been removed since 2008. Lastly, one Bighead Carp was incidentally caught by a fisherman in 2016. The lagoons at Garfield and Humboldt Park have both had Bighead Carp removed following natural die-offs and sampling. All ponds yielding positive eDNA detections and 18 of the 21 IDNR urban fishing ponds have been sampled. Lincoln Park South was not sampled because it was drained in 2008, resulting in three Bighead Carp being removed, and is no longer a source of Asian carp as a result. Auburn Park was too shallow for boat access but had extremely high visibility. Therefore, the pond was visually inspected with no large bodied fish observed. Lastly, Jackson Park and Garfield Park were drained in 2015 and, similar to Lincoln Park South, are no longer a source of Asian carp. A map of all the Chicago area fishing ponds that were sampled or inspected as part of this project can be found in Figure 1. For more detailed results see 2019 interim summary report document (Monitoring Response Work Group [MRWG] 2018).

During 2020 our sampling efforts were mitigated due to Covid-19. One call was reported to our agency. A report of a leaping fish within the pond behind the Cancer of Center of America (42.449339 -87.828856) was made on April 4, 2020 by a private citizen. A fisher at the park indicated to the citizen that it was ‘a carp’. The citizen had seen videos of Asian carp leaping into boats and was suspicious it that the reported fish was not an Asian carp. Due to COVID-related restrictions, the agency did not directly respond to this report with a site visit. The pond was assessed remotely to the best of our abilities and findings were reported to the private citizen. The pond was located approximately 1 mile from Lake Michigan, but did not directly connect to Lake Michigan, the Des Plaines River, or the DuPage River. An approximately 65-foot change in elevation exists between Lake Michigan and the pond so direct connection through a flood is highly unlikely. It was determined that there was an extremely low chance of potential transfer into Lake Michigan if the sighting was an Asian carp. Crews are still working to obtain access to the pond to perform an in-person assessment. If access is granted, a response will occur.

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

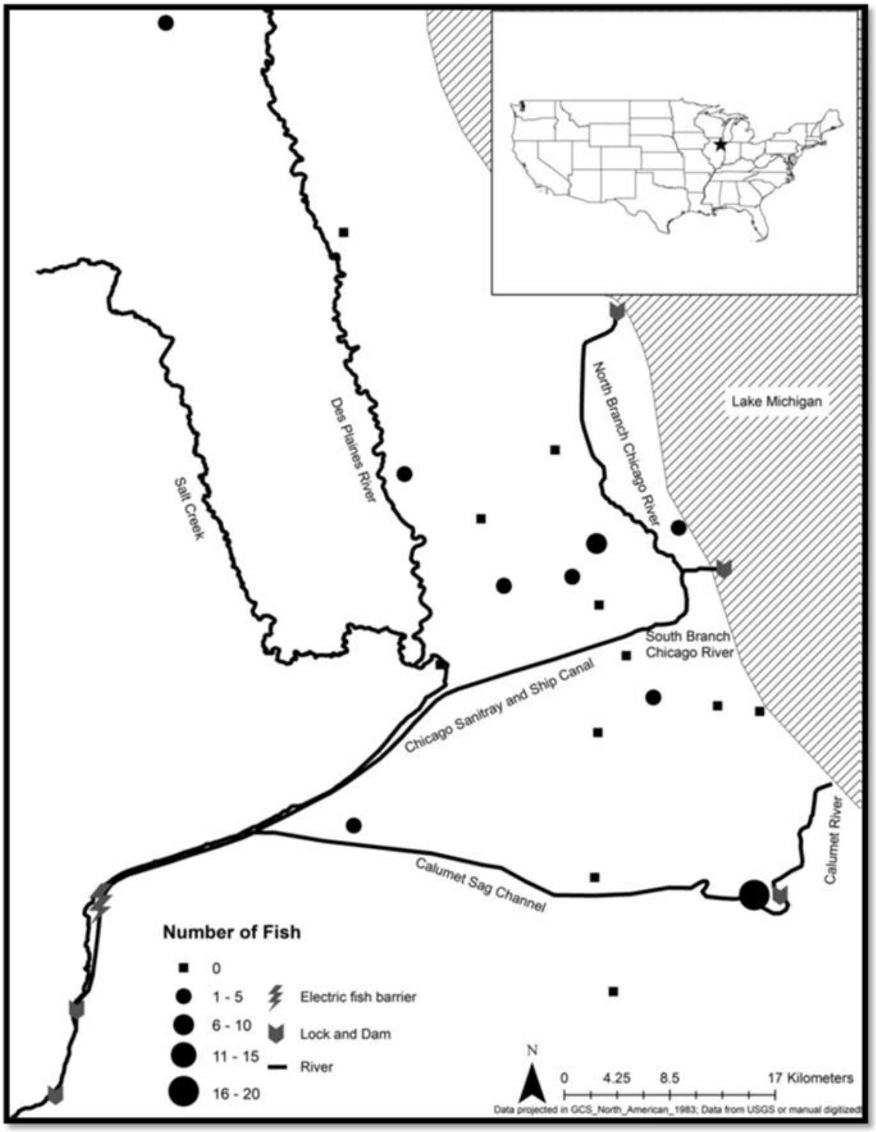

Figure 1. *Chicago area fishing ponds from which Asian carp have been removed and those from which no Asian carp have been collected or reported (squares).*

Multiple Agency Monitoring of the Illinois River for Decision Making

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Participating Agencies: Illinois Department of Natural Resources (IDNR, co-lead); Illinois Natural History Survey – Illinois River Biological Station (INHS, co-lead); U.S. Army Corps of Engineers – Chicago District (USACE, field support)

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

Introduction and Need:

Detection and monitoring of Asian carp (Bighead Carp, Black Carp, Grass Carp and Silver Carp) populations in pools below the Electric Dispersal Barrier System (EDBS) are pertinent to understanding their upstream progression and minimize the risk of establishment above the EDBS. Surveillance is particularly important in pools directly upstream for each Asian carp species known expanse with Bighead Carp and Silver Carp being within the Dresden Island Pool, Grass Carp being in the Chicago Area Waterway, and Black Carp being within the Peoria Pool. Extensive monitoring also provides managers the ability to evaluate the impacts of management actions (e.g., contracted removal) and collect data to assist other projects (e.g., Spatially Explicit Asian Carp Population [SEACarP] model). Data collected from a standardized multiple gear sampling approach have been used to create accurate and comparable relative abundance estimates of specific species and detect the presence of previously unrecorded invasive species (Ickes et al. 2005). A standardized multiple gear approach was used here to create a comprehensive dataset that provided an understanding of the current geographic range of Asian carp across all pools downstream of the EDBS, their abundances, and the threat they pose to entering Lake Michigan.

Objectives:

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

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

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

Project Highlights:

- In 2020, an estimated 7,845 person-hours were expended sampling fixed and random sites downstream the EDBS including 169 hours of electrofishing, 1,353.46 hoop netting net nights, 440.01 minnow fyke netting net nights, and 91.64 fyke netting net nights.
- A total of 252,911 fish representing 107 species and 13 hybrid groups were captured in 2020.
- No Asian carp (large or small) were captured in Lockport or Brandon Road pools in 2020.
- The leading edge of the Bighead Carp and Silver Carp populations remained around river mile 281 (north of I-55 Bridge within the Dresden Island Pool near the Rock Run Rookery) in 2020.
- Small Silver Carp and Bighead Carp (< 6 inches/152.4 millimeters [mm]) were captured in Peoria Pool (river mile 216; ~108 miles from Lake Michigan) in 2020. 14 miles further upriver than 2019.
- Data from projects outside of the Monitoring Response Work Group (MRWG) Monitoring Response Plan (MRP) were incorporated because of standardization, creating a comprehensive synthesis of each Asian carp species' status across the entire Illinois River Waterway below the EDBS in 2020.

Methods:

The Multiple Agency Monitoring of the Illinois River for Decision Making used the time-tested, standardized, multiple gear approach developed by the USACE's Upper Mississippi River Restoration program (Gutreuter *et al.* 1995, Ratcliff *et al.* 2014) to monitor Asian carp populations in the Illinois River Waterway below the EDBS. This approach utilized daytime boat pulsed DC electrofishing, fyke netting, minnow fyke netting, and paired large and small hoop netting in a stratified random approach. Detailed descriptions on gear specifications and sampling protocol can be found in Ratcliff *et al.* (2014).

The standardized sampling protocol used during this project is also used in the USACE's Upper Mississippi River Restoration program's Long-Term Resource Monitoring (Ratcliff *et al.* 2014), the Long-Term Survey and Assessment of Large River Fishes in Illinois Monitoring (Fritts *et al.* 2017), and the Water Level Management Assessment of the Illinois River Project. Therefore, data collected external to the MRWG MRP were incorporated to create a comprehensive dataset that included all pools of the Illinois River. Data outside of the MRWG MRP were provided by U.S. Geological Survey (USGS) and the INHS. Data were provided in the preliminary format to meet the need for timely best science on the condition that neither the USGS, INHS, nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the data.

Historically sampled fixed sites, upstream of the known Asian carp invasion front within Brandon Road Pool and Lockport Pool, were also sampled with DC electrofishing. Fixed sites were sampled every other week in March through November providing a higher frequency and lengthier temporal range than the randomized sampling design. This enabled for determining if Asian carp were present in the relative vicinity of the EDBS or expanded further upriver in periods outside of the standard sampling window as well as maintaining collection of historic trend data.

Overall relative abundance indices, and pool specific relative abundance indices, within each pool below the EDBS, were generated for each Asian carp species within each gear type from the comprehensive dataset. Calculating absolute abundance requires extensive data collection and a probability-based array, which can be extremely costly and time consuming (Hayes et al. 2007). A relative abundance index is considerably easier, less expensive, and less time consuming all the while directly relating to the absolute abundance (Pope et al. 2010). The relative abundance index of catch per unit effort (CPUE) was calculated as the number of fish per hour for electrofishing and the number of fish per net night (24 hours) for fyke net, minnow fyke net, and hoop net samples.

Results and Discussion:

Electrofishing Effort and Catch

An estimated 2,655-person hours were expended completing 169.92 hours of electrofishing (678 transects) downstream of the EDBS in 2020. Electrofishing yielded 81,108 individual fish representing 97 species and 11 hybrid groups for a mean CPUE±SE of 484.33±24.05 fish/hour (Table 1). Electrofishing catch was dominated by Gizzard Shad (39.51%; n = 32,042), Emerald Shiner (14.17%, n = 11,495), and Bluegill (8.88%, n =7,199) in 2020 (Table 2). Overall Silver Carp CPUE was 8.02±0.80 fish/hour while no Bighead Carp were captured which was a slight decrease from 2019 levels of 9.81±0.97 Silver Carp/hour and 0.03±0.02 Bighead Carp/hour. Silver Carp CPUE was highest in the lower Illinois River pools (Starved Rock Pool on downstream) with no Bighead Carp, Black Carp, Grass Carp or Silver Carp captured during electrofishing in the pools nearest to the EDBS (Brandon Road and Lockport Pools) during 2020 (Figure 2). In the Dresden Island Pool, the pool nearest to the EBDS with a known Asian carp population, no Silver Carp were captured during electrofishing in 2020 compared to a 0.06±0.06 Silver Carp/hour catch rate in 2019. No Bighead Carp were captured 2020 as in 2019. Asian carp tended to be larger in size in the upper river pools compared to lower river pools (Figure 3). Of the Asian carp captured during electrofishing in 2020 among all the pools, 76 of them were < 6 inches. All 76 small Silver Carp were captured in the Peoria Pool. The furthest upstream a small

Asian carp (< 6 inches) was captured during electrofishing in 2020 was in Peoria pool (River Mile 212; ~105 river miles downstream of Lake Michigan).

Hoop Netting Effort and Catch

An estimated 4,440-person hours were expended setting and running 696 hoop nets (1,357.46 hoop net nights) downstream of the EDBS in 2020. Hoop netting yielded 9,899 fish representing 43 species and 5 hybrid groups for a mean CPUE (number of fish/net night) of 7.4±0.49 (Table 1). Channel Catfish comprised the largest proportion of the hoop net catch (45.77%; n = 4,531), followed by Smallmouth Buffalo (21.14 %; n = 2,093) and Common Carp (9.8%; n = 978) during 2020 (Table 3). No Asian carp were captured in Lockport, Brandon Road, Dresden Island, or Marseilles pools during hoop netting, but were captured in the other downstream pools (3 Bighead Carp, 33 Grass Carp and 23 Silver Carp) during 2020 (Table 3). Bighead Carp hoop netting CPUE among all pools was 0.00±0.00, while Silver Carp CPUE was 0.01±0.00 in 2020 which were lower than the 2019 rates of 0.04±0.02 Bighead Carp per net night and 0.03±0.09 Silver Carp per net night. Greater catch rates of Asian carp in hoop nets were found in the lower river pools compared to the upper river pools (Figure 2). Asian carp captured in hoop nets tended to be larger in upper river pools compared to lower river pools (Figure 3).

Minnow Fyke Netting Effort and Catch

An estimated 2,550-person hours were expended setting and running 463 minnow fyke nets (440.01 minnow fyke net nights) downstream of the EDBS in 2020. Minnow fyke netting yielded 158,165 fish representing 83 species and 4 hybrid groups for a mean CPUE (number of fish/net night) of 353.65±63.41 (Table 1). Most of the minnow fyke catch was comprised of Gizzard Shad (32.48%; n = 51,365), Bluegill (23.36%; n = 36,942), and Emerald Shiner (14.24%; n = 22517) during 2020 (Table 4). Two Bighead Carp, no Black Carp, two Grass Carp and 2,178 Silver Carp were captured during minnow fyke effort. One Grass Carp was captured in LaGrange and 1 was captured in Peoria. Both Bighead Carp where captured in the Peoria Pool. Most of the Silver Carp (96%) were captured in the Peoria Pool with 1 being captured in Starved Rock Pool and 77 being captured in LaGrange Pool. Overall Silver Carp minnow fyke net CPUE among all pools was 5.189±3.28 individuals/net night in 2020 which was an increase from the 0.04±0.02 Silver Carp per net night capture in 2019. Greater catch rates of Silver Carp were still found in the lower river compared to the upper river (Figure 2). Minnow fyke netting captured the majority of small Asian carp within all of the pool and among all gears (Figure 3). The furthest upstream a small Asian carp (<6 inches) was captured during minnow fyke nets in 2020 was in Starved Rock pool (River Mile 216; ~108 river miles downstream of Lake Michigan). This location is further downstream than previous years, as small Asian carp were captured in Marseilles Pool in 2015 and 2016 (river mile 263; ~61 miles from Lake Michigan) but further upstream compared to 2019 (River Mile 201; ~120 river miles downstream of Lake Michigan).

Fyke Netting Effort and Catch

An estimated 1,110 hours were expended setting and running 93 fyke nets (91.64 net nights) downstream of the EDBS in 2020 (Table 1). A total of 3,739 fish representing 45 species and 5 hybrid groups were captured during fyke netting with a mean CPUE of 41.20±5.89 fish/net night (Table 1). Fyke net catch was dominated by Bluegill (34.02%, n = 1,272), Black Crappie (19.34%; n = 723) and White Bass (9.84%, n = 9.84) in 2020 (Table 5). A total of one Bighead Carp, zero Black Carp, two Grass Carp, and one Silver Carp were captured during fyke netting. All Asian carp captured during fyke netting were collected below Peoria Lock and Dam. However, no fyke net samples were collected in Lockport, Brandon Road, Starved Rock or Alton pools due to lack of suitable habitat for this gear. Overall Bighead Carp fyke net CPUE among all pools of 0.01±0.01, Grass Carp CPUE was 0.02±0.01 and Silver Carp CPUE was 0.01±0.01 were similar to that of 2019 levels which were 0.2±0.08 Bighead Carp per net night and 0.1±0.05 Silver Carp per net night. Higher catch rates of Bighead Carp, Grass Carp and Silver Carp were found in the lower river pools compared to the upper river pools during fyke netting in 2020 as in 2019 (Figure 2).

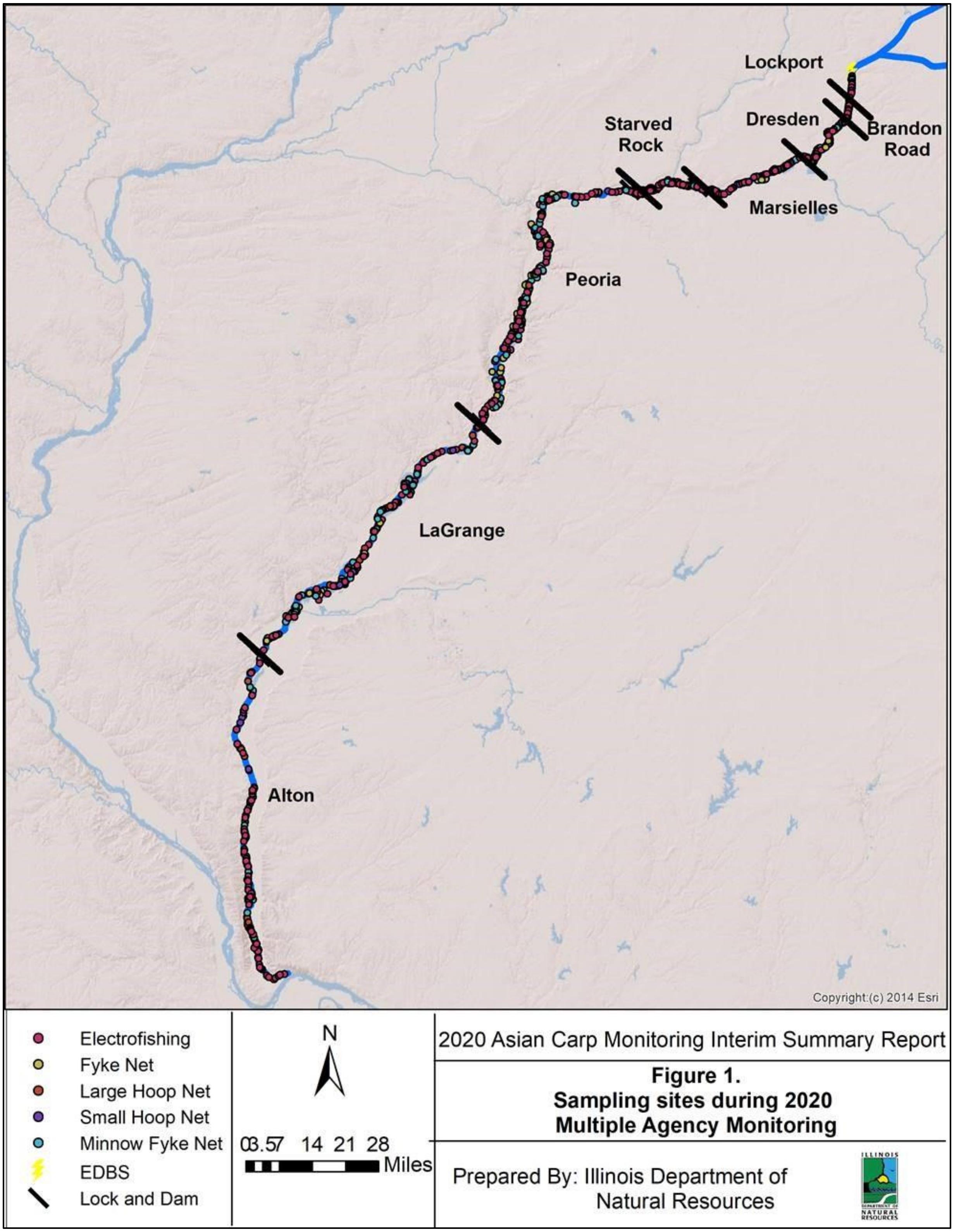


Figure 1. *Sampling sites used during Multiple Agency Monitoring of the Illinois River for Decision Making plan below the electric dispersal barrier within the Illinois River Waterway.*

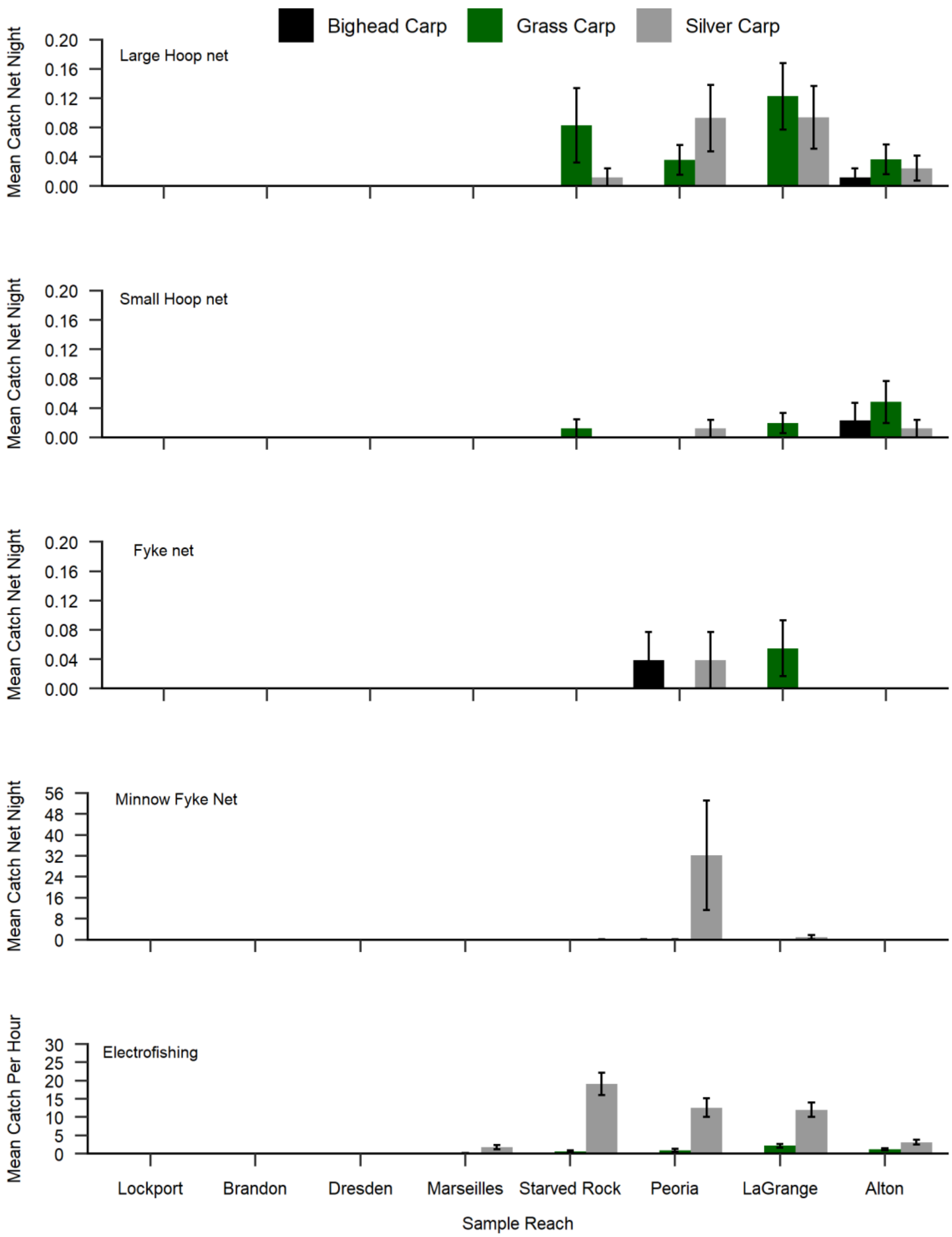
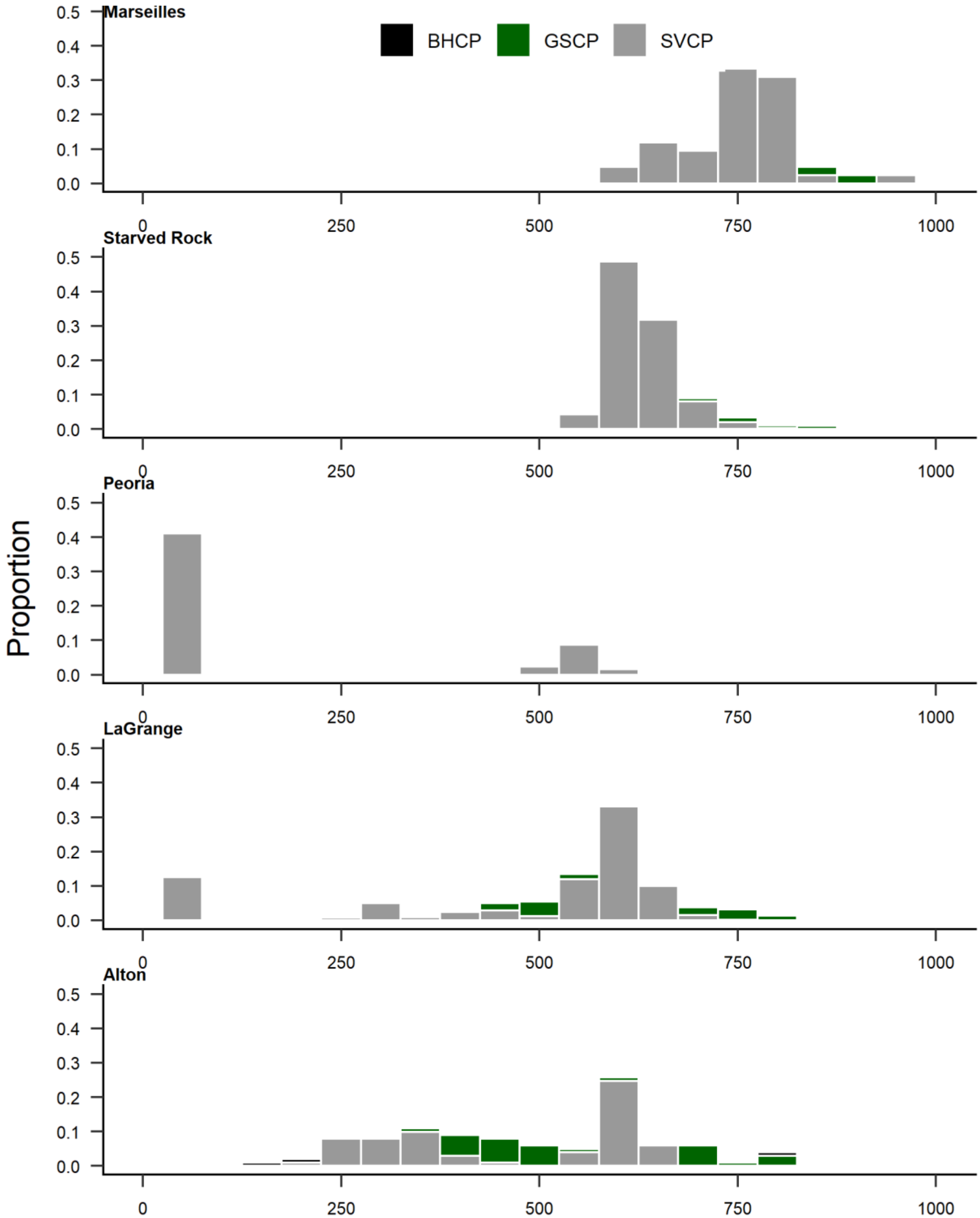


Figure 2. *Mean Catch per unit effort of Bighead Carp (black), Grass Carp (green), and Silver Carp (grey) by gear type among the various pools of the Illinois River Waterway during 2020 sampling. Due to the varying units of efforts nets and electrofishing results should not be directly compared to one another. Error bars represent ± 1 SE.*

Figure 3. *Overall length frequency distributions, per 50 mm length bin, of Bighead Carp (black), Grass Carp (green) and Silver Carp (grey) captured within each pool of the Illinois River during 2020. All gear types (electrofishing, fyke netting, hoop nets and minnow fyke nets) were aggregated together.*



Recommendations:

Implementing a standardized multiple gear sampling approach created a comparable and comprehensive picture of Asian carp dynamics throughout the entire the Illinois River Waterway allowing for a holistic assessment. Standardization also allowed monitoring projects outside of the MRP to be incorporated, amplifying the robustness of the picture of Asian carp status and detections in the Illinois River Waterway. The leading edge of Asian carp within the Illinois River Waterway does not appear to have encroached closer to the EDBS, with Bighead Carp and Silver Carp remaining in the Dresden Island Pool. No Black Carp were detected during any of this monitoring. The numbers and catch rates of small Asian carp (< 12 inches) were greater than what was found in 2019 indicating 2020 may have been a better reproductive year. We recommend continued sampling below the EDBS using a multiple gear approach that includes electrofishing, fyke netting, hoop netting, and minnow fyke netting following this standardized protocol. Minimally the same level of effort and an assessment of sample size requirement to ensure efficacy of the project should occur. It is also recommended that lapilli otoliths and sex of a subsample of Asian carp be collected within each pool during the fall, in addition to length and weight data. Collecting these additional metrics should increase the inferences that can be drawn from this dataset, supply necessary supplemental data to the SEACarP model, and further assess the impacts of Asian carp removal efforts increasing the ability to aid MRWG objectives. Finally, data collected from projects outside using the same standardized methods of the MRP should continue to be incorporated into this dataset, when allowed and appropriate. Inclusion of these data allow for formulating the most comprehensive picture of Asian carp expanse and response within the Illinois River Waterway.

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Table 1. *Electrofishing, hoop netting, minnow fyke netting, and fyke netting effort with catch summaries for 2020 in pools below the Electric Dispersal Barrier from* ***June 15 – October 31, 2020.***

Electrofishing Effort - 2020	**Lockport Pool**	**Brandon Pool**	**Dresden Pool**	**Marseilles Pool**	**Starved Rock Pool**	**Peoria Pool**	**LaGrange Pool**	**Alton Pool**
Estimated person-hours	82.5	90	142.5	187.5	157.5	217.5	277.5	225
Electrofishing hours	11.25	9	18	23.25	26.25	31.5	30	20.25
Samples (transects)	45	36	72	93	105	126	120	81
All Fish (*N*)	1,158	1,646	6,544	14,683	16,992	15,164	14,742	10,144
Species (*N*)	26	27	50	69	65	65	64	55
Hybrids (*N*)	0	1	6	5	6	6	5	3
Bighead Carp (*N*)	0	0	0	0	0	0	0	0
Bighead Carp < 6 in. (N)	0	0	0	0	0	0	0	0
Silver Carp (*N*)	0	0	0	40	488	320	360	63
Silver Carp < 6 in. (N)	0	0	0	0	0	76	0	0
CPUE (No. fish/hour)	102.9±27.6	182.9±56.1	362.5±30.9	654.4±99.6	667.6±66.4	481.4±52.5	491.4±52.5	499.4±73.2
Small Hoop Net Effort- 2020	**Lockport Pool**	**Brandon Pool**	**Dresden Pool**	**Marseilles Pool**	**Starved Rock Pool**	**Peoria Pool**	**LaGrange Pool**	**Alton Pool**
Estimated person-hours	210	210	210	180	180	270	480	300
Net nights	78.29	80.42	81.54	79.60	84.53	83.27	107.18	83.64
Samples (net sets)	42	42	42	42	42	42	54	42
All Fish (N)	802	156	340	355	1,157	482	326	141
Species (N)	13	14	13	10	9	13	14	14
Hybrids (N)	1	1	1	2	0	0	0	0
Bighead Carp (N)	0	0	0	0	0	0	0	2
Bighead Carp < 6 in. (N)	0	0	0	0	0	0	0	0
Silver Carp (N)	0	0	0	0	0	1	0	1
Silver Carp < 6 in. (N)	0	0	0	0	0	0	0	0
CPUE (No. fish/net night)	10.7±3.1	2.0±0.4	4.2±0.9	4.5±1.0	13.8±3.3	5.9±1.7	3.1±0.4	1.7±0.3
Large Hoop Netting Effort - 2020	**Lockport Pool**	**Brandon Pool**	**Dresden Pool**	**Marseilles Pool**	**Starved Rock Pool**	**Peoria Pool**	**LaGrange Pool**	**Alton Pool**
Est. person-hours	210	210	210	180	180	270	480	300
Net nights	77.94	80.01	80.93	79.12	84.12	82.37	107.07	83.41
Samples (net sets)	42	42	42	42	42	42	54	42
All Fish (*N*)	162	321	1,397	917	1,405	707	819	412
Species (*N*)	11	16	18	11	13	18	18	19
Hybrids (*N*)	1	2	2	2	0	1	2	1
Bighead Carp (*N*)	0	0	0	0	0	0	0	1
Bighead Carp < 6 in. (N)	0	0	0	0	0	0	0	0
Silver Carp (*N*)	0	0	0	0	1	8	10	2
Silver Carp < 6 in. (N)	0	0	0	0	0	0	0	0
CPUE (No. fish/net night)	2.1±0.3	4.0±0.6	17.6±2.6	12.2±2.2	16.9±3.7	8.7±1.3	7.7±1.1	5.0±1.1
Fyke Netting Effort - 2020	**Lockport Pool**	**Brandon Pool**	**Dresden Pool**	**Marseilles Pool**	**Starved Rock Pool**	**Peoria Pool**	**LaGrange Pool**	**Alton Pool**
Est. person-hours	0	0	120	120	0	270	600	0
Net nights	0	0	15.13	13.84	0	26.58	36.08	0
Samples (net sets)	0	0	15	15	0	27	36	0
All Fish (*N*)	0	0	1,027	300	0	584	1,828	0
Species (*N*)	0	0	25	16	0	29	37	0
Hybrids (*N*)	0	0	4	2	0	1	3	0
Bighead Carp (*N*)	0	0	0	0	0	1	0	0
Bighead Carp < 6 in. (N)	0	0	0	0	0	0	0	0
Silver Carp (*N*)	0	0	0	0	0	1	0	0
Silver Carp < 6 in. (N)	0	0	0	0	0	0	0	0
CPUE (No. fish/net night)	0	0	68.6±23.6	21.8±4.5	0	22.3±2.9	52.0±10.5	0
Minnow Fyke Netting Effort - 2020	**Lockport Pool**	**Brandon Pool**	**Dresden Pool**	**Marseilles Pool**	**Starved Rock Pool**	**Peoria Pool**	**LaGrange Pool**	**Alton Pool**
Est. person-hours	210	240	540	450	390	390	810	330
Net nights	20.79	20.68	68.09	68.23	68.61	68.08	83.44	42.09
Samples (net sets)	24	24	72	73	72	72	84	42
All Fish (*N*)	3,802	2,790	30,770	22,496	8,372	37,397	44,636	7,347
Species (*N*)	28	28	48	52	49	53	52	44
Hybrids (*N*)	0	0	1	1	0	1	2	1
Bighead Carp (*N*)	0	0	0	0	0	1	0	0
Bighead Carp < 6 in. (N)	0	0	0	0	0	2	0	0
Silver Carp (*N*)	0	0	0	0	1	0	0	0
Silver Carp < 6 in. (N)	0	0	0	0	0	2,100	77	0
CPUE (No. fish/net night)	188.3±0.38.6	147.0±63.4	415.4±190.7	2139.9±9	127.1±26.7	558.7±225.4	542.5±189.0	178.3±36.9

Table 2. *Electrofishing catch summary for 2020 in pools below the Electric Dispersal Barrier.*

Species	Lockport Pool	Brandon Pool	Dresden Pool	Marseilles Pool	Starved Rock Pool	Peoria Pool	LaGrange Pool	Alton Pool	No. Captured	Percent
Age-0 fish (young-of-the-year)	0	0	0	0	0	0	0	5	5	0.01%
American Eel	0	0	0	0	0	0	0	1	1	0.00%
Banded Darter	0	0	0	3	0	0	0	0	3	0.00%
Banded Killifish	144	198	173	283	324	17	0	0	1,139	1.40%
Bigmouth Buffalo	0	0	10	8	68	27	90	52	255	0.31%
Black Buffalo	0	0	1	1	23	2	20	31	78	0.10%
Black Bullhead	2	0	0	0	0	0	0	0	2	0.00%
Black Crappie	0	0	1	14	10	13	82	22	142	0.18%
Black Redhorse	0	0	0	0	1	0	0	0	1	0.00%
Blacknose Shiner	0	0	2	0	1	0	0	0	3	0.00%
Blackside Darter	0	0	0	3	0	4	4	0	11	0.01%
Blackstripe Topminnow	1	3	49	21	72	3	14	0	163	0.20%
Blue Sucker	0	0	0	0	0	0	0	1	1	0.00%
Bluegill	27	50	1,501	1,241	2,700	569	794	317	7,199	8.88%
Bluegill x Orangespotted Sunfish hybrid	0	0	3	0	2	2	1	0	8	0.01%
Bluntnose Minnow	194	93	649	676	412	57	20	5	2,106	2.60%
Bowfin	0	0	0	0	0	0	15	19	34	0.04%
Brook Silverside	1	0	5	32	1	1	277	159	476	0.59%
Bullhead Minnow	2	0	12	562	2,002	422	604	70	3,674	4.53%
Central Mudminnow	2	1	0	0	0	0	0	0	3	0.00%
Channel Catfish	2	5	13	56	103	114	103	97	493	0.61%
Channel Shiner	0	0	0	0	2	18	9	64	93	0.11%
Chestnut Lamprey	0	0	0	0	0	0	1	0	1	0.00%
Common Carp	39	70	200	88	76	356	435	226	1,490	1.84%
Common Carp x Goldfish hybrid	0	0	1	1	1	0	5	14	22	0.03%
Creek Chub	1	0	1	1	0	1	0	0	4	0.00%
Emerald Shiner	65	35	34	1,698	2,204	3,330	3,076	1,053	11,495	14.17%
Fathead Minnow	0	0	0	0	0	0	1	0	1	0.00%
Flathead Catfish	0	0	0	4	13	30	50	47	144	0.18%
Freckled Madtom	0	0	0	0	1	0	1	0	2	0.00%
Freshwater Drum	0	1	7	20	75	233	527	219	1,082	1.33%
Gizzard Shad	486	843	1,690	6,063	3,762	6,370	5,991	6,837	32,042	39.51%
Golden Redhorse	0	0	19	52	29	15	7	0	122	0.15%
Golden Shiner	5	1	25	6	5	6	25	12	85	0.10%
Goldeye	0	0	0	0	0	0	7	12	19	0.02%
Goldfish	24	17	10	1		10	2	8	72	0.09%
Grass Carp	0	0	0	2	16	30	64	25	137	0.17%
Grass Pickerel	0	2	3	8	0	1	0	1	15	0.02%
Green Sunfish	30	64	309	443	228	21	16	19	1,130	1.39%
Green Sunfish x Bluegill hybrid	0	1	13	11	11	3	0	0	39	0.05%
Green Sunfish x Orangespotted Sunfish	0	0	0	0	1	2	0	2	5	0.01%
Green Sunfish x Pumpkinseed hybrid	0	0	1	1	1	0	1	0	4	0.00%
Green Sunfish x Redear hybrid	0	0	0	0	0	1	0	0	1	0.00%
Highfin Carpsucker	0	0	0	1	4	3	0	0	8	0.01%
Hornyhead Chub	0	0	1	0	0	0	0	0	1	0.00%
Johnny Darter	0	0	3	16	0	7	19	4	49	0.06%
Largemouth Bass	21	35	701	486	333	168	187	64	1,995	2.46%
Logperch	0	1	16	70	8	57	23	1	176	0.22%
Longear Sunfish	0	0	1	1	0	0	0	0	2	0.00%
Longnose Gar	0	0	6	13	10	13	53	35	130	0.16%
Mimic Shiner	0	0	0	13	0	0	0	0	13	0.02%
Mississippi Silvery Minnow	0	0	0	0	0	0	0	1	1	0.00%
Mooneye	0	0	0	1	4	0	1	0	6	0.01%
Mud Darter	0	0	0	0	0	8	6	3	17	0.02%
Northern Hogsucker	0	0	0	2	1	1	0	0	4	0.00%
Northern Pike	0	0	0	6	1	3	0	0	10	0.01%
Northern Sunfish	0	0	55	8	2	0	0	0	65	0.08%
Orangespotted Sunfish	3	5	278	46	418	175	112	57	1,094	1.35%
Oriental Weatherfish	12	0	0	0	0	1	0	0	13	0.02%
Pallid Shiner	0	0	0	3	0	0	0	0	3	0.00%

Table 2. *Continued*

Species	Lockport Pool	Brandon Pool	Dresden Pool	Marseilles Pool	Starved Rock Pool	Peoria Pool	LaGrange Pool	Alton Pool	No. Captured	Percent
Pugnose Minnow	0	0	0	0	0	0	35	0	35	0.04%
Pugnose Shiner	0	0	0	0	0	0	35	0	35	0.04%
Pumpkinseed	61	44	179	5	3	6	0	0	298	0.37%
Pumpkinseed x Bluegill hybrid	0	0	25	3	0	1	1	0	30	0.04%
Pumpkinseed x Orangespotted Sunfish	0	0	1	0	0	0	0	0	1	0.00%
Quillback	0	0	0	35	3	4	7	1	50	0.06%
Rainbow Darter	0	0	0	3	0	0	0	0	3	0.00%
Red Shiner	0	0	0	0	1	8	163	21	193	0.24%
Redear Sunfish	0	0	4	9	9	3	5	5	35	0.04%
Redfin Shiner	0	0	0	0	1	0	0	0	1	0.00%
River Carpsucker	0	0	8	31	327	20	53	25	464	0.57%
River Shiner	0	0	0	95	136	61	126	18	436	0.54%
Rock Bass	0	19	15	1	1	0	0	0	36	0.04%
Round Goby	8	12	12	11	2	0	0	0	45	0.06%
Sand Shiner	0	1	17	390	210	40	13	4	675	0.83%
Sauger	0	2	3	9	23	77	63	24	201	0.25%
Sauger x Walleye hybrid	0	0	0	0	1	2	0	0	3	0.00%
Shorthead Redhorse	0	0	1	15	27	8	28	20	99	0.12%
Shortnose Gar	0	0	0	0	11	33	36	91	171	0.21%
Silver Carp	0	0	0	40	488	396	360	63	1,347	1.66%
Silver Chub	0	0	0	0	2	18	3	0	23	0.03%
Silver Redhorse	0	0	0	3	6	0	0	0	9	0.01%
Silverband Shiner	0	0	0	85	29	71	40	7	232	0.29%
Skipjack Herring	0	0	0	0	4	16	29	12	61	0.08%
Slenderhead Darter	0	0	0	2	3	4	2	0	11	0.01%
Smallmouth Bass	0	108	198	168	250	37	11	0	772	0.95%
Smallmouth Buffalo	0	0	152	154	490	171	229	126	1,322	1.63%
Speckled Chub	0	0	0	0	4	0	0	1	5	0.01%
Spotfin Shiner	0	0	10	1,277	1,673	240	45	7	3,252	4.01%
Spottail Shiner	1	3	46	180	75	940	240	1	1,486	1.83%
Spotted Bass	0	0	0	0	0	0	0	1	1	0.00%
Spotted Gar	0	0	0	1	0	0	4	2	7	0.01%
Spotted Sucker	0	0	0	0	1	0	0	0	1	0.00%
Stonecat	0	0	0	0	0	0	1	0	1	0.00%
Striped Bass x White Bass hybrid	0	0	0	2	0	0	0	5	7	0.01%
Striped Shiner	0	0	0	3	0	0	0	0	3	0.00%
Suckermouth Minnow	0	0	2	9	1	8	4	2	26	0.03%
Sunfish hybrid	0	0	6	4	0	1	0	0	11	0.01%
Tadpole Madtom	0	0	1	1	6	3	6	0	17	0.02%
Threadfin Shad	9	10	30	15	45	4	0	12	125	0.15%
Unidentified	0	0	0	0	0	4	4	0	8	0.01%
Unidentified Buffalo	0	0	0	1	0	0	0	0	1	0.00%
Unidentified Carpsucker	0	0	0	24	0	0	0	0	24	0.03%
Unidentified Esocidae (pikes)	0	0	0	1	0	0	0	0	1	0.00%
Unidentified minnows	0	0	1	82	105	45	25	4	262	0.32%
Unidentified suckers	0	0	0	28	89	548	20	11	696	0.86%
Unidentified sunfishes	0	0	2		9	4	4	1	20	0.02%
Walleye	0	0	0	3	1	1	1	0	6	0.01%
Warmouth	2	0	8	1	0	2	14	7	34	0.04%
Western Mosquitofish	5	0	0	1	0	46	61	19	132	0.16%
White Bass	0	0	1	14	20	204	301	164	704	0.87%
White Crappie	0	0	3	10	5	13	68	6	105	0.13%
White Perch	0	0	0	0	2	11	1	0	14	0.02%
White Perch x Yellow Bass hybrid	0	0	0	0	0	0	1	0	1	0.00%
White Sucker	0	5	2	0	0	0	0	0	7	0.01%
Yellow Bass	0	0	0	1	4	18	95	1	119	0.15%
Yellow Bullhead	11	17	24	1	0	2	0	0	55	0.07%
Total Captured	1,158	1,646	6,544	14,683	16,992	15,164	14,777	10,144	81,108	--
No. Species	26	27	50	69	65	65	64	55	97	--
No. Hybrid Groups	0	1	6	5	6	6	5	3	11	--

Table 3. *Hoop netting catch summary for 2020 in pools below the Electric Dispersal Barrier.*

Species	Lockport Pool	Brandon Pool	Dresden Pool	Marseilles Pool	Starved Rock Pool	Peoria Pool	LaGrange Pool	Alton Pool	No. Captured	Percent
American Eel	0	0	0	0	0	0	0	1	1	0.01%
Bighead Carp	0	0	0	0	0	0	0	3	3	0.03%
Bigmouth Buffalo	0	0	0	0	1	4	1	3	9	0.09%
Black Buffalo	0	1	6	21	8	2	11	13	62	0.63%
Black Bullhead	0	1	0	0	0	0	0	1	2	0.02%
Black Crappie	1	4	17	8		1	9	9	49	0.49%
Blue Catfish	0	0	0	0	0	0	0	5	5	0.05%
Bluegill	64	47	251	39	12	38	45	11	507	5.12%
Brown Bullhead	4	1	0	0	0	0	0	0	5	0.05%
Bullhead spp.	0	2	0	0	0	0	0	0	2	0.02%
Channel Catfish	229	126	560	699	1,926	587	353	51	4,531	45.77%
Common Carp	20	61	156	23	93	172	249	204	978	9.88%
Common Carp x Goldfish hybrid	2	23	2	1	0	1	1	4	34	0.34%
Flathead Catfish	0	1	4	11	12	30	41	70	169	1.71%
Freshwater Drum	0	0	0	9	3	21	39	66	138	1.39%
Gizzard Shad	0	0	0	0	0	1	0	2	3	0.03%
Golden Redhorse	0	0	7	1	0	0	0	0	8	0.08%
Goldfish	5	8	0	0	0	0	0	0	13	0.13%
Grass Carp	0	0	0	0	8	3	15	7	33	0.33%
Green Sunfish	7	4	0	0	0	0	0	0	11	0.11%
Green Sunfish x Bluegill hybrid	0	0	0	2	0	0	0	0	2	0.02%
Largemouth Bass	1	1	7	2	0	1	0	0	12	0.12%
Longnose Gar	0	0	4	0	0		0	0	4	0.04%
No fish caught	0	0	0	0	0	0	0	0	0	0.00%
Northern Pike	1	0	1	0	0	0	0	0	2	0.02%
Northern Sunfish	0	0	2	0	0	0	0	0	2	0.02%
Orangespotted Sunfish	0	0		2	0	0	0	0	2	0.02%
Pumpkinseed	99	51	105	0	0	0	0	0	255	2.58%
Pumpkinseed x Bluegill hybrid	0	0	1	1	0	0	0	0	2	0.02%
Quillback	0	0	1	0	0	0	0	0	1	0.01%
River Carpsucker	0	0	14	5	37	10	11	5	82	0.83%
Rock Bass	0	27	1	0	0	0	0	0	28	0.28%
Rusty Crayfish	1	0	0	0	0	0	0	0	1	0.01%
Sauger	0	6	0	0	0	3	2	0	11	0.11%
Sauger x Walleye hybrid	0	1	0	0	0	0	0	0	1	0.01%
Shorthead Redhorse	0	0	0	1		2	5	2	10	0.10%
Shortnose Gar	0	0	0	0	1	1	5	3	10	0.10%
Silver Carp	0	0	0	0	1	9	10	3	23	0.23%
Silver Redhorse	0	0	5	0	0	0	0	0	5	0.05%
Smallmouth Bass	0	3	1	1	4	0	0	0	9	0.09%
Smallmouth Buffalo	0	0	581	446	454	250	285	77	2,093	21.14%
Striped Bass x White Bass hybrid	0	0	0	0	0	0	2	0	2	0.02%
Sunfish hybrid	2	2	8	0	0	0	0	0	12	0.12%
Unidentified sunfishes	0	0	2	0	0	0	0	0	2	0.02%
Warmouth	0	2	0	0	0	0	0	0	2	0.02%
White Bass	1	0	1	0	2	48	28	7	87	0.88%
White Crappie	0	0	0	0	0	2	25	6	33	0.33%
White Perch	2	1	0	0	0	0	0	0	3	0.03%
White Sucker	1	22	0	0	0	0	0	0	23	0.23%
Yellow Bass	1	0	0	0	0	3	7	0	11	0.11%
Yellow Bullhead	523	82	0	0	0	0	1	0	606	6.12%
Total Captured	964	477	1,737	1,272	2,562	1,189	1,145	553	9,899	--
No. Species	17	20	20	14	14	20	19	21	43	--
No. Hybrid Groups	1	2	2	3	0	1	2	1	5	--

Table 4. *Minnow fyke netting catch summary for 2020 in pools below the Electric Dispersal Barrie*r

Species	Lockport Pool	Brandon Pool	Dresden Pool	Marseilles Pool	Starved Rock Pool	Peoria Pool	LaGrange Pool	Alton Pool	No. Captured	Percent
Alewife	1	0	0	0	0	0	0	0	1	0.00%
Banded Darter	0	0	0	0	0	0	0	0	1	0.00%
Banded Killifish	393	1,367	362	154	24	3	0	0	2,303	1.46%
Bighead Carp	0	0	0	0	0	2	0	0	2	0.00%
Black Bullhead	2	0	3,308	1	0	0	1	4	3,316	2.10%
Black Crappie	1	2	21	229	11	41	97	41	443	0.28%
Blacknose Shiner	0	0	0	0	1	0	0	0	1	0.00%
Blackside Darter	0	0	1	0	0	11	0	0	12	0.01%
Blackstripe Topminnow	2	23	52	106	69	47	115	10	424	0.27%
Bluegill	992	329	15,892	16,832	576	133	1,049	1,139	36,942	23.36%
Bluegill x Orangespotted Sunfish hybrid	0	0	0	0	0	1	1	1	3	0.00%
Bluegill x Redear Sunfish hybrid	0	0	0	0	0	0	1	0	1	0.00%
Bluntnose Darter	0	0	0	19	0	0	0	0	19	0.01%
Bluntnose Minnow	1,079	645	3,675	1,213	388	34	24	6	7,064	4.47%
Bowfin	0	0	3	0	1	5	3	4	16	0.01%
Brook Silverside	0	0	1	5	2	1	249	83	341	0.22%
Brook Stickleback	0	0	2	0	0	0	0	0	2	0.00%
Brown Bullhead	0	0	1	0	0	0	0	0	1	0.00%
Bullhead Minnow	25	2	33	622	1,102	409	527	246	2,966	1.88%
Central Mudminnow	2	0	1	9	0	0	0	0	12	0.01%
Central Stoneroller	0	0	0	0	0	1	0	0	1	0.00%
Channel Catfish	2	0	2	9	17	16	13	24	83	0.05%
Channel Shiner	0	0	0	0	0	8	13	0	21	0.01%
Common Carp	21	1	876	3	1	24	11	1	938	0.59%
Common Carp x Goldfish hybrid	0	0	7	0	0	0	0	0	7	0.00%
Creek Chub	0	0	0	2	0	1	0	0	3	0.00%
Emerald Shiner	5	1	4,578	56	752	5,004	9,982	2,139	22,517	14.24%
Fathead Minnow	2	14	3	0	0	0	1	0	20	0.01%
Flathead Catfish	0	0	0	0	11	0	5	4	20	0.01%
Freckled Madtom	0	0	0	0	0	0	0	1	1	0.00%
Freshwater Drum	0	0	2	35	6	90	927	66	1,126	0.71%
Gizzard Shad	14	1	371	123	200	22,556	27,237	863	51,365	32.48%
Golden Shiner	0	0	18	5	2	125	100	63	313	0.20%
Goldfish	10	1	360	0	0	1	0	0	372	0.24%
Grass Carp	0	0	0	0	0	1	1	0	2	0.00%
Grass Pickerel	0	0	0	1	0	0	0	0	1	0.00%
Green Sunfish	151	145	238	167	16	1	10	6	734	0.46%
Green Sunfish x Bluegill hybrid	0	0	0	2	0	0	0	0	2	0.00%
Johnny Darter	0	0	0	20	2	77	44	12	155	0.10%
Largemouth Bass	1	3	139	37	10	15	29	3	237	0.15%
Logperch	0	0	0	28	2	165	51	8	254	0.16%
Longnose Gar	0	0	34	3	10	9	23	4	83	0.05%
Mimic Shiner	0	0	0	0	1	8	0	4	18	0.01%
Mud Darter	0	0	0	0	0	78	119	0	197	0.12%
Northern Pike	0	1	0	0	0	1	0	0	2	0.00%
Northern Sunfish	0	0	1	1	0	0	0	0	2	0.00%
Orangespotted Sunfish	2	61	24	46	58	34	106	5	336	0.21%
Oriental Weatherfish	53	10	7	0	0	0	0	0	70	0.04%
Pallid Shiner	0	0	0	8	2	0	0	0	10	0.01%
Pirate Perch	0	0	0	0	0	0	0	1	1	0.00%
Pugnose Minnow	0	0	0	0	2	0	529	24	555	0.35%
Pugnose Shiner	0	0	0	0	2	0	529	24	555	0.35%
Pumpkinseed	400	41	317	7	0	0	0	0	765	0.48%
Red Shiner	0	0	0	2	0	16	102	10	130	0.08%
River Carpsucker	0	0	1	2	1	2	0	0	6	0.00%
River Shiner	0	1	2	24	6	99	96	90	318	0.20%
Rock Bass	0	13	23	3	0	0	0	0	39	0.02%
Round Goby	149	96	101	27	2	7	2	0	384	0.24%

Table 4. *Continued*

Species	Lockport Pool	Brandon Pool	Dresden Pool	Marseilles Pool	Starved Rock Pool	Peoria Pool	LaGrange Pool	Alton Pool	No. Captured	Percent
Sand Shiner	1	0	3	74	173	17	16	14	298	0.19%
Sauger	0	0	0	0	3	1	7	0	11	0.01%
Shorthead Redhorse	0	0	0	0	3	0	2	0	5	0.00%
Shortnose Gar	0	0	1	2	27	40	56	18	144	0.09%
Silver Carp	0	0	0	0	1	2,100	77	0	2,178	1.38%
Silver Chub	0	0	0	0	3	35	11	9	58	0.04%
Silver Redhorse	0	0	1	0	0	0	0	0	1	0.00%
Silverband Shiner	0	0	0	0	34	103	274	786	1,197	0.76%
Skipjack Herring	0	0	0	0	3	0	30	3	36	0.02%
Slenderhead Darter	0	0	0	3	0	23	3	3	32	0.02%
Smallmouth Bass	0	2	5	24	4	9	0	0	44	0.03%
Smallmouth Buffalo	0	0	0	0	2	0	1	0	3	0.00%
Spotfin Shiner	14	1	51	2,199	1,575	833	1	7	4,681	2.96%
Spottail Shiner	0	1	39	101	37	1,009	323	55	1,565	0.99%
Spotted Gar	0	0	1	0	1	3	3	2	10	0.01%
Striped Shiner	0	0	0	3	0	0	0	0	3	0.00%
Suckermouth Minnow	0	0	1	2	0	2	0	1	6	0.00%
Sunfish hybrid	9	4	10	5	0	0	0	0	28	0.02%
Tadpole Madtom	4	0	22	1	3	3	11	2	46	0.03%
Threadfin Shad	0	0	1	7	3		2	0	13	0.01%
Trout Perch	0	0	0	1	1	1	0	0	3	0.00%
Unidentified	0	0	0	0	0	0	541	0	541	0.34%
Unidentified buffalo	0	0	0	65	0	0	0	0	65	0.04%
Unidentified catfishes	0	0	1	0	0	0	0	0	1	0.00%
Unidentified minnows	2	0	9	127	1,178	1,724	78	64	3,182	2.01%
Unidentified perches	0	0	0	0	0	1	18	0	19	0.01%
Unidentified shads	0	0	0	0	0	0	4	0	4	0.00%
Unidentified suckers	0	0	0	0	6	694	172	29	901	0.57%
Unidentified sunfishes	0	0	33	0	1,974	232	136	1,297	3,672	2.32%
Walleye	0	0	1	0	1	0	0	0	2	0.00%
Warmouth	3	1	2	3	0	0	4	2	15	0.01%
Western Mosquitofish	6	1	99	8	7	148	256	57	582	0.37%
White Bass	0	0	0	2	40	1,364	1,030	93	2,529	1.60%
White Crappie	0	0	0	57	18	18	74	41	208	0.13%
White Perch	0	0	0	1	0	0	8	0	9	0.01%
White Sucker	0	4	0	1	0	0	0	0	5	0.00%
Yellow Bass	0	0	0	4	0	10	28	2	44	0.03%
Yellow Bullhead	456	19	33	0	0	1	2	0	511	0.32%
Total Captured	3,802	2,790	30,770	22,496	8,374	37,397	45,165	7,371	158,165	--
No. Species	28	28	48	52	49	53	52	44	83	--
No. Hybrid Groups	0	0	1	1	0	1	2	1	4	--

Table 5. *Fyke netting catch summary for 2020 in pools below the Electric Dispersal Barrier.*

Species	Lockport Pool	Brandon Pool	Dresden Pool	Marseilles Pool	Starved Rock Pool	Peoria Pool	LaGrange Pool	Alton Pool	No. Captured	Percent
Bighead Carp	0	0	0	0	0	1	0	0	1	0.03%
Bigmouth Buffalo	0	0	0	0	0	1	7	0	8	0.21%
Black Buffalo	0	0	1	0	0	0	2	0	3	0.08%
Black Bullhead	0	0	4	0	0	0	0	0	4	0.11%
Black Crappie	0	0	48	75	0	87	513	0	723	19.34%
Bluegill	0	0	629	125	0	209	309	0	1,272	34.02%
Bluegill x Warmouth hybrid	0	0	1	1	0	0	0	0	2	0.05%
Bowfin	0	0	0	0	0	4	25	0	29	0.78%
Brown Bullhead	0	0	0	0	0	0	4	0	4	0.11%
Channel Catfish	0	0	24	8	0	7	5	0	44	1.18%
Common Carp	0	0	7	2	0	20	38	0	67	1.79%
Flathead Catfish	0	0	0	1	0	3	8	0	12	0.32%
Freshwater Drum	0	0	1	4	0	16	51	0	72	1.93%
Gizzard Shad	0	0	10	2	0	12	18	0	42	1.12%
Golden Redhorse	0	0	0	0	0	2	0	0	2	0.05%
Golden Shiner	0	0	4	0	0	0	0	0	4	0.11%
Grass Carp	0	0	0	0	0	0	2	0	2	0.05%
Green Sunfish	0	0	2	0	0	4	1	0	7	0.19%
Green Sunfish x Bluegill hybrid	0	0	6	1	0	2	1	0	10	0.27%
Green Sunfish x Pumpkinseed hybrid	0	0	2	0	0	0	0	0	2	0.05%
Highfin Carpsucker	0	0	0	0	0	0	1	0	1	0.03%
Largemouth Bass	0	0	4	17	0	9	21	0	51	1.36%
Longnose Gar	0	0	10	0	0	1	27	0	38	1.02%
Northern Hogsucker	0	0	0	0	0	0	1	0	1	0.03%
Northern Pike	0	0	2	0	0	12	1	0	15	0.40%
Northern Sunfish	0	0	1	0	0	0	0	0	1	0.03%
Orangespotted Sunfish	0	0	0	0	0	10	3	0	13	0.35%
Pumpkinseed	0	0	166	0	0	0	1	0	167	4.47%
Pumpkinseed x Bluegill hybrid	0	0	2	0	0	0	1	0	3	0.08%
Quillback	0	0	0	0	0	1	2	0	3	0.08%
Redear Sunfish	0	0	68	0	0	15	5	0	88	2.35%
River Carpsucker	0	0	2	2	0	1	11	0	16	0.43%
Rock Bass	0	0	3	0	0	0	0	0	3	0.08%
Sauger	0	0	0	0	0	11	13	0	24	0.64%
Shorthead Redhorse	0	0	3	1	0	1	13	0	18	0.48%
Shortnose Gar	0	0	0	2	0	37	106	0	145	3.88%
Silver Carp	0	0	0	0	0	1	0	0	1	0.03%
Smallmouth Bass	0	0	1	0	0	0	0	0	1	0.03%
Smallmouth Buffalo	0	0	0	2	0	1	39	0	42	1.12%
Spotted Gar	0	0	0	0	0	0	4	0	4	0.11%
Tadpole Madtom	0	0	0	0	0	0	1	0	1	0.03%
Threadfin Shad	0	0	1	4	0	0	1	0	6	0.16%
Unidentified suckers	0	0	0	1	0	8	0	0	9	0.24%
Walleye	0	0	0	0	0	1	2	0	3	0.08%
Warmouth	0	0	2	0	0	0	2	0	4	0.11%
White Bass	0	0	0	6	0	56	306	0	368	9.84%
White Crappie	0	0	6	34	0	38	177	0	255	6.82%
White Perch	0	0	1	0	0	1	1	0	3	0.08%
White Perch x Yellow Bass hybrid	0	0	0	0	0	0	1	0	1	0.03%
Yellow Bass	0	0	0	12	0	12	103	0	127	3.40%
Yellow Bullhead	0	0	16	0	0	0	1	0	17	0.45%
Total Captured	0	0	1,027	300	0	584	1,828	0	3,739	--
No. Species	0	0	25	16	0	29	37	0	45	--
No. Hybrid Groups	0	0	4	2	0	1	3	0	5	--

USGS Illinois River Monitoring and Evaluation

Travis Harrison, Kevin Hop, Enrika Hlavacek, and Brent Knights (U.S. Geological Survey, Upper Midwest Environmental Sciences Center)

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

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

Introduction and Need:

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

Objectives:

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

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

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

(3) Validate benthic classification system developed using high-resolution hydroacoustic data from priority removal areas of the Illinios River to integrate environmental variables

with decision support tools (objective 4) to further understanding of bigheaded carp life history and other factors that might influence the efficacy and efficiency of removal or control management approaches.

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

Project Highlights:

ILRCdb application and associated visualization and analytical tool updates include: (1) continued maintenance of the ILRCdb application, with new data uploads and the addition of customized reporting features; (2) post-processed visualizations of boat activity, gear deployments, telemetered fish movement, and catch locations during Unified Method fishing events; (3) completed benthic classification data layers for priority removal areas of the Illinois River; and (4) initial development of an online, centralized platform for existing invasive carp-related data layers to support adaptive management objectives and informed removal efforts.

Methods:

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

Tracking data from boats, gear deployments, and catch locations during Unified Method fishing events have been collected and post-processed into animated visualizations in a GIS environment. These visualizations, created in Esri ArcScene and ArcGIS Pro, show the movement of boats and gear deployments in relation to telemetered fish movement and catch events to assess efficiencies of removal. Identifying areas and times of effective boat and net coordination can be used to maximize efficiencies in future implementations of the Unified Method for mass removal.

Hydroacoustic and sonar data, collected from priority removal areas in the Illinois River using high-resolution sonar equipment, have been processed into benthic classification layers that characterize riverine habitats using GIS and object-based image analysis software. These benthic classifications (e.g., landform and substrate classification) have been validated using additional ground-sampling data layers. These data layers will be incorporated as web mapping services into analyzes and decision support tools aimed at furthering the understanding of invasive carp life history, behavior, and distribution.

An online platform for invasive carp-related data, informational products, and decision support tools is being developed to provide a portal for researchers and managers to access these data and tools. Tools within the platform include programmatic (e.g., API) access to directly query data from database applications, web mapping services and web maps for interactive visualization of invasive carp-related data layers (without the need for desktop GIS software), and tools to geographically query areas with similar conditions to user-defined locations or specific catch/removal locations. Incorporated data and tools aim to inform targeted removal efforts or deterrent deployments based on an integrated analysis of datasets collected by the multi-agency partnership.

Results and Discussion:

Invasive carp monitoring and removal data from the Illinois River continues to be collected by partner agencies and included in the ILRCdb application. Data collection protocols similar to the sampling approach used by the Long Term Resource Monitoring (LTRM) element of the Upper Mississippi River Restoration Program and the FISH app continue to be used. Data quality control checks are integrated with the ILRCdb during the data upload process to minimize potential data errors. Database application updates, new version releases, and additional customized data summary features are implemented as needed.

Post-processed tracking and activity data from boats and gear deployments into animated visualization overviews of Unified Method fishing events has been completed for several Dresden Island Unified Method events. In the future, adapting the methodology to track and manage boats and gear in near-real time while in the field would provide further benefit to managers coordinating implementations of the Unified Method.

Validation of hydroacoustic survey data (e.g., multi-beam and sidescan sonar), collected in priority management areas throughout the Illinois River and processed into a suite of benthic data layers, has been completed. These benthic habitat classification layers (i.e., geomorphology), derived from bathymetric measures such as slope, roughness, and terrain ruggedness, are available in a GIS-ready format and as web mapping services. These benthic data layers can be incorporated into analyses or online tools to support adaptive management and informed removal strategies. By providing a detailed, underwater view of the riverine environment, these data layers can be used during the planning, design, and installation of control and containment technologies (e.g., deterrent systems, Unified Method fishing events) in strategic locations. These datasets, along with other invasive carp-related datasets, are complete and publicly available but exist in disparate digital data repositories and oftentimes require specialized software to visualize and use. Integrating these datasets into an online, easy-to-use data hub will allow for greater discovery and usability by the multi-agency partnership.

The development of an online platform for invasive carp-related data, informational products, and decision support tools will provide ease of access to and use of these data and tools. Web mapping services and applications provide for user-friendly visualization and interaction with invasive carp-related data layers (without the need for desktop GIS software) and can be expanded to include analytical functionality. Incorporating data, tools, and analyses can inform targeted removal efforts or deterrent deployments in strategic locations. Integrating benthic habitat classification data layers, habitat suitability layers, environmental condition variables, and invasive carp-related monitoring and removal data allows for users to spatially search for areas with underlying conditions similar to areas of large bigheaded carp catch events (or known areas with dense bigheaded carp populations), allowing for targeted removal efforts to continue throughout the Illinois River. In addition to an online platform, programmatic access to applications such as the FishTracks Telemetry Database and ILRCdb allows researchers to directly query data and integrate them into analyses.

MANAGEMENT AND CONTROL PROJECTS

Contracted Commercial Fishing Below the Electric Dispersal Barrier

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Participating Agencies: Illinois Department of Natural Resources (IDNR), Illinois Natural History Survey (INHS)

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

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

Introduction and Need:

Contracted Commercial Fishing Below the EDBS uses contracted commercial fishers to reduce Asian carp (Bighead Carp, Black Carp, Grass Carp and Silver Carp) abundance and monitor for changes in range in the Des Plaines River and upper Illinois River, downstream of the EDBS. By decreasing Asian carp abundance, we anticipate reduced migration pressure towards the barrier, lessening the chances of Asian Carp gaining access to upstream waters in the Chicago Area Waterway System (CAWS) and Lake Michigan. Monitoring for upstream expansion of Asian carp should help identify changes in the leading edge, distribution, and relative abundance of Asian carp in the Illinois Waterway (IWW). The "leading edge" is defined as the furthest upstream location where multiple Bighead Carp or Silver Carp have been captured in conventional sampling gears during a single trip or where individuals of either species have been caught in repeated sampling trips to a specific site. Trends in catch data over time may also contribute to the understanding of Asian carp population abundance and movement between and among pools of the IWW.

Objectives:

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

(2) Reduce Asian carp densities, lessening migration pressure to the EDBS, thus decreasing chances of Asian carp accessing upstream reaches (e.g., CAWS and Lake Michigan).

(3) Inform other projects (e.g., hydroacoustic verification and calibration, Spatially Explicit Asian Carp Population [SEACarP] model, small fish monitoring, telemetry master plan)

with Asian carp population distribution, dynamics, and movement in the IWW downstream of the EDBS.

Project Highlights:

- Since 2010, contracted commercial fishers effort in the upper IWW below the dispersal barrier includes 4,317 miles (6,947km) of gill/trammel net, 20 miles (31 km) of commercial seine, 245 Great Lakes pound net nights, and 4,369 hoop net nights.
- In total, 101,579 Bighead Carp, 1,157,698 Silver Carp, and 10,461 Grass Carp were removed by contracted fishers from 2010-2020. The total estimated weight of Asian carp removed is 5147.5 tons (10,295,000 lbs.).
- No Asian carp have been collected in Lockport or Brandon Road Pools since the inception of this project in 2010.
- The leading edge of the Asian carp population remains near Rock Run Rookery in Dresden Island Pool (~river mile 281; 46 miles from Lake Michigan). No appreciable change has been found in the leading edge over the past 10 years.
- Since 2010, this program has been successful at managing the Asian carp population in the upper Illinois River. Continued implementation of this project will provide the most current data on Asian carp populations at their leading edge and reduce pressure on the EDBS.

Methods:

Contracted commercial netting occurred from February through December in Lockport, Brandon Road, Dresden Island, Marseilles, and Starved Rock pools of the IWW. The section of the Kankakee River from the Des Plaines Fish and Wildlife Area boat launch downstream to the confluence with the Des Plaines River was included in the Dresden Island Pool (Figure 1). These areas are closed to commercial fishing by Illinois Administrative Rule (*i.e. Part 830: Commercial Fishing and Musseling in Certain Waters of the State, Section 830.10(b): Waters Open to Commercial Harvest of Fish)*; therefore, an agency biologist is required to accompany contracted commercial fishing crews working in this portion of the river. Contracted commercial fishers with assisting agency biologists typically fished four days a week during each week of the field season except for two weeks in both June and September sampling occurred upstream of the EDBS for the Seasonal Intensive Monitoring project. Harvest operations were put on hold in early March because of the Covid-19 Pandemic, safety protocols were developed to continue essential work, and operations resumed in May.

Contract fishing occurred at targeted sites throughout each pool monthly. Four fixed sites each in Lockport, Brandon Road, Dresden Island, and Marseilles pools were also sampled monthly (Figure 1). These data were merged to gain a comprehensive understanding of Asian carp spatial and temporal abundance below the EDBS, especially at their upper-most extent in the Dresden Island pool. However, because Asian carp abundance and fishing locations are heterogeneous spatially within pools, areas of special interest to Monitoring and Response Work Group (MRWG) (Rock Run Rockery and Dresden Island above I-55) were analyzed individually. This will make pertinent results more easily interpreted allowing better relative abundance inferences to be drawn in areas of highest concern (e.g. Dresden Main Channel Above I-55).

Large mesh (2.5 - 5.0 inch; 63.5 mm-127 mm) gill and trammel nets set in 100 to 1,200 yard segments were used and fish herding techniques (e.g., pounding on boat hulls, hitting the water surface with plungers, driving with motors trimmed up) were utilized to drive fish into the net (Butler et al. 2018). Nets were typically set for 20-30 minutes but overnight net sets occasionally occurred in off-channel habitat and in non-public backwaters with no boat traffic. Entangled fish were removed from the net, identified, enumerated, and recorded. All Asian carp and Common Carp were checked for telemetry tags and all non-tagged Asian carp were harvested and utilized by private industry for purposes other than human consumption (e.g., chum bait, converted to liquid fertilizer, pet treats, food for injured animals, etc.). All tagged Asian carp and all non-Asian carp by-catch were released into the water alive. A representative sample of up to 30 individuals of each Asian carp species (Bighead Carp, Grass Carp, and Silver Carp) from each pool were measured for total length (mm), weighed (g), and sexed (male or female) 1-2 times a week to provide estimates of total weight harvested, and gather morphometric data on harvested Asian carp over time.

Unified Fishing Methods (UFM) were implemented in Dresden Island Pool, and the East and West Pits of Hanson Material Services in Marseilles Pool lasting approximately a week each. Gill and trammel nets were set, and fishers used systematic herding techniques in unison to drive fish into nets. Block nets were used to partition the East and West Pits and the sections were cleared of Asian carp. Great Lakes pound nets were set to block fish from movement out of areas and commercial seines were pulled to remove mass amounts of Asian carp.

Contracted Commercial Fishing Below the Electric Dispersal Barrier

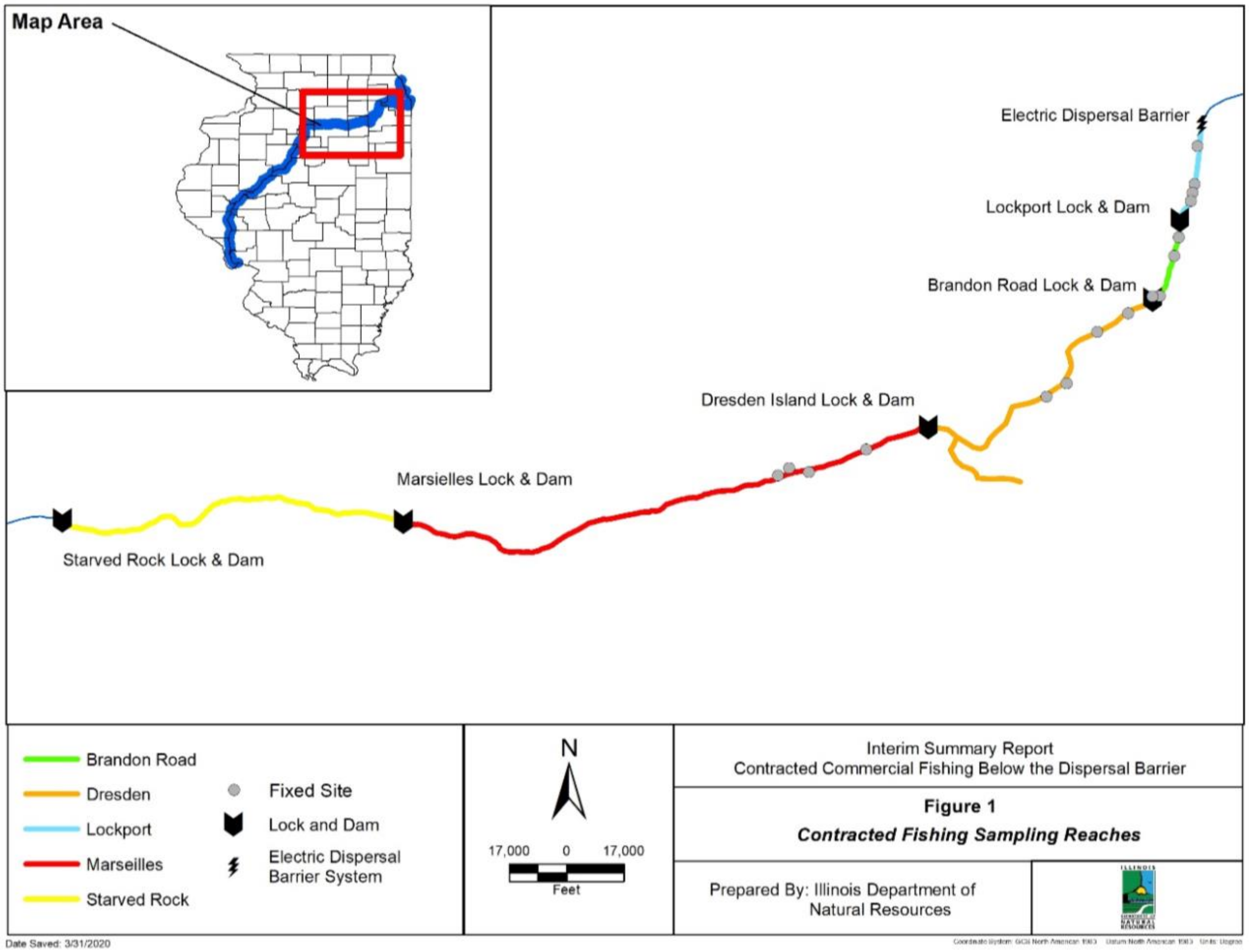

Figure 1. *Contracted commercial fishing sampling area and locations of fixed sites sampling of the contract fishing below the electric dispersal barrier project.*

Results and Discussion:

An estimated 12,667 person-hours were expended harvesting Asian carp via contracted fishing in 2020, a slight decrease from the estimated 13,782 hours expended in 2019. Contract fishing operations were stopped from early March through early May, resulting in the decrease in person-hours. A total of 4,283 miles (6,983 km) of gill/trammel net, 19 miles (31 km) of commercial seine, 239 Great Lakes pound net nights and 4,369 hoop net nights have been deployed in the upper Illinois Waterway since 2010 (Table 1). The total estimated weight of Asian carp caught and removed from 2010-2020 was 10,295,000 pounds (1,269,701 individuals: Table 1). Silver Carp, Bighead Carp, and Grass Carp accounted for 81.1% (1,160,280 individuals), 16.3% (101,617 individuals), and 1.1% (10,517 individuals) of the total tons harvested since 2010, respectively (Table 1). Silver Carp remain the most abundant Asian carp species in the Upper Illinois River, in contrast to 2010 when Bighead Carp comprised approximately 80% of total Asian carp catch.

The mean 2020 gill/trammel net catch per unit effort (CPUE; number of fish/1,000 yards of net) in Starved Rock and Marseilles Pools combined was 319.1, a slight decrease from 377.7 in 2019 (Figure 2). In Dresden Island Pool (leading edge) total Asian carp CPUE was 1.5 in 2020, also a decrease from 2.0 in 2019, and drastically lower than a record high CPUE of 7.3 in 2018. For details regarding gill/trammel CPUE of Asian carp for all pools combined from other years, see those years' respective Interim Summary Reports (MRRP 2012-2018).

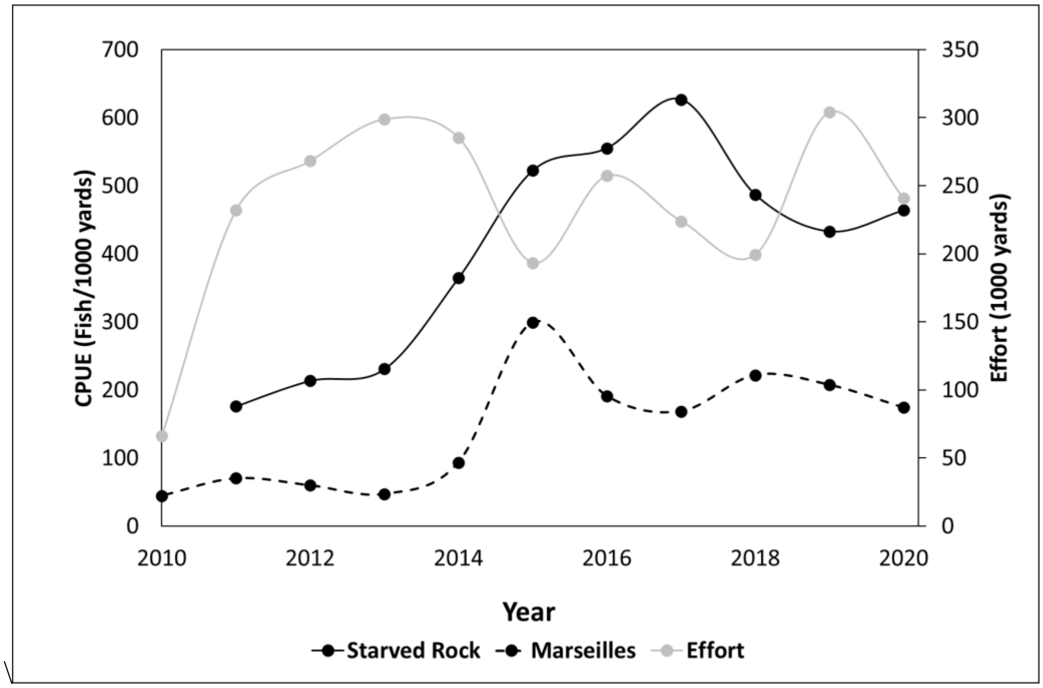

Figure 2. *Annual mean catch per unit effort (CPUE; number of fish per 1,000 yards of gill/trammel net) of Asian carp for Starved Rock (2011-2020; solid black line) and Marseilles (2010-2020; dashed black line), including effort (2010-2020; light grey line).*

Effort and Catch of Asian Carp within Pools

Lockport Pool:

In 2020, Asian carp detection efforts included 47,800 yards (43.7 km) of gill/trammel net set. No Asian carp were observed or captured in Lockport pool.

Brandon Road Pool:

In 2020, Asian carp detection efforts included 52,000 yards (47.5 km) of gill/trammel net set. No Asian carp were observed or captured in Brandon Road pool.

Contracted Commercial Fishing Below the Electric Dispersal Barrier

Dresden Island Pool:

Asian carp abundance is relatively low in Dresden Island Pool compared to downstream pools, and monitoring is essential because the leading edge of the Silver and Bighead Carp population occurs here. In 2020, 0.1% of the total harvested Asian carp came from Dresden Island Pool. Contracted commercial fishing efforts included 688,250 yards (629.33 km) of gill/trammel net. A total of 140 Silver Carp, 22 Bighead Carp, and 3 Grass Carp were harvested from the Dresden Island Pool (including Rock Run Rookery, lower Kankakee River and the Dresden Nuclear Power Station warm water discharge; Figure 3), amounting to 1.2 tons (2400 lbs.) removed. Catch per unit effort estimates for the entire Dresden Island Pool are highly stochastic, likely due to changes in access to fishing hotspots, varying demographics through time (size structure), and environmental and hydrological variation (Figure 3). However, in recent years there has been a decline in CPUE among all three Asian carp species upstream of the Interstate 55 bridge in Dresden Island Pool, with a steady increase in effort since the inception of the program (Figure 3). Similarly, Asian carp CPUE has been declining in Rock Run Rookery since 2011 (Figure 3). Overall in Dresden Island Pool, Asian carp relative catch decreased by 90% from 2018 (1,686 Asian carp) and by 97% from 2010 (5,963 Asian carp). In 2018, IDNR biologists and contracted fishers gained access to the Dresden Nuclear Power Station's warm water discharge, where most Asian carp catch from Dresden Pool has been concentrated since (52% in 2019, 58% in 2020). With the amount of Asian carp removed from this area in recent years, we believe the population within the pool decreased, leading to a decreased catch rate in 2020.

Unified Fishing Method – Dresden Island Pool:

No Spring Dresden Island Pool UFM occurred due to inclement weather, flooding, and COVID-19. The Fall UFM in the Dresden Pool occurred from 10/20/2020 to 10/23/2020. Contracted commercial fishers accompanied by IDNR/INHS staff sampled the entire Dresden Island Pool, including Rock Run Rookery and the lower part of the Kankakee River. Sampling was comprised of 30,100 yds (27.5 km) of gill/trammel net and 120 minutes (12 runs) of electrofishing. A total of 17 Silver Carp, 13 Bighead Carp, and 2 Grass Carp were collected downstream of I-55, and 9 Silver Carp and 3 Bighead Carp were collected in Rock Run Rookery (43 Asian Carp total). No Asian Carp were collected in new locations upstream of I-55. All netting effort and Asian carp numbers from the UFM are included in the Dresden Island Pool totals in the previous paragraph.

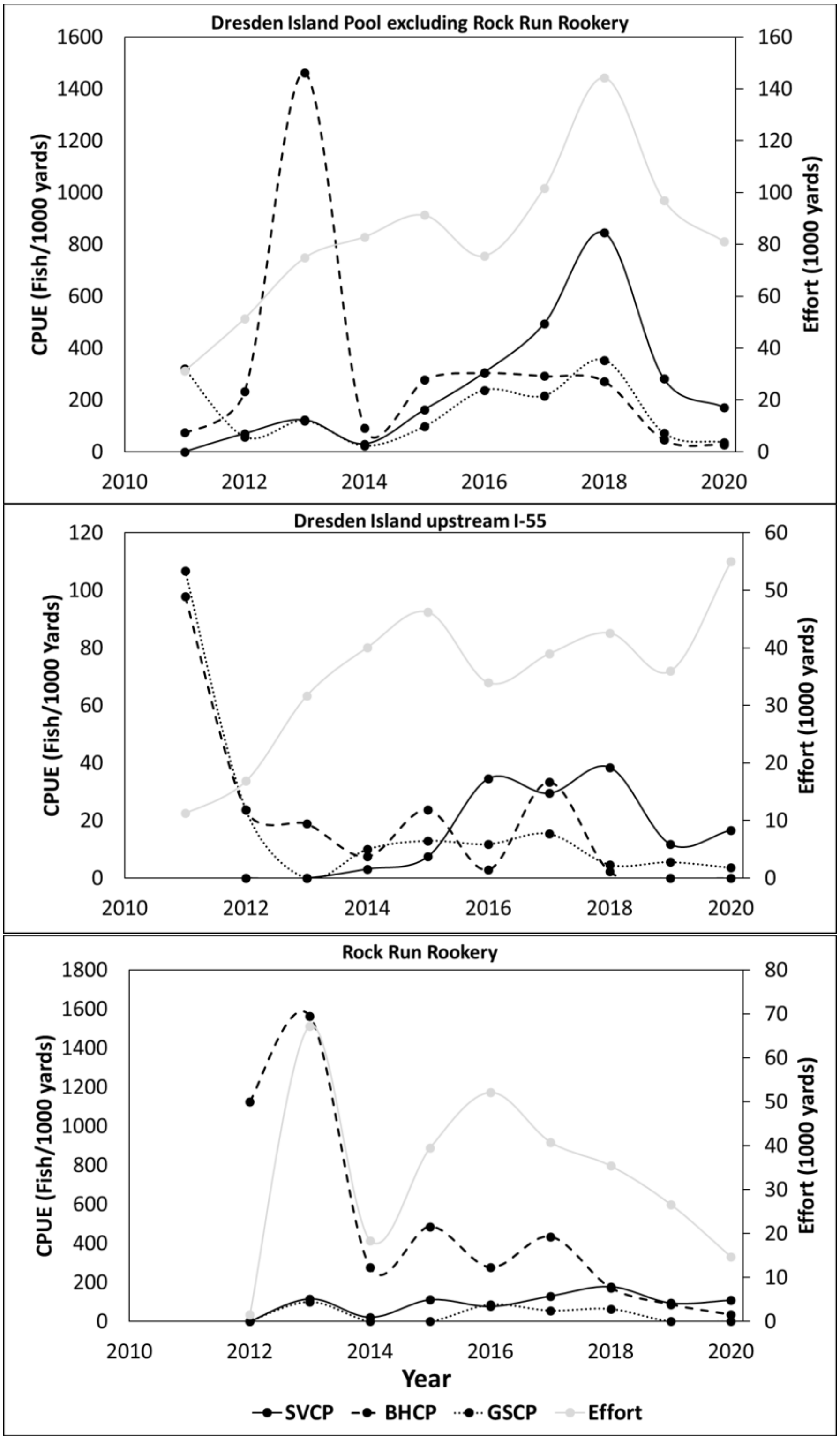

Figure 3. *Catch Per Unit Effort trends of Silver Carp (Solid black line), Bighead Carp (Dashed black line), Grass Carp (Dotted black line), and effort (Solid light grey line) in Dresden Island Pool excluding Rock Run Rookery (top panel), Dresden Island Pool upstream of the Interstate-55 bridge (middle panel) and Rock Run Rookery (bottom panel) from 2011-2020.*

Contracted Commercial Fishing Below the Electric Dispersal Barrier

Marseilles Pool:

In 2020, 21% of the total harvested Asian carp came from the Marseilles Pool. Contracted commercial fishing efforts included: 203,208 yards (186) of gill/trammel net. A total of 33,969 Silver Carp; 1,414 Bighead Carp; and 31 Grass Carp were harvested from Marseilles pool in 2020, amounting to 189.9 tons (379,800 lbs.) removed (Figure 4; Table 1). Silver Carp dominated the Asian carp catch in the Marseilles pool in 2020 (96%), consistent with the past seven years. Prior to 2013, Bighead Carp was the dominant Asian carp species caught in the Marseilles Pool (>55%). In 2020, the catch of Bighead Carp was only 4% (Table 1). The 2020 gill/trammel net CPUE (# caught per 1000 yds.) of Asian carp for Marseilles Pool was 174.2, a 15.6% decrease from 2019 (206.4; Figure 2).

Unified Fishing Method – East Pit of Hanson Material Services:

The East Pit UFM occurred from 03/03/2020 to 03/13/2020. Contracted commercial fishers with assisting agency biologists (IDNR and INHS) set 37,750 yds (34.5 km) of gill/trammel nets. A total of 15,295 Silver Carp and 336 Bighead Carp (15,631 Asian carp total) were removed. All netting effort and Asian carp numbers from the UFM are included in the Marseilles Pool totals in the previous paragraph.

Unified Fishing Method – West Pit of Hanson Material Services:

The West Pit UFM was postponed due to COVID-19 and occurred from 05/04/2020 to 05/08/2020. Contracted commercial fishers with assisting agency biologists (IDNR and INHS) set 20,900 yds (19.1 km) of gill/trammel nets. A total of 3,279 Silver Carp, 59 Bighead Carp, and 1 Grass Carp (3,338 Asian carp total) were removed. All netting effort and Asian carp numbers from the UFM are included in the totals in the first paragraph under Marseilles Pool.

Starved Rock Pool:

In 2020, 78% of the total harvested Asian carp came from Starved Rock Pool. Contracted commercial fishing efforts included: 278,432 yards (254.6 km) of gill/trammel net set. A total of 125,857 Silver Carp, 2,257 Bighead Carp, and 1,054 Grass Carp were harvested from Starved Rock pool in 2020 from gill/trammel nets, amounting to 422.2 tons (930,791 lbs.) removed (Figure 4; Table 1). Silver Carp dominated the catch of Asian carp in Starved Rock Pool in 2020 (97%), consistent with years past. The 2020 gill/trammel net CPUE (# caught per 1000 yds.) of Asian carp for Starved Rock Pool was 463.9, a 2.8 % decrease from 2019 (477.7) (Figure 2).

Bycatch:

Gill and Trammel nets:

A total of 184,364 fish representing 41 species and 4 hybrid groups were captured in gill/trammel nets in the 2020 contracted commercial fishing effort (Table 2). Asian carp comprised 89.3% of the total catch, *Ictiobus spp.* (i.e., Bigmouth, Black, and Smallmouth Buffalo) comprised 8.5% of the total catch, and Common Carp comprised 12.8% of the total catch. A total of 1,449 game fishes representing 14 species and 2 hybrid groups (i.e., *Pomoxis spp.*, *Micropterus spp.*, Ictalurids, Esocids, Percids, Moronids), were captured in gill/trammel nets in 2020. Game fishes comprised 3.9% of the total catch of fishes captured in gill/trammel nets in 2020. Similar to previous years, Flathead and Channel Catfishes were the most dominant game species captured in 2020, occupying 86.7% of the total game fishes captured in gill/trammel nets.

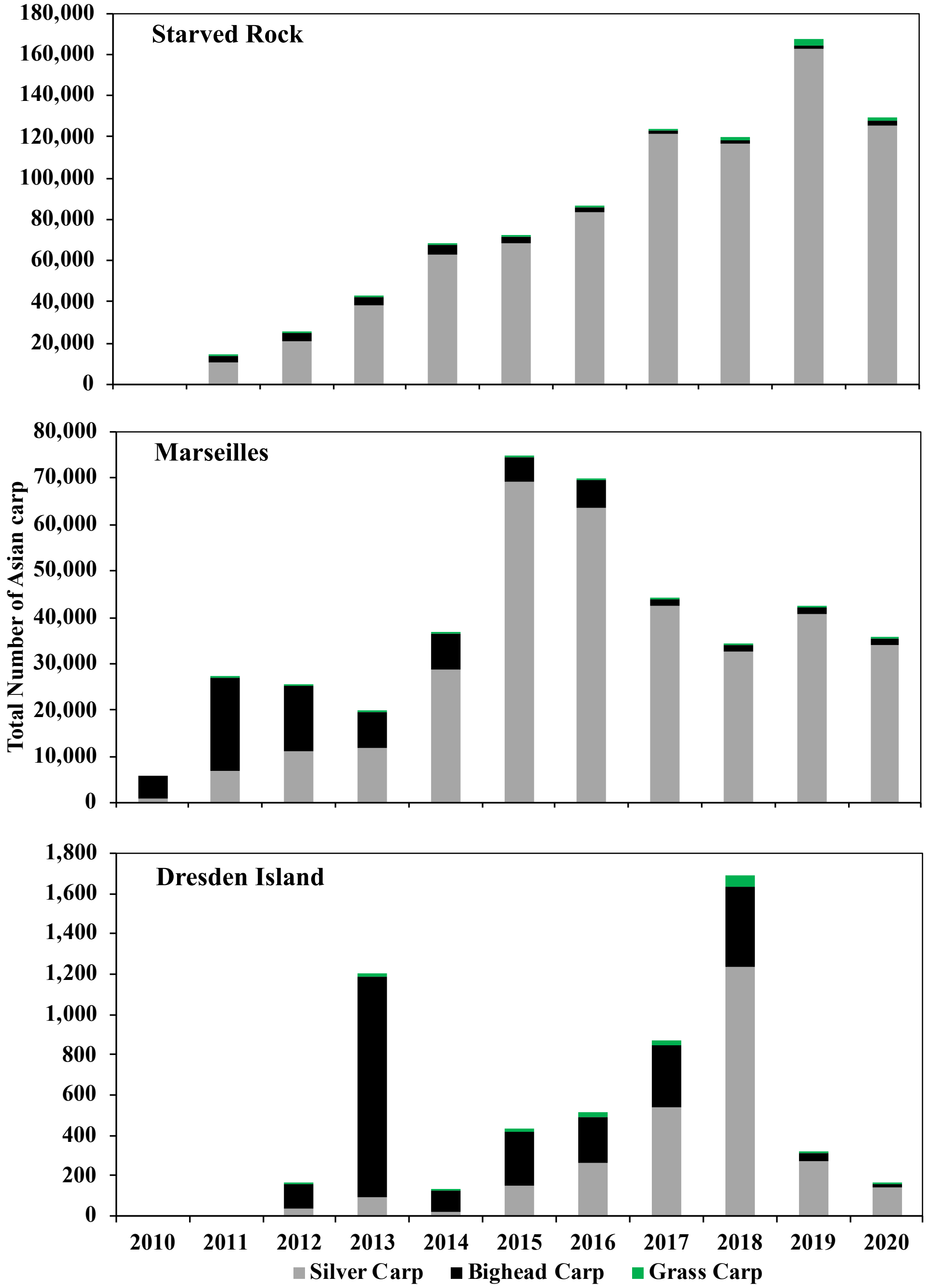

Figure 4. *Annual catch of Silver Carp, Bighead Carp, and Grass Carp in Starved Rock (2011-2020), Marseilles (2010-2020) and Dresden Island (2011-2020) pools.*

Contracted Commercial Fishing Below the Electric Dispersal Barrier

Commercial Seine:

No commercial seine effort was expended in 2020 by IDNR contract fishers.

Great Lakes Pound Net:

No Great Lakes pound net effort was expended in 2020 by IDNR contract fishers.

Recommendations:

Since 2010, this program has been successful at managing the Asian carp population in the Upper IWW by significantly decreasing relative biomass near the population front in Dresden Pool (Coulter et al. 2018). Despite significant limitations posed by Covid-19 throughout 2020, all planned effort was accomplished, and total biomass removed was similar to previous years. With these efforts we hope to further reduce Asian carp abundance at and near the detectable population front, as well as reduce potential propagule pressure on the EDBS. In addition to those core goals, MWRG Detection and Removal Workgroup Leads identified several future priorities. These include gaining a better understanding of Asian carp abundance and distribution in Dresden Island Pool, assess how Asian carp species are responding to removal at multiple scales, and identify locations or pools where harvest can have the greatest impact on Asian carp populations. Long term harvest data provides information necessary to model changes in Asian carp relative abundance and population demographics among pools of the Upper IWW in response to management actions. This project will continue to directly inform multiple MRWG Workgroups (Detection, Removal), and objectives will continue to be adapted by workgroup leads to better accomplish overall MRWG priorities. Contracted commercial fishing is a critical tool in managing Asian carp populations and we recommend this program continue in 2021.

References:

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Coulter, D.P., R. MacNamara, D. C. Glover, J. E. Garvey. 2018. Possible unintended effects of management at an invasion front: Reduced prevalence corresponds with high condition of invasive bigheaded carps. Biological Conservation 221:118-126.

Contracted Commercial Fishing Below the Electric Dispersal Barrier

Table 1. *Contracted fishers' efforts by gear type, harvest numbers, and tons of Asian carp removed from Lockport, Brandon Road, Dresden Island, Marseilles and Starved Rock pools, years 2010-2020.*

Year	Effort						Harvest							
River Pool	**Net Sets *(N)***	**Miles of Net**	**Seine Hauls *(N)***	**Miles of Seine**	**Hoop Net Nights *(N)***	**Pound Net Nights *(N)***	**Bighead Carp (N)**	**Silver Carp (N)**	**Grass Carp (N)**	**Total (N)**	**Bighead Carp (tons)**	**Silver Carp (tons)**	**Grass Carp (tons)**	**Total (tons)**
2010														
Lockport	41.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brandon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dresden	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Marseilles	1,316.0	75.5	0.0	0.0	0.0	0.0	4,888.0	0.0	1,075.0	5,963.0	53.1	0.0	8.1	61.2
Starved Rock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
All pools	1,357.0	79.8	0.0	0.0	0.0	0.0	4,888.0	0.0	1,075.0	5,963.0	53.1	0.0	8.1	61.2
2011														
Lockport	8.0	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brandon	22.0	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dresden	47.0	17.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.1	0.4
Marseilles	671.0	219.2	0.0	0.0	0.0	0.0	20,087.0	34.0	7,023.0	27,144.0	212.8	0.1	43.1	255.9
Starved Rock	151.0	44.6	0.0	0.0	0.0	0.0	2,964.0	132.0	10,730.0	13,826.0	20.5	0.5	53.6	74.6
All pools	899.0	294.6	0.0	0.0	0.0	0.0	23,051.0	166.0	17,753.0	40,970.0	233.5	0.6	96.8	330.9
2012														
Lockport	46.0	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brandon	73.0	13.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
Dresden	125.0	31.5	0.0	0.0	0.0	0.0	120.0	3.0	36.0	159.0	1.8	0.0	0.2	2.1
Marseilles	611.0	238.7	0.0	0.0	0.0	0.0	13,978.0	162.0	11,090.0	25,230.0	127.5	0.8	65.7	194.0
Starved Rock	176.0	66.0	0.0	0.0	0.0	0.0	3,994.0	243.0	20,589.0	24,826.0	22.9	1.5	99.4	123.8
All pools	1,031.0	355.2	0.0	0.0	0.0	0.0	18,092.0	409.0	31,715.0	50,216.0	152.2	2.3	165.4	319.9
2013														
Lockport	112.0	16.8	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
Brandon	145.0	21.4	0.0	0.0	0.0	0.0	0.0	6.0	0.0	6.0	0.0	0.1	0.0	0.1
Dresden	307.0	81.5	0.0	0.0	0.0	0.0	1,089.0	12.0	90.0	1,191.0	13.3	0.1	0.8	14.2
Marseilles	608.0	233.9	0.0	0.0	0.0	0.0	7,677.0	370.0	11,477.0	19,524.0	73.3	2.6	58.7	134.6
Starved Rock	228.0	105.8	0.0	0.0	0.0	0.0	3,938.0	369.0	38,666.0	42,973.0	21.8	2.0	165.5	189.3
All pools	1,400.0	459.3	0.0	0.0	0.0	0.0	12,704.0	758.0	50,233.0	63,695.0	108.4	4.8	224.9	338.2

Contracted Commercial Fishing Below the Electric Dispersal Barrier

Table 1. *Continued*

Year	Effort						Harvest							
River Pool	**Net Sets *(N)***	**Miles of Net**	**Seine Hauls *(N)***	**Miles of Seine**	**Hoop Net Nights *(N)***	**Pound Net Nights *(N)***	**Bighead Carp (N)**	**Silver Carp (N)**	**Grass Carp (N)**	**Total (N)**	**Bighead Carp (tons)**	**Silver Carp (tons)**	**Grass Carp (tons)**	**Total (tons)**
2014														
Lockport	253.0	30.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brandon	252.0	30.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dresden	326.0	62.0	0.0	0.0	0.0	0.0	104.0	5.0	25.0	134.0	1.0	0.1	0.2	1.3
Marseilles	509.0	218.3	3.0	1.1	0.0	16.0	7,735.0	169.0	28,076.0	35,980.0	72.7	1.0	113.8	187.5
Starved Rock	228.0	105.9	1.0	0.2	366.7	0.0	4,430.0	561.0	63,037.0	68,028.0	21.6	2.9	338.5	363.0
All pools	1,568.0	447.1	4.0	1.2	366.7	16.0	12,269.0	735.0	91,138.0	104,142.0	95.3	3.9	452.6	551.8
2015														
Lockport	343.0	48.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brandon	283.0	49.4	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
Dresden	375.0	77.1	0.0	0.0	110.8	0.0	272.0	11.0	150.0	433.0	2.4	0.1	0.8	3.4
Marseilles	378.0	141.2	9.0	1.1	22.5	25.0	5,298.0	216.0	68,909.0	74,423.0	39.1	1.2	232.4	272.8
Starved Rock	198.0	78.6	4.0	0.5	141.2	0.0	2,908.0	641.0	68,681.0	72,230.0	16.5	3.1	192.4	212.1
All pools	1,577.0	394.5	13.0	1.6	274.5	25.0	8,478.0	870.0	137,740.0	147,088.0	58.1	4.4	425.7	488.3
2016														
Lockport	473.0	57.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brandon	427.0	52.3	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
Dresden	552.0	80.0	0.0	0.0	0.0	0.0	232.0	22.0	263.0	517.0	2.3	0.3	1.5	4.1
Marseilles	486.0	204.0	30.0	7.6	85.7	67.0	5,937.0	76.0	62,642.0	68,655.0	44.7	0.6	260.9	306.2
Starved Rock	249.0	88.6	14.0	2.2	683.1	0.0	2,048.0	606.0	83,859.0	86,513.0	10.8	2.9	233.8	247.5
All pools	2,187.0	482.0	44.0	9.8	768.7	67.0	8,217.0	705.0	146,764.0	155,686.0	57.8	3.8	496.1	557.7
2017														
Lockport	449.0	52.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brandon	484.0	59.6	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
Dresden	573.0	97.6	0.0	0.0	343.3	4.0	307.0	28.0	538.0	873.0	4.6	0.4	4.3	9.2
Marseilles	368.0	140.4	7.0	2.2	48.7	74.0	1,529.0	51.0	40,144.0	41,724.0	13.8	0.4	178.0	192.2
Starved Rock	375.0	114.1	3.0	1.3	938.6	0.0	1,123.0	1,118.0	123,642.0	125,642.0	4.8	6.4	355.3	366.5
All pools	2,249.0	464.5	10.0	3.5	1,330.6	78.0	2,959.0	1,198.0	164,324.0	168,481.0	23.2	7.1	537.6	567.9

Table 1. *Continued*

Year	Effort						Harvest							
River Pool	Net Sets *(N)*	Miles of Net	Seine Hauls *(N)*	Miles of Seine	Hoop Net Nights *(N)*	Pound Net Nights *(N)*	Bighead Carp (N)	Silver Carp (N)	Grass Carp (N)	Total (N)	Bighead Carp (tons)	Silver Carp (tons)	Grass Carp (tons)	Total (tons)
2018														
Lockport	395.0	43.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brandon	391.0	44.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
Dresden	960.0	130.9	0.0	0.0	0.0	8.0	398.0	53.0	1,235.0	1,686.0	5.1	0.6	10.1	15.8
Marseilles	413.0	86.5	10.0	2.4	224.5	22.0	1,397.0	35.0	32,369.0	33,801.0	12.9	0.2	150.1	163.3
Starved Rock	585.0	140.2	0.0	0.0	1,403.7	0.0	1,645.0	1,406.0	117,052.0	120,103.0	8.0	7.7	374.0	389.8
All pools	2,755.0	446.7	10.0	2.4	1,628.2	30.0	2,463.0	1,587.0	151,257.0	156,307.0	26.2	9.1	535.7	571.0
2019														
Lockport	297.0	33.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brandon	263.0	30.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dresden	779.0	93.6	0.0	0.0	0.0	2.0	45.0	8.0	274.0	327.0	0.6	0.1	6.8	7.6
Marseilles	563.0	125.0	5.0	1.5	0.0	26.0	1,586.0	84.0	44,002.0	45,672.0	17.2	0.7	239.4	257.3
Starved Rock	1,131.0	220.5	1.0	0.1	0.0	1.0	2,157.0	2,830.0	163,017.0	168,004.0	11.9	15.8	543.6	571.3
All pools	3,036.0	504.1	6.0	1.5	0.0	29.0	3,803.0	3,001.0	208,315.0	215,119.0	29.8	17.0	791.8	838.6
2020														
Lockport	231.0	27.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brandon	254.0	29.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dresden	491.0	60.7	0.0	0.0	0.0	0.0	22.0	3.0	140.0	165.0	0.2	0.0	1.0	1.2
Marseilles	340.0	115.5	0.0	0.0	0.0	0.0	1,414.0	31.0	33,969.0	35,414.0	10.9	0.5	103.6	115.0
Starved Rock	461.0	158.2	0.0	0.0	0.0	0.0	2,257.0	1,054.0	125,857.0	129,168.0	6.5	4.5	411.2	422.2
All pools	1,777.0	391.0	0.0	0.0	0.0	0.0	3,693.0	1,088.0	159,966.0	164,747.0	17.6	5.0	515.8	538.4
2010-2020														
Lockport	2,648.0	327.2	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
Brandon	2,594.0	336.5	0.0	0.0	0.0	0.0	0.0	12.0	0.0	12.0	0.0	0.1	0.0	0.1
Dresden	4,535.0	732.6	0.0	0.0	454.1	14.0	2,589.0	145.0	2,751.0	5,485.0	31.6	1.8	25.8	59.2
Marseilles	6,263.0	1,798.2	64.0	15.8	381.3	23.0	71,526.0	1,228.0	340,776.0	413,530.0	678.1	8.1	1,453.9	2,140.1
Starved Rock	3,782.0	1,122.5	23.0	4.3	3,533.4	1.0	2,764.0	8,960.0	815,130.0	851,554.0	145.3	47.3	2,767.3	2,960.0
All pools	19,822.0	4,317.0	87.0	20.0	4,368.8	245.0	101,579.0	10,346.0	1,158,657.0	1,270,582.0	855.0	57.3	4,247.0	5,159.3

Contracted Commercial Fishing Below the Electric Dispersal Barrier

Table 2. *Total Asian carp and bycatch captured by contracted fishers using gill and trammel nets in the Upper Illinois River (Starved Rock, Marseilles, Dresden, Brandon and Lockport pools) during 2020 and total Asian carp and bycatch species captured since 2010.*

Species	**Contracted Fishing Gill and Trammel Net Catch 2020**							**2010-2020**	
	Starved Rock Pool	**Marseilles Pool**	**Dresden Pool**	**Brandon Pool**	**Lockport Pool**	**No. Captured**	**Percent (%)**	**No. Captured**	**Percent (%)**
Alligator Gar	0	0	0	0	0	0	0	1	0
American Brook Lamprey	0	0	0	0	0	0	0	1	0
Bighead Carp	2,257	1,414	22	0	0	3,693	0.02	96,205	0.06
Bigmouth Buffalo	66	256	303	0	0	625	0	35,237	0.02
Black Buffalo	4	1	25	0	0	30	0	2,400	0
Black Bullhead	0	0	0	0	0	0	0	3	0
Black Crappie	0	11	0	0	0	11	0	189	0
Blue Catfish	0	5	0	0	0	5	0	45	0
Blue Sucker	0	0	0	0	0	0	0	14	0
Bluegill	0	0	2	0	0	2	0	16	0
Bowfin	0	1	1	0	0	2	0	28	0
Carp x Goldfish	0	0	0	1	0	1	0	177	0
Channel Catfish	123	236	43	3	7	412	0	7	0
Common Carp	1,079	481	306	97	60	2,023	0.01	43,997	0.03
Flathead Catfish	73	46	5	0	0	124	0	2.771	0
Freshwater Drum	243	667	52	2	1	965	0.01	22	0.02
Gizzard Shad	4	0	1	0	0	5	0	2,689	0
Gizzard Shad <6 in	0	0	0	0	0	0	0	376	0
Golden Redhorse	5	0	0	0	0	5	0	147	0
Goldeye	0	0	0	0	0	0	0	14	0
Goldfish	0	0	2	1	1	4	0	97	0
Grass Carp	1,054	31	3	0	0	1,008	0.01	9,351	0.01
Greater Redhorse	0	0	0	0	0	0	0	1	0
Highfin Carpsucker	0	0	0	0	0	0	0	6	0
Hybrid Striped Bass	6	0	0	0	0	6	0	113	0
Hybrid Sunfish	0	0	0	0	0	0	0	8	0
Largemouth Bass	5	13	0	0	0	21	0	391	0
Longnose Gar	10	8	0	0	0	47	0	817	0
Mooneye	1	1	0	0	0	2	0	28	0
Muskellunge	1	0	0	0	0	1	0	11	0

Contracted Commercial Fishing Below the Electric Dispersal Barrier

Table 2. Continued.

Species	Contracted Fishing Gill and Trammel Net Catch 2020							2010-2020	
	Starved Rock Pool	Marseilles Pool	Dresden Pool	Brandon Pool	Lockport Pool	No. Captured	Percent (%)	No. Captured	Percent (%)
Northern Hogsucker	0	0	0	0	0	0	0	1	0
Northern Pike	2	0	0	0	0	2	0	45	0
Paddlefish	8	17	0	0	0	25	0	345	0
Quillback	8	0	3	0	0	11	0	981	0
River Carpsucker	80	3	6	0	0	89	0	6,164	0
River Redhorse	0	0	0	0	0	0	0	9	0
Rock Bass	0	0	0	0	0	0	0	1	0
Sauger	0	1	0	0	0	8	0	236	0
Shorthead Redhorse	0	0	0	0	0	0	0	58	0
Shortnose Gar	7	0	0	0	0	1	0	230	0
Silver Carp	125,855	33,969	139	0	0	159,963	0.87	1,069,414	0.71
Silver Redhorse	11	0	0	0	0	11	0	112	0
Silver x Bighead Carp	2	0	1	0	0	3	0	10	0
Skipjack Herring	0	1	0	0	0	1	0	121	0
Smallmouth Bass	2	0	0	0	0	2	0	44	0
Smallmouth Buffalo	6,321	7,324	1,471	2	11	15,129	0.08	198,271	0.13
Spotted Gar	0	0	0	0	0	0	0	10	0
Striped Bass	0	0	0	0	0	0	0	1	0
Threadfin Shad	0	0	0	0	0	0	0	1	0
UI* Buffalo	0	0	0	0	0	0	0	3,704	0
UI* Carpsucker	0	0	0	0	0	0	0	470	0
UI* Catostomid	0	0	0	0	0	0	0	2,066	0
UI* Moronid	0	0	0	0	0	0	0	865	0
UI* Redhorse	20	0	0	0	0	20	0	32	0
UI* Cyprinid	0	0	0	0	0	0	0	0	0

Contracted Commercial Fishing Below the Electric Dispersal Barrier

Table 2. Continued.

Species	Contracted Fishing Gill and Trammel Net Catch 2020							2010-2020	
	Starved Rock Pool	Marseilles Pool	Dresden Pool	Brandon Pool	Lockport Pool	No. Captured	Percent (%)	No. Captured	Percent (%)
Walleye	17	1	0	0	0	18	0	236	0
White Bass	3	1	0	0	0	4	0	668	0
White Crappie	0	1	0	0	0	1	0	119	0
White Perch	0	0	0	0	0	0	0	5	0
White Sucker	3	0	0	0	0	3	0	21	0
Yellow Bass	0	3	0	0	0	3	0	200	0
Yellow Bullhead	0	0	1	0	0	1	0	6	0
Total Captured	137,271	44,492	2,418	106	80	184,367	100	1,507,934	100
No. Species	27	24	19	5	6	36	0	51	0
No. Hybrid Groups	3	0	1	1	0	4	0	11	0

Contracted Commercial Fishing Below the Electric Dispersal Barrier

Table 3. *Total Asian carp and bycatch captured by contracted fishers using commercial seines and Great Lakes pound nets in the Upper Illinois River (Starved Rock-Lockport) during 2019 and total Asian carp and bycatch species captured since 2010.* ****No commercial seine or Great Lakes pound nets effort was expended in 2020.***

	Commercial Seine Catch				Great Lakes Pound Net Catch					
	2019		2010 -2019		2019		2010 -2019		2010 -2019	
Species	Marseilles	Percent (%)	No. Captured	Percent (%)	Marseilles	Dresden	No. Captured	Perxent (%)	No. Captured	Percent (%)
Bighead Carp	10	0.31	4,570	4.57	35	0	35	0.39	625	1.29
Black Buffalo	0	0	18	0.02	0	0	0	0	36	0.07
Black Bullhead	0	0	0	0	0	0	0	0	2	0
Black Crappie	137	4.24	244	0.24	11	2	13	0.14	369	0.76
Bluegill	0	0	6	0.01	0	0	0	0	149	0.31
Bigmouth Buffalo	31	0.96	963	0.96	0	0	0	0	435	0.9
Bowfin	0	0	2	0	0	1	1	0.01	6	0.01
Common Carp	1	0.03	94	0.09	3	2	5	0.06	237	0.49
Channel Catfish	181	5.6	928	0.93	47	2	49	0.54	1,741	3.61
Flathead Catfish	1	0.03	11	0.01	0	0	0	0	14	0.03
Freshwater Drum	834	25.8	9,356	9.35	7,581	2	7,583	83.98	21,500	44.53
Goldeye	0	0	2	0	0	0	0	0	0	0
Golden Redhorse	0	0	23	0.02	0	0	0	0	6	0.01
Grass Carp	0	0	40	0.04	0	0	0	0	1	0
Gizzard Shad	337	10.42	6,042	6.04	0	20	20	0.22	3,270	6.77
Gizzard Shad <6	0	0	482	0.48	0	0	0	0	1,196	2.48
Hybrid Striped Bass	0	0	0	0	0	0	0	0	12	0.02
Highfin Carpsucker	0	0	2	0	0	0	0	0	2	0
Largemouth Bass	4	0.12	69	0.07	6	3	9	0.1	160	0.33
Longnose Gar	0	0	64	0.06	0	3	3	0.03	39	0.08
Mooneye	0	0	2	0	0	0	0	0	0	0
Northern Pike	0	0	1	0	0	2	2	0.02	26	0.05
Paddlefish	1	0.03	5	0	0	0	0	0	0	0
Quillback	0	0	1,586	1.58	0	0	0	0	216	0.45
River Carpsucker	932	28.83	3,758	3.76	52	1	53	0.59	1,377	2.85
Sauger	0	0	24	0.02	0	0	0	0	0	0
Spotted Bass	0	0	0	0	0	0	0	0	8	0.02

Contracted Commercial Fishing Below the Electric Dispersal Barrier

Table 3. *Continued*

	Commercial Seine Catch				Great Lakes Pound Net Catch					
	2019		2010 -2019		2019		2010 -2019		2010 -2019	
Species	**Marseilles**	**Percent (%)**	**No. Captured**	**Percent (%)**	**Marseilles**	**Dresden**	**No. Captured**	**Perxent (%)**	**No. Captured**	**Percent (%)**
Shorthead Redhorse	0	0	4	0	0	0	0	0	51	0.11
Skipjack Herring	0	0	22	0.02	0	0	0	0	2	0
Smallmouth Buffalo	137	4.24	6,858	6.85	653	6	659	7.3	3,110	6.44
Smallmouth Bass	0	0	4	0	163	0	0	0	2	0
Shortnose Gar	0	0	38	0.04	0	0	0	0	1	0
Silver Carp	80	2.47	58,396	58.35	282	0	282	3.12	4,881	10.11
Silver Redhorse	0	0	10	0.01	0	0	0	0	1	0
UI* Buffalo	0	0	2,159	2.16	0	0	0	0	2,084	4.32
UI* Centrarchid	0	0	71	0.07	0	0	0	0	0	0
UI* Carpoides	0	0	396	0.4	0	0	0	0	903	1.87
UI* Catastomid	0	0	900	0.9	0	0	0	0	1,757	3.64
UI* Moronid	528	16.33	1,225	1.22	0	0	0	0	1,385	2.87
Walleye	0	0	3	0	0	0	0	0	1	0
White Bass	0	0	1,069	1.07	250	0	250	2.77	2,244	4.65
White Crappie	19	0.59	125	0.12	0	0	0	0	49	0.1
White Perch	0	0	11	0.01	0	0	0	0	4	0.01
White Sucker	0	0	3	0	0	0	0	0	4	0.01
Yellow Bass	0	0	487	0.49	66	0	66	0.73	350	0.72
Yellow Bullhead	0	0	0	0	0	0	0	0	28	0.06
Total Captured	**3,233**	**100**	**100,073**	**100**	**8,986**	**44**	**9,030**	**100**	**48,284**	**100**
No. Species	15	-	36	-	11	11	15	-	35	-
No. Hybrid Groups	0	-	0	-	0	0	0	-	1	-

Asian Carp Population Modeling to Support an Adaptive Management Framework

Participating Agencies: U.S. Fish and Wildlife Service (USFWS) – Columbia Fish and Wildlife Conservation Office (lead), U.S. Geological Survey (USGS) – Upper Midwest Sciences Center, Southern Illinois University, and Illinois Department of Natural Resources

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

Introduction and Need:

The goal of this project is to develop objective model-based tools to support bigheaded carp (Silver Carp and Bighead Carp) control efforts via the adaptive management framework. Adaptive management is a decision-making framework designed to reduce uncertainty in a how a system works via system manipulation and monitoring (Walters 1986). Models are used in adaptive management to generate predictions of how complex systems, such as how bigheaded carp populations will respond to management activities, thereby forming the foundation for learning and improved long-term management outcomes.

In support of an adaptive management framework, this project includes continued development of a quantitative simulation model. The model was developed to inform management and research decisions with the goal of minimizing the abundance of bigheaded carp in the upper Illinois River waterway, thereby reducing risk of population expansion toward the Great Lakes and reducing potential impacts on native species.

This report includes revised model results based on the feedback received during FY 2020. During FY 2020, the model was subjected to peer review by collecting critical feedback from three quantitative research groups with experience in population ecology. Additional peer review and feedback was collected during a daylong workshop that included quantitative experts with experience in population modeling. In addition to revised model results, updates on supporting objectives, project coordination, and model communication are provided.

We used the simulation model to evaluate different management scenarios. Management scenarios explored herein relate to (1) additive mortality (i.e., mortality in addition to the background, "natural mortality") of adult bigheaded carp (> 500 mm total length) in the lower pools (Alton, La Grange, Peoria) and upper pools (Starved Rock, Marseilles, and Dresden Island) of the Illinois River; and (2) deterrence of movement of bigheaded carp (all sizes) through existing bottlenecks at Starved Rock Lock and Dam (L&D), Marseilles L&D, or Dresden Island L&D. Additive mortality and deterrence of movement can be achieved by a variety of tools or strategies. This report focused on the effects of varied levels of both – not the source or cause of the additive mortality or additive deterrence. Recommendations on which tools or strategies are most likely to achieve desired levels of additive mortality or additive deterrence are beyond the scope of this interim summary report.

This project includes coordination among state and federal agencies and academic universities. The USFWS leads U.S. Department of Interior efforts for this project with considerable support from the USGS. Their Interim Summary Report (ISR), "Asian carp population model to support and adaptive management framework, USGS contribution" describes their contributions to efforts associated with the simulation model.

Objectives:

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

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

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

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

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

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

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

2020 Project Highlights:

- Updated demographic parameters for Silver Carp and Bighead Carp across the Illinois River with an additional 13,000 fish from 2018 and 2019.

- Solicited critical feedback from quantitative experts including feedback on model assumptions, design, and analysis to promote model-based tool development and improvements and incorporated feedback and rerun model simulations.
- Model predictions indicated that additional lower pool mortality was a more effective long-term control strategy than additional upper pool mortality. Similarly, model results from scenarios that focused on upstream movement deterrence indicated that reduced passage immediately upstream of source populations was more effective than alternative sites located further upstream. Further, model simulations provide evidence that the most effective long-term strategy to manage Silver Carp is by using a combination of control methods. Larger reductions in Silver carp relative abundance were realized by combining upstream movement deterrence with additional mortality in lower and upper pools. This result highlights the compounding benefits associated with using a multipronged strategy. Detailed results are provided in this report.
- Continued to work closely with MRWG technical workgroups to prioritize future data collections and research using population model assumptions and limitations as a decision support tool.
- Products include a manuscript, supporting data, code for the manuscript, and a new software package:
  - Manuscript under revision (Erickson et al.).
  - Erickson RA and JL Kallis. 2021. Analysis of carp demographics data. U.S. Geological Survey software release. Reston, Va. https://doi.org/10.5066/P9Q6SUML.
  - Erickson, R.A., J.L. Kallis, A.A. Coulter, D. Coulter, R. MacNamara, J.T. Lamer, W.W. Bouska, K.S. Irons, L.E. Solomon, A.J. Stump, M.J. Weber, M.K. Brey, C.J. Sullivan, G.G. Sass, J.E. Garvey, D.C. Glover. 2021. Bighead and silver carp individual fish data from the Mississippi, Ohio, and Illinois rivers from 1997 to 2018. U.S. Geological Survey data release. https://doi.org/10.5066/P9IAOZ8G.
  - Erickson, RA. 2020. fishStan: Hierarchical Bayesian models for fisheries. U.S. Geological Survey software release. Reston, Va. https://doi.org/10.5066/P9OVU2GC.

Methods:

Simulation model parameterization

The model was parametrized using results from published studies. Growth, length-weight, and size-at-maturity relationships were estimated by fitting Bayesian hierarchical models (Erickson et al. *in review*) to empirical data. The approach of Then et al. (2018) was used to estimate natural mortality as a function of growth parameters. Monthly inter-pool transition probabilities were estimated using a multistate movement model (Coulter et al. 2018).

A Ricker stock-recruitment model, expressed in terms of steepness was used to characterize reproduction for each pool. The steepness parameterization requires three terms including recruitment (R_0) and spawning stock biomass (S_0) levels from an unfished population and steepness (h), which is defined as the proportion of R_0 at 20% of S_0 (Kinsey et al. 2019). Values for the initial slope of the stock-recruitment relationship (Tsehaye et al. 2013) were converted to h, for each species. Appropriate S_0 and R_0 values were not available for our study species. Thus, we set R_0 in the largest pool included in our study (i.e., Alton Pool) to an arbitrary value of 1,000 and scaled the remaining values by pool length. Values of S_0 for each pool were calculated as a function of R_0 by assuming a stable age distribution using mean demographic rates from Erickson et al. (*in revision*).

Model structure

Bigheaded carp population dynamics were modeled in annual time steps using growth, inter-pool movement, and recruitment sub-models. Sub-models were applied in sequential fashion, beginning with survival. The number of fish in pool p length class l surviving to the next time step was calculated as follows:

$$N_{p,l,t+1} = N_{p,l,t}(1 - M)(1 - v_l F_p)$$

where M is the time, length, and pool invariant annual natural mortality rate and F_p and v_l are user-defined terms representing an additional additive mortality rate and length-specific vulnerability. To account for annual growth, pool-specific populations, in terms of numbers at length, are multiplied by the probability of transitioning from the current length class to the next length class. Transition probabilities were calculated using an age-independent formulation of the Von Bertalanffy growth function (Sullivan et al. 1999), which describes the change in length over one time step Δl as a function of current length l_t, asymptotic length L_∞, and the growth coefficient k:

$$\Delta l = (L_\infty - l_t)(1 - e^{-k})$$

Annual net movement was simulated by multiplying by a movement matrix. Only fish larger than the length at 50% maturity were allowed to move between pools. Each element of the movement matrix describes the transition probabilities among the six pools included in the underlying movement model developed by Coulter et al. (2018).

To complete the population dynamics model, recruitment to the population was estimated using a Ricker stock-recruitment relationship. The number of recruits was estimated as a function of spawning stock biomass, which we defined as the product of length-specific abundance, probability of maturity, and mass summed overall length classes. Recruits were assigned to a given length class using the Von Bertalanffy growth function solved for length at age one.

Asian Carp Population Modeling to Support an Adaptive Management Framework

Initial populations

The model was initialized using stable age distributions constructed from mean demographic rates (Erickson et al. *in revision*). Abundances were determined using stock-recruitment functions for each pool. The amount of spawning stock biomass was based on hydroacoustics surveys. More specifically, spawning stock biomass values were calculated by multiplying the pool specific S_0 value by the pool-specific relative density, which we defined as the hydroacoustics-based density estimate divided by the maximum density across all pools. Lastly, consistent with field data and our assumption about size-dependent movement between pools, fish smaller than the length at 50% maturity were removed from initial populations in the upper pools.

Incorporating uncertainty

The model incorporates two levels of variance including uncertainty in demographic rates and temporal variance. Uncertainty in bigheaded carp demographic rates was incorporated by repeating 25-year simulations for each management scenario using 1,000 iterations of growth, maturity, natural mortality, length-weight, and movement parameters, randomly selected from the mean Bayesian posterior distributions. Interannual variability in reproductive success (i.e., frequent year class failure and occasional reproductive success) was included using a Bernoulli distribution. We assumed that within a given time step, reproductive success was synchronized across pools (Sullivan et al. 2018). For each annual time step the number of individuals estimated from the stock-recruitment functions was added to the populations with probability 0.5, which was estimated from the relative frequency of historically observed and successful reproduction in the La Grange pool of the Illinois River and quantified using 2000 – 2015 USGS Long-Term Resource Monitoring Program (LTRMP) data. Annual data was classified as successful when the catch of age-0 fish (i.e., < 250 mm total length [TL]) was greater than zero.

Evaluation

The model was used to evaluate bigheaded carp population responses to different management actions involving increased adult mortality and decreased upstream movement rates. We considered different combinations of increased additive mortality (0 to 1 in 0.25 intervals) in the lower- (Alton, LaGrange, Peoria) and upper-pools (Starved Rock, Marseilles, Dresden Island). Additive mortality was limited to adult fish (i.e., ≥500 mm total length). Deterrence to upstream movement effects on bigheaded carp populations were evaluated under different combinations of deterrence efficacies including 0.25, 0.5, and 0.75 of baseline movement values at Starved Rock L&D, Marseilles L&D, Dresden Island L&D. Lastly, we evaluated the combined effects of upstream movement deterrence and increased adult mortality.

Proportional reduction in bigheaded carp abundance relative to the no action scenario (i.e., zero additive mortality, baseline movement rates) was used to measure performance of the different management scenarios. Proportional reduction was calculated by dividing the total number of

Dresden Island fish alive at the end of the 25-year simulation by the number alive under the no action scenario using iterations as replicates (N=1,000). For each parameter draw (both demographic rates and stochastic spawning years), we compared different harvest and movement scenarios. This controlled for the variation in demographic rates. However, sometimes management scenarios had larger relative populations than no action, reference scenarios. This occurred due to the variability of the quasi-stable stochastic distributions. We compared the performance of different control scenarios using mean effectiveness values and variability. Patterns in proportional reduction were explored using heatmaps. Control scenario effects on variability around the mean were examined using boxplots with variation derived from individual iterations. Lastly, we evaluated how proportional reduction values varied in response to changes in the steepness parameter. To accomplish this objective, we varied steepness by approximately 50% and compared the results to values based on our default assumptions.

Results and Discussion:

Summary

During FY20, demographic rate estimates were updated with current data. Results were included in a manuscript titled “Demographic rate variability of Bighead and Silver carps along an invasion gradient”, which was submitted to a peer-reviewed journal – Journal of Fish and Wildlife Management (Objective 1). To prioritize bigheaded carp data needs and research, we explored how model inputs (e.g., parameter uncertainty, assumptions) impact model outputs. Results of these analyses, including data and research recommendations were included in our 2019 Interim Summary Report (ACRCC 2019). The modeling workgroup, in coordination with the MRWG, also made the decision to conduct a feasibility study to determine how successfully SCAA/L modeling (e.g., Syslo et al. 2020) could be completed given current data availability (Objective 6). Data inputs for SCAA/L’s are extensive, and it is unclear whether existing sampling and harvest data, which would be used to parametrize the model, are suitable and available in sufficient quantity to perform a robust analysis. The feasibility study will be conducted during FY21. During FY20, we also collaborated with the telemetry workgroup to improve the multi-state movement model used to describe carp movement between pools (Objective 5). Once completed, the updated movement model will be incorporated into the simulation model.

There remains a need to scrutinize the simulation model by publishing in a peer-reviewed journal (Objective 4). To facilitate this process, model parameterization results were submitted for publication (Erickson et al. *in revision*). In addition, we subjected the model to review by collecting written feedback from three quantitative research groups with experience in population ecology (Objective 3). Further feedback was collected during a daylong workshop hosted by the MRWG modeling workgroup and attended by quantitative experts from academia and MRWG representatives (Objective 7). Feedback was incorporated into the model, including changes to the recruitment sub-model, assumptions about fish movement, and initial population sizes. Below, we present updated results from the revised model.

Simulation model

To evaluate the effectiveness of potential bigheaded carp control strategies we developed a forward simulation model that accounted for uncertainty in key demographic parameters including growth, pool-to-pool movement, size-at-maturity, and weight-at-length. Patterns in model predictions were consistent for both species of bigheaded carp. Consequently, to minimize redundancy, results and discussion reported herein focus on Silver Carp findings.

Results from the updated population model were consistent with previous model predictions (ACRCC 2018). Additional mortality effects on Dresden Island Pool proportional reductions, however, were stronger in results from the updated model, whereas upstream movement deterrence effects were weaker. We attributed this result to assumptions about the size at which fish move among pools. Consistent with patterns in length frequency data, we assumed that Silver Carp did not move between pools until reaching a certain size (i.e., size at 50% maturity) in the updated model, whereas the previous model allowed individuals of all sizes to move.

Similar to previous results, evaluation of upstream movement deterrence and additional adult mortality indicated that high reductions (i.e., proportional reduction > 0.9) of Silver Carp are possible using either control strategy. Model predictions from both control strategies revealed that the spatial allocation of control efforts was important. For example, we found that additional lower pool mortality was a more effective long-term control strategy than additional upper pool mortality. Similarly, model results from scenarios that focused on upstream movement deterrence indicated that reduced passage immediately upstream of source populations was more effective than alternative sites located further upstream. Lastly, although population size from scenarios that included increased mortality and reduced upstream passage generally decreased relative to the no action scenario, a small fraction of iterations resulted in somewhat larger populations at terminal year. We attributed this finding to multiple factors including simulation stochasticity and modeling artifacts (e.g., if a simulated population is smaller due to harvest then a simulated spawn year causes a population spike).

Evaluation of model results from scenarios that focused only on additional mortality of adult-sized Silver carp as a management tool revealed that additional lower pool mortality was a more effective long-term control strategy than additional upper pool mortality. The proportional change of Dresden Island Pool Silver Carp from scenarios that included only additional upper pool mortality ranged 0.42 to 0.87 (Figure 1). In contrast, results from scenarios that included only additional lower pool mortality ranged 0.6 to 1 (Figures 1 and 2). Further, high reductions in Silver carp relative abundance in Dresden Island Pool were not possible without additional lower pool mortality, whereas the reverse was not true (Figures 1 and 2). For example, large reductions in Silver carp relative abundance were observed when additional lower pool mortality rates were greater than 0.5. This result was consistent across all levels of upper pool mortality. In contrast, setting upper pool mortality rates to an unrealistically high level (i.e., 1) still required a minimum lower pool mortality rate of 0.25 to reach high reduction levels.

Using bigheaded carp movement models (Coulter et al. 2018) to incorporate the spatial components of the Illinois River System (i.e., navigation pools) revealed that long-term management goals in the upper pools can likely be achieved at lower adult mortality levels than previously thought. For example, to achieve upper pool management goals Tsehaye et al. (2013) found that considerably high mortality rates (e.g., 0.7) of all size classes was required to collapse bigheaded carp populations. In contrast, our results suggest that upper pool population abundance can be greatly reduced at relatively moderate mortality levels using size-selective approaches such as harvest.

Model scenarios that focused on the deterrence of upstream movement rates suggest that reductions in upstream passage can yield considerable reductions in Dresden Island Pool relative abundance (Figure 3). Strong effects of deterring upstream movement were realized at intermediate deterrence efficiency levels in scenarios that did not have any additional mortality. For example, setting upstream movement at Dresden Island L&D at 0.5 of the baseline value resulted in a proportion change of 0.24 and this effect increased as the location of deterrence moved downstream. Specifically, a similar 0.5 deterrence of upstream movement resulted in a proportional change of 0.44 when upstream movement deterrence was located at Marseilles L&D and 0.48 when located at Starved Rock L&D. Achieving large reductions however, required combining upstream movement deterrence with additive upper pool or lower pool mortality. For example, reducing passage at Starved Rock L&D by 50% still required a minimum lower pool mortality rate of 0.5 to achieve large reductions in Silver Carp relative abundance.

We found evidence that the most effective long-term strategy to manage Silver Carp is by using a combination of control methods. Larger reductions in Silver carp relative abundance were realized by combining upstream movement deterrence with additional mortality in lower and upper pools. This result highlights the compounding benefits associated with using a multipronged strategy.

The reproductive capacity of Silver Carp is a critical component for modeling population dynamics and evaluating population responses to control scenarios. Although our model was parameterized using empirical data, Silver Carp stock-recruitment parameters suitable for our model were not available. It was for this reason that we used literature values derived from meta-analysis to model compensatory density-dependence in Silver Carp recruitment (Tsehaye et al. 2013). To explore how misspecifications in the strength of compensatory density-dependence in recruitment influenced our findings, we compared results from scenarios that assumed varying levels of steepness. Model results indicated that population resilience to additional mortality and population variance at terminal time increased marginally with steepness (Figure 4). For example, comparing the baseline steepness value to the highest steepness scenario had an almost 40% relative increase in the population size without additional mortality and an almost 20% increase in relative population size with 50% mortality in the lower pools.

Recommendations:

- Updated model results were consistent with previous findings. Results indicated that increased lower pool mortality and deterrents to upstream movement could have a significant impact on bigheaded carp populations and therefore support shared long-term bigheaded carp management goals. To reduce bigheaded carp populations in the upper pools, we recommend increasing mortality rates on source populations located in the lower pools. To evaluate control effectiveness, we recommend continued support for on-going control efforts (e.g., harvest) and monitoring in the focal areas above Starved Rock L&D.
- Model results can be used to recommend combinations of upper pool and lower pool mortality benchmarks that will achieve management goals. To validate model predictions, however, mortality recommendations must be compared with actual rates of additional mortality. We recommend quantifying additional mortality rates using assessment models (e.g., statistical catch-at-age model) or other appropriate tools.
- Modeling efforts did not account for effects to species other than Bigheaded carp. Consequently, unintended consequences of control strategies, particularly upstream movement deterrence should be evaluated.
- Due to limitations associated with the telemetry-based movement model, we were unable to provide mortality recommendations on an individual pool level. To address this limitation, we recommend continued support for on-going telemetry work, especially development of an updated movement model using current data.
- Support research designed to address key model assumptions and limitations such as density feedback loops, variation in the relation between size and age, factors influencing pool-to-pool movement probabilities, and size-dependent vulnerability to harvest.

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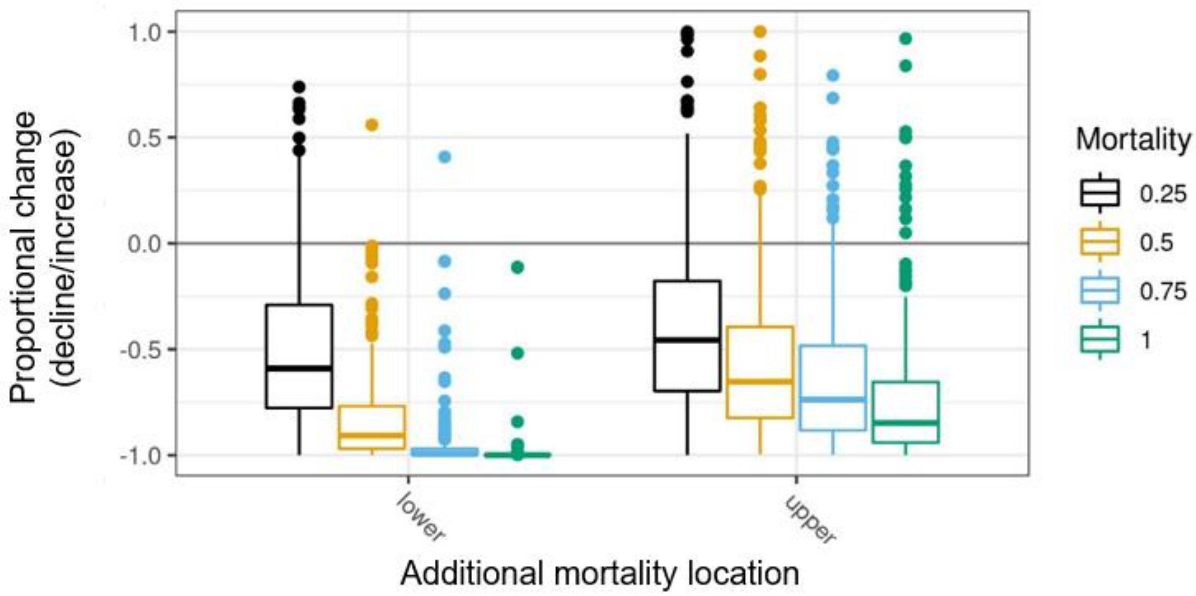


Figure 1. *Boxplots of proportional change relative to the no-action scenario in Dresden Island Pool population size for upper pool or lower pool additional mortality scenarios (i.e., additive mortality for Silver Carp ≥500 mm TL). Positive values indicate population increases whereas negative values indicate population declines. Distributions are based on 1,000 iterations per scenario.*

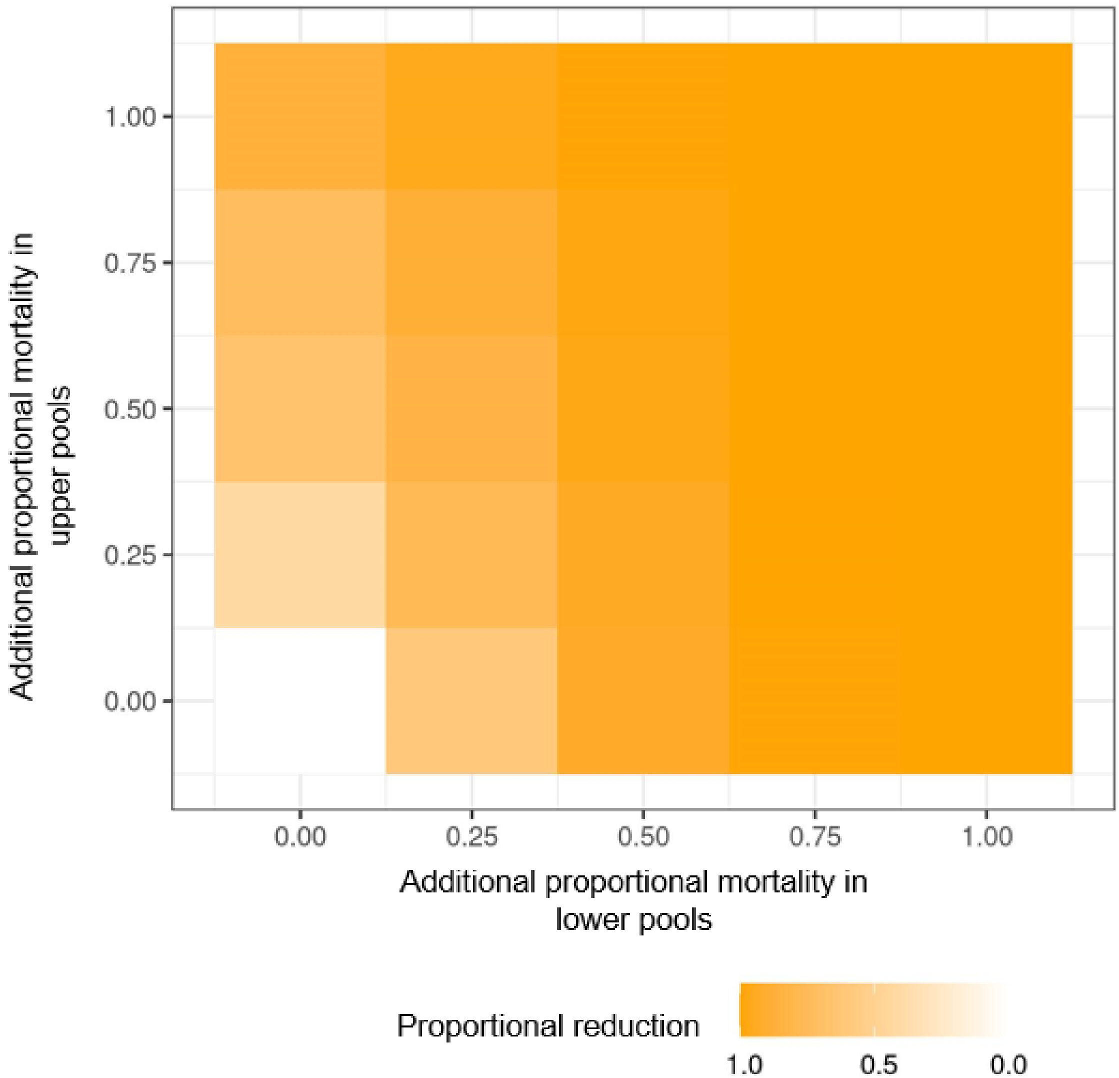


Figure 2. *Mean proportional reduction relative to the no-action scenario in Dresden Island Pool for additional mortality scenarios (i.e., additive mortality for Silver Carp ≥500 mm TL)*

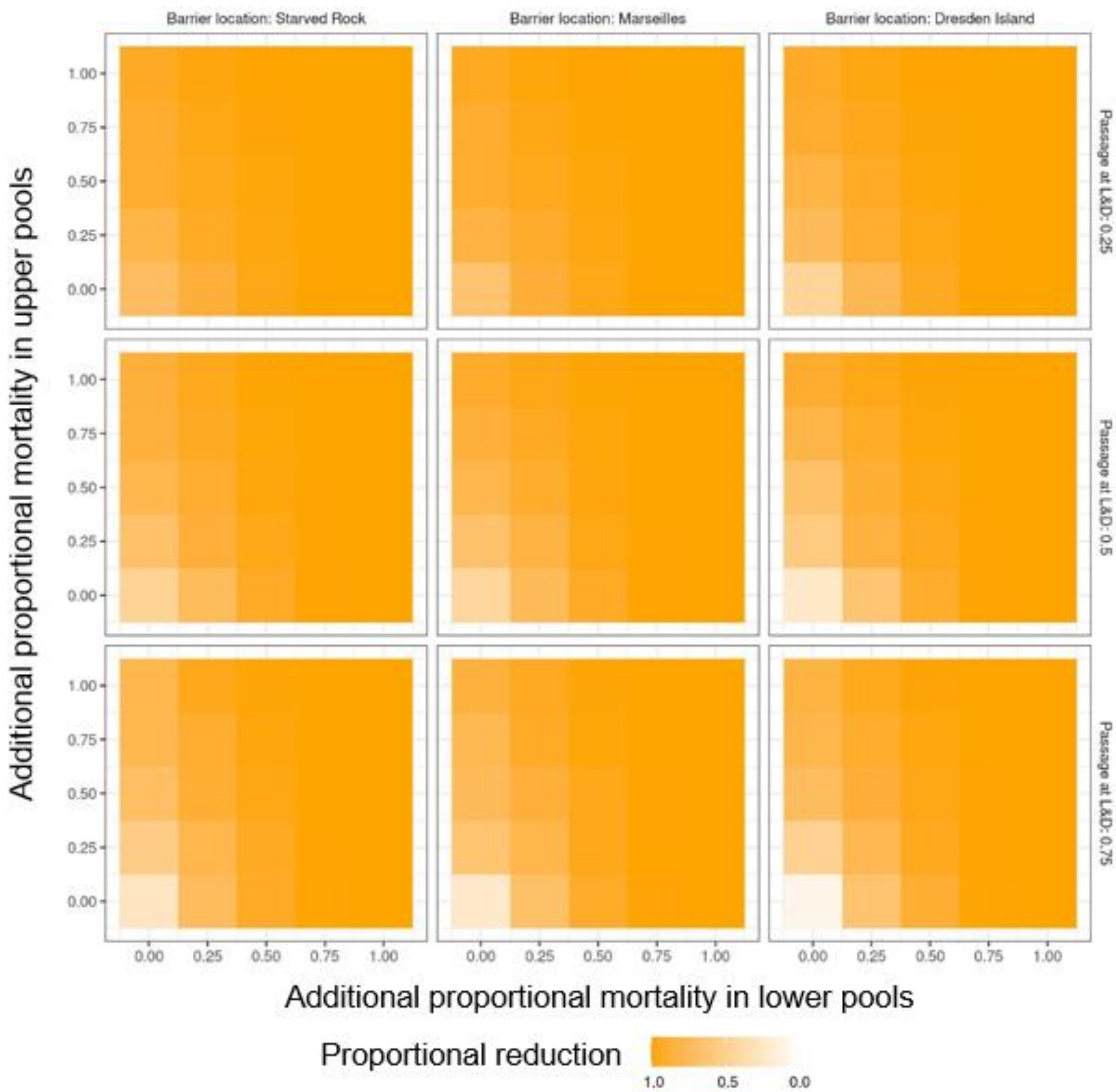


Figure 3. *Mean proportional reduction relative to the no-action scenario in Dresden Island Pool for additional mortality scenarios (i.e., additive mortality for Silver Carp ≥500 mm TL) and upstream movement deterrence (0.25, 0.5, and 0.75 of baseline values; all sizes).*

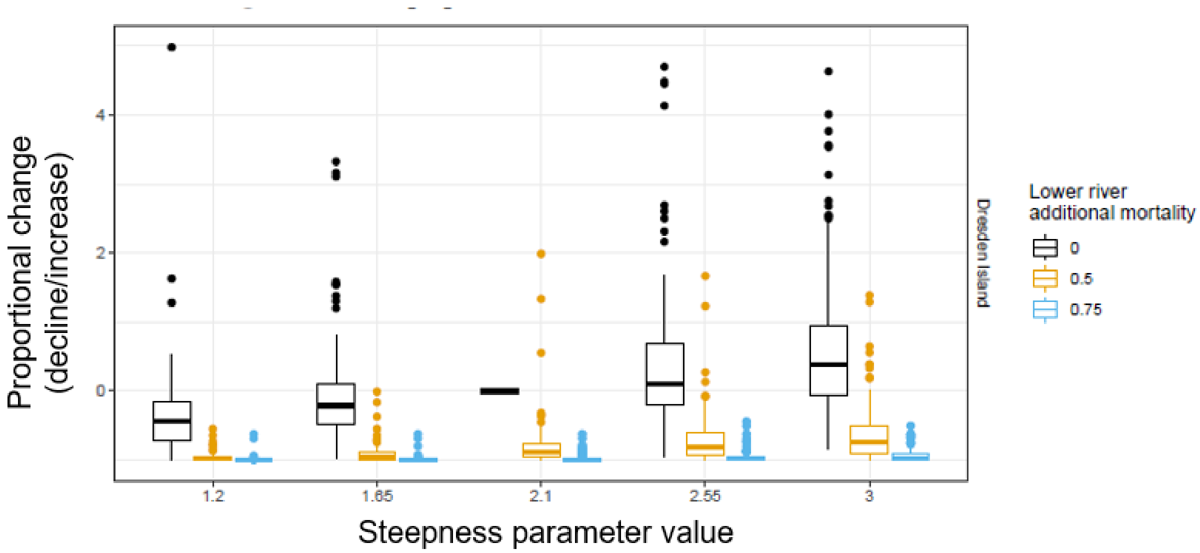


Figure 4. *Boxplots of proportional change relative to the no-action scenario in Dresden Island Pool population size for lower pool additional mortality scenarios (i.e., additive mortality for Silver Carp ≥500 mm TL) and varying steepness values. A literature-based steepness value of 2.1 was used in all other simulations. Positive values indicate population increases whereas negative values indicate population declines. Distributions are based on 1,000 iterations per scenario.*

Telemetry Support for the Spatially Explicit Asian Carp Population Model

Eric J. Brossman and Nathan T. Evans (U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office, Wilmington Substation

Participating Agencies: U.S. Fish and Wildlife Service (USFWS), Carterville Fish and Wildlife Conservation Office, Wilmington Substation

Pools Involved: Peoria

Introduction and Need:

The Spatially Explicit Asian Carp Population (SEACarP) model was developed as a means of assessing Asian carp population status in the Illinois Waterway (IWW). Movement is the backbone of the SEACarP model and is the primary source of information about how researchers expect the population to respond to management strategies. Therefore, the model functions as an important tool that can be used by fisheries managers to inform harvest and control of adult Asian carp (Silver Carp and Bighead Carp) in the IWW. Because harvest effects such as changes in fish density and size distributions are likely to impact movement and will thus influence our ability to predict population responses, continued monitoring of Asian carp movement in the IWW is necessary. In 2020, due to safety concerns surrounding the COVID-19 pandemic, the USFWS did not implant acoustic transmitters in any Asian carp. However, USFWS collected telemetry data via five 69 kHz receivers dispersed throughout Peoria Pool and uploaded this data to the FishTracks database. Moreover, USFWS worked with the transmitter manufacturer to delay tag production and delivery of the transmitters ordered in 2020 until March 2021. These tags will be implanted in Illinois River Asian carp as soon as is safely possible. This telemetry data complements telemetry data being collected throughout the IWW describing inter-pool transfer of adult Asian carps and is used to parameterize the transition probability component of the SEACarP model. This research provides an improved understanding of Asian carp movement in the IWW and its effects on population dynamics.

Objectives:

(1) Tag ≥ 150 individual adult Asian carp between 350 mm and 550 mm TL within Peoria Pool.

(2) Deploy and maintain an array of five 69 kHz receivers throughout Peoria Pool.

(3) Provide data from acoustic receivers to the Telemetry Work Group of the Monitoring and Response Work Group for use in the SEACarP model.

Telemetry Support for the SEACarP Model

Project Highlights:

- Due to safety concerns surrounding the COVID-19 pandemic, USFWS did not implant acoustic transmitters in any Asian carp in 2020.
- Data from the five 69 kHz acoustic receivers were collected, processed, and provided to the Telemetry Work Group.
- 150 V-9 acoustic transmitters were ordered with delivery rescheduled for March 2021.

Methods:

The acoustic receivers were collected throughout the fall of 2020 and the data were downloaded to the FishTracks database in December 2020. The receivers will be redeployed with the beginning of the new monitoring season in early Spring 2021.

Results and Discussion:

A total of 23,706 detections from 62 adult Silver Carp were recorded across the five USFWS-maintained 69 kHz receiver array in 2020. All detections came from two 69 kHz receivers in the Peoria Pool (Peoria Narrows and Henry Marina) (Figure 1). All data were uploaded to the Fish Tracks database in December 2020.

Future Work:

Support of the SEACarP model through this project will continue into FY 2021. USFWS - Wilmington will tag an additional 150 adult Asian carp between 350 mm and 550 mm in Starved Rock Pool and Peoria Pool. Future work will include expanding the array coverage to include a minimum of six 69 kHz receivers. The Monitoring and Response Work Group Telemetry Work Group will be consulted prior to deployment to optimize placement within the IWW.

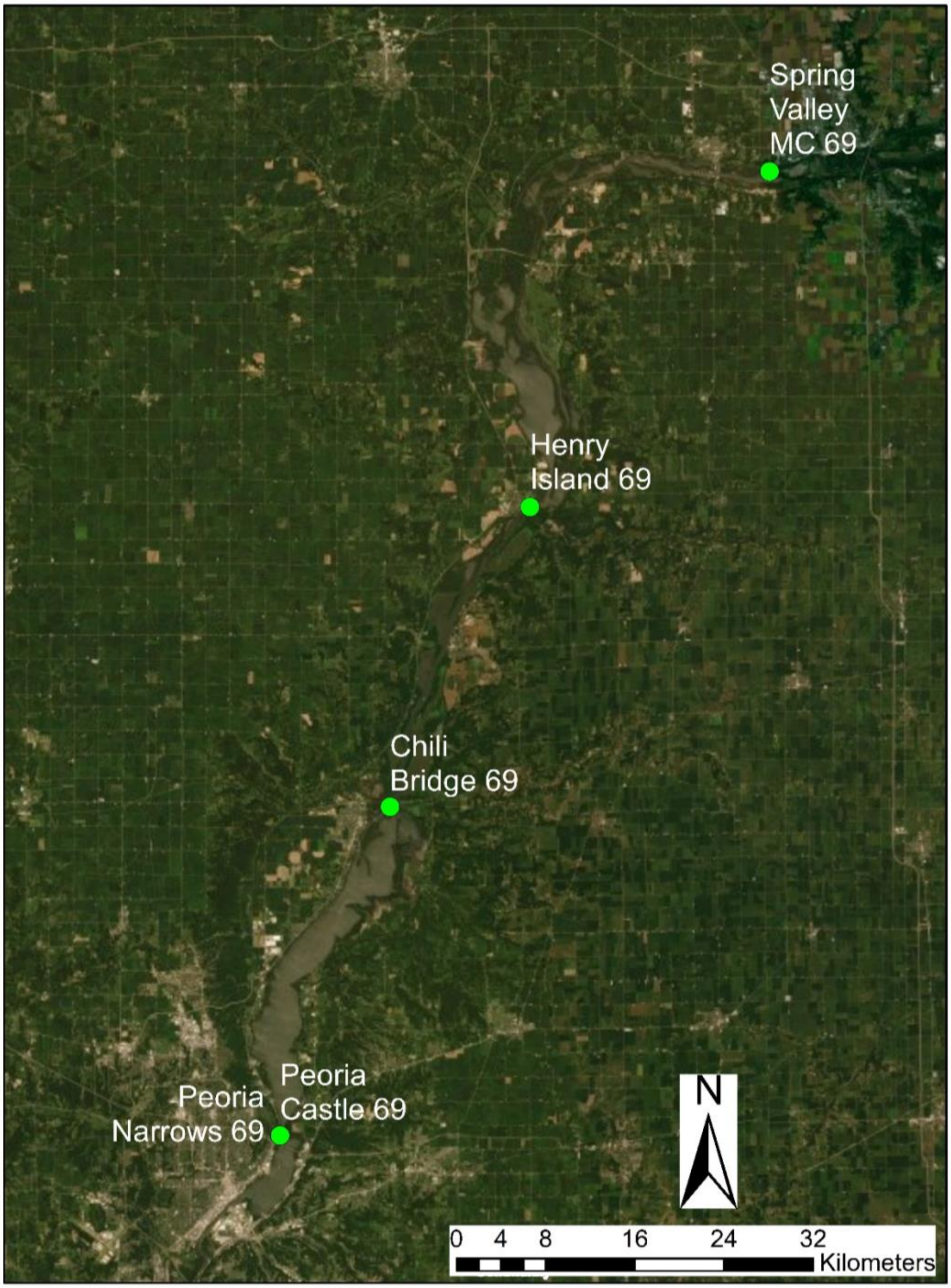


Figure 1. *Map of USFWS-maintained 69-kHz acoustic receivers deployed in Peoria Pool throughout 2020.*

Asian Carp Demographics

Edward Sterling, Jahn Kallis, Bryon Rochon, Jacob Griffin, Jason Goeckler (U.S. Fish and Wildlife Service, Columbia Fish and Wildlife Conservation Office)

Participating Agencies: U.S. Fish and Wildlife Service-Columbia Fish and Wildlife Conservation Office (lead) and Illinois Department of Natural Resources

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

Introduction and Need:

The long-term effects of control measures on the abundance and distribution of Illinois River Asian carp is determined by the extent to which demographic rates (i.e., growth, recruitment, mortality, movement) are altered. To evaluate control success and predict population level responses to different control scenarios requires robust data sets and analyses. Examples include demographic data to test for predicted control effects (e.g., changes in sex ratio, growth, condition) and data to parameterize decision support tools such as the simulation-based Spatially Explicit Asian carp Population (SEACarP) model. Herein, we update Asian carp demographic data collected from the six lower pools of the Illinois River (Alton, La Grange, Peoria, Starved Rock, Marseilles, and Dresden Island) during spring and fall 2018 and 2019 with fall 2020 data from Alton, La Grange, and Peoria pools. The primary goal of these collections were to address data gaps including information on Asian carp size at maturity and growth and to provide a comprehensive dataset that can be used to evaluate success of ongoing and future control efforts using multiple indicators.

Objectives:

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

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

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

(4) Provide data to update parameter estimates associated with the SEACarP model.

(5) Identify advantages and limitations of using dozer trawl to inform hydroacoustics data by comparing species composition and size structure from dozer trawl collections with those from capture gears currently being used to inform hydroacoustics (i.e., gill and trammel nets, electrofishing).

Project Highlights:

- Collected over 4,500 Silver Carp from six pools of the Illinois River during 2018 – 2020 and processed nearly 700 aging structures. 1,307 Silver Carp were collected from the lower three pools of the Illinois River during fall 2020 with the electrified dozer trawl.
- Contributed to the comprehensive Asian carp dataset using Silver Carp captured from three pools of the Illinois River with the electrified dozer trawl. Standardized data collections included length, age, sex, and relative abundance.
- Provided data useful to measure population responses to changes in management strategies.
- Coordinated with the MRWG Monitoring Work Group to share age and maturity determination procedures.
- Coordinated with the Illinois Natural History Survey (INHS) to provide recommendations on precision and accuracy of Asian carp ageing structures.
- Confirmed the electrified dozer trawl as an effective standardized method for demographic data collection.

Results and Discussion:

Herein, we report summary results from field sampling conducted by the USFWS Columbia Fish and Wildlife Conservation Office (Columbia FWCO) and age estimates from the laboratory. Results from fall 2018 and 2019 collections were updated with the addition of 2020 data. Laboratory and field data have been incorporated into the larger demographics dataset managed by the Monitoring and Response Work Group (MRWG) modeling sub-workgroup and used to update parameter estimates in the SEACarP model.

1,307 Silver Carp (1,303 stock sized individuals) were collected from the lower three pools of the Illinois River during fall 2020 with the electrified dozer trawl (Hammen et al. 2019; Table 1). Total effort was 149 5-minute trawls. Due to COVID-19 restrictions, Starved Rock, Marseilles, and Dresden Island pools were not sampled.

Table 1. *Fall 2020 summary data including pool-specific effort (number of 5-minute trawls), Silver Carp total catch (number), mean Silver Carp catch per unit effort (number/h) and standard error, and total length (TL) range of Silver Carp captured. Results are based on fishery-independent sampling using the electrified dozer trawl.*

Pool	Season	Effort (#)	Total catch (#)	Mean CPUE (SE)	TL range (mm)
Peoria	Fall	49	796	195 (43)	(125-760)
La Grange	Fall	50	388	92 (12)	(310-741)
Alton	Fall	50	123	28 (5)	(270-780)

Relative Abundance

Project Objective 1 included the quantification of Silver Carp relative abundance. Temporal patterns in Silver Carp catch rates of stock-sized individuals (250+ mm total length (TL); Phelps & Willis 2013) varied among pools. Alton and Peoria pool catch rates averaged approximately 100 Silver Carp per hour during 2018 and 2019, but shifted dramatically during 2020, decreasing in Alton Pool and increasing in Peoria Pool (Figure 1). La Grange Pool catch rates averaged approximately 100 Silver Carp per hour during 2018 and 2020 but were considerably lower during 2019.

Catch rates vary in response to population size, fish catchability, or a combination of these factors. Relative abundance expressed as catch per unit effort is proportional to population size, provided catchability is constant across samples. To evaluate the assumption of constant catchability, mean temperature and water level data were examined, which suggest that catchability likely varied among pools and years. Mean water temperature was consistent among pools during 2018 and 2019, varying less than 5° C. Water temperatures in Alton, La Grange, and Peoria pools were approximately 15° cooler during 2020 sampling. River stage was consistent in Peoria Pool during 2018 – 2020 but varied among years in Alton and La Grange pools. Relative to fall 2018 and 2019 levels, which were comparable, river stage was down 10 feet during 2020 in Alton and La Grange pools.

In addition to variation is fish catchability, pool-specific catch rates were likely influenced by mortality and pool-to-pool movement rates. This conclusion is based on previous research, including work in the Illinois River, which revealed that Silver Carp move readily in large river systems (Coulter et al. 2018, Norman & Whitledge 2015). In addition to movement, total mortality (natural, fishing) likely influenced annual catch rates through its effects on fish loss. Although recruitment events can drive population increases, our data demonstrated no evidence that pool-specific abundances increased considerably because of reproduction (see length-frequency distributions, Figures 2, 3).

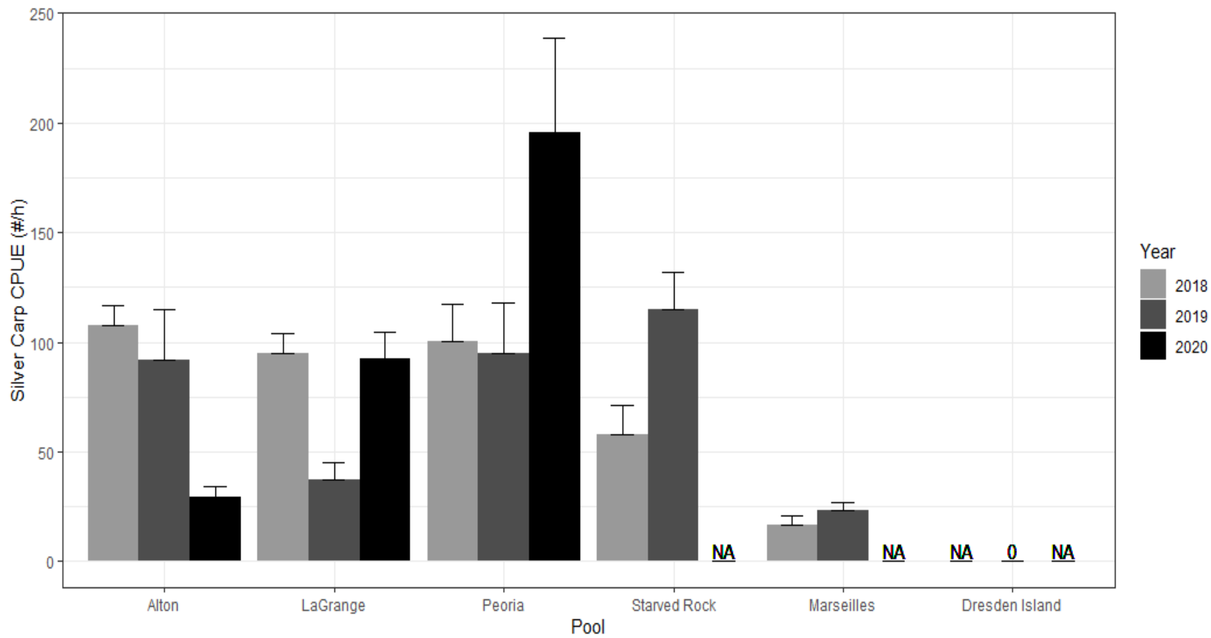


Figure 1. *Mean Silver Carp catch per unit effort (number/hour) and standard error. All fish were sampled using the electrified dozer trawl during fall 2018-2020.*

Length Structure

Silver Carp catches were dominated by individuals greater than 450 millimeters (mm) TL in all pools, regardless of sampling year (Figures 2, 3). Length structure data were consistent with populations exhibiting source-sink dynamics. Individual fish lengths corresponding to sub-stock sizes were captured from pools located below Starved Rock Lock & Dam (source populations) whereas captures from pools located above Starved Rock Lock & Dam (sink populations) were devoid of sub-stock sizes. Among source populations, fish in the Alton and La Grange pools were comparable in size but were generally larger than fish in the Peoria Pool (Figure 2).

Length frequency data were used to explore spatial and temporal recruitment patterns. Patterns in annual pool-specific catches of sub-stock sized fish suggest that there was little to no recruitment associated with the 2019- or 2020-year classes, but relatively high recruitment associated with the 2018-year class in the Alton and La Grange pool populations (Figure 3). This conclusion is further supported by 2019 and 2020 data, which show progression/growth of the 2018-year class.

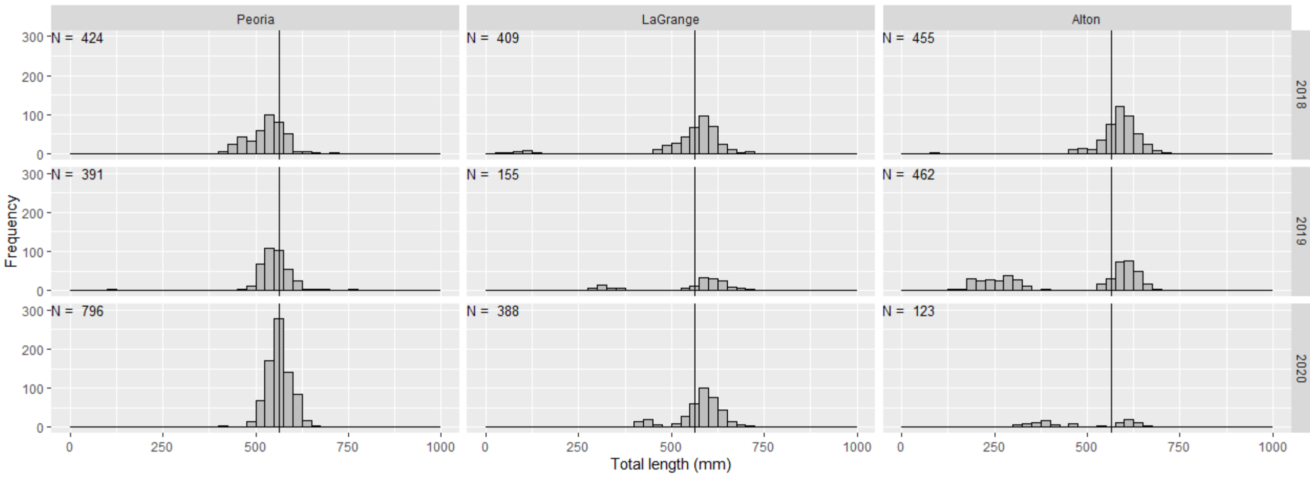


Figure 2. *Length-frequency histograms and total catch (N) of Silver Carp sampled from Starved Rock, Marseilles and Dresden Island pools (upper pools). All samples, excluding the Dresden Island 2019 sample (collected using commercial gillnets) were collected using electrified dozer trawl during fall 2018-2019. The vertical black line represents the overall mean length captured between all pools in 2018-2020.*

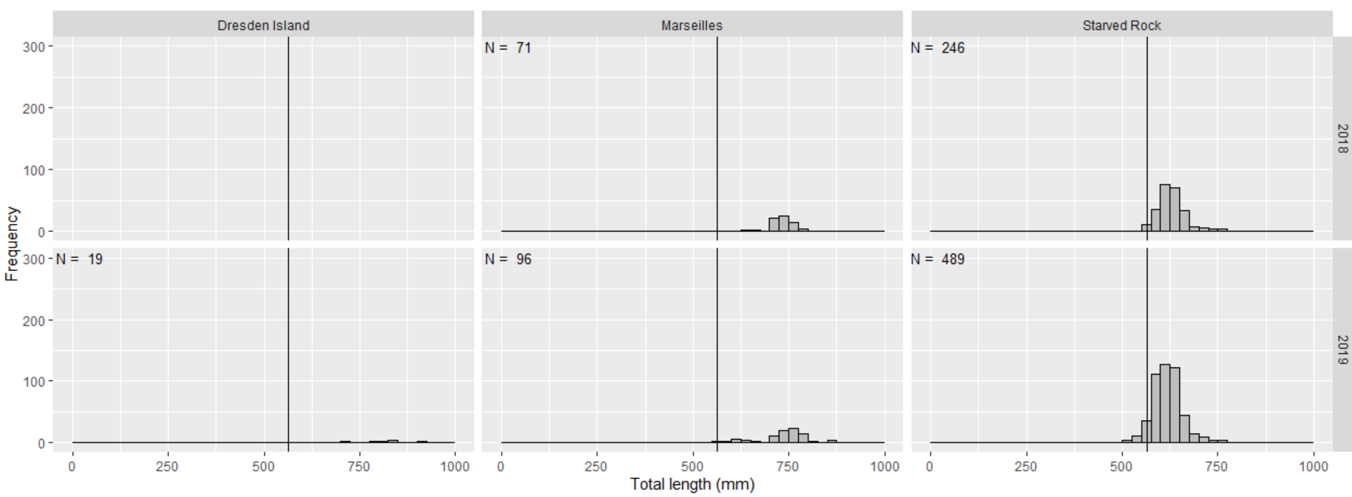


Figure 3. *Length-frequency histograms and total catch (N) of Silver Carp sampled from Alton, LaGrange, and Peoria pools (lower pools). All samples were collected using electrified dozer trawl during fall 2018-2020. The vertical black line represents the overall mean length captured between all pools in 2018-2020.*

Condition

We examined how fish condition (i.e., relative weight) varied across pools and among sampling years using a standard weight equation for Silver Carp (Lamer 2015). Relative weight is calculated by dividing individual fish weight by the standard weight of fish of the same length. Relative weight standards are often generated using a 75th regression line percentile approach (Murphy et al. 1991), however, the Silver Carp relative weight equation was developed using a 50th percentile approach (Wege and Anderson 1978, Lamer 2015), which defines a relative weight of 1.00 as an average condition fish. Median relative weight ranged 0.99 (lower pools) – 1.01 (upper pools) indicating that Silver Carp populations in the Illinois River were in slightly below average condition in the lower pools and slightly above average condition in the upper pools. Relative weights of fish captured downstream of Starved Rock Lock & Dam did not vary across pools or sampling years. A similar pattern was detected in fish captured upstream of Starved Rock Lock & Dam (Figure 4).

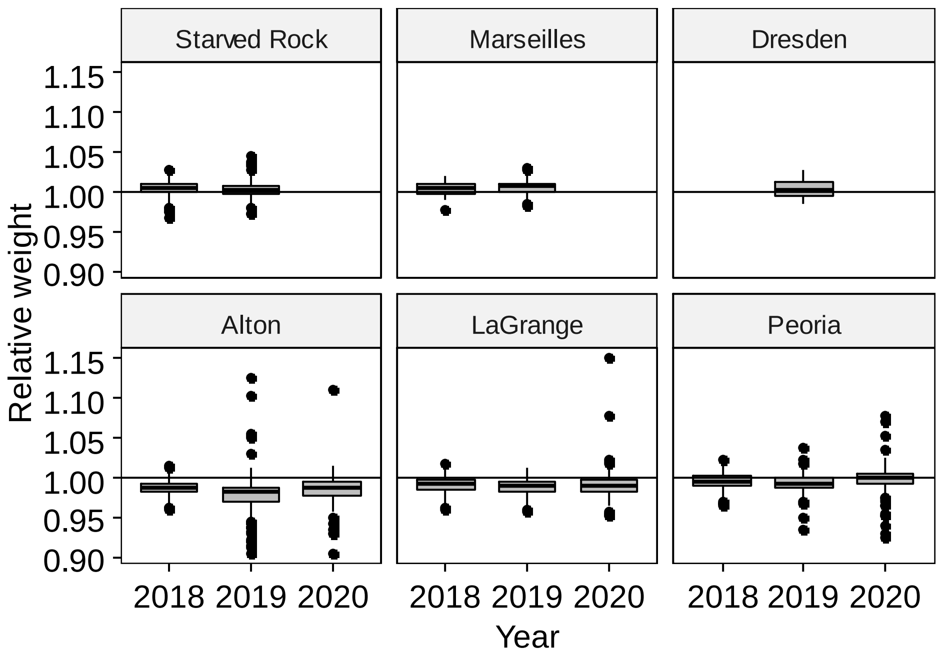
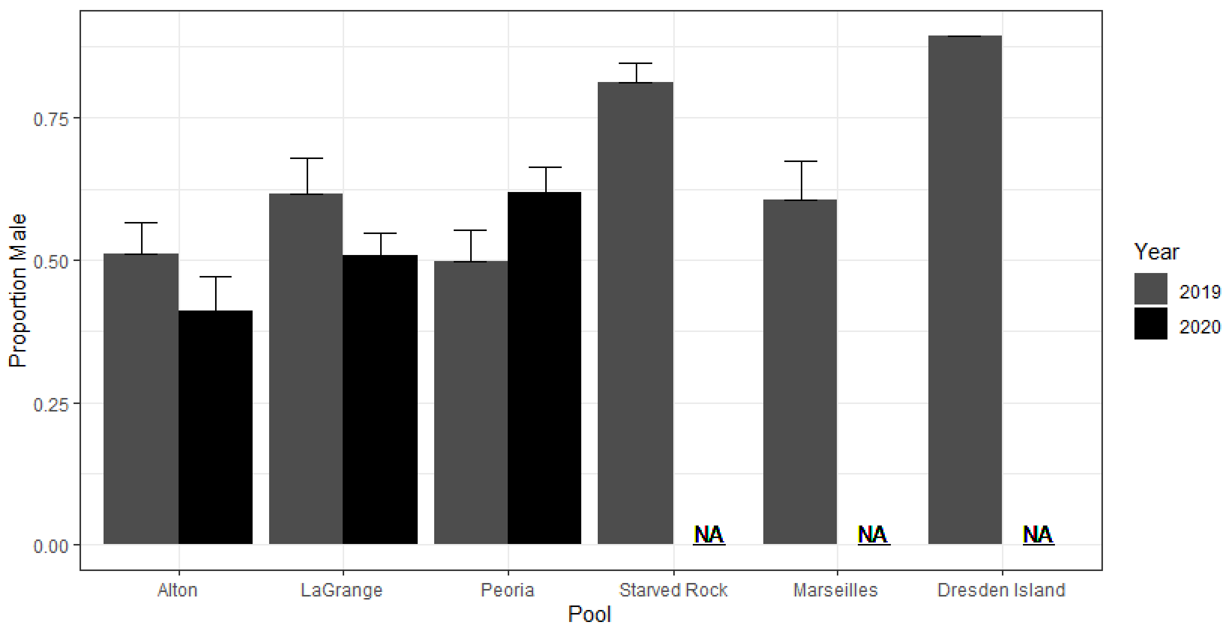


Figure 4. *Boxplots of individual Silver Carp relative weight data by pool and sampling year. All fish were sampled using electrified dozer trawl during fall 2018-2020, except for Dresden Island fish (N = 19), which were collected using commercial gill nets.*

Sex Ratios

Data on the sex of individual fish were collected during spring and fall sampling efforts. The goal of these data collections was to provide (1) baseline sex ratio data across pools, (2) data to evaluate the potential implications of using sex-independent demographic rates (e.g., growth, length-weight) in population models, and (3) data to test for potential shifts in population sex structure in response to harvest. For example, exploited populations can be male-dominated due to size-based sexual dimorphism and size-biased harvest that preferentially removes large-bodied individuals (e.g., Fenberg and Roy 2008). We expected that if the Illinois River commercial harvest program was influencing sex ratios, the proportional catch of male individuals would be lower in pools that did not receive intensive contract commercial harvest pressure (i.e., Alton, La Grange, Peoria) during 2019 relative to those that did (i.e., Starved Rock, Marseilles, Dresden Island). With exception to Marseilles Pool, 2019 results were generally consistent with our prediction (Figure 5). Proportion male was higher in pools upstream of Starved Rock L&D relative to downstream pools. Due to COVID-19 sampling restrictions, comparisons between pools upstream and downstream of Starved Rock Lock and Dam were not possible in 2020. However, increased harvest in Peoria Pool initiated in 2020 (Project: Enhanced Contract Fishing in Peoria Pool, Asian Carp Regional Coordinating Committee [ACRCC]-MWRG 2020) was consistent with our prediction. Whereas proportion male declined slightly in Alton and La Grange pools, proportion male in Peoria Pool increased somewhat (Figure 5).

Figure 5. *Pool specific means and standard errors describing the proportion of Silver Carp males in the total catch for Alton, La Grange, Peoria, Starved Rock, Marseilles, and Dresden Island pools. All fish were sampled using electrified dozer trawl during fall 2019-2020, except for Dresden Island data (N = 19 individuals), which were collected using commercial gill nets.*



Maturity Status

Similar to other length- or age-structured population models, the SEACarP model incorporates a size at maturity relationship and uncertainty to estimate recruitment during each annual time step. Despite a large data set (approximately 43,000 fish) the number of immature fish available for analysis remains low (6 males, 24 females). Due to COVID-19 restrictions, spring collections were cancelled. Consequently, we were unable to collect maturity status data during 2020. Maturity status will be evaluated during 2021 sampling.

Age Data

Objective 2 of our project sought to build a large age structure dataset using lapilli otoliths from fall caught fish to improve age-based estimates. We processed 141 samples in 2018, 350 samples in 2019, and 201 samples in 2020 (Figures 6, 7). This includes fish collected during a 2018 intensive removal effort in Peoria, Marseilles, and Dresden Island pools. Age data collected under this project will be incorporated into larger Asian carp data set managed by the MRWG modeling workgroup and used to estimate demographic rates (i.e., Erickson et al. *in revision*) for purposes of monitoring status and trends and population modeling.

Figure 6. *Pool specific length at age data in Starved Rock, Marseilles, and Dresden Island (upper pools) pools of the Illinois River. Fish were collected during fall 2018, and 2019 using a combination of electrified dozer trawl and commercial gill nets.*

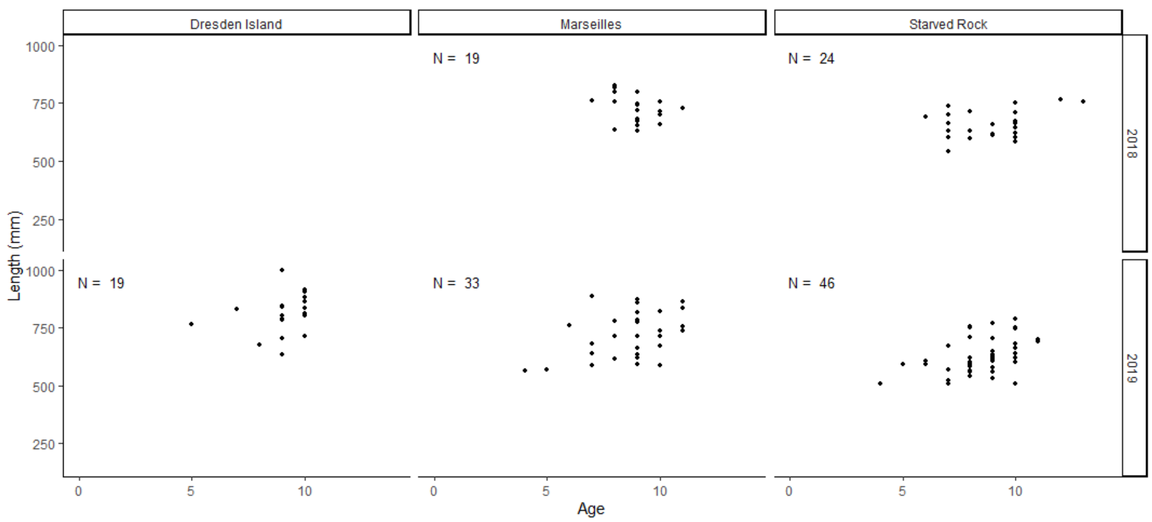
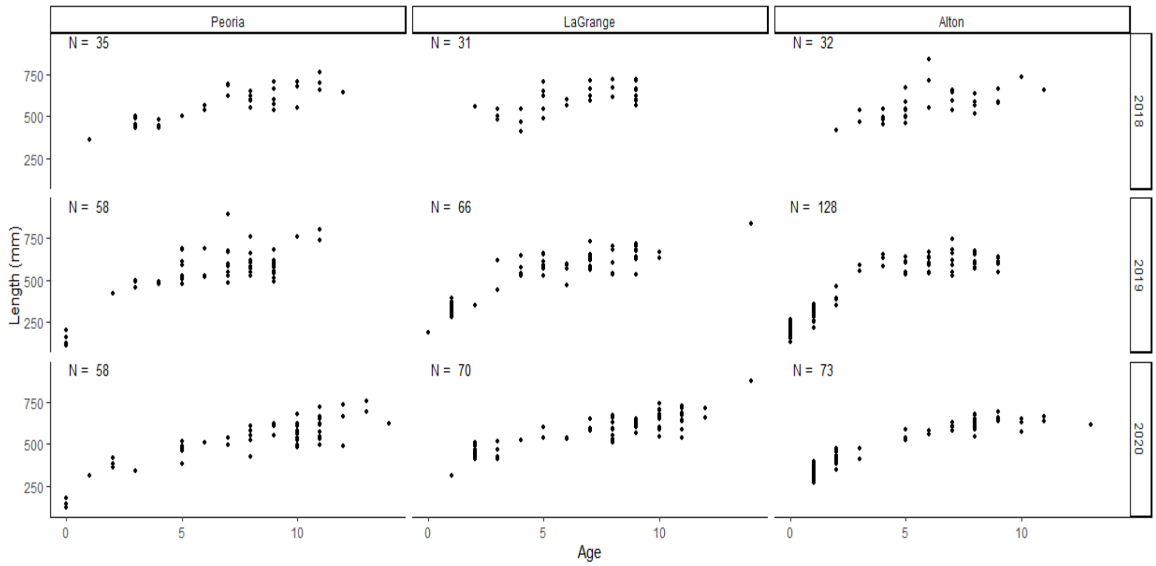


Figure 7. *Pool specific length at age data in Alton, La Grange, and Peoria (lower pools) pools of the Illinois River. Fish were collected during fall 2018, 2019, and 2020 using a combination of electrified dozer trawl and commercial gill nets.*



Informing Hydroacoustics

Mobile hydroacoustics surveys are used to track Asian carp population changes in the Illinois River (Project: Using Long-term Asian Carp Abundance and Movement Data to Reduce Uncertainty of Management Decisions, ACRCC-MWRG 2018). To derive density estimates, hydroacoustics must be paired with conventional capture gears, such as gillnets and electrofishing. There remains a need, however, to evaluate how alternative gears, such as dozer trawl would impact hydroacoustics estimates (Objective 5). Dozer trawl effects on hydroacoustics estimates were explored by following the general procedures described in MacNamara et al. (2016). More specifically, we used dozer trawl data to calculate Marseilles Pool Silver Carp proportional catch using 50 mm length bins and compared our results to combined gillnet and electrofishing data. Proportional catch in approximately 70 percent of length bins were similar, varying less than 10 percent. Disparities existed in the smallest two length bins (550 – 600 mm, 600 – 650 mm). Whereas dozer trawl Silver Carp proportional catch was 0.83 and 0.91, proportional catch from combined electrofishing and gillnet was 0.07 and 0.63. These results suggest that Silver Carp density estimates would increase with the addition of dozer trawl data.

Asian Carp Demographics

Recommendations:

Herein, we described results from three years of fisheries-independent biological collections. We recommend continued monitoring of Asian carp populations in order to evaluate impacts to native species, trigger response actions (e.g., Contingency Response Plan), evaluate control efforts, and explore management alternatives using model-based tools. We recommend coordination with MRWG work groups to ensure monitoring objectives are being addressed efficiently and with minimal redundancy. Further, we recommend utilizing the data described herein to evaluate effectiveness of control actions (for example, use of fisheries assessment models to quantify fishing mortality). Collaboration with other workgroups to address critical knowledge gaps is recommended. For example, age data collected through this project can be utilized in combination with hydroacoustics data to describe the relationship between stock and recruitment, which is critical to understanding how populations below Starved Rock Lock & Dam will respond to harvest. Given that the dozer trawl is more efficient at capturing Silver Carp than conventional boat electrofishing (Hammen et al. 2019), we recommend using standardized dozer trawl data in combination with other data sources to inform hydroacoustics surveys. Lastly, because results from highly mobile species such as Asian carp are often confounded by movement patterns, we recommend continued efforts to understand pool-to-pool transition rates.

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Evaluation of a Modular Electric Deterrent Barrier

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

Pools Involved: Not applicable

Introduction and Need:

Electric barriers have been used to impede or direct the movements of fishes for many years. However, almost all electric barriers used by fisheries agencies are constructed at fixed locations and are therefore stationary. Stationary electrical barriers on the Chicago Sanitary and Ship Canal (CSSC) currently serve as a line of defense in blocking the expansion of Asian carp into the Laurentian Great Lakes. Although useful for specific control purposes, such designs lack spatial flexibility and thus the capacity for adaptive management applications. Modular electric barriers may provide managers with the option to deploy control measures in a variety of locations to achieve various management objectives. A modular deterrent barrier was procured by INHS from Smith-Root, Inc. with the intent of aiding fisheries managers in inhibiting the movement of Asian carp in appropriate locations. Because habitat and environmental conditions (e.g., conductivity, waterbody dimensions) vary spatially, the modular system can potentially be adapted to generate a suitable electric field for deterring fish movements under a variety of situations. The modular electric barrier may be suitable for management scenarios including blocking entry into specific habitats during critical time periods and directing fishes into entrapment or entanglement gears during intensive harvest operations. Before routine deployments of this modular barrier can be performed, measures must be taken to evaluate the effectiveness of the barrier system at deterring Asian carp and other fishes, assess the voltage gradients produced by this system in a natural waterway to identify potential gaps in coverage and better understand the gradient of electrical energy that fish will encounter when confronting the barrier, and thoroughly develop field and safety protocols. This project will evaluate the effectiveness of the modular electric barrier system at preventing passage of Asian carp, and provide guidelines for the transport, deployment, and safe operation of the barrier. Findings will aid decision-making by management agencies regarding deployment of this control system, which will contribute to broader efforts to prevent the spread of Asian carp.

Objectives:

(1) Evaluate the effectiveness of a modular electric deterrent barrier for inhibiting passage of Asian carp and other fishes, develop operational protocols, and identify operational costs and constraints.

(2) Conduct field trials to map the electric field produced by the modular electric barrier and develop deployment guidelines for the optimal use of the barrier system.

Project Highlights:

- A modular electric deterrent barrier system has been procured by INHS. Because this barrier system is modular, it can be transported and deployed at a variety of locations. This system consists of a series of pulsers, generators, and winch-housed electrode cables that can be scaled to produce an electric field capable of deterring fishes across a range of waterbody conductivities and channel dimensions.
- A field deployment of the modular electric barrier in 2020 determined that sufficient voltage gradients (i.e., > 1.0 V cm^{-1}) for deterring the movements of Asian carp were produced at and near the electrodes when the barrier was operated at recommended settings. Voltage gradients between 0.5 – 1.0 V cm^{-1} were observed up to 3 m downstream of the anode, which should provide an incrementally increasing deterrent for further advancement into the electric field before maximum voltage gradients are encountered. The field produced by the modular barrier system is therefore suitable for the purposes of controlling movements of Asian carp.
- INHS has produced deployment guidelines that should provide a thorough overview of the considerations, planning, and procedures that are required to operate the modular barrier system. The modular electric barrier system should be available to partner agencies for use at locations where preventing passage of Asian carp or other invasive fishes has been determined to be a high priority, and where other deterrent measures are not sufficient or readily available to achieve desired objectives.

Methods:

The modular electric barrier system consists of nine pulser cabinets, five generators, and two electrode cables housed on electric barge winches. Generators provide power to the pulser cabinets that convert AC waveforms into pulsed-DC waveforms and modulate power output to the electrodes. Pulser cabinets have an operating system that allows the user to adjust voltage, duty cycle, pulse frequency, and waveform (e.g., pulse, burst). The anode and cathode cables run parallel on the bottom of the waterbody and create a horizontal electric field, with current running between the electrodes to form an arc from the bottom to the surface. The system is scalable, such that the number of pulsers and generators can be varied to produce an effective electric field across a range of water conductivities and channel dimensions.

During 2020, INHS personnel deployed the modular electric barrier during dry ground conditions within a non-meandering section of the Lost Fork of Skillet Creek located adjacent to the Sam Parr Biological Station (Marion County, IL). Two pulsers and one 22-kW three-phase generator were required to produce a suitable electric field based on the maximum water depth (1 m) and ambient conductivity (300 µS cm^{-1}) at the study site. A tractor was used to maneuver all barrier components into place, and the winch cable electrodes were placed on the bottom of the stream perpendicular to the bank and spaced 2 m apart. The upstream electrode served as the anode and the downstream electrode served as the cathode. A fiber optic cable was used to connect pulsers for communication and synchronization of pulsed power delivery. Power delivery settings used for the field deployment were those recommended by Smith Root, Inc. for effective deterrence of Silver Carp. Pulsers were set at a 7% duty cycle (percentage of on time) and 60 Hz using a standard pulsed square wave. Voltage of each pulser was first set to 690 DC V and then adjusted by single volt increments (fine voltage adjustments were made to keep output current balanced between pulsers), with a resulting output current of 70 – 76 A.

INHS personnel measured voltage gradients (V cm^{-1}) at the water surface along the cross-section of the stream 1 m upstream of the anode, at the anode, 1 m downstream of the anode, at the cathode, 1 m downstream of the cathode, and within three downstream transects from the anode. Downstream transects were conducted 1 m off each stream bank and within the thalweg. Cross section measurements were recorded at 0.5 m intervals bank to bank and downstream measurements were recorded at 1-m intervals from 1 m upstream of the anode to 7 m downstream of the anode. All power settings were configured prior to conducting measurements. All measurements were conducted after a 60 s "soft start" where load on the generators was slowly ramped up to allow for proper output regulation of the generator's voltage and frequency as load increased. Measurements were made using an insulated probe with 3.05 m test leads mounted 1 cm apart on a 1.27 cm diameter PVC pipe and connected to a Fluke 87V industrial true-rms multimeter. At each measurement point, the probe was submerged to a depth of 5 cm and rotated 360° to find and record the maximum peak voltage.

Results and Discussion:

Sufficient voltage gradients (i.e., > 1.0 V cm^{-1}) for deterring the upstream movement of Silver Carp were observed at locations near the electrodes, but not upstream and downstream of the electrodes (Figure 1). The greatest voltage gradients were recorded immediately above the anode and cathode. Along the shallow bank, where depths were 0 – 0.5 m, voltage gradients at the surface exceeded 6 V cm^{-1}. Within both of these transects however, voltage gradients fell below 1.0 V cm^{-1} where depth was the greatest (i.e., in the thalweg at 1 m depth). The voltage gradients equidistant between electrodes did not exceed the peak gradients measured at the electrodes (maximum between electrodes = 2.6 V cm^{-1}), but unlike the electrode transects, between-electrode gradients never fell below 1.3 V cm^{-1} (Figure 1). Thus, an adequate barrier for deterring upstream movement of Silver Carp was achieved at and between the electrodes using the recommended settings for operation. Because field strength increased with proximity to the electrodes, these incremental voltage increases may also deter fish before maximum voltage gradients would be experienced at the electrodes. Voltage gradients below 1.0 V cm^{-1} but greater than 0.5 V cm^{-1} were detected a maximum of 3 m downstream of the anode. Voltage gradients were negligible (< 0.1 V cm^{-1}) at points greater than 7 m downstream of the anode.

The modular electric barrier system performed within expected parameters, producing voltage gradients that are actually higher than those produced by the electric deterrent barrier system on the CSSC (Holliman 2011, Parker et al. 2015), which should be sufficient to deter passage by

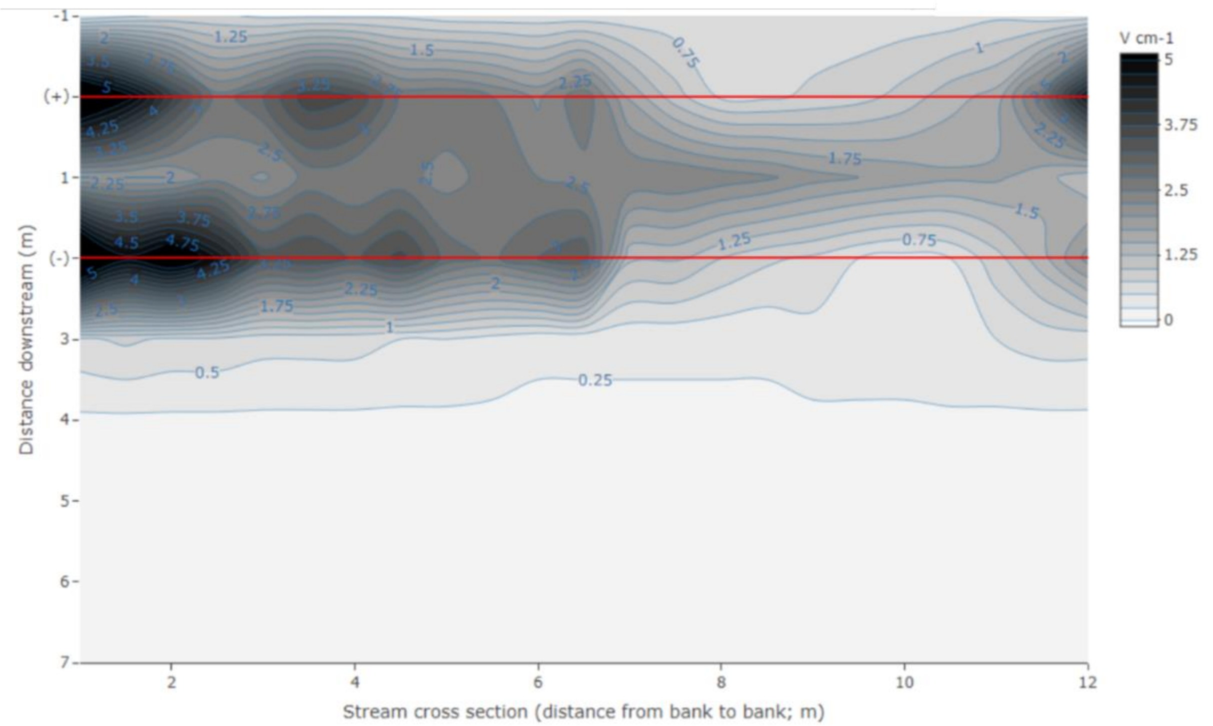

Figure 1. *Map of the electric field produced by the modular electric barrier during deployment in the Lost Fork deployment.*
Red lines represent location of each electrode. Voltage gradients (V cm^{-1}) were measured at the water surface along the cross-section of the stream at 1 m upstream of the anode (-1), at the anode (+), 1 m downstream of the anode (1), at the cathode (-), 1 m downstream of the cathode (3), and within three downstream transects 0-7 m from the anode. Data beyond 1 m downstream of the cathode are interpolated.

Asian carp and other fishes when in continuous operation (Holliman 2011). Previous pond trials demonstrated that the modular barrier system could prevent the majority of fish from entering the area immediately near the electrodes even when operating below recommended power settings, with the small number of fish detections within the electric field often resulting in mortality (Collins et al. 2018). However, the goal of a deterrent barrier isn't to kill fish, but to prevent their movements. Voltage gradients between 0.5 – 1.0 V cm^{-1} were observed up to 3 m downstream of the anode, which should provide an incrementally increasing deterrent for further advancement into the electric field before maximum voltage gradients are encountered. The field produced by the current modular barrier system when operating under recommended settings is therefore suitable for the purposes of controlling movements of Asian carp.

Surface voltage gradients scaled inversely with depth. This pattern was expected, as the electric current had to pass through a larger volume of water as depth increased. We deployed the barrier at a wadeable stream site to safely take detailed voltage gradient measurements. However, at sites with greater depths and channel widths, this relative pattern in voltage gradients between electrodes can be expected if the system is properly configured and standardized by the physical conditions to produce a 1.0 V cm^{-1} gradient at the water's surface. The scale of the barrier (i.e., number of components) should therefore be planned in advance based upon the maximum channel depth that is present at the deployment site in order to achieve a minimum threshold of voltage gradient throughout the waterbody. The location of the thalweg within the channel should also be considered, as the greatest electrical current transmission into the water will likely occur closest to the pulsers, following the path of least resistance. Thalweg voltage gradients might therefore be expected to be higher when the thalweg is on the same side of the channel as the pulsers, increasing barrier effectiveness. However, features of the channel bed and objects within the channel may distort the electric field, and could introduce gaps in coverage that fish could exploit. Metal-hulled boats are well known to distort electric fields in water and may allow fish passage during transit of an electric barrier zone (Dettmers et al. 2005, Sparks et al. 2011, Parker et al. 2015). Closed-hull boats are capable of passing through the barrier without substantial safety risk to passengers but may diminish barrier effectiveness. Boat traffic through the electric barrier zone should therefore be restricted whenever possible.

Fish size is well known to affect the ability of an electric field to immobilize fish (Dolan and Miranda 2003, Reynolds and Kolz 2012). Smith-Root, Inc. designed the modular electric barrier to deter "adult" Silver Carp and Bighead Carp. No minimum length threshold was provided by Smith-Root for this life stage. However, Holliman (2011) found that the current operating parameters of the CSSC deterrent barriers incapacitated Bighead Carp in the 46-72 mm size range. The measured field produced by the modular barrier system in this study therefore should prevent passage of all post-larval sizes of Asian carp, but all conditions that may be encountered at a deployment site should be carefully considered in order to ensure effective deterrence. Small juvenile Asian carp may be capable of swimming through gaps in the electric field if the system is not properly configured or the waterbody physical and/or chemical conditions exceed operating parameters.

Recommendations:

The modular electric barrier has been demonstrated to produce continuous field strengths that exceed the minimum thresholds found to deter passage by Asian carp (Holliman 2011). Pond trials also indicated that the modular barrier system was effective at preventing entry of Asian carp and other fishes into the area immediately near the electrodes (Collins et al. 2018). The experience gained in deploying this deterrent tool in both pond and field settings has also proven valuable for understanding the practical applicability of the system and potential pitfalls that fisheries professionals may encounter when attempting to use the modular barrier for invasive species management and control purposes. The modular electric barrier system should therefore be available to partner agencies for use at locations where preventing passage of Asian carp or other invasive fishes has been determined to be a high priority, and where other deterrent measures are not sufficient or readily available to achieve desired objectives. INHS has produced deployment guidelines that should provide a thorough overview of the considerations, planning, and procedures that are required to operate the modular barrier system. INHS personnel who have experience with operating the modular electric barrier may also be available to provide consultation on all aspects of the use of this system.

Although entirely capable of producing an electric field that will deter passage of Asian carp, the ultimate utility of the modular electric barrier is dependent on thorough consideration of the goals and objectives that an agency wishes to achieve, and a comprehensive accounting of the costs and tradeoffs associated with the use of this barrier. Careful consideration should be paid to the configuration guidelines for the system based on the physical dimensions and range of water conductivity expected at any deployment site. Not all locations within the Illinois Waterway or its backwaters, side channels, or tributaries are appropriate for deployment of this system because of prohibitively high-water conductivity. This system was not designed to replace or supplement the fixed barriers operating in the CSSC. Furthermore, the modular barrier system will require appropriate storage and maintenance of all its components to continue to operate effectively into the future.

Along with the system configuration required for a given deployment site, careful consideration should be paid to powering the system for extended periods of time, especially in remote locations where a three-phase – Y distribution system is not available. If connected to a three-phase – Delta distribution system, proper operation is not guaranteed. The current power sources (22 kW generators) require a considerable quantity (hundreds to thousands of gallons for multi-day deployments) of gasoline to operate for extended time periods, which must be factored into deployment costs. Other power sources (municipal three-phase – Y, and three-phase – Y propane or diesel generators) could potentially power the barrier system more efficiently and at lower cost, but Smith-Root, Inc. may need to be consulted and/or a qualified electrician may need to be contracted in order to implement appropriate power and phase conversions.

Any planned uses that may exceed the designed capabilities of the system or that may employ the electric barrier for purposes other than a static fish deterrent will require consultation with qualified engineers in order to make appropriate modifications and ensure system safety and efficacy. INHS does not currently recommend modification of this system for boat electrofishing. Despite these constraints, this electric barrier may have a number of potential applications, and additional modifications could allow for other uses for which the current barrier, as designed, was not originally intended. The modular barrier system may be useful for preventing entry of Asian carp or other fishes into backwaters, side channels, lock chambers, tributaries, or other areas where their presence is undesirable, or it may be able to guide fish into entrapment of entanglement gears to enhance harvest. This modular electric barrier provides another potential tool that is available for control and management of Asian carp populations in North America.

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Alternate Pathway Surveillance in Illinois - Law Enforcement

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Participating Agencies: Illinois Department of Natural Resources (IDNR, lead)

Pools Involved: Not applicable

Introduction and Need:

The IDNR Invasive Species Unit (ISU) was created as a specialized law enforcement component to the overall Asian carp project. ISU is staffed with two full-time Conservation Police Officers with a combined thirty plus years of law enforcement experience. ISU is dedicated to searching for illegal activities within the commercial fishing, aquaculture, transportation, bait, pet, aquarium, and live fish market industries. The ISU focuses its energies and resources on the likely pathways Asian carp could spread by human means. ISU has exposed the risks human activities bring to the entire Asian carp project by making significant arrests in nearly every industry it has investigated. An investigative law enforcement element benefits the entire project and creates an additional layer of protection to the waterways.

Objectives:

(1) Train Conservation Police Officers in aquatic invasive species enforcement techniques to increase law enforcement capabilities within the aquatic life industry.

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

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

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

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

Project Highlights:

- The owner of a Missouri fish farm previously charged with selling and shipping live tilapia to Illinois customers, which is in violation of fish importation regulations, entered into a deferred prosecution agreement with the Illinois Attorney General's Office and was ordered to pay $8,000 in restitution to the State of Illinois.

- A New Mexico fish farmer charged with multiple counts of shipping live tilapia to unapproved aquaculture facilities and without the required permits pled guilty to all counts and paid the designated fines.
- ISU investigated an anonymous complaint of a bait shop illegally selling frozen shad and Asian carp parts as bait. The investigation revealed the shad were illegally harvested from a prohibited area and the Asian carp bait violated Viral Hemorrhagic Septicemia regulations. The business was brought into compliance with all regulations.

Methods:

ISU generated enforcement activity based upon surveillance operations, on-site facility inspections, fish truck inspections, record audits, permit reviews, Internet monitoring, public complaints, agency personnel concerns, and outside agency cooperation.

Results and Discussion:

- ISU instructed Invasive Species and Aquatic Life Industry Enforcement Techniques to Conservation Police Recruit Class 20-27 at the Illinois State Police Academy.
- A total of 10 random commercial inspections of minnow dealers were conducted. Three were found to be operating with expired licenses. An aquaculture inspection identified a facility raising tilapia without the required letter of authorization. ISU caught two out-of-state fish farms illegally shipping live fish to Illinois customers without fish importation permits, and several customers stocked the untested fish in ponds. None of the commercial inspections located any live Asian carp in trade.
- ISU distributed AIS outreach materials to approximately 20 recreational fishermen during AIS boat and foot patrol details. No illegal live species of bait were found, but ISU received and answered many questions related to the use of live bait, including the use of injurious species.
- ISU investigated complaints pertaining to the following species: Asian carp, snakeheads, sharks, red swamp crayfish, marbled crayfish, rusty crayfish, yabby crayfish, roe bearing species, comet goldfish, and tadpole madtoms.
- ISU attended the Aquatic Life Resources Task Force meeting in St. Louis, Missouri to develop commercial fishing enforcement strategies for 2020. ISU participated in the Great Lakes Fishery Commission Law Enforcement Committee meeting to plan 2020 law enforcement projects. ISU completed training courses on the following topics: How interstate commerce laws affect cases involving the transfer and transportation of commercial fish and invasive species between different jurisdictions, digital forensics, the dark web, social media investigations, laws of arrest, and crimes in progress.

Alternate Pathway Surveillance in Illinois - Law Enforcement

Recommendations:

Encourage continued cooperation and communications with State and Federal partners to manage invasive species safely and effectively.

Asian Carp Enhanced Contract Removal Program

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

Pools Involved: Peoria Pool.

Introduction and Need:

The Asian Carp Regional Coordinating Committee and the Monitoring and Response Work Group recognize the value of increased harvest of Asian carp in the Illinois River informed by current fishery stock assessment data. Modeling from Southern Illinois University and the U.S. Fish and Wildlife Service have provided insights recommending that removal from downstream reaches can heighten protection of the Great Lakes by preventing fish population growth in upstream reaches.

Objectives:

(1) Aid in reaching a target removal rate of 20 to 50 million pounds of Asian carp per year from the IWW below Starved Rock Lock and Dam.

(2) Removal under the Enhanced Contract Fishing Program for 2019/2020 has a goal of 4.5 million pounds, while working toward a goal of removing 15 million pounds by 2022.

(3) Coordinate fishers and processors to increase cooperation with an end goal of increasing the scale of removal operations to satisfy larger orders for harvested Asian carp.

(4) Leverage other programs such as the Market Value Program to continue building increased demand for harvested Asian carp.

Project Highlights:

- Removed more than 3,300,000 pounds under this program from the Peoria Pool of the Illinois River.
- Entered into thirty-one contracts with Illinois-licensed commercial fishers targeting the Peoria Pool.
- Processed more than $330,000 in payments to fisherman.
- Selected a firm/team to create a Branding & Marketing Strategy and created a new name and logo for Asian carp. Preparation toward a launch event is well under way.

Upper Illinois Waterway Contingency Response Plan: Barrier Maintenance Fish Suppression

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Nathan Evans (US Fish and Wildlife Service – Carterville Fish and Wildlife Conservation Office, Wilmington Substation)

Nicholas Barkowski, John Belcik (US Army Corps of Engineers – Chicago District)

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).

Location: Lockport Pool near the Electric Dispersal Barrier System

Pools Involved: Lockport

Introduction and Need:

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.

All three barriers (Barrier 2A, 2B, and the Demo) 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 online 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 (EDBS) as a whole by maintaining power in the water continuously regardless of a lapse in operation at any single barrier. Due to the configuration of barriers A and B, there is a need to assess the risk of 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 length of 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 EDBS. 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. This Interim Summary Report outlines the number of changes in the EDBS operations that triggered a fish clearing decision by the MRWG, the decisions that were made by the MRWG, and the results of any actions taken in response to changes in EDBS operations.

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

(1) Remove fish >300 mm (12 inches) in total length from between applicable barrier arrays before maintenance operations are initiated at upstream arrays and after maintenance is completed at downstream arrays by collecting or from 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 in total length between applicable barrier arrays, if present, 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 arrays 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 a change in the known population front for this size class of invasive Asian carps.

Project Highlights:

- The MRWG agency representatives met and discussed the risk level of Asian carp presence at the EDBS at each primary barrier loss of power in the water.
- Two 15-minute electrofishing run were completed between Barriers 2A and 2B to supplement existing data in support of the MRWG clearing decision.
- **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. A change in operations at the barrier that results in a loss of power in the water less than one minute is considered to be too short of a duration to allow for upstream passage of fish. At the occurrence of any barrier outage greater than one minute, 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 known population front for this size class in any given year. 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 the EDBS, 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 by the MRWG for fishes to be removed from the barrier area when a clearing action was recommended. 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 10 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, 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 more 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 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. It should be noted that the presence of Asian carp less than 300 mm have been primarily captured in Peoria Pool with only one fish captured just upstream of Starved Rock Lock and Dam since 2017.

A key factor to any response is risk of Asian carp being at or in the EDBS. 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 EDBS 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.

Initial clearing action is likely to use split beam hydroacoustics and side scan SONAR imaging to determine if fish are present in the target area of the EDBS, including the area between Barrier 2A and 2B or between the active barrier array and the demonstration barrier. This action is aimed specifically at identifying the number of fish over 300 mm. This sonar scan may be completed upon request or the MRWG may decide to utilize the most recent data available as USFWS continues bi-weekly surveillance of the vicinity. If one or more fish targets over 300 mm are present, the MRWG will convene and decide if a clearing action is warranted for the area between affected barriers. Initial response to any loss of power to the water should occur within a week of the outage; upon completion of the sonar survey, fish detections, sizes, and locations will help formulate timely clearing efforts if deemed necessary. Additional clearing actions can range from nearly "instantaneous" response with electrofishing to combined netting and electrofishing, or any combination of other deterrent technologies that may or may not require

US Coast Guard (USCG) closures of the Canal/Waterway. The USCG generally requires at least a 45 day notice for requests to restrict navigation traffic in the waterway.

Results and Discussion:

In 2020, hydroacoustic scans at the barriers did not occur. COVID-19 restrictions prevented USFWS from safely conducting the scans and traditional monitoring in Lockport was used to assess risk.

During 2020, Demo, Barrier 2A and 2B were the primary barriers to fish passage in the upstream direction within the EDBS at various points during the year. A total of 14 outages occurred across all of the barriers during 2020. A majority of the outages were associated with planned maintenance events that are required to keep the barriers operating appropriately. These outages were all coordinated through the MRWG as USACE confirmed schedules. Outages by barrier, length of time and reason for outages are documented in Table 1).

In terms of maintenance, 10 planned outages occurred across all three barriers during 2020. Demo was taken offline from December of 2019 through 31 January, 2020 for maintenance. In an attempt to minimize outages, USACE scheduled dive operations and 2B annual maintenance to coincide with one another. Dive operations began on January 20th, 2020 to inspect the electrodes at both the Demo and Permanent Barrier 1. Due to safety concerns for divers, Demo (which was already off for annual maintenance) and 2B were shutdown. At the completion of dive operations on January 31st, Demo was re-energized and 2B remained off for the completion of annual maintenance. During the scheduled outages of Demo and 2B, 2A remained on for the entire time except one instance on 21 January 2020. A power outage at the Barrier Facility resulted in a 20-minute outage at 2A. Given the risk levels and the cold temperatures, it was determined that no action was required at that time. Once annual maintenance was complete, 2B was re-energized on 4 February 2020. 2A underwent annual maintenance from 18-26 February 2020 in which both Demo and 2B were operating. A planned outage at 2A occurred due to dive operations occurring at the NRG powerplant just downstream of the barriers. NRG asked USACE to shutdown 2A as an extra step of precaution for a dive operation. USACE obliged and 2A was off for a total of 5 hrs on 9 March 2020. 2A was shutdown again 4-12 May 2020 for maintenance to the cooling system. Two additional outages occurred at Demo and 2A for a controls inspection to prepare for planned outages associated with replacing barrier control equipment. Demo inspection occurred on 21 September 2020 and was off for a total of 4 hours and 2A was inspected from 9-11 November 2020. Since Demo was shutoff at this time, resulting in only 2B operating at the time, USACE voluntarily conducted a clearing action between 2A and 2B once 2A was re-energized after the inspection. USACE conducted two 15-minute electrofishing surveys and no fish were observed or captured during the surveys. Demo was then shutdown for controls replacement and subsequently annual maintenance from 2 November to

January 12th 2021. In total, only one clearing action was conducted for planned maintenance operations.

Overall, a total of 3 outages occurred outside of planned maintenance activities. The first to occur was the 20-minute outage already discussed in the previous paragraph. Once USACE was aware of the outage, the MRWG was informed. Another unscheduled outage occurred at 2A from 13-14 March 2020. A fault occurred at 2A and only the narrow array of 2A was down while the wide array continued to operate. In addition, 2B and Demo were in operation at the time as well. Given these circumstances, it was determined that no response was needed. Demo also experienced an unscheduled shutdown on 2 October 2020 for approximately 4 hours due to a system fault. Both 2A and IB were operational during that time and no clearing action was determined. Table one provides a summary of all the barrier outages in 2020.

Table 1: Summary of barrier outages. Unplanned outages are marked with an asterisk (*).

Barrier Outage Summary			
Barrier	**Start Date**	**End Date**	**Array**
Demo	12/18/2019	1/31/2020	n/a
IIB	1/20/2020	2/4/2020	Both
IIA*	21-Jan-20	1/21/2020	Both
IIA	18-Dec-20	2/26/2020	Both
IIA	9-Mar-20	3/9/2020	Both
IIA*	13-Mar-20	14-Mar-20	Narrow
IIA	4-May-20	5/12/2020	Both
Demo	9/21/2020	9/21/2020	n/a
Demo*	10/2/2020	10/2/2020	n/a
Demo	11/2/2020	1/12/2021	n/a
IIA	11/9/2020	11/11/2020	Both
IIB	11/30/2020	12/11/2020	Both
IIB	12/15/2020	12/16/2020	Both

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 low dose piscicides, complex noise generation, and other techniques.

APPENDICES

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

ILLINOIS NATURAL HISTORY SURVEY
PRAIRIE RESEARCH INSTITUTE

SIU CARBONDALE

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

Pools Involved: Brandon Road, Dresden Island, Marseilles, Starved Rock, Peoria, and LaGrange Pool and adjacent backwater lakes

Introduction and Need:

Due to their ability to efficiently filter large volumes of water and capture small particle sizes, Bighead Carp and Silver Carp can deplete zooplankton densities and alter zooplankton community composition (Sass et al. 2014; DeBoer et al. 2018), potentially competing with native fishes for food resources (Sampson et al. 2009) and altering flows of organic matter (Collins and Wahl 2017). The trophic impact of Asian carp is of great concern because of the importance of zooplankton as grazers as well as prey for fish early life stages and native planktivores. In the Illinois River, densities of large-bodied crustacean zooplankton have been substantially reduced, whereas rotifer densities have increased since the establishment of Asian carp (Sass et al. 2014). An aggressive Asian carp removal program has been implemented in the upper navigation pools of the Illinois Waterway to limit further advances of Asian carp towards Lake Michigan. One challenge with the removal program has been assessing whether or not removals have caused ecologically meaningful changes in Asian carp abundance. In addition to preventing the expansion of Asian carp into the Great Lakes, this removal program may also benefit native fish assemblages in the Illinois Waterway by mitigating some of the ecological impacts that Asian carp have had on this system. However, the extent and pace of ecosystem responses to such removals are uncertain. Zooplankton are known to be a rapid index of ecosystem response, as most riverine zooplankton taxa have relatively short generation times and high productivity rates. Additionally, zooplankton are distributed throughout the Illinois Waterway and are a critical food web component for larval and adult native fishes, making them ideal performance metrics for assessing the effectiveness of Asian carp control efforts. This project will investigate whether zooplankton-based assessment metrics can be used to quantitatively evaluate the extent to which the removal strategy is working to reverse ecosystem impacts from Asian carp in the Illinois Waterway. This work will help inform management agencies regarding ecosystem responses to Asian carp removals and define ecosystem-based benchmarks for Asian carp control efforts.

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

Objectives: Zooplankton are being sampled throughout the Illinois Waterway to:

(1) Quantify zooplankton abundance, body size distribution, biomass, and community composition in the Illinois Waterway through time.

(2) Assess the sensitivity of a range of zooplankton taxa to Asian carp abundance.

(3) Use sensitive zooplankton taxa to develop benchmarks for evaluating the outcome of Asian carp control and removal efforts.

Project Highlights:

- A total of 113 zooplankton samples were collected from the Illinois Waterway during 2020. The data derived from these samples, and associated water chemistry data, will be incorporated into the long-term data set of zooplankton assemblages in the Illinois Waterway and used to evaluate the effects of Asian carp planktivory on zooplankton metrics and understand the ecosystem responses to Asian carp harvest efforts.
- June densities of Chydoridae, *Synchaeta* sp., and *Trichocerca* sp. were investigated as potential assessment metrics, but none of these density metrics proved as sensitive to Asian carp density as the June *Bosmina* sp. metric.
- Once all potential performance metrics have been evaluated across all months of available data, observed environmental conditions and Asian carp densities will be used to calculate expected densities of key zooplankton taxa when Asian carp densities are reduced to a target density. The difference between these target predictions and the observed densities of the performance metric will be compared to the residuals from the model that used observed Asian carp density to assess whether Asian carp removals have met management targets for zooplankton recovery.

Methods:

Field sampling for assessment of zooplankton trends took place biweekly from May to September of 2020 at established sites to maintain consistency and data comparability. Zooplankton were collected by obtaining vertically-integrated water samples using a diaphragmatic pump. At each site, 90 L of water was filtered through a 55 μm mesh to obtain crustacean zooplankton and 10 L of water was filtered through a 20 μm mesh to obtain microzooplankton. Organisms were transferred to sample jars and preserved in either Lugols solution (4%; for macrozooplankton) or buffered formalin (10%; for rotifers). Data on environmental factors known to influence zooplankton communities in large rivers (temperature, dissolved oxygen concentration, turbidity, chlorophyll concentration, total phosphorus concentration) was also collected on each sampling site visit. In the laboratory, individual organisms were identified to the lowest possible taxomomic unit, counted, and measured using a microscope-mounted camera and measurement software. Zooplankton densities were calculated as the number of individuals per liter of water sampled. Biomass was calculated using standard length-mass regressions for each taxa.

Previous analyses evaluated the influence of Asian carp densities and environmental factors in different navigation pools on June densities of *Bosmina* sp., cyclopoid copepods, *Polyartha* sp., *Brachionus* sp., and *Keratella* sp. During 2020, these analyses were extended to Chydoridae, *Synchaeta* sp., and *Trichocerca* sp. Current analyses used data from 2012-2018 collected at monitoring sites representative of the Dresden Island (Channahon), Marseilles (Morris), Starved Rock (Ottawa), Peoria (Henry), and LaGrange (Havana) navigation pools. Asian carp density estimates were generated by annual hydroacoustic surveys conducted each October by Southern Illinois University – Carbondale. Reliable Asian carp density estimates were not available for the Peoria and LaGrange pools in 2018 and so these pool-year combinations were not used in the analyses. Discharge data for each pool was obtained from upstream USACE gages located at the Dresden Island, Marseilles, and Starved Rock Lock and Dam. Data from the USGS gage at Kingston Mines (USGS 5568500) was used for LaGrange Pool flow rates. A reduced maximum likelihood approach was used to model mean June density of each zooplankton taxa at each sampling station. Repeated measures models with sampling station as the repeatedly sampled unit and compound symmetric covariance structure were used. We assessed whether adding mean June values for water temperature, discharge, dissolved oxygen concentration, or a combination of these variables improved model fit from a base model with only Asian carp density. Akaike's information criteria corrected for small sample bias (AIC_c; Anderson 2008) was used as the basis of our model comparisons, with models within two AIC_c units considered to have similar support. A null model (i.e., intercept only) was also included for comparison to assess whether there was meaningful support for any of the models in the set. Adjusted coefficients of determination were calculated as a measure of model fit for the most supported models and to compensate for potential overfitting from adding multiple explanatory factors.

Results and Discussion:

During 2020, a total of 113 zooplankton samples were collected from the Illinois Waterway. Sample processing is ongoing. The data derived from these samples, and associated water chemistry data, will be incorporated into the long-term data set of zooplankton assemblages in the Illinois Waterway. Analyses of additional potential zooplankton performance metrics indicated that the most supported models of Chydoridae, *Synchaeta* sp., and *Trichocerca* sp. responses to Asian carp densities explained insufficient amounts of variation (r^2 values < 0.50) and most model parameters were found to be insignificant ($P > 0.05$). None of these metrics was found to be as sensitive as June *Bosmina* sp. density to variation in abundances of Asian carp among navigation pools.

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

Different zooplankton taxa may be expected to vary in their apparent sensitivity to Asian carp density due to size-dependent vulnerability to planktivory, life history characteristics, and sensitivity to both biotic and abiotic factors. Previous analyses have indicated considerable spatiotemporal variation in zooplankton assemblage composition, density, and biomass within the Illinois Waterway, likely driven by seasonal environmental variation and spatial differences in temperature, water chemistry, and hydrology, as well as varying Asian carp densities. The observed relationship between *Bosmina* sp. density and Asian carp density is consistent with previous observations of negative associations between Asian carp relative abundance and cladoceran abundances in the Illinois River (Sass et al. 2014). However, Chydorid densities do not appear to show a similar response, indicating that Asian carp planktivory does not affect all cladoceran taxa similarly. Likewise, rotifer abundances in the Illinois River have been found to be positively associated with Asian carp abundance, potentially due to release from competition or predation by larger-bodied crustacean zooplankton (Sass et al. 2014), but the analyses of 2012-2018 data have found that Asian carp density accounts for very little of the variation in densities of any rotifer taxa. A full assessment of all relevant zooplankton taxa across all months of available data will be necessary to identify which zooplankton taxa provide the most informative metrics for assessing the impact of Asian carp removal on ecosystem recovery.

Recommendations:

Continued monitoring and analyses of zooplankton data from the Illinois Waterway will assess the influence of environmental factors known to affect zooplankton communities in large rivers (turbidity, chlorophyll *a*, total phosphorus, temperature, discharge), as well as the effect of Asian carp densities in different pools of the Illinois Waterway. Future analyses should expand these investigations to all relevant zooplankton taxa across all months of available data to identify which metrics prove most informative for assessing the impact of Asian carp removals. The most informative performance metrics will then be modelled using observed environmental conditions and Asian carp densities in each pool to calculate the difference between observed and expected values of each metric. The same models and environmental conditions will then be used to predict what the target metric value would be if Asian carp had been reduced to a specific density, and the difference between the target predictions and observed metric values will be compared to the residuals obtained from the model that used observed Asian carp density. If the target interval (i.e. goal Asian carp density prediction residuals ± 1.5 SE) overlaps the limits based on the observed carp density, Asian carp removal at this site would be concluded to have met the management target for zooplankton recovery. Changes in Asian carp density through time within pools, particularly the substantial declines in the Starved Rock, Marseilles, and Dresden Island pools due to targeted removal efforts in recent years, will be useful for evaluating the utility of any identified performance metrics. As Asian carp harvest is expected to accelerate in the Peoria Pool, continued collection of zooplankton samples will be needed to evaluate if these removal efforts are meeting management targets for reversing the ecosystem effects of planktivorous Asian carp. Identified performance metrics will also provide a simple means of communicating the ecosystem responses of harvest efforts to a general audience (e.g., policy makers and the general public).

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