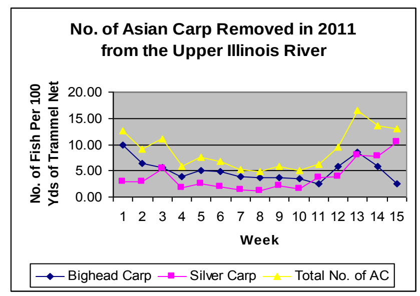
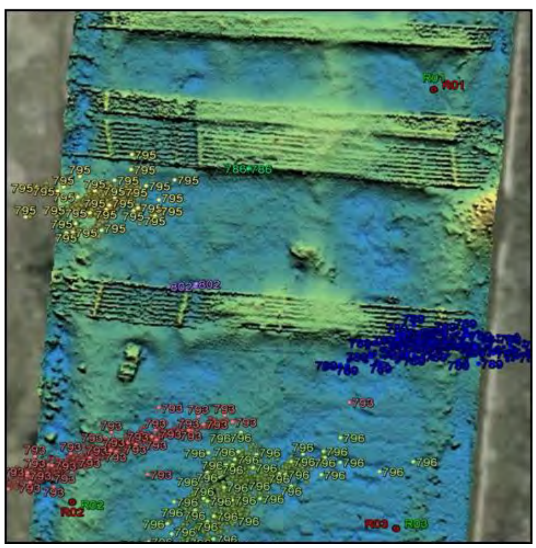
Asian Carp Regional Coordinating Committee

Monitoring and Rapid Response Workgroup

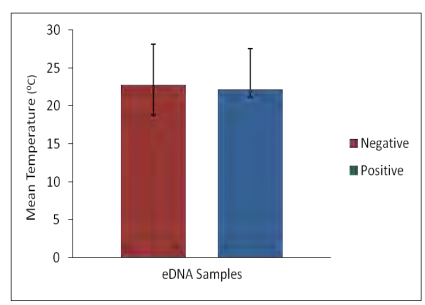
2011 Asian Carp Monitoring and Rapid Response Plan Interim Summary Reports

April 2012





QUICK SUMMARY:		
Number of Days Fished	61	days
Number of Net Crews	300	crew-days
Miles of Nets Fished	267.4	miles
Number of Bighead Carp	23,117	fish
Number of Silver Carp	17,766	fish
Number of Grass Carp	171	fish
Number of Asian Carp (AC)	41,035	fish
Tons of AC Harvested	351.7	tons
Average number AC per 1,000 yards net	87.2	fish



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

ACKNOWLEDGEMENTS

This compilation of interim summary reports for projects included in the 2011 Asian Carp Monitoring and Rapid Response Plan was created by a team of biologists, scientists, and managers from state and federal agencies implementing the plan. Although too numerous for individual recognition here, we would like to acknowledge everyone in the Illinois Department of Resources, US Army Corps of Engineers, US Fish and Wildlife Service, US Geological Survey, US Environmental Protection Agency, US Coast Guard, Illinois Natural History Survey, Southern Illinois University, Western Illinois University, Northern Illinois University, and Metropolitan Water Reclamation District of Greater Chicago for supporting or assisting with field work during 2010 and 2011 Asian carp monitoring, removal, and rapid response efforts. This and earlier versions of this document have benefitted from reviews by K. Baerwaldt, K. Irons, R. Simmonds, and S. Finney K. Baerwaldt and K. Irons provided pictures for the cover. V. Santucci assembled this compilation of interim reports.

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2011 Monitoring and Rapid Response Plan Interim Summary Reports

EXECUTIVE SUMMARY

The latest version of the Asian Carp Monitoring and Rapid Response Plan (MRRP) was prepared by the Monitoring and Rapid Response Workgroup (MRRWG) and released by the Asian Carp Regional Coordinating Committee (ACRCC) in May 2011. It included 18 individual project plans detailing tactics and protocols to achieve the specific goal of preventing Asian carp from establishing populations in the Chicago Area Waterway System (CAWS) and Lake Michigan. For the purpose of this document, the term „Asian carp" refers to Bighead Carp (*Hypophthalmichthys nobilis*) and Silver Carp (*H. molitrix*), exclusive of other Asian carp species such as Grass Carp (*Ctenopharyngodon idella*) and Black Carp (*Mylopharyngodon piceus*). Projects in the MRRP were classified geographically as occurring either upstream or downstream of the Dispersal Barrier in Romeoville, Illinois and grouped into five categories: Monitoring Projects, Removal Projects, Barrier Effectiveness Evaluations, Gear Effectiveness Evaluations and Development Projects, and Alternative Pathway Surveillance.

To foster an adaptive management approach to Asian carp monitoring and removal, the 2011 MRRP recommended completion of project interim reports summarizing the previous year"s monitoring and removal efforts. These reports would be used to inform modifications and enhancements to projects included in an updated plan for the coming year.

This document is a compilation of interim reports for the 18 individual projects found in the 2011 MRRP. The reports include summaries of activities completed during the 2011 and, in some cases, 2010 field seasons. Most reports are preliminary in nature and contain preliminary data summaries, analyses, and interpretations. Whereas results and conclusions may change as more data is collected and analyses are refined over time, they still provide a scientific basis for proposed modifications to the 2012 MRRP and related field activities.

Individual report details, including data summary tables and figures, can be found herein and are marked by a page number in parentheses next to the project name. A brief summary of individual project highlights follows.

MONITORING PROJECTS

Fixed Site Monitoring Upstream of the Dispersal Barrier (2) – This project included twice monthly standardized monitoring with DC electrofishing gear and contracted commercial fishers at five fixed sites in the CAWS upstream of the Dispersal Barrier.

- Over 6,000 estimated person-hours spent sampling at fixed sites and additional netting locations upstream of the Barrier in 2010 and 2011.
- 341 hours spent electrofishing and 91 miles of trammel/gill net deployed.
- Sampled 93,659 fish representing 64 species and two hybrid groups.
- No Bighead or Silver Carp captured or observed during electrofishing in either year, nor were any captured or observed during net sampling in 2011.

- No Silver Carp captured or seen during contracted commercial netting in 2010 and one adult Bighead Carp (mature male 34.6 inches in length and 19.6 pounds) captured by netters in Lake Calumet on 22 June 2010. Stands as the only verified live Bighead or Silver Carp known from the CAWS upstream of the Dispersal Barrier to date.
- Based on power analysis, recommend reducing number of electrofishing transects and net sets at five fixed sites, and based on results of the eDNA snapshot, will add randomly selected electrofishing and netting locations throughout waterway outside of fixed sites to enhance areal coverage.

Reach Monitoring Upstream of the Dispersal Barrier (11) – This project expanded monitoring coverage in the CAWS to areas outside the fixed sites. Four reaches that include all of the CAWS upstream of the Dispersal Barrier were sampled seasonally with DC electrofishing gear.

- An estimated 760 person-hours spent sampling at four reaches upstream of the Barrier in 2010 and 2011.
- Completed 544 electrofishing transects and a total of 166 hours of electrofishing over both years.
- Sampled 5,270 fish representing 43 species and two hybrid groups.
- No Bighead or Silver Carp captured or observed in either year.
- Community analysis comparing fixed site and reach electrofishing samples from 2010 showed higher catches of fish and higher species richness in samples from fixed sites.
- Based on community analyses and results of the eDNA sampling, recommend discontinuing reach monitoring and instead initiating randomized sampling in areas of the CAWS outside of the fixed sites with electrofishing and netting gear to maintain areal coverage of the waterway. Randomized sampling will increase frequency of sampling outside the fixed sites and can be incorporated into fixed site monitoring program.

Strategy for eDNA Monitoring in the CAWS and Upper Des Plaines River (20) – This project presents a strategy for weekly eDNA monitoring in the CAWS upstream and downstream of the Dispersal Barrier and in the upper Des Plaines River downstream from Hofmann Dam.

- 2011 eDNA weekly monitoring collected 1,864 samples from May through October and an additional 684 samples during the October snapshot event.
- Monitoring results were typically reported every 14 days.
- For weekly monitoring, 18 samples from upstream of the barrier were sequenced as positive for Silver Carp DNA and zero samples from upstream of barrier returned positive results for Bighead Carp DNA.
- For the snapshot, 16 samples were positive for Silver Carp eDNA and zero samples were positive for Bighead Carp DNA.
- An estimated 881 person-hours were spent collecting and filtering 5,210 liters of water in 2011.
- Consecutive eDNA positives triggered one response action in Lake Calumet during August 2011. No Asian carp were sampled or observed during conventional gear sampling and all eDNA samples collected immediately before the event were negative for both species.

- Recommend continuing eDNA monitoring at locations upstream of the Dispersal Barrier and will consider results from weekly and snapshot sampling when updating eDNA and conventional gear monitoring strategies for the 2012 MRRP.

Larval Fish and Productivity Monitoring (34) – Sampling for fish eggs and larvae and productivity monitoring took place biweekly from June-October 2010 and April-October 2011 at 9 sites downstream of the Dispersal Barrier (LaGrange to Brandon Road pools) and 5 sites in the CAWS upstream of the barrier.

- Asian carp larvae were not collected above the LaGrange Pool during both 2010 and 2011.
- Phosphorus concentrations increase with increasing distance upriver, with the highest levels observed in the Des Plaines River and the CAWS. Chlorophyll *a* concentrations do not appear to be correlated with phosphorus concentrations, and are highest in the lower Illinois River.
- Zooplankton densities in the CAWS appear to be similar to or higher than those observed in the Illinois River, suggesting that the CAWS is capable of providing sufficient food resources for Asian carp.
- The highest zooplankton densities were observed in the Little Calumet River and in Lake Calumet, suggesting that these areas may be the most likely locations to find Asian carp within the CAWS.
- Recommend continuation of larval fish sampling and productivity monitoring to monitor Asian carp reproduction and further analyze patterns in potential Asian carp food resources.

Young-of-Year and Juvenile Asian Carp Monitoring (39) – Monitoring for the presence of young-of-year Asian carp in the Illinois River, Des Plaines River, and CAWS occurred through sampling planned by other projects in the MRRP and targeted a segment of the Asian carp population typically missed with adult sampling gears.

- Sampled for young Asian carp in 2010 and 2011 throughout the CAWS, Des Plaines River, and Illinois River between river miles 83 and 334 by incorporating sampling from several existing monitoring projects.
- Sampled with active gears (DC electrofishing, small mesh purse seine, midwater trawl, beach seine, and cast net) and passive gears (experimental gill nets, mini-fyke nets, and trap nets). Completed 621 hours of electrofishing across years and sites.
- Examined nearly 40,000 Gizzard Shad <6 inches long in the CAWS and Illinois Waterway upstream of Starved Rock Lock and Dam and found no young Asian carp.
- Low catches of young Asian carp at all sites suggested poor recruitment years.
- Farthest upstream catch was a single Silver Carp in the Peoria Pool near Henry, Illinois (river mile 190) over 100 downstream from the Dispersal Barrier.
- Recommend continued monitoring for young Asian carp, adding mini-fyke nets to fixed site monitoring downstream of the barrier, and a new project to enhance understanding of young Asian carp distribution and habitat selection.

Fixed Site Monitoring Downstream of the Dispersal Barrier (44) – This project included monthly standardized monitoring with DC electrofishing gear and contracted commercial fishers at four fixed sites downstream of the Dispersal Barrier in Lockport Pool and downstream from the Lockport, Brandon Road, and Dresden Island locks and dams. It provides information on the location of the Asian carp detectable population front and upstream progression of populations over time.

- Estimated 2,515 person-hours spent sampling at fixed sites and additional netting locations downstream of the Dispersal Barrier in 2010 and 2011.
- 58.5 hours spent electrofishing and 46.6 miles of trammel/gill net deployed.
- Sampled 22,801 fish representing 67 species and four hybrid groups.
- No Bighead or Silver Carp were captured by electrofishing or netting in Lockport and Brandon Road pools, although one adult Bighead Carp was observed in Brandon Road Pool by a net crew in October 2011.
- One Bighead Carp captured and no Silver Carp captured or seen during electrofishing in Dresden Island Pool. A total of 21 Bighead Carp and no Silver Carp captured during contracted commercial netting at Dresden Island Pool fixed sites and additional netting locations. Detectable population front of mostly Bighead Carp located just north of I-55 Bridge at river mile 280 (47 miles from Lake Michigan). No appreciable change in upstream location of the population front in past five years.
- Sampled 14 Bighead Carp and 132 Silver Carp by electrofishing and 450 Bighead Carp and 184 Silver Carp by netting at fixed sites and additional netting locations in Marseilles Pool. Presence of mature adults capable of spawning occurred in this pool about 55 miles from Lake Michigan. However, Asian carp larvae and juveniles were not detected upstream of Peoria Pool or more than 100 miles downstream of the Dispersal Barrier and 137 miles from Lake Michigan.
- Recommend continued monitoring of fixed sites downstream of the dispersal barrier and propose incorporating hoop nets and mini-fyke nets in the sampling protocols to enhance monitoring for adult Bighead Carp and detection of Asian carp juveniles, if present.

REMOVAL PROJECTS

Rapid Response Actions in the CAWS (56) – This project uses a threshold framework to support decisions for response actions to remove any Asian carp from the CAWS upstream of the Dispersal Barrier with conventional gear or rotenone.

- Completed six response actions with conventional gears and rotenone in the CAWS upstream of the Dispersal Barrier during 2010 and 2011. All but one of the actions was triggered by eDNA monitoring results.
- Estimated over 9,700 person-hours were spent to complete 111 hours of electrofishing, set 31.8 miles of trammel/gill net, treat 2.5 miles (173 acres) of river with rotenone, make four 800-yard long commercial seine hauls, and deploy four tandem trap nets equal to 22.5 net-days of effort.
- Across all response actions and gears, sampled over 108,057 fish representing 52 species and 2 hybrid groups.

- No Bighead or Silver Carp were captured or observed during response actions, nor were positive detections for Asian carp DNA reported from eDNA samples taken immediately before conventional gear and rotenone sampling.
- Developed a threshold framework to guide rapid response decisions.
- US Fish and Wildlife Service is maintaining in storage a supply of rotenone and sodium permanganate to facilitate a rotenone response action should conditions warrant such an action in the future.
- Recommend continued vigilance in removing any Bighead or Silver Carp from the CAWS upstream of Lockport Lock and Dam and use of the existing threshold framework to guide decisions on rapid response actions in the CAWS. Also recommend establishing the capability to conduct targeted response actions at selected locations in the CAWS outside the threshold framework when information gained from such actions may benefit monitoring protocols, research efforts, or Asian carp removal and control efforts.

Barrier Maintenance Fish Suppression (65) – This project provides a fish suppression plan to support US Army Corps of Engineers maintenance operations at the Dispersal Barrier. The plan includes fish sampling to detect juvenile or adult Asian carp presence in the Lockport Pool downstream of the barrier, surveillance of the barrier zone with split-beam hydroacoustics, side-scan sonar and DIDSON imaging sonar, and operations to clear fish from between barriers by mechanical or chemical means.

- Successfully displaced all fish >12 inches long from the area between Barrier 2A and 2B, energized Barrier 2A to normal operational parameters, and brought Barrier 2B down for maintenance. Barrier 2A became the principal barrier until maintenance operations were completed.
- Used novel protocols and high-tech equipment to accomplish project objectives. Fish were cleared with pneumatic water guns and success of the clearing action was evaluated with split-beam hydroacoustics, side-scan sonar, and DIDSON imaging sonar.
- Met strategic objectives without the use of chemicals or loss of barrier function.
- Completed the operation with no injuries or accidents reported.
- Stood up an Incident Management Team and prepared an Incident Action Plan to facilitate management of the action and communication among agencies and stakeholders.
- Recommend the continued use of water guns and remote sensing for future barrier maintenance fish suppression operations.

Barrier Defense Asian Carp Removal Project (72) – This program was established to reduce the numbers of Asian carp downstream of the Dispersal Barrier through controlled commercial fishing. We anticipate that reducing Asian carp populations will lower propagule pressure and the chances of Asian carp gaining access to waters upstream of the barrier. Primary areas fished include Dresden Island, Marseilles, and Starved Rock pools.

- Contracted commercial fishers and assisting IDNR biologists deployed 350 miles of net in the upper Illinois Waterway during 2010 and 2011.

- A total of 28,098 Bighead Carp, 18,842 Silver Carp, and 187 Grass Carp were removed by contracted netting. The total weight of Asian carp removed was 414.2 tons (62.4 tons in 2010 and 351.8 tons in 2011).
- Recommend continued targeted harvest of Asian carp in the upper Illinois Waterway with contracted commercial fishers and assisting IDNR biologists.

BARRIER EFFECTIVENESS EVALUATIONS

Telemetry Master Plan (80) – This project uses ultrasonically tagged Asian carp and surrogate species to assess if fish are able to challenge and/or penetrate the Dispersal Barrier and pass through navigation locks in the upper Illinois Waterway. An array of stationary acoustic receivers and mobile tracking was used to collect information on Asian carp and surrogate species movements.

- To date, we have acquired 3.7 million detections from 182 tagged fish, with a 75% detection rate.
- Our preliminary conclusion from the small fish and adult fish telemetry studies is that the barriers are effectively preventing all upstream passage of tagged fish.
- We have observed tagged Common Carp passing through the Lockport Lock in both directions.
- Based on the few Asian carp tagged in Dresden Island Pool, our preliminary conclusion is that the leading edge of adult Asian carp in Dresden Island Pool has not changed.
- Recommend continued small fish testing at the barrier and expanded acoustic detection network in the upper Illinois Waterway, in cooperation with USFWS and SIUC, for enhanced monitoring of the leading edge of adult Asian carp populations.

Evaluation of Fish Behavior at the Dispersal Barrier (90) – This project uses Dual-Frequency Identification Sonar (DIDSON) and caged fish experiments to monitor fish behavior at the barrier. Caged fish experiments will describe behavior of various-sized fish (not Asian carp) subjected to the barrier‟s electric field and DIDSON surveys will determine relative abundance of fish upstream, in, near, and downstream of the Dispersal Barrier.

- Field effort for this project totaled approximately 12 weeks and 2,380 person-hours.
- Completed 133 individual caged fish trials with 666 fish. Wild fish observations were made at 240 sites totaling 2,400 minutes (40 hours) of in-water observations.
- All field work was completed without a single safety incident.
- A large amount of fish behavior data was collected that will provide valuable information to managers.
- Recommend continued caged fish trials and wild fish surveys at the barrier during 2012. Will utilize a digital video camera rather than DIDSON imaging sonar to monitoring fish behavior during 2012 caged fish trials. DIDSON will continue to be used during wild fish trials.

Des Plaines River and Overflow Monitoring (93) – This project included periodic monitoring for Asian carp presence and spawning activity, in the upper Des Plaines River downstream of the

Hofmann Dam. In a second component, efficacy of the Asian carp barrier fence constructed between the Des Plaines River and CSSC was assessed by monitoring for any Asian carp juveniles that may be transported to the CSSC via laterally flowing Des Plaines River floodwaters passing through the barrier fence.

- Captured 1,178 fish electrofishing and netting on the upper Des Plaines River.
- No Asian carp were captured or observed.
- Investigated the physical barrier in the area of an overtopping event, located fish that breached the barrier, and identified potential problems with the physical barrier (that have since been repaired).
- Recommend continued monitoring for the presence of Asian carp adults and/or juveniles at the three sites in the upper Des Plaines River and continued investigations in the area of overtopping events.

GEAR EFFECTIVENESS EVALUATIONS AND DEVELOPMENT PROJECTS

Asian Carp Gear Efficiency and Detection Probability Study (98) – This project is assessing efficiency and detection probability of gears currently used for Asian carp monitoring (e.g., DC electrofishing, gill nets, and trammel nets) and others potential gears (e.g., mini-fyke nets, hoop nets, trap nets, seines, and cast nets) by sampling at 10 sites in the Illinois River, lower Des Plaines River, and CAWS that have varying carp population densities. Results will inform decisions on appropriate levels of sampling effort and monitoring regimes, and ultimately improve Asian carp monitoring and control efforts.

- There was low abundance of Asian carp above Morris (Marseilles Pool), and none were captured in Brandon Road Pool or the CAWS.
- Few age-0 Asian carp were caught, including none upstream from Henry, Illinois (Peoria Pool).
- Highest catch rates of Silver Carp were with electrofishing gear, Bighead Carp with hoop nets and trap nets, and hybrid Asian carp with hoop nets and electrofishing.
- Recommend further sampling to determine whether observed trends are consistent across years, and for sufficient sample size to determine relative gear efficiency and conduct detection probability modeling.

Exploratory Gear Development Project (103) – A professional net designer has been consulted to develop and build enhanced purse seines, trawls, and gill nets for more effective harvest of Asian carp. Enhanced gears will be evaluated in areas known to have abundant Asian carp populations. If effective, gears may be used in place of rotenone for removal actions in the CAWS and for commercial fishing in the lower Illinois River or other Asian carp infested waterways.

- Purchased a 75-m long x 4-m deep purse seine modified for Asian carp sampling and deployed the seine in the Missouri River during December. Successfully caught some Asian carp, but few appeared to be present in the area sampled.
- Worked with a professional net designer to develop a modified shrimp trawl called a paupier (butterfly) net for Asian carp sampling. Ran several trials with the net and caught

dozens of 12- to 18-inch Asian carp and by-catch of Gizzard Shad and juvenile Paddlefish.
- Completed laboratory and field experiments that identified the most effective electrical waveforms and power settings for attraction and immobilization of small Asian carp with DC boat electrofishing gear.
- Recommend further modifications to purse seine and paupier net design to increase Asian carp catch rates for monitoring and harvest purposes.

Unconventional Gear Development Project (108) –The goal of this project is to develop an effective trap or netting method capable of capturing low densities of Asian carp in the deep-draft canal and river habitats of the CAWS, lower Des Plaines River, upper Illinois River, and possible Great Lakes spawning rivers.

- Convened a committee of scientific experts to identify potential new gears to capture Asian carp where population densities are low and aquatic habitats are unique, such as the deep-draft channels of the CAWS.
- Brought in three professional commercial fishers for a tour of the CAWS and discussions of new and modified sampling gears for Asian carp monitoring and removal.
- Moving forward with purchase and evaluation of three gears: 6-foot diameter hoop nets, 30-foot deep tied down gill nets, and Lake Michigan style pound (trap) nets.
- Recommend testing effectiveness of these modified gears during 2012 in areas of the waterway with varying abundances of Asian carp and in combination with other sampling gears. In addition, efforts will be made by IDNR to encourage local bow fishing clubs to schedule a night-time carp tournament targeting Lake Calumet, the Little Calumet River, and the Calumet-Sag Channel. Further recommend a pilot study to assess corn or soybean meal as a surface attractant for Asian carp to aid in detection and removal efforts in areas where carp abundance is low.

Fish Population Estimation Project (111) – This project is a pilot study to determine the feasibility of using standard mark-recapture techniques (e.g., Petersen or Schnabel methods) to estimate abundance of targeted species at various locations in the CAWS. Estimates of actual population abundance will be useful for gear efficiency evaluations and detection probability modeling.

- Attempted a mark-and-recapture population estimate for non-Asian carp species during the 2011 Lake Calumet Rapid Response.
- Small sample sizes for the marked population and recaptured mark sample precluded the calculation of meaningful population estimates.
- Recommend shifting population estimates from surrogate species to Bighead and Silver Carp populations in areas of the upper Illinois Waterway sampled during gear effectiveness evaluations. These estimates are being planned for 2012 as part of a new project assessing effects of removal efforts on Asian carp populations and native fish communities.

Water Gun Development and Testing (113) – Pneumatic water guns that emit high pressure underwater sound waves have potential to deter fishes or kill them if they are in close enough proximity to the wave source. This technology is being evaluated to determine its effects on structural components of the CAWS (e.g., canal walls and in-water equipment) and as an alternative tool to rotenone for fish suppression in support of Dispersal Barrier maintenance.

- Seismic testing of water guns occurred in the CSSC during fall 2011 and preliminary analyses indicated that, in general, seismic energy from the water gun is approximately an order of magnitude or greater than background energy for land and in water data. The largest coal plant data was approximately one third of the water gun energy.
- Video surveillance identified no visible scalloping or removal of rock from the canal wall or any visible disturbance to green vegetative growth on wall.
- Water guns were used to successfully clear fish from between barriers (no fish >12 inches present) in support of USACE barrier maintenance operations during October 2011.
- Recommend additional seismic testing of the effects of water guns on navigation locks and equipment in the CAWS and on behavior of Asian carp in a downstream location of the Illinois River near Morris, Illinois.

ALTERNATIVE PATHWAY SURVEILLANCE

Surveillance of Bait, Sport, and Food Fish Trade in Illinois (117) – This project creates a more robust and effective enforcement component of IDNR‟s invasive species program by increasing education and enforcement activities at bait shops, bait and sport fish production/distribution facilities, fish processors, and fish markets/food establishments known to have a preference for live fish for release or food preparation.

- Completed visual inspections of bait shops in nine Chicago-area counties in Illinois during winter ($N = 44$) and summer ($N = 52$) and found no Asian carp contaminants in the bait trade.
- Obtained 136 water samples from bait tanks during summer 2010 bait shop visits and found no Bighead or Silver Carp DNA in any samples.
- Determined Chicago area bait shops obtain minnows from one of three area wholesalers and do not harvest bait from the wild.
- Recommend developing and implementing a visual and eDNA inspection program for minnow wholesalers rather than periodic surveys of individual bait shops to monitor Asian carp contamination in the bait trade. Also, recommend additional eDNA and conventional gear monitoring at urban fishing ponds and increased surveillance of fish haulers stocking local water bodies, area fish production facilities, and Chicago area live fish markets and food establishments to reduce unintentional introductions of Asian carp in waters of or connected to Lake Michigan.

2011 Monitoring and Rapid Response Plan Interim Summary Reports

April 2012

INTRODUCTION

The Asian Carp Regional Coordinating Committee (ACRCC) was established in 2009 to provide coordinated communication and response to accomplish the goal of preventing Asian carp from becoming established in the Great Lakes. For the purpose of this document, the term „Asian carp‟ refers to Bighead Carp (*Hypophthalmichthys nobilis*) and Silver Carp (*H. molitrix*), exclusive of other Asian carp species such as Grass Carp (*Ctenopharyngodon idella*) and Black Carp (*Mylopharyngodon piceus*). To facilitate the accomplishment of the overarching goal, the ACRCC formed multiple work groups, including the Monitoring and Rapid Response Work Group (MRRWG). The MRRWG is co-led by the Illinois Department of Natural Resources (IDNR) and the Great Lakes Fishery Commission (GLFC) and is comprised of liaisons from key state and federal agencies as well as independent technical specialists (see Appendix A for membership). Guided by the ACRCC Framework (ACRCC 2010), the MRRWG was assigned the task of developing and implementing a Monitoring and Rapid Response Plan (MRRP) for Asian carp that were present or could gain access to the Chicago Area Waterway System (CAWS).

The latest version of the MRRP was released in May 2011. It included 18 individual project plans detailing tactics and protocols to identify the location and abundance of Asian carp in the CAWS, lower Des Plaines River and upper Illinois River, and initiate appropriate response actions to address such findings (MRRWG 2011). This plan was used to guide and coordinate 2011 action agency efforts to accomplish strategic objectives and achieve the specific goal of preventing Asian carp from establishing populations in the CAWS and Lake Michigan. Projects were classified geographically as occurring either upstream or downstream of the Dispersal Barrier in Romeoville, Illinois and grouped into five categories: Monitoring Projects, Removal Projects, Barrier Effectiveness Evaluations, Gear Effectiveness Evaluations and Development Projects, and Alternative Pathway Surveillance (MRRWG 2011).

The workgroup has adopted an adaptive management approach to Asian carp monitoring and removal and considers the MRRP to be a working document that is continually open to modification and enhancement. To foster an adaptive management approach, the 2011 plan recommended completion of interim project summary reports for the previous year‟s monitoring and removal efforts. These reports could include preliminary data summaries or more in-depth data analysis and interpretation, and they would be used to inform modifications and enhancements to projects included in the updated MRRP for the coming year.

This document is a compilation of summary reports covering each of the 18 project plans included in the 2011 MRRP. It should be viewed as a companion document to the updated 2012 MRRP. Reports include summaries of activities completed during the 2010, 2011 or, for some projects, 2010 and 2011 field seasons. Also included are highlights of past activities and recommended updates to monitoring and removal actions that will be considered for the 2012 plan. Most are interim reports with data summaries, analyses, and interpretations that are preliminary in nature but still offer a scientific basis for 2012 project updates and field activities. Results and conclusions may change as more data is collected and analyses are refined over time. A few projects or portions of projects were completed in 2011, and in these cases, final reports have been included here with their author‟s permission.

INTERIM PROJECT REPORTS

Fixed Site Monitoring Upstream of the Dispersal Barrier

David Wyffels, Michael McClelland, Tristan Widloe,
Brennan Caputo, Matthew O‟Hara, Victor Santucci and Kevin Irons;
Illinois Department of Natural Resources

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

Introduction: Standardized sampling can provide useful information to managers tracking population growth and range expansion of aquatic invasive species. Information gained from regular monitoring (e.g., presence, distribution, and population abundance of target species) is essential to understanding the threat of invasion and informs management decisions and actions to reduce the risk of population establishment. Detections of Asian carp eDNA upstream of the Dispersal Barrier during 2009 initiated the development of a monitoring plan using electrofishing and contracted commercial fishers to sample for Asian carp at five fixed sites upstream of the Dispersal Barrier. Sampling results from 2010 and 2011 contributed to our understanding of Asian carp population abundance in the CAWS providing guidance for conventional gear or rotenone rapid response actions designed to remove fish from areas where they have been captured or observed.

Objectives: Fixed site sampling is being conducted to:

1) Monitor for the presence of Asian carp in the CAWS upstream of the Dispersal Barrier;
2) Determine relative abundance of Asian carp in locations and habitats where they are likely to congregate;
3) Supplement Asian carp distribution data obtained through other projects (e.g., reach and eDNA monitoring); and
4) Obtain information on the non-target fish community to help verify sampling success, guide modifications to sample locations, and assist with detection probability modeling and gear evaluation studies.

Materials and Methods: Five fixed sites were selected at the upstream reaches of the CAWS near Lake Michigan. To maximize the potential effectiveness of netting and electrofishing, particularly given the apparent low densities of Asian carp in the generally deep-water habitat of the CAWS, stations were located in areas where the likelihood of capture is greatest (i.e., where eDNA had been detected, below migration barriers, or both). These areas were identified for intensive sampling under the assumption that Asian carp upstream of the Dispersal Barrier would congregate below the next existing barriers, namely the T.J. O'Brien Lock, the Chicago Lock and the Wilmette Pumping Station. Habitat and sampling conditions were taken into consideration in the selection of the locations and boundaries of the fixed sites.

Electrofishing Methods - Electrofishing samples took place twice a month from June through November in 2010. In 2011 electrofishing took place once per month during March and December and twice per month from April through November. All boat electrofishing used pulsed DC current and most samples were taken with two dip netters. Three 15-minute electrofishing runs per mile of waterway was the targeted effort for each site except Lake Calumet. The typical number of electrofishing transects completed during each site visit was: Site 1 (Lake Calumet) – 6; Site 2 (Calumet/Little Calumet River) – 16; Site 3 (Chicago Sanitary and Ship Canal (CSSC)/South Branch Chicago River) – 14; Site 4 (North Branch Chicago River/North Shore Channel) – 6; and Site 5 (North Shore Channel) – 6. Exact sampling areas within the sites were left to the discretion of the field crews; however, this level of effort in trial runs covered a high percentage of the waterway shoreline. Electrofishing was conducted in a downstream direction in areas with noticeable current velocity and runs were generally parallel to shore (including following shoreline into off channel areas). Boat operators were allowed to switch the pedal on and off at times to prevent pushing fish in front of the boat and increasing the chances of catching an Asian carp. Common Carp were counted without capture and all other fish were netted and placed in a tank where they were identified and counted, after which they were returned live to the water. Periodically, a subsample of 10 fish of each species per site was measured in total length and weighed to provide length-frequency data for gear evaluations. Schools of young-of-year (YOY) Gizzard Shad <6 inches long were subsampled by netting a portion of each school encountered and placing them in a holding tank along with other captured fish. Young-of-year shad were examined closely for the presence of Asian carp and counted to provide an assessment of young Asian carp in the waterway.

Netting Methods – Netting samples took place twice a month from June through September 2010. In 2011, netting samples took place once per month during March and December and twice per month from April through November. Five additional netting trips in areas upstream of the barrier and outside the fixed sites took place from April through August 2011. Contracted commercial fishers were used for net sampling at the fixed sites and the additional sampling locations. The nets used were large mesh (3.0-4.0 inches) trammel or gill nets eight feet high or greater, and in lengths of 100 or 200 yards. Most sets were 200 to 400 yards long, although some sets were shorter (100 yards) and longer (up to 600 yards). The typical total length of net set during each site visit was: Site 1 (Lake Calumet) – 2,000 yards; Site 2 (Calumet/Little Calumet River) – 2,000 yards; Site 3 (Chicago Sanitary and Ship Canal (CSSC)/South Branch Chicago River) – 1,000 yards; Site 4 (North Branch Chicago River/North Shore Channel) – 400 yards; and Site 5 (North Shore Channel) – 400 yards. An IDNR biologist or technician was assigned to each commercial net boat to monitor operations and record data. Nets were attended at all times. Net set locations within each fixed site were left to the discretion of the commercial fishers. Net sets were of short duration and included driving fish into the nets with noise (i.e., “pounding” with plungers on the water surface, banging on boat hulls, or racing tipped up motors). Netting effort was standardized as 15- to 20-minute sets with “pounding” no further than 150 yards from the net. Captured fish were identified to species and recorded on data sheets. Periodically, a subsample of 10 fish of each species per site were measured in total length and weighed.

Data analysis- Fixed Site 2 and 3 electrofishing data were tested for sampling power to provide guidance for potential modifications of sampling design. A one sample t-test power analysis was performed using mean catch and standard deviation values calculated from 2010 collections to evaluate power ($\alpha = 0.05, 1-\beta = 0.80$) of the 2011 sampling effort. Power values of $1-\beta > 0.80$ were used to indicate that a reduction in electrofishing runs was appropriate given known estimates of variance in the data set.

Results and Discussion: Crews logged over 6,000 person-hours of effort while sampling at fixed site electrofishing and netting stations and additional netting locations upstream of the Dispersal Barrier in 2010 and 2011. Over both years, there was a total of 341 hours of electrofishing completed and just over 90 miles of trammel/gill net deployed (Table 1). Monitoring effort was high in the CAWS compared to other river monitoring programs. For example, there were 211 hours spent electrofishing in the CAWS during 2011 vs. about 50 hours of electrofishing annually in a similar length of the lower Illinois Waterway (LaGrange Pool) sampled as part of the Long Term River Monitoring Program (LTRMP; Kevin Irons, personal communication). The extensive sampling effort in the CAWS was instituted by design because little was known about the abundance and distribution of Asian carp or other species upstream of the barrier when the initial monitoring plan was developed. The work group initiated high sampling effort to maximize the chances of capturing any Asian carp that might be present in the waterway. The consensus was that sampling effort might be reduced in the future if supported by sound monitoring data and an increased understanding of Asian carp population demographics.

Electrofishing catch – A total of 86,028 fish representing 58 species were sampled by electrofishing at fixed sites during 2010 and 2011 (Table 1). The five most common species captured in 2010 were Gizzard Shad, Common Carp, Largemouth Bass, Bluntnose Minnow and Bluegill (Table 2). Combined these species accounted for 81.5% of the 2010 electrofishing catch. The five most abundant species and four others, Emerald Shiner, Pumpkinseed, Golden Shiner and Spotfin Shiner made up more than 90% of the 2010 electrofishing catch. The five most common species captured in 2011 were Gizzard Shad, Common Carp, Bluegill, Bluntnose Minnow and Pumpkinseed (Table 2). These species accounted for 74.3% of the 2011 electrofishing catch, and when combined with six other species, Largemouth Bass, Spotfin Shiner, Golden Shiner, White Sucker, Brook Silverside, and Emerald Shiner accounted for more than 90% of the 2011 catch. No Bighead or Silver Carp have been captured or observed to date during fixed site electrofishing in the CAWS. In addition, we examined a total of 11,834 YOY gizzard shad in 2010 and 13,684 in 2011 and detected no Asian carp YOY.

Netting catch – A total of 7,631 fish representing 24 species were sampled by contracted commercial fishers in 2010 and 2011 (Table 1). The five most common species captured in 2010 were Common Carp, Black Buffalo, Smallmouth Buffalo, Freshwater Drum and Channel Catfish. These fish made up 96.3% of the 2010 netting catch. The five most common species captured at fixed and additional netting sites during 2011 were Common Carp, Freshwater Drum, Black Buffalo, Quillback and Common Carp x Goldfish hybrids (Table 3). These species accounted for 90% of the 2011 netting catch. No Silver Carp were observed or collected in net sampling upstream of the Dispersal Barrier in either year nor were any Bighead Carp encountered in the CAWS during 2011. However, one adult Bighead Carp (mature male 34.6 inches in length and 19.6 pounds) was captured by contracted commercial netters in Lake Calumet on 22 June, 2010. This capture on the first day of sampling at designated fixed sites confirmed the presence of live Asian carp in the CAWS upstream of the barrier. The catch triggered an 11-day conventional gear rapid response action in Lake Calumet, the Calumet River, and Calumet Harbor that produced no additional captures or observations of Bighead or Silver Carp (see Rapid Response Interim Report). Excluding Grass Carp, the Lake Calumet Bighead Carp stands as the only verified live Asian carp known from the CAWS upstream of the Dispersal Barrier to date.

Power analysis – The one sample t-test power analysis resulted in $1-\beta = 0.83$ for Fixed Site 2 and $1-\beta=0.93$ for Fixed Site 3. These results indicated that current sample size is more than sufficient at these sites and a reduction in the number of electrofishing transects can be achieved without losing power to assess relative abundance of fish populations through electrofishing catch rates.

Recommendations: From results of extensive sampling with conventional gears to date, we conclude that if there are any live Bighead Carp or Silver Carp in the CAWS upstream of the Dispersal Barrier, they likely are there in low numbers. This conclusion and results of the one sample power analysis suggest that the sample size for fixed sites may be reduced during the 2012 sampling season. The number of sites (5) and frequency of visits to each site (18) will remain the same as in 2011, whereas only the number of electrofishing transects and net sets will be reduced at some sites. The table below shows the present and recommended number of electrofishing transects and net sets for fixed sites on each sample date in 2012.

	Number of 15-min. electrofishing transects		Number of 200-yard trammel/gill net sets	
Fixed site	2011	2012	2011	2012
1 - Lake Calumet	6	6	10	10
2 - Little Calumet River	16	8	10	8
3 - CSSC/South Branch	14	8	5	5
4 - North Branch	6	4	2	2
5 - North Shore Channel	6	4	2	2
Total	48	30	29	25

Recent results from the eDNA snapshot sample showed near simultaneous positive detections for Silver Carp DNA at several locations throughout the CAWS (see eDNA Monitoring Report). Although the snapshot did not identify the source of DNA in the waterway, there is the possibility that the detections resulted from live fish. In light of these results and the recommended discontinuation of reach electrofishing in 2012 (see Reach Monitoring Report below), we propose adding randomly selected electrofishing and netting sites to the fixed site monitoring project. The addition of random sites will allow us to maintain vigilance in monitoring upstream of the barrier and continue robust spatial coverage of CAWS sampling. These sites would be selected *a priori* in a geographically stratified-random procedure that included only areas outside of the fixed sites. The reduction in fixed site sample sizes will allow some random sites to be sampled each day of fixed site sampling and on one additional electrofishing and netting day each month. The goal will be to have each electrofishing boat and crew complete 10 15-minute transects per day and each net boat and crew complete 8-10 200-yard net sets per day (1,600-2,000 yards of net/day). The table below shows the recommended number of electrofishing transects and net sets for twice monthly fixed site sample days and once monthly additional days for 2012.

	Number of 15-min. electrofishing transects per trip		Number of 200-yard trammel/gill net sets per trip	
Random site reaches	Fixed site days (twice monthly)	Additional days (1 day/month)	Fixed site days (twice monthly)	Additional days (1 day/month)
1 – Calumet Connecting Channel/ Calumet River	4	0	0	3
2 - Little Calumet River/Cal-Sag Channel	2	2	2	3
3 - Chicago River/South Branch/CSSC	2	2	3	3
4 - North Branch/ North Shore Channel	2	2	2	3
Total	10	6	7	12

Project Highlights:

- Estimated over 6,000 person-hours spent sampling at fixed sites and additional netting locations upstream of the Barrier in 2010 and 2011.
- 341 hours spent electrofishing and 91 miles of trammel/gill net deployed.
- Sampled 93,659 fish representing 64 species and two hybrid groups.
- No Bighead or Silver Carp captured or observed during electrofishing in either year, nor were any captured or observed during net sampling in 2011.
- No Silver Carp captured or seen during contracted commercial netting in 2010 and one adult Bighead Carp (mature male 34.6 inches in length and 19.6 pounds) captured by netters in Lake Calumet on 22 June 2010. Stands as the only verified live Bighead or Silver Carp known from the CAWS upstream of the Dispersal Barrier to date.
- Based on power analysis, recommend reducing number of electrofishing transects and net sets at five fixed sites, and based on results of the eDNA snapshot, will add randomly selected electrofishing and netting locations throughout waterway outside of fixed sites to enhance areal coverage.

Table 1. Summary statistics for electrofishing and netting effort and catch at fixed sites and additional netting locations upstream of the Dispersal Barrier, 2010 and 2011.

	Fixed sites		
Electrofishing effort	2010 (Jun-Nov)	2011 (Mar-Dec)	Total
Person-days	128	218	346
Estimated person-hours	1,280	2,180	3,460
Electrofishing hours	130	211	341
Samples (transects)	519	844	1,363
Electrofishing catch			
All Fish (*N*)	33,689	52,339	86,028
Species (*N*)	51	58	59
Hybrids (*N*)	2	2	2
Bighead Carp (*N*)	0	0	0
Silver Carp (*N*)	0	0	0
CPUE (fish/hour)	259	248	252

	Fixed sites		Additional sites	
Netting effort	2010 (Jun-Sep)	2011 (Mar-Dec)	2011 (Apr-Aug)	Total
Person-days	118	212	18	348
Estimated person-hours	885	1,590	135	2,610
Samples (net sets)	208	352	37	597
Total miles of net	23.8	60.4	6.6	90.9
Netting catch				
All Fish (*N*)	2,439	5,062	130	7,631
Species (*N*)	17	18	8	23
Hybrids (*N*)	1	1	1	1
Bighead Carp (*N*)	1	0	0	1
Silver Carp (*N*)	0	0	0	0
CPUE (fish/100 yards of net)	5.8	4.8	1.1	4.8

Table 2. Total number and percentage of fish captured by electrofishing fixed sites upstream of the Dispersal Barrier during 2010 and 2011. Common Carp were counted without capture, whereas other species were netted and placed in a holding tank before being identified, counted, and released.

	2010		2011		Total	
Species	Number captured	Percent (%)	Number captured	Percent (%)	Number captured	Percent (%)
Gizzard Shad	17,105	50.8	21,480	41.0	38,585	44.8
Common Carp	5,202	15.4	5,568	10.6	10,770	12.5
Largemouth Bass	2,888	8.6	3,329	6.4	6,217	7.2
Bluegill	1,104	3.3	4,702	9.0	5,806	6.8
Bluntnose Minnow	1,165	3.5	3,648	7.0	4,813	5.6
Pumpkinseed	807	2.4	3,481	6.6	4,288	5.0
Golden Shiner	739	2.2	1,409	2.7	2,148	2.5
Spotfin Shiner	628	1.9	1,485	2.8	2,113	2.5
Emerald Shiner	873	2.6	889	1.7	1,762	2.1
White Sucker	514	1.5	977	1.9	1,491	1.7
Brook Silverside	396	1.2	960	1.8	1,356	1.6
Green Sunfish	147	0.4	786	1.5	933	1.1
Alewife	71	0.2	688	1.3	759	0.9
Yellow Perch	340	1.0	283	0.5	623	0.7
Goldfish	285	0.8	246	0.4	531	0.6
White Perch	234	0.7	196	0.4	430	0.5
Yellow Bullhead	87	0.3	220	0.4	307	0.4
Freshwater Drum	144	0.4	117	0.2	261	0.3
Smallmouth Bass	89	0.3	146	0.3	235	0.3
Fathead Minnow	121	0.4	113	0.2	234	0.3
Spottail Shiner	72	0.2	152	0.3	224	0.3
Black Crappie	54	0.2	135	0.3	189	0.2
Mosquitofish	3	<0.1	168	0.3	171	0.2
Channel Catfish	75	0.2	86	0.2	161	0.2
Blackstripe Topminnow	8	<0.1	143	0.3	151	0.2
White Bass	77	0.2	68	0.1	145	0.2
Black Bullhead	45	0.1	83	0.2	128	0.2
Yellow Bass	85	0.2	41	0.1	126	0.2
Rock Bass	42	0.1	75	0.1	117	0.1
Orangespotted sunfish	19	0.1	93	0.2	112	0.1
Hybrid sunfish	31	0.1	75	0.1	106	0.1
Round Goby	32	0.1	67	0.1	99	0.1
Oriental Weatherfish	12	<0.1	64	0.1	76	0.1
Quillback	35	0.1	32	0.1	67	0.1

Table 2. Continued.

Species	2010 Number captured	2010 Percent (%)	2011 Number captured	2011 Percent (%)	Total Number captured	Total Percent (%)
Smallmouth Buffalo	35	0.1	26	0.1	61	0.1
Banded Killifish	3	<0.1	57	0.1	60	0.1
White Crappie	23	0.1	31	0.1	54	0.1
Chinook Salmon	23	0.1	28	0.1	51	0.1
Black Buffalo	3	<0.1	33	0.1	36	<0.1
Brown Bullhead	2	<0.1	32	0.1	34	<0.1
Central Mudminnow	20	0.1	13	<0.1	33	<0.1
Creek Chub	3	<0.1	21	<0.1	24	<0.1
Carp x Goldfish hybrid	7	<0.1	9	<0.1	16	<0.1
Rainbow Trout	1	<0.1	13	<0.1	14	<0.1
Threadfin Shad	13	<0.1			13	<0.1
Bigmouth Buffalo	7	<0.1	5	<0.1	12	<0.1
Walleye	3	<0.1	7	<0.1	10	<0.1
Sand Shiner	2	<0.1	7	<0.1	9	<0.1
Northern Pike	2	<0.1	6	<0.1	8	<0.1
Salmonid smolt			8	<0.1	8	<0.1
Ghost Shiner	4	<0.1	3	<0.1	7	<0.1
Grass Pickerel			6	<0.1	6	<0.1
Bowfin	2	<0.1	3	<0.1	5	<0.1
Brown Trout	1	<0.1	4	<0.1	5	<0.1
Coho Salmon	4	<0.1	1	<0.1	5	<0.1
Warmouth			4	<0.1	4	<0.1
Grass Carp			4	<0.1	4	<0.1
River Shiner			3	<0.1	3	<0.1
Bullhead Minnow			3	<0.1	3	<0.1
Unidentified cyprinid	1	<0.1	2	<0.1	3	<0.1
Spotted Sucker			2	<0.1	2	<0.1
Flathead Catfish			2	<0.1	2	<0.1
Rainbow Smelt			1	<0.1	1	<0.1
Unidentified Buffalo sp.	1	<0.1			1	<0.1
Total catch	33,689	100.0	52,339	100.0	86,028	100.0
Species (*N*)	51		58		59	
Hybrid groups (*N*)	2		2		2	

Table 3. Total number and percentage of fish captured with trammel and gill nets at fixed sites and additional netting locations upstream of the Dispersal Barrier during 2010 and 2011. Additional netting did not take place during 2010.

	2010		2011		Total	
Species	Number captured	Percent (%)	Number captured	Percent (%)	Number captured	Percent (%)
Common Carp	1,859	76.2	2,630	50.6	4,489	58.8
Freshwater Drum	85	3.5	1,218	23.4	1,303	17.1
Black Buffalo	248	10.2	460	8.9	708	9.3
Smallmouth Buffalo	110	4.5	144	2.8	254	3.3
Carp x Goldfish hybrid	34	1.4	181	3.5	215	2.8
Quillback	8	0.3	182	3.5	190	2.5
Gizzard Shad	6	0.2	162	3.1	168	2.2
Channel Catfish	47	1.9	118	2.3	165	2.2
Bigmouth Buffalo	11	0.4	37	0.7	48	0.6
Goldfish	2	0.1	29	0.6	31	0.4
Smallmouth Bass	14	0.6	3	0.1	17	0.2
Flathead Catfish	5	0.2	8	0.2	13	0.2
Grass Carp	3	0.1	9	0.2	12	0.2
Largemouth Bass	2	0.1	6	0.1	8	0.1
Alewife	2	0.1			2	<0.1
Bighead Carp	1	<0.1			1	<0.1
Bluegill	1	<0.1			1	<0.1
White Bass			1	<0.1	1	<0.1
Walleye	1	<0.1			1	<0.1
River Carpsucker			1	<0.1	1	<0.1
Chinook Salmon			1	<0.1	1	<0.1
White Perch			1	<0.1	1	<0.1
Rainbow Trout			1	<0.1	1	<0.1
Lake Trout			1	<0.1	1	<0.1
Total catch	2,439	100.0	5,193	100.0	7,632	100.0
Species (*N*)	17		19		23	
Hybrid groups (*N*)	1		1		1	

Reach Monitoring Upstream of the Dispersal Barrier

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Introduction: Reach electrofishing upstream of the dispersal barrier was implemented to expand monitoring beyond fixed sites and increase the possibility of encountering Asian carp in the CAWS. It also provided an opportunity to gain further information on distribution patterns of target and non-target fish species. Additional fish distribution information gained from reach monitoring was deemed useful in assessing locations for possible removal actions or other sampling and control measures. These data also were considered useful for evaluating fixed site locations and adjusting future sampling protocols.

Electrofishing was selected as the gear of choice to sample the four waterway reaches because it allows for extensive coverage of the waterway with moderate effort. The four reaches were originally scheduled to be sampled monthly, but the MRRWG supported a reduced level of sampling effort (seasonal sampling) after results of rotenone and conventional gear rapid response actions indicated low Asian carp abundance in the CAWS and a reduced threat of immediate invasion.

Objectives: DC Electrofishing was used to:

1) Seasonally monitor for the presence of Asian carp throughout the CAWS upstream of the Dispersal Barrier;
2) Determine Asian carp distribution in the CAWS; and
3) Obtain information on the non-target fish community to help verify sampling success, guide modifications to sampling, and assist with rare fish capture modeling and gear evaluation studies.

Methods: We designated four reach segments that encompassed 76 miles of Chicago waterways and allowed monitoring of the entire CAWS upstream of the Dispersal Barrier. Sampling at reach segments occurred three times per year on a seasonal basis during spring, summer, and fall. Sampling was conducted using pulsed-DC boat electrofishing. Reach electrofishing typically excluded areas of the waterway designated as fixed sites because these areas were sampled by electrofishing twice each month as part of fixed site monitoring. However, a limited number of samples were collected at fixed sites in 2011 to provide a direct comparison with reach samples. Electrofishing crews had a goal of three 15-minute electrofishing transects (or runs) per river mile within a reach segment and selection of run locations were at the discretion of the sampling crews. Crew leaders were responsible for providing starting point locations for each transect either with GPS coordinates or by marking on provided maps.

Electrofishing Protocol – The electrofishing protocol for reach sampling was similar to the protocol used for fixed site sampling. Electrofishing was conducted in a downstream direction in areas with noticeable current velocity and runs were generally parallel to shore (including following shoreline into off channel areas). The operator had the option of switching the pedal on and off at times to prevent pushing fish in front of the boat, thereby increasing the chances of catching an Asian carp. Common Carp were counted without capture and all other fish were netted and placed in a live well where they were identified and counted, then returned live to the water. Most captured fish were measured to total length and weighed to provide length-frequency data for gear evaluations. Young-of-year Gizzard Shad (YOY; <6 inches long) were examined closely to check for the presence of Asian carp for a potential assessment of young Asian carp in the waterway.

Reach Locations – A description of reach locations and approximate number of electrofishing runs is summarized below. The duration of each electrofishing transect was generally 15 minutes.

Reach 1 - Chicago Sanitary and Ship Canal (CSSC) from Dispersal Barrier to the Stickney Water Reclamation Plant (WRP; RM 296-316; ~20 transects).
Reach 2 - CSSC and Calumet – Sag Channel junction to Calumet Harbor (RM 303.5-333; ~30 transects).
Reach 3. CSSC from Stickney WRP (RM 316) to Chicago Lock (RM 327; ~20 transects)
Reach 4. North Branch Chicago River (RM 326.5) to Wilmette Pumping Station (~30 transects).

Data Analysis – Data obtained from reach and fixed site electrofishing samples above the Dispersal Barrier in 2010 were used to evaluate differences in fish communities and fish species diversity between the two monitoring projects. Potential redundancies between fish collections from the two projects could then be identified and used to guide modifications to sampling protocols.

Fish community differences in terms of fish species contributions and assemblage patterns were tested using Analysis of Similarity (ANOSIM), Non-metric Multidimensional Scaling (NMDS), and similarity percentages procedure (SIMPER; Clark and Warwick 2001). Fish community tests were performed using total abundances from 2010 data for all fish species collected at a given site (electrofishing transect) for each monitoring project. The community data was first used to create a Bray-Curtis similarity matrix of coefficients representing a calculation of all fish species and their total catch for each electrofishing sample. Pair-wise comparisons of samples were then made against each other; high comparison values in the matrix indicated high similarity between a given pair of samples (Bray and Curtis 1957). The ANOSIM procedure functions somewhat like Analysis of Variance, thus a one-way ANOSIM allowed for a statistical calculation of the fish communities between reach and fixed sites from the similarity matrix. The NMDS procedure provides graphical representation of fish assemblage patterns between reach and fixed samples. A two-dimensional NMDS plot was created from samples classified according to the project from which they were taken. The NMDS plot mapped sample values from the Bray-Curtis similarity matrix according to their distances in similarity from one another, therefore samples of high similarity grouped close together. The SIMPER procedure was used to isolate contributions of individual fish species to reach and fixed site samples. SIMPER gives higher contribution percentages to fish species with consistently higher abundances across samples, while fish species with uneven extremes in catch would have a lower contribution percentage regardless of an overall high catch value. A 99% cut-off level was used to identify the species that were most likely to be observed among collections for each monitoring project. Species diversity was tested using species richness, evenness, Shannon diversity, and Simpson diversity to provide additional insight into fish species collection patterns between reach and fixed sites.

Results and Discussion: A total of 2,734 fish representing 33 fish species (plus hybrid sunfish and Common Carp x Goldfish hybrids) were collected during the 2010 reach monitoring effort (Table 1). Reach sites were sampled on multiple episodes in July, August, and October resulting in a combined 460 person-hours of effort from 244 total collections and 78.1 hours of electrofishing. The greatest total catch was observed in Reach 4 (North Branch Chicago River up to Wilmette Pumping Station) with 949 fish collected during 21.0 hours of electrofishing. Reach 3 (CSSC from Stickney WRP - Chicago Lock) had the greatest catch per unit effort (CPUE) at 54.6 fish/hour and Reach 2 (CSSC and Calumet – Sag Channel junction to Calumet Harbor) recorded the greatest fish species richness at 25 total species collected. Mean number of fish species collected per electrofishing transect within a reach was low in 2010; on average only two fish species were collected per electrofishing transect. Seven fish species comprised 91% of the total abundance of reach monitoring samples in 2010 (Table 2). Gizzard Shad were most abundant ($N = 1{,}444$) making up 52.8% of the total catch, followed by Common Carp (518; 18.9%), Largemouth Bass (155; 5.7%), Pumpkinseed (117; 4.3%), Bluegill (109; 4.0%), Emerald Shiner (85; 3.1%), and Smallmouth Bass (61; 2.2%). No adult Asian carp were observed or sampled in 2010 and a total of 912 YOY Gizzard Shad were examined with no Asian carp YOY detected.

A total of 2,383 fish representing 35 fish species (plus hybrid sunfish) were collected in the 2011 reach monitoring effort (Table 1). All reaches were sampled three times resulting in a combined 300 person-hours of effort from 348 total collections and 87.8 hours of electrofishing. Reach sampling episodes occurred in June, July, August, September, and October. Reach 4 netted the highest total catch (998 total fish), CPUE (52.6 fish/hour), and species richness (26 species for both) among reaches sampled. As in 2010, the mean number of fish species collected per electrofishing transect was low in 2011; on average only three species were collected per transect. Five fish species comprised 91% of the total abundance of reach monitoring samples in 2011 (Table 3). Gizzard Shad had the greatest abundance ($N = 833$) making up 34.9% of the total catch, followed by Common Carp (406; 17.0%), Golden Shiner (214; 9.0%), Pumpkinseed (202; 8.5%), Bluegill (143; 6.0%), Largemouth Bass (113; 4.7%), Spotfin Shiner (106; 4.4%), Bluntnose Minnow (70; 2.9%), and White Sucker (60; 2.5%). No adult Asian carp were observed or sampled in 2011 and a total of 280 YOY Gizzard Shad were examined with no Asian carp YOY detected.

Fish Community Analyses – Fish community and diversity analyses from 2010 reach and fixed site electrofishing showed some differences in fish species assemblages between monitoring projects. The ANOSIM test revealed a significant difference between reach vs. fixed site samples (P=0.001, Global R=0.378). However, the NMDS analysis suggested that reach and fixed site samples were considerably similar as many data points overlapped in the NMDS plot (Figure 1).

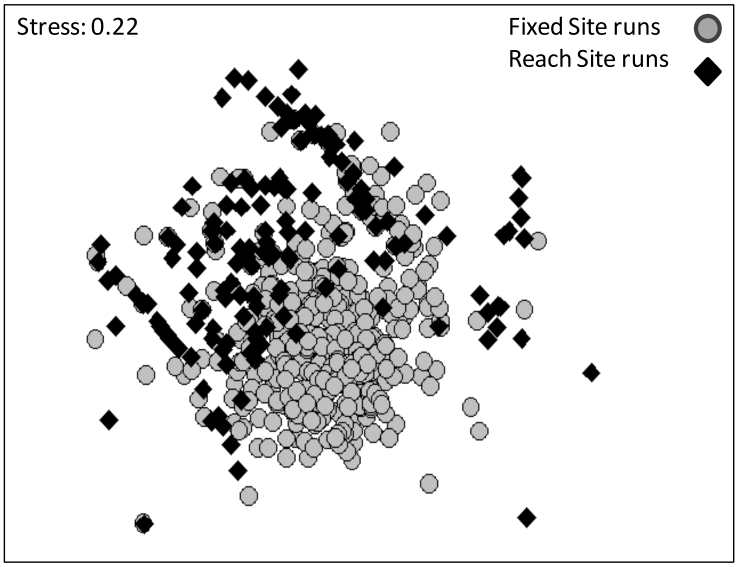

Figure 1. NMDS plot of reach and fixed site electrofishing runs from the CAWS upstream of the Dispersal Barrier.

The SIMPER procedure provided a finer resolution of fish species that contributed to the differences observed by the ANOSIM procedure (Table 4). The greatest contribution to similarity among reach and fixed site samples was a dominance of Gizzard Shad, Common Carp, and Largemouth Bass in all collections. Observed differences between collections resulted from a greater number of species contributing to catches at fixed sites compared to catches at reach sites. In addition, catch rates were substantially higher in fixed site electrofishing samples than in reach site samples (Table 4).

The significant difference to the fish community of reach vs. fixed sites samples observed by the ANOSIM test was likely due to a greater diversity of fish species collected by fixed site sampling rather than a complete difference in composition of fish species collected during each project. Species diversity indices showed greater mean Shannon diversity and mean Simpson diversity for fixed sites compared to reach sites (Table 5), due to the greater mean species richness among fixed site samples (seven species/sample for fixed sites vs. three species/sample for reach sites). Species evenness was greater for reach sites than fixed sites, which was likely due to a much smaller suite of fish species captured on a consistent basis at the reach sites.

Reach monitoring added a considerable amount of effort in the CAWS upstream of the Dispersal Barrier and provided collections in areas not sampled through fixed site monitoring. Even though the ultimate result of no Bighead or Silver Carp captured or observed was the same for fixed site and reach electrofishing, there was a high proportion of reach transects with no fish sampled in 2010 (22%) and 2011(39%). Reach catches were consistent with those of fixed site monitoring in 2010 in that only one fish species (Golden Redhorse) was collected by reach monitoring that was not collected by fixed site monitoring. Conversely, fixed site monitoring provided 26 fish species that were not detected during reach monitoring, and which resulted in the higher mean species richness and mean Shannon and Simpson diversities at fixed sites. Although reach monitoring added to total sampling effort in the CAWS, the data obtained on the non-target fish community was largely redundant to that of fixed site monitoring.

Comparisons of reach and fixed site electrofishing samples supported the workgroup‟s selection of the five fixed sites as locations in the CAWS that sustain higher quality fish communities. On average, we caught more fish and a greater variety of fish by electrofishing at fixed sites than at reach sites. Several factors, including proximity to Lake Michigan, water quality, habitat diversity, and electrofishing efficiency, may explain differences among samples from fixed sites and reaches. Identifying the relative importance of these variables in shaping fish community structure and sampling success is beyond the scope of this project. However, if factors affecting distributions of other fish species in the CAWS are similar for Asian carp, then we might expect that any Asian carp upstream of the barrier will be drawn to the fixed sites or at least spend a higher proportion of time in those areas than in other areas of the waterway. Based on this analysis, it appears reasonable to continue intensive monitoring at the fixed sites upstream of the Dispersal Barrier.

Recommendations: Given the results of the fish community analyses, we recommend discontinuing reach electrofishing to gain efficiencies in the CAWS monitoring program. Our analyses showed that reach electrofishing required a high degree of effort and provided little additional information than that found through fixed site monitoring. However, additional sampling beyond fixed site stations may yet be beneficial, particularly in light of positive detections for silver carp DNA at several locations throughout the CAWS during 2011 (see eDNA Monitoring Report). We recommend replacing reach monitoring with a randomized sampling regime of electrofishing and netting sites outside the boundaries of fixed site monitoring stations. Randomized sampling will maintain monitoring vigilance throughout the waterway upstream of the barrier and increase the frequency of sampling in these areas compared to reach monitoring. Randomized sampling can be incorporated into the fixed site monitoring project with a recommended reduction in electrofishing transects at selected fixed sites. For more details see the Fixed Site Monitoring Report above.

Project Highlights:

- Estimated 760 person-hours spent sampling at four reaches upstream of the Barrier in 2010 and 2011.
- Completed 544 electrofishing transects and a total of 166 hours of electrofishing over both years.
- Sampled 5,117 fish representing 44 species and two hybrid groups.
- No Bighead or Silver Carp captured or observed in either year.
- Community analysis comparing fixed site and reach electrofishing samples from 2010 showed higher catches of fish and higher species richness in samples from fixed sites.

- Based on community analyses, recommend discontinuing reach monitoring and instead initiating randomized sampling in areas of the CAWS outside of the fixed sites with electrofishing and netting gear to maintain areal coverage of the waterway. Randomized sampling will increase frequency of sampling outside the fixed sites and can be incorporated into fixed site monitoring program.

Table 1. Total fish catch, species richness, effort (hrs), and catch per unit effort in number of fish collected per hour during Reach Sampling in 2010 and 2011.

Location	N	Total Catch	Total Species	Effort (hrs)	$CPUE_N$ (fish/hr)	Mean Species/ Transect
2010						
Reach 1	51	234	10	16.3	14.3	1
Reach 2	90	890	25	28.6	31.1	2
Reach 3	49	661	19	12.1	54.6	3
Reach 4	54	949	18	21.0	45.2	3
Total	244	2,734	33	78.1	35.0	2
2011						
Reach 1	91	176	12	22.5	7.8	1
Reach 2	110	598	24	27.8	21.5	5
Reach 3	37	171	10	9.3	18.5	2
Reach 4	74	998	26	19.0	52.5	4
* Fixed Site 2	17	72	9	4.3	16.9	2
* Fixed Site 3	6	0	0	1.5	0.0	0
* Fixed Site 4	4	73	11	1.1	68.2	5
* Fixed Site 5	8	292	14	1.9	152.1	7
* N. Branch, Chicago R.	1	3	2	0.5	5.7	2
Total	348	2,383	35	87.8	27.1	3

* Fixed Sites and the North Branch of the Chicago River were sampled in conjunction with Reach transects during Reach Site sampling

Table 2. Numbers of fish sampled with DC electrofishing gear at four reaches in the CAWS upstream of the Dispersal Barrier in 2010.

Fish Species	Reach Site 1	Reach Site 2	Reach Site 3	Reach Site 4	Total
Gizzard Shad	177	332	299	636	1444
Common Carp	35	248	174	61	518
Largemouth Bass	5	72	26	52	155
Pumpkinseed	3	11	41	62	117
Bluegill	1	20	35	53	109
Emerald Shiner	1	75	8	1	85
Smallmouth Bass		60	1		61
Golden Shiner	1	5	22	24	52
Spotfin Shiner			19	9	28
Goldfish	7	7	11	1	26
White Sucker		4		20	24
Green Sunfish		3	2	10	15
White Bass	3	7	4		14
Bluntnose Minnow		10		3	13
Yellow Bullhead	1	3	7	2	13
Freshwater Drum		11			11
Common Carp x Goldfish hybrid			2	6	8
Golden Redhorse		7			7
Rock Bass		5			5
Channel Catfish			4		4
Creek Chub			1	2	3
Hybrid sunfish		2		1	3
White Crappie		2	1		3
Yellow Perch		1		2	3
Yellow Bass				2	2
Bigmouth Buffalo		1	1		2
Black Buffalo		1			1
Black Crappie			1		1
Bullhead Minnow				1	1
Chinook Salmon		1			1
Fathead Minnow			1		1
Rainbow Trout		1			1
Round Goby		1			1
Warmouth				1	1
White Perch			1		1

Table 3. Numbers of fish sampled with DC electrofishing gear at four reaches in the CAWS upstream of the Dispersal Barrier in 2011. A limited number of additional samples were taken at Fixed Site 2-5 for direct comparison to reach samples.

Fish Species	Reach Site 1	Reach Site 2	Reach Site 3	Reach Site 4	Fixed Site 2	Fixed Site 3	Fixed Site 4	Fixed Site 5	N Branch Chicago River	Total
Gizzard Shad	32	269	67	378	52		33		2	833
Common Carp	96	159	54	72	10		6	9		406
Golden Shiner	4		6	102			1	101		214
Pumpkinseed	5	1	26	110	1		1	58		202
Bluegill	3	15	3	73			10	39		143
Largemouth Bass		40	9	36	1		1	26		113
Spotfin Shiner	3			75			17	11		106
Bluntnose Minnow	4			40			1	25		70
White Sucker		3		47			1	9		60
Goldfish	10	7	1	14	2			1		35
Smallmouth Bass		34								34
Green Sunfish		4	1	12			1	6		24
Alewife		10		9				1		20
Emerald Shiner	1	9		3			1	1		15
Rock Bass		11						4		15
Brown Bullhead	13	1								14
Yellow Bass	4	5		3						12
Channel Catfish	1	6	1	1						9
White Bass		8		1						9
Common Shiner				8						8
Black Bullhead		2		3	1					6
Freshwater Drum		6								6
Yellow Perch		2		2						4
Shorthead Redhorse		2			2					4
Hybrid sunfish			2	1						3
Brook Silverside		1		1					1	3
Black Crappie				2				1		3
Orangespotted Sunfish					2					2
Smallmouth Buffalo		1			1					2
Bigmouth Buffalo		1								1
Black Buffalo		1								1
Golden Redhorse				1						1
Bowfin				1						1
Mosquitofish			1							1
Oriental Weatherfish				1						1
Round Goby				1						1
White Perch				1						1

Table 4. SIMPER output for mean abundance and percent contributions of fish species between fixed and reach site samples in 2010. Fish species listed represent those contributing to 99% of the similarity among sites.

	Fixed Sites		Reach Sites	
	Mean Abund	%Contribution	Mean Abund	%Contribution
Gizzard Shad	43.86	50.89	7.98	46.98
Common Carp	13.34	26.23	2.86	37.37
Largemouth Bass	7.41	9.73	0.73	9.94
Bluegill	2.83	3.45	0.56	1.68
Pumpkinseed	2.07	2.37	0.59	1.66
Golden Shiner	1.89	1.27	0.28	0.86
Spotfin Shiner	1.61	1.25		
Bluntnose Minnow	2.99	1.18		
Emerald Shiner	2.24	1.10		
White Sucker	1.32	0.98	0.13	0.27
Yellow Perch	0.87	0.34		
Goldfish	0.73	0.29	0.14	0.33

Table 5. Comparison of species richness, evenness, and diversity indices for DC electrofishing samples from reach and fixed sites in the CAWS upstream of the Dispersal Barrier during 2010.

Mean	Fixed Sites	Reach Sites
Species Richness	7.4	2.9
Evenness	0.65	0.75
Shannon Diversity	1.23	0.64
Simpson Diversity	0.59	0.45

Strategy for eDNA Monitoring in the CAWS and Upper Des Plaines River

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Participating Agencies: US Army Corps of Engineers (lead), US Fish and Wildlife Service – Carterville, Columbia, and La Crosse Fish and Wildlife Conservation Offices and US Environmental Protection Agency (field and lab support); Illinois Department of Natural Resources (field support)

Introduction: Invasive aquatic nuisance species pose a major threat to aquatic ecosystems worldwide. Within Illinois, the manmade CSSC, constructed in the early 1900s, provided an unnatural portal for invasive species dispersal between the geologically separated Mississippi River and Great Lakes drainage basins. In 2002, in an effort to curtail the spread of invasive species between the two basins, the U.S. Army Corps of Engineers (USACE), constructed a dispersal barrier system within the CSSC. The primary objective of the barrier system when initiated was to stop the dispersal of the invasive round goby into the Mississippi River basin; however, once the project was completed, it was found that the round goby had already surpassed the barrier. Since then, a new threat to the Great Lakes from the Mississippi River basin has become the primary objective of the dispersal barrier system. Invasive Asian carps, including bighead carp and silver carp have been steadily dispersing upstream through the Mississippi, Illinois, and Des Plaines Rivers. In the past, traditional fishery techniques were used to detect the leading edge of the Asian carp population south of the dispersal barriers; however, this method was somewhat ineffective at targeting these species at low densities. The University of Notre Dame (UND), with funding from the USACE, developed a method that detected “environmental” deoxyribonucleic acid (eDNA) left behind in the aquatic system by the targeted species (Jerde et al. 2011).

Environmental DNA enters the system through a variety of mechanisms, some of which include sloughing of external epidermal cells into the water, sloughing of internal epidermal cells into feces and into the water, and as tissue residues following injury or predation. The detection of eDNA in water samples is based on whole DNA extraction from filtered particulate organic and inorganic matter found in the water and polymerase chain reaction (PCR) assays for species-specific mitochondrial DNA markers. eDNA is a genetic surveillance tool used to detect the presence of Bighead Carp, Silver Carp, and hybrid Bighead x Silver Carp DNA in the aquatic environment. At present, eDNA evidence cannot discern the source of the DNA or the characteristics of the fish, verify whether live Asian carp are present, the number of Asian carp in an area, or whether a viable population of Asian carp exists. A positive result does not reveal how Asian carp DNA traveled to that location. For example, the current testing does not explain whether the eDNA is from a live or dead Asian carp, from water containing Asian carp DNA transported from other locations, or other sources.

In the summer of 2010, federal agencies assumed the lead for eDNA monitoring from UND. The USACE is responsible for coordinating sampling, processing samples, and posting results. The U.S. Fish and Wildlife Service (USFWS) and IDNR are responsible for sample collection. The latest sampling strategy for eDNA was developed by the MRRWG and released in May 2011 as part of the workgroup‟s monitoring plan for the calendar year. The plan called for the use of the eDNA methodology to aid in monitoring for the presence of Asian carp in the CAWS. It called for weekly rotational sampling at three designated reaches each month and a flex week where sampling could be repeated at a site or an alternative site could be targeted as needed. In addition, a spatially comprehensive and temporally truncated eDNA sampling event, dubbed the „snapshot‟ was planned for the end of the monitoring season. The goal of the snapshot strategy was to obtain a comprehensive system-wide view of Asian carp DNA distribution in the CAWS at one time.

In general, as the eDNA method is refined and calibrated, investigating unknowns about the surveillance tool by directly testing the viability of theories and assumptions is considered important by the MRRWG. For example, the eDNA calibration study being conducted by the USACE, USFWS, and USGS will test the detection rate, decay rates, and alternate vectors of the eDNA methodology. The intent of the eDNA snapshot was to test the viability of the assumption that a small number of Asian carp (or some other contributing source of genetic material) were causing eDNA positive results in different locations of the CAWS.

Objectives: Objectives stated in the plan for the use of eDNA sampling were as follows:

1) Determine whether Asian carp DNA is accumulating in Lake Calumet and below structures that impede fish passage into Lake Michigan;
2) Detect Asian carp DNA in areas targeted for rapid response actions, as a measure of the effectiveness of conventional gear or rotenone removal efforts;
3) Determine the instantaneous distribution of Asian carp DNA in the CAWS;
4) Monitor for the presence of Asian carp DNA in other strategically important areas, such as the upper Des Plaines River below Hofmann Dam, confluence of the CSSC and Calumet-Sag Channel, and the Lockport Pool of the CSSC immediately upstream and downstream of the electric Dispersal Barrier.

Methods:

Study Sites – Sampling each month rotated among three designated reaches: North Shore Channel (W 41.9740º, N 87.7044º), Chicago River/South Branch Chicago River (W 41.8892º, N 87.6085º), and Lake Calumet (W 41.6529º, N 87.5679º)/Little Calumet River (W 41.6786º, N 87.5783º). Every fourth week of sampling was considered a flex week, during which time sampling could occur at one of the aforementioned reaches or at an alternative reach: Upper Des Plaines River (W 41.8258º, N 87.8203º), Lockport Pool above (W 41.6531º, N 88.0572º) and below (W 41.5722º, N 88.0775º) the electric dispersal barrier, or confluence of the CSSC and Calumet-Sag Channel (W 41.68617º, N 87.86217º).

Field Sampling – Monitoring using the eDNA methodology typically occurred on a Monday or Tuesday of each week and extended from May through October 2011 (17 weeks). Sampling was cancelled or postponed due to contamination concerns if a combined sewer overflow (CSO) occurred two days prior to sampling and/or if observed precipitation exceeded 1.5 inches in 24 hours five days prior to sampling. Each week of sampling, 120 two-liter bottles were collected from the upper 2 inches of the water‟s surface.

Sampling crews included a sample collector, data recorder, and boat driver and were comprised of personnel from the IDNR, USFWS, and U.S. Environmental Protection Agency (USEPA). Locations for sample collections within a designated reach were mapped out on aerial photos prior to sampling. When a crew arrived at a designated sampling location, two-liters of water from the upper 2 inches of the surface would be collected by the sample collector. For each sample collected, the data recorder would record sample coordinates (decimal degrees), surface water temperature and depth (using a HawkEye® H22PX Handheld Sonar System), channel location (right bank descending, left bank descending, or mid-channel), and time of collection. Once a sample was collected it was returned to a cooler capable of holding 20 samples prior to being transported back to the laboratory for filtering. As a quality control measure, each cooler contained one control sample which was a two-liter bottle filled with deionized (DI) water. In addition, six duplicate samples (two samples collected in tandem from the same sampling location) were also collected within each reach.

Laboratory Processing – Depending on the size of the reach being sampled, sample collection typically took 3 to 5 hours. Once samples were collected, they were transported back to the USEPA Chicago Environmental Research Laboratory. Samples were released via a chain of custody form to filtering staff comprised of USACE personnel. Prior to filtering a sample, one-liter of DI water was filtered through a 0.45-1 micron glass fiber filter using a -75 kPA vacuum. Control samples were placed in a 15 mL conical tube and held in a -20ºC freezer. Collected samples were then filtered through a 0.45-1 micron glass fiber filter, placed in a 50 mL conical tube, and held in a -20ºC freezer. Multiple filter papers were often used due to the turbidity of the collected samples. The following day, samples would be divided among two shipping containers containing Styrofoam coolers and approximately 25 lbs. of dry ice pellets, and shipped to the USACE Environmental Research and Development Center (ERDC) for analysis.

For detailed sample collection, filtering, and analysis protocols please refer to the eDNA Monitoring of Invasive Asian Carp in the Chicago Area Waterway System Quality Assurance Project Plan (eDNA QAPP; USACE 2011).

Snapshot Sampling – The sampling event occurred from 25-27 October 2011 and concluded eDNA sampling for the 2011 calendar year. The USFWS provided the field support for the snap-shot event with support from USEPA. The USACE lead the filtering efforts, while the USFWS provided trained staff for filtering support. All personnel adhered to field and laboratory protocols outlined in the eDNA QAPP (USACE 2011). Two field crews and two filtering crews were scheduled for each sampling day with each crew working approximately 8 to 10 hour shifts. The following six sites were sampled as part of the snapshot:

- 25 October 2011: North Shore Channel (120 samples), Chicago Lock/Bubbly Creek (120 samples)
- 26 October 2011: CSSC above confluence (120 samples), upstream of barrier (120 samples)

- 27 October 2011: Lake Calumet/below O'Brien (120 samples), Cal-Sag above confluence (120 samples)

Samples were filtered, stored in a -20ºC freezer until the completion of the event, and were then shipped to the ERDC for processing. Processing of the samples occurred from November 2011 – January 2012, so as not to impact the processing of samples from regular weekly eDNA monitoring.

Results:

Weekly Monitoring – Weekly eDNA monitoring occurred from May through October 2011 and results were reported on average every 14 days. A total of 1,864 water samples were collected and analyzed along with 93 control samples. Of the total water samples collected, 1,693 samples were taken from reaches upstream of the Dispersal Barrier, 57 from downstream of the Dispersal Barrier, and 114 from the upper Des Plaines River downstream from Hofmann Dam (Table 1). Eighteen (18) samples were positive for Silver Carp DNA and zero (0) samples were positive for Bighead Carp DNA in reaches upstream of the dispersal barrier. In the Lockport Pool reach below the dispersal barrier, all samples collected were negative for Silver and Bighead Carp DNA. For samples collected from the upper Des Plaines River reach, two (2) samples were positive for Silver Carp DNA whereas zero (0) samples were positive for Bighead Carp DNA.

Temperature and depth information was recorded for each sample collected; however, on four sampling occasions either temperature only was recorded or equipment failed resulting in no temperature and depth data. The mean temperature for 14 samples testing positive for Asian carp genetic material was 22.2ºC (SD±5.32), while the mean temperature for 1,624 samples testing negative was 22.8ºC (SD±3.98; Figure 1). Mean channel depth for 11 samples testing positive for Asian carp genetic material was 3.0 m (SD±2.61), while mean depth for 1,455 samples testing negative was 3.41 m (SD±2.46; Figure 2).

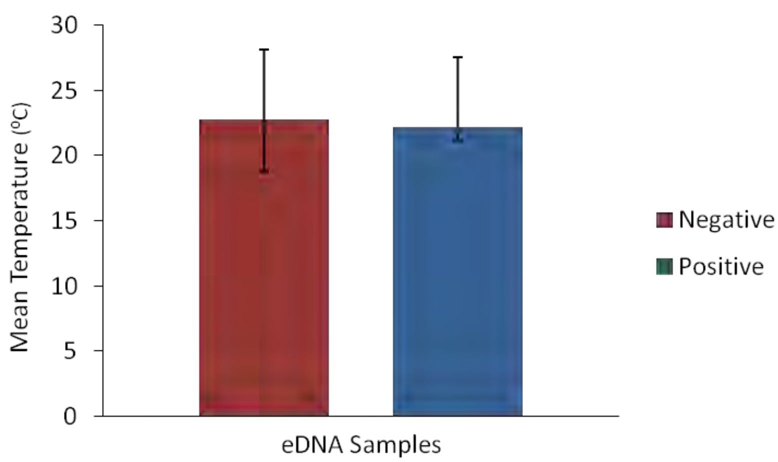

Figure 1. Mean temperature and standard deviation for samples testing negative and positive for Asian carp DNA.

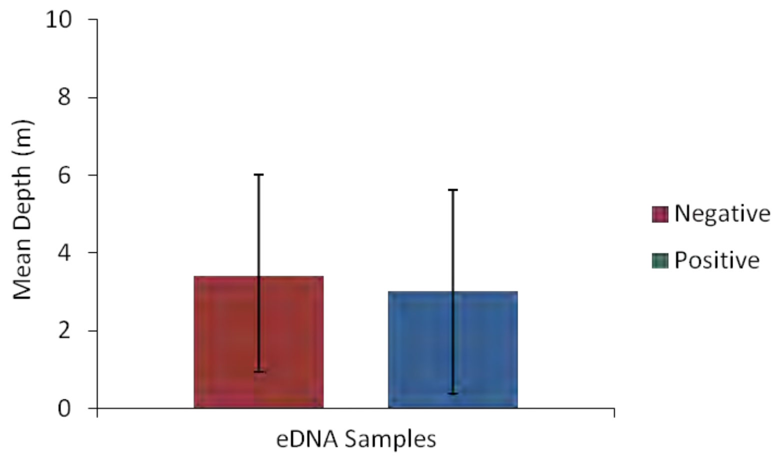

Figure 2. Mean depth and standard deviation for samples testing negative and positive for Asian carp DNA.

Sampling effort for the 2011 season was 631.75 estimated person-hours spent in the collection and filtering of 3,386 liters of water collected above the barrier (Table 2). Estimated person-hours for sample collection and filtering in the Lockport Pool below the Dispersal Barrier were 21.25 for 114 liters of water. During the upper Des Plaines River sample collection and filtering of 228 liters of water, 44 estimated person-hours were expended.

eDNA Snapshot – As part of the eDNA Snapshot sampling event, a total of 684 water samples were collected and analyzed along with 36 control samples. All of the water samples were collected above the electric Dispersal Barrier in the CAWS (Table 3). Sixteen (16) samples were positive for silver carp DNA and zero (0) samples were positive for bighead carp DNA. Sampling effort for the eDNA snapshot sampling event was 183.5 estimated person-hours spent in the collection and filtering of 1,482 liters of water collected above the barrier (Table 4).

Conclusions: Although eDNA is a relatively new monitoring method, it has been validated by an independent external peer review as an early detection monitoring tool for Bighead and Silver Carp DNA and is used in the MRRP as a trigger for response actions. As stated earlier, at present, eDNA evidence cannot verify whether live Asian carp are present, whether the DNA may have come from a dead fish, or whether water containing Asian carp DNA may have been transported from other sources such as bilge water, storm sewers, or piscivorous birds. We also do not fully understand how environmental variables (light, temperature, water velocity) impact the detection rate, degradation rate, or persistence of DNA in the environment. Additionally, we currently do not have an understanding of how the number of positive samples correlates to the strength of the DNA source. To better understand and interpret eDNA results, USACE is leading an interagency eDNA Calibration Study (ECALS) with USGS and USFWS to reduce the uncertainty surrounding eDNA results. ECALS will investigate eDNA vectors (alternative viable sources and pathways for DNA), develop more efficient markers that will decrease the processing time for eDNA samples and give us broad estimates of population abundance, determine the effect of environmental variables on eDNA, and model eDNA transport in the CAWS.

Determine whether Asian carp DNA is accumulating in Lake Calumet and below structures that impede fish passage into Lake Michigan and detect Asian carp DNA in areas targeted for rapid response actions, as a measure of the effectiveness of conventional gear or rotenone removal: The regular 2011 monitoring field season resulted in 17 eDNA sampling events, with Lake Calumet being the only reach having consecutive sampling events with positive eDNA results. As part of the 2011 MRRP developed by the MRRWG, three consecutive eDNA reach sampling events with positive detections for Asian carp elicit a Level 1 rapid response. A Level 1 response includes 2 to 4 electrofishing boats and crews and 1-2 commercial fishing boats and crews sampling for 2-3 days. The rapid response in Lake Calumet was terminated by the third day with no Asian carp captured. Samples collected prior to the rapid response resulted in no positive detections of Asian carp DNA. It appears as though Asian carp DNA was collecting in Lake Calumet over the course of the field season and if this was the result of Asian carp being present, this may be attributed to the prime aquatic habitat within Lake Calumet. The lake is highly productive and includes deep draft pools, shallow backwaters and side channels, gravel bars, and submerged and emergent aquatic vegetation - habitats that are conducive to Asian carp habitation. Lake Calumet also provides prime habitat for piscivorous avian species that might also be a source of Asian carp DNA.

Determine the instantaneous distribution of Asian carp DNA in the CAWS: The snapshot results indicate that, over a short period of time, Silver Carp DNA was distributed at several locations throughout the CAWS, but was not detected in Lake Calumet or the CSSC above the confluence of the Calumet-Sag Channel. Asian carp eDNA has previously been detected at all locations that yielded a positive result in the snapshot. Consistent with weekly eDNA monitoring results in 2011, only Silver Carp DNA was detected during the snapshot event (no Bighead Carp DNA was detected).

The snapshot sampling event was not designed to identify the specific sources of DNA in the CAWS. Potential examples of sources include multiple fish (live or dead), input from storm sewer discharge/combined sewer outfalls, fish-eating birds, and recreational/commercial vessels transporting fish or DNA. Additionally, what remains unknown is how the number of positive samples correlates to the strength of the DNA source. For example, 10 of 114 samples returned positive hits for Silver Carp DNA in the Calumet-Sag Channel above the confluence of the CSSC, but at this point in time, the MRRWG is still working to understand the relationship between the number of hits and the DNA source (fish or other source).

The current Monitoring and Rapid Response protocol identifies the need for the results from one site to return one or more positive hits in three consecutive sampling trips to trigger a response action. The MRRWG puts more value on the repetition of positive hits at a site than the number of positive hits returned during one monitoring event. Response actions are triggered by a consistent pattern of DNA over several sampling occasions, indicating a potential affinity to the site by Asian carp or Asian carp DNA over time, and not in a single instant. The Calumet-Sag Channel has not been in the standard rotation of sites sampled for eDNA; therefore, the criteria that invoke a response have not been met, as outlined in the 2011 Monitoring and Rapid Response Plan.

In 2011, the MRRWG spent over 5,000 estimated person-hours monitoring with conventional gears in the CAWS upstream of the Dispersal Barrier. Over 325 hours of electrofishing and 78 miles of contracted commercial netting sampled over 68,000 fish representing more than 60 species. No Bighead or Silver Carp were captured or observed above the barrier during 2011. The workgroup will continue extensive effort to achieve the overall goal of preventing Asian carp from establishing self-sustaining populations in the CAWS and Lake Michigan. The MRRWG will maintain vigilance in the entire CAWS with the continuation of eDNA and conventional gear monitoring during 2012, as well as adding new gears such as large frame hoop nets and surface-to-bottom gill/trammel nets (see Gear Evaluation and New Gear Development reports).

Snapshot results will be considered as we develop our 2012 MRRWG eDNA sampling strategy and conventional gear monitoring protocols. All monitoring results inform our adaptive management approach as discussed in the 2011 Monitoring and Rapid Response Plan which was released last May. The MRRWG will be initiating eDNA testing and intensive monitoring in early May and conventional gear sampling in March.

Monitor for the presence of Asian carp DNA in other strategically important areas, such as the upper Des Plaines River below Hofmann Dam, confluence of the CSSC and Calumet-Sag Channel, and the Lockport Pool of the CSSC immediately upstream and downstream of the electric Dispersal Barrier: As part of routine sampling the Lockport Pool (up and downstream of Barrier) and Des Plaines River were sampled once during the 2011 field season. Lockport Pool was sampled on the 6 September with all 120 samples containing no positives for Asian carp DNA. In 2009, six miles of the Lockport Pool above the electric dispersal barrier were treated with rotenone, a piscicide. The intent of the pre-barrier-maintenance rotenone application was to eradicate any Asian carp trapped within the barrier (between the demonstration barrier and Barrier 1A) or downstream of the barrier to Lockport Lock and Dam. Following the application, one Bighead Carp was retrieved from below the barrier in Lockport Pool. Since the rapid response, fish abundance within the pool has notably declined and has not fully rebounded two years later. In 2010, eDNA sampling of the Lockport Pool resulted in five (5) positive detections for Silver Carp above the barrier, and 5 Bighead and 25 Silver Carp positive detections below the barrier. Variability in eDNA detection at this location may be a result of Asian carp moving into the pool, but eventually dispersing back downstream where better habitat exists, or due to alternative eDNA sources (e.g., boat hull, piscivorous birds, etc.). Results from the USACE eDNA calibration study may provide more evidence in the future as to which source of eDNA is most probable.

One-hundred and twenty samples were collected from the Des Plaines River on 6 July. Samples were collected from three reaches: Riverside Station (upstream location, downstream of Hofmann Dam), Columbia Woods Station (mid-site location), and Lemont Road Station (downstream location). Two samples from the Riverside Station had positive detections for silver carp DNA. In 2010, a positive detection for Bighead Carp DNA came from the Columbia Woods Station, while 5 positive detections for Silver Carp DNA came from the Lemont Road Station. One positive detection for Silver Carp DNA occurred in the upper Des Plaines River in 2009; however, the precise location of this sample is unknown. If the 2010 and 2011 detections represent live fish, these data may indicate that Silver Carp may have dispersed upstream approximately 21 kilometers in the course of a year. Future eDNA monitoring should continue in the upper Des Plaines River and include sampling upstream of Hofmann Dam to determine if this barrier has been surpassed or if an alternative source (e.g. boat hull, piscivorous birds, etc.) is causing the positive detections.

Implementation of additional quality control samples to identify any potential quality control issues and their sources, and to provide a better understanding of sample result reproducibility: During the 2011 field season, the collection of duplicate samples was implemented as part of the standard eDNA collection protocol. Duplicate samples are two samples collected concurrently at the same location and were designated on aerial sampling maps with a star. Duplicate samples were put into practice to provide a quantitative assessment of reproducibility as well as a quality control measure. Out of 17 sampling events during the 2011 season, only one sampling event resulted in a duplicate sample returning a positive for eDNA. The sample was collected from the Little Calumet River on 19 July. Results indicated that one of the 2L duplicate samples was positive for Silver Carp DNA while the other 2L sample was negative for genetic material. Since Asian carp eDNA is rare in the CAWS, the probability of it being collected and detected in samples taken concurrently is low. ECALS is investigating eDNA methodology and the distribution of Asian carp eDNA within the water column (different depths of water sampled) and within a 2L sample.

Additional sample data analysis and conclusions: Surface water temperature and channel depth were recorded for each sample collected during the 2011 field season. The results do not show a trend for either variable or between positive and negative samples. Average temperature ranged from 16.8 ºC to 27.5 ºC for positive samples while negative samples ranged from 18.8 ºC to 26.8 ºC. Mean channel depth for positive samples ranged from 0.4 m to 5.6 m while negative samples ranged from 1.0 m to 5.9 m. Both mean surface water temperatures and channel depth fall within the range suitable for Asian carp habitation.

Environmental DNA has proved to be a new technology useful for the detection of genetic material of rare organisms in aquatic environments. Further calibration of the method is needed to better interpret results and enhance its use as an aquatic invasive species management tool. Although additional studies of the technology are needed, the technique appears promising for use by aquatic resource managers in the detection of rare, non-native invasive species as well as endangered and threatened species.

Project Highlights:

- 2011 eDNA weekly monitoring collected 1,864 samples from May through October and an additional during 684 samples during the October snapshot event.
- Monitoring results were typically reported every 14 days.
- For weekly monitoring, 18 samples from upstream of the barrier were sequenced as positive for Silver Carp DNA and zero samples from upstream of barrier returned positive results for Bighead Carp DNA.
- For the snapshot, 16 samples were positive for Silver Carp eDNA and zero samples were positive for Bighead Carp DNA.

- An estimated 881 person-hours were spent collecting and filtering 5,210 liters of water in 2011.
- Consecutive eDNA positives triggered one response action in Lake Calumet during August 2011. No Asian carp were sampled or observed during conventional gear sampling and all eDNA samples collected immediately before the event were negative for both species.
- Recommend continuing eDNA monitoring at locations upstream of the Dispersal Barrier and will consider results from weekly and snapshot sampling when updating eDNA and conventional gear monitoring strategies for the 2012 MRRP.

Table 1. Date and results for sites sampled in weekly eDNA monitoring during the 2011 season.

Date Sampled	Site Sampled	# Samples Collected	Date Reported	Silver Carp Results	Bighead Carp Results
10-May	Chicago Lock/Bubbly Creek	114	3-Jun	1 positive; 113 negative	Zero positive; 114 negative
16-May	North Shore Channel	114	7-Jun	Zero positive; 114 negative	Zero positive; 114 negative
15-Jun	Lake Calumet & Little Calumet River	114	14-Jul	7 positive (all from Lake Calumet); 107 negative	Zero positive; 114 negative
23-Jun	Chicago Lock/Bubbly Creek	114	14-Jul	Zero positive; 114 negative	Zero positive; 114 negative
27-Jun	North Shore Channel	114	19-Jul	1 positive; 113 negative	Zero positive; 114 negative
5-Jul	Des Plaines River	114	10-Aug	2 positive; 112 negative	Zero positive; 114 negative
12-Jul	Lake Calumet & Little Calumet River	100	21-Jul	2 positive (all from Lake Calumet); 99 negative	Zero positive; 101 negative
19-Jul	Lake Calumet & Little Calumet River	114	29-Jul	2 positive (One from Lake Calumet, One from Little Calumet River); 112 negative	Zero positive; 114 negative
1-Aug	Lake Calumet	57	16-Aug	Zero positive; 57 negative	Zero positive; 57 negative
17-Aug	Chicago Lock/Bubbly Creek	114	2-Sep	1 positive; 113 negative	Zero positive; 114 negative
22-Aug	North Shore Channel	114	8-Sep	Zero positive; 114 negative	Zero positive; 114 negative
30-Aug	Lake Calumet & Little Calumet River	114	21-Sep	1 positive; 113 negative	Zero positive; 114 negative
6-Sep	Lockport Pool (Above & Below Barrier)	114	3-Oct	Zero positive; 114 negative	Zero positive; 114 negative

Table 1. Continued.

Date Sampled	Site Sampled	# Samples Collected	Date Reported	Silver Carp Results	Bighead Carp Results
13-Sep	Chicago Lock/Bubbly Creek	111	3-Oct	Zero positive; 111 negative	Zero positive; 111 negative
4-Oct	North Shore Channel	114	1-Nov	2 positive; 112 negative	Zero positive; 114 negative
11-Oct	Lake Calumet & Little Calumet River	114	1-Nov	Zero positive; 114 negative	Zero positive; 114 negative
18-Oct	Chicago Lock/Bubbly Creek	114	16-Nov	1 positive; 113 negative	Zero positive; 114 negative

Table 2. Labor expended, sampling effort, and results for individual reaches sampled in weekly eDNA monitoring during 2011.

			Labor Expended		Sample Effort		Results (Negative or Positive)			
							Bighead Carp		Silver Carp	
				Estimated	Samples Collected	Total Effort	Negative	Positive	Negative	Positive
Sample Reach	Dates	Location	Persons	person-hours	(*N*)	(Liters)	(*N*)	(*N*)	(*N*)	(*N*)
Upstream of Electric Barrier										
Chicago Lock to Bubbly Creek	10-May, 23-Jun, 17-Aug, 13-Sep, 18-Oct	CAWS								
eDNA Sampling			3	60	567	1134	567	0	564	3
eDNA Filtering			4	136	567	1134				
North Shore Channel	16-May, 27-Jun, 22-Aug, 4-Oct	CAWS								
eDNA Sampling			3	37.5	456	912	456	0	453	3
eDNA Filtering			4	122	456	912				
Lake Calumet	15-Jun, 12-Jul, 19-Jul, 1-Aug, 30-Aug, 11-Oct	CAWS								
eDNA Sampling			3	57.75	339	678	339	0	328	11
eDNA Filtering			4	104	339	678				
Little Calumet River North Leg	15-Jun, 12-Jul, 19-Jul, 30-Aug, 11-Oct	CAWS								
eDNA Sampling			3	33	275	550	274	0	273	1
eDNA Filtering			4	61	275	550				
Lockport Pool (Above Barrier)	6-Sep	CAWS								
eDNA Sampling			3	4.5	57	114	57	0	57	0
eDNA Filtering			4	16	57	114				
Downstream of Electric Barrier										
Lockport Pool (Below Barrier)	6-Sep	CAWS	3	11.25	57	114	57	0	57	0
eDNA Collection			4	10	57	114				
eDNA Filtering										
Des Plaines River										
Riverside Station	5-Jul	DPR								
eDNA Sampling			3	3	38	76	38	0	36	2
eDNA Filtering			4	10	38	76				
Columbia Woods Station	5-Jul	DPR								
eDNA Sampling			3	3	38	76	38	0	38	0
eDNA Filtering			4	14	38	76				
Lamont Station	5-Jul	DPR								
eDNA Sampling			3	3	38	76	38	0	38	0
eDNA Filtering			4	11	38	76				

Table 3. Date and results for sites sampled during the eDNA snapshot event.

Date Sampled	Site Sampled	# Sampled Collected	Silver Carp Results	Bighead Carp Results
25-Oct	Chicago Lock/Bubbly Creek	114	2 positive; 112 negative	Zero positive; 114 negative
25-Oct	North Shore Channel	114	1 positive; 113 negative	Zero positive; 114 negative
26-Oct	Chicago San. & Ship Canal (Above Confluence)	114	Zero positive; 114 negative	Zero positive; 114 negative
26-Oct	Lockport Pool (Above Barrier)	114	2 positive; 112 negative	Zero positive; 114 negative
27-Oct	Cal-Sag Channel (Above Confluence)	114	10 positive; 104 negative	Zero positive; 114 negative
27-Oct	Lake Calumet & Little Calumet River	114	1 positive (Little Cal River); 113 negative	Zero positive; 114 negative

Table 4. Labor expended, sampling effort, and results for individual reaches sampled during the eDNA snapshot sampling event.

Operation and gear	Dates	Location	Labor Expended: Persons	Labor Expended: Estimated person-hours	Sample Effort: Samples Collected (*N*)	Sample Effort: Total Effort (Liters)	Bighead Carp: Negative (*N*)	Bighead Carp: Positive (*N*)	Silver Carp: Negative (*N*)	Silver Carp: Positive (*N*)
Upstream of Electric Barrier										
Chicago Lock to Bubbly Creek	25-Oct	CAWS								
eDNA Sampling			3	11.25	114	228	112	2	114	0
eDNA Filtering			4	20	114	228				
North Shore Channel	25-Oct	CAWS								
eDNA Sampling			3	9	114	228	113	1	114	0
eDNA Filtering			4	19	114	228				
Chicago Sanitary and Shipping Canal (AC)	26-Oct	CAWS								
eDNA Sampling			3	10.5	114	228	114	0	114	0
eDNA Filtering			4	25	114	228				
Lake Calumet	27-Oct	CAWS								
eDNA Sampling			3	9	57	114	57	0	57	0
eDNA Filtering			4	8	57	114				
Little Calumet River North Leg	27-Oct	CAWS								
eDNA Sampling			3	6	57	114	56	1	57	0
eDNA Filtering			4	9	57	114				
Cal-Sag Channel (AC)	27-Oct	CAWS								
eDNA Sampling			3	9	114	228	104	10	114	0
eDNA Filtering			4	19	114	228				
Lockport Pool (Above Barrier)	26-Oct	CAWS								
eDNA Sampling			3	12.75	114	342	112	2	114	0
eDNA Filtering			4	16	114	342				

Larval Fish and Productivity Monitoring in the Illinois Waterway

ILLINOIS NATURAL HISTORY SURVEY
PRAIRIE RESEARCH INSTITUTE

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Participating Agencies: Illinois Natural History Survey (lead); Eastern Illinois University and Western Illinois University (field support).

Introduction: Information on the distribution of larval Asian carp is needed to identify adult spawning areas, determine reproductive cues, and characterize relationships between environmental variables and survival of young. Larval fish sampling is being used to assess the timing and extent of Asian carp reproduction in the Illinois River, and may prove to be an early detection method in the CAWS. This information may also be useful for designing future control strategies that target Asian carp spawning and early life history.

Asian carp are filter-feeding planktivores that have the ability to deplete plankton densities and alter zooplankton community composition. Because Asian carp require sufficient food resources to optimize feeding and maximize their growth, they are likely to associate with areas of higher phytoplankton and zooplankton densities. Identifying such areas by sampling nutrient concentrations, chlorophyll *a* concentrations, and zooplankton abundance may indicate sites where Asian carp are most likely to be located in the CAWS. This information will also be useful for examining relationships among nutrients, phytoplankton, zooplankton, and the abundances of Asian carp and other planktivorous fishes throughout the Illinois Waterway.

Objectives: Larval fish sampling is being conducted to:

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

Productivity variables are being measured to:

1) Identify high-productivity areas where Asian carp may be more likely to be located.
2) Determine relationships between productivity variables and the abundance of Asian carp and other planktivorous fishes.
3) Examine relationships among nutrients, phytoplankton, and zooplankton density in the Illinois Waterway.

Methods: Larval fish and productivity sampling took place at 14 sites throughout the Illinois Waterway (Figure 1). Sampling occurred at approximately bi-weekly intervals from April to October. Four larval fish samples were collected at each site on each sampling date. Sampling transects were located on each side of the river channel, parallel to the bank, at both upstream and downstream locations within each study site. Samples were collected using a 0.5 m-diameter ichthyoplankton push net with 500µm mesh. Fish eggs and larvae were collected in a meshed tube at the tail end of the net, transferred to sample jars, and

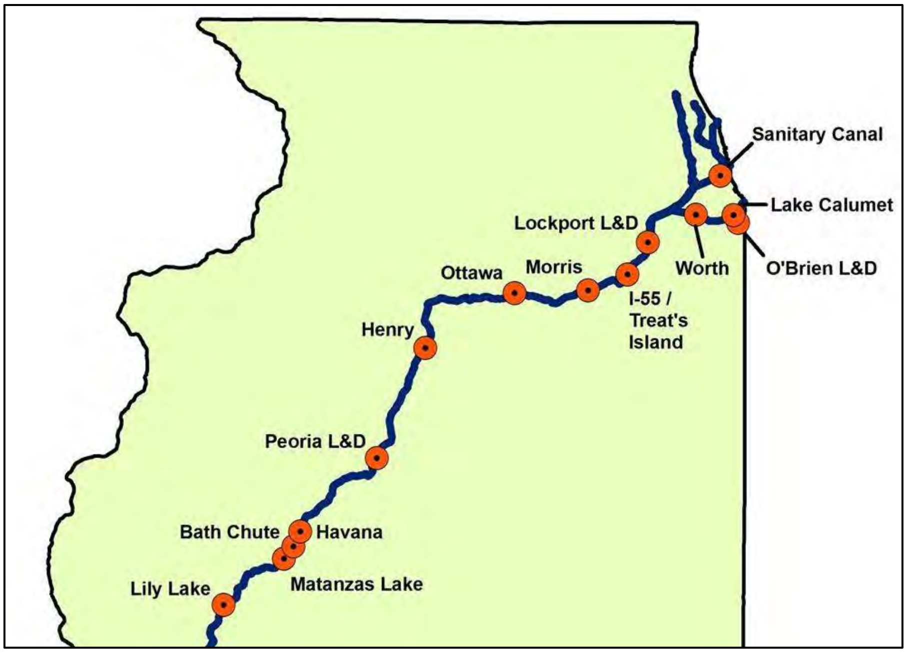

Figure 1. Map of larval fish and productivity sampling sites in the Illinois Waterway.

preserved in 90-percent ethanol. The presence of any eggs was noted and all eggs were retained for future analyses. Larval fish were identified to the lowest possible taxonomic unit in the laboratory. Larval fish densities were calculated as the number of individuals per m^3 of water sampled.

Productivity patterns were evaluated by measuring total phosphorus and chlorophyll *a* concentrations, as well as zooplankton abundance. Water samples were collected at upstream and downstream locations at each site using a vertically-integrated tube sampler. Chlorophyll *a* concentrations were estimated fluorometrically following acetone extraction, whereas total phosphorus concentrations were determined by measuring sample absorbance with a spectrophotometer after an acid molybdate extraction. Zooplankton were collected by obtaining vertically-integrated water samples obtained using a diaphragmatic pump. At each location, 90 L of water was filtered through a 55 µm mesh to obtain crustacean zooplankton, whereas 10 L of water was filtered through a 20 µm mesh to obtain rotifers. Organisms were transferred to sample jars and preserved in Lugols solution (4%). In the laboratory, individual organisms were identified to the lowest possible taxonomic unit, counted, and measured using a digitizing pad. Zooplankton densities were calculated as the number of individuals per liter of water sampled.

Results: In 2010, larval fish samples were collected from 3 June – 2 October. Overall, 240 samples were collected and 2,050 larval fish were captured. Larval fish densities were highest in June and July, but declined substantially after July (Figure 2). Larval and early-juvenile Asian carp (n = 78) were only collected in June from the Illinois River at Havana. In 2011, larval fish were sampled from 27 April – 13 October. During this time, 560 samples were collected and 7,677 larval fish were captured. Observed larval fish densities were highest in the Illinois River in June, but peaked in the Des Plaines River and in the CAWS in July (Figure 2). Larval Asian carp (n=2) were only collected in June from the Illinois River below Peoria Lock and Dam. Clupeids, primarily Gizzard Shad, were the most numerous larval fish taxa captured during both years. Cyprinid larvae, excluding Asian carp, and centrarchids, primarily *Lepomis* species, were important components of the ichthyoplankton drift upstream of the Peoria Pool. Lesser numbers of catostomids, sciaenids, moronids, percids, ictalurids, and atherinids were also captured in larval fish samples.

Productivity sampling largely coincided with larval fish sampling during both 2010 and 2011. In 2010, total phosphorus concentrations were found to increase with increasing distance upriver, and were highest in the Des Plaines River and in the CAWS, although phosphorus concentrations declined at sites closest to Lake Michigan (Figure 3). Phosphorus and chlorophyll concentrations were not found to be correlated, with the highest chlorophyll concentrations occurring in the lower Illinois River (Figure 3).

Macrozooplankton densities were found to vary little among sites in the Illinois River. Densities of Dreissenid veligers were relatively low in the Illinois River, but increased substantially in the Des Plaines River and in the CAWS (Figure 4). Rotifer densities declined with increasing distance upriver, but increased again to their highest levels in the CAWS. Densities of all zooplankton groups were highest in the Little Calumet River and in Lake Calumet.

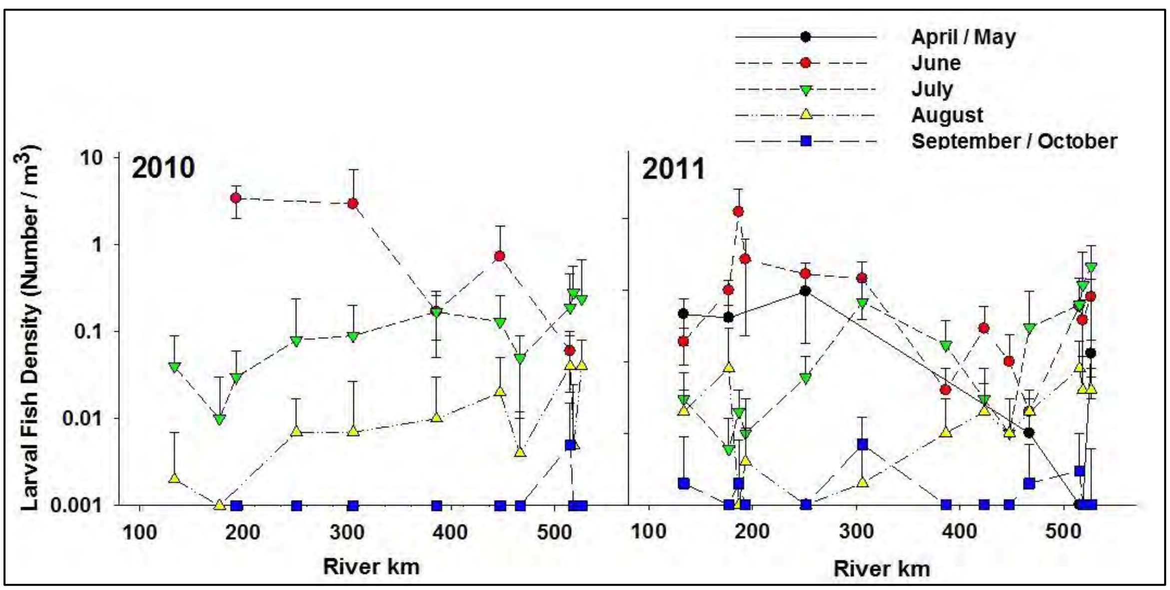

Figure 2. Monthly mean (± SD) densities of larval fish in the Illinois Waterway during 2010 and 2011. River km is measured as distance upstream from the Mississippi River.

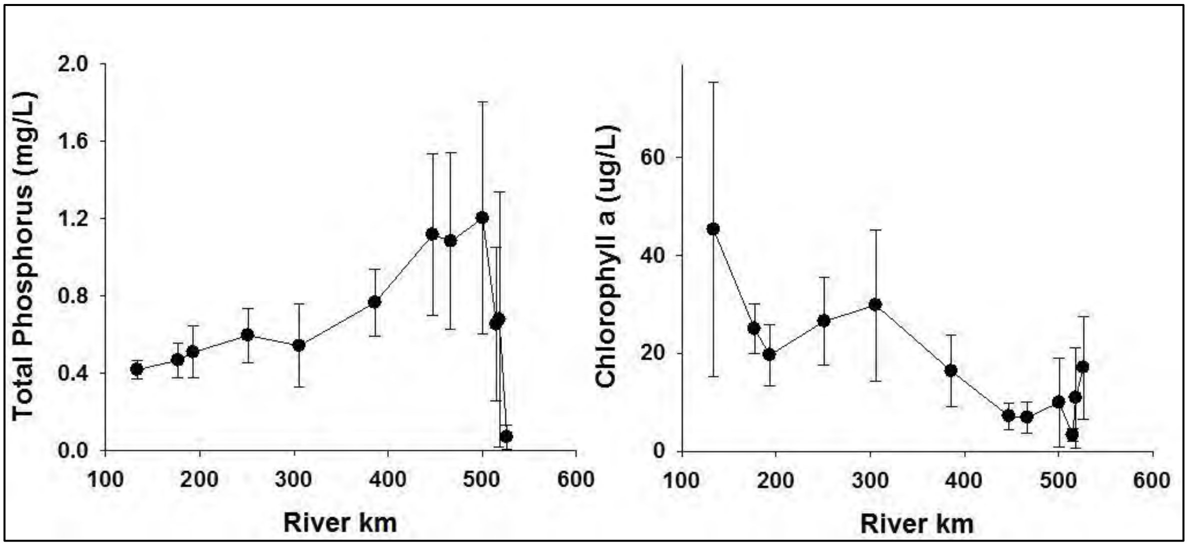

Figure 3. Mean (± SD) total phosphorus and chlorophyll *a* concentrations in the Illinois Waterway during 2010. River km is measured as distance upstream from the Mississippi River.

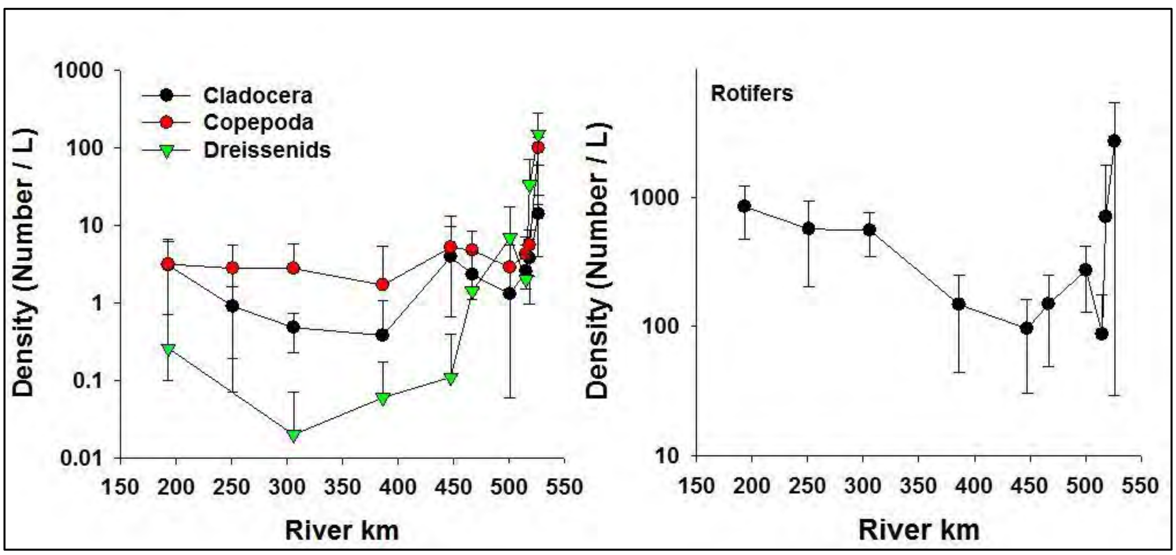

Figure 4. Mean densities (± SD) of macrozooplankton groups and rotifers observed in the Illinois Waterway during 2010. River km is measured as distance upstream from the Mississippi River.

Discussion: The scarcity of Asian carp larvae collected in both 2010 and 2011, combined with the low catch rates of juvenile Asian carp (see Young-of-Year and Juvenile Asian Carp Monitoring report) suggests that either Asian carp spawning was limited, or that larval and juvenile survival were low during these years. Additionally, despite extensive sampling, no Asian carp larvae were observed upstream of the Peoria Lock and Dam, suggesting that Asian carp reproduction was limited to the lower Illinois River during these years. No evidence of Asian carp reproduction was observed in the CAWS.

Productivity data suggest that although phosphorus concentrations are highest in the CAWS, other factors are contributing to observed patterns in chlorophyll *a* concentrations, which were highest in the lower Illinois River. High chlorophyll *a* concentrations may make the lower Illinois River particularly well suited to Silver Carp, which are capable of filtering phytoplankton. Zooplankton densities appear to remain fairly constant among sites in the Illinois River, but were highly variable among sites in the CAWS, with the highest densities of all zooplankton groups being observed in the Little Calumet River and in Lake Calumet. These areas appear to offer the most abundant food resources for planktivorous fishes in the CAWS and may be the most likely locations to find Asian carp within this system. Coincidentally, these are the locations where eDNA data have suggested the presence of Asian carp, triggering previous rapid response actions. The only live Asian carp known from the CAWS to date also came from Lake Calumet. Productivity samples from 2011 are still being processed and will allow for a more thorough evaluation of productivity patterns once this data becomes available.

Recommendations: Larval fish sampling should continue in the future in order to monitor for Asian carp reproduction during years where conditions are more favorable for the production of Asian carp larvae and juveniles. Continued productivity sampling will allow for a more thorough analysis of patterns in potential Asian carp food resources. Future analyses should also examine relationships among productivity variables and abundances of Asian carp and other planktivorous fishes.

Project Highlights:

- Asian carp larvae were not collected above the LaGrange Pool during both 2010 and 2011.
- Phosphorus concentrations increase with increasing distance upriver, with the highest levels observed in the Des Plaines River and the CAWS. Chlorophyll *a* concentrations do not appear to be correlated with phosphorus concentrations, and are highest in the lower Illinois River.
- Zooplankton densities in the CAWS appear to be similar to or higher than those observed in the Illinois River, suggesting that the CAWS is capable of providing sufficient food resources for Asian carp.
- The highest zooplankton densities were observed in the Little Calumet River and in Lake Calumet, suggesting that these areas may be the most likely locations to find Asian carp within the CAWS.
- Recommend continuation of larval fish sampling and productivity monitoring to monitor Asian carp reproduction and further analyze patterns in potential Asian carp food resources

Young-of-year and Juvenile Asian Carp Monitoring

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Introduction: Bighead and Silver Carp are known to spawn successfully in larger river systems where continuous flow and moderate current velocities transport their semi-buoyant eggs during early incubation and development. Spawning typically occurs at water temperatures between 18 and 30ºC during periods of rising water levels. Environmental conditions suitable for Asian carp spawning may be available in the CAWS and nearby Des Plaines River, particularly during increasingly frequent flooding events.

Successful reproduction is considered an important factor in the establishment and long term viability of Asian carp populations. The risk that Asian carp will establish viable populations in Lake Michigan increases if either species is able to successfully spawn in the CAWS. Successful spawning in the upper Des Plaines River also could pose a threat because larval fish may be washed into the CSSC upstream of the dispersal barrier during extreme flooding. The transport of larvae to the CSSC can occur despite the installation of concrete barrier and fencing between the waterways because larval fish are small enough to pass through the ¼-inch mesh fencing used for the separation project. Whereas larvae washed into the CSSC likely would be transported downstream past the Dispersal Barrier during flooding, these fish might become established in the lower Lockport Pool, recruit to the juvenile life stage, and challenge the Dispersal Barrier. An additional threat may occur if juvenile Asian carp from spawning events in downstream pools migrate to the Lockport Pool via navigation locks. Even though there has been no evidence of successful Asian carp reproduction in the CAWS, Des Plaines River, or upper Illinois River, targeting young-of-year and juvenile Asian carp in monitoring efforts is needed because these life stages may not be detected in conventional sampling geared toward adults.

Objectives: We will use multiple gears suitable for sampling small fish to:

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

Methods: In 2010 and 2011, sampling for young-of-year and juvenile Asian carp occurred through other projects outlined in the MRRP (MRRWG 2011). Young fish were targeted in the following projects: Fixed Site Monitoring Upstream of the Dispersal Barrier, Reach Sampling Upstream of the Dispersal Barrier, Fixed Site Monitoring Downstream of the Dispersal Barrier, Gear Efficiency and Detection Probability Study, Rapid Response Actions in the CAWS, Des Plaines River and Overflow Monitoring Project, and Barrier Maintenance Fish Suppression Project. See individual project summary reports and the 2011 MRRP for specific locations of sampling stations.

Pulsed-DC electrofishing was the principal gear used to monitor for young Asian carp. Fixed site monitoring in the CAWS upstream of the barrier occurred twice monthly from June-November 2010 and March-December 2011 at five stations and included about 48 15-minute electrofishing transects per sample week. Reach monitoring occurred seasonally in 2010 and 2011, sampled four reaches that encompassed the entire 76 miles of the CAWS upstream of the barrier, and averaged about 270 15-minute electrofishing transects per year. Ninety electrofishing transects were completed over three days in August 2011 for the Lake Calumet rapid response. Electrofishing at downstream fixed sites occurred monthly from April-November 2010 and March-November 2011 at four sites in the Lockport, Brandon Road, Dresden Island, and Marseilles pools (16 15-minute transects per month). Two CAWS and eight downriver stations were each sampled three times between May and October 2011 for the gear efficiency study. Six 15-minute electrofishing transects were completed at each site visit. A total of 10.5 hours of electrofishing was completed in the upper Des Plaines River downstream from Hofmann Dam. And finally, two barrier maintenance fish sampling events occurred in the Lockport Pool downstream of the barrier in October-November 2010. Electrofishing for this event included 48 15-minute transects over 6 days of sampling.

Standard electrofishing protocols were modified such that schools of small fish <6 inches long (typically Gizzard Shad) were subsampled by netting a portion of each school encountered during each electrofishing run. Netted small fish were held in a holding tank and examined individually for the presence of Asian carp before being returned to the waterway. Keeping small shad tallies separate from larger fish provided for an estimate of the relative abundance of young Asian carp, if present in each sample of small fish.

In addition to electrofishing, small fish were targeted with mini-fyke nets, trap nets, small mesh experimental gill nets, small mesh purse seine, midwater trawl, cast net, and beach seine in the gear efficiency study and with the same gears, except no cast nets or beach seines in the barrier maintenance project. Trap nets also were used for the 2011 Lake Calumet Rapid Response. Effort varied by gear and project. For the gear efficiency study, each site visit included 8 x 4-hour gill net sets, 8 mini-fyke net-nights, 8 trap net nights, 4 purse seine hauls, 4 5-minute midwater trawl tows, 3-4 cast net throws, and 3-4 beach seine hauls (see Gear Efficiency Report below). For the barrier maintenance project, combined effort for the six days of sampling was 1,950 yards of gill net, 40 mini-fyke net-nights, 8 trap net-nights, 10 purse seine hauls, and 10 5-minute midwater trawl tows. Trap net effort for the 2011 rapid response action was 22.4 net-nights.

Results and Discussion: Young Asian carp were targeted with six gears in 2010 and eight gears in 2011. Sampling included active gears, such as electrofishing seining and trawling, and passive gears, such as experimental gill nets, trap nets and mini-fyke nets. Electrofishing accounted for the most effort (Table 1; 621 hours combined for both years) and was part of sampling for all river reaches and projects. Sampling with other gears also extended throughout the waterway and was included in gear evaluation, rapid response, and barrier maintenance monitoring efforts. In general, sampling effort was highest in the CAWS upstream of the Dispersal Barrier and lowest in the upper Des Plaines River between Hofmann Dam and the CSSC-Des Plaines River confluence (Table 1).

No juvenile Asian carp <12 inches long were captured in 2010 and low catches were reported in 2011 (Table 1). These results are consistent with those from larval fish monitoring (see Larval Fish and Productivity Report above) and other sampling programs on the Illinois River (e.g., INHS LTRMP; Kevin Irons, personal communication), and they may reflect poor Asian carp recruitment in the waterway over the past two years. Of the eight juvenile Asian carp captured to date (Table 1), seven were caught in the LaGrange Pool (1 Bighead Carp, 4 Silver Carp, and 1 Bighead x Silver Carp hybrid) and one was caught in the Peoria Pool. The young Silver Carp caught in the Peoria Pool was an older juvenile (6-12 inches long) taken with a purse seine near Henry, Illinois (river mile 190). This location is about 106 miles from the Dispersal Barrier and it represents the farthest upstream detection of Asian carp juveniles (<12 inches long) in the Illinois Waterway in recent years. In the past two years, we examined 39,683 Gizzard Shad <6 inches long in the CAWS and Illinois Waterway upstream of Starved Rock Lock and Dam and found no young Asian carp in the samples.

Recommendations: We used multiple gears coordinated through several projects to monitor for young Asian carp in the CAWS, Des Plaines River, and Illinois River during 2010 and 2011, and found no Asian carp juveniles upstream of Starved Rock Lock and Dam and only low numbers downstream of the dam. While these results are encouraging in our efforts to prevent Asian carp from establishing populations in the CAWS and Lake Michigan, they likely are only temporary and may quickly change if conditions limiting recruitment success (e.g., flow, water quality, competition for food and space, and abundance of spawning stock) improve in the future. We recommend continued vigilance in monitoring for juvenile Asian carp in the CAWS and Illinois Waterway through existing monitoring projects and enhanced efforts. Proposed enhancements for 2012 include incorporating overnight sets of mini-fyke nets in monthly sampling at fixed sites downstream of the Dispersal Barrier and developing a new project to improve our understanding of juvenile Asian carp distribution and habitat selection in the Illinois River. The USFWS Carterville Conservation Office will take the lead with this new project and develop a project plan for the 2012 MRRP. Another development that will benefit the workgroup‟s understanding of Asian carp recruitment demographics is the preparation of a white paper on the distribution of small Asian carp in the Mississippi Basin. This cooperative effort by IDNR, USACE, and USFWS will gather data on Asian carp spawning and the distribution of young from researchers and management biologists across the basin. These data will be summarized and made available in a living document that can be used to identify data gaps and track the Asian carp invasion.

Project Highlights:

- Sampled for young Asian carp in 2010 and 2011 throughout the CAWS, Des Plaines River, and Illinois River between river miles 83 and 334 by incorporating sampling from several existing monitoring projects.
- Sampled with active gears (DC electrofishing, small mesh purse seine, midwater trawl, beach seine, and cast net) and passive gears (experimental gill nets, mini-fyke nets, and trap nets). Completed 621 hours of electrofishing across years and sites.
- Examined nearly 40,000 Gizzard Shad <6 inches long in the CAWS and Illinois Waterway upstream of Starved Rock Lock and Dam and found no young Asian carp.
- Low catches of young Asian carp at all sites suggested poor recruitment years.
- Farthest upstream catch was a single Silver Carp in the Peoria Pool near Henry, Illinois (river mile 190) over 100 downstream from the Dispersal Barrier.
- Recommend continued monitoring for young Asian carp, adding mini-fyke nets to fixed site monitoring downstream of the barrier, and a new project to enhance understanding of young Asian carp distribution and habitat selection.

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

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

Fixed Site Monitoring Downstream of the Dispersal Barrier

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Introduction: Standardized sampling can provide useful information to managers tracking population growth and range expansion of aquatic invasive species. Information gained from regular monitoring (e.g., presence, distribution, and population abundance of target species) is essential to understanding the threat of possible invasion upstream of the Dispersal Barrier. For this project, we use DC electrofishing and contracted commercial netters to sample for Asian carp in the four pools downstream of the Dispersal Barrier. A goal of this monitoring effort is to identify the location of the detectable population front of advancing Asian carp in the Illinois Waterway and track changes in distribution and relative abundance of leading populations over time. The detectable population front is defined as the farthest upstream location where multiple Bighead or Silver Carp have been captured in conventional sampling gears during a single trip or where individuals of either species have been caught in repeated sampling trips to a specific site. Monitoring data from 2010 and 2011 have contributed to our understanding of Asian carp abundance and distribution below the Dispersal Barrier and the potential threat of upstream movement toward the Dispersal Barrier.

Objectives: Standardized sampling with conventional gears will be used to:
1) Monitor for the presence of Asian carp in the four pools below the Dispersal Barrier;
2) Determine relative abundance of Asian carp in locations and habitats where they are likely to congregate;
3) Supplement Asian carp distribution data obtained through other projects (e.g., Asian Carp Barrier Defense Project and Telemetry Master Plan); and
4) Obtain information on the non-target fish community to help verify sampling success, guide modifications to sample locations, and assist with detection probability modeling and gear evaluation studies.

Materials and Methods: The sample design includes intensive electrofishing and netting at four fixed sites in each of the four pools below the Dispersal Barrier (Lockport, Brandon Road, Dresden Island and Marseilles pools). The fixed sites were located primarily in the upper portions below lock and dam structures, and in habitats where Asian carp are likely to be located (backwaters and side-channels).

Electrofishing Protocol - In 2010, electrofishing samples were taken at four fixed sites in each of the four pools once per month from April through November. Electrofishing samples in 2011 took place monthly from March through November. All electrofishing was pulsed DC current and included one or two netters (two netters were preferred). Electrofishing was conducted in a downstream direction in areas with noticeable current velocity and runs were generally parallel to shore (including following shoreline into off channel areas). The operator was encouraged to switch the pedal on and off at times to prevent pushing fish in front of the boat and increasing the chance of catching an Asian carp. Common carp were counted without capture and all other fish were netted and placed in a tank where they were identified and counted, after which they were returned live to the water. Periodically, a subsample of 10 fish of each species per site were measured in total length and weighed to provide length-frequency data for gear evaluations. Schools of young-of-year (YOY) Gizzard Shad <6 inches long were subsampled by netting a portion of each school encountered and placing them in a holding tank along with other captured fish. Shad YOY were examined closely for the presence of Asian carp and counted to provide an assessment of any young Asian carp in the waterway. All captured Asian carp, as well as those observed but not netted were counted in the catch due to the difficulty in capturing Asian carp with electrofishing gear.

Netting Protocol – Net sampling occurred once per month from July through September 2010 for Lockport and Brandon Road pools and March through August 2010 for Dresden Island and Marseilles pools. In 2011, netting took place once per month from March through November in all four pools. We also conducted net sampling at additional locations downstream of the barrier in 2011 to better monitor Asian carp abundance and distribution in pools below the barrier. Contracted commercial fishers were used for net sampling at all fixed sites. Gear included large mesh (3.0-4.0 inches) trammel or gill nets 8 feet high and in lengths of 100 or 200 yards. An IDNR biologist or technician was assigned to each commercial net boat to monitor operations, record data, and check for ultrasonically-tagged Asian carp and Common Carp (left pelvic fin clips or telemetry surgery wounds on the ventral left area of the fish, posterior to the pelvic fin and anterior to the anal opening). Nets were attended at all times. Netting locations within each fixed site were left to the discretion of the commercial fishers. Net sets were short duration and included driving fish into the nets with noise (e.g. "pounding" with plungers on the water surface, banging on boat hulls, or racing tipped up motors). Netting effort was standardized as 15- to 20-minute long sets with "pounding" no further than 150 yards from the net. Captured fish were identified to species and tallies were recorded on data sheets. Periodically, a subsample of 10 fish of each species per site was measured in total length and weighed.

Results and Discussion:

Electrofishing Effort and Catch – An estimated 940 person-hours were expended completing 58.5 hours of electrofishing at fixed sites downstream of the barrier in 2010 and 2011 (Table 1). Electrofishing captured a total of 19,127 fish representing 67 species. Gizzard Shad, Common Carp, Smallmouth Buffalo, Bluegill and Largemouth Bass were the five most common species captured in 2010 and they accounted for 71.2 % of the total catch (Table 2). These five species and Emerald Shiner, Golden Redhorse, River Carpsucker, Freshwater Drum, Threadfin Shad, Smallmouth Bass, Channel Catfish, Longnose Gar, White Bass and Bigmouth Buffalo made up more than 90% of the 2010 electrofishing catch. In 2011, Gizzard Shad, Common Carp, Bluegill, Emerald Shiner and Smallmouth Buffalo were the five most abundant species caught (Table 2). They accounted for 83.6% of the total catch. Nine species, the five most common ones and Largemouth Bass, Green Sunfish, Threadfin Shad and Bluntnose Minnow, combined to make up more than 90% of the 2011 catch. No Bighead or Silver Carp were sampled by electrofishing in Lockport and Brandon Road pools in either year, and one Bighead Carp and no Silver Carp were captured at Dresden Island Pool fixed sites. In contrast, 14 Bighead Carp and

132 Silver Carp were sampled by electrofishing at fixed sites in Marseilles Pool. In addition to adult catches, we examined a total of 504 YOY Gizzard Shad in 2010 and 7,115 in 2011 at downstream fixed sites and detected no Asian carp YOY.

Although no live Silver Carp were captured or seen upstream of the Brandon Road Lock and Dam, two dead Silver Carp were observed by a US Army Corps of Engineers biologist electrofishing at fixed sites downstream of the barrier in July 2011. The dead Silver Carp were located on the deck of an upstream–bound tow that was staged in the Brandon Road Pool just downstream of the Lockport Lock (Figure 1). The carp apparently were on the barge deck for some time, as they were decomposing and releasing body fluids into the water.

Figure 1: Dead Silver Carp on barge decking from an upstream-bound tow staged just downstream of Lockport Lock and Dam (Photo by Matthew Shanks).

Netting Effort and Catch – An estimated 1,575 person-hours were expended setting and running 46.6 miles of net at fixed sites and additional netting locations downstream of the Dispersal Barrier in 2010 and 2011 (Table 1). Net sampling caught 3,674 fish representing 21 species. Common Carp, Smallmouth Buffalo, Channel Catfish, Bighead Carp and Common Carp x Goldfish hybrid were the five most common species captured in 2010 (Table 3). These five species accounted for 96.8% of the total catch in that year. Common Carp, Smallmouth Buffalo, Bighead Carp, Silver Carp and Bigmouth Buffalo were the five most common species captured in 2011, and they accounted for 88.5 % of the total catch (Table 3).

No Bighead or Silver Carp were caught by netting in the Lockport or Brandon Road pools, although one adult Bighead Carp was observed avoiding a net at an additional netting location in the Brandon Road Pool during October 2011. This fish was spotted just south of the CSSC and

Des Plaines River confluence, a location where individual Bighead and Silver Carp have been observed on occasion in the past. Additional netting effort targeting this and other areas in the Brandon Road Pool during the remainder of the year resulted in no additional sightings or captures of Asian carp.

Catches of Bighead Carp at fixed and additional sampling sites increased with downstream location, whereas catches of Silver Carp were limited to samples from the Marseilles Pool (Tables 1 and 3; note that 13 Silver Carp and 66 Bighead Carp were caught in the Dresden Island Pool during barrier defense removal netting in 2011; see Barrier Defense Removal Report below). We caught one Bighead Carp with nets at fixed sites in the Dresden Island Pool in 2010 and 8 Bighead Carp at similar sites in 2011. Net catches of Bighead Carp in downstream Marseilles Pool were 28 in 2010 and 392 in 2011. Similarly, additional netting efforts caught fewer Bighead Carp in Dresden Island Pool ($N = 12$) compared to Marseilles Pool ($N = 29$). Higher catches of Asian carp during this past year compared to 2010 were due to increased netting effort at fixed sites in 2011, sampling at additional netting locations downstream of the barrier (equal to nearly 1,000 person-hours and >24 miles of net), and protracted sampling into late fall 2011. Netting continued through November in all pools this past year, but ended in August and September in 2010. Data from the barrier defense removal project showed a substantial increase in netting catch-per-unit-effort (CPUE) in late fall compared to late summer (see Barrier Defense Removal Project report below). Late fall catch rates in barrier defense sampling were particularly high in Marseilles Pool, the reach with the highest catches of Asian carp at downstream fixed sites (Table 1).

Results of electrofishing and net sampling with contracted commercial fishers are beginning to reveal patterns of Asian carp distribution and relative abundance in the upper Illinois Waterway. Based on monitoring results to date, we would characterize abundance of Bighead and Silver Carp as rare in Lockport Pool below the barrier (river mile 291-296) and in Brandon Road Pool (river mile 286-291). The number of Asian carp captured and observed in these pools has been low and limited to an occassional individual fish. These carp may represent “wonderers” from the downstream populations making occasional forays upstream in search of food or spawning habitat.

The Dresden Island Pool (river mile 272-286) supported a small population of Asian carp adults that were mostly Bighead Carp or Bighead x Silver Carp hybrids. The detectable adult population front is located in this pool at Treats Island just north of the I-55 Bridge where it crosses over the lower Des Plaines River near river mile 280. This location is about 47 miles from Lake Michigan (Chicago Harbor = river mile 327). The USACE first identified a small population of Bighead Carp in Dresden Island Pool near Moose Island in 2006 (river mile 276; Kelly Baerwaldt, personal communication). For reasons unknown, the detectable population front has made little upstream progress in the past five years.

The Marseilles Pool (river mile 245-272) contained moderately abundant populations of both Bighead and Silver Carp relative to downstream locations (e.g., Starved Rock Pool; see Barrier Defense Removal Report). These populations of mature adults were located within 55 miles of Lake Michigan and showed a potential for spawning; we observed gravid females and males running ripe in Marseilles Pool during 2010 and 2011. For this reason and to reduce propagule pressure on the Dispersal Barrier located just 24 miles upstream, contracted commercial fishers directed most of their netting effort and removed the greatest quantity of Asian carp from Marseilles Pool during the past two years. Although Asian carp populations in the Marseilles Pool may be capable of spawning, we have no evidence in recent years that any successful reproduction has occurred in this or in other reach of the upper Illinois Waterway or CAWS. Extensive monitoring in 2010 and 2011 detected no Asian carp larvae upstream of Peoria Lock and Dam (river mile 158) and no juveniles above Henry, Illinois (river mile 190; over 100 miles from the Dispersal Barrier).

Recommendations: Extensive monitoring and removal efforts have allowed us to begin to characterize and manage the risk of Asian carp populations moving upstream toward the CAWS and Lake Michigan. Similar patterns in abundance among sampling gears (electrofishing and trammel/gill netting) and monitoring/removal projects (also see Barrier Defense Removal report) adds confidence to the finding that relative abundance of Asian carp decreased with upstream location in the waterway. However, with just one full and one partial year of monitoring data to date, we were unable to make direct comparisons in CPUE between years. Additional years of standardized sampling are necessary to quantitatively estimate changes in relative population abundance within sites over time.

We recommend continued monitoring of Asian carp populations at fixed sites downstream of the barrier with electrofishing gear and contracted commercial fishers. We also propose adding two passive gears, hoop nets and mini-fyke nets, to the sampling protocol. These gears should increase our effectiveness at capturing adult Bighead Carp and juveniles of both species should successful spawning take place in the upper waterway in the future. Hoop nets were shown to be effective for capturing Bighead Carp adults in the MRRWG Gear Evaluation Study (see report below) and mini-fyke nets have been shown effective for capturing juveniles of both Asian carp species (Irons et al. 2011).

Project Highlights:

- Estimated 2,515 person-hours spent sampling at fixed sites and additional netting locations downstream of the Dispersal Barrier in 2010 and 2011.
- 58.5 hours spent electrofishing and 46.6 miles of trammel/gill net deployed.
- Sampled 22,801 fish representing 67 species and four hybrid groups.
- No Bighead or Silver Carp were captured by electrofishing or netting in Lockport and Brandon Road pools, although one adult Bighead Carp was observed in Brandon Road Pool by a net crew in October 2011.
- One Bighead Carp captured and no Silver Carp captured or seen during electrofishing in Dresden Island Pool. A total of 21 Bighead Carp and no Silver Carp captured during contracted commercial netting at Dresden Island Pool fixed sites and additional netting locations. Detectable population front of mostly Bighead Carp located just north of I-55 Bridge at river mile 280 (47 miles from Lake Michigan). No appreciable change in upstream location of the population front in the past five years.
- Sampled 14 Bighead Carp and 132 Silver Carp by electrofishing and 450 Bighead Carp and 184 Silver Carp by netting at fixed sites and additional netting locations in Marseilles Pool. Presence of mature adults capable of spawning occurred in this pool about 55 miles from Lake Michigan. However, Asian carp larvae and juveniles were not detected

upstream of Peoria Pool or more than 100 miles downstream of the Dispersal Barrier and 137 miles from Lake Michigan.

- Recommend continued monitoring of fixed sites downstream of the dispersal barrier and propose incorporating hoop nets and mini-fyke nets in the sampling protocols to enhance monitoring for adult Bighead Carp and detection of Asian carp juveniles, if present.

Table 1. Summary statistics for electrofishing and netting effort and catch at fixed sites and additional netting locations downstream of the Dispersal Barrier, 2010 and 2011. Additional netting did not take place in 2010.

	2010					2011				
	Pool					Pool				
Electrofishing effort	Lockport	Brandon	Dresden	Marseilles	Total	Lockport	Brandon	Dresden	Marseilles	Total
Sample dates	19 Apr - 1 Nov		20 Apr - 27 Oct			23 Mar - 15 Nov				
Person-days	9	11	11	11	42	12	12	14	14	52
Estimated person-hours	90	110	110	110	420	120	120	140	140	520
Electrofishing hours	5	5.25	6	6.25	22.5	9	9	9	9	36
Samples (transects)	17	21	24	25	87	36	36	36	36	144
Electrofishing catch										
All fish (*N*)	603	402	1,767	2,516	5,288	3,497	3,037	3,386	3,919	13,839
Species (*N*)	15	29	44	45	58	23	33	42	49	67
Hybrids (*N*)	0	1	2	1	2	1	2	2	1	3
Bighead Carp (*N*)	0	0	1	6	7	0	0	0	8	8
Silver Carp (*N*)	0	0	0	64	64	0	0	0	68	68
CPUE (fish/hour)	121	77	294	403	235	389	337	376	435	384

	2010					2011				
	Pool					Pool				
Netting effort	Lockport	Brandon	Dresden	Marseilles*	Total	Lockport	Brandon	Dresden	Marseilles	Total
Sample dates	29 Jul - 27 Sep		9 Mar-12 Aug			21 Mar - 11 Nov				
Person-days	4.5	4.5	7.5	7.5	24	13.5	13.5	13.5	13.5	54
Estimated person-hours	33.8	33.7	56.2	56.3	180	101.2	101.3	101.2	101.3	405
Samples (net sets)	13	13	16	17	59	30	35	35	34	134
Total miles of net	0.8	0.8	1.8	0.7	4.0	4.7	4.1	4.8	4.8	18.4
Netting catch										
All fish (*N*)	0	34	498	29	561	12	326	530	677	1,545
Species (*N*)	0	3	12	2	13	1	8	18	15	21
Hybrids (*N*)	0	0	2	0	2	0	1	1	1	1
Bighead Carp (*N*)	0	0	1	28	29	0	0	8	392	400
Silver Carp (*N*)	0	0	0	1	1	0	0	0	145	145
CPUE (fish/100 yard of net)	0.0	2.6	15.8	2.4	8.1	0.1	4.5	6.3	8.0	4.8

Table 1. Continued.

	2010					2011				
	Pool					Pool				
Additional netting effort	Lockport	Brandon	Dresden	Marseilles	Total	Lockport	Brandon	Dresden	Marseilles	Total
Sample dates	--	--	--	--	--	1 Apr - 12 Dec				
Person-days	--	--	--	--	--	6	36	84	6	132
Estimated person-hours	--	--	--	--	--	45	270	630	45	990
Samples (net sets)	--	--	--	--	--	13	43	80	4	140
Total miles of net	--	--	--	--	--	1.8	8.5	13.2	0.8	24.3
Additional netting catch										
All fish (*N*)	--	--	--	--	--	6	521	822	219	1,568
Species (*N*)	--	--	--	--	--	2	8	19	11	21
Hybrids (*N*)	--	--	--	--	--	1	1	2	0	2
Bighead Carp (*N*)	--	--	--	--	--	0	1	12	29	42
Silver Carp (*N*)	--	--	--	--	--	0	0	0	38	38
CPUE (fish/100 yard of net)	--	--	--	--	--	0.2	3.5	3.5	15.6	3.7

*Only Bighead and Silver Carp were recorded from Marseilles Pool net samples in 2010.

Table 2. Total number and percentage of fish captured in 2010 and 2011 fixed site electrofishing below the dispersal barrier. Common carp were counted by observation.

	2010						2011					
	Pool				All	Percent	Pool				All	Percent
Species	Lockport	Brandon	Dresden	Marseilles	pools	(%)	Lockport	Brandon	Dresden	Marseilles	pools	(%)
Gizzard Shad	322	247	568	1,107	2,244	42.4	3,027	2,344	1,755	2,017	9,143	66.1
Common Carp	100	85	297	46	528	10.0	268	236	316	52	872	6.3
Bluegill	0	7	246	63	316	6.0	19	81	461	142	703	5.1
Smallmouth Buffalo	0	2	108	327	437	8.2	0	1	101	321	423	3.1
Emerald Shiner	131	7	19	45	202	3.8	25	82	46	272	425	3.1
Largemouth Bass	6	9	171	53	239	4.5	40	27	242	66	375	2.7
Threadfin Shad	0	1	19	72	92	1.7	3	0	3	183	189	1.4
Green Sunfish	5	4	33	12	54	1.0	44	53	87	22	206	1.5
Golden Redhorse	0	0	14	128	142	2.7	0	0	14	68	82	0.6
River Carpsucker	0	0	16	95	111	2.1	0	0	7	88	95	0.7
Smallmouth Bass	0	0	38	49	87	1.6	0	11	36	46	93	0.7
Freshwater Drum	5	1	33	58	97	1.8	2	10	16	34	62	0.4
Longnose Gar	1	0	45	30	76	1.4	2	0	41	34	77	0.6
Bluntnose Minnow	0	2	3	3	8	0.2	7	15	77	45	144	1.0
Channel Catfish	3	2	26	47	78	1.4	1	28	26	11	66	0.5
Bigmouth Buffalo	0	0	8	61	69	1.3	0	0	1	72	73	0.5
Spotfin Shiner	20	1	3	6	30	0.6	1	2	0	100	103	0.7
Silver Carp	0	0	0	64	64	1.2	0	0	0	68	68	0.5
Quillback	0	0	7	60	67	1.3	0	0	0	44	44	0.3
White Bass	1	0	2	67	70	1.3	0	1	2	30	33	0.2
Pumpkinseed	1	3	13	0	17	0.3	22	25	22	2	71	0.5
Yellow Bullhead	4	4	19	0	27	0.5	8	29	20	0	57	0.4
Spottail Shiner	0	4	1	9	14	0.3	1	3	22	34	60	0.4
Bullhead Minnow	0	0	0	0	0	0.0	0	0	1	61	62	0.4
Shorthead Redhorse	0	2	8	23	33	0.6	0	0	8	18	26	0.2
Hybrid sunfish	0	0	18	0	18	0.3	6	5	18	5	34	0.2
Goldfish	2	1	6	0	9	0.2	3	14	12	2	31	0.2
Orangespotted Sunfish	0	0	5	0	5	0.1	0	16	3	2	21	0.2
White Sucker	0	2	2	1	5	0.1	0	17	2	1	20	0.1
Northern Hog Sucker	0	0	0	20	20	0.4	0	0	1	1	2	<0.1
Silver Redhorse	0	0	2	10	12	0.2	0	0	3	6	9	0.1

Table 2. Continued.

	2010						2011					
	Pool				All	Percent	Pool				All	Percent
Species	Lockport	Brandon	Dresden	Marseilles	pools	(%)	Lockport	Brandon	Dresden	Marseilles	pools	(%)
Black Crappie	0	0	4	2	6	0.1	0	1	8	4	13	0.1
White Crappie	0	0	0	7	7	0.1	2	4	0	5	11	0.1
Golden Shiner	0	1	3	0	4	0.1	1	5	3	4	13	0.1
Bighead Carp	0	0	1	6	7	0.1	0	0	0	8	8	0.1
Rock Bass	0	1	1	1	3	0.1	0	0	12	0	12	0.1
Shortnose Gar	0	0	4	5	9	0.2	0	0	0	5	5	0.1
Northern Pike	0	5	1	1	7	0.1	0	6	1	0	7	0.1
Yellow Bass	0	0	2	2	4	0.1	2	0	1	6	9	0.1
Skipjack Herring	0	0	0	4	4	0.1	4	0	1	3	8	0.1
Sauger	0	1	0	6	7	0.1	0	1	0	3	4	<0.1
Logperch	0	3	1	2	6	0.1	0	0	0	5	5	<0.1
White Perch	1	1	1	1	4	0.1	0	2	0	4	6	<0.1
Oriental Weatherfish	0	1	3	0	4	0.1	6	0	0	0	6	<0.1
Flathead Catfish	0	1	5	1	7	0.1	0	1	0	1	2	<0.1
Round Goby	0	1	2	0	3	0.1	0	6	0	0	6	<0.1
Black Buffalo	0	0	0	2	2	<0.1	0	0	1	5	6	<0.1
Carp x Goldfish hybrid	0	1	4	1	6	0.1	0	1	0	0	1	<0.1
Brook Silverside	0	0	0	0	0	0.0	0	0	1	6	7	<0.1
Grass Carp	0	0	0	4	4	0.1	0	1	1	0	2	<0.1
Walleye	0	0	0	3	3	0.1	0	0	1	2	3	<0.1
Longear Sunfish	0	0	1	2	3	0.1	0	0	1	2	3	<0.1
Grass Pickerel	0	0	0	1	1	<0.1	1	4	0	0	5	<0.1
Highfin Carpsucker	0	0	0	5	5	0.1	0	0	0	0	0	0.0
River Shiner	0	0	0	0	0	0.0	0	0	0	4	4	<0.1
Brown Bullhead	0	0	0	0	0	0.0	0	0	3	0	3	<0.1
Mosquitofish	0	0	0	0	0	0.0	0	2	1	0	3	<0.1
Suckermouth Minnow	0	0	0	0	0	0.0	0	0	1	2	3	<0.1
Warmouth	0	0	0	0	0	0.0	1	0	2	0	3	<0.1
Blackstripe Topminnow	0	0	0	0	0	0.0	1	0	2	0	3	<0.1
River redhorse	0	0	0	3	3	0.1	0	0	0	0	0	0.0
Banded Darter	0	0	0	0	0	0.0	0	0	0	2	2	<0.1
Common Shiner	0	0	0	0	0	0.0	0	0	2	0	2	<0.1

Table 2. Continued.

	2010						2011					
	Pool				All	Percent	Pool				All	Percent
Species	Lockport	Brandon	Dresden	Marseilles	pools	(%)	Lockport	Brandon	Dresden	Marseilles	pools	(%)
Unidentified Notropis	0	0	0	0	0	0.0	0	2	0	0	2	<0.1
Redear Sunfish	0	0	2	0	2	<0.1	0	0	0	0	0	0.0
Spotted Gar	0	0	1	0	1	<0.1	0	0	1	0	1	<0.1
Goldeye	0	0	0	0	0	0.0	0	0	0	1	1	<0.1
Sand Shiner	0	0	0	0	0	0.0	0	1	0	0	1	<0.1
Blackside Darter	0	1	0	0	1	<0.1	0	0	0	0	0	0.0
White Perch hybrid	0	0	0	0	0	0.0	0	0	1	0	1	<0.1
Alewife	1	0	0	0	1	<0.1	0	0	0	0	0	0.0
Chinook Salmon	0	0	0	0	0	0.0	0	1	0	0	1	<0.1
Trout Perch	0	0	0	0	0	0.0	0	0	0	1	1	<0.1
Spotted Sucker	0	1	0	0	1	<0.1	0	0	0	0	0	0.0
Paddlefish	0	0	0	1	1	<0.1	0	0	0	0	0	0.0
Bowfin	0	0	1	0	1	<0.1	0	0	0	0	0	0.0
All species	603	402	1,767	2,516	5,288	100.0	3,497	3,037	3,386	3,919	13,839	100.0
Species (*N*)	15	29	44	45	58		23	33	42	49	67	
Hybrid groups (*N*)	0	1	2	1	3		1	2	2	1	3	

Table 3. Total number and percentage of fish captured for 2010 and 2011 trammel/gill net sampling at fixed sites and additional netting locations below the Dispersal Barrier. Note that Asian carp were the only species counted during 2010 net sampling in Marseilles Pool.

	2010						2011					
	Pool				All	Percent	Pool				All	Percent
Species	Lockport	Brandon	Dresden	Marseilles	pools	(%)	Lockport	Brandon	Dresden	Marseilles	pools	(%)
Common Carp	0	32	262	0	294	52.4	17	760	559	26	1,362	43.8
Smallmouth Buffalo	0	1	172	0	173	30.8	0	4	513	128	645	20.7
Bighead Carp	0	0	1	28	29	5.2	0	1	20	421	442	14.2
Silver Carp	0	0	0	1	1	0.2	0	0	0	183	183	5.9
Bigmouth Buffalo	0	0	4	0	4	0.7	0	1	51	70	122	3.9
Channel Catfish	0	1	37	0	38	6.8	0	18	47	12	77	2.5
Black Buffalo	0	0	0	0	0	0.0	0	0	62	12	74	2.4
Carp x Goldfish hybrid	0	0	9	0	9	1.6	1	44	6	0	51	1.6
Freshwater Drum	0	0	4	0	4	0.7	0	4	36	12	52	1.7
Goldfish	0	0	0	0	0	0.0	0	8	22	1	31	1.0
Grass Carp	0	0	0	0	0	0.0	0	6	7	8	21	0.7
River Carpsucker	0	0	4	0	4	0.7	0	0	5	12	17	0.6
Flathead Catfish	0	0	1	0	1	0.2	0	0	4	4	8	0.3
Quillback	0	0	0	0	0	0.0	0	0	3	4	7	0.2
Longnose Gar	0	0	0	0	0	0.0	0	1	5	0	6	0.2
Skipjack Herring	0	0	0	0	0	0.0	0	0	4	0	4	0.1
Northern Pike	0	0	0	0	0	0.0	0	0	3	0	3	0.1
Largemouth Bass	0	0	2	0	2	0.4	0	0	0	1	1	<0.1
Striped Bass hybrid	0	0	1	0	1	0.2	0	0	1	0	1	<0.1
Gizzard Shad	0	0	0	0	0	0.0	0	0	1	0	1	<0.1
Shortnose Gar	0	0	0	0	0	0.0	0	0	0	1	1	<0.1
Yellow Bullhead	0	0	0	0	0	0.0	0	0	1	0	1	<0.1
Walleye	0	0	1	0	1	0.2	0	0	0	0	0	0.0
Silver Redhorse	0	0	0	0	0	0.0	0	0	1	0	1	<0.1
Spotted Gar	0	0	0	0	0	0.0	0	0	0	1	1	<0.1
All species	0	34	498	29	561	100.0	18	847	1,351	896	3,112	100.0
Species (*N*)	0	3	12	2	13		2	10	20	16	24	
Hybrid groups (*N*)	0	0	2	0	2		1	1	2	1	2	

Rapid Response Actions in the CAWS

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

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

Objectives: Rapid response objectives were to:

1) Remove Asian carp from the CAWS upstream of the Dispersal Barrier when warranted;
2) Develop a threshold framework for response actions with conventional gears and rotenone to guide management decisions; and
3) Determine Asian carp population abundance through intense targeted sampling efforts at locations deemed likely to hold fish.

Methods: Both rotenone and conventional gear response actions took place in the CAWS upstream of the Dispersal Barrier during 2010 and 2011. For the rotenone response, we used a block net (500 feet long x 20 feet deep with ½-inch ace mesh) to partition off a 2.5-mile section of the Little Calumet River downstream from O‟Brien Lock and Dam. A 5% liquid rotenone solution was then applied from boats within the target area to achieve a dosage of 3.4 ppm and a contact time of 8.0 hours. Boat balers and pumps were used to ensure rotenone was well distributed within the water column. The treatment area was detoxified with liquid sodium permanganate at a weight-based dose that was four times the applied rotenone concentration. Dead and dying fish were collected by boat for 6 days after rotenone was applied, including the day of application. Recovered fish were transported to a processing station where they were identified, counted, subsampled for length and weight, and weighed in mass. Length and weights were recorded only during the first 2 days of recovery and identification and counting continued for a third day. On days 4-6, recovered fish were examined for the presence of Asian carp and mass weighed to provide a total weight of recovered fish. All recovered fish were housed in lined roll-off dumpsters and transported to a landfill for disposal. Total number and weight of each fish species sampled during the event and standing stock biomass for the treatment area was estimated with species-specific data collected the first three days of fish recovery. The combined weight of fish identified and counted was about 50% of the total weight of fish recovered.

A variety of gears were used in conventional gear response actions, including DC electrofishing, trammel and gill nets fished by agency biologists and contracted commercial fishers, a commercial seine, and standard trap nets. Trammel and gill nets typically were 8-10 feet deep x 300 feet long in bar mesh sizes ranging from 2.75-4.5 inches. The commercial seine was 1,600-foot long x 30 feet deep and had a cod end made of 2.0-inch bar mesh netting. Trap nets had either 3- x 5- or 4- x 6-foot boxes and were equipped with single circular throats and 50-foot leads. Monitoring with split-beam hydroacoustics gear also was incorporated in the 2011 response action. For most response actions, electrofishing and netting protocols were similar to those used for fixed site monitoring (15-minute electrofishing transects and "pounded" short duration net sets; see Fixed Site Monitoring Upstream of Dispersal Barrier report). However, in some responses we were able to leave nets fishing for longer duration, including over night, when navigational portions of the waterway were closed to commercial and recreational vessels (e.g., Little Calumet River response) or when recreational boating was temporarily suspended in non-navigational areas (e.g., North Shore Channel and Lake Calumet responses).

Results and Discussion: We completed six response actions over the past two years. Warm water discharge sampling and rapid responses in the North Shore Channel, Little Calumet River (aka Operation Pelican), Bubbly Creek/South Branch Chicago River, and Lake Calumet occurred in 2010 and a second rapid response took place in Lake Calumet during August 2011 (Table 1). The Little Calumet River response included sampling with conventional gear and rotenone, whereas other response actions utilized only conventional gear sampling.

Response actions were labor intensive and employed extensive sampling effort targeting any Asian carp that might be present in the waterway. We spent an estimated 8,701 person-hours on 2010 response actions and an additional 1,066 person-hours in 2011 (Table 1). Rotenone was particularly labor intensive accounting for about two-thirds of the total person-hours (5,701) spent on response actions in 2010. Combined sampling effort for 2010 responses was 88.5 hours of electrofishing, 2.5 miles (173 acres) of river treated with rotenone, 20.6 miles of trammel/gill net (246 sets), and 0.9 miles of commercial seining (2 hauls). Effort for the Lake Calumet response in 2011 was 22.5 hours of electrofishing (90 transects), 11.2 miles of trammel/gill net (97 sets), 0.9 miles of commercial seining (2 hauls), 22.4 trap net-days, and 9.0 hours of hydroacoustics monitoring. Across all actions and gears in both years, we sampled 108,057 fish representing 52 species and 2 hybrid groups. Gizzard Shad and Common Carp were the predominant species sampled during conventional gear and rotenone responses (Table 2, 3, and 4). Other abundant species in the catch were Ghost Shiner, Bluntnose Minnow, Freshwater Drum, Alewife, Channel Catfish, Goldfish, Round Goby, Pumpkinseed, and Largemouth Bass.

No Bighead or Silver Carp were captured or observed during any of the response actions to date. In addition, we examined 1,605 YOY Gizzard Shad during the second Lake Calumet response and found no Asian carp YOY. Gizzard Shad young also were sampled during 2010 responses, but they were not recorded separately from sampled adults.

All actions, except the 2010 Lake Calumet Rapid Response, where triggered by positive eDNA detections for Bighead and/or Silver Carp. The Lake Calumet response was initiated on 23 June 2010 a day after a live Bighead Carp was captured by contracted commercial netters during fixed site monitoring. Response triggers evolved over time as more information from standard monitoring and rapid response actions was gathered. The initial response, warm water discharge sampling, occurred during February and March 2010. This response was initiated after initial results from 2009 eDNA monitoring showed positive detections for Asian carp DNA in several locations throughout the CAWS. Soon afterward the MRRWG determined that rapid response actions take place either when live Bighead or Silver Carp were captured or observed in the CAWS upstream of Lockport Lock and Dam or when positive detections for either species occurred in two consecutive eDNA sampling events at a given location. These criteria guided management decisions that lead to the remaining four response actions completed in 2010.

A threshold framework for response actions with conventional gears and rotenone was developed before the 2011 field season. The framework was released in the 2011 MRRP and is redrawn here as Figure 1. It includes three thresholds for response based on positive eDNA detections and captured or observed Asian carp and three levels of response actions beginning with a conventional gear response and terminating in a rotenone action. The MRRWG changed the eDNA threshold for response from positive detections for either species in two consecutive eDNA sampling events from a given location to three consecutive eDNA sampling events from a given location. The increase was due to uncertainty in the meaning of positive eDNA detections for Asian carp (e.g., do positive detections represent live or dead fish, one or many fish, or sources other than live fish, such as DNA from barges, piscivorous birds, or the metropolitan sewer system). The absence of Bighead and Silver Carp in 2010 response actions also raised questions concerning the efficacy of eDNA as a response trigger, although it should be noted that eDNA sampling immediately prior to response actions in 2010 and 2011 always agreed with results of conventional gear and rotenone sampling (i.e., water samples collected immediately before response actions produced no positives for Bighead or Silver Carp DNA). Furthermore, the MRRWG continues to support the use of eDNA as an early detection tool for Asian carp invasion monitoring (see Strategy for eDNA Monitoring report above). The threshold framework guided response decisions in 2011 and lead to a single rapid response action in Lake Calumet after positive detections for Silver Carp DNA were found in three consecutive sampling events at the lake.

The MRRWG has used rotenone twice in the CAWS as a tool for electrical barrier maintenance and Asian carp rapid response. Both of these events used large quantities of rotenone, and quantities needed for future rapid response actions are unknown at this time. In addition, the raw materials used to manufacture rotenone are not always available on short notice. Due to concerns over the short-term availability of the large quantities of rotenone potentially needed for a rapid response action, the US Fish and Wildlife Service was asked to purchase and store rotenone. The Service purchased approximately 2,000 gallons of rotenone, and is storing it at the

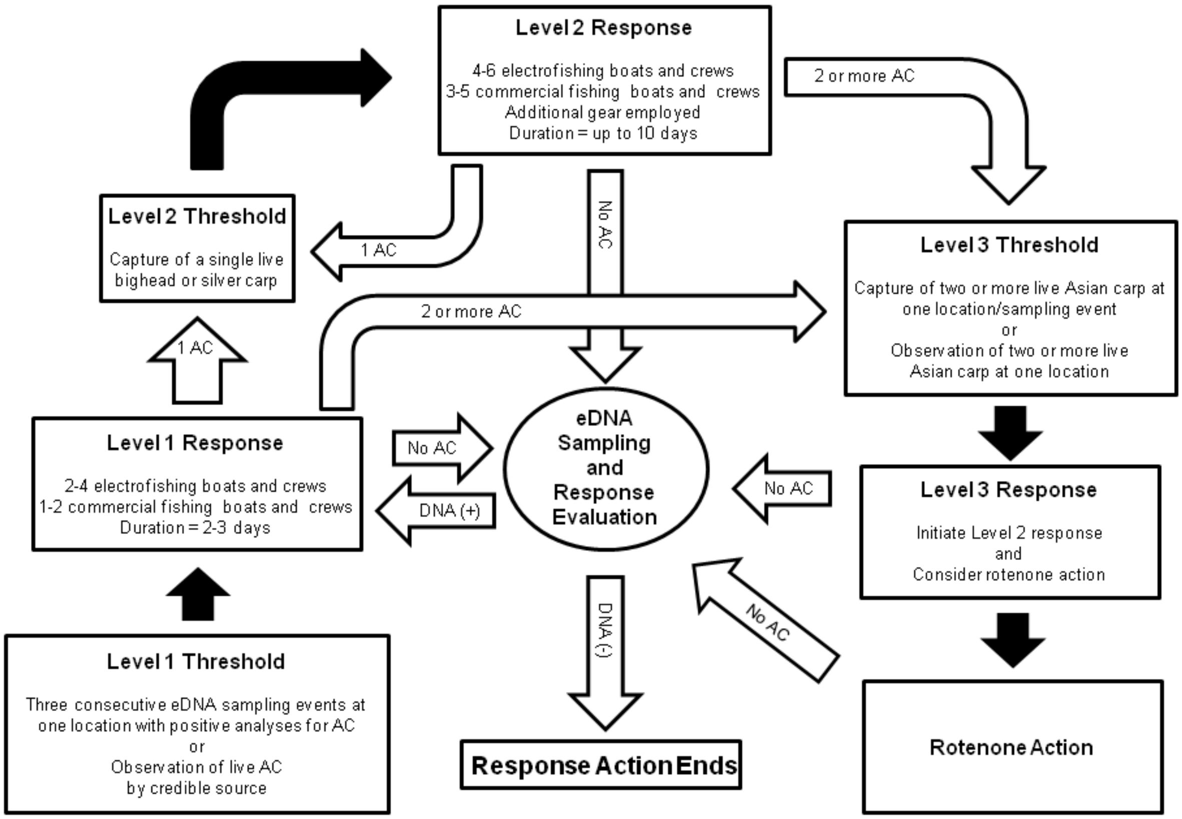

Figure 1. Thresholds for Asian carp (AC) response actions with conventional gears and rotenone.

lost Mound Unit of the Savanna District, Upper Mississippi River National Wildlife and Fish Refuge. The Illinois Department of Natural Resources also has donated, and the Service is storing, more than 700 gallons of sodium permanganate left over from the previous rapid response event.

Recommendations: We recommend continued vigilance in removing any Bighead or Silver Carp from the CAWS upstream of Lockport Lock and Dam. Rapid response actions with conventional gears and rotenone represent the best available tools for localized removal or eradication of Asian carp to prevent them from becoming established in the CAWS or Lake Michigan. The existing threshold framework should continue to be used to guide management decisions on rapid response actions in the CAWS. In light of the 2011 eDNA monitoring and snapshot results, we also recommend establishing the capability to conduct targeted response actions at selected locations in the CAWS outside the threshold framework when information gained from such actions may benefit monitoring protocols, research efforts, or Asian carp removal and control efforts. Maintaining a sufficient supply of rotenone and sodium permanganate in nearby storage will facilitate rapid response with rotenone when such an action is supported by the MRRWG and action agency representatives.

Project Highlights:

- Completed six response actions with conventional gears and rotenone in the CAWS upstream of the Dispersal Barrier during 2010 and 2011. All but one of the actions was triggered by eDNA monitoring results.
- Estimated over 9,700 person-hours were spent to complete 111 hours of electrofishing, set 31.8 miles of trammel/gill net, treat 2.5 miles (173 acres) of river with rotenone, make four 800-yard long commercial seine hauls, and deploy four tandem trap nets equal to 22.5 net-days of effort.
- Across all response actions and gears, sampled over 108,057 fish representing 52 species and 2 hybrid groups.
- No Bighead or Silver Carp were captured or observed during response actions, nor were positive detections for Asian carp DNA reported from eDNA samples taken immediately before conventional gear and rotenone sampling.
- Developed a threshold framework to guide rapid response decisions.
- US Fish and Wildlife Service is maintaining in storage a supply of rotenone and sodium permanganate to facilitate a rotenone response action should conditions warrant such an action in the future.
- Recommend continued vigilance in removing any Bighead or Silver Carp from the CAWS upstream of Lockport Lock and Dam and use of the existing threshold framework to guide decisions on rapid response actions in the CAWS. Also recommend establishing the capability to conduct targeted response actions at selected locations in the CAWS outside the threshold framework when information gained from such actions may benefit monitoring protocols, research efforts, or Asian carp removal and control efforts.

Table 1. Summary effort and catch statistics for Asian carp warm water discharge sampling and rapid response actions in the CAWS upstream of the Dispersal Barrier, 2 February – 9 July 2010 and 1- 4 August 2011. NC indicates fish not counted.

Operation (date) and Gear	Estimated person-hours	Sample Effort: Samples (*N*)	Sample Effort: Total effort (varies)	Catch (captured and observed): All fish (*N*)	Species (*N*)	Hybrids (*N*)	Bighead Carp (*N*)	Silver Carp (*N*)
2010 Response Actions								
Discharge Sampling (2 Feb - 25 Mar)								
AC and DC electrofishing	700	132 transects	72.0 hours	12,939	35	1	0	0
Trammel/gill nets	300	126 net sets	6.0 miles	467	3	0	0	0
North Shore Channel (11 - 13 May)								
DC electrofishing	150	6 transects	20.0 hours	NC	--	--	0	0
Trammel/gill nets	240	21 net sets	1.7 miles	573	9	1	0	0
Little Calumet River (20 - 23 May)								
Rotenone	5,371	1 application	173 acres	67,224	38	2	0	0
DC electrofishing	40	4 transects	4.0 hours	892	27	1	0	0
Trammel/gill nets	320	33 net sets	2.7 miles	946	9	1	0	0
DC electrofishing fish salvage	180	6 transects	6.0 hours	126	15	0	0	0
Bubbly Creek (15 - 16 Jun)								
DC electrofishing	120	15 transects	4.0 hours	1,086	26	1	0	0
Trammel/gill nets	120	12 net sets	0.8 miles	139	3	1	0	0
Lake Calumet (23 Jun - 9 Jul)								
DC electrofishing	510	--	54.5 hours	5,247	23	1	0	0
Trammel/gill nets	450	83 net sets	9.4 miles	2,915	12	1	0	0
Commercial seine	200	2 hauls	0.9 miles	6,835	10	0	0	0
2011 Response Actions								
Lake Calumet (1-4 Aug)								
DC electrofishing	280	90 transects	22.5 hours	5,366	37	2	0	0
Trammel/gill nets	484	97 net sets	11.2 miles	2,323	14	1	0	0
Commercial seine	200	2 hauls	0.9 miles	834	12	0	0	0
Tandem trap nets	72	12 sets	22.4 net-days	145	16	0	0	0
Hydroacoustics	30	--	9.0 hours	--	--	--	--	--

Table 2. Total number of fish captured with electrofishing gear, trammel/gill nets, and commercial seines during Warm Water Discharge Sampling and Bubbly Creek, North Shore Channel, and Lake Calumet rapid response actions, 2 February - 9 July 2010.

	Response Action								
	Warm water discharges		Bubbly Creek		North Shore Channel	Lake Calumet			
Species	Electro-fishing	Trammel/ Gill nets	Electro -fishing	Trammel/ Gill nets	Trammel/ Gill nets	Electro -fishing	Trammel/ Gill nets	Commercial seine	All actions
Common Carp	2,306	464	192	129	469	156	2,054	3,943	9,713
Gizzard Shad	6,935	1	253		40	124	35	2,193	9,581
Bluntnose Minnow	720		103			2,004			2,827
Emerald Shiner	89		1			2,011			2,101
Freshwater Drum	8		1			64	221	365	659
Goldfish	578		7	2	7	3			597
Largemouth Bass	322		71		9	178		4	584
Bluegill	403		109			69			581
Channel Catfish	137	2		6	5	4	40	284	478
Yellow Perch	323					98			421
Black Buffalo	1						350	2	353
Sunfish sp.	278								278
Minnow sp.	250								250
Pumpkinseed	131		93						224
White Sucker	116				11	79			206
Smallmouth Buffalo	1		3			11	161	9	185
Rock Bass	2		2		2	171			177
Golden Shiner	39		120			3			162
Smallmouth Bass	5					132	11		148
Mosquitofish	120								120
Bigmouth Buffalo	25					27	34		86
Round Goby	56					29			85
Spotfin Shiner			46						46
Green Sunfish	8		27			9			44
Quillback	10					30	3		43
Orangespotted Sunfish			1			34			35
Carp x Goldfish hybrid				2	27		2		31
White Crappie	10		3			3		11	27
Hybrid sunfish	2		21			3			26
Black Crappie	18		6						24
White Bass	1					4		14	19
Black Bullhead	12		3		2				17
Grass Carp	2						2	10	14
Yellow Bullhead	11		2						13
White Perch	10						1		11
Fathead Minnow			9						9
Yellow Bass			6						6
Spottail Shiner	1		3						4
Walleye	2								2
Rainbow Trout	2								2
Brook Silverside	2								2
Banded Killifish	2								2
Sand Shiner	1								1
Oriental Weatherfish			1						1
Flathead Catfish							1		1
Creek Chub			1						1
Brown Bullhead						1			1
Bowfin			1						1
Blackstripe Topminnow			1						1
All species	12,939	467	1,086	139	573	5,247	2,915	6,835	30,200
Species (*N*)	35	3	26	3	9	23	12	10	45
Hybrids (*N*)	1	0	1	1	1	1	1	0	2

Table 3. Estimated number of fish recovered after rotenone application and total number of fish captured by DC electrofishing and trammel/gill net sampling during the Little Calumet River Rapid Response, 20-26 May 2010. Rotenone recovery estimates were based on the total weight of all fish recovered and a subsample of fish (equal to 50% of the total weight of recovered) that were identified and counted.

Species	Rotenone	DC Electrofishing All species	DC Electrofishing Sport fish only	Trammel/ Gill nets	All gears
Gizzard Shad	22,298	45		148	22,491
Common Carp	9820	272		561	10,653
Ghost Shiner	6945				6,945
Emerald Shiner	4342	73	1		4,416
Alewife	3485	7	1		3,493
Freshwater Drum	3178	5	5	174	3,362
Bluntnose Minnow	2374	52			2,426
Goldfish	2293	72		5	2,370
Round Goby	2109	100			2,209
Channel Catfish	1959	24	1	33	2,017
Rock Bass	1244	5	1		1,250
Pumpkinseed	1098	97	26		1,221
White Perch	1059	24		1	1,084
Bluegill	783	25	9		817
Spotfin Shiner	464				464
Golden Shiner	434	1			435
Yellow Bullhead	366	2		2	370
Black Crappie	333		10		343
White Sucker	319	21	3		343
Fathead Minnow	325	11			336
White Crappie	319	1	1		321
Largemouth Bass	219	21	61		301
Yellow Perch	268	5	3		276
Black Bullhead	264	7			271
Black Buffalo	205			16	221
Spottail Shiner	213				213
Orangespotted Sunfish	174				174
White Bass	82	2	1		85
Green Sunfish	49	10	1		60
Carp x Goldfish hybrid	53			5	58
Smallmouth Bass	45		2		47
Grass Carp	43				43
Warmouth	18				18
Yellow Bass	10	5		1	16
Smallmouth Buffalo	12				12
Brown Bullhead	8				8
Flathead Catfish	8				8
Hybrid sunfish	2	1			3
Grass Pickerel	2				2
Bigmouth Buffalo		2			2
Johnny Darter	1				1
Oriental Weatherfish		1			1
Rainbow Trout		1			1
All species	67,224	892	126	946	69,188
Species (*N*)	38	27	15	9	41
Hybrids (*N*)	2	1	0	1	2

Table 4. Total number of fish captured with DC electrofishing gear, trammel/gill nets, commercial seine, and tandem trap nets in the 2011 Lake Calumet Rapid Response, 1-4 August.

	Gear						
		Trammel/Gill nets					
Species	DC electrofishing	Blocking sets	Short sets	Long sets	Commercial seine	Tandem trap nets	All gears
Common Carp	259	197	519	738	16	11	1,740
Gizzard Shad <6.0 in.	1,605						1,605
Gizzard Shad >6.0 in.	667	2		4	305		978
Largemouth Bass	869	2	2		2	5	880
Channel Catfish	25	6	22	19	414	30	516
Black Buffalo	10	130	174	116	14	1	445
Pumpkinseed	397					15	412
Bluegill	334					2	336
Bluntnose Minnow	321						321
Freshwater Drum	45	60	69	70	67	9	320
Smallmouth Bass	187	5			2		194
Emerald Shiner	154						154
Yellow Perch	134						134
Brook Silverside	96						96
Smallmouth Buffalo	2	12	57	17	2	1	91
Bigmouth Buffalo		1	41	8			50
Golden Shiner	47						47
Green Sunfish	41						41
White Crappie	9				1	29	39
White Perch	9	1				29	39
Goldfish	34		2		1		37
Quillback	3	4	7	5	7	4	30
Carp x Goldfish hybrid	1		2	16			19
White Sucker	19						19
Rock Bass	19						19
Flathead Catfish	4	3		8	1		16
White Bass	12					1	13
Black Bullhead	10		1			1	12
Black Crappie	8					4	12
Round Goby	12						12
Yellow Bass	8						8
Orangespotted Sunfish	8						8
Yellow Bullhead	2					2	4
Banded Killifish	4						4
Brown Bullhead	2				1	1	4
Grass Carp		1	2				3
Hybrid sunfish	3						3
Central Mudminnow	2						2
Fathead Minnow	1						1
Spotfin Shiner	1						1
Northern Pike	1						1
Bowfin	1						1
All species	5,366	424	898	1001	834	145	8,668
Species (*N*)	37	10	9	7	10	13	39
Hybrids (*N*)	2	2	2	2	2	2	2

Barrier Maintenance Fish Suppression

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

Introduction: The US Army Corps of Engineers operates three electric aquatic invasive species dispersal barriers (Barrier 1, 2A and 2B) in the Chicago Sanitary and Ship Canal at approximate river mile 296.1 near Romeoville, Illinois. Barrier 1 (formerly the Demonstration Barrier) became operational in April 2002 and is located farthest upstream (about 800 feet above Barrier 2B). Barrier 1 is operated at a setting that has been shown to repel adult fish (Holliman 2011). Barrier 2A became operational in April 2009 and is located 220 feet downstream of Barrier 2B. Both Barrier 2A and 2B can operate at parameters shown to repel juvenile and adult fish >5.4 inches long at a setting of 2.0 volts per inch or fish >2.5 inches long at a setting of 2.3 volts per inch (Holliman 2011). The higher setting has been in use since December 2011.

Barrier 2A and 2B must be shut down for maintenance approximately every 6 months and the Illinois Department of Natural Resources has agreed to support maintenance operations by providing fish suppression at the barrier site. Fish suppression can vary widely in scope and may include application of piscicide (rotenone) to keep fish from moving upstream past the barriers when they are down. This was the scenario for a December 2009 rotenone operation completed in support of Barrier 2A maintenance and 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 has operated as the principal barrier from the time it was brought on line and tested in April 2011. Barrier 2A is held in warm standby mode, which means it can be energized to normal operating level in a matter of minutes. Because the threat of Asian carp invasion is from downstream waters, there is a need to clear fish from the 220-foot length of canal between Barrier 2A and 2B each time Barrier 2B is shut down for scheduled maintenance. The suppression plan calls for Barrier 2A to be energized during the fish clearing operation and function as the principal barrier until maintenance is completed, after which Barrier 2B can be re-energized and 2A brought back to warm standby mode.

Prior to fish clearing operations, the MRRWG completed two pre-maintenance sampling events to determine the abundance of Asian carp in the Lockport Pool downstream of the electric barriers and gauge the level of fish suppression activities needed to support barrier maintenance. Sampling occurred in fall 2010 and targeted adult and juvenile Asian carp with a variety of sampling gears. Summaries of 2010 pre-maintenance sampling and an October 2011 fish suppression operation are included below.

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

1) Determine abundance of Asian carp juveniles and adults in the CSSC between the electric barriers and Lockport Lock and Dam;
2) Eliminate all fish <12 inches long from between Barrier 2A and 2B before maintenance operations are initiated by driving fish from the area with mechanical technologies (canal drawdown to increased current velocity, surface and underwater noise, or water guns), or if needed, a small-scale rotenone action; and
3) Assess the success of fish clearing operations by surveying the area between Barrier 2A and 2B with remote sensing gear (split-beam hydroacoustics, side-scan sonar, and DIDSON imaging sonar). Success is defined as no fish >12 inches long in the between-barrier area, as determined with remote sensing gear.

Methods:

Lockport Pool Sampling – Sampling took place in the Lockport Pool between the Dispersal Barrier and Lockport Lock and Dam on two occasions during fall 2010, 19-21 October and 16-18 November. All sampling was by agency biologists surveying the area with conventional gears and split-beam hydroacoustics. We targeted adult Asian carp with trammel nets and tandem trap nets, juvenile carp with experimental gill nets, mini-fyke nets, a midwater trawl, and a small mesh purse seine, and adults and juveniles with DC electrofishing gear and hydroacoustics. Trammel nets were 6-10 feet deep x 100-250 feet long and had 3.0- or 3.5-inch bar mesh netting. Experimental gill nets were 6-10 feet deep x 150 feet long with 0.75- to 2.0-inch bar mesh netting. Trap nets had 3- x 5-foot boxes and were equipped with single circular throats and 50-foot leads, whereas mini-fyke nets had 2- x 3-foot boxes and were equipped with single restricted circular throats and 25-foot leads. The purse seine had a mesh size of 0.75 inches and was 15 feet deep x 100 feet long. Midwater trawl tows were 10 minutes long and hydroacoustics transects were 30 minutes long. The midwater trawl, purse seine, and hydroacoustics were used only in October and trap nets were used only in November. We used other gears in both sampling events. The sample area was closed to commercial and recreational vessels during the October event. This allowed trammel and gill nets to be set in midchannel portions of the canal for long duration (overnight). We used short and long term sets with trammel and gill nets and generally targeted side channel and backwater areas during the second sampling event because the canal was not closed to navigation in November. Electrofishing occurred along the canal walls and in shallower side channel and backwater areas during both events.

All captured fish were identified to species and enumerated. A subsample of 20 fish of each species caught for each sampling gear was measured (mm total length) in support of the INHS study evaluating the effectiveness of different gears used to capture Asian carp. Except for Asian carp and surrogate species suitable for acoustic tagging, all captured fish were returned live to the waterway. Suitable surrogate species were transferred to a transport boat and returned to a shore station for surgical implantation of sonic transmitters (see Telemetry Master Plan report below).

Fish Clearing Operation – We used a canal drawdown and water guns to clear fish from between Barrier 2A and 2B during 24-26 October 2011. After fish clearing, the area between the barriers was surveyed with split-beam hydroacoustics, side-scan sonar, and DIDSON imaging sonar to assess whether any fish >12 inches long remained in the target area. A 12-inch minimum size was selected because results of intensive fall 2010 sampling in the Lockport Pool and other extensive monitoring (see Young-of-Year and Juvenile Asian Carp Monitoring report above) suggested that young-of-year (YOY) and juvenile Asian carp probably were not present in the CAWS or upper Illinois Waterway. More detailed methods of the October 2011 fish clearing operation can be found in the final project report reprinted in Appendix B.

Results and Discussion:
Lockport Pool Sampling – An estimated 870 person-hours were spent sampling Lockport Pool downstream of the barrier in October and November 2010 (Table 1). Effort for each gear combined over the two events was 12.0 hours of DC electrofishing, 3.0 miles of trammel net (40 sets), 1,950 yards of experimental gill net (39 sets), 40 mini fyke net-days, 1.7 hours of midwater trawling, over 1,100 cubic yards of purse seining, 8 trap net-days, and 1.5 hours of hydroacoustics transects. We sampled a total of 6,404 fish representing 35 species 3 hybrids. Electrofishing captured the most fish followed in order by mini-fyke nets, experimental gill nets, tandem trap nets, and trammel nets. Few fish were caught trawling or purse seining (Table 1). Gizzard Shad were by far the most abundant species caught. They made up 50% of the catch in October (Table 2) and 64% of the catch in November (Table 3). Other abundant species in the catch were Emerald Shiner, Green Sunfish, Common Carp, Bluegill, White Perch, Channel Catfish, Bluntnose Minnow, and Threadfin Shad. No Bighead or Silver Carp were captured or observed during sampling. In addition, we examined 3,295 YOY Gizzard Shad and found no juvenile Asian carp.

Results of intensive sampling during fall 2010 (no Asian carp captured or observed), combined with results from the December 2009 rotenone action (one Bighead Carp captured) and 2 years of monthly monitoring at Lockport Pool fixed sites (no Asian carp captured or observed) suggest abundance of Asian carp in the Lockport Pool downstream of the Dispersal Barrier may be classified as rare. The catch in fall 2010 sampling was dominated by small-bodied fishes and YOY of larger species (e.g., Gizzard Shad, Channel Catfish, White Perch, and Largemouth Bass), even though we used gears that targeted both juvenile and adult fish. Low catches of large fish may indicate that adults have been slow to repopulate this reach of the canal after fish populations were eradicated with rotenone in 2009. In addition, we caught 3 of 28 Common Carp tagged and released in the Lockport Pool downstream of the barrier as part of the barrier telemetry study. This recapture rate (>10%) indicates successful detection of a small subpopulation of adult fish and provides additional support that adult fish abundance was low in the lower portion of Lockport Pool.

In contrast, there was a high relative abundance of small fish in the catch. The high relative abundance of small fish may reflect successful reproduction by several species in the pool (including sport fish) and/or the inability of the barrier to prevent juveniles from immigrating to the lower pool from upstream locations when operating at a setting of 2.0 volts per inch (as was the case prior to the fall sampling events). Immigration of small fish from the upper canal may be lower today because the barrier is now operating at a setting that has been shown to repel fish as small as 2.5 inches. Regardless, monitoring efforts in recent years have shown that successful Asian carp reproduction and recruitment is limited to areas downstream of the Lockport Pool and over 100 miles from the Dispersal Barrier (see Larval Fish and Productivity Monitoring and Young-of-Year and Juvenile Asian Carp Monitoring reports above). Results of fall 2010 Lockport Pool sampling are consistent with these findings and further suggest that there was a low risk of occurrence for young Asian carp in the Lockport Pool downstream of the barrier.

Fish Clearing Operation – Based on results of remote sensing surveys, all fish >12 inches long were successfully cleared from the area between Barrier 2A and 2B, permitting Barrier 2A to be activated and Barrier 2B to be taken down for maintenance. The process of energizing Barrier 2A, driving fish downstream with water guns, and evaluating success of the clearing operation with a combination of sonar devices allowed barrier maintenance to occur with a fully functional barrier to upstream fish movement always in place. This process also prevented the need for a labor intensive and costly rotenone application. We were successful in clearing fish from between the barriers with water guns on Day 2 of the operation. On Day 1, we employed a canal drawdown in addition to water guns to clear fish. The drawdown was able to produce sustained high water velocity at the barrier (maximum flow of 11,000 cfs and mean channel velocities of 2.0-2.5 feet per second), but it created air bubble disturbance in the target area that interfered with the sonar evaluation. For more detailed results of the October 2011 operation, see the reprinted final project report in Appendix B.

Recommendations: We recommend the continued use of water guns and remote sensing for future barrier maintenance fish suppression operations. Scheduling should include initial dates of operation, a contingency date for bad weather or equipment failure, and a third date for a small-scale rotenone operation, if mechanical clearing fails to clear target-sized fish. When needed, canal closure requests should be made to US Coast Guard – Lake Michigan Sector a minimum of 45 days prior to scheduled operations. Although confidence in results of sonar evaluations was high, we propose conducting additional assessments of the combined sonar technique prior to the next required fish clearing operation. Results from additional assessments will be used to further refine the technique and enhance its use as an evaluation tool for barrier maintenance fish suppression.

Project Highlights:

- Successfully displaced all fish >12 inches long from the area between Barrier 2A and 2B, energized Barrier 2A to normal operational parameters, and brought Barrier 2B down for maintenance. Barrier 2A became the principal barrier until maintenance operations were completed.
- Used novel protocols and high-tech equipment to accomplish project objectives. Fish were cleared with pneumatic water guns and success of the clearing action was evaluated with split-beam hydroacoustics, side-scan sonar, and DIDSON imaging sonar.
- Met strategic objectives without the use of chemicals or loss of barrier function.
- Completed the operation with no injuries or accidents reported.
- Stood up an Incident Management Team and prepared an Incident Action Plan to facilitate management of the action and communication among multiple participating agencies and stakeholders.

- Recommend the continued use of water guns and remote sensing for future barrier maintenance fish suppression operations.

Table 1. Summary effort and catch statistics for Lockport Pool Barrier Maintenance fish sampling events, 19-21 October and 16-18 November 2010.

		Sample Effort		Catch (captured and observed)				
Operation and Gear	Estimated person-hours	Samples (*N*)	Total effort (varies)	All fish (*N*)	Species (*N*)	Hybrids (*N*)	Bighead Carp (*N*)	Silver Carp (*N*)
October Sampling								
DC electrofishing		13 transects	6.0 hours	2,968	15	1	0	0
Trammel nets		20 net sets	0.8 miles	67	5	0	0	0
Experimental gill nets		15 net sets	750 yards	394	15	1	0	0
Mini-fyke nets	560	20 sets	20 net-days	643	18	0	0	0
Midwater trawl		10 tows	100 minutes	9	4	1	0	0
Purse seine		10 hauls	1,134 $yards^3$	21	3	0	0	0
Hydroacoustics		3 transects	1.5 hours	--	--	--	--	--
November Sampling								
DC electrofishing		12 transects	6.0 hours	1,162	17	1	0	0
Trammel nets		20 net sets	2.1 miles	9	1	0	0	0
Experimental gill nets	310	24 net sets	1,200 yards	467	18	0	0	0
Mini-fyke nets		20 sets	20.0 net-days	529	20	0	0	0
Tandem trap nets		4 sets	8.0 net-days	135	13	1	0	0

Table 2. Total number of fish captured with DC electrofishing gear, trammel nets, experimental gill nets, mini-fyke net, midwater trawl, and purse seine in Lockport Pool Barrier Maintenance Fish Sampling, 19-21 October 2010.

	Gear						
Species	DC electro-fishing	Trammel net	Experimental gill net	Mini-fyke net	Midwater trawl	Purse seine	All gears
Gizzard Shad <6 in.	2,351		25	50			2,426
Gizzard Shad >6 in.	126		93				219
Emerald Shiner	356			28		5	389
Green Sunfish	2		3	249	1		255
Common Carp	8	64	65				137
Bluegill	1			118			119
White Perch	1		98	6	3		108
Channel Catfish	5	1	18	76	1		101
Threadfin Shad	53		1			16	70
Freshwater Drum	5	1	48				54
Largemouth Bass	47		7				54
Yellow Bullhead			18	19			37
Bluntnose Minnow				26			26
Spottail Shiner				22			22
Pumpkinseed	5		2	9			16
Black Crappie				12			12
Orangespotted Sunfish				9			9
Skipjack Herring			7				7
Goldfish	1	1	4				6
Black Bullhead			1	4			5
Oriental Weatherfish				5			5
White Bass	3			1			4
White Perch hybrid					4		4
Yellow Bass			1	3			4
Central Mudminnow	2						2
Golden Shiner				2			2
Warmouth				2			2
White Crappie				2			2
White Sucker			2				2
Hybrid sunfish	1						1
Carp x Goldfish hybrid			1				1
Fathead Minnow	1						1
All species	2,968	67	394	643	9	21	4,102
Species (*N*)	15	5	15	18	4	3	28
Hybrids (*N*)	1	0	1	0	1	0	3

Table 3. Total number of fish captured with DC electrofishing gear, trammel nets, experimental gill nets, mini-fyke nets, and tandem trap nets in Lockport Pool Barrier Maintenance Fish Sampling, 16-18 November 2010.

	Gear					
Species	DC electro-fishing	Trammel net	Experimental gill net	Mini-fyke net	Dual frame trap net	All gears
Gizzard Shad <6 in.	800		52	15	2	869
Gizzard Shad >6 in.	43		229	6	3	281
Channel catfish	2		13	168	2	185
Emerald Shiner	122			30		152
White Perch			83	9	43	135
Bluntnose Minnow	45			76		121
Green Sunfish	7		1	96	7	111
Bluegill				69	8	77
Threadfin Shad	67					67
Common Carp	11	9	44	1	1	66
Pumpkinseed	2			16	26	44
Yellow Bullhead	14		7	19	2	42
Largemouth Bass	34		5			39
Yellow Bass			8	4	26	38
Black Bullhead	1		4	3	7	15
Round Goby	6			3		9
Skipjack Herring	1		6			7
Black Crappie				4	2	6
Orangespotted Sunfish				3	3	6
Goldfish	2		2	1		5
White Sucker	1		3			4
Spottail Shiner				3		3
White Bass			2		1	3
White Crappie			3			3
Golden Shiner	2					2
Sauger			2			2
White Perch hybrid					2	2
Black Buffalo			1			1
Carp x Goldfish hybrid	1					1
Coho Salmon				1		1
Freshwater Drum	1					1
Golden Redhorse			1			1
Mosquitofish				1		1
Oriental Weatherfish				1		1
Spotted Sucker			1			1
All species	1,162	9	467	529	135	2,302
Species (*N*)	17	1	18	20	13	32
Hybrids (*N*)	1	0	0	0	1	2

Barrier Defense Asian Carp Removal Project

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Participating agencies: Illinois Department of Natural Resources – Division of Fisheries (lead).

Introduction: This project uses controlled commercial fishing to reduce the numbers of Asian carp in the upper Illinois and lower Des Plaines rivers downstream of the Dispersal Barrier. By decreasing the number of Asian carp in this area, we anticipate a lowering of propagule pressure at the barrier and reduced chances of carp gaining access to upstream waters in the CAWS and Lake Michigan. Trends in harvest data over time also may contribute to our understanding of Asian carp population abundance in and movement between river pools. The project was initiated in 2010 and continued through 2011. It utilized ten contracted commercial fishing crews to remove Asian carp with large mesh trammel nets and gill nets primarily and with other gears on occasion (e.g., seines and hoop nets). The target area is closed to commercial fishing by Illinois Administrative Rule; therefore an IDNR biologist was required to accompany commercial fishing crews working in this portion of the river.

Objectives: Ten commercial fishers will be employed to:

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

Methods: Contracted commercial fishing took place from June-September 2010 in the Dresden Island and Marseilles pools and from April-December 2011 in the Dresden Island, Marseilles, and Starved Rock pools. Five commercial fishing crews with assisting IDNR biologists were deployed 1-2 weeks each month of the field season. Down weeks were usually scheduled between fishing weeks to allow the fish to repopulate preferred habitats. Constantly fishing the same area was shown to drive the fish out and greatly reduce catches. Commercial fishers arrived on Monday of each sampling week and fished Tuesday through Friday. Each boat set a minimum of 1,000 yards of 3.0- to 4.25-inch mesh trammel or gill nets each day. Whereas most fishing occurred in backwater areas known to hold Asian carp, main channel and side channel habitats also were targeted. Specific netting locations were at the discretion of the commercial fisher with input from the IDNR biologist assigned to each boat. Set duration typically was 20-30 minutes long and fish were driven to the nets with noise (e.g., pounding on boat hulls, hitting the water surface with plungers, running with motors tipped up). Nets were occasionally set overnight in off channel locations with no boat traffic. Biologists enumerated the catch of Asian carp and by-catch species and checked the catch for ultrasonically-tagged Asian carp and Common Carp. Each week, a representative sample of up to 30 of each Asian carp species (Bighead, Silver, and Grass Carp) from each pool was measured and weighed to estimate total weight harvested. Common Carp was the only other species removed. Other by-catch species were released immediately to the water where taken. At the end of the day the catch was transported to the boat ramp and transferred to a refrigerated truck for temporary storage. Harvested fish were taken to a processing plant where they were used for non-consumptive purposes (e.g., converted to liquid fertilizer).

Results and Discussion:
Contracted commercial fishing crews and IDNR biologists spent an estimated 4,140 person-hours in 2010 and 6,750 person-hours in 2011 netting for Asian carp during barrier defense removal efforts. Effort equal to 350 miles of net has been deployed in the upper Illinois Waterway to date. The combined catch of Asian carp (Bighead, Silver, and Grass Carp) was 6,073 fish during 2010 and 41,054 fish during 2011 (Table 1). The total weight of Asian carp caught and removed was 828,331 pounds or 414.2 tons. Asian carp harvest in both years was highest for Bighead Carp (82.0% in 2010 and 56.3% in 2011), followed by Silver Carp (17.7% in 2010 and 43.35 in 2011) and Grass Carp (<0.5%). The higher proportion of Silver Carp in the 2011 catch was largely due to a high proportion of Silver Carp in the catch from Starved Rock Pool, a location not sampled during the first year of the program.

Dresden Island Pool is located 10-24 miles downstream from the Dispersal Barrier and Marseilles Pool is 24-51 miles downstream. Starved Rock Pool has the farthest downstream sampling location and is 51-65 miles downstream from the Dispersal Barrier. We targeted Marseilles Pool with the majority of effort because it held the largest concentration of Asian carp closest to the barrier (Table 1). The Starved Rock Pool was included for the first time in 2011 and sampling there led to increased catch rates overall due to the higher density of Asian carp (primarily Silver Carp) in the pool.

Although Asian catch-per-unit-effort (CPUE; *N*/100 yards of net) varied seasonally, patterns generally were similar for Bighead and Silver Carp (Figure 1). Catch rates were higher during cooler months (week 1 and 2 in April and weeks 13-15 in November and December) when Asian carp tend to be less active and easier to net. Lower summer catch rates in backwaters also may reflect movement of a portion of the Asian carp population from these habitats to the main channel, possibly in relation to spawning. Data from preliminary hydroacoustics surveys conducted by SIUC in Hanson Material Services" East Pit indicated lower fish abundance in this backwater during summer than in spring. However, these data were preliminary and additional work is needed to determine the extent of and mechanisms triggering seasonal movement patterns in Asian carp populations. The sharp increase in Silver Carp CPUE over the last three weeks of sampling (Figure 1) may be attributed to crews gaining access to the old gravel pit in Starved Rock Pool"s Sheehan Island where Silver Carp CPUE was exceptionally high (28-60 Silver Carp/100 yards of net).

Catch of Asian Carp Among and Within Pools – Dresden Island Pool was fished 9 of 15 sampling weeks during 2011. Sampling in this pool resulted in the removal of 75 Asian carp (62 Bighead Carp and 13 Silver Carp; Table 2). We did not fish this area each week because crews netting at fixed sites upstream and downstream of the barrier frequently targeted Dresden Island Pool during additional net sampling downstream of the barrier (see Fixed Site Monitoring

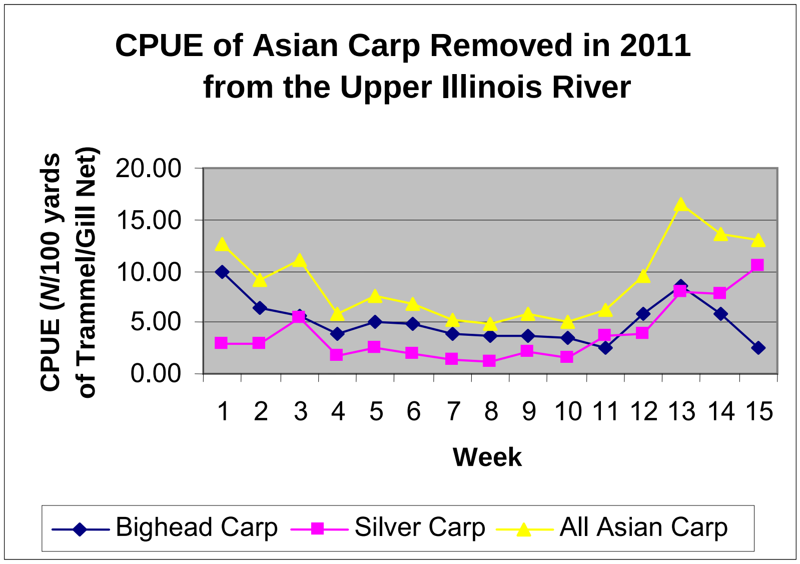

Figure 1. Catch-per-unit-effort (CPUE) of Bighead and Silver Carp harvested during contracted commercial netting efforts in the upper Illinois Waterway, April-December 2011.

Downstream of the Barrier report above). Asian carp CPUE was low for this pool (0.5 fish/100 yards of net).

The Marseilles Pool was fished during all 15 weeks plus one additional week in Hanson Material Services (HMS)-West Pit, and it had the highest number of Asian carp removed (N = 27,110; Table 2). Most (74%) of the fish removed from this pool were bighead carp. Asian carp CPUE was moderate in Marseilles Pool (7.3 fish/100 yards of net). The HMS-East Pit had slightly more Asian carp removed than the West Pit. However, CPUE was highest in the West Pit where 43% of the fish were caught, followed by HMS-East Pit where the proportion of the catch was 53% and Peacock Slough (4% of the catch; Table 2). Though CPUE was similar for HMS-East Pit and Peacock Slough the number of Asian carp removed was dramatically higher in the east pit where 14,429 were removed compared to only 1,090 in Peacock Slough. Peacock Slough is smaller in area thus limiting the number of nets that can be set. In addition, Peacock Slough was fished for only 10 of the 15 weeks due to low water levels.

Starved Rock Pool was fished for the first time in 2011, whereas the other pools were also fished in 2010. Though this pool is further downstream of the Dispersal Barrier it was thought that thinning the Asian carp in this pool would help reduce the number moving up to Marseilles Pool. Starved Rock Pool was fish for all 15 weeks and we removed 13,694 Bighead and Silver Carp. Unlike Marseilles Pool, Silver Carp made up the majority of the catch of in Starved Rock Pool (78%; Table 2). The CPUE for Asian carp was 17.4 fish/100 yards of net in this pool and it was the highest of the three pools sampled. During the last four weeks of the removal program we received permission to fish the Big Bend Hunt Club in the middle of Sheehan Island. This old gravel pit held a high concentration of Asian carp, predominantly silver carp. During this four week period 6,938 Asian carp were removed. The catch rate at Big Bend Hunt Club was 36.5 fish per 100 yards of net, which was the highest of any area fished. It was not uncommon to have three or four boats make just one set of 600 yards each and fill their boats to capacity.

Catch of Asian Carp Throughout the Year – Below are graphs which depict weekly CPUE at HMS-East Pit and HMS-West Pit in Marseilles Pool and the Starved Rock Pool. HMS-West had an extra week of fishing in October, thus Week 16 represents December at this location, whereas Week 15 represents December at the other locations. The data generally shows higher catch rates for Asian carp during the cooler months of the year (Figures 2, 3, and 4). During these months the fish"s metabolism slows down and they have a tendency to stay in the nets. During the warmer months the fish will bust out of the nets or jump over them, especially Silver Carp.

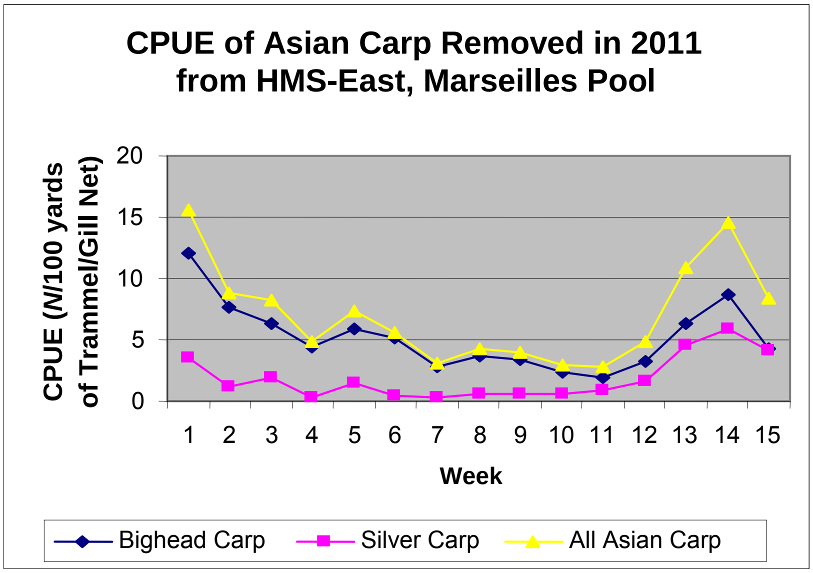

Figure 2. Catch-per-unit-effort (CPUE) of Bighead and Silver Carp harvested during contracted commercial netting efforts in Hanson Material Services (HMS)-East Pit, April-December 2011.

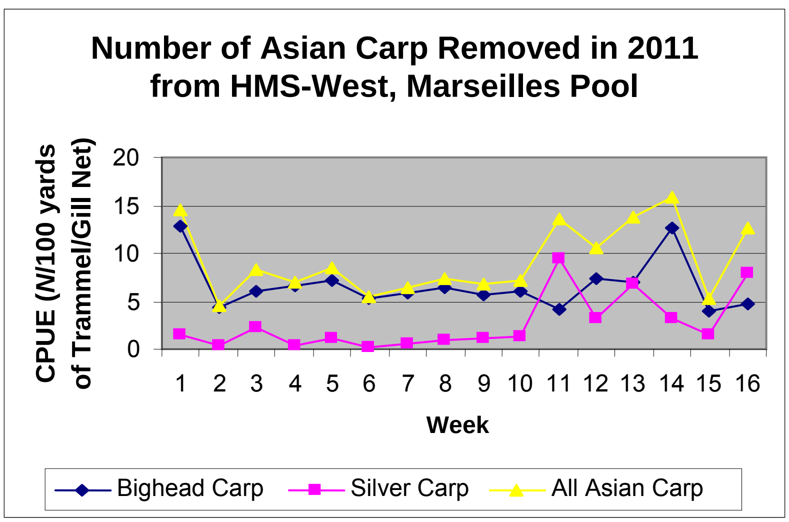

Figure 3. Catch-per-unit-effort (CPUE) of Bighead and Silver Carp harvested during contracted commercial netting efforts in Hanson Material Services (HMS)-West Pit, April-December 2011.

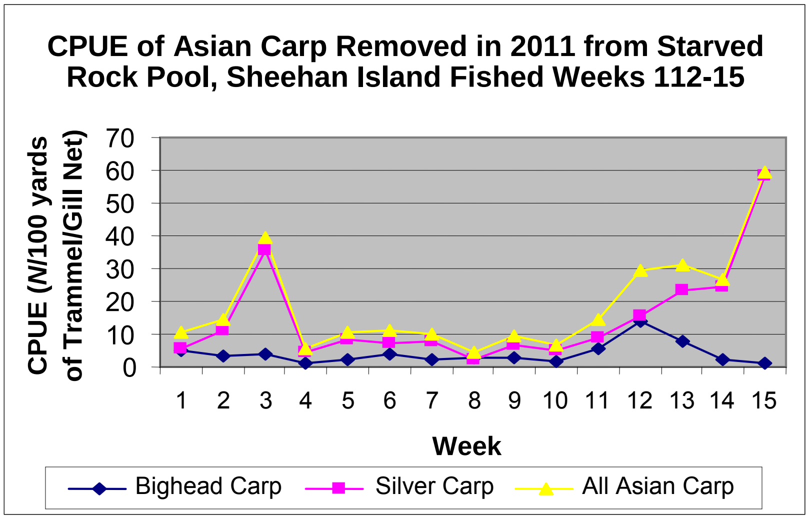

Figure 4. Catch-per-unit-effort (CPUE) of Bighead and Silver Carp harvested during contracted commercial netting efforts in Starved Rock Pool, April-December 2011. Sheehan Island was only fished during the last four weeks of the year.

Catch of By-Catch Species – A total of 52,924 fish representing 30 species and 2 hybrids were caught in trammel and gill nets during the 2011 Asian carp removal effort (Table 3). Of this total, Asian carp (Bighead, Silver, and Grass Carp) made up 78% percent of the catch and the three Buffalo spp. and Common Carp made up an additional 19% of the catch (Figure 5). The high proportion of these species in the catch (97%) demonstrates the high degree of selectivity of the fishing method employed. The low proportion of game fish (1.1%) and other species (1.5%) in the catch suggests the intensive harvest program for Asian carp probably has had little effect on non-targeted fish populations in the river. We caught only 600 individuals and 12 species of game fish during 2011. Of these, Flathead Catfish and Channel Catfish made up 86% of the game fish catch. Impacts on non-target fish populations was further reduced because we only removed the three Asian carp species and Common Carp (5% of the catch) from the river system. All other species were returned to the water immediately after capture.

Recommendations: We recommend continuing the Asian carp removal program in the upper Illinois Waterway to reduce carp abundance at and near the detectable population front and prevent further upstream movement by populations toward the Dispersal Barrier and Lake Michigan. Utilizing contracted commercial netters with assisting IDNR biologists has proven to be a successful approach for Asian carp removal in areas of the waterway not open to permitted commercial fishing. This approach should continue. With additional multi-seasonal years of harvest data, we will be able to track changes in relative abundance of Asian carp populations over time and between locations in the upper waterway. This information will assist in determining the risk of further upstream invasion and challenges to the barrier. There also is a need to assess the effects of the removal program on actual carp population densities and patterns of immigration and emigration at the population front. This research has been planned for 2012 (see Monitoring Asian Carp Population Metrics and Control Efforts plan in MRRWG 2012).

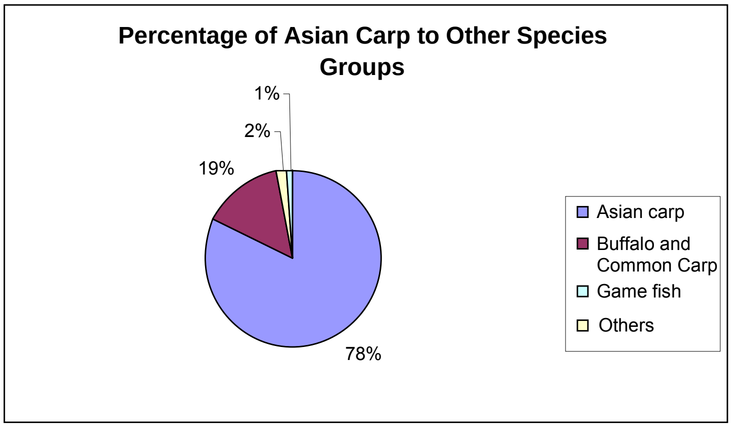

Figure 5. Proportion of Asian carp and other fish species groups captured with trammel and gill nets during contracted commercial netting efforts in the Upper Illinois Waterway, April-December 2011.

Project Highlights:

- Contracted commercial fishers and assisting IDNR biologists deployed 350 miles of net in the upper Illinois Waterway during 2010 and 2011.
- A total of 28,098 Bighead Carp, 18,842 Silver Carp, and 187 Grass Carp were removed by contracted netting. The total weight of Asian carp removed was 414.2 tons (62.4 tons in 2010 and 351.8 tons in 2011).
- Recommend continued targeted harvest of Asian carp in the upper Illinois Waterway with contracted commercial fishers and assisting IDNR biologists. Potential benefits include reduced carp abundance at and near the detectable population front and the possible prevention of further upstream movement by populations toward the Dispersal Barrier and Lake Michigan.

Table 1. Netting effort and number and weight of Bighead, Silver, and Grass Carp harvested from the upper Illinois Waterway, June-September 2010 and April-December 2011. Contracted commercial fishers and IDNR observers captured Asian carp with large mesh trammel and gill nets (3.0-4.25 inches bar mesh). CPUE is catch-per-unit-effort (number of fish/100 yards of net).

	Effort		Harvest								
Year and river pool	Net sets (*N*)	Net length (miles)	Big-head Carp (*N*)	Silver Carp (*N*)	Grass Carp (*N*)	Total (*N*)	CPUE (*N*/100 yds.)	Big-head Carp (tons)	Silver Carp (tons)	Grass Carp (tons)	Total (tons)
2010											
Dresden Island	138	7.9	93	1	16	110	0.8	1.00	0.01	0.18	1.18
Marseilles	1,316	74.8	4,888	1,075	0	5,963	4.5	53.11	8.11	0.00	61.21
All pools	1,454	82.7	4,981	1,076	16	6,073	4.1	54.10	8.12	0.18	62.39
2011											
Dresden Island	56	9.2	66	13	5	84	0.5	0.78	0.10	0.02	0.89
Marseilles	671	213.6	20,087	7,023	34	27,144	7.3	229.39	46.00	0.16	275.55
Starved Rock	151	44.6	2,964	10,730	132	13,826	17.6	21.36	53.32	0.65	75.33
All pools	878	267.4	23,117	17,766	171	41,054	8.7	251.53	99.42	0.83	351.77
2010-2011											
Dresden Island	194	17.1	159	14	21	194	0.6	1.77	0.11	0.19	2.07
Marseilles	1,987	288.4	24,975	8,098	34	33,107	6.5	282.50	54.11	0.16	336.77
Starved Rock	151	44.6	2,964	10,730	132	13,826	17.6	21.36	53.32	0.65	75.33
All pools	2,332	350.0	28,098	18,842	187	47,127	7.6	305.63	107.53	1.01	414.17

Table 2. Effort, number of Asian carp removed, and CPUE (N/100 yards of net) for various areas in the upper Illinois Waterway, April-December 2011.

	Effort		Number Removed			CPUE		
Pool and sample area	Weeks fished	Number of 100-yard sets	Big-head Carp	Silver Carp	Total	Big-head Carp	Silver Carp	Total
Dresden Island								
I-55 Area	9	162	66	13	79	0.4	0.1	0.5
Marseilles								
HMS-East Pit	15	2,192	10,691	3,738	14,429	4.9	1.7	6.6
HMS-West Pit	15	1,264	8,521	3,032	11,553	6.7	2.4	9.1
Peacock Slough	10	190	869	221	1,090	4.6	1.2	5.7
Other areas	5	113	6	32	38	<0.1	0.3	0.3
Total for Pool	15	3,475	20,087	7,023	27,110	5.8	1.5	7.3
Starved Rock								
Sheehan Island	4	190	1,152	5,786	6,938	6.1	30.4	36.5
Other areas	11	595	1,812	4,944	6,756	3.0	8.3	11.4
Total for Pool	15	785	2,964	10,730	13,694	3.8	13.7	17.4

Table 3. Asian carp and by-catch fish species captured with trammel and gill nets in the Dresden Island, Marseilles, and Starved Rock pools of the upper Illinois Waterway in 2011. Species other than Asian carp and Common Carp were returned to the river immediately after capture.

Species	Number caught	Percent (%)
Bighead Carp	23,117	43.68
Silver Carp	17,776	33.59
Smallmouth Buffalo	3,853	7.28
Bigmouth Buffalo	3,850	7.27
Common Carp	2,574	4.86
Freshwater Drums	573	1.08
Flathead Catfish	313	0.59
Channel Catfish	201	0.38
Black Buffalo	188	0.36
Grass Carp	171	0.32
Paddlefish	78	0.15
River Carpsucker	61	0.12
Quillback	37	0.07
Largemouth Bass	28	0.05
Sauger	19	0.04
Shortnose Gar	16	0.03
White Bass	13	0.02
Longnose Gar	11	0.02
Walleye	9	0.02
Skipjack Herring	9	0.02
Blue Catfish	8	0.02
Gizzard Shad	6	0.01
Yellow Bass	3	0.01
Striped Bass hybrid	2	0.00
Spotted Gar	1	0.00
White Crappie	1	0.00
Black Crappie	1	0.00
River Redhorse	1	0.00
Muskellunge	1	0.00
Northern Pike	1	0.00
Common Carp x Goldfish hybrid	1	0.00
Goldeye	1	0.00
All species	52,924	100.00

Telemetry Master Plan

Kelly Baerwaldt; US Army Corps of Engineers – Great Lakes and Ohio River
and
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Participating Agencies: US Army Corps of Engineers (lead), US Fish and Wildlife Service and Illinois Department of Natural Resources (field support), and Metropolitan Water Reclamation District of Greater Chicago (project support).

Introduction: Invasive aquatic nuisance species pose a major threat to aquatic ecosystems worldwide. Within Illinois, the manmade Chicago Sanitary & Ship Canal (CSSC), constructed in the early 1900s, provided an unnatural portal for invasive species dispersal between the geologically separated Mississippi River and Great Lakes drainage basins. In 2002, in an effort to curtail the spread of invasive species between the two basins, the U.S. Army Corps of Engineers (USACE) constructed an electric dispersal barrier within the CSSC. The primary objective of the barrier, when initiated, was to stop the dispersal of the invasive Round Goby into the Mississippi River basin. However, once the project was completed, it was found that the Round Goby had already surpassed the barrier. Since then, a new threat to the Great Lakes from the Mississippi River basin has become the primary objective of the dispersal barrier system. Invasive Asian carps, including Bighead Carp and Silver Carp have been steadily dispersing upstream through the Mississippi, Illinois, and Des Plaines rivers.

The Asian Carp Regional Coordinating Committee (ACRCC) developed the Asian Carp Control Strategy Framework to protect the Great Lakes from two species of Asian carp present in the Illinois Waterway (IWW). As part of this Framework, the ACRCC formed a sub-committee, the Asian Carp Monitoring and Rapid Response Work Group (MRRWG), to develop and implement a series of scientific studies to detect, monitor, and respond to the invasion before a reproducing population of Asian carp established in Lake Michigan. Telemetry has been identified as one of the primary tools to assess the efficacy of the Barrier.

The following outlines the sampling strategy for implementing a network of acoustic receivers supplemented by mobile surveillance to track the movement of Bighead Carp, Silver Carp, and associated surrogate fish species in the area around the barrier in the CSSC, entitled the Telemetry Master Plan. This network was installed and is maintained through a partnership between USACE, the U.S. Fish and Wildlife Service (USFWS), the Metropolitan Water Reclamation District of Greater Chicago (MWRD), and the Illinois Department of Natural Resources (IDNR) as part of the MRRWG‟s monitoring plan (MRRWG 2011).

The primary objective of the Telemetry Master Plan is to assess the effect and efficacy of the Barrier on tagged fish in the upstream and downstream environment of the CSSC of the upper IWW using ultrasonic telemetry. The goals and objectives are identified as:

Goal 1: Determine if fish approach and/or penetrate the Barrier

- **Objective** Monitor the movements of tagged fish (adult and small fish) in the vicinity of the Barrier using receivers placed immediately upstream, within, and immediately downstream of the Barrier, in addition to mobile tracking.
- **Objective** Determine if there is adequate detection coverage to effectively assess efficacy of the Barrier.

Goal 2: Determine if Asian carp pass through navigation locks in the upper IWW
- **Objective** Monitor the movements of tagged fish at Dresden Island, Brandon Road, and Lockport locks and dams using stationary receivers placed above and below each dam.

Goal 3: Determine the leading edge of the Asian carp range expansion
- **Objective** Describe existing conditions of habitat use and movement in the areas of the upper IWW and tributaries where Asian carp have been captured and compare to areas in the CAWS where Asian carp are rare or absent
- **Objective** Download, analyze and share telemetry data

The Telemetry Master Plan includes the tagging of fish with individually coded ultrasonic transmitters in the upper IWW; the network proposed is comprised of 32 acoustic receivers and supplemented by a mobile hydrophone unit to collect information from tags (N=200) implanted into free-swimming Asian carp (Bighead Carp and Silver Carp) and surrogate species in 2010 and 2011. Asian carp were collected from the Dresden Island Pool of the IWW; surrogate species were collected from the Lockport and Brandon Road Pools of the IWW. Tagged surrogates were released both above and below the Barrier; however, no tagged Asian carp were released above the barrier. It was determined that no Asian carp caught in Lockport Pool would be tagged and returned: this may result in the distortion of eDNA surveillance (see eDNA Monitoring Strategy). All fish were released at or near point of capture only after they were deemed viable and able to swim under their own power.

Methods:
Sample Size – Based on MRRWG expert opinion, it was recommended that 200 tags be implanted for telemetry monitoring. To increase our confidence that we are adequately describing the behavior of an entire population, a power analysis is typically needed to ensure we are using an accurate number of fish to draw conclusions from. However, we are operating under many constraints and confounding factors in the barrier environment. Specifically, the exact population size of Asian carp is unknown and varies greatly within the study limits. In Dresden Island Pool Bighead Carp are moderately abundant while Silver Carp seem to be rare. In Brandon Road pool there has not been any live capture of either Bighead or Silver Carp. In Lockport Pool below the Barrier, one Bighead Carp was captured during a December 2009 rotenone event. In June 2010, one Bighead Carp was captured from above the Barrier in Lake Calumet, off the Calumet River. For surrogate species, the upper IWW also has a limited number of adequate species to select from (surrogate species selection is described in the next section), and often these fish are found in low abundance, especially immediately below the Barrier. Tentatively, 200 tags is an implantation estimate to increase our confidence of adequately describing the behavior of populations in the upper IWW. Increases in tags used also increases the burden to stationary receivers for detection and, at this time, USACE recommends not exceeding this number so the system is not overwhelmed. In fact, at the end of the 2011

season, with 182 tags in the water, it was determined that this number should not be exceeded due to the capacity of the acoustic network.

Species Selection (Primary and Surrogate) – Asian carp (Bighead and Silver Carp) are the primary species of concern. However, as mentioned previously, populations of both species vary and are considered rare near or at the barrier. Therefore, in order to test the direct response of fish, surrogate species are also selected for tag implantation and monitoring. Dettmers and Creque (2004) cited the use of Common Carp (*Cyprinus carpio*) as a surrogate species for use in telemetry in the CSSC because "Common Carp are naturalized and widespread throughout the CSSC and Illinois water bodies in general. Common Carp are known to migrate relatively long distances and they grow to large sizes that approximate those achieved by invasive carps. Based on these characteristics, tracking of Common Carp should provide a good indicator of how Asian carp would respond to the dispersal barrier if they were in close proximity to this deterrent." These characteristics could justify the use of other species; we propose Buffalo spp. (Smallmouth and Black), Grass Carp (another species of Asian carp), and Freshwater Drum for use as surrogate species.

Recent laboratory tests investigated the field strength of the barrier at the current operating parameters (2.0 V/inch [0.79 V/cm], 15 Hz and 6.5 ms) on different sizes of Asian carp (Holliman 2011). Those laboratory tests, which did not replicate all field conditions, indicate the barrier may not be 100% effective against fish less than 5.4 inches in length. To assess this finding, we incorporated a small fish phase into the telemetry master plan, where small sizes of non Asian carp fish were implanted with transmitters and released in and around the barrier field to determine their responses defined by behavior and movement patterns relative to the barrier. This part of the study required tagged small fish released above and below barrier 2B in two batches to account for environmental differences between early summer and early fall: one batch in June 2011 and the second in October 2011. Each batch had approximately 15 tagged fish released, divided evenly between release points. Fish were collected from Lockport and Brandon Road pools.

Small transmitters were surgically implanted into 14 non-Asian carp species in June 2011 and 16 non-Asian carp species in October 2011. Fish ranged in size from 2.1 to 7.6 inches; species included were White Sucker, Sunfish spp., Bullhead spp., Largemouth Bass, Skipjack Herring, Common Carp and Crappie spp. Species for tagging were selected based on body type, total length, swimming characteristics (speed, position in water column), and availability of catch. Fish were captured using mini-fyke nets and DC electrofishing. We released fish immediately upstream and immediately downstream of Barrier 2B. Fish movements were continuously tracked by stationary receivers that triangulate the position of the fish to give precise location and movement data (VR4 Receivers).

Capture/Release Location Selection – Based on MRRWG expert opinion, allocation of 200 tags was proposed. To date, ultrasonic transmitters have been implanted and allocated as such:

2010

- 105 tags implanted into adult Asian carp and surrogate species (July - Nov 2010)
    - CSSC/Chicago River above Barrier: 20 Common Carp

- Lockport Pool above Barrier: 18 Common Carp; 2 Freshwater Drum
    - Lockport Pool below Barrier: 29 Common Carp
    - Brandon Road Pool: 1 Grass Carp; 1 Smallmouth Buffalo, 17 Common Carp
    - Dresden Island Pool: 17 Bighead Carp

2011

- 47 tags into adult surrogate species in Lockport Pool (45 Common Carp, 1 Freshwater Drum, 1 Channel Catfish)
- 30 tags into small, non-Asian carp species at barrier (species include White Sucker, Green Sunfish, Pumpkinseed, Skipjack Herring, Largemouth Bass, Smallmouth Bass, Crappie spp., and Bullhead spp.).

The total number of tagged fish in the system is 182. This includes the 152 adult fish (Asian carp and surrogate species) and 30 small fish (all non-Asian carp species).

Tagged surrogate fish were released both above and below the Barrier at or near their point of capture; however, it is important to note no tagged Asian carp were released above the Barrier. USFWS and IDNR assisted USACE in fish tagging and supplied electrofishing boats and crews to capture and return fish to release points.

Tag Specifications and Implantation Procedure – V16 ultrasonic transmitters (69 kHz; 10 g in water and 65 mm in length; Vemco) for remote individual identification were surgically implanted into adult Bighead Carp, Silver Carp, Grass Carp, Freshwater Drum, Common Carp, Channel Catfish and Buffalo spp. during 2010 and 2011. Tagging efforts were focused in June-August and October-November; no tags were placed into fish if extreme water temperatures (above 90°F) were present. Extreme water temperatures associated with the IWW increase chances of infection and add excessive stress on fish, increasing mortality.

Ultrasonic transmitters were less than 2% of body weight (Winter 1996); adult fish implanted with V16 transmitters were ≥ 1.1 lbs (500g) in weight. The V16 transmitters have a minimum life expectancy of 870 days. Smaller fish were implanted with V6 transmitters (180 kHz; 0.5g in water and 16.5 mm in length; Vemco); these transmitters have a life expectancy of 105 days. All small fish were required to be a minimum of 0.09 ounces (2.5 grams) in weight. Each transmitter was tested for recognition prior to its use with a portable hydrophone and receiver (Vemco Model VH110 hydrophone, and Vemco Model VR100 receiver, respectively), supplied by USACE.

Asian carp were collected from the IWW, in Dresden Island Pool (RM 271.5 to 286). Surrogate species were collected from the Brandon Road Pool (RM 286 to 291), Lockport Pool below the Barrier (RM 291 to 296) and above the Barrier (RM 297 to 303). The primary method of capture was electrofishing; although supplemental gears such as nets were also used to harvest fish for tagging. Fish collected were weighed, measured, and sex was identified if possible.

Surgical procedures were consistent with protocols detailed in DeGrandchamp et al. 2007. Once captured, the fish were moved to a holding tank with buffered (sodium bicarbonate) river water and carbon dioxide (CO_2) gas was diffused into the tank for anesthetization or treated with clove oil for anesthetization (Summerfelt and Smith 1990). Once fish were anesthetized they were measured (total length, TL, mm), weighed (kg), and placed in a V-board. Untreated river water was circulated over their gills. Scales were removed from the ventral left area of the fish, posterior to the pelvic fin and anterior to the anal opening. For the Silver Carp, the surgical incision was made further dorsally to account for the displacement of the body cavity due to the well-developed ventral keel. After the removal of scales, the area was disinfected with betadine. All surgical utensils were sanitized in 70% ethanol.

A scalpel (no. 22) and curved hemostats were used to insert the tag and avoid damage to organs. The transmitter was pushed down and away from the incision site to alleviate any added stress on the wound. Incisions were closed with Ethilon® monofilament suture material attached to an FS-2 curved cutting needle using 5 to 7 simple interrupted sutures, as documented by Summerfelt and Smith (1990) and DeGrandchamp et al. (2007). The incision and sutures were sealed with cyanoacrylate resin (superglue gel) to prevent infection and to hold the wound and suture knots together securely. Immediately following the surgical procedure, fish were placed in a recovery tank supplemented with dissolved oxygen. After the fish regained control of buoyancy and orientation, they were released at the capture site (all capture sites were identified with GPS coordinates) or at the specified release location at the Barrier (small fish). Fish were only released if they were able to swim independently.

Small Fish Methods – During the week of 20 June 2011 and 4 October 2011, USACE, with field assistance from USFWS, captured and surgically implanted ultrasonic transmitters (Vemco V6 180 kHz, weight in water 0.5g) into 30 small fish captured from the Lockport or Brandon Road pools of the IWW. In general, the total length of fish ranged from 54 mm (2.1 inches) to 193 mm (7.6 inches). Species for tagging were selected based on body type, total length, swimming characteristics (speed, position in water column), and availability in the catch. Fish were captured using mini-fyke nets and DC electrofishing. Fish were anesthetized, tagged, and put in an oxygenated recovery chamber. Fish were held for a minimum of 12 hours in holding pens to acclimate; dissolved oxygen was kept on the fish for 12 hours, then fish were transferred to river water before release. Fish were only released if they appeared to be in exceptional health and able to freely swim under their own power. Tagged fish were released in two batches (Figure 1). Fourteen fish were released immediately upstream of Barrier 2B; the remaining fifteen fish were released immediately downstream of Barrier 2B and one tagged fish escaped near the surgical site 3.5 miles south of the Barriers. Fish movements were continuously tracked by stationary receivers.

Acoustic Network – A system of passive receivers (Vemco VR2W and VR4 Receivers) was placed throughout the IWW in order to monitor movement. The receivers log data from tagged fish when they swim within the detection range of the receiver (typically at least one quarter mile from the receiver). The detection limits of each receiver were tested with a test tag. VR2W‟s were placed from below Dresden Island Lock and Dam (RM 271 of Marseilles Pool, IWW) to above the barrier in the CAWS. In some areas, two VR2W‟s were placed to increase the detection capability in high noise or wider riverine settings, or to duplicate monitoring efforts in high risk environments (where receivers may be subject to damage or loss). VR2W‟s were deployed using a variety of methods: stationary deployment using a lead line or

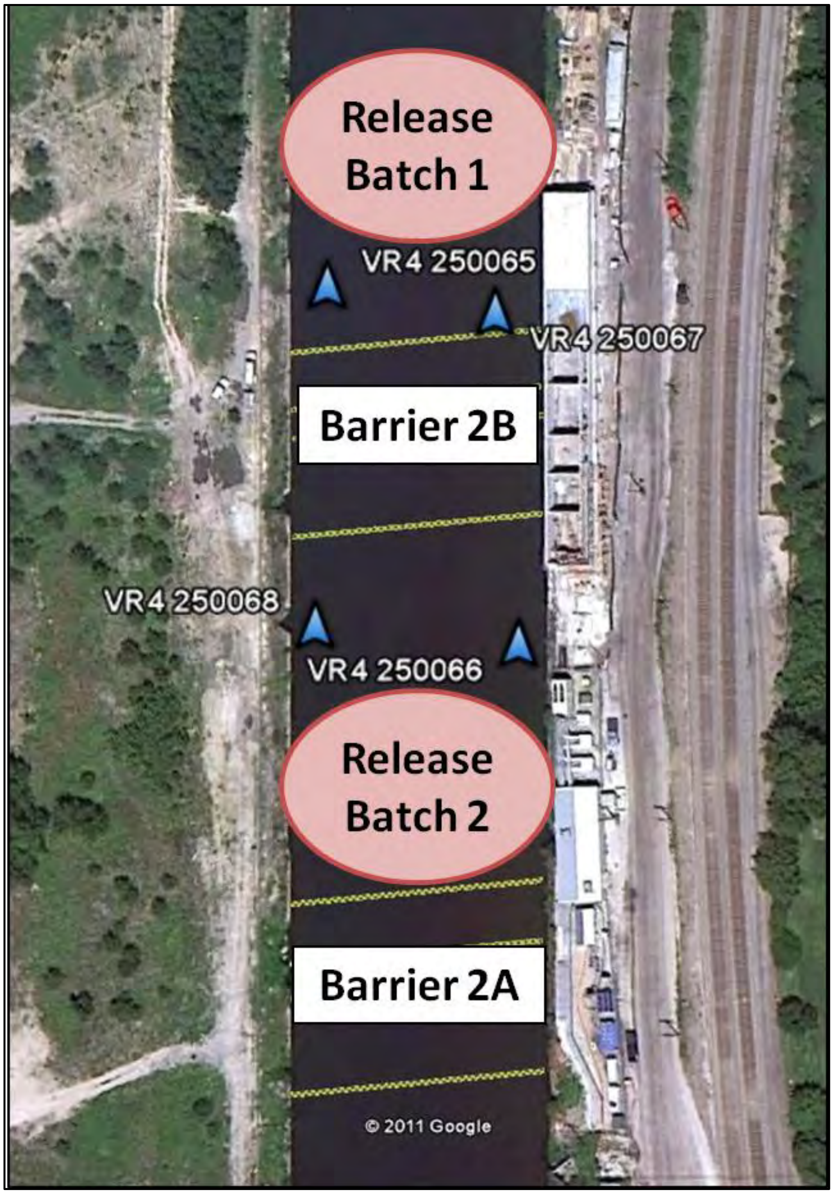

Figure 1. Release locations for two groups of small fish tagged with acoustic transmitters during 2011 barrier efficacy assessments.

marked buoy, or deployment on fixed structures (canal walls, mooring cells, lock guide walls). In the immediate vicinity of the Barrier, receivers were placed inside the canal walls in manhole covers constructed for previous telemetry studies.

Emergence of a new technology enabled USACE to deploy Vemco VR4 model receivers. These receivers work together as a Vemco Positioning System (VPS) to triangulate the position of the fish in the water to give precise location and movement data. They are submersible for at least 5 years and data is downloaded via wireless modem, thus eliminating the need for manual retrieval (which is optimum for the electrical field environment created by the Barrier). These receivers are deployed from the bottom of the canal using a specialized float collar to keep them upright and protected from passing vessels. Currently, we have 8 VR4 receivers covering the areas around Barrier 2A and 2B. VR4 data is sent to Vemco for processing. Data processing typically takes about 3-4 weeks for full analysis.

Mobile tracking – The use of a mobile unit (Vemco VR-100 unit with a portable directional and omni-directional hydrophone that is operated out of a boat) enables our crew to manually locate any tagged fish using the signal emitted from the transmitter inside the fish. The mobile unit is used to occasionally (monthly) locate fish in the study area to ensure we still have the adequate number of active tags in the system being monitored. The mobile unit can also identify the exact location of any tagged fish to supplement data provided by stationary receivers which only give an approximation of a tagged fish location.

Results and Discussion: The results discussed in this section will address the three goals of the study. In 2011, we deployed 32 stationary receivers (VR2W‟s and VR4‟s) in the IWW and CAWS to collect stationary tracking data, supplemented by monthly mobile tracking. To date, 3.7 million detections from 182 tagged fish, with a 75% detection rate, indicate that no tagged fish have crossed any of the electric barriers in the upstream direction.

By the end of 2011, individually coded transmitters had been surgically implanted into 182 fish as follows:

- 112 fish below the barrier (both Asian carp and surrogate species);
- 40 adult fish above the barrier (surrogate species);
- 30 non-Asian carp species were tagged and released at the Barrier.

Goal 1: Determine if fish approach and/or penetrate the Barrier

Adult Fish Testing

During 2011, several tagged, adult Common Carp were observed approaching the wide array of Barrier 2B from downstream, but these fish were not able to make it upstream into the narrow array. No tagged adult fish were observed approaching the Barriers from upstream and we have not observed any tagged adult fish passing through any of the Barriers in either direction.

Anomaly:
In early August we discovered a stationary tag in the CSSC located upstream of the Barrier about 2.5 miles near the I-355 Bridge. The fish was a 23-inch Common Carp tagged on 27 October, 2010 below the Barrier in Lockport Pool. From October 2010 through July 2011, we had a near 100% detection on the fish, meaning we knew where it was at all times. It has been very active, but had remained within Lockport Pool downstream of the Barrier. We have about 131K detections from this fish documenting its movement.

On 5 July 2011, we had 1,973 detections from our Barrier receivers for this tag. Our positioning showed the fish challenging the Barrier array then exiting the array in the downstream direction (away from the Barrier). We then detected the tag on our next downstream stationary receiver, below Romeoville Road, for about 30 minutes until 7:31AM. At this point, we lost contact with the tag and it had not been detected on our stationary network since.

The next contact was on 11 August when a mobile tracking crew located the tag upstream of the Barrier. This was puzzling because the tagged fish would have had to pass by 12 receivers and not be detected if it had truly passed through the barriers while submerged.

In response to this anomaly, we conducted two additional mobile tracking trips to identify the exact position of the tag, which was limited to a 50- x5 0-foot area. It had not moved since the 11 August detection and crews were able to place stationary receivers around the tag to monitor any movement. Divers were deployed to the site to search for the tag; there was much debris on the bottom but the tag was not found, and no fish were observed in the vicinity.

We will continue to monitor the location of this tag but our preliminary conclusion is that the tag or the fish was removed by some external source and discarded upstream of the Barrier. We will also be conducting a study in spring 2012, simulating a tag being dragged through the barrier under a barge to see if it is indeed detected by all receivers in the area.

Small Fish Testing

In June and October 2011, 30 non-Asian carp small fish were tagged with transmitters. Fish ranged in size from 2.1 to 7.6 inches. Species include: White Sucker, Sunfish spp., Bullhead spp., Largemouth Bass, Skipjack Herring, Common Carp, and Crappie spp.. Species for tagging were selected based on body type, total length, swimming characteristics (speed, position in water column), and availability on our catch. Fish were captured using mini-fyke nets and DC electrofishing. Fourteen fish were released immediately upstream of Barrier 2B and 15 fish were released immediately downstream of Barrier 2B. One additional tagged fish escaped at the Cargill boat launch where all surgeries were performed. Fish movements were continuously tracked by stationary receivers that triangulate the position of the fish to give precise location and movement data.

Results indicate that from 20 June 2011 through 20 October 2011, none of the fish released below the Barrier moved upstream, they all remained below the barrier. The dominant behavior observed for fish released below the Barrier was short range pacing between Barrier 2B and 2A with intermediate rests near the 2A array. Six of the fourteen fish released upstream of the Barrier did pass downstream through both arrays of Barrier 2B, five moved down into the array of 2B and remained there, and the last three moved upstream away from the barriers. We have nearly 540K detections from our small fish study. Differences in the length of time each transmitter was detected by the receiver network ranged from several days to months. Possible reasons for transmitters to lose connection with the network may include but are not limited to fish moving out of detection range, avian predation and interactions with high voltage outputs near the active 2B electrodes.

Our preliminary conclusion from the small fish and adult fish studies is that the barriers are effectively preventing all upstream passage of tagged fish.

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

We have observed ten occurrences of tagged Common Carp moving downstream through the Lockport Lock and three upstream movements of tagged Common Carp through the Lockport Lock. Out of the three Common Carp to pass upstream through the Lockport Lock, only one originated from the Brandon Road Pool and moved through the lock in early May 2011. The remaining two carp were released in the lower Lockport Pool and passed downstream into the Brandon Road Pool before returning through the lock in early August 2011. Upstream passage was observed on both rising and falling hydrographs with flow rates ranging from 3,186 to 5,000 cubic feet per second (cfs). Only one out of the ten fish to pass downstream through the Lockport Lock originated from the Brandon Road Pool and returned through the lock in late May 2011. The nine other fish to pass downstream through the lock were originally released within the lower Lockport Pool. All downstream lock passages were observed between 22 May and 8 August 2011. Nine out of ten downstream passages coincided with spikes in the hydrograph of the CSSC on 26 May, 9 June and 23 July when peak flow rates ranged from 13,889 to 14,904 cfs. It may be noted that one Common Carp downstream lockage occurred through the Brandon Road Lock in 2010. We did not observe any lock passages by Asian carp. Therefore, our preliminary conclusion is that Common Carp can navigate through the locks on the upper IWW, but we have not observed the same behavior for Asian carp. This was likely due to the smaller sample size of Asian carp tagged relative to the surrogate species.

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

In 2010, we were able to capture and tag 17 Bighead Carp in Dresden Island Pool, near Moose Island at RM 276.0. To date none of these fish have left Dresden Island Pool, and our mobile tracking has not detected them in areas outside of the three river miles surrounding their release point. Our detection rate for Dresden Island Pool was 53%, lower than our system average detection of 75%. The decreased detection may be attributed to the fishing/eradication efforts targeting large Asian carp in that pool. Based on the tagged fish data from this pool, our preliminary conclusion is that the leading edge of adult Asian carp in Dresden Island Pool has not changed.

In 2012, the USFWS and SIUC will supplement the downstream efforts by enhancing the array to extend from Dresden Island Pool down to Starved Rock Lock and Dam, and also target Asian carp for implantation of transmitters (all life stages). USACE will support these efforts as needed.

Recommendations: It is evident that we need to continue small fish testing at Barrier 2A and 2B to ensure it is effective at repelling small size classes of fish. This was an addition to our 2011 Telemetry Plan and we recommend including it as a primary objective to our 2012 Telemetry Plan. In addition, we recommend increasing our acoustic network to better cover the upper IWW, in cooperation with USFWS and SIUC. New receiver deployments should be strategically placed to cover habitats of interest as well as possible escape routes from the study area including the Des Plaines and Kankakee tributary confluences. We suggest having a more concentrated effort on the leading edge of Asian carp, and tagging more Asian carp in Dresden Island and Marseilles pools should be another primary objective of the 2012 Telemetry Plan. In addition, we recommend Asian carp tagged in the Dresden Island and Marseilles pools have external Floy tags and metal jaw tags attached to better alert fishers in these pools to tagged fish.

Project Highlights:

- To date, we have acquired 3.7 million detections from 182 tagged fish, with a 75% detection rate.
- Our preliminary conclusion from the small fish and adult fish telemetry studies is that the barriers are effectively preventing all upstream passage of tagged fish.
- We have observed tagged Common Carp passing through the Lockport Lock in both directions.
- Based on the few Asian carp tagged in Dresden Island Pool, our preliminary conclusion is that the leading edge of adult Asian carp in Dresden Island Pool has not changed.
- Recommend continued small fish testing at the barrier and expanded acoustic detection network in the upper Illinois Waterway, in cooperation with USFWS and SIUC, for enhanced monitoring of the leading edge of adult Asian carp populations.

Evaluation of Fish Behavior at the Dispersal Barrier Using DIDSON

Brad Rogers;
US Fish and Wildlife Service – Carterville Fish and Wildlife Conservation Office

Participating Agencies:
US Fish and Wildlife Service (lead); US Army Corp of Engineers (field support); and US Coast Guard (project support).

Introduction: The aquatic nuisance species barrier system on the CSSC has been operating in some capacity since April 2002. At that time, only a single barrier (Barrier 1), commonly referred to as the Demonstration Barrier, was constructed and operational. In 2009 Barrier 2A began operation. Barrier 2A is a more robust barrier that is capable of producing electric fields greater in intensity than those created by Barrier 1. A third barrier (Barrier 2B), even more advanced than both the previous two barriers, came online in 2011. Barrier 2B is now the primary and preferred barrier for operation.

Optimum operating parameters for the Dispersal Barrier were determined by studying fish behavior in a laboratory setting (Holliman 2011). Specifically, various electrical settings and the associated fish behaviors were used in the experiment to determine the optimum settings. Research and testing included exposing juvenile silver carp 5.4 to 11 inches in length to barrier electric fields in a tank at various combinations of the three operating parameters (pulse frequency, pulse duration, and voltage). Results indicated that all of the fish tested were immobilized by the electric field that was in use from August of 2009 to November 2011 at Barrier 2A and 2B. Subsequent phases of testing have focused on smaller carp to determine whether small fish, 2 to 3 inches in length, will be immobilized or deterred by the same settings. Based on these results, the operating parameters were changed in November 2011 and are currently set at 2.3 V/inch ultimate field strength, 30 Hz, and 2.5 ms pulse length.

Laboratory trials provide good evidence that the operating parameters will deter fish of larger sizes. However, additional field trials are warranted to ground truth laboratory tests, particularly with the final barrier complete and operational. We conducted surveys with Dual-Frequency Identification Sonar (DIDSON) to examine abundance and behavior of fishes located in and around the Dispersal Barrier. In addition, DIDSON was used to monitor the response of various sized surrogate fish placed in nonconductive cages moved through the barrier field. These *in situ* assessments will add to our understanding of the effectiveness of the Dispersal Barrier in preventing fish passage between the Mississippi and Great Lakes basins.

Methods

Data Collection and Equipment Limitations – DIDSON is an acoustic camera that can be used in turbid water to observe fish behavior and location in real time, with minimal disturbance. All field observations in this study were taken with a DIDSON and all of the data gathered was spatially and temporally referenced. Other data gathered during each recording or sampling event included information on the settings of the DIDSON, water quality parameters (e.g., temperature and conductivity), and weather conditions. Observations were made of wild fish and fish that were contained in cages.

As with all hydroacoustic technologies, the DIDSON has some technical limitations. DIDSON can measure the length of fish (Burwen et al. 2010), but is rarely able to determine species (Zeigler et al. 2009). Given this, fishes of a particular size observed during field measurements were considered surrogates for Asian carp when determining barrier efficacy. A single DIDSON unit will not provide complete cross-section coverage in the CSSC. The DIDSON can be set in a variety of ways to gather high quality images in close proximity to the unit, or to gather images of decreasing quality from a greater distance. Operating parameters of the DIDSON were changed accordingly depending on the objective of the data being collected. Recent pilot studies have shown the Dispersal Barrier has no effect on the electronic components of the DIDSON (Cornish et al. 2010).

Caged Fish Behavior – Fish behavior in the barrier system provides valuable information about the efficacy of the barrier for fish of different sizes. The DIDSON was used to view the behavior of known surrogate fish (Gizzard Shad) that we placed into non-conductive cages.

Fish were placed in cages and allowed to acclimate to the cage for 10 minutes before testing began. The behavior exhibited at the end of the acclimation period was used as the baseline "no reaction" behavior. Caged fish were then moved through the barrier system and cage movement parameters (duration, location across the canal, and distance traveled) were recorded. We also observed the behavior of fish in the cage at locations away from the Dispersal Barrier as a control. For comparison, control fish were put through the same process as the test fish in areas where there was no electric input.

Fish behaviors were documented by recording four simple behavioral observations including no response, fright/flight response, incapacitation, and recovery. Attempting to record more detailed behaviors was not practical based on the limitations of the DIDSON, however general notes on observed behavior were recorded.

In-Barrier Observations – To determine if fish are passing into or through the Dispersal Barrier, we took DIDSON recordings at known locations at, and in, the barrier electric field. Observations made in the field consisted of time marking of any significant, unusual, or unexpected events in the recordings so that they could easily be located during post processing. All other data were recorded as in caged fish experiments. Data were viewed and cross referenced with a map of the electric field to determine if, and where, fish are repelled by the electric field and the fields corresponding strength.

Dispersal Barrier Site Affinity by Fishes – Relative abundance of fish near, in, and at adjacent areas of the Dispersal Barrier will provide valuable information about affinity or lack of affinity of fishes to the barrier area. The DIDSON was used to gather fish count data at randomly and systematically selected sites above and below the Dispersal Barrier. These data will be used for comparisons of fish count data at or near the barrier to determine if a significant difference exists.

Results and Discussion: The volume and post processing time for behavior data from the DIDSON is immense. Therefore, a limited amount of analyses have been performed on the data that were collected in 2011. A full analysis of the 2011 data is expected in April 2012.

In 2011, 3 weeks were spent at the barrier testing equipment and methods to determine which would be best to help fulfill the objectives. When actual field testing began, 133 individual caged fish trials were performed using 666 fish. Wild fish observations were made at 240 sites totaling 2,400 minutes (40 hours) of in-water observations. The 2011 field effort for this project totaled approximately 12 weeks and 2,380 person hours.

A preliminary analysis was performed on a portion of the caged fish data to provide an update to interested parties at the 72nd Midwest Fish and Wildlife Conference in Des Moines, Iowa in December 2011. This analysis of data is not comprehensive or complete and served primarily to provide an initial check that the data were being collected correctly and that models for analysis were functioning properly. No definitive conclusions can be made from these analyses at this time. Once the complete data set is fully reviewed and analyzed conclusions will be reported.

Despite the preliminary nature of the data analysis, some information on initial trends in fish behavior around the barrier has emerged. Swimming behaviors were exhibited less at in-barrier sites than control sites located outside of the barrier. Fish were incapacitated more at in-barrier sites than control sites. A significant amount of fish that were incapacitated at in-barrier sites were able to recover in 5 minutes or less once being passed through the entire electric field. As voltage increased, swimming behaviors decreased while flight behavior and incapacitation increased. Once the final analysis has been completed, a full report will be provided.

Recommendations: We recommend continuing caged fish trials and wild fish surveys to further characterize fish abundance and behavior at the barrier. One change that will be made for 2012 is using a digital video camera to observe caged fish. The DIDSON worked for this part of the study but was determined to be most appropriate for the wild fish observations. Much higher quality data can be collected during the caged fish trials by using a video camera. Also, a non-conductive boat hull will be added to the sampling protocols in order to compare differences in fish behavior in close proximity to both metal and non-metal boats. There is also the potential to add the use of a barge in the caged fish studies to test for effects that large vessels traversing the barrier may have.

Project Highlights

- Field effort for this project totaled approximately 12 weeks and 2,380 person-hours.
- Completed 133 individual caged fish trials with 666 fish. Wild fish observations were made at 240 sites totaling 2,400 minutes (40 hours) of in-water observations.
- All field work was completed without a single safety incident.
- A large amount of fish behavior data was collected that will provide valuable information to managers.
- Recommend continued caged fish trials and wild fish surveys at the barrier during 2012. Will utilize a digital video camera rather than DIDSON imaging sonar to monitoring fish behavior during 2012 caged fish trials. DIDSON will continue to be used during wild fish trials.

Monitoring for Asian Carp in the Des Plaines River and Des Plaines River Overflow

Nicholas Bloomfield and Pamela Thiel;
US Fish and Wildlife Service –La Crosse Fish and Wildlife Conservation Office

Participating Agencies: US Fish and Wildlife Service– La Crosse Fish and Wildlife Conservation Office (lead); Illinois Department of Natural Resources, US Environmental Protection Agency, and Metropolitan Water Reclamation District of Greater Chicago (field support).

Introduction: The upper Des Plaines River joins the Chicago Sanitary and Shipping Canal (CSSC) in the Brandon Road Pool immediately below the Lockport Lock and Dam. Asian carp have been observed in this pool up to the confluence and have free access to enter the upper Des Plaines River. In 2010 and 2011, Asian carp eDNA was detected above the confluence in the upper Des Plaines River (see eDNA monitoring report above). There is concern that Asian carp could gain access to the CSSC upstream of the Dispersal Barrier during high water events when water flows laterally from the upper Des Plaines River into the CSSC. The construction of a physical barrier to reduce the likelihood of lateral movement was completed in the fall of 2010.

The physical barrier constructed by the US Army Corps of Engineers consists of concrete barriers and 0.25-inch mesh fencing and was built along 13.5 miles of the upper Des Plaines River where it runs adjacent to the CSSC. The barrier was designed to stop adult and juvenile Asian carp from infiltrating the CSSC, although it will likely allow Asian carp eggs and fry to pass. It is critical to understand the population status, monitor for any potential spawning events, and determine the effectiveness of the physical barrier to help inform management decisions and direct removal actions.

Objectives: This project has two major objectives:

1) Monitor for Bighead and Silver Carp and their spawning activities in the Des Plaines River upstream of the confluence with the CSSC; and

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

Methods: Three sites were chosen to monitor for Asian carp using electrofishing and short term sets of gill and trammel nets: downstream from the Hofmann Dam in Riverside, the Columbia Woods area near Willow Springs, and upstream from the railroad bridge near Lemont (Figure 1). Lemont Railroad Bridge was sampled on 28 June and 20 October 2011, Columbia Woods on 29 June and 19 October 2011, and the Hofmann Dam site on 20 July2011. Hofmann Dam was only sampled once due to access issues during low water in the fall. Columbia Woods and Lemont Railroad Bridge were sampled using pulsed DC electrofishing. Hofmann Dam was sampled using 3-phase AC electrofishing. Nets used at the three sites included 0.75- to 2.0-inch mesh experimental gill nets, 3.5-inch mesh trammel nets, and 3.0-inch mesh gill nets.

There was one high water event in 2011 in which floodwaters from the upper Des Plaines River moved laterally into the CSSC at one location (Figure 2). A thorough search around the physical barrier was conducted for migrating and impinged fish where water ran through and under the fencing, as well as beyond the physical barrier to the confluence with the CSSC.

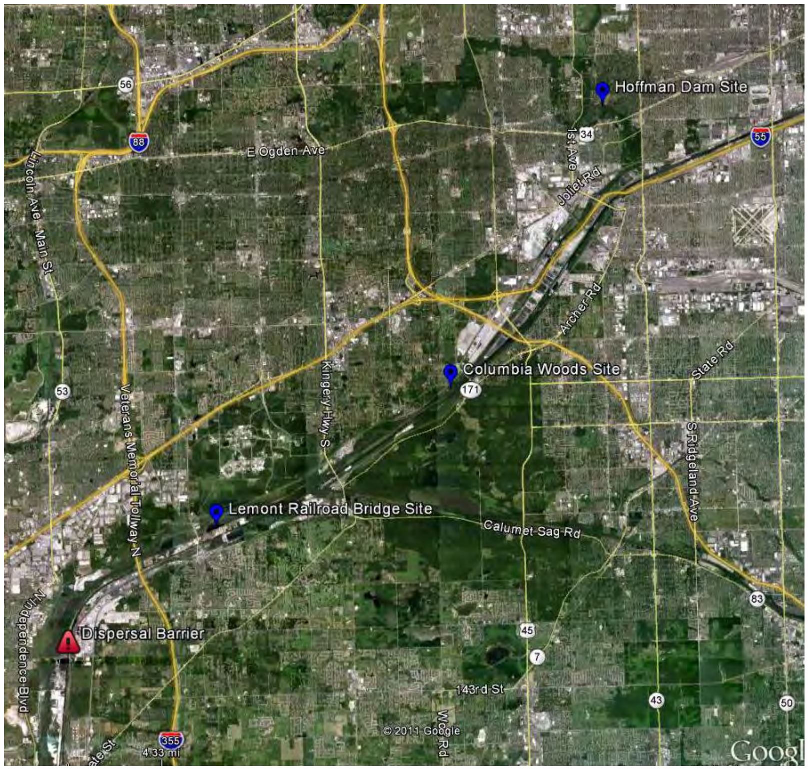

Figure 1. Asian carp sample sites in the upper Des Plaines River.

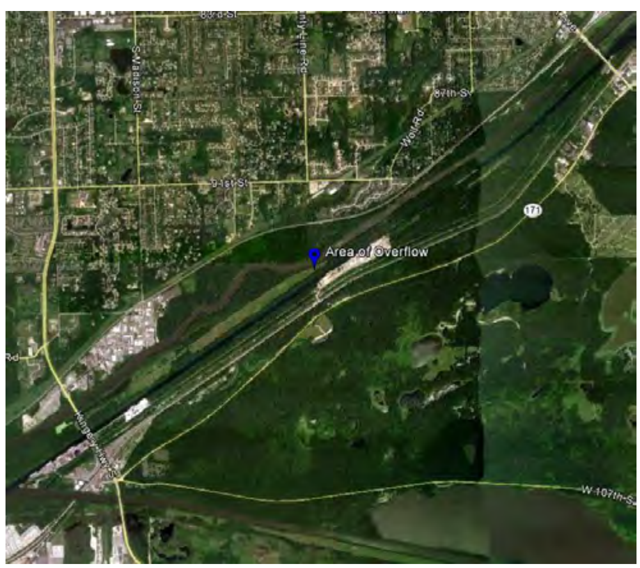

Figure 2. Location where the upper Des Plaines River overflowed into the CSSC, July 2011.

Results and Discussion: Electrofishing at the three sites captured 1,141 fish representing 37 species from 11 families (Table 1). A total of 10.5 hours were spent electrofishing: 4.2 hours at Lemont, 4.3 hours at Columbia Woods, and 2.0 hours at Hofmann Dam. Netting captured 37 fish representing 10 species from seven families (Table 2). A total of 31 net sets covering 1,452 yards were fished for a combined total of 40.3 hours. No Asian carp were captured or observed.

All three sites have areas that are suitable habitat for Asian carp. Hofmann Dam is likely an impassable barrier (Pescitelli and Rung 2010). This creates an opportunity to find Asian carp that have stacked in the area downstream of the dam while trying to migrate upstream. Much of the habitat in this stretch is riffle, but there are slack water areas Asian carp may find appealing. The Columbia Woods site is a deep, slow moving stretch of river, while the Lemont railroad bridge site has a large, shallow backwater site. The fish communities at these two sites indicate a more lentic environment as well. If Asian carp were present in large numbers, monitoring at the three sites likely would detect their presence.

Heavy rains on 23 July 2011 caused the Des Plaines River to overflow into the CSSC in one location beginning on 24 July 2011. The area was searched on 25 July 2011 as water levels were receding. No fish were found to be impinged in the fencing or dead nearby. Upon investigation, it was discovered the water had scoured a hole underneath the fencing and much of the flow was diverted under the fence as opposed to through the 0.25 in mesh. Several small fish were observed that had breached the barrier, and three were captured: a 29 mm Bluegill, a 25 mm Bluegill, and a 34 mm Bluntnose Minnow. The scour hole under the carp fence was brought to the attention of the US Army Corp of Engineers and repairs were made to shore up the barrier.

Recommendations: We recommend that monitoring for the presence of Asian carp juveniles and adults in the upper Des Plaines River continues in 2012. Des Plaines River stage will continue to be monitored during heavy rainfall events and investigations of the carp barrier fence will take place, as needed, in areas where overtopping occurs.

Project Highlights:

- Captured 1,178 fish electrofishing and netting on the upper Des Plaines River.
- No Asian carp were captured or observed.
- Investigated the physical barrier in the area of an overtopping event, located fish that breached the barrier, and identified potential problems with the physical barrier (that have since been repaired).
- Recommend continued monitoring for the presence of Asian carp adults and/or juveniles at the three sites in the upper Des Plaines River and continued investigations in the area of overtopping events.

Table 1. Number of fish captured by electrofishing at three sites in the upper Des Plaines River.

Common name	Lemont	Columbia Woods	Riverside	Total
Bluegill	98	106	17	221
Common Carp	54	69	13	136
Largemouth Bass	75	55	3	133
White Sucker	20	21	46	87
Channel Catfish	31	24	19	74
Spotfin Shiner	29	38	5	72
Black Crappie	42	20	4	66
Gizzard Shad >6 in.	27	14	6	47
Bluntnose Minnow	25	13	1	39
Green Sunfish	23	13	2	38
Orangespotted Sunfish	26	6	2	34
Northern Pike	15	13	4	32
Round Goby	7	3	16	26
Sauger	12	6	6	24
Sand Shiner	1	2	18	21
Golden Shiner	9	1	3	13
Spottail Shiner	9	1	1	11
Blackstripe Topminnow	4	6		10
Bowfin	10			10
Blackside Darter			7	7
Spotted Sucker	3	1	1	5
Gizzard Shad <6 in.	3	1		4
Pumpkinseed	2	1	1	4
River Carpsucker	2	2		4
Yellow Bullhead	2	1		3
Longnose Gar	2		1	3
Walleye			2	2
Hornyhead Chub		1	1	2
Emerald Shiner		1	1	2
Smallmouth Bass			2	2
Rock Bass			2	2
Muskellunge			1	1
Yellow Perch			1	1
Fathead Minnow		1		1
Grass Carp			1	1
Black Bullhead			1	1
Smallmouth Buffalo			1	1
Quillback		1		1
Total	**531**	**421**	**189**	**1141**

Table 2. Number of fish captured by netting at three sites in the upper Des Plaines River.

Common name	Lemont	Columbia Woods	Riverside	Total
Northern Pike	8	2	1	11
Common Carp	5	2		7
White Sucker	4	1	1	6
Bluegill	1		1	2
Channel Catfish	1	1		2
Rock Bass	1			1
Gizzard Shad >6 in.		1		1
Sauger		1		1
Walleye		1		1
River Carpsucker		1		1
Total	**24**	**10**	**3**	**37**

Evaluation of Gear Efficiency and Asian Carp Detectability

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

Introduction: A variety of traditional sampling gears (electrofishing, gill nets, trammel nets) are being employed by various agencies to capture Asian carp, but the relative efficiency of each of these gears, and the amount of effort required to detect Asian carp when they are present in low densities, has not been evaluated. A variety of alternative sampling gears (hydroacoustics, midwater trawls, purse seines, trap nets, mini-fyke nets, hoop nets, cast nets, seines) are also available that may potentially be more effective at capturing Asian carp than methods currently being used. Evaluating the ability of these methods to capture both juvenile and adult Asian carp will allow managers to customize monitoring regimes and more effectively determine abundances of Asian carp. Data gathered from gear evaluations can also be used to model single-sample detection probabilities, cumulative detection probabilities, and site occupancy rates for Asian carp. Determining the probability of detecting Asian carp with each sampling gear in different areas of the Illinois Waterway would allow for determination of appropriate levels of sampling effort and help improve the efficiency of monitoring programs. Results of this study will help improve Asian carp monitoring and control efforts in the Illinois River and the CAWS, and will contribute to a better understanding of the biology of these invasive species in North America.

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

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

Methods: Gear evaluations are being conducted at 10 sites located throughout the Illinois Waterway (Figure 1). Sampling gears are being evaluated at sites in the middle Illinois River (where Asian carp are present in high densities), the upper Illinois/Des Plaines River (where Asian carp are present in low to moderate densities), and in the CAWS (where Asian carp are either absent or present in very low densities). All sampling gears are being tested seasonally (spring, summer, and fall) at each site. Gears and effort are shown in the table below. All captured fish are being identified to species and measured for total length and weight.

Figure 1. Gear evaluation sample sites in the Illinois Waterway.

Gear / Method	Target	Effort per site-visit
Large mesh hoop net	Adults	12 net-nights
Trap net	Adults	8 net-nights
Trammel net w/ pounding	Adults	4 sets
Large mesh purse seine	Adults	4 hauls
Large mesh gill net – sinking	Adults	4 x 4 hour sets
Small mesh gill net – sinking	Juveniles	4 x 4 hour sets
Small mesh gill net – floating	Juveniles	4 x 4 hour sets
Mini-fyke net	Juveniles	8 net-nights
Small mesh purse seine	Juveniles	4 hauls
Midwater trawl	Juveniles	4 x 5 minute tows
Cast net	Juveniles	3-4 hauls
Beach seine	Juveniles	3-4 hauls
DC electrofishing	Both	6 x 15 minute transects
Hydroacoustics	Both	2 x 15 minute transects

Results: Each site was sampled three times in 2011 from May 1 - October 5. Overall, 1,372 Asian carp were caught, comprising 899 Silver Carp, 357 Bighead Carp, and 116 identified as Bighead x Silver Carp hybrids. All three taxa were most abundant at Henry; no Asian carp were captured in the CAWS. The furthest upstream site at which Silver Carp were caught was Ottawa, whereas Morris and I-55/Treat‟s Island represented the upstream limits for Bighead x Silver Carp hybrids and Bighead Carp, respectively (Figure 2).

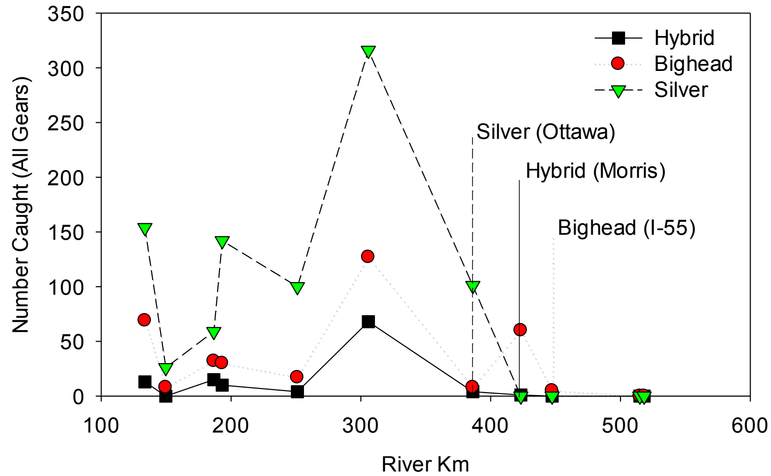

Figure 2. Total number of Asian carp caught at each sampling site in the Illinois River in 2011. River km is measured as distance upstream from the Mississippi River.

Eight age-0 Asian carp (<300 mm long; <12 inches) were collected across all samples, including 6 (4 Silver Carp, 1 Bighead Carp, and 1 hybrid) at Lily Lake, and 1 Silver Carp at each of Peoria Lock & Dam and Henry (Figure 3). The highest abundance of age-1 Asian carp (<500 mm; <20 inches) was at Henry (n=212) while one age-1 Bighead Carp was caught at each of Ottawa and Morris (Figure 3).

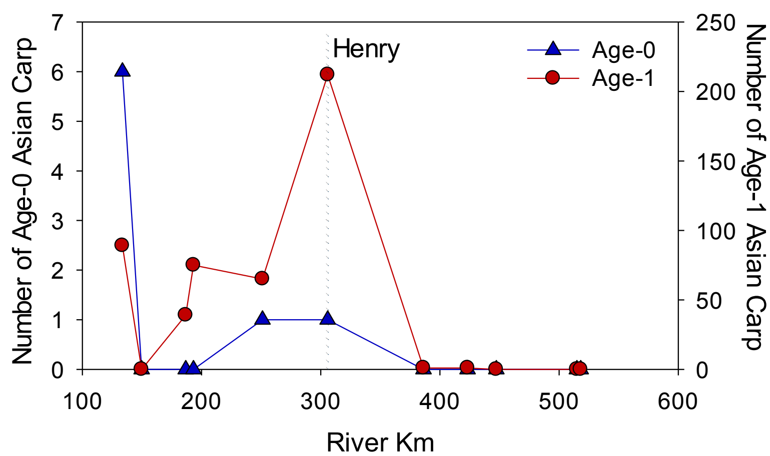

Figure 3. Number of Age-0 (<300 mm; <12 inches) and Age-1 (<500 mm; <20 inches) Asian carp caught at each sampling site in the Illinois River in 2011. River km is measured as distance upstream from the Mississippi River.

Most Silver Carp were caught using electrofishing (59% of Silver Carp), followed by hoop nets (18%) and gill nets (11%). Hoop nets (53%) and trap nets (35%) were the most effective gears for sampling Bighead Carp, while hoop nets (46%), electrofishing (29%), and trap nets (15%) were the most effective for capturing hybrid carp (Figure 4).

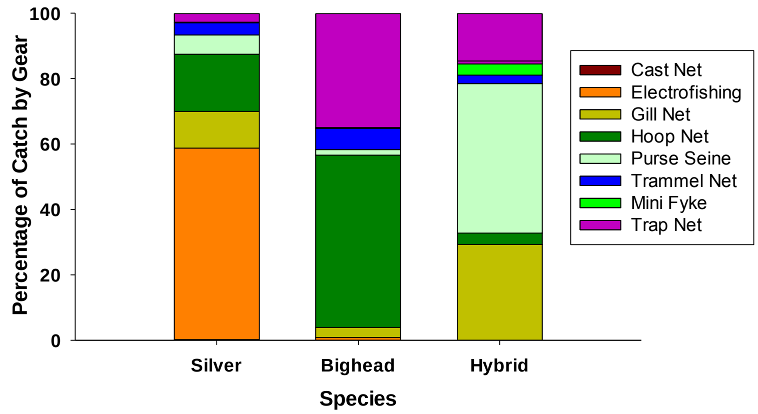

Figure 4.Percentage of total catch caught by each gear of Silver Carp, Bighead CCarp, and hybrid Asian carp in the Illinois River in 2011.

Discussion: All taxa of Asian carp were most abundant in the La Grange and Peoria pools; abundance decreased through the Starved Rock, Marseilles, and Dresden Island pools and no Asian carp were captured or observed in Brandon Road Pool or the CAWS. Overall catch of age-0 fish was low, as expected due to poor recruitment in the system since 2007. However, the virtual absence of age-0 and age-1 fish above Henry is notable, and supports other data suggesting that spawning may not occur in upper reaches of the Illinois River. There appeared to be variable capture effectiveness by different gears, with Silver Carp being most effectively sampled using electrofishing, while Bighead Carp were most effectively sampled using passive gears set overnight. Gears targeting juvenile Asian carp (beach seines, small mesh purse seines, midwater trawls, cast nets, and mini-fyke nets) were generally effective at capturing small fishes; however, few Asian carp were captured. This was likely due to the poor recruitment of Asian carp in 2011.

Recommendations: Further sampling is required to determine whether observed trends are consistent across years, and for sufficient sample size to determine relative gear efficiency. Given that few age-0 Asian carp were caught, sampling during high recruitment years will be required to determine sampling efficacy for this life stage across gears. Analysis of 2011 hydroacoustic data is underway and will be included in future reports. Video collected during electrofishing transects is also being analyzed as a potential alternative metric of Silver Carp density. Data analysis will include relative gear efficiency, occupancy modeling, and detection probability modeling.

Project Highlights:

- There was low abundance of Asian carp above Morris (Marseilles Pool), and none were captured in Brandon Road Pool or the CAWS.
- Few age-0 Asian carp were caught, including none upstream of Henry, Illinois (Peoria Pool).
- Highest catch rates of Silver Carp were with electrofishing gear, Bighead Carp with hoop nets and trap nets, and hybrid Asian carp with hoop nets and electrofishing.

- Recommend further sampling to determine whether observed trends are consistent across years, and for sufficient sample size to determine relative gear efficiency and conduct detection probability modeling.

Exploratory Gear Development Project

Wyatt Doyle, Heather Calkins and Tracy Hill;
US Fish and Wildlife Service – Columbia Fish and Wildlife Conservation Office

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

Introduction: Future action plans for controlling carp in the CAWS and CSSC include the ultimate use of rotenone. Due to the indiscriminate lethality to all species of fish, the use of rotenone is highly scrutinized by the public and is inordinately expensive compared to mechanical removal methods. Therefore it is imperative to develop methods and gear types which are more effective in capturing Asian carp, detecting population increases and reducing Asian carp densities where they threaten native fisheries. In addition, non-entanglement gears have an advantage in reducing bi-catch mortality in native fishes like Paddlefish who occupy similar habitats as Asian carp.

Current gears used for monitoring large juvenile and adult Asian carp include electrofishing and entanglement netting (gill and trammel nets). However, there are other fishing gears not commonly used in the Midwest that may have an application for these fish. Large mid-water trawls, oceanic purse seines, large diversion and mechanical trap nets, and ultra fine twine gill nets are all potentially effective alternatives to capture Asian carp in lieu of rotenone and should be explored further. Ultimately, gears would be developed that could be employed by commercial fishermen and would be manageable by a traditional sized boat and crew.

Asian carps seem to be more sensitive to entanglement gear than other fishes and have been known to jump over nylon, cotton and monofilament nets. New high-strength, low-diameter net twine materials are now available through select distributors and net manufacturers. These materials have been widely used in benthic trawls in our rivers and we anticipate adapting them to other traditional (gill and trammel nets) and exploratory gears (pound and purse seines) to increase catch rates and allow smaller crews to manage bigger gear.

In 2008, the Columbia FWCO contracted a net designer to develop a 125-foot trawl pulled between two large boats. The adult carp were corralled by the net but were too quick to be captured in the bag (though there may be some application for juveniles). The net was modified on location and tested as a small purse-seine. When this pseudo-purse seine was used behind dikes on the Missouri River it effectively herded dozens of carp in each haul while also capturing rarely seen juvenile Paddlefish. This field testing provided valuable feedback for net modification. Conceptually tested, the net designer has been working on a purse seine prototype that can be used by researchers and commercial fishermen to target Asian carp. The net contains a unique spook curtain feature that should allow it to be used over a wide range of depths and benthic conditions (snags) without becoming entangled. The net will have easily detachable zippered panels that will enable deployment in tight or wide spaces and will ultimately be designed out of high tensile strength Dyneema mesh to make it light and easily deployed. Conceptually, this custom riverine design should provide greater flexibility for net deployment.

In addition to working with net development, the Columbia Fish and Wildlife Conservation Office partnered with Jan Dean of the Natchitoches, LA National Fish Hatchery to investigate electrical waveforms and power setting for attraction and immobilization of small Asian carp with DC boat electrofishing gear. Results of this investigation are presented in Appendix E.

Objectives:

There are two major objectives for this study plan:

1) Develop gears to be used in place of rotenone to target Asian carp upstream of the Dispersal Barrier; and
2) Develop supplemental gears for the commercial fishery that will be more target-specific to Asian carp with less fish by-catch.

Results and Discussion:

Purse Seine – We purchased a purse seine from *Innovative Net Systems* which was custom designed for carp applications. Net trials were performed in a remnant flood scour hole formed by the Missouri River which held large numbers of adult carp. The nylon 4.5-inch mesh (stretch) floating net was built in three sections 75 meters (m) long x 4 m deep with metal rings attached at 0.5-m intervals along a weighted line. The purse seine was deployed and pursed from a single boat in approximately 7-10 m of water. Our sonar showed most fish were deeper than the net"s bottom, but some fish were present in the capture area and appeared to not be vulnerable to the size of mesh we used. Although some carp and other species were captured, we weren"t confident there were enough large fish available to test the nets efficacy.

It did not appear that fish evaded the net by jumping over the float line which may have been attributed to cooler temperatures. Observations from Mr. Faulkner, net designer/maker contracted to assist in the net"s deployment, were that the length of the net would need to be extended to the full 225 m to compensate for a relatively short (depth) net. Additionally, a "bunt" would need to be installed to give fish a place to escape rather than under or over the net. Behaviorally, we need to understand the reaction of the fish to a closing net in terms of how to retrieve the net (fast vs. slow) or supplement the net with items such as an additional top-purse or a bottom spook curtain. Future work will include the use of the DIDSON (Dual-frequency identification sonar) camera to understand the behavior and how best to modify the net. Through our limited use, we suspect the net will have limited application to areas where little to no current exists, water is moderately deep (4-6 m) and a high density of fish are present. Areas below locks and within the main channel of the Illinois River during the summer will be well suited for this gear when the river is at a low stage.

Paupier (Butterfly Net) – The paupier is an adaptation of a shrimp skimmer net commonly used in the Gulf of Mexico. We have used two prototypes to date with progressive success. The net is designed to fish from frames on the sides of the boat that are raised and lowered with 12-volt winches. The frame could be designed to fit any traditional large river plate boat for around $3,500. Initial trials revealed carp would readily go into the mouth of the gear, but not the bag unless an internal fyke existed. Other observations showed that mesh size is important to target specific size of fish since they would "charge" the mesh stretching it to its capacity. We captured dozens of smaller carp with the second prototype of this net and believe there is potential for this gear"s success for large harvest and monitoring of Asian carp and other native species.

The first prototype was built with polyethylene 133 mm stretch mesh with a mouth of 2.7 m wide x 2 m deep x 10 m long. The net was affixed to an aluminum square frame fitting the mouth dimension and supported by cables to the front of the boat (Figure 1). The gear was used on the Illinois River at above normal water flow during the month of December. A DIDSON cameral was deployed off a second boat to observe behavior inside the net. Trials revealed that carp would freely swim into the mouth of the net but would not enter the bag (Figure 2). Visual data shows carp would remain in the net swimming with the boat and would "bump" off the mesh when encountered. Despite encountering hundreds of appropriate sized carp, only a few were captured. During the same trial runs, Buffalo spp. and Freshwater Drum were readily captured illustrating the gears efficacy for some species as currently designed but not carp.

Figure 1. Paupier prototype I deployment in a Missouri River floodplain scour hole.

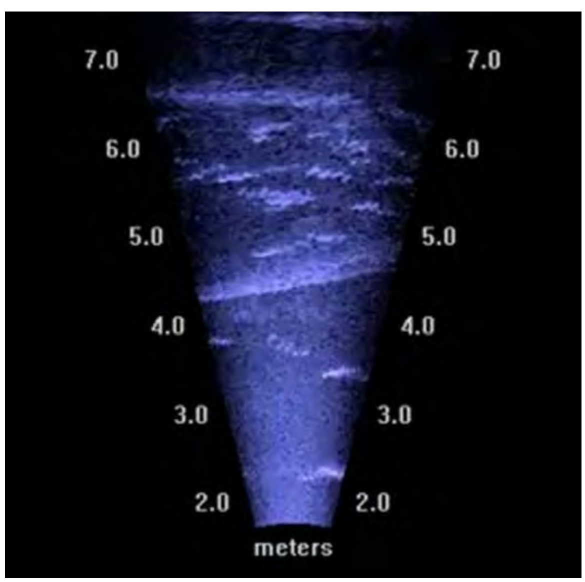

Figure 2. DIDSON image of fish in and around mouth of paupier prototype I during Illinois River trial.

The second prototype was built with 114 mm stretch polyethylene mesh fitted for a 4 m wide x 2.2 m deep frame without a bottom support. The absence of a bottom support allowed for no cables to be run in front of the net, thereby reducing noise at the mouth given off by vibrating cable. This net also included a horizontal fyke that closed to 12 inches within three meters of the net‟s mouth. This net was deployed within two midsize tributaries of the Missouri River during December. Although some larger fish were encountered, there were more smaller age-0 and age-1 carp available during the event. The net was highly effective at capturing dozens of Asian carp in the 12- to 18-inch size range along with bi-catch of gizzard shad and juvenile paddlefish in one 10 minute run (Figure 3). We suspect that with additional modifications, this net will find application in sampling early life stages of paddlefish and will be effective at targeting smaller Asian carp. Although we demonstrated that the net could be deployed without a bottom support, it put excessive torque on the frame. We are currently working with an engineer to develop better supported trussing and deployment mechanism for the frames.

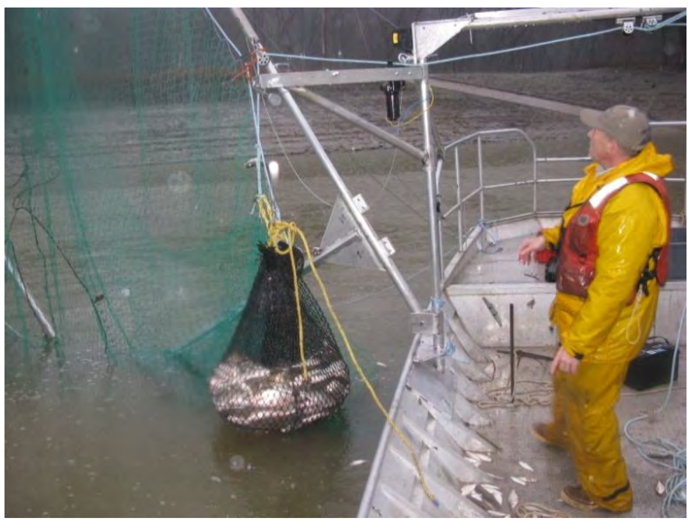

Figure 3. Paupier prototype II with load of 12- to 18-inch Asian carp, Gizzard Shad and juvenile Paddlefish from Perche Creek, Missouri.

Recommendations: We plan to continue modifying purse seine and paupier net designs to improve their usefulness for Asian carp monitoring and harvest. Behavior of fish responding to purse seining will be assessed with DIDSON imaging sonar to inform further modifications to the net and set/retrieval protocols. We anticipate a jumping response for fish targeted with the paupier in warmer waters that we did not observe during winter trials. We also see a need to sample in water shallower than 3 feet deep so a third prototype will be designed to skim the water surface and target backwater areas that are expansive within the Illinois River system.

Project Highlights:

- Purchased a 75-m long x 4-m deep purse seine modified for Asian carp sampling and deployed the seine in the Missouri River during December. Successfully caught some Asian carp, but few appeared to be present in the area sampled.

- Worked with a professional net designer to develop a modified shrimp trawl called a paupier (butterfly) net for Asian carp sampling. Ran several trials with the net and caught dozens of 12- to 18-inch Asian carp and by-catch of Gizzard Shad and juvenile Paddlefish.
- Completed laboratory and field experiments that identified the most effective electrical waveforms and power settings for attraction and immobilization of small Asian carp with DC boat electrofishing gear.
- Recommend further modifications to purse seine and paupier net design to increase Asian carp catch rates for monitoring and harvest purposes.

Unconventional Gear Development Project

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Participating Agencies: Illinois Department of Natural Resources and Illinois Natural History Survey (co-leads); Great Lakes Fisheries Commission, The Nature Conservancy, US Fish and Wildlife Service – Carterville Fish and Wildlife Conservation Office, and US Geological Survey – Columbia Environmental Research Center and Northern Rocky Mountain Sciences Center (project support).

Introduction: A working group of fishery biologist/scientist was assembled beginning in June of 2011, meeting throughout the calendar year, to discuss development of successful control or eradication tools for Asian carp based on existing experience and science. Traditional fisheries gears such as electrofishing, trammel and gill netting, fyke nets, hoop nets, mini fyke nets, and purse seines are currently being used and evaluated (MRRWG 2011). Because of the growing knowledge of Asian carp populations, it is recognized that a gear to find these fish where abundances are quite low, but in unique habitats was desired. Therefore, discussions identified gears used elsewhere in the world and in differing ecosystems (e.g., extremely large seines with army‟s of people used in China, larger hoop nets than currently used from the southern Mississippi River, and large pound or trap nets such as in the Great Lakes fishery). To further identify gears and strategies, a small group of commercial fishers with various experience and geographical backgrounds were recruited. With the following goals in mind, we developed a work plan to identify 2-3 gears/techniques that may increase our ability to detect and/or remove Asian carps from ecosystems such as the CAWS and upper Illinois Waterway.

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

1) Convene a panel of experts to discuss nontraditional gear development and available attractants or repellents;
2) Develop alternate traps and net designs and combinations of gears and attractants/repellents to enhance Asian carp capture rates; and
3) Evaluate gear and combination system prototypes in areas with low to moderate Asian carp population densities.

Results and Discussion: The working group of fishery scientists was formed from the participating agencies. Discussions of challenges in the CAWS and needs were assessed to further the direction of gear development needs. Two gears were selected by the fishery scientists to move forward, relatively quickly because of the perceived benefits, they are:

- Deepwater Experimental Gill Nets - Nets will be 30-foot deep x 100 yards long and made with high strength braided line with panels of various mesh sizes tied down from side-to-side to create loose panels of net from top to bottom (rather than more typical top-to-bottom tied down nets). Designed to sample the entire water column in the CAWS. (Monofilament nets were ultimately decided upon because of material supply issues).

- Large Mesh Hoop Nets - Made with 6-foot diameter hoops. Designed to sample for bighead carp in mid or side channel habitat with flow.

The working group agreed upon bringing together 3 commercial fishers based upon recommendations of group/peers to further elucidate the issues. The advising commercial fishers had the following backgrounds:

- One designs and builds his own boats and gear and fishes commercially in Lake Michigan. This fisher contracted with state and federal agencies on fisheries research and invasive species removal projects. He is currently working on a project to remove unwanted Lake Trout from large lakes/reservoirs in the western U.S.
- One specializes in commercial harvest of Common Carp, Sucker spp., and White Bass with large commercial seines. He has contracted with state and federal agencies in the past for both fisheries research and removal efforts.
- One is a retired marine commercial fisher that has fished for just about everything marketable in the sea off New England. Two of his specialties include purse seining and trawling. He has consulted on trawl development projects for harvest of freshwater fish species in the past.

These commercial fishers and scientific experts met in Chicago, Oct 2011, for a tour of the CAWS. Upon completion of CAWS tour, each fisher shared their thoughts on how to best sample the waterway. Initial discussion covered the purpose of the gear development project, which is to capture Asian carp in deep draft channels, like the CAWS, when population abundance is low. All of the fishers recognized the difficulty of sampling in the CAWS, but thought modified gears might do the trick. Four gears were discussed and considered:

- Large commercial bag seines
- Large pound and trap nets
- A two-boat mid-water trawl
- Large purse seines

Follow-up meetings of the working group recognized each of these gears may have benefits. Large pound nets were identified as having unique capabilities and brought forward for further development. Sample design and strategy for the pound nets is underway with field sampling expected for the 2012 field season. Six-foot diameter hoop nets and deepwater gill nets will be evaluated along a standardized regime for assessing other gears (see Evaluation of Gear Effectiveness Project report above) beginning in spring 2012.

Recommendations: With selection of novel gears completed, we recommend assessing the effectiveness of these gears for capturing Asian carp in the CAWS and downstream areas of the Illinois Waterway. Assessments will include comparisons across varying densities of Asian carp and among a variety of sampling gears. Because we are in the evaluation stage of this gear development project, going forward we recommend incorporating future evaluation plans in the on-going Evaluation of Gear Effectiveness Project co-lead by the Illinois Natural History Survey and the Illinois Department of Natural Resources. As has been done in the past, all efforts will be coordinated with US Fish and Wildlife Service – Columbia Fish and Wildlife Conservation Office to prevent duplication of efforts in new gear development and assessment. Future work on unconventional gear development will include efforts by IDNR to encourage local bow fishing clubs to schedule a night-time carp tournament targeting Lake Calumet, the Little Calumet River, and the Calumet-Sag Channel. We further recommend a pilot study to assess corn or soybean meal as a surface attractant for Asian carp to aid in detection and removal efforts in areas where Asian carp abundance is low.

Project Highlights:

- Convened a committee of scientific experts to identify potential new gears to capture Asian carp where population densities are low and aquatic habitats are unique, such as the deep-draft channels of the CAWS.
- Brought in three professional commercial fishers for a tour of the CAWS and discussions of new and modified sampling gears for Asian carp monitoring and removal.
- Moving forward with purchase and evaluation of three gears: 6-foot diameter hoop nets, 30-foot deep tied down gill nets, and Lake Michigan style pound (trap) nets.
- Recommend testing effectiveness of these modified gears during 2012 in areas of the waterway with varying abundances of Asian carp and in combination with other sampling gears. In addition, efforts will be made by IDNR to encourage local bow fishing clubs to schedule a night-time carp tournament targeting Lake Calumet, the Little Calumet River, and the Calumet-Sag Channel. Further recommend a pilot study to assess corn or soybean meal as a surface attractant for Asian carp to aid in detection and removal efforts in areas where carp abundance is low.

Fish Population Estimation Project

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

Introduction: Population estimates within LaGrange Reach, Illinois River suggest over 4,100 silver carp were present in 2008. This reach-wide estimate took considerable time and effort; however, smaller focused studies in the CAWS will be more manageable and useful to evaluate our ability to assess CAWS fish population abundance in specific gears and areas of the CAWS. Understanding the effectiveness of various techniques used for sampling and removal of Asian carp requires estimation of population abundance in a given area. In evaluating rare species, it is likely that quick or accurate numerical or biomass standing stock estimates will be very difficult or impossible to determine. Therefore, as a pilot study, we used standard mark-recapture techniques to estimate standing stocks of relatively abundant surrogate species in one CAWS location - Lake Calumet. Surrogate species targeted for marking included various sizes of Common Carp, Buffalo spp., and Gizzard Shad, as well as other species that were similar in size and thought to occur in habitats similar to those typically used by Bighead or Silver Carp.

Objectives:

1) Determine the feasibility of using standard mark-recapture techniques (e.g., Petersen or Schnabel methods) to estimate abundance of targeted surrogate species of various sizes; and, if successful
2) Provide population data for use in evaluation of gear efficiencies and detection probability modeling.

Materials and Methods: To estimate the abundance of a surrogate fish species (i.e., Quillback and Common Carp), a Peterson mark-recapture study was conducted within the north end of Lake Calumet after it was physically separated from the rest of the lake by block nets during the August 2011 rapid response event (see Rapid Response Actions report above). All sizes of Quillback and Common Carp that were captured in the commercial seining effort on August 2 were marked by clipping the upper corner of the caudal fin, after which they were released back into Lake Calumet. The total number of fish marked was tallied. Other fish species captured during the commercial seine haul were tallied and returned to Lake Calumet. If a marked fish was captured later in the day (2 August 2011) by another gear it was immediately released. A variety of gears (i.e., commercial seine, gill nets, trammel nets, tandem fyke nets and DC boat electrofishing) were used to determine the number of marked and unmarked individuals on 3-4 August 2011. Any recaptured individual received an additional fin clip (left pelvic fin ray) to ensure that it was not counted twice.

Results and Discussion: On the first day of sampling, a total of 99 fish representing 11 species were captured in one 800-yard commercial seine haul. From these fish, 10 Common Carp and three Quillback were marked and released back into Lake Calumet. In the following days, over 8,000 fish, including 1,208 common carp and 27 quillback were sampled by trammel nets, gill nets, tandem fyke nets, commercial seine and DC boat electrofishing. Of these fish, only one marked Common Carp was recaptured. Low catches of target species in the marking sample and low numbers of recaptured marked fish precluded the calculation of population estimates in Lake Calumet.

Recommendations: Achieving project objectives during 2011 was not possible due to difficulties marking sufficient numbers of targeted non-Asian carp fish species. In lieu of estimating population abundance for surrogate species, we recommend determining population estimates for Bighead and Silver Carp populations in selected areas of Starved Rock, Marseilles, and Dresden Island pools. Data obtained from Bighead and Silver Carp populations rather than surrogate species will better inform gear efficiency evaluations and detection probability models directed at Asian carp. Population estimates from conventional sampling gears and hydroacoustics surveys currently are planned for summer 2012 as part of ongoing and new research by Southern Illinois University Carbondale and Illinois Department of Natural Resources evaluating the response of Asian carp populations to commercial fishing harvest and contracted commercial fishing removal (see Monitoring Asian Carp Population Metrics and Control Efforts plan in MRRWG 2012).

Project Highlights:

- Attempted a mark-and-recapture population estimate for non-Asian carp species during the 2011 Lake Calumet Rapid Response.
- Small sample sizes for the marked population and recaptured mark sample precluded the calculation of meaningful population estimates.
- Recommend shifting population estimates from surrogate species to Bighead and Silver Carp populations in areas of the upper Illinois Waterway sampled during gear effectiveness evaluations and barrier defense removal. These estimates are being planned for 2012 as part of a new project assessing effects of removal efforts on Asian carp populations and native fish communities.

Progress Report on Seismic Testing of the Water Gun in the Chicago Area Waterway System

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Participating Agencies: US Geological Survey – Illinois Water Science Center and Northern Rocky Mountain Sciences Center (co-leads); Northern Illinois University (project support).

Introduction

There is an immediate need to develop and implement control strategies to prevent Asian carp from entering the Great Lakes Ecosystem from the Mississippi River. Seismic technology may provide one possible solution by emitting high pressure underwater sound waves as a physical deterrent. These sound waves are produced by a pneumatic water gun that compresses water with a piston through a cylinder, inducing cavitations in the water behind the compressed burst; as these cavities collapse, a pulsed sound pressure wave is generated. The sound wave may deter fishes or kill them if they are in close enough proximity to the wave source. The water gun may be operated as either a stationary or mobilized barrier as a means to deter invasive fishes. Prior to deployment of the water gun, potential impacts on structures needed to be evaluated. Two locations within the Chicago Area Waterway System are in various stages of that evaluation, a location on the Chicago Sanitary and Ship Canal (CSSC) near Lemont, and an area outside of the O‟Brien Lock and Dam on the Southside of Chicago.

Chicago Sanitary and Ship Canal Testing

Seismic testing of the water gun was conducted on the CSSC near Lemont the week of 26 September 2011. The two largest water guns, the 343 cubic inch (ci) and the 120 ci, were fired in the canal at varying distances from the canal wall to determine what seismic energy was transmitted in the canal, at the canal wall, and within the Earth at varying distances from the canal, both on the land surface and within boreholes away from the canal wall.

Seismic data collection consisted of several components. Three hydrophones were deployed in the water at 4‟, 12‟ and 20‟ depths below the water level in the approximately 25‟ deep canal. The hydrophones were located approximately 3 feet away from the canal wall. A PVC tube was affixed to the canal wall with a 3-component geophone installed at approximately 3 feet below water level. This 3-component geophone would collect seismic energy at the canal/water boundary. Three 3-component geophones were also installed at 5, 35, and 100 feet distances from the canal wall on land surface. The 3-component geophones were also installed at the approximate elevation of the watergun in the canal (approximately 12.5 feet of water) in boreholes to collect seismic energy propagating through the carbonate bedrock and set block.

The water gun operation consisted of activating the two largest waterguns (343 ci and 120 ci) at varying distances away from the canal wall. The water guns were set at approximately 12.5 feet depth below the water in the canal, which is approximately half the depth of the canal water column at that location. The water guns were fired at the standard maximum pressure used; 2000 psi; and at distances from 30 to 90 feet away from the canal wall at 10 foot intervals. In previous studies, the 30 feet had been documented as a "safe" distance for not destroying equipment. The canal width at the testing site was approximately 167 feet, so data was collected until greater than half the distance from the wall or 90 feet. The water gun shots at 2,000 psi were repeated 10 times at each 10-foot distance increment to account for variability. The water level in the canal did not differ dramatically throughout the testing.

Data were collected on 24 channels from the hydrophones and geophones for each shot. Data for the 343 ci water gun were collected at 30, 40, 50, 60, 70, 80, and 90 feet from the canal wall (10 shots per set distance). Data for the 120 ci water gun was collected at 30 feet (10 shots). An underwater video camera shot was taken before and after of the wall near the PVC pipe installed for the canal wall seismic monitoring. Ancillary data was also collected with the NIU‟s non-3-component geophones for a few shots.

This data collection with the water guns is being compared to the seismic signals from various background signals within the CSSC area, such as barge and railroad traffic, industrial process noise, etc. Background testing from barge traffic was collected from several barges during testing with the identical geophone and hydrophone setup. Seismic data was collected at the coal power plant immediately downstream of the electric fish barrier. Surface 3-component surface geophones were installed extending laterally away from the crane loading coal onto barges and adjacent to the canal. Data was collected during barge loading. The Hanson Materials site was very accommodating, but a suitable location to install geophones was not found. It was decided that operations were very similar to the coal plant operations and to use the coal plant data. Seismic data of freight train noise was collected at a location near the electric fish barrier. A grid of 3-component surface geophones was laid on U.S. Army Corps of Engineers (USACE) property at the upstream end of the electric fish barrier site to assess two-dimensional variations in the background noise. Data was collected on several freight trains passing through.

Preliminary Interpretation:
Staffs from the NIU and the USGS are processing the data at present. The data can be looked at in terms of millivolts energy equivalents at present. In the future, these millivolt readings will be converted into ground motion (e.g. inches/second) or pressure (pounds per square inch). Key findings are:

1. The 343 ci gun at 30 feet produced consistent readings in the range of approximately 90 millivolts at the 3-component geophones located at 5 feet from the canal wall on land and in the borehole. Barge noise on the same geophones was approximately 1 millivolt with the largest readings approximately 5 millivolts. Data collection of railroad energy had 3-component surface geophone data in the range of approximately 1 millivolt with the largest reading approaching 3 millivolts. Coal plant noise was more erratic. During the length of testing, energy generally ranged around 1 millivolt, but there were several (5 of 14 data files collected) instances where 4 and greater millivolts being recorded with 2 files having maximum values of 12 and 31 millivolts.

2. Barge traffic (12 barges) and the 343 ci water gun data can be compared using the hydrophone data. The hydrophone data from the watergun varied from 113-122 millivolts. Barge data varied from 0.1 to 14 millivolts, with a median of 0.3 millivolts. One reading was over 10 (13.5 mv).
3. Barge traffic (12 barges) and the 343 ci water gun data can be compared using the 3-component geophone mounted on the canal wall data. The geophone data from the watergun varied from 103-108 millivolts. Barge data varied from <1 to 126 millivolts, with a median of 1.4 millivolts. Three of the twelve barge recordings have data over 10 (89, 118, and 126 mv). One was noted to be during a time when the barge stopped near the testing area and backed up, possibly causing cavitation.
4. In general, seismic energy from the water gun is generally approximately an order of magnitude or greater than background energy for land and in water data. The largest coal plant data was approximately one third of the water gun energy. Occasional larger barge readings at the 3-component geophone on the wall may be due to the mechanical affixing of the pvc pipe to the wall. There were no corresponding increases in energy in the hydrophones or land/borehole geophones during these events, except for an increase in hydrophone energy in one data set.
5. Video file was not of the highest quality, but no visible scalloping or removal of rock was noted. Green vegetative growth on wall did not appear to be disturbed either.
6. The USACE also installed an approximately 1.5-inch cable attached with ziplocks to a tree to mimic equipment at their installation. Verbal review by the USACE during testing stated there was nothing observed that would affect the placement or security of the cable installation.

Upon completion of testing in the canal, the USACE allowed the use of the water gun for fish clearing operations in support of electric barrier maintenance. Water guns were used to clear fish during an October 2011 fish suppression action at the barrier site near Romeoville, Illinois. The water gun field trial at the barrier appeared to clear the one fish greater than12 inches (minimum target length evaluated) from the 220-foot distance of canal between Barrier 2A and 2B, as evaluated using remote sensing sonar equipment and techniques by staff of the U.S. Fish and Wildlife Service and the Southern Illinois University Carbondale. Results of the October action are included in the Barrier Maintenance Fish Suppression report above and in Appendix B.

Recommendations: We recommend the continued use of water guns to clear fish from between barriers in support of barrier maintenance operations and additional testing of this technique as a deterrent and control strategy for invasive species management. Additional seismic testing of water guns effects on navigation locks and equipment is tentatively scheduled to take place at O'Brien Lock and Dam in late spring to early summer 2012. A similar methodology will be used at the O'Brien location as was used at the CSSC near Lemont location. To date, permissions have been obtained, and boreholes have been drilled for the testing. Additional testing of the effects of water guns on Asian carp behavior is scheduled to occur in a downstream location near Morris, Illinois later this spring/summer.

Project Highlights:

- Seismic testing of water guns occurred in the CSSC during fall 2011 and preliminary analyses indicated that, in general, seismic energy from the water gun was approximately an order of magnitude or greater than background energy for land and in water data. The largest coal plant data was approximately one third of the water gun energy.

- Video surveillance identified no visible scalloping or removal of rock from the canal wall or any visible disturbance to green vegetative growth on the wall.
- Water guns were used to successfully clear fish from between barriers (no fish >12 inches present) in support of USACE barrier maintenance operations during October 2011.
- Recommend additional seismic testing of the effects of water guns on navigation locks and equipment in the CAWS and on behavior of Asian carp in a downstream location of the Illinois River near Morris, Illinois.

Surveillance of Bait, Sport, and Food Fish Trade in Illinois

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

Introduction: Juvenile Asian carp have been included in the live bait trade in the past, and are similar in appearance to species used as bait (e.g., Gizzard Shad and Threadfin Shad), which may be inadvertently transported along with more typical bait fish species (i.e. Fathead Minnows, Golden Shiners, and White Suckers). Given that sources of many bait stocks are from regions of the United States where Bighead and Silver Carp have established populations, the possibility exists that fisherman are unintentionally distributing Asian carp throughout the Great Lakes region through contaminated bait stocks. One potential source for Asian carp presence in the CAWS is through unintentional release of Asian carp in contaminated bait stocks when fisherman discard unused bait into rivers and streams. Other anthropogenic distribution pathways also exist, including the unintentional transport and stocking of Asian carp with introduced sport species and/or the deliberate transport of carp to live fish markets and retail food establishments.

Screening of fish tanks at wholesale and retail bait supply facilities and increased enforcement activities related to fish hauling and stocking are direct approaches to evaluating alternative introduction pathways. In addition to continuing surveillance efforts at bait shops, Illinois Department of Natural Resources staff and Conservation Police Officers (CPOs) plan to perform education and enforcement activities at sport fish production/distribution facilities, fish processors, and fish markets/food establishments known to have a preference for live fish for release or food preparation.

Objectives: To create a more robust and effective enforcement component of IDNR‟s invasive species program, we propose to:

1) Continue visual and eDNA surveillance of fish tanks at wholesale and retail bait suppliers in the Chicago metro region;
2) Increase surveillance of fish haulers stocking local water bodies, area fish production facilities, and live fish markets and food establishments;
3) Perform administrative import and export audits and inspections to ensure compliance with the federal Lacey Act and Illinois Injurious Species Rule; and
4) Increase checks on commercial fishers and other personnel working on GLRI funded programs.

Results and Discussion: In 2010, 57 wholesale and retail establishments that sold live minnows were identified in Cook, Lake, McHenry, Kane, DuPage, Kendall, Kankakee, Will, and Grundy counties. The list included all known bait shops in the Chicago metro area. IDNR staff and CPOs inspected shops operating over winter (N = 43 shops; February/March) and again during summer (N = 52 shops; August/September; staff only). No Asian carp were identified in visual inspections of minnow tanks made during both seasons. Additionally, 2-L water samples taken from minnow tanks during August (*N* = 139 samples) for eDNA screening produced no positive detections for Bighead or Silver Carp DNA. A questionnaire completed by bait shop owners/operators indicated all minnows were purchased from one of three regional minnow distributors and no live wild-caught bait was collected or sold. Asian carp education and outreach literature was disseminated to bait shop personnel to increase awareness and reduce chances of future contamination. A final report by University of Notre Dame that details methods and results from summer bait shop surveys, eDNA monitoring at Chicago area bait shops, and calibration of eDNA with bait species (Jerde et al. 2012) is reprinted in Appendix C.

Other work to meet surveillance project objectives is currently under way. Administrative audits of import, export, and transport permits have been undertaken by program staff and potential violators have been targeted for field inspections by CPOs. Planning for visual inspections of live fish sales and brokers in northeastern Illinois (Chicago/Chinatown) is nearly complete. Inspections are planned for spring/summer 2012. Administrative rules associated with Asian carp import, transport, harvest, and use in Illinois have been reviewed and proposed changes to Illinois Administrative Rules (a 2-year process) are being discussed.

Although not identified as a specific objective in this project, IDNR investigated the alternative distribution pathway of unintentional transport and stocking of Asian carp with introduced sport species. Four Urban Fishing Program ponds in the Chicago area were sampled with DC electrofishing gear and trammel nets to monitor for the presence of Asian carp. No Asian carp were captured or observed in two ponds (Cermak Quarry and Gompers Park Lagoon), whereas 20 large Bighead Carp weighing between 48 and 80 pounds were removed from two others, Flatfoot Lake (*N* = 17) and Schiller Pond (*N* = 3). Otolith microchemistry analysis and a subsequent review of IDNR Urban Fishing Program stocking records and reports of Asian carp in urban fishing ponds throughout the State revealed that the Bighead Carp probably were transported to the area as contaminants in shipments of catchable-sized Channel Catfish from out-of-state dealers during the late 1990s and early 2000s. The problem does not appear to be on-going today. A report by IDNR detailing results of urban pond investigations (IDNR 2011) is available on the asiancarp.us website and reprinted here in Appendix D.

Recommendations: We recommend continued surveillance of the bait trade in the Chicago metropolitan area by focusing enforcement activities on wholesale bait dealers. Conducting regular inspections of the three area bait wholesalers should be more economical and efficient than monitoring individual bait stores. Increased surveillance of fish haulers stocking local water bodies, area fish production facilities, and especially live fish markets and food establishments also are recommended to obtain information on the risk of these alternative distribution pathways and prevent illegal importation of live Asian carp. In addition, we will prepare a new project plan for the 2012 MRRP that develops monitoring schedules and protocols for urban fishing lakes in the Chicago region.

Project Highlights:

- Completed visual inspections of bait shops in nine Chicago-area counties in Illinois during winter (*N* = 44) and summer (*N* = 52) and found no Asian carp contaminants in the bait trade.

- Obtained 136 water samples from bait tanks during summer 2010 bait shop visits and found no Bighead or Silver Carp DNA in any samples.
- Determined Chicago area bait shops obtain minnows from one of three area wholesalers and do not harvest bait from the wild.
- Recommend developing and implementing a visual and eDNA inspection program for minnow wholesalers rather than periodic surveys of individual bait shops to monitor Asian carp contamination in the bait trade. Also, recommend additional eDNA and conventional gear monitoring at urban fishing ponds and increased surveillance of fish haulers stocking local water bodies, area fish production facilities, and Chicago area live fish markets and food establishments to reduce unintentional introductions of Asian carp in waters of or connected to Lake Michigan.

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Appendix A. Participants of the Monitoring and Rapid Response Workgroup, Including Their Roles and Affiliations.

Co Chairs
John Rogner, Assistant Director, Illinois Department of Natural Resources
John Dettmers, Senior Fishery Biologist, Great Lakes Fishery Commission

Agency Representatives
Vic Santucci, IDNR
Kevin Irons, IDNR
Kelly Baerwaldt, USACE
Sam Finney, USFWS

Independent Technical Experts
Scudder Mackey, Habitat Solutions NA/University of Windsor
Irwin Polls, Ecological Monitoring and Associates
Phil Moy, Wisconsin Sea Grant
Duane Chapman, US Geological Survey
John Epifanio, University of Illinois

Agency Participants
Matt Shanks, USACE
Felicia Kirksey, USACE
Shawna Herleth-King, USACE
Chuck Shea, USACE
Mark Cornish, USACE
Doug Keller, Indiana DNR
Matt O'Hara, IDNR
Jim Mick, IDNR
Steve Pescitelli, IDNR
Rob Maher, IDNR
Dan Sallee, IDNR
Steve Shults, IDNR
Rob Sulski, ILEPA
Rob Simmonds, USFWS
Tracy Hill, USFWS
Pam Thiel, USFWS
Mike Hoff, USFWS
Aaron Woldt, USFWS
Jeff Stewart, USFWS
Janet Pellegrini, USEPA

Appendix B. October 2011 Barrier Maintenance Fish Suppression Final Report (IDNR 2012).

BARRIER DEFENSE & FISH SUPRESSION
October 23-25, 2011
Final Report

Table of Contents

Overview

The U.S. Army Corps of Engineers (USACE) operates three electric aquatic invasive species barriers (Barrier 1, 2A and 2B) in the Chicago Sanitary and Ship Canal at approximate river mile 296.1 near Romeoville, Illinois. Barrier 1 (formerly the Demonstration Barrier) is located farthest upstream (about 800 feet above Barrier 2B) and is operated at a setting that has been shown to repel adult fish. Barrier IIA is located 220 feet downstream of Barrier 2B and both of these barriers operate at parameters that have been shown to repel fish as small as 5.4 inches long. Barrier 2A and 2B must be shut down for maintenance approximately every 6 months and the Illinois Department of Natural Resources (IDNR) has agreed to support maintenance operations by providing fish suppression at the barrier site. Fish suppression can vary widely in scope and may include application of pesticide (rotenone) to keep fish from moving upstream past the barriers when they are down. This was the scenario for a December 2009 rotenone operation completed in support of Barrier 2A maintenance and 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.

At the time, Barrier 2B was operating at parameters that have been shown to repel most sizes of fish (2.0 volts per inch at the water surface) and Barrier 2A was in warm standby mode. Because the threat of Asian carp invasion is from downstream waters, there is a need to clear fish from the 220 foot length of canal between Barrier 2A and 2B before Barrier 2A is fully energized and Barrier 2B is shut down for maintenance. The USACE increased parameters of Barrier 2A and 2B to levels (2.3 volts per inch) that will repel even very small fish in December 2011.

An operation was initiated from October 24-26, 2011 to clear fish. The Operation included physical fish driving techniques and, if necessary, a small-scale rotenone action. Physical driving techniques took place during the mornings of 24-25 October and incorporated water level drawdown to increase current velocity at the barriers combined with watergun technology to drive fish from the target area. Then surveys were conducted with split beam hydroacoustics, side scan sonar, and DIDSON to evaluate the success of physical fish clearing actions. If these physical techniques proved ineffective at clearing fish then a small-scale rotenone was planned for October 26, 2011. However this proved not to be necessary.

Executive Summary of Actions

- IDNR was asked to clear fish from between Barrier 2A and 2B in support of barrier maintenance scheduled by the USACE.
- Initially, planned as an event weeks prior to needed maintenance activities, USCG requirements for closure (and 30 day notice) anytime both barriers are operating precluded fish suppression operations prior to October 24. Thus, water cannon and assessment as well

as rotenone application plans were put into place for implementation Oct 23-25 as outlined in Incident Action Plans (IAP's) (Appendix A).

- IAP's were developed for Barrier Maintenance and Fish Suppression Activities by the Illinois Department of Natural Resources – Incident Management Team (IMT) over a course of months prior to event. IMT training and support was provided by Great Lakes Restoration Initiative funding of Asian carp work to provide guidance in multi-jurisdictional responses such as these. USCG had a separate incident management plan to provide for the Safety Zone navigation closure and safe operation of our action within the Chicago Sanitary and Ship Canal (CSSC). We communicated with the USCG daily throughout the operation.
- Check-in of staff and briefing of operation occurred Sunday October 23.
- Closures of the CSSC were granted by the USCG and were in place for Monday's and Tuesday's event from 0730 to 1030 daily.
- Increased flows were requested from MWRD dispatchers for the Monday morning fish suppression, with flows reaching around 11,000 cfs (mean channel velocity =2.0-2.5 ft/sec) at the electric barrier. It was thought that increased flow would prevent fish from loitering below/over the barriers and further help in flight from water guns.
- Water guns were deployed by USGS and fired for approximately 30 minutes above and over the barriers, at which time barrier 2A was turned on.
- SIUC ran transects with side-scanning sonar and hydroacoustics covering 98% of the water column between barriers 2A and 2B. USFWS followed with DIDSON camera surveys of CSSC walls and focused on areas as communication with SIUC suggested.
- At 1050, we were advised that a possible fish signature existed between the operating barriers, and increased flows produced bubbles that further confused the assessment over a significant portion of the area between the barriers. We deemed this fish suppression trial unsuccessful, and asked for 2A to be taken back down.
- Following review, and further briefing Monday PM, fish suppression continued Tuesday AM during the CSSC closure from 0730-1030.
- Flows were quite low (1610 cfs, 0.27 ft/sec) at the start of Day 2 operations. With obstructive bubbles on previous day, we aimed at reducing this interference and requested maintenance of low flow conditions from MWRD.
- Also different from day 1 and plans in IAP, we turned on barrier 2A and we ran remote sensing just after closure (0730) but before gun deployment to help determine source of bubbles (water gun, flows, sediments, etc. and to identify fish in the vicinity of the barrier. We did not lower 2A after this survey. We also asked MWRD to reduce flow, to allow for contrast of prior day.

- At completion of the survey the water guns were deployed by USGS for approximately 30 minutes. Flows at the time were low (1610 cfs; 0.27 ft/sec) but slowed upon conclusion of runs. We allowed 20 minutes for any fish to clear zone that may have been stunned in this reduced flow, and then sent SIUC survey boat in.
- Results of initial scan on Tuesday (prior to water guns) suggested one fish target >12 inches.
- Second remote sensing/transects was performed by SIUC beginning at 0852, with USFWS DIDSON surveys following. The flows were extremely low at this time (500 cfs; 0.15 ft/sec).
- Flows were allowed to return to a more normal level near 2,000 cfs.
- A third and final scan of the area and data analysis was completed at (1015). Noted was that bubbles were not present and very good pictures of the zone were provided, presumably due to the low flow conditions.
- John Rogner with consult of USFWS Charlie Wooley and others advised that no fish targets were seen on either of the surveys after water gun deployment on Oct 25 at 1024, and approved the turning off of barrier 2B for maintenance, allowing 2A to serve as the primary barrier until the USACE completes maintenance and testing.
- IDNR asks that 2B be turned off.
- After this decision, we were able to call off any further operations and scheduled closures for fish suppression, cancel crew travel to the area for rotenone application, and begin demobilizing staff and equipment from the area. Demobilization of all was completed by noon on Tuesday.
- All staff was able to make it home safely on Tuesday, whereas tents, port-a-potties, dumpsters, etc. were picked up by week's end.
- Permanganate that was delivered to site the week prior to operations was shipped to a secure storage facility offered by the USFWS in Savanna, IL on November 2.
- There were no injuries or accidents reported during this operation.

Situation Unit Report for October 24, 2011

Subject: **SITREP #1**
Barrier Defense
Romeoville, IL

From: Sam Finney, Situation Unit Leader
To: Kevin Irons, Incident Commander
Date: October 24, 2011
Reporting Period: 1900 hrs 10/23/11 to 1400 hrs 10/23/11

1. Introduction

1.1. Background

1.1.1 Incident Category

Exotic Species Control

1.1.1 Site Description

The electric aquatic nuisance barrier is a man-made designed to prevent the transfer of Aquatic Nuisance Species to Lake Michigan.

1.1.2.1 Location

Chicago Sanitary and Shipping Canal, Mile Marker 295.7 to 297

1.1.2.2 Description of Threat

Invasion of Great Lakes ecosystem by Asian Carp via Illinois River waterway

2. Current Activities

2.1. Operations Section

The day began with breakfast and operations briefing at 0500. The metropolitan Water Reclamation District (MWRD) was contacted at 0600 and began the drawdown of Lockport Pool as crews gathered on the water. Flow increases were noticed within a half an hour. At 0746 water was "shut off" by MWRD. The US Coast Guard made radio announcement of the closed Restricted Navigation Area at 0748. At 0755 the air cannon boats began firing in the areas between the barriers. Gizzard shad and other small fish were noted on the water's surface and increased gull activity was reported. At 0814 flows of 9700 CFS with a velocity of 1.8 feet/second were announced by the USGS. At 0826 both cannon boats had been firing for approximately 30 minutes and water velocity was visibly slower. The canon boats exited the area between the barriers at 0829 and at 0830 both the request for barrier IIA was made and it began operations along with barrier IIB. The Southern Illinois University (SIU) vessel *Shovelnose* immediately entered the area between the barriers and began sonar (hydroacoustic and split beam) transects of the area between the barriers. At 0841 5760 CFS was reported by USGS. At 0851 SIU sonar surveys were completed and DIDSON surveys began immediately to search areas not covered by the *Shovelnose*, mainly areas near the canal walls. SIU post processing of sonar data was also began at this time. DIDSON surveys concluded at 0936.

Post processing of SIU sonar data identified two fish like targets in the split beam data. More targets may have been nearby those identified (West canal wall on the outside bend) but there was a larger amount of interference with the equipment than that viewed during test runs and the interference was thought to be coming from air bubbles or flocculant material from the canal bottom that had been dislodged by the increasing flows. Additionally, 10 large fish-like targets from the hydroacoustics were identified below barrier IIB on the east side of the canal. DIDSON data analysis indicated no large fish like targets were observed in the areas scanned by that tool during their survey. The DIDSON crew was sent to the GPS coordinates of the 10 fish like targets identified with the hydroacoustics to attempt to confirm or deny them as fish. DIDSON data showed that the targets were stationary objects, most likely rock substrate.

Charlie Wooley and John Rogner discussed the situation via telephone. Due to the 2 fish like targets identified with split beam, and the interference (i.e. inability to scan the entire channel for fish) of sonar scanning techniques by bubbles/flocculant material, the decision was made to turn back down IIA and not make the barrier switch at that time.

Operational time period 2 on Tuesday October 25 will deploy the water guns in the same way, but not induce increased flows. It is hopeful that this will give us a better assessment of the success of the techniques used today.

If Tuesday operations are not successful, a small rotenone operation scheduled for Wednesday will clear the area of any fish, and allow IIB to be taken down for maintenance.

2.2. Planning Section

Development of IAP does continue on a daily basis. The plan for the next operational period has been approved. No other activity for this time period.

2.3. Logistics Section

Logistics is balancing resources to minimize costs. Everything is running smoothly.

2.4. Finance Section

The proper forms are being asked for by active and demobilized staff.

2.5. Safety Officer

No accidents reported.

2.6. Liaison Officer

No contact to or from stakeholders has been made. The incident remains small and unimposing.

2.7. Information Officer

No media activity has occurred or is expected. No press release is expected.

2.8 Security

No incidents. Department of Natural Resources officers continue to patrol and maintain security.

3. Weather Forecast for Tomorrow

Day: Partly cloudy skies early. A few showers developing later in the day. High 72F. Winds SSW at 20 to 30 mph. Chance of rain 30%.

Night: Showers and thundershowers likely. Low 43F. WSW winds shifting to NNE at 10 to 20 mph. Chance of rain 60%.

Situation Unit Report for October 25, 2011

Subject: **SITREP #2**
Barrier Defense
Romeoville, IL

From: Sam Finney, Situation Unit Leader
To: Kevin Irons, Incident Commander
Date: October 25, 2011
Reporting Period: 1400 hrs 10/24/11 to 1300 hrs 10/25/11

1. Introduction

1.2. Background

1.1.1 Incident Category

Exotic Species Control

1.1.2 Site Description

The electric aquatic nuisance barrier is a man-made designed to prevent the transfer of Aquatic Nuisance Species to Lake Michigan.

1.1.2.1 Location

Chicago Sanitary and Shipping Canal, Mile Marker 295.7 to 297

1.1.2.2 Description of Threat

Invasion of Great Lakes ecosystem by Asian Carp via Illinois River waterway

2. Current Activities

2.1. Operations Section

The day's operations began at 0600. At 0730 the USACE turned on Barrier IIA and the US Coast Guard made radio announcement of the closed Restricted Navigation Area. The Southern Illinois University (SIU) vessel *Shovelnose* immediately entered the area between the barriers and began sonar (hydroacoustic and split beam) transects of the area between the barriers. Flow was reported to be 1200 CFS at 0736. By 0748 the first sonar survey was completed. It was reported that the sonar data looked better than the previous operational period, presumably from a lack of bubbles or flocculant suspended in the water column thought to have caused issues during yesterday's operations. A single fish of the target size (>12") was identified in the area between the barriers, right at the water's surface. At 0806 the water cannons began firing to herd or harm any fish that may be in the area. By 0839 the cannons ceased firing. Flow was reported as dropping and at 400 CFS at 0850. At 0852 the SIU sonar boat began the second of three sonar surveys to identify any remaining fish in the area between the barriers and to confirm that the air cannons did not cause bubbles that would interfere with sonar readings. This second round of sonar testing was completed at 0906, as flow neared 0 CFS. No sonar interference was seen, indicating the sonar interference was from the increased flow yesterday and not from the cannons. Moreover, post processing of the data did not indicate and target fish in the area between the barriers. At 0919, the DIDSON boat began its survey and completed their survey by 0949. The SIU sonar boat then began a third sonar survey for further assurance that the area was clear of fish. That survey was completed and data were processed by 1015. Data from the DIDSON boat and the second two SIU sonar "runs" all indicated that the area was clear of fish targets >12".

Charlie Wooley, Sam Finney, and John Rogner discussed the results via telephone. Concurrence was reached that the area was cleared and barrier IIB could be taken down and Barrier IIA left up. The RNA was lifted. Crews began demobilization, and the operation was considered completed and successful.

2.2. Planning Section

Development of IAP's has ceased as the operation was terminated.

2.3. Logistics Section

Logistics has ceased operations as the incident was terminated.

2.4. Finance Section

The proper forms have been turned in by demobilized staff.

2.5. Safety Officer

No accidents reported.

2.6. Liaison Officer

No known contact to or from stakeholders has been made.

2.7. Information Officer

No media activity has occurred or is expected. No press release is expected.

2.8 Security

No incidents.

3. Weather Forecast for Tomorrow

Operation has ceased.

A Summary of USGS Flow Monitoring of the Chicago Sanitary and Ship Canal for Fish Barrier Maintenance-October 24-25, 2011

USGS-Illinois Water Science Center

On October 24-25, 2011, the US Geological Survey – Illinois Water Science Center staff made a series of acoustic Doppler current profiler (ADCP) discharge measurements in the Chicago Sanitary and Ship Canal (CSSC) at a location approximately 100 feet downstream of the 135th Street bridge (Romeoville Road) in support of maintenance operations for the Corps of Engineers electric fish barrier at the request of the Illinois Department of Natural Resources (IDNR). The barrier maintenance required the clearing of fish from the channel reach between barriers 2A and 2B. The methodologies used to clear fish from the channel reach were developed through a coordinated multi-agency effort.

Figure 1. Google Earth image showing location of the electric fish barriers 1, 2A, and 2B on the Chicago Sanitary and Ship Canal and the approximate discharge measurement cross-section.

The first component of the fish clearing operation was an increase of flows in the CSSC. The Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) was able to vary the flow in the CSSC by adjusting flows through the turbines and sluice gates at the Lockport Powerhouse. The USGS was tasked with making discharge measurements downstream of the fish barrier to document the flow conditions throughout the fish clearing operations. The discharge measurements were made following standard USGS protocol for hydroacoustic flow measurement. A 600 kHz ADCP was deployed from the USGS M/V Sangamon for the measurements. The discharge measurements were made by traversing the channel from bank-to-bank, continuously profiling water depth, velocity and discharge.

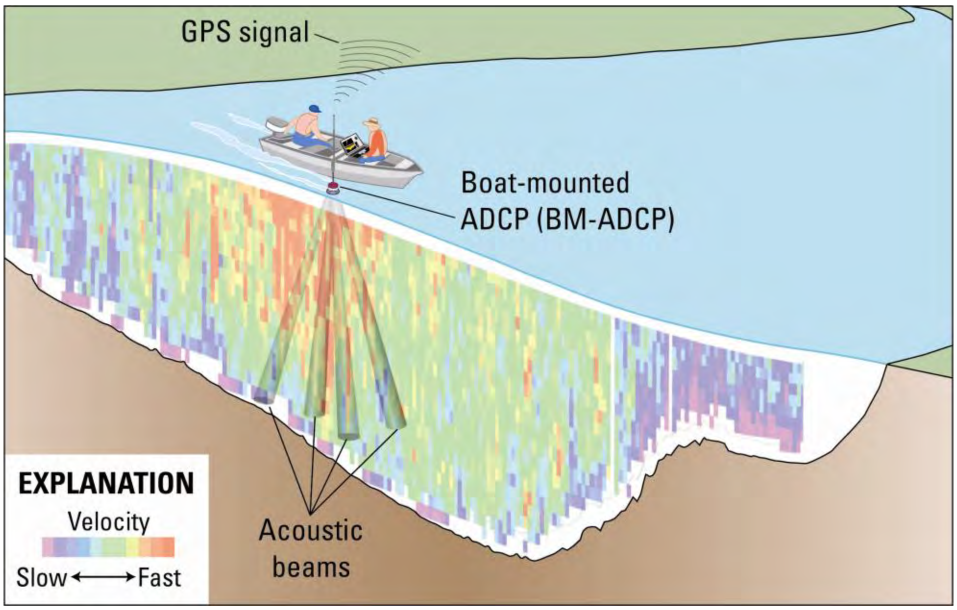

Figure 2. A simplified schematic diagram showing the collection of acoustic Doppler current profiler data during a river discharge measurement.

On October 24, 2011 at 4:30 AM CST the USGS crew arrived on-site and began making ADCP discharge measurements. The first ADCP discharge measurement was made at 4:48 - 4:51 AM CST at a flow rate of 3,982 cfs. At approximately 5 AM CST, the MWRDGC increased the flow through the Lockport Powerhouse from approximately 4,000 cfs to approximately 9,000 cfs. The increased flow was not detected at the fish barrier location until approximately 5:32 AM CST. The increased flow rate was maintained (with some variation) until approximately 7 AM CST, at which time the flow rate was reduced to approximately 4700 cfs (figure 3). All reported flows were verbally transmitted to the IDNR by the MWRDGC.

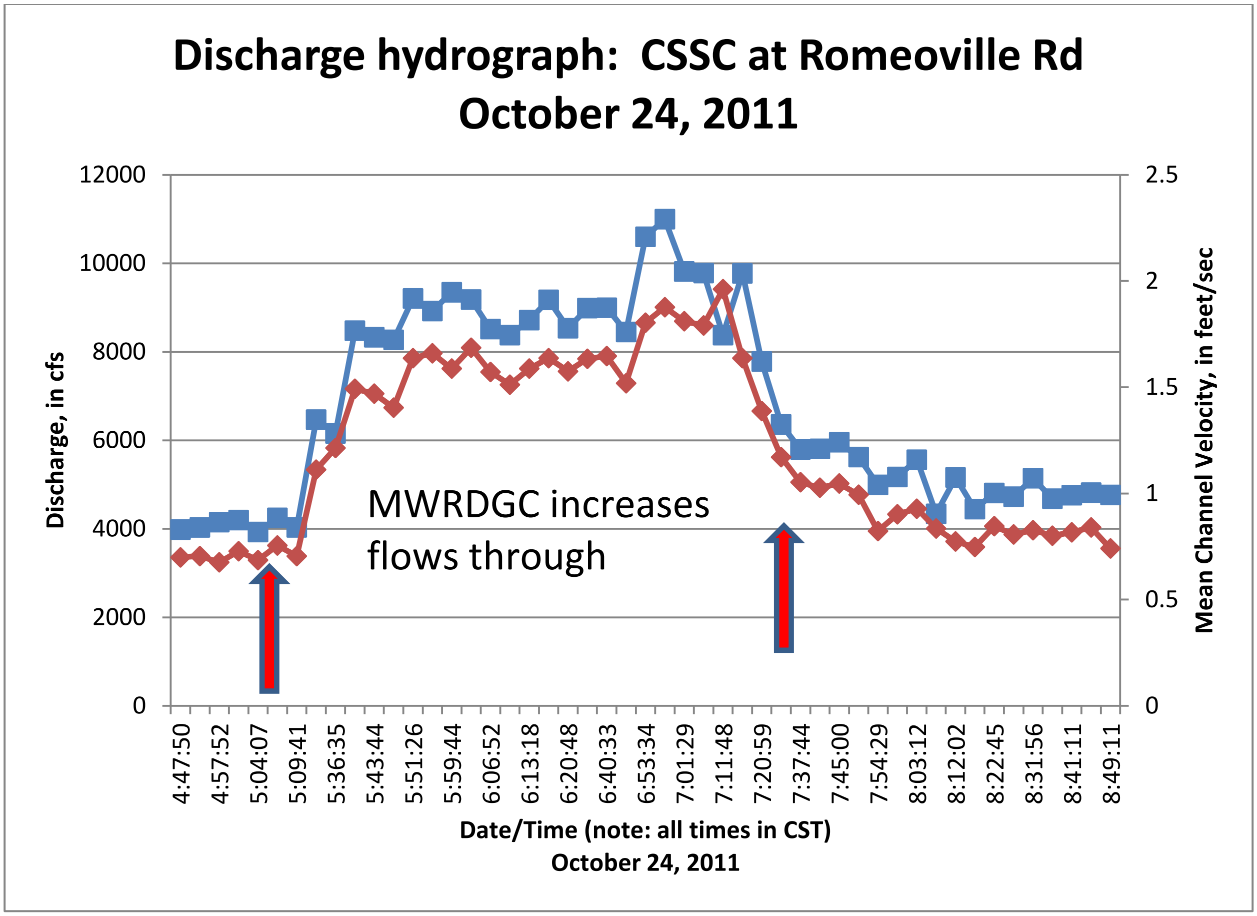

Figure 3. Discharge (blue) and mean channel velocity (red) hydrographs for the Chicago Sanitary and Ship Canal downstream of the fish barrier on October 24, 2011.

The USGS made 50 ADCP discharge measurements during this first day of fish clearing operations. The discharge measurements on October 24, 2011 ranged from 3,928 cfs prior to MWRDGC increasing the flow to 11,000 cfs during the drawdown. The average channel velocity ranged from 0.71 ft/sec to 2.03 ft/sec.

The maximum discharge of 11,000 cfs on October 24, 2011 was recorded during discharge measurement transect #26 (figure 4). The velocity magnitude contour plot shows most of the channel velocity in the 2.0-2.5 ft/sec range. Lower velocities in the 0.5-1.0 ft/sec range are found near the channel bed and along the right bank (near power plant barge loading facility).

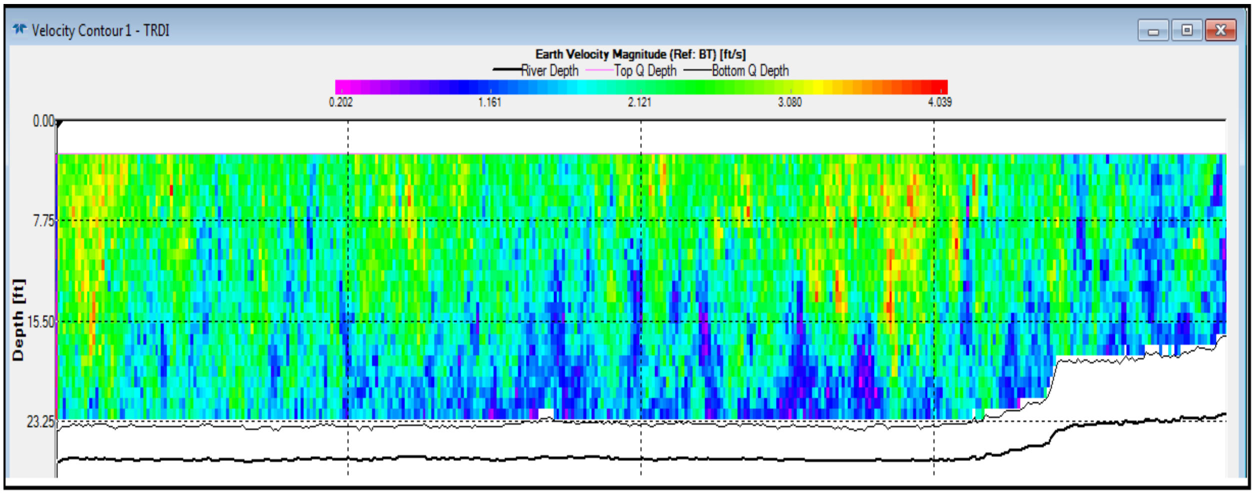

Figure 4. Velocity magnitude contour plot from the acoustic Doppler current profiler discharge measurement transect # 26 on October 24, 2011 in the Chicago Sanitary and Ship Canal. Total discharge was 11,000 cfs.

On October 25, 2011 at 6:45 AM CST the USGS crew arrived on-site and began making ADCP discharge measurements. This second day of fish clearing operations would be made at a much lower flow rate than the previous day. The first ADCP discharge measurement was made at 7:08 - 7:11 AM CST at a flow rate of 1,591 cfs. At approximately 7:30 AM CST, the MWRDGC decreased the flow through the Lockport Powerhouse from approximately 1,500 cfs to approximately 0 cfs. The decreased flow was not detected at the fish barrier location until approximately 7:40 AM CST. The decreased flow rate was maintained (with some variation) until approximately 8 AM CST, at which time the flow rate was increased to approximately 1700 cfs (figure 5).

The USGS made 39 ADCP discharge measurements during this second day of fish clearing operations. The discharge measurements on October 25, 2011 ranged from 1,704 cfs prior to MWRDGC decreasing the flow to -114 cfs during the shutdown and back up to 2,265 when flows were restored after the fish clearing operation. The average channel velocity ranged from 0.01 ft/sec to 0.44 ft/sec.

The minimum discharge of -114 cfs on October 25, 2011 was recorded at 08:17 CST during discharge measurement transect #23 (figure 6). The negative total discharge indicates a reverse flow direction towards the fish barrier and occurred when MWRDGC was not discharging water through the Lockport powerhouse and the channel was filling. The velocity magnitude contour plot shows most of the channel velocity in the 0.0-0.3 ft/sec range.

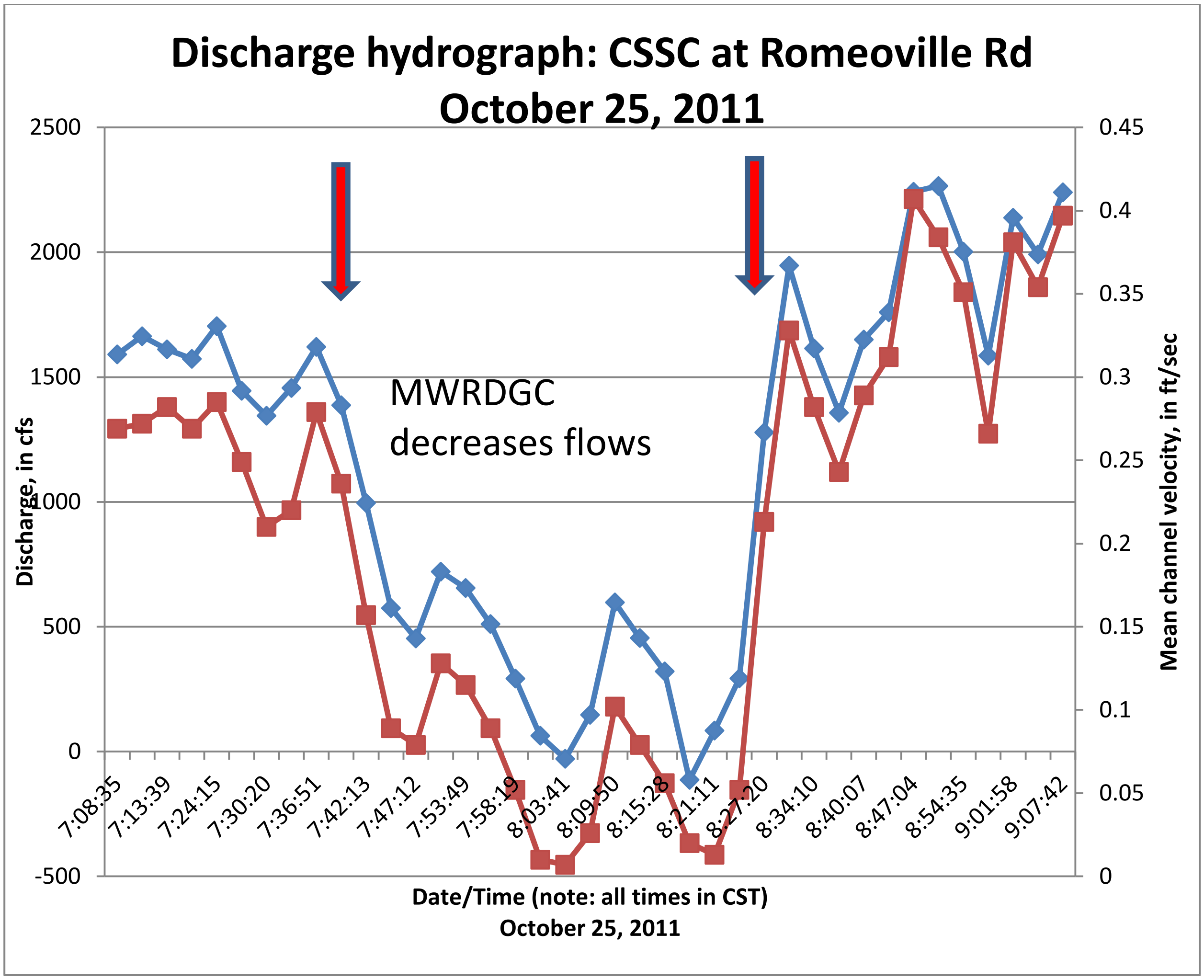

Figure 5. Discharge (blue) and mean channel velocity(red) hydrographs for the Chicago Sanitary and Ship Canal downstream of the fish barrier on October 25, 2011.

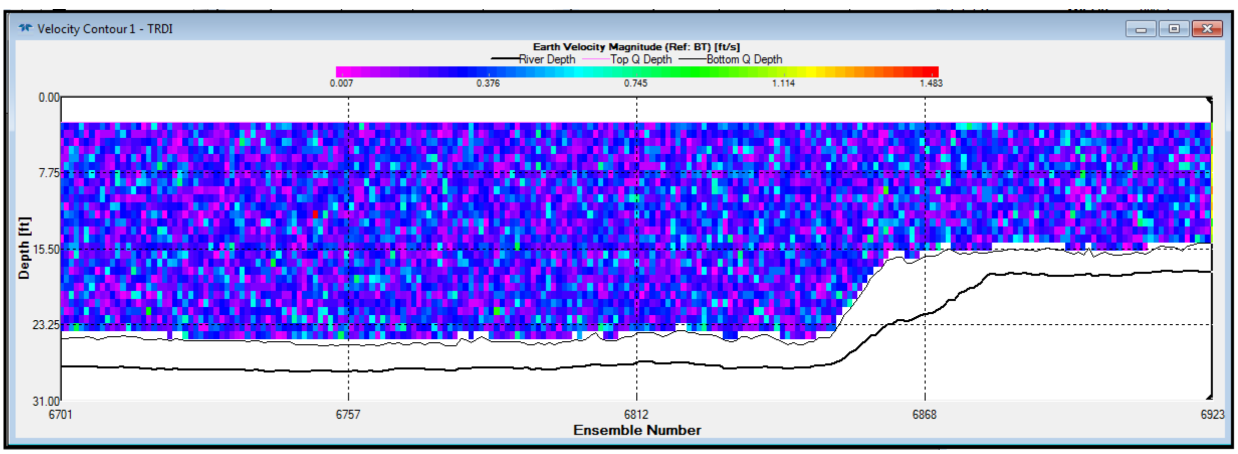

Figure 6. Velocity magnitude contour plot from the acoustic Doppler current profiler discharge measurement transect # 23 at 08:17 CST on October 25, 2011 in the Chicago Sanitary and Ship Canal. Total discharge was -114 cfs.

Summary of Water Gun Deployment to Clear Fish From Between Barrier 2A and 2B in the Chicago Sanitary and Ship Canal

Jackson Gross – U.S. Geological Survey, Northern Rocky Mountain Science Center, Bozeman, Montana

Water gun operations in the Chicago Sanitary and Ship Canal (CSSC) utilized two separate boat and water gun configurations. Limiting factors in the operation were a thirty minute operational time for water gun deployment between the two electrical barriers, the ability to deploy the technology; shot interval, and the ability to float a significant volume of compressed air as mechanical compressors could not be utilized. The largest boat (boat A), provided by Jim Lamer and Western Illinois University deployed two S80 water guns (120-in^3 chamber volume). This 28-foot vessel had two davits, each capable of lifting over 2000 lbs of mass, and was large enough to float and support the weight of thirteen dry air cylinders (310 ft^3, 2400PSI, Part#SP20, Midwest Welding and Supply Inc. Naperville, Il.), a cylinder pallet, and the two water guns. The second boat (boat B), a 26-foot vessel provided by the Illinois Department of Natural Resources, was used to deploy two, 1-in^3 water guns and support three dry air cylinders (310 ft^3, 2400PSI, Part#SP20, Midwest Welding and Supply Inc. Naperville, Il.). The two small water guns, 1-in^3 Bolt Model 10, were deployed by hand. Water gun deployment and operations during the exercise consisted of Dr. Jackson Gross (1-in^3 water guns) and 2 contracted seismic engineers (120-in^3 chamber volume water gun) from Bolt Technology Inc (Norwalk, CT). They were necessary for technical expertise in water gun installation, high pressure air handling and deployment logistics for operations and safety.

Prior to entering the CSSC and the electric field, pilot experiments were conducted in Illinois River back water habitats provided by Hanson Material Services, Morris, IL. The volume of air to be floated by each vessel was predetermined and tested experimentally in Morris, prior to entering the CSSC. Calculations were derived from maximum firing rate, water gun air volumes, and the thirty minute working period allotted for being in the electric field between Electric Barrier IIA and IIB. Pilot experiments simulated actual water gun deployment in the CSSC and boats were prepared and operated for thirty minutes to validate boat stability and mobility, firing rate and interval, and air consumption on both boats. For operator safety in the CSSC, each boat was covered with switchboard dielectric mats (Dielectric II, ¼ in. thickness, 30,000V strength rating, Grainger part #5T435) and operators and water gun engineers were fitted with electricians lineman's rubber insulated gloves (dielectric I, 18 in., 7500V strength rating, NOVAX Class I) and boots (dielectric II, 16 in. steel toe 14000V strength rating, Onguard Industries LLC, part #88722).

Water guns were suspended from each boat at a depth of 4 m. This depth was chosen as there are cement and wire structures in the canal 1-2 meters off the bottom and previous studies with the S80 water gun had shown that Northern pike exposed to two pulses within 3 and 6 m (>70PSI or 224dB re 1uPa) to the 120 in.^{3} water gun experienced 100% swim bladder rupture. A gun suspended 3.05 m from the surface or 4 m off the bottom, insured that no depth in the 7-m deep canal would provide a safe zone for a fish from the pulse pressure. The boats could also get within a meter of the wall of the CSSC and also target fissures (<2 m deep) where a fish could also potentially seek shelter. On boat A, the 120 in.^{3} water guns were spaced approximately 4 m apart, with the distance being maintained by the boat's davits, whereas on boat B, the two 1 in.^{3} water guns were only spaced 2.53 m apart, and were hung from the bow on the port and starboard sides of the boat.

The approach taken for water gun operations in the CSSC was different for each boat. The firing sequence for the S80 water guns, boat A, was altered between guns, with a pulse pressure being emitted every 8 sec. This allowed each gun to fire every 16 sec. providing ample time to refill and re-engage the piston. The Bolt Model 10s on boat B were fired simultaneously with a 5 sec. interval between pulses. Air pressure in each type of gun was also different, as the S80 was fired at 2000 PSI input pressure on boat A and the Bolt Model 10 was fired at 1650 PSI input pressure on boat B. The firing sequence was initiated inside the electric field beginning at Barrier IIB. Each boat would maneuver from wall to wall with boat A, closest to Barrier IIB. Boat A would spend the first five minutes, 10 m from the periphery of the strongest field of Barrier IIB. Boat B would maneuver between each wall, while focusing efforts between Barrier IIB and the parasitic cables and cement blocks. As boat A began to move west towards Barrier IIA, boat B would also continue to move closer to Barrier IIA. Since boat B was more maneuverable, Boat B would also focus its efforts around fissures in the canal structure emitting multiple pulses at each opening and continue back toward Barrier IIB along the canal walls working behind boat A as it pressed towards Barrier IIA. When the allotted thirty minutes expired for water gun application, both boats proceeded to move out of Barrier IIA and exhausted remaining air in the cylinders.

Evaluation of fish suppression efficacy of increased flows and water guns between Dispersal Barrier IIA and IIB in the Chicago Sanitary and Ship Canal

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Materials and methods

Southern Illinois University at Carbondale (SIUC) conducted a total of four remote sensing surveys between the high-field electrical arrays of Dispersal Barrier IIA and IIB with a combination of split-beam hydroacoustics and side-scan sonar to evaluate the fish suppression efficacy of increased flows and water guns on 24 October 2011 (Operational Period 1, 1 survey) and 25 October 2011 (Operational Period 2, 3 surveys). Hydroacoustics was carried out using two BioSonics, Inc. side-looking split-beam transducers (transducer 1 = 208 kHz, 6.8° -6 dB beam angle; transducer 2 = 201 kHz, 6.4° -6 dB beam angle) set at 15 cm below the surface; each transducer was set to 5 ping/s with a 0.40 ms pulse duration and data was collected from 0 to 50 m. Acoustic transducers were off-set in angle to maximize coverage across the Chicago Sanitary and Ship canal (CSSC) (transducer 1 = 86°; transducer 2 = 79°). Split-beam acoustic transducers were calibrated on-axis with a 200 kHz tungsten carbide sphere on 23 October 2011 following Foote et al. (1987) and transects completed on 4 October 2011 in passive, listening mode following Mitson (1995) indicated no electrical interference in signal transmission from Dispersal Barrier electrical arrays. A 1200 kHz HDS side-scan sonar tow fish (40° beam angle in either direction with a 10° offset from 90°) was towed at 1-m depth to detect and measure potential fish targets as well as to provide detailed imagery of the Dispersal Barriers. Each survey consisted of five transects conducted parallel to the side walls of the CSSC for an estimated 97.6% cumulative coverage of the entire water column within approximately 15 min (Figure 1). Before each split-beam acoustics transect, temperature was recorded and input into Visual Acquisition 6 prior to data collection to compensate for the effect of water temperature on two-way transmission loss via its effect on the speed of sound in water and absorption coefficients.
In all, a total of 5 transects were completed for each of the 4 sampling episodes. Data collection took approximately 15 minutes for each of the 4 sampling episodes, and analyses (outside of the barrier area) took approximately 20 minutes each.

Remote sensing analyses

At the conclusion of each survey, remote sensing data were immediately post-processed to determine the number, location, depth, and total length (TL) of potential fish targets. Side-scan sonar and split-beam acoustics data were analyzed using Sea Scan Survey 2.3 and EchoView 5.0, respectively. Side-scan sonar data were inspected visually and potential fish targets measured to the nearest 1-mm TL. Waypoints and depth of potential fish targets exceeding 30.48 cm in length were relayed to the USFWS to inspect the targets with a DIDSON camera. Data collected from the split-beam transducer 1 was analyzed 1 m from the transducer to 0.63 m away from the side wall on the opposite side of the CSSC to account for the near-field distance (Simmonds and MacLennan 2005) and dead-zone (Ona and Mitson 1996), respectively; data from transducer 2 was analyzed from 1 m to the point at which the beam intersected the bottom of the canal, parasitic structures, or low-field electrical arrays (Figure 1). Target strength (TS) was compensated for two-way signal loss as it is affected by range from the transducer, the speed of sound, absorption, and angle at which echoes were received. Potential fish targets were determined using the split-beam single target detection algorithm (method 2) in EchoView 5.0 (Table 1). Size of potential fish targets was determined using the relationship between maximum side-aspect TS and TL (Love 1971). Given that the TS to TL relationship is wavelength dependent, separate functions were used for each transducer (Figure 2). Detection of fish ≥ 30.48-cm

TL was the primary objective of this evaluation as a conservative estimate for the size of Asian carp (*Hypophthalmichthys* sp.) that may be present; compensated-TS values lower than this size were omitted from the analyses (Table 1).

Results

Operational Period 1

The single remote sensing survey on 24 October 2011 began at 0831 CDT when average water velocity at the electric barriers was 36 cm/s (1.2 feet/s; see USGS flow monitoring report). The survey followed a short-term drawdown of the canal that increased average water velocity at the barrier to between 43-61 cm/s (1.4-2.0 feet/s) at peak flows of 234-311 m^3/s (8,272-11,000 cfs), and physical clearing operations with water guns conducted by the USGS. No fish targets were detected with the side-scan sonar during this survey; however, a group of 10 potential targets was located along the East bank of the CSSC, just downstream of the low-field arrays. These targets were identified as large rocks via USFWS DIDSON camera. Split-beam acoustics identified 40 potential fish targets ≥ 30.48 cm, yet 38 of these targets, ranging in from an estimated size of 32.70 to 88.91 cm TL with a mean of 51.28 cm TL, were within a large plume of entrained air bubble interference along the entire West bank of the CSSC between the high-field arrays of Dispersal Barrier IIA and IIB (Figure 3); thus, it is difficult to determine whether the majority of these targets were actual fish or merely entrained air bubbles. The mean depth of the targets within the high-interference air bubble zone was 1.01 m and ranged from 0.57 to 1.57 m, indicating that most of these targets were near the surface. Many small dead and/or stunned fish were observed floating at the surface during this survey, presumably because they were forced through the upstream barrier when high flows were initiated. However, these fish were not limited to the Western part of the CSSC, whereas the air bubble interference and fish targets therein were restricted to the West bank of the CSSC. One potential fish was detected on the trailing edge of the air bubble interference that was estimated to be 77.42-cm TL, but was 0.59-m deep at the same depth that other air bubble interference was detected and therefore may also have been an entrained air bubble. One clear fish target was detected 4 m from the East bank of the CSSC outside of any air bubble interference during the upstream transect along the West bank (41.641697° N, 88.059893° W). This fish was estimated to be 44.34-cm TL, was 3.99 m deep, and echoes were detected from this fish multiple times indicating that the fish was swimming upstream with the boat. Due to the presence of one clear fish target that exceeded the 30.48-cm threshold and the large area that could not be surveyed reliably due to the large amount of air bubble interference along the entire distance of the survey extending up to 15 m from the West bank of the CSSC, the fish suppression was deemed not successful.

Operational Period 2

On 25 October 2011, a total of three remote sensing surveys were conducted. The first survey was initiated at 0733 during low flow conditions (flow < 48 m^3/s or 1,700 cfs; water velocity = 8.2 cm/s or 0.27 feet/s) and prior to USGS water gun deployment to decrease the likelihood of air bubble interference. Only one fish target was detected during this survey, which was located with split-beam hydroacoustics. The fish was estimated to be 34.46-cm TL, located 0.83-m deep, and approximately 18-m from the East bank of the CSSC (Figure 4). Equipment failure with the GPS system did not allow us to obtain exact coordinates for this fish. There was a clear reduction in the amount of noise in the echogram from this survey as compared to the survey conducted on 24 October 2011 (Figure 4). The area backscattering coefficient (ABC) recorded with transducer 1 from the East bank of the CSSC on the first survey of 25 October 2011 was 0.63×10^{-3} (m^2/m^2) in comparison to 1.83×10^{-3} (m^2/m^2) on 24 October 2011. Discounting any change in the number of actual fish targets, this represents a 66% decrease in noise caused by entrained air bubbles.

The second remote sensing survey began at 0852, immediately following USGS water gun deployment (flow = 20 m^3/s or 720 cfs; velocity = 3.9 cm/s or 0.13 feet/s). No fish were detected above the 30.48-cm TL threshold with split-beam acoustics or side-scan sonar. The ABC recorded with transducer 1 from the East bank of the CSSC from this survey was 0.36 x 10^{-3} (m^2/m^2) representing an 80% decrease in acoustic noise from 24 October 2011 and a 43% decrease from the first survey conducted only 1.25 hours earlier, assuming the majority of change in ABC was from air bubble interference.

The third remote sensing survey began at 0950 (flow = 64 m^3/s or 2,265 cfs; velocity = 11.6 cm/s or 0.38 feet/s), during which no fish above the 30.48-cm TL threshold were detected with either gear (Figure 5). The ABC during this survey collected with transducer 1 from the East bank of the CSSC was 1.11 x 10^{-3} (m^2/m^2) indicating that noise interference increased from the survey conducted 1 hour previous, but was still 39% less than the previous day.

Discussion

Based on split-beam acoustics and side-scan sonar, suppression of fish ≥ 30.48-cm TL between the high-field arrays of Dispersal Barrier IIA and IIB was successful, but not immediately. The combination of increased flows, water gun deployment, and the use of remote sensing gears to evaluate the success of fish clearing techniques is the first of its kind. This unprecedented event eliminated the need to apply rotenone to kill fish present in the area, which is an extremely expensive and labor intensive undertaking. Given that SIUC was unable to reliably survey the area on 24 October 2011 due to air bubble interference, and the fact that this area was not surveyed immediately prior to fish suppression techniques, it is difficult to determine whether the increased flow through the CSSC was necessary to clear fish from the Dispersal Barriers. It should be noted that many floating dead fish of various sizes were present on the morning of 25 October 2011 within and below the Dispersal Barriers prior to water gun deployment, yet it is unclear whether these fish were killed by being forced through the electrical field via high flows on the previous day (generally not thought to be a lethal outcome) or died as a result of high sound pressure waves generated by the USGS water guns. Given that the high flows generated on 24 October 2011 would have swept fish through the area rapidly, there is an increased possibility that these fish were killed by water gun firing.

It was apparent that high flows through the Dispersal Barriers interfered with signal transmission of the split-beam acoustics on 24 October 2011, but signal transmission was not affected by the water guns, based on changes in ABC collected before and after water gun deployment during low-flow conditions on 25 October 2011. Thus, low to no flow through the Dispersal Barrier would be the recommended conditions for evaluating the success of fish suppression techniques with remote sensing gears in the future. However, low to no flow condition may increase the likelihood of fish stunned by water guns and/or electrical fields to remain within the area. Given that the remote sensing gear cannot differentiate between healthy or moribund fish, this may increase the likelihood of false-positive detection. As such, the lowest flow possible to flush moribund or stunned fish from the dispersal barrier that 1) limits the amount of air bubble noise interference, and 2) reduces the chance of forcing fish from upstream through the electrical field, is necessary to determine prior to the next fish suppression operation between the Dispersal Barriers. Another option would be to wait until fish stunned or killed by the water guns float to the surface and/or are flushed downstream before initiating remote sensing surveys, yet, this option may require longer canal closures and thus may not be feasible to accomplish. This method could be supported if both barriers were allowed to operate for extended times without navigation closures. Nevertheless, remote sensing surveys should be conducted both prior to and after any fish suppression technique(s) are deployed to determine which technique is most effective and which techniques may not be necessary (e.g., high flows).

The relationship between maximum side-aspect TS and TL used in this study (i.e., Love 1971) was developed from multiple species from several studies and includes fish that do or do not have gas bladders. It has been estimated that 50% of the dorsal- and side-aspect TS from a fish is generated by the gas bladder of fish (Jones and Pearce 1958), with the skeleton and flesh (Volberg 1963) and scales (Diercks and Goldsberry 1970) reflecting the other half, listed in decreasing order of magnitude. Thus, the dorsal- and side-aspect TS of a given fish species and size is an emergent property of the size and morphology of the gas bladder, body morphology, proximate composition, and possibly the type and size of scales. Given that the gas bladder of Asian carp are much larger than the majority of fish species (personal observation), the TS threshold used in this study was likely conservative for detecting Asian carp. Therefore information concerning both the maximum side-aspect TS and dorsal-aspect TS for Asian carp and other fish species common in the Great Lakes and Mississippi River Basin would help to refine the search window for detecting Asian carp, would refine size-distribution estimates of Asian carp from acoustic surveys conducted along the Illinois River from the Marseilles reach to the confluence with the Mississippi River by SIUC, and may even help to determine species composition.

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Use of DIDSON for Verification of Barrier Clearing in the CSSC

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Introduction

A DIDSON crew from the Carterville Fish and Wildlife Conservation office of the U.S. Fish and Wildlife Service participated in the fish suppression and clearing action at the electric fish barrier at Romeoville, Illinois on October 24th and 25th 2011. The DIDSON crew was responsible for scanning areas between Barriers IIA and IIB that may have been missed by the split beam and side-scan sonars (see SIU report; e.g., the walls of the canal) and for verifying the identity of objects identified by side-scan and split-beam sonars.

The Dual-Frequency Identification Sonar (DIDSON) is a non-intrusive acoustic camera that can be used in turbid water to observe fish behavior and location in real time. The DIDSON can be set in a variety of ways to gather high quality video images in close proximity to the unit, or images of decreasing quality at greater distances. Recent pilot studies have shown that the electric barriers have no effect on the electronic components of the DIDSON.
The DIDSON has some technical limitations. A single unit will not provide complete cross-sectional coverage in the CSSC. Also, a DIDSON can digitally measure the length of fish but is not normally able to identify species. Given this, any fish observed during field surveys can be considered surrogates for similarly-sized Asian carp.

Methods

In order to scan the entire underwater portion of the canal walls, two passes with the DIDSON were necessary for each wall. A pass was made travelling upstream through barriers IIA and IIB, starting at the Romeoville Road Bridge and ending above the upper parasitic structure. The first pass focused the DIDSON on the lower half of the wall and the second pass focused on the upper half of the wall. Runs were made in the following order: west wall, lower half; east wall, lower half; west wall, upper half; east wall, upper half. This order was followed on both the 24th and 25th. The scans were made following barrier clearing with water guns on the 24th. We scanned before use of water guns on the 25th.

Video recordings of each run were made. Length of recordings in minutes and seconds are listed below:
24 October –
Run #1 – 6:34
Run #2 – 6:34
Run #3 – 6:50
Run #4 – 5:29

25 October –
Run #1 – 3:55
Run #2 – 4:09
Run #3 – 4:20
Run #4 – 3:27

During the runs, one crew member watched the computer screen and noted the times at which any fish were seen. This allowed for rapid review of the DIDSON footage upon completion of the runs.

Videos were scrutinized for fish, and any fish found were measured for total length using the DIDSON software.
On 24 October, the DIDSON crew went back into the barrier at the request of the SIUC crew, which was running the split-beam hydroacoustics, to verify the presence of boulders (or concrete) in an area next to the east wall and just downstream of the low field array on barrier IIB.
DIDSON settings were as follows: Receiver Gain 40 dB, Window Start 1.67 meters, Window Length 10 meters, Frequency 1.8 MHz.

Results

24 October – During all four DIDSON runs, one or more fish was observed at the beginning of the run over farthest downstream parasitic structure. The number and length of fish found on each run were:

Run #1 – 1 fish (25 cm TL)
Run #2 – 1 fish (23 cm TL)
Run #3 – 2 fish (23 and 22 cm TL)
Run #4 – 1 fish (23 cm TL)

No fish greater than 300 mm total length (12 inches) were observed.

The objects that the SIUC split-beam hydroacoustics had identified as fish were confirmed to be boulders or concrete blocks on the bottom of the canal.

25 October – During all four DIDSON runs, no fish were observed in the electric barrier. After run #4, as the crew left the electric barrier, 8 fish were recorded over the farthest downstream parasitic structure. The total lengths of those fish were as follows: 21, 30, 30, 22, 24, 22, 29, and 30 cm.

Conclusions

DIDSON technology proved useful for relatively fine scale surveying of the barrier walls. It was used to successfully verify inanimate objects identified by the split-beam hydroacoustics. DIDSON promises to be a useful tool if used in conjunction with other technologies for future barrier clearing verification efforts. It should be noted that, due to the limited amount of area the DIDSON ensonifies at any one time, it cannot be the primary technology used to scan an area as large as the CSSC.

Public Information Officer Report

November 28, 2011

To: Amy Giesing, Planning Section Chief
Fr: Tim Schweizer, Information Officer
Re: Information Report – Barrier Defense and Fish Suppression Operation, Romeoville, IL – Oct, 23-26, 2011

In consideration that the Barrier Defense and Fish Suppression Operation of October 2011 was deemed a routine, planned operation in support of USACE electrical barrier maintenance, and in consultation with the CEQ and ACRCC Communication Work Group, no advance media announcement of the operation was made.

A media release on the operation was drafted and the IDNR ICS Information Officer was present on site during the operation in the event that questions would arise from the public or media representatives who may have become aware of the operation.

Photos and video of the operation and a summary of results of the operation were provided to the ACRCC Communications Work Group.

Safety Officer Report

February 9, 2012

To: Amy Giesing, Planning Section Chief

Fr: Rich Lewis, Safety Officer

Re: Safety Report – Barrier Defense and Fish Suppression Operation, Romeoville, IL
October 23-26, 2011

Prior to the operation, IMT personnel met with ACOE and Coast Guard to ensure that our safety plan was okay with them. All agencies concurred that the safety message was complete.

There were no incidents throughout the operational periods. Everyone did a very good job of prioritizing safety. No additional safety concerns were recommended in the after action review.

Finance Officer Report

Overtime		$40,491.05	**$40,491.05**
Travel	Hotel	$3,154.86	
	Travel	$1,195.50	**$4,350.36**
Chemical	Liquid Sodium Permanganate	$15,547.38	
	Chemical Shipping	$1,063.00	
	Chemical Berms	$3,447.00	**$20,057.38**
Chemical Use	Respirator Exam	$1,728.00	
	Chemical Jackets	$1,788.74	
	Items Rotenone Pump	$454.66	
	Fit Testing	$1,850.00	
	Goggles	$240.00	
	Items to Pump Chemicals	$158.96	**$6,220.36**
Safety/Medical	AED and Supplies	$1,870.00	
	Eyewash	$69.34	
	AED Training (Patterson)	$77.28	
	Paramedics	$495.95	
	AED Training	$49.00	**$2,561.57**
Supplies/Misc	T Cards and Rack	$190.19	
	Round Rings & Straps	$1,079.07	
	Supplies	$22.73	
	6 Ft Tables	$249.95	
	Lights & Supplies	$333.02	
	Polypropylene Rope	$34.99	
	Life Jackets	$1,426.20	
	Sprinkler/Utility Pump	$380.26	
	Gloves	$1,443.40	
	Marine Radios	$2,316.93	
	Supplies	$124.44	
	Tent Supplies	$53.27	
	Lanyards	$20.20	
	Port-A-Potties & Wash Stations	$233.31	
	IMT Jackets	$697.00	
	Trash Removal	$131.42	**$8,736.38**
Total			**$82,417.10**

APPENDIX A

Incident Action Plans (IAP) for Operational Period 1 (23-24 October 2011), Period 2 (24-25 October 2011), and Period 3 (25-27 October 2011) (Excluded here for space considerations)

Appendix C. Bait Trade eDNA Surveillance Final Report (Jerde et al. 2011).

Environmental DNA surveillance of the Chicago area bait trade for juvenile bighead and silver carp contamination

Christopher L. Jerde[1,2,3], Michelle L. Budny[2], Matthew A. Barnes[2], Andrew R. Mahon[2,3,4], Matthew P. Galaska[2], Jillian M. Deines[2], W. Lindsay Chadderton[3,5], and David M. Lodge[2,3]

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[2]University of Notre Dame, Department of Biological Sciences
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[5] The Nature Conservancy

Acknowledgements

The many bait shop owners that voluntarily answered the questionnaire and allowed for water samples to be collected aided in this project's success. For anonymity we do not list the shops, but we are very appreciative of their participation and cooperation.

Vic Santucci, Steve Pescitelli, Robert Rung, Rob Miller, Frank Jakubicek, and Scott Bartell administered bait shop questionnaires and collected the water samples from bait shops. The quality of the information gained from the visitation and questionnaires is a reflection of their diligent work and dedication to preventing Asian carp from becoming established in the Great Lakes and surrounding waterways.

Reuben Keller provided helpful suggestions to improve the questionnaire. This research was conducted at the Center for Aquatic Conservation at the University of Notre Dame. Joanna McNulty provided administrative support.

Midway Bait & Tackle (Osceola, IN) supported bait purchases.

This work was supported by a contract through the Illinois Department of Natural Resources (RC11CAFWS74) and through a cooperative agreement with the US Fish and Wildlife Service under the Great Lakes Restoration Initiative (#981, Environmental DNA surveillance – Applied early detection).

Great Lakes RESTORATION

CENTER FOR AQUATIC CONSERVATION

Contact:

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Summary & Key Findings

In 2010, 52 bait shops in the Chicago area were inspected by the Illinois Department of Natural Resources for the presence of invasive species contaminants in live fish stocks being sold for bait. As part of this effort, a questionnaire was conducted to document the types of bait and contaminants encountered in the trade, the wholesale source of regional bait stocks, the awareness of invasive species issues by bait shop employees and owners, and the systems and conditions used to hold bait prior to its sale. Additionally, water samples (n=136) were collected from 94 bait tanks for screening the presence of bighead carp, silver carp, and goldfish DNA. The primary objective of this study was to evaluate the current threat of Asian carp spread posed by the bait trade pathway in the Chicago area.

The use of environmental DNA (eDNA) for surveillance is meant to complement existing, visual inspection efforts, as it should be more sensitive to detection of rare and cryptic species or life stages, especially in crowded tanks. Calibration studies are however required to demonstrate and quantify detection capabilities to justify further use of the tool. Thus, we used bait holding tanks, modeled after those observed in the Chicago bait shops, to evaluate the sensitivity of eDNA surveillance to detecting the presence of variable densities of target species mixed in with non target bait species. The primary interest in performing the calibration work was to answer the following questions:

1. How long must a contaminated stock be held before eDNA can be used to detect presence?
2. How long after target bait contaminant species are removed from holding tanks is detectable eDNA present?
3. How many target individuals are needed in a mixed bait stock before a positive detection is made, and what is the impact on detection from high densities of non target taxa?
4. How reliable is eDNA surveillance for the bait trade?

Bighead and silver carp were not observed in any of the 52 bait shops visited or detected in water samples using environmental DNA surveillance methods. Without exception, few contaminant species were observed. Environmental DNA methods successfully identified the presence of goldfish at one location where visual inspection of the bait tanks identified goldfish as a contaminant and a number of additional bait shops where they were not recorded during visual inspections. This observation is an indication that eDNA surveillance is more sensitive to detecting low levels of contamination than visual inspection. Furthermore visual inspections, and eDNA screenings found no evidence that the Chicago area bait trade is currently a pathway for Asian carp introduction. Finally nearly 80% of the bait stocks were sourced from two regional wholesalers, which implies that future surveillance may be more effective at the wholesale rather than retail level of the bait trade.

The calibration studies provided additional support for the efficacy of continued application of eDNA for surveillance of the bait trade. In trials with as few as one or two fish per 50 liter holding tank, positive detections were made within one hour of exposure. However, there was some variability in detection and there is evidence of modest levels of type II error: concluding a target organism is absent when actually present. In contrast, when the target organism is removed from the bait stock, the DNA signal persists no longer than 3 days. In the presence of large quantities of non-target bait, this is reduced to no more than 4 hours. Consequently, eDNA is a reliable indicator of presence when a target species is detected, however, the conditions leading to type II errors suggest more research is needed to decrease the false negative rate.

Figure 1: Example of 75-liter liter bait tank with 350 minnows and 10 goldfish after 24 hours of exposure.

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Introduction

Biological invasion, the establishment and spread of nonindigenous organisms in new ecosystems, occurs at alarming rates with severe consequences for biodiversity (Wilcove et al. 1998), human and environmental health (Daszak et al. 2000), and economies worldwide (Keller et al. 2009). Accordingly, the need for invasive species prevention and management is urgent. Lodge et al. (2006) depicted biological invasion as a stepwise process (e.g., entrainment in pathway, introduction, establishment, and spread) and noted that management strategies can target different steps in the process. Leung et al. (2002) and others have emphasized that among the options for invasive species management, prevention and early detection represent the most effective and efficient. However, to maximize the effectiveness of prevention and early detection, all possible invasion pathways must be identified and monitored with the best available technology.

One well-documented invasion pathway is the live bait trade (Litvak and Mandrak 1993, 1999). Numerous examples of successful biological invasions originating within the bait trade exist, from crayfish (DiStefano et al. 2009) to earthworms (Keller et al. 2007). Nevertheless, there is little regulation and monitoring of the bait trade, and where regulations do exist, they are often poorly enforced (Peters and Lodge 2009). Uncertainty over which species occur, and at what frequency (either deliberately or as contaminants), within the bait trade pathway underscores the need for development of improved surveillance tools targeting this pathway.

The Asian carps (i.e., the silver carp *Hypopthalmichthys molitrix* and the bighead carp *H. nobilis*) currently represent a group of organisms of great concern within the bait trade pathway (USACE 2010). Asian carps were accidentally introduced to the wild during the 1970s and have spread northward through the Mississippi River basin over the last 40 years (Kolar et al. 2007). Asian carps were used in federal and private aquaculture facilities to control nuisance algae and plankton blooms primarily in catfish ponds where fish likely escaped due to flooding and proximity to watersheds. Currently, Asian carp are believed to threaten the Great Lakes ecosystem through numerous pathways, including movement within the bait trade, but almost all management and research to date has emphasized the direct connection between the Mississippi River and Great Lakes basin via the Chicago Sanitary and Ship Canal (CSSC)(Jerde et al. 2011), with other pathways remaining relatively unmonitored (ACRCC 2010).

To date, no live bighead or silver carp have been reported or detected as contaminants to the IDNR (Vic Santucci, Pers. Comm.). Never the less, the bait trade may represent a potentially important pathway of Asian carp invasion for several reasons. Juvenile Asian carp are difficult to distinguish from more common baitfish in the region (e.g., gizzard shad (*Dorosoma cepedianum*), fathead minnows (*Pimephales promelas*)), and the proximity of many of these bait shops to the CSSC and Lake Michigan make them a potentially important vector for Asian carp introductions.

Interest exists in developing environmental DNA (eDNA) surveillance methods for the bait trade for Asian carp and other contaminant species (ACRCC 2010). Surveillance for eDNA potentially offers several advantages over visual inspection. While visual inspection is relatively labor-intensive and costly, with trained experts needed to travel to every bait shop of interest, eDNA requires only that water samples are collected, and these can be processed by a laboratory off site (Jerde et al. 2011). Additionally, eDNA has demonstrated success in detecting organisms in large bodies of water, such as frogs in France (Ficetola et al 2008) and Asian carp in the CSSC (Jerde et al 2011). However, eDNA surveillance remains untested regarding the detection of small fish which are rapidly introduced to and removed from small tanks such as those found in bait or aquarium shops. Additionally, eDNA sensitivity remains relatively un-calibrated, with positive eDNA detections unable to provide information on quantities of organism or temporal trends (ACRCC 2010).

In this report, we address several of these concerns as we develop eDNA methods for bait trade surveillance. Specifically, we present the results of a Chicago-area bait shop questionnaire to evaluate Asian carp presence in the bait trade pathway. Additionally, we report on laboratory calibration experiments conducted to evaluate the reliability of detection.

Methods

Bait shop questionnaire and visual tank inspections

In consultation with the Illinois Department of Natural Resources (IDNR), a bait shop questionnaire was designed to document bait contamination in the Chicago area. The questionnaire included questions regarding the conditions and procedures used to maintain the health of live bait while in stores, the regularity of contaminant species arriving in bait shipments, pricing, the wholesale source, diversity and availability of bait, and the display of educational and outreach information related to invasive species. The questionnaires also served as the record for samples collected for eDNA screening and the documentation of any visual detections of species contaminants. The questionnaire is provided in the appendix.

The IDNR inspection team included six fisheries biologists divided into three, two-person teams. Each team worked with bait shop owners and employees to complete the questionnaire (Figure 2B). Participation in the questionaire by the bait shop was voluntary. The questionnaires were transferred to UND scientists when water samples were transferred, and responses to the questionnaires were entered into an electronic database at UND.

The IDNR inspection team identified bait and contaminants to species. Visual inspection of bait tanks consisted of using dip nets to sub sample each tank repeatedly. Although no standardized protocol exists, inspectors generally collected at least 3-5 subsamples per tank for small tanks (50-75 l) and increased the number of subsamples for larger tanks. Any contaminants were isolated, identified, and recorded. All tanks in a shop were visually inspected.

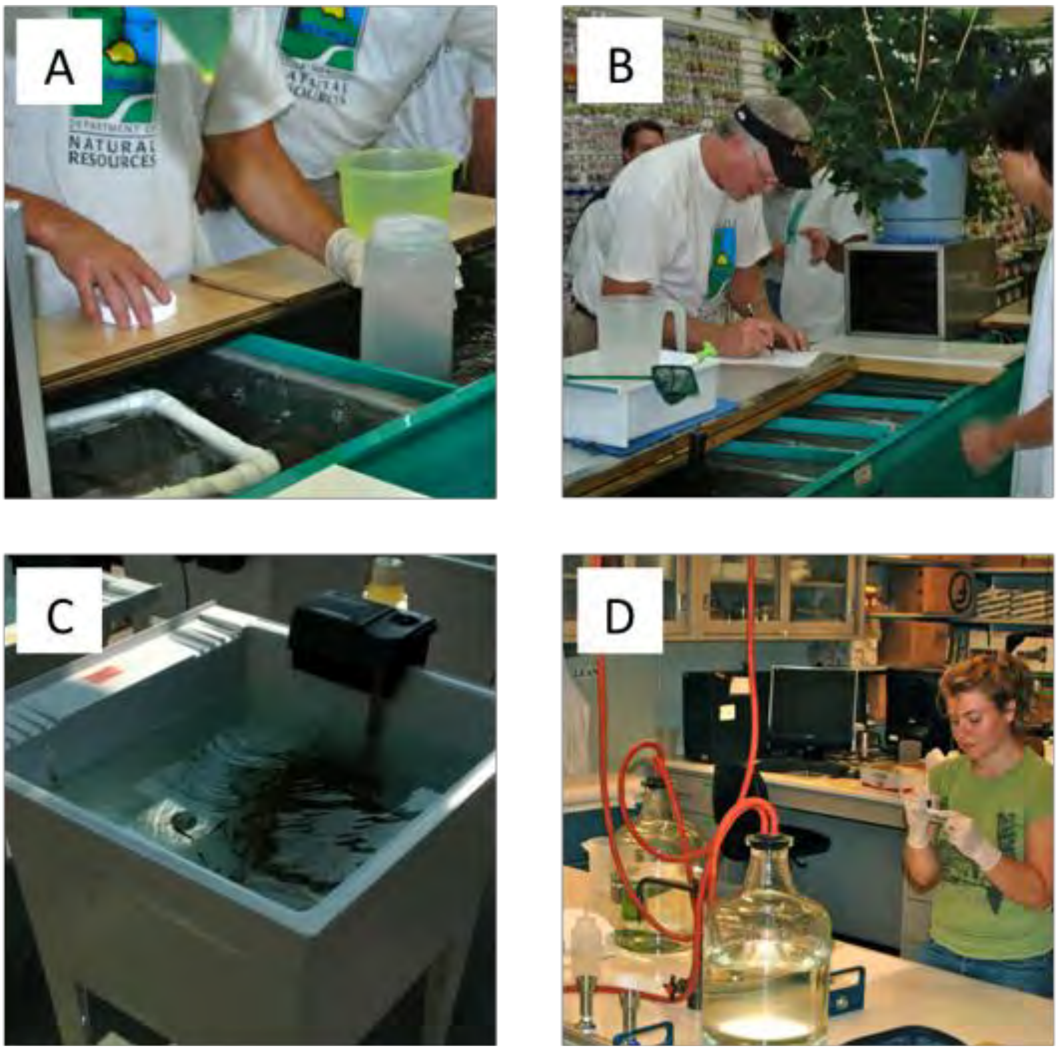


Figure 2: (A) Water samples being collected from Chicago area bait shops (B) Questionnaires being conducted by Illinois Department of Natural Resources personnel (C) The experimental basins used for the calibration studies that mimicked the bait holding set-ups at many of the bait shops (D) M. Budny filtering water samples at the University of Notre Dame

Bait shop eDNA screening for bighead and silver carp

After administering the questionnaires and performing visual inspections at bait shops, the inspection team collected water samples from bait tanks using standard UND protocols (Mahon et al. 2011), (Figure 2A). From previous inspections, it was known that many shops had between one and four bait tanks, often with recirculating water systems. Some of these recirculating water systems were dedicated to a single holding tank while other bait holding setups connected all tanks with a common water source. For the Chicago bait trade eDNA effort, 250 two-liter water bottles were sterilized and prepared, so that if deemed necessary, the visitation teams could take at least one water sample per tank at each bait shop. Tanks that had connected water systems had fewer samples collected, as the DNA would likely be spread throughout all tanks.

Inspections generally started by 8am and were completed by 3pm. All water samples were stored in coolers and transported to the UND on ice for filtering in the lab. All samples were filtered at UND and the resulting filter papers were stored at -20C within 24 hours of collection.

The bait trade water samples were vacuum filtered through a 1.5 micron glass fiber filter paper. Any cellular materials shed/sloughed by target species are trapped on the filter paper. Following water filtration, DNA was extracted from the materials trapped on the filter paper using a commercially available DNA extraction kit (www.mobio.com). Extraction involves using silica beads to lyse cellular materials. Once DNA was extracted, a species specific, short (~200-300 base pair (bp)) fragment of the mitochondrial control region (d-loop) was amplified using standard polymerase chain reaction (PCR) techniques that employ oligonucleotide primers. Bighead and silver carp primers, available in Jerde et al. (2011), were used for screening.

Following amplification reactions, the PCR products were screened using standard agarose gel electrophoresis methods and visualized using ethidium bromide staining under UV light exposure. Positive (DNA from a target species is detected) and negative reactions were determined visually, all gels were photo-documented, and samples of extracted DNA were archived. All protocols are documented in Mahon et al. (2010) and types and sources of error for the eDNA procedure are discussed in Darling & Mahon (2011).

Goldfish marker development and testing

To complement the existing bighead and silver carp markers, we designed a set of species-specific molecular markers to amplify a 106bp fragment of the mitochondrial cytochrome *B* (cytB) gene from goldfish (*Carassius auratus*). The purpose was to use the goldfish marker in commercial bait tank screening and also in laboratory calibration experiments. Goldfish are a common, and well-established bait contaminant found throughout the United States (Fuller et al. 1999). The goldfish markers were designed by obtaining molecular sequence data from Genbank (http://ncbi.nlm.nih.gov) and comparing the information for goldfish sequences to other species common to the bait trade along with other local and invasive fauna including common carp (*Cyprinus carpio*), golden shiners (*Notemigonus crysoleucas*), snakehead (*Channa sp.*), fathead minnows (*Pimephales promelas*), bighead carp, and silver carp. By creating an aligned dataset with the available cytB data, we utilized the AlleleID computer software package (Premier Biosoft, Inc.) to design PCR primers that only target and amplify goldfish. The potential markers were then tested on genomic DNA from target and non-target species. Upon testing we found that two markers (goldcytB-F1 and goldcytB-R1; Table 1) were suitable for use in these bait trade analyses and calibration studies.

Table 1. Molecular markers designed to amplify a 106bp fragment of goldfish (*C. auratus*) mitochondrial cytB DNA.

Primer	Primer sequence
goldcytB-F1	5'-GCTTCTCCGTAGATAATG-3'
goldcytB-R1	5'-TTCGTGAAGAAACAGTAG-3'

Laboratory Calibration Experiment Sample Collection

Table 2. Experimental set-up for laboratory calibrations

Trial #	# Goldfish (target)	# Non-Target Individuals	Water Volume (l)	Sampling Schedule	N = # of samples
1	1	0	50	twice daily	27
2	2	0	50	twice daily	27
3	0	2	50	twice daily	27
4	10	0	350	twice daily	27
5	2	50	50	progressive	31
6	10	50	50	progressive	29
7	10	350	50	progressive	31
8	2	350	50	progressive	31

To clarify how target organism density, the presence of non-target organisms, and DNA accumulation and degradation influence eDNA detection ability, we conducted a calibration experiment in a laboratory solarium from February to April 2011. Sterilized 75 l plastic utility sinks were filled with 50 l of well water. Water in each tank was circulated with a 113.6 l/hr capacity water pump to simulate bait shop conditions (Figure 1 & Figure 2C). An additional high volume tank was established using a 400 l sterilized cattle tank filled with 350 l of well water and aerated. Feeder goldfish served as the target organisms, while fathead minnows and golden shiners were used as non-target organisms. Eight trials were run with varying numbers of each species to establish a range of target organism densities and target-to-non-target organism ratios (Table 2). Trial 3 contained two brook stickleback (*Culaea inconstans*) to serve as a negative control. Each trial (1-8, Table 2) consisted of a DNA accumulation phase, which examined the time to eDNA detection (time to event, repeated measures) once an organism is present, as well as a DNA degradation phase, which examined time to negative DNA detection due to the degradation of any remaining eDNA in the water column.

Surface water samples were collected in autoclaved 2 l Nalgene bottles. One control sample per tank was taken prior to organism addition to ensure the absence of target DNA at the onset of the experiment. Once organisms were added, sampling for each trial followed one of two schedules to provide multiple levels of time resolution. In the “progressive” sampling schedule, one surface water sample was taken every hour following goldfish addition for the first four hours to provide high resolution of eDNA detection ability as DNA accumulates. After this, we progressively increased the sampling interval to two hours (two sampling events), four hours (one sampling event), and six hours (two sampling events) to complete the initial 24 hour period. For the remaining six days of the DNA accumulation phase, samples were taken at 24 hour intervals. To initiate the DNA degradation phase, goldfish were removed from tanks after 1 week (non-target organisms, if present, remained). We again followed the same progressive sampling schedule used in the accumulation stage. The second sampling schedule, “twice daily,” involved taking a water sample following organism addition and then twice daily throughout the remainder of the DNA accumulation and degradation phases. Four trials followed the progressive sampling schedule and four trials were sampled twice daily (Table 2).

Temperature was recorded at each sampling event, and any fish that died were recorded and replaced. During the DNA accumulation phase, well water (tested for non-presence of target DNA) was added after each sampling event to maintain a 50 l volume. Once the DNA degradation phase was initiated, we no longer replaced water volume lost through sampling and natural evaporation. Once the water level became too low to effectively sample (approximately five to six days), the remaining water was filtered and processed as one sample (~20 l total volume).

Sample filtering and DNA extraction

Water sample filtering and DNA extraction followed methods given in Mahon et al. (2010) and Jerde et al. (2011). A two-liter water sample was vacuum-filtered through a sterilized filter apparatus onto 1.5-µm pore size glass fiber filters following collection. To evaluate sterilization of filter apparatus, 1 l of deionized water was passed through prior to each water sample, and these equipment control filter samples were stored in 15 mL tubes at -20 ˚C until further processing. DNA was extracted from filters using the PowerWater DNA Isolation Kit (MO-Bio Laboratories, Inc., Carlsbad, CA) and stored at -20 ˚C until further processing. All samples were extracted and 10% of all equipment controls, coming from positive detection samples, were evaluated.

For each water sample collected as a part of the accumulation and degradation tests, eight replicate PCR reactions were performed to test for the presence of goldfish DNA.

Primers goldcytB-F1 and goldcytB-F2 designed for this series of experiments (see above) were used along with a reaction cocktail consisting of 0.75U/µl Taq Polymerase 10X PCR buffer (5 PRIME), 2.5 mM Mg^{2+} solution (5 PRIME), 10nmol of each dNTP, DNA template, and water to a final reaction volume of 25µl to amplify a 106 bp fragment on the mitochondrial cytochrome *B* gene. The PCR thermal program included an initial incubation at 94°C for 2 min and 35 cycles at 94°C for 15 sec, 53°C for 15 sec, and 72°C for 30 sec. This was followed by a final extension at 72°C for 3min. The samples were then screened on an ethidium bromide stained 1% agarose gel. Positive detections for goldfish were identified by a single, prominent band at 106bp on the gel. All PCR screenings included positive and negative control reactions. After samples were processed, 10% of the positive samples had their equipment controls chosen at random and processed to check for contamination.

Samples were screened on a ThermoFisher Scientific Nanodrop fluorometer to record their protein to nucleic acid ratio (260:280) for each sample. Measuring the absorbance ratios of the DNA extractions from collected eDNA samples is one way to examine purity and success of the DNA extractions because DNA absorbs UV light at 260 and 280 nanometres, and proteins absorb UV light at 280 nm. Samples that contain 100% pure DNA have a 260/280nm absorbance ratio of 2.0. Samples that are contaminated with high concentrations of potentially inhibiting proteins have a 260/280nm ratio of approximately 0.57 (100% protein; see Supplementary Table 1).

Results

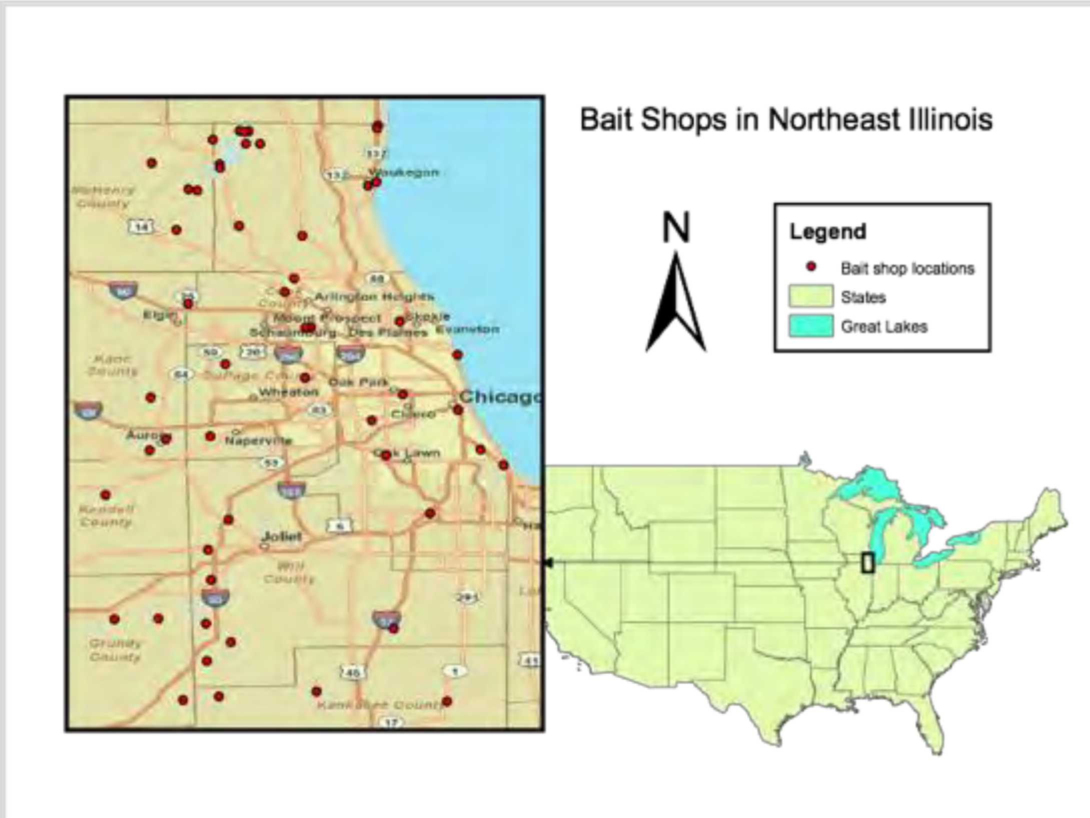


Figure 3: Bait shop locations throughout Northeast Illinois that were visited as a part of this study. 136 water samples were collected from 94 tanks at the 52 shops visited.

Bait shop questionnaires and visual inspection

The Illinois Department of Natural Resources inspected 52 bait shops in the Chicago metropolitan area (Figure 3). Initially 57 bait shops were identified in the region, but five shops were closed either permanently or on the day of visitation. The survey comprises over 90% of the known operating bait shops in the Chicago area. All shops voluntarily participated in the questionnaire with nearly all questions (97%) answered.

Most common bait types

Bait inventory varied between bait shops, but the most common live baitfish species were fathead minnows, golden shiners, and suckers (Cypriniformes: Catostomidae; Figure 4). Gizzard shad, which can be difficult to distinguish from juvenile bighead and silver carp, were only sold frozen (i.e. dead).

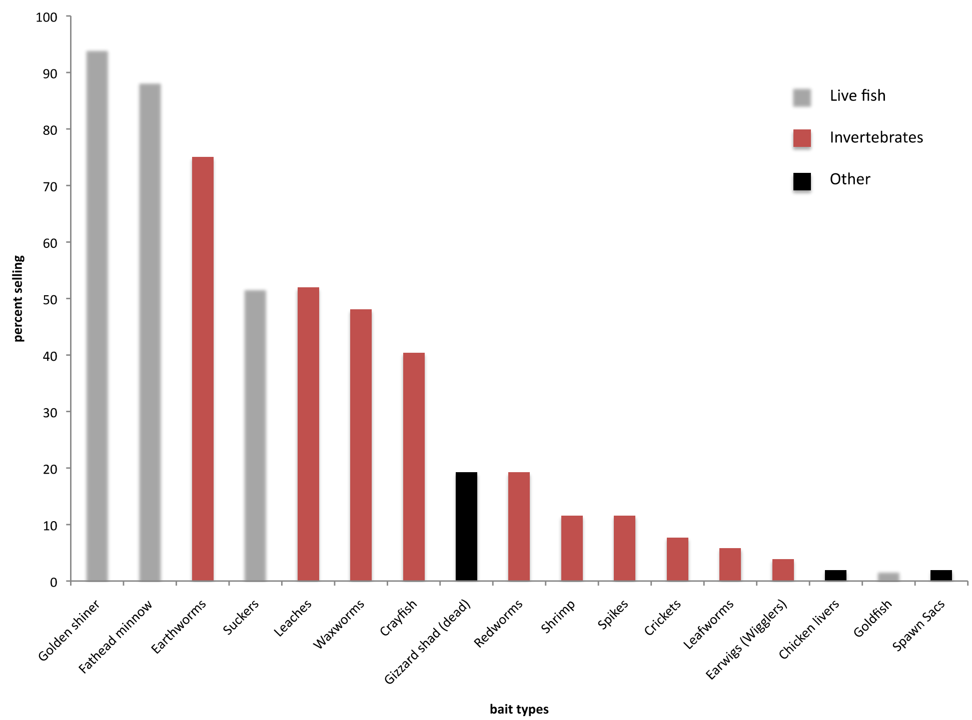


Figure 4: The distribution of available bait in the Chicago area

Tank conditions

Bait shops in the Chicago area maintain, on average, two bait tanks. Most bait shops utilized recirculating tanks with filtered water, and the water in the tanks is replaced at regular intervals, which varies between shops from daily to weekly, Most bait tanks are chemically treated to reduce disease spread, algal growth, and/or remove chlorine.

Of the 94 tanks from 52 shops visited, volume could only be calculated from three-dimensional measurements for 30 tanks in 21 shops (only two-dimensional measurements were recorded for all of the other tanks). Five tanks from three shops had large volumes (>500 l), so they were not included in the final average tank size calculation. The average tanks volume was 155 l (SD 64 l). Many of the tanks were fashioned out of utility wash-basins (~ 75 l, (Figure 1) or cattle troughs (~400 l). Bait holding tanks were routinely not filled to capacity with water. Tank conditions, volumes, and set up information was used in the design of the calibration experiments.

Visual inspection and detection of bait contaminates

No bighead or silver Asian carp were observed, but some tanks contained tadpole (4), green sunfish (*Lepomis cyanellus*) (2), goldfish (1), or brook sticklebacks (1). Employees also reported brown bullhead (*Ameiurus nebulosus*), sticklebacks, sunfish (*Lepomis sp.*), perch (*Perca sp.*), largemouth bass (*Micropterus salmoides*), tadpoles, and bluegills (*Lepomis macrochirus*) as the most common contaminate species. As part of the bait stock used in the calibration studies, brook stickleback was the only contaminant found (~1% abundance, n=22 of more than 1800 minnows).

Invasive species awareness and concern

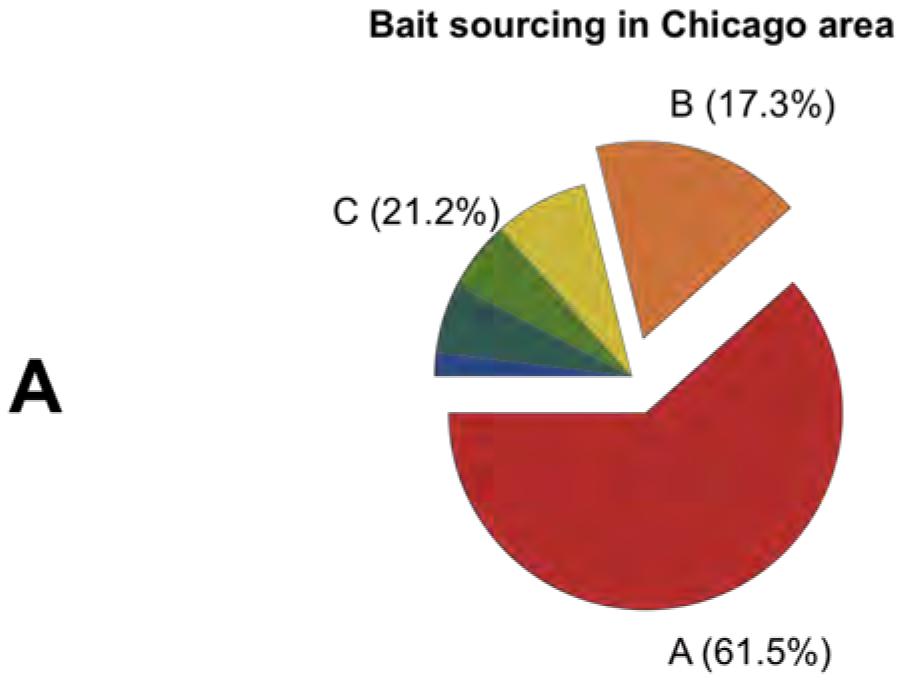
The majority of bait shop employees indicated that they are aware of invasive species issues (90%), yet only 33% of bait shops had posted signs or provided educational materials on invasive species awareness/concern. The “Stop Aquatic Hitchhikers” campaign is one notable out-reach program. Although 61% of employees recognized the program, only 21% of bait shops had a Stop Aquatic Hitchhikers display placard.

Asian carp have been a high profile invasive species in the Chicago area for the last two years. When asked, employees from 27 shops (52%) indicated they would be able to identify a juvenile Asian carp, and two of these employees expressed the need for a reference to be confident in the identification. More than half of bait shops (52%) had posters or handouts instructing fishermen to avoid dumping their bait into local waterways.

Wholesale sources of live bait

Of the 52 stores visited, the majority of bait shops sourced their bait (78.8%) from two wholesalers (Figure 5A; wholesalers A & B). Wholesaler A resides in southeast Wisconsin, while wholesaler B resides in northern Illinois. The remaining wholesalers are spread throughout the region, including at least one wholesaler from Indiana. No wholesalers outside of Wisconsin, Illinois, or Indiana were identified as a primarily bait source for any of the shops visited. The secondary connection of wholesalers is unknown, so many of the wholesalers found in the C grouping may ultimately source their bait from wholesalers A or B.

Although two wholesalers supplied the majority of bait shops, the perception of bait contamination by the retailers varied among shops. The most notable finding was an increased abundance of contamination in the spring, when juvenile game and non-target fish are relatively the same size as bait species (Figure 5B). Visual inspections of the tanks confirmed what the shop owners expressed, there are relatively very few contaminants identified in the bait stocks (for this 2010 screening effort). In repeated visual inspections of the Chicago area bait trade, no bighead or silver carp contaminants have ever been discovered, and to date, no reports of bait contamination by fishermen, bait shop owners, or wholesale bait suppliers have been provided to the Illinois DNR (Vic Santucci, pers. comm.)



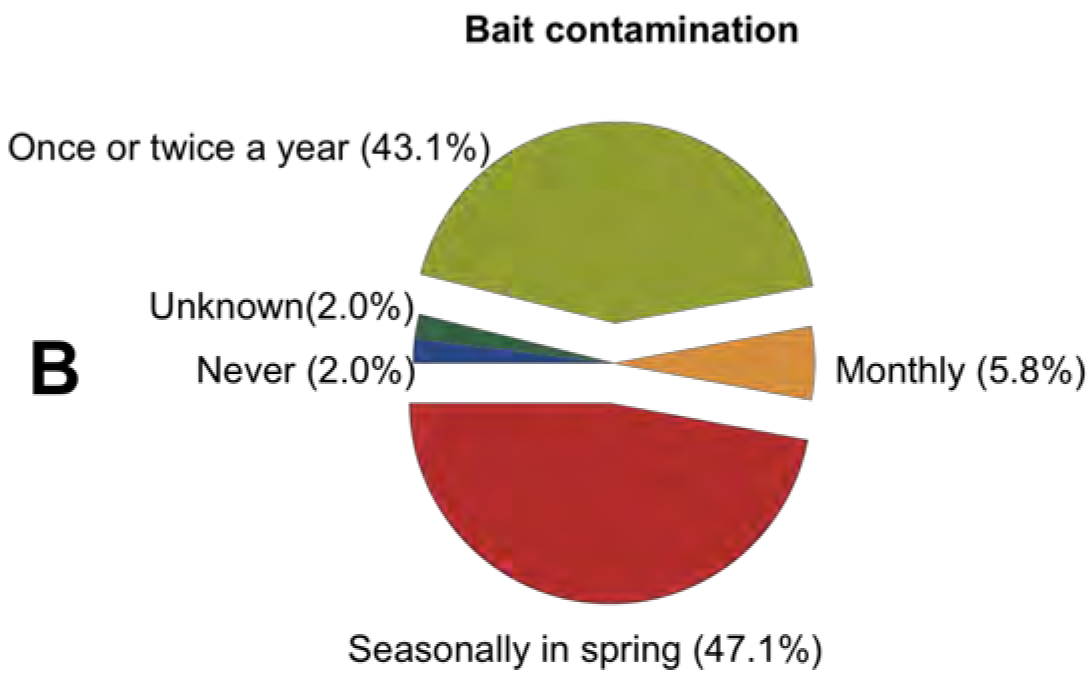


Figure 5: (A) The majority of shops sell bait from two wholesalers (labeled A & B). Wholesaler A is located in southeastern Wisconsin where wholesaler B is in northern Illinois. Wholesalers grouped into category C are from northeastern Illinois and northwestern Indiana. All wholesalers identified in this questionnaire are within 161 kilometers (100 miles) of Chicago's city center. (B) Retailers noted that contamination was uncommon in bait shipments, but most often occurred in the spring. No relationship between bait source (wholesaler) and frequency of contamination to retailers was observed.

Environmental DNA screening of bait shops

All water samples collected (n=136) as part of the bait shop inspection effort were screened for bighead carp, silver carp, and goldfish. No bighead or silver carp DNA was detected in any of the samples. However, goldfish DNA was detected in 21 samples (15%). Goldfish was identified visually as a contaminant in only one tank, which was also identified using environmental DNA (the technician reporting the result was blind to the questionnaire results). Over 4,000 PCR reactions were conducted for this project as part of the eDNA protocols (Mahon et al. 2010).

Calibration studies

Similarity between target and bait

The calibration studies were performed using goldfish and available bait species (fathead minnows and golden shiners). The length of the bait species was significantly longer than the goldfish (t-test; p<0.01), but the mass was not (t-test; p=0.62). Table 3 provides details of the comparisons.

Table 3: Length and weight statistics for target (goldfish) and bait species.

	Goldfish (n=29)		Minnow (n=25)	
	Length (cm)	Weight (g)	Length (cm)	Weight (g)
Mean	3.2	1.23	4.54	1.31
Std. Dev.	0.45	0.61	0.57	0.55
Std. Error	0.084	0.11	0.11	0.11

Goldfish only

For all goldfish only trials, the initial test (t=0) of the bait tank water was absent of any goldfish DNA. Across densities of 1 fish per 50 l (Figure 6A), 1 fish per 25 l (Figure 6C), and 1 fish per 35 l (Figure 6E), positive detection occurred immediately following introduction (first sample taken at t=1 hour), even in the large capacity holding tank (Figure 6E). This result is consistent with previous environmental DNA calibration studies with koi (Jerde et al. 2010). However, with one goldfish, there were type II errors (false negative detections) recorded through time. On five occasions of 12 total, the eDNA method failed to detect presence of the goldfish. As such, the probability of a type II error was approximately 0.4. It should be noted that observational records of the goldfish in question during this study indicate the fish was relatively inactive compared to the other experimental trails. In contrast, the other two densities of goldfish had no type II errors (0%) – environmental DNA always detected the target fish. Samples from each tank, taken at t=105 hours and t=121 were extracted at the same time and showed absence of DNA, resulting in no detection. These false negatives were due to a process error in the DNA extractions of these samples and were eliminated from the results. No samples collected concurrently from the control basin (two sticklebacks present) tested positive for goldfish DNA (n=14).

After goldfish from all basins were removed, the water was repeatedly sampled to quantify the persistence of eDNA signal. Across all densities in goldfish only tests, no samples tested positive after 84 hours (Figures 6 B, D, & F). One sample, collected from a control basin (no target species present) tested positive for goldfish DNA during the degradation experiment at *t*=83. It is believed this sample was mislabeled with the ten goldfish sample, but this cannot be confirmed and cross contamination between tanks cannot be ruled out. This is the only known instance of a positive detection in the absence of target organism. At the end of the degradation study in the 50 liter basins (up to seven days), all of the remaining water was filtered (approximately 20 l) and 20 liters was filtered from 350 liter trough. None of the final samples tested positive for goldfish DNA.

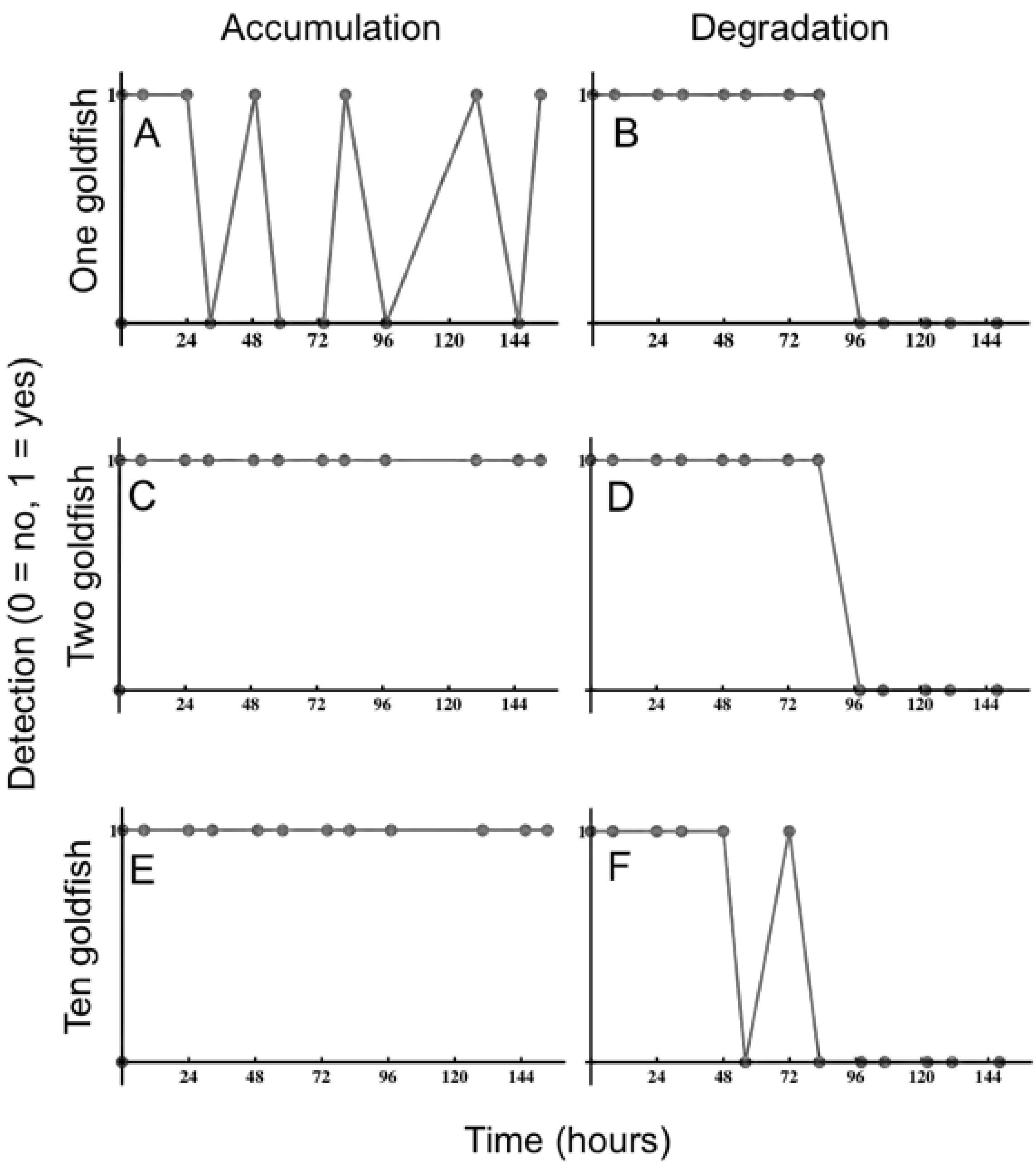


Figure 6: Goldfish only trials of DNA accumulation and degradation. Panel A shows variability in detection through time when only one goldfish is present, and panel B shows the degradation of the signal within 84 hours after the goldfish is removed. Detection of two (C) and ten (E) goldfish occurs immediately after introduction (*t*=1) and the signal degrades within the same 84-hour window (D & F).

Goldfish and bait

10 goldfish to 50 baitfish

When 10 goldfish were introduced to 50 baitfish in 50 l of water, detection occurred within one hour (*t*=1), and there was no indication of contamination from the pre-goldfish addition sample (*t*=0; Figure 7A). The positive detections continued until hour 24 and was not detected again until hour 120. In total, three samples of 13 collected were negative while goldfish were present. The type II error (false negative detections) probability from this trial was (0.23; Figure 7E). The negative detections occurred when there was a drop in the DNA:protein absorption ratio with the lowest recorded ratio occurring at hour 72 (0.98). This type of inhibition of signal has been previously reported in the literature (Glasel 1995) and is summarized in Supplementary Table 1.

The degradation phase had positive detection occurring only to hour four (*t*=4), with no positives detections thereafter, including at hour 144, when all the remaining water in the experimental tank was filtered and screened (Figure 7B). All DNA:protein absorption ratios were above one throughout the degradation phase (Figure 7F). One notable fish die-off event of minnows (28 individuals) occurred at hour 48 (Figure 7D). Those minnows were replaced and the experiment continued.

2 goldfish to 50 baitfish

The 2 goldfish to 50 baitfish experimental trail paralleled the results of the 10 goldfish to 50 baitfish trial in almost every way: detection occurred within one hour (*t*=1), there was no indication of contamination from the pre-goldfish addition sample (*t*=0), and a total of three samples failed to detect the presence of goldfish resulting in a type II error probability of 0.21 (Figure 8A). The failure to detect spanned a time from 48 to 102 hours, which corresponded to the lowest measured DNA:protein absorption ratios measured during the experimental trial (Figure 8E) and also to the non-target fish mortality event (Figure 8C).

The degradation phase had positive detection occurring only to hour four (*t*=4), with no positives detections thereafter, including at hour 144, when all the remaining water in the experimental tank was filtered and screened (Figure 8B). All DNA:protein absorption ratios were above one throughout the degradation phase (Figure 8F). There were very few minnows lost in this experimental trial overall (Figures 8C & D).

10 goldfish to 350 baitfish

Similar to previous trials, when 10 goldfish were introduced to 350 baitfish in 50 liters of water, detection occurred within one hour (*t*=1), and there was no indication of contamination from the pre goldfish addition sample (*t*=0; Figure 9A). The positive detection continued until hour 24 and then was not detected again until hour 72. In total, two samples of 14 collected were negative while goldfish were present. The type II error probability from this trial was (0.14). The negative detections occurred when there was a drop in the DNA:protein absorption ratio (Figure 9E) .

The degradation phase similarly had positive detection occurring only to hour four (*t*=4), with no positives detections thereafter, including at hour 144, when all the remaining water in the experimental tank was filtered and screened (Figure 9B). All DNA:protein absorption ratios were above one throughout the degradation phase (Figure 9F). This trial had characteristically large baitfish mortality throughout. No baitfish were present or replaced in the tank after hour 48 (Figure 9D).

2 goldfish to 350 baitfish

When 2 goldfish were introduced to 350 baitfish in 50 liters of water, detection occurred within one hour (*t*=1), and there was no indication of contamination from the pre goldfish addition sample (*t*=0; Figure 10A). The positive detection continued until hour 48 and then was not detected again until hour 120. In total, three samples of 14 collected were negative while goldfish were present. The type II error probability from this trial was 0.21. The negative detections occurred when there was a drop in the DNA:protein absorption ratio (Figure 10E).

The degradation phase similarly had positive detection occurring only to hour four (*t*=4), with no positives detections thereafter, including at hour 144, when all the remaining water in the experimental tank was filtered and screened (Figure 10B). All DNA protein absorption ratios were above one throughout the degradation phase (Figure 10F). This trial had characteristically large baitfish mortality throughout (Figure 10C & D). No baitfish were present or replaced in the tank after hour 48 (Figure 10D).

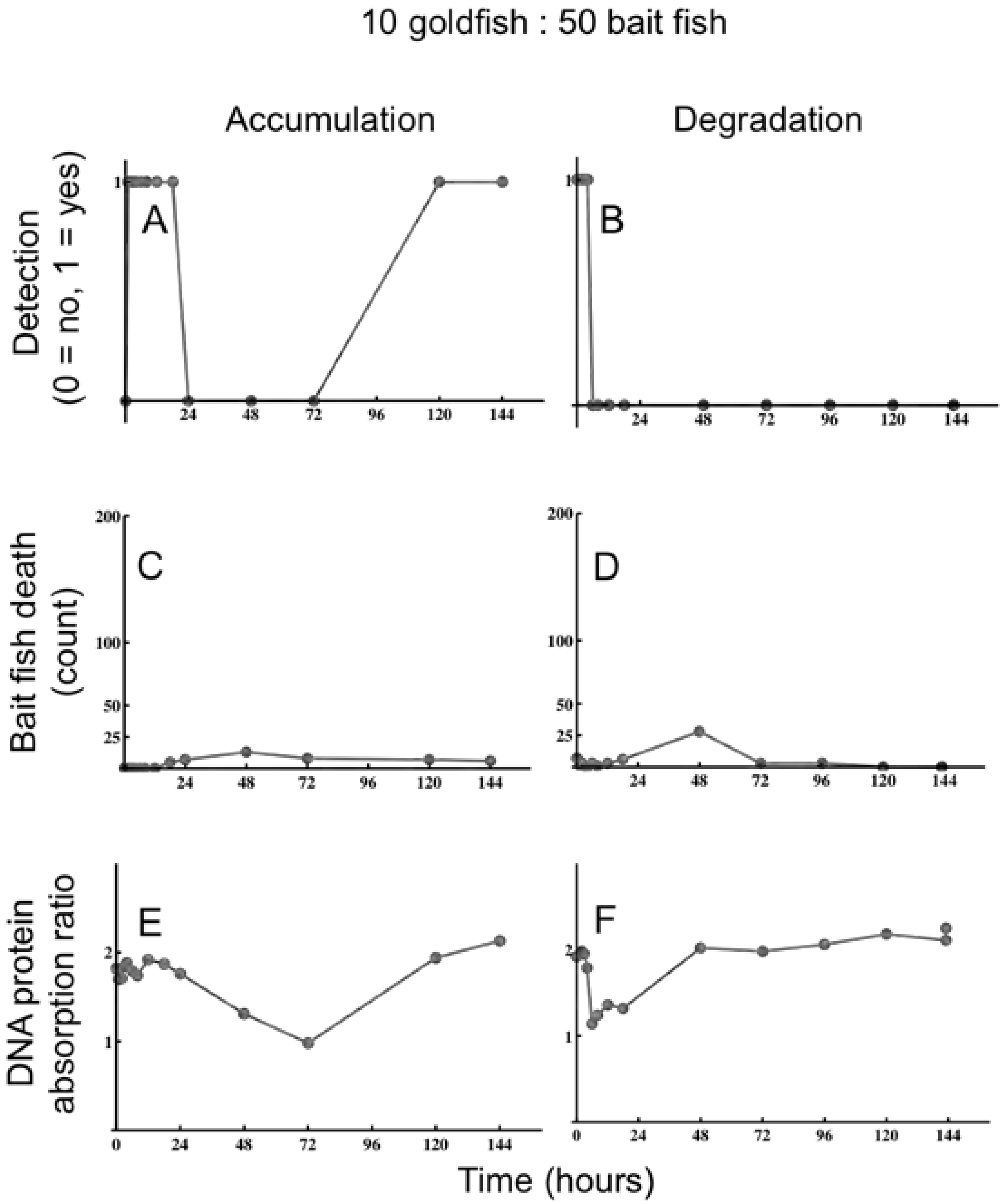


Figure 7: Calibration results for accumulation and degradation of DNA trial of 10 goldfish (target) to 50 baitfish (non-target).

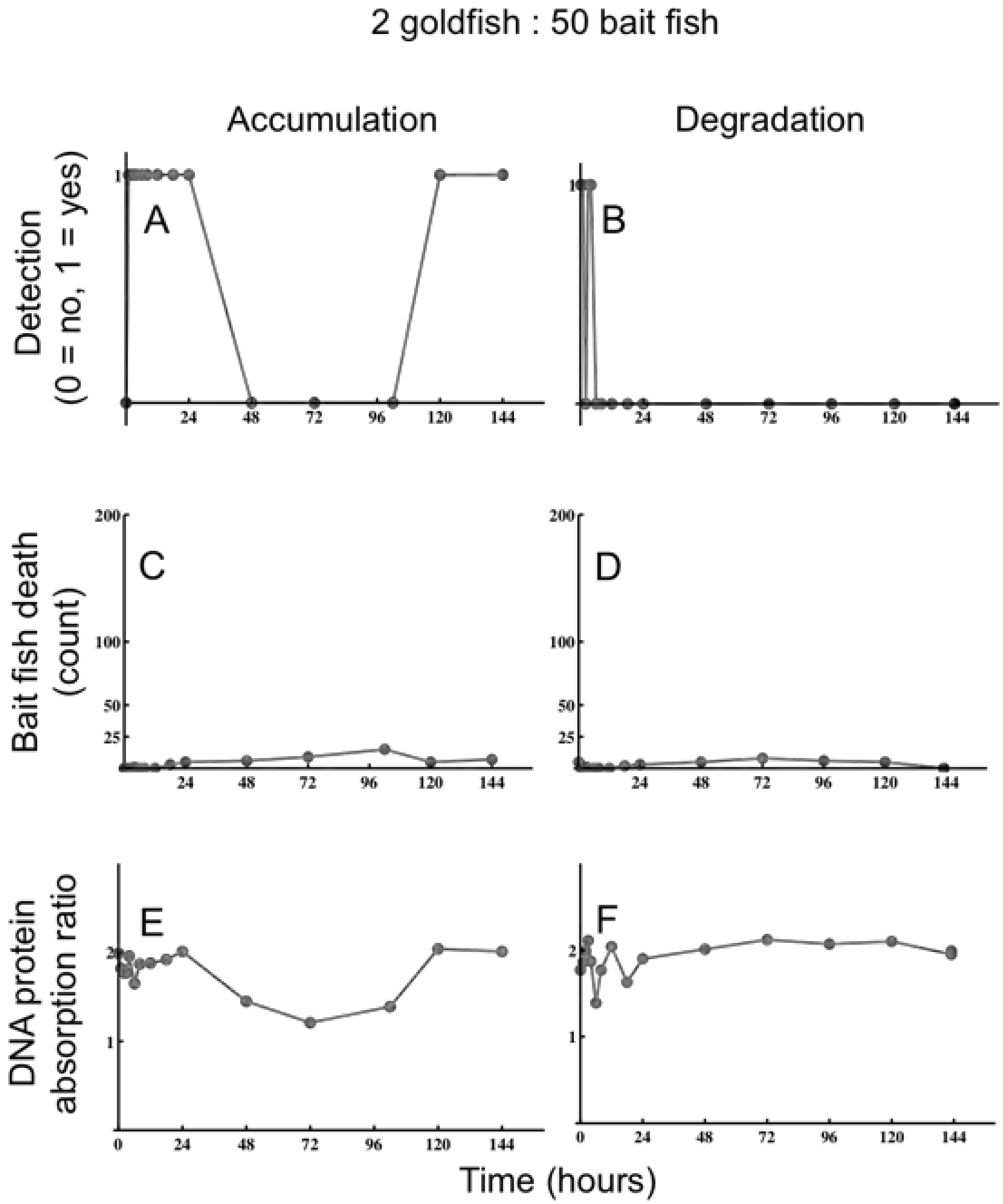


Figure 8: Calibration results for accumulation and degradation of DNA trial of 2 goldfish (target) to 50 baitfish (non-target).

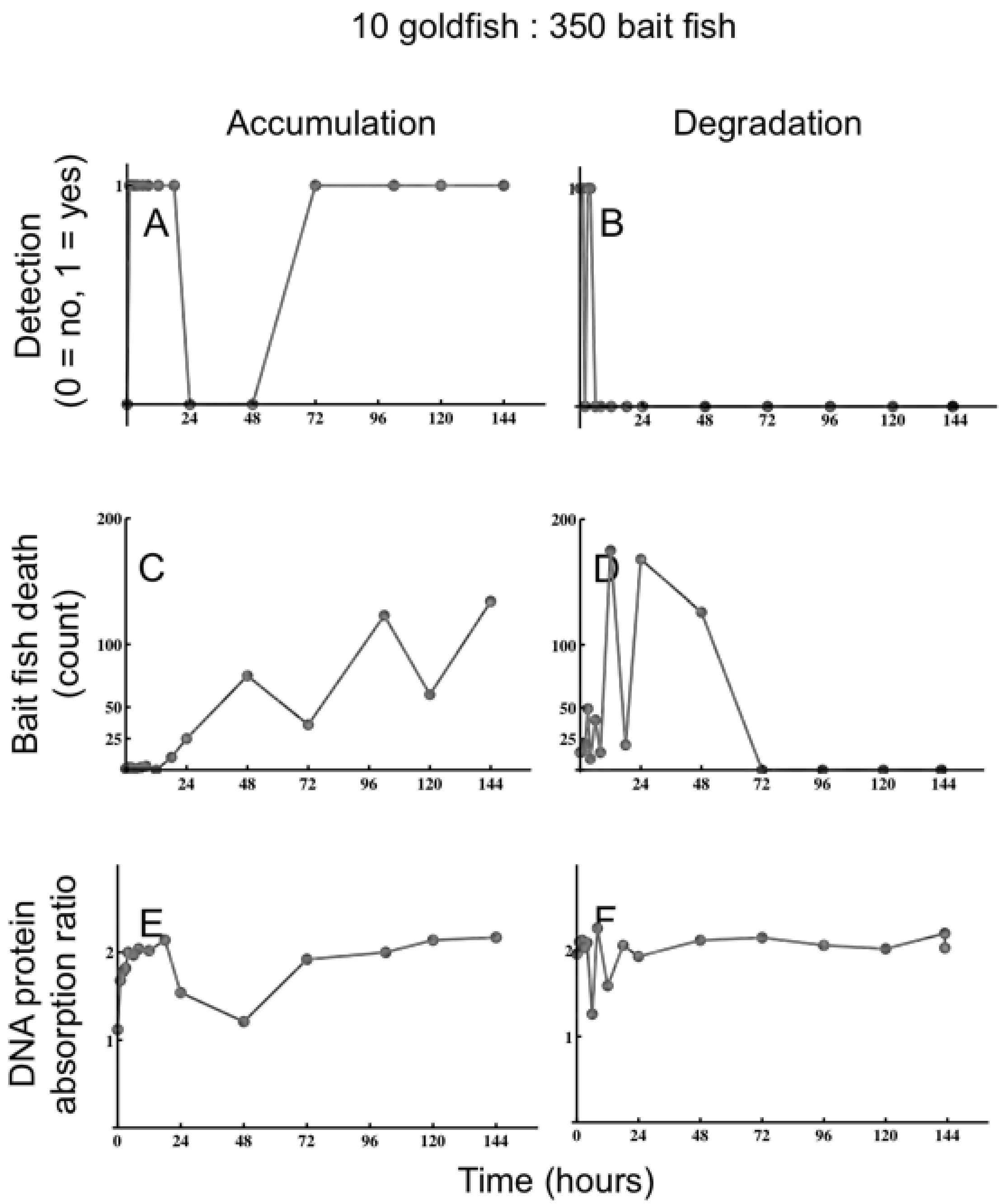


Figure 9: Calibration results for accumulation and degradation of DNA trial of 10 goldfish (target) to 350 baitfish (non-target).

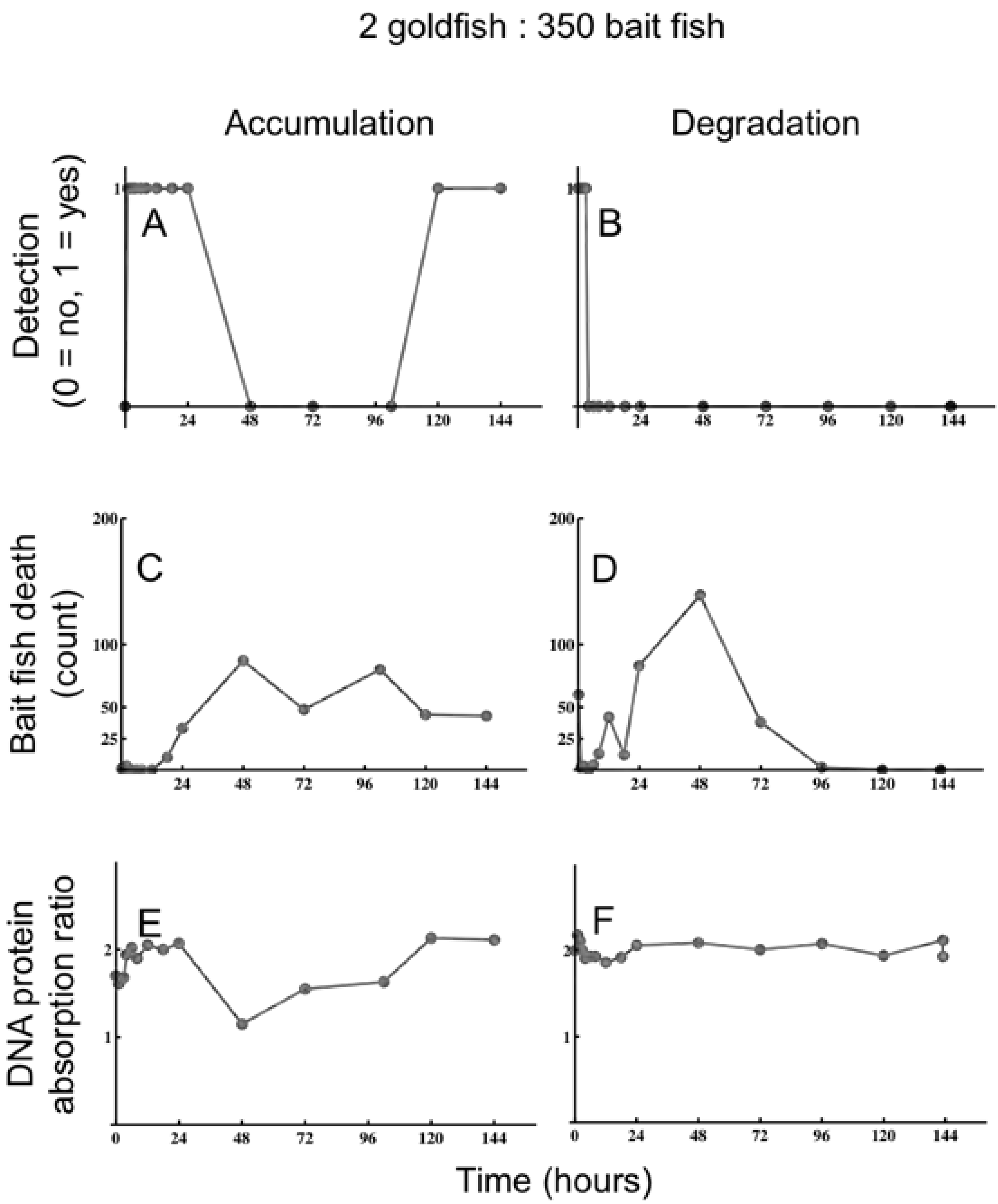


Figure 10: Calibration results for accumulation and degradation of DNA trial of 2 goldfish (target) to 350 baitfish (non-target).

Discussion

No Asian carp were found, and no Asian carp DNA was detected in the Chicago area bait trade. Although the bait trade has been proposed as one of the alternative pathways leading to Asian carp establishment in the Great Lakes (ACRCC 2010, USACE 2010), currently no evidence exists that this pathway poses an immediate threat. In our study, we worked with IDNR fisheries managers to inspect the bait shops and record critical information for further development and refinement of a bait trade surveillance program, which may include continued application of environmental DNA. Where the bait shop surveillance results for Asian carp allow for cautious optimism that the bait trade is not, or at least not yet (see management recommendations), a critical vector of Asian carp introduction, the calibration studies reveal that environmental DNA has the potential to be a helpful tool for continued surveillance efforts because of its sensitively and reliability in detecting targeted species at low density.

Although visual inspection and eDNA surveillance did not detect any Asian carp in the Chicago bait trade, other contaminants were discovered (i.e. goldfish, tadpoles, and sticklebacks) and the more general concern about rapid and wide spread movement of species through the bait trade remains (Keller et al. 2007). Because bait is largely and regularly sourced from a limited number of wholesalers (78.8% from two wholesalers), and retailers go to great lengths to ensure the health of live bait to increase profits, and anglers tend to dump any unused bait into their fishing destination (Litvak & Mandrak 1993), the potential exists that if Asian carp make their way into the wholesale bait trade, then Asian carp will be rapidly spread throughout the region. As such, the most significant management recommendation emerging from this work is the need to regularly and continually monitor for contaminated wholesale bait stocks using a variety of methods at the bait rearing (aquaculture), fish hauling, wholesale, retail, and private angler levels of this bait trade pathway.

The questionnaire results further highlight the potential risk of the bait trade pathway for invasive species, and in particular Asian carp, dispersal. Although most of the shop owners and employees are aware of the Asian carp threat to the Great Lakes, approximately half thought they could recognize a juvenile Asian carp in contaminated bait. As the persons most likely to encounter contaminants, and without a regular and formal bait trade surveillance plan, there is a pressing need for education and outreach at retail stores and an incentivized system for reporting contamination – particularly if the owners and employees can identify targeted invasive species. Additionally, bait shops did not have materials about invasive species, or the perils of bait deposits at the fishing destination, readily available or displayed. Recommendations to address education and outreach needs are detailed in the following section.

Target species were detectable within one hour of introduction in all trials, except negative controls. In contrast, when the target species was removed, the eDNA signal persisted up to three days when only target fish were used, but that persistence diminished to less than four hours in trials with moderate densities of bait present. Although there is a need to reduce the false negative error rate to improve the reliability of eDNA testing, it is clear that if eDNA indicates the presence of a target species, individuals are present or were present in the very near past. Previous studies have shown the positive correlation between target organism abundance and positive eDNA detections (Ficetola et al. 2008, Andersen et al. 2011, Thomsen et al. 2012), but here, because the fish density was manipulated, error probabilities, which are critical for management (Darling & Mahon 2011), were estimated for all trials.

Environmental DNA exists in a complex cycle involving biotic and abiotic influences on persistence and degradation (Levy-Booth et al 2007), and an improved understanding of this cycle will reduce errors in interpreting eDNA results, particularly with respect to variability in type II errors. In this study, we evaluated the eDNA protein absorption ratio. In instances of the accumulation phase, where type II errors occurred, there was a decrease in the DNA protein absorption ratio, indicating much less DNA was extracted from the sample (Glasel 1995). The mechanism leading to this decreased DNA extraction is currently unknown, but future studies should evaluate samples to ensure DNA is present. Samples with low DNA concentrations (<1 See supplementary Table 1) should be flagged as potentially leading to false negatives (type II errors).

This study covered less then 15% of the estimated 400-600 bait shops on the southern shoreline of the Great Lakes and employed traditional (visual inspection) and indirect (environmental DNA) surveillance tools. From the results, we suggest the Chicago bait trade pathway is not a significant vector of Asian carp introduction into the Great Lakes, but this conclusion is without widespread regional and seasonal testing. With the following management recommendations, we outline a number of actions that would strengthen the conclusion with respect to the bait trade threat and would ultimately protect the Great Lakes from Asian carp and other non-indigenous species damages.

Management recommendations for future bait trade sampling

Regional surveillance of bait wholesalers

Data collected in Chicago indicates that the majority of bait is sourced from a small number of wholesales, and that bait is being moved across state boundaries. A regional surveillance program focused on wholesalers, which included multiple seasonal surveys of these sources, would provide a far more comprehensive assessment of the risks posed by the bait pathway. We recommend that priority be given to bait wholesalers whose facilities are located in close proximity to areas known to support juvenile Asian carp (e.g. southern Illinois River, central Mississippi River) or waterways with other high-risk invasive species (e.g. black carp, snakehead). Wholesalers in the central Mississippi watershed should be of primary concern. Additionally, the risk posed by fish haulers moving bait into the Great Lakes Region, from southern or eastern states, should also be assessed where access to wholesalers or bait aquaculture facilities is not possible.

High risk bait retailers

To account for the risk posed by retailers that augment their bait stocks with locally caught, seasonal fish, regional surveillance of wholesalers should be coupled with targeted surveys of bait retailers located in high-risk areas. High risk should be defined in this case as areas in close proximity to potential sources of bait contamination (e.g.

juvenile Asian carp), or areas close to waterways containing irreplaceable values that are vulnerable to invasive species (e.g. inland waters free of introduced species). However, the assumption that Asian carp are more likely to be present in the bait trade in regions where wild populations are already abundant needs to be tested. If bighead and silver carp are present in the bait trades in southern and central Mississippi River states, it would suggest the potential threat posed by Asian carp in Northern Illinois and other southern or western Great Lakes states will increase as these species continue to invade upstream. Surveillance needs are therefore likely to shift closer to the Great Lakes as populations increase upstream.

Survey timing

Surveillance effort should be timed for late spring or early summer when juvenile Asian carp are known to be present in natural waterways (Shrank et al 2001, Kolar et al. 2007). Under reasonable food conditions, Asian carp should grow quickly and be more readily identified as they become larger, so there is presumably a limited window during which we might expect to see juvenile Asian carp in the bait trade (Although this hypothesis should also be tested). Bait collected in late spring or early summer probably poses the greatest risk of containing juvenile Asian carp. However, the time during which other high-risk species of concern are likely to be present and accessible to bait collectors needs to be identified. An advantage of the eDNA method, is that the same sample can be tested for multiple species (Jerde et al. 2011, Darling and Mahon 2011).

Reporting and bait tracking system

Surveillance efforts would be enhanced by regulating the need for mandatory tracking and reporting by retail and wholesalers of the sources of all bait. Access to data on where bait is being sourced would both enable high risk bait collection practices or potential regional sources to be identified, and the source of any contaminants detected from eDNA or visual inspections to be traced – as demonstrated with the adoption of similar tracking and reporting requirements following the outbreak of Viral Hemorrhagic Septicemia (VHS) in the Great Lakes. A number of state agencies (e.g. Wisconsin DNR http://dnr.wi.gov/fish/vhs/vhs_wildbait.html, 22 April, 2011) established permit and certification processes that required licensed bait dealers to identify where wild bait was sourced, and that that bait be inspected before being sold. In the absence of government regulations, retailers should be encouraged to report contamination, and adopt an industry certification process that identifies bait free of invasive species.

Management of non commercial (personal) bait

Retail and wholesale bait surveillance does not account for the risk posed by bait collection for personal use. Efforts to conduct surveillance should be met with outreach, education, inspections, and regulation. Rules that were established to prohibit movement of water and live fish between water bodies, to prevent the spread on VHS (http://www.dnr.state.il.us/legal/adopted/875.pdf) could equally be effective at preventing the inadvertent movement of juvenile Asian carp or other invasive species as live bait by recreational fishers, but must be met with some enforcement to be effective.

Supplementary materials

Bait shop questionnaire

General information

Inspector Name (s):____________________________________ Time:______________
Date:________________

Shop Name:____________________________
Address:____

eDNA sample information

Sample ID	Size of bait	Type of bait	Tank Dim.	Type of tank: (flow through, recirculation)	Notes: location in shop, water quality, dead bait present

Notes:

Is the water filtered? ____________ Is the water replaced regularly? __________________

Do they treat the water with any chemicals?_________________________ How often?______________

How many tanks are in the shop?_________________________

Where (or from whom) is the bait purchased?

Is the water shared between tanks?_______________ Where is the water sourced from?_____________

How often is bait contaminated with other species? _________________________________

Do you have any system for checking for contaminated bait?
____________Explain_______________________

Could you identify a Juvenile AC?__________________

Economics

Would the shop person advertise "Asian carp free certified bait?" Yes/No

Is the shop owner not / somewhat / very concerned about Asian carp?

How much profit is made on a dozen minnows?______________

Types of Bait and purchase prices

Type	Alive ($)	Dead ($)	Source (date of recent shipment)
Minnows			
Gizzard shad			
Earthworms			
Crayfish			
Insects (beetles, crickets, meal worms)			
Leeches			
*			

Is there any other bait sold in the shop but not present today:________________? Add to table*

How many minnows are purchased in a shipment?___________ Shipments per year?____________

Are live gizzard shad ever sold in the shop:_______________? Source_____________?

Do you collect bait from local (Wisc, Ill, Ind) waters?_____________

Education and Outreach

Is there any invasive species signage up in the bait shop? Yes/No

Was there a "Stop Aquatic Hitchhikers" sign posted? Yes/No

Was the shop person aware of the Stop Aquatic Hitchhikers campaign? Yes/No

Was the person interviewed aware of invasive species issues? Yes/No

Was there any information available (leaflet, sign) about what to do with unused bait? Yes/No

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Follow up and results

Would the owner and/or person interviewed be willing to answer follow-up questions: Yes/No

Bait shop owner:__________________________ Contact:____________________________________

Bait shop employee interviewed:___________________________

Contact:_____________________________

Supplementary Table 1. DNA purity in relation to protein concentrations in samples as examined by 260/280nm absorbance ratios. Adapted from Glasel (1995).

% DNA	% Protein	260/280nm ratio
100	0	2.00
95	5	1.99
90	10	1.98
70	30	1.94
30	70	1.73
10	90	1.32
5	95	1.06
0	100	0.57

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Appendix D. Bighead Carp in Illinois Urban Fishing Ponds report (IDNR 2011).

Illinois Department of Natural Resources
Division of Fisheries
Aquatic Nuisance Species Program

Bighead Carp in Illinois Urban Fishing Ponds

December 2011

Bighead Carp in Illinois Urban Fishing Ponds

The Illinois Department of Natural Resources (IDNR) fields many public reports of observed or captured Asian carp. All reports are taken seriously and investigated through phone/email correspondence with individuals making a report, requesting and viewing pictures of suspect fish, and visiting locations where fish are being held or reported to have been observed in the wild. 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 or silver carp from valid sources and locations where these species are not known to previously exist elicit a sampling response with boat electrofishing gear and trammel or gill nets. Typically, no bighead or silver carp are captured during sampling responses. However, this pattern changed recently when several very large bighead carp (>48 pounds) were captured by electrofishing and netting in Flatfoot Lake, an urban fishing pond located in Cook County.

Flatfoot Lake

Flatfoot Lake is a 19-acre borrow pit pond located in Beaubien Woods Forest Preserve on Chicago"s south side. It has a maximum depth of 15.4 feet, although much of the pond is <5 feet deep. The south bank is 900-1,200 feet north of the Little Calumet River. A raised railroad track runs between the pond and river separating the two water bodies. A visual site inspection by IDNR and Forest Preserve District of Cook County (FPDCC) staff on 21 September 2011 indicated that no surface water connection exists between Flatfoot Lake and the Little Calumet River. Flatfoot Lake is in the IDNR Urban Fishing Program and it has been stocked with catchable-sized channel catfish and hybrid sunfish annually for more than a decade.

Responding to a report of very large fish suspected of being Asian carp, IDNR biologists sampled Flatfoot Lake with DC electrofishing gear and trammel nets on 20 September 2011. Over 3.5 hours of electrofishing and netting resulted in the capture of 14 bighead carp that measured between 46.4 and 50.9 inches total length and weighed over 48 pounds. All but one of the fish was caught by electrofishing. Four large grass carp also were captured and removed. Biologists observed three additional bighead carp that avoided capture during this initial removal effort.

The pond was again sampled with DC electrofishing gear and gill nets for 3.0 hours on 27 September. In this effort, an IDNR Asian carp crew and FPDCC biologists captured and removed two bighead carp that each weighed 76 pounds. A third bighead carp was observed, but not captured. On 29 September, IDNR and forest preserve biologists made another attempt to capture remaining bighead carp in the pond. Approximately 3.0 hours of gill netting and electrofishing caught no fish, but a single bighead carp was again sighted.

On 1 November 2011, the IDNR crew, forest preserve biologists, and a contracted commercial fishing crew electrofished and trammel netted in Flatfoot Lake for 30 minutes targeting remaining Asian carp. One bighead carp measuring 50.1 inches total length and weighing 80 pounds was captured and removed, as was a 65 pound grass carp. In total, 10.0 hours of DC electrofishing and trammel/gill netting over four days resulted in the capture and removal of 17 bighead carp and five grass carp from Flatfoot Lake. No additional bighead carp are thought to be present in the pond at this time based on combined sampling results from conventional gears.

Other Urban Fishing Ponds in the Chicago Region

Biologists from IDNR and FDDCC sampled two additional Cook County ponds included in the IDNR Urban Fishing Program on 28 September 2011. Cermak Quarry is a 3-acre reclaimed quarry pond that has a maximum depth of 18 feet and Schiller Pond is a 6-acre dug pond with a maximum depth of 6.3 feet. Both are located adjacent to the upper Des Plaines River, but outside of the 100 year flood designation. Neither pond has a direct connection or overflow to the river. Even if they did, they would not pose an immediate threat to the CAWS or Lake Michigan because the Des Plaines River confluence with the Chicago Sanitary and Ship Canal (CSSC) is in the Brandon Road Pool over 6 miles downstream from the Dispersal Barrier.

Approximately 1.0 hour of gill netting and electrofishing at Cermak Pond caught no bighead or silver carp, nor were any observed during sampling. In contrast, three bighead carp were caught and removed from Schiller Pond after 2.0 hours of gill netting and electrofishing. These carp all were large adults that weighed 56, 60, and 62 pounds. No additional bighead or silver carp were seen during sampling and none are thought to be present in either pond based on conventional sampling.

As a further response to the bighead carp in Flatfoot Lake and Schiller Pond, IDNR reviewed Asian carp captures in all urban fishing lakes located in the Chicago Metropolitan area (Figure 1). Of the 21 urban fishing lakes in the program, five have verified captures of bighead carp either from sampling, pond rehabilitation with piscicide, or natural die offs; two had reported sightings of Asian carp that were not confirmed by sampling (Table 1). The distance from urban fishing ponds to Lake Michigan ranged from 0.1 to 25.7 miles. The distance from ponds to Chicago Area Waterway System (CAWS) waterways upstream of the Dispersal Barrier ranged from 0.01 to 5.1 miles. Although some ponds are located near to Lake Michigan or CAWS waterways, most are isolated and have no surface water connection to the Lake or CAWS upstream of the Dispersal Barrier (Table 1). Lagoons in Gompers Park, Jackson Park, and Lincoln Park are the exceptions. The Lincoln Park South Lagoon is no longer a potential source of Asian carp because the fish population was rehabilitated in 2008, after which it was dropped as a Chicago urban stocking site. Gompers Park Lagoon and Jackson Park Lagoon have never had a report of Asian carp, nor have any been captured or observed during past sampling events. Nevertheless, fishing ponds close to CAWS waterways (Gompers Park Lagoon) or Lake Michigan (Jackson Park Lagoon, Washington Park Lagoon) should be examined for the presence of Asian carp as soon as possible because of the increased likelihood of human transfers of fish between waters within close proximity to one another.

Otolith Microchemistry and Aging

Otolith microchemistry analysis uses stable isotopes and strontium:calcium ratios (Sr:Ca) from fish otoliths (inner ear bones) and ambient water to provide insights into the environmental history of fish (Whitledge 2009). Because fish deposit calcium and associated minerals from ambient water on otoliths as they grow, these structures can provide a record of the type of water that the fish has been residing in over time. Beginning in 2010, we removed heads from bighead carp obtained from Chicago area urban fishing ponds and transferred them to Dr. Gregory Whitledge at Southern Illinois University Carbondale (SIUC) for otolith microchemistry analysis. Heads were removed from three bighead carp from Columbus Park Lagoon, one from

Garfield Park Lagoon, 14 from Flatfoot Lake, and three from Schiller Pond. In addition, we removed post-cleithra bones from all carp, except one each from Columbus and Garfield parks, and forwarded them to SIUC for age determination. To date, results of Sr:Ca analysis are available for fish from the Columbus Park and Garfield Park lagoons and aging has been completed for the Columbus Park fish. Stable isotope analysis for these fish and complete otolith analysis and aging of Flatfoot Lake and Schiller Pond fish are on-going.

Dr. Whitledge (personal communication) reports that all of the fish examined to date showed a decline in Sr:Ca from initially high values in the otolith core (800-1200 umol/mol; within 50-150 microns of the otolith center) to a stable ~600 umol/mol thereafter out to the edge of the otolith. Otolith Sr:Ca of 600 umol/mol is consistent with what would be expected for a resident fish in these lagoons based on their water Sr:Ca (1.73 mmol/mol). These data indicate that the fish spent their early life in water(s) with higher Sr:Ca ratios and the remainder of their life as residence of the lagoons. The small proportion of the otolith with higher Sr:Ca ratios near the otolith center suggests these fish were transferred into the lagoons during age-0 or age-1. In addition, Dr. Whitledge found that the otolith core Sr:Ca values were too high to represent fish of Illinois River origin or other sites previously examined in northern Illinois (Whitledge 2009).

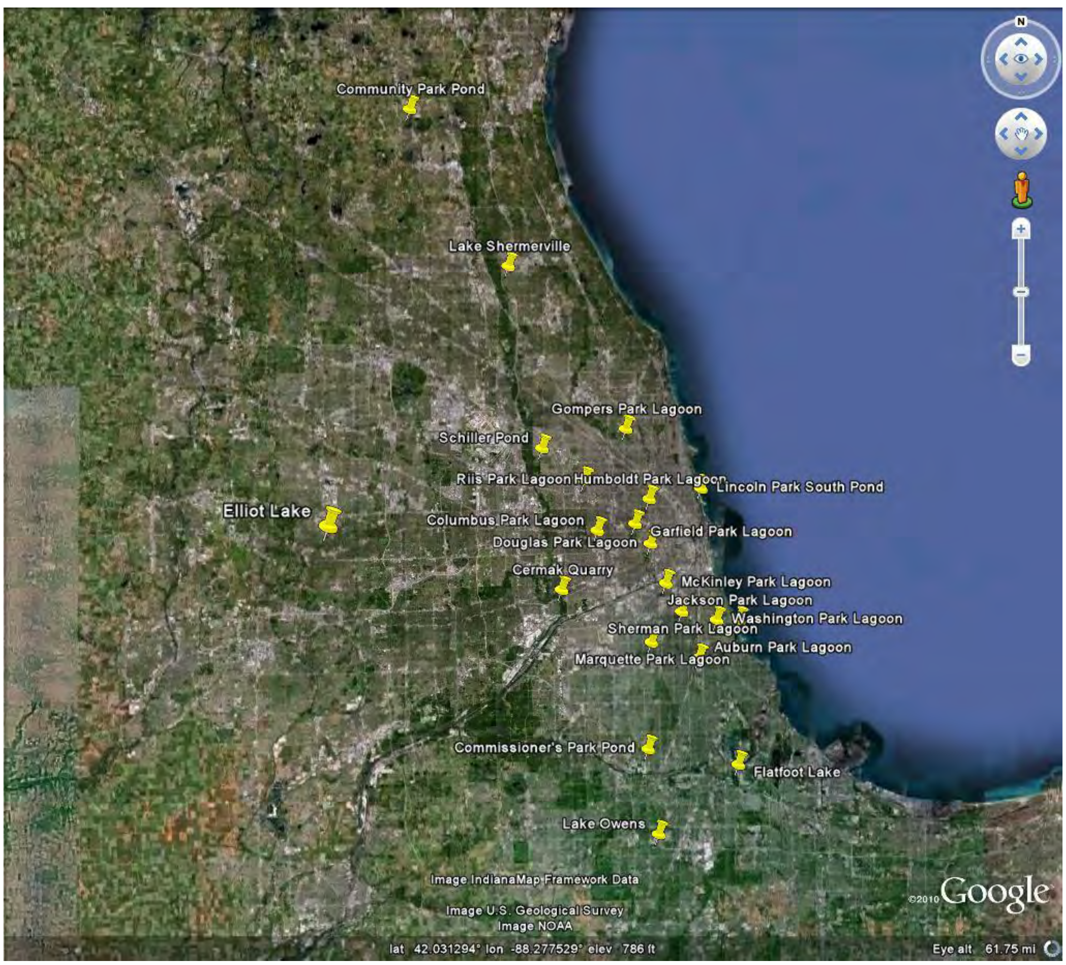

Figure 1. Locations of urban fishing ponds in the Chicago region.

Table 1. A list of Chicago area urban fishing ponds, reported and verified occurrence of bighead carp (all were large adults removed by indicated methods), proximity to Lake Michigan (LM) or the Chicago Area Waterway System (CAWS), and surface water connection to LM and CAWS. Silver carp have not been captured in any urban fishing ponds. Lincoln Park South Lagoon was dropped as an urban stocking site after 2008 pond rehabilitation. NR indicates none reported or observed/captured during routine AC electrofishing samples. DCEL is DC electrofishing and TN/GN is trammel/gill net. Waterways are: LM=Lake Michigan; CALSC = Cal-Sag Channel; CALR = Calumet River; CSSC = Chicago Sanitary and Ship Canal; NBCR = North Branch Chicago River; LCALR = Little Calumet River; Channel; BUBCR = Bubbly Creek; NSC = North Shore; DH = Diversey Harbor; and JH = Jackson Harbor.

Urban Fishing Pond	County	Town	Presence of bighead carp (number-year)	Distance to LM (miles)	Distance to CAWS (miles-waterway)	Surface water connection to LM and CAWS upstream of Dispersal Barrier
Commissioner"s Park Pond	Cook	Alsip	NR	9.7	0.9-CALSC	None
Auburn Park Lagoon	Cook	Chicago	NR	3.7	5.1-CALR	None
Columbus Park Lagoon	Cook	Chicago	3 winterkill-2011	7.8	4.1-CSSC	None
Douglas Park Lagoon	Cook	Chicago	NR	4.2	1.8-CSSC	None
Garfield Park Lagoon	Cook	Chicago	1 summerkill-2010	5.0	3.2-NBCR	None
Gompers Park Lagoon	Cook	Chicago	NR	4.1	0.01-NBCR	Overflow to NBCR
Humboldt Park Lagoon	Cook	Chicago	Reported, none sampled	3.8	2.2-NBCR	None
Jackson Park Lagoon	Cook	Chicago	NR	0.1	4.7-CALR	Overflow to JH
Lincoln Park South Lagoon	Cook	Chicago	3 pond rehab-2008	0.1	1.3-NBCR	Overflow to DH
Marquette Park Lagoon	Cook	Chicago	NR	6.3	4.2-CSSC	None
McKinley Park Lagoon	Cook	Chicago	Reported, none sampled	3.8	0.9-CSSC	None
Sherman Park Lagoon	Cook	Chicago	NR	3.6	1.9-BUBCR	None
Washington Park Lagoon	Cook	Chicago	NR	1.7	3.3-BUBCR	None
Riis Park Lagoon	Cook	Chicago	NR	7.7	4.8-NBCR	None
Flatfoot Lake	Cook	Dolton	15 DCEL-2011 2 TN/GN - 2011	5.0	0.2-LCALR	None
Lake Owens	Cook	Hazelcrest	NR	12.2	4.8-LCALR	None
Cermak Quarry	Cook	Lyons	None sampled	10.7	1.3-CSSC	None
Lake Shermerville	Cook	Northbrook	NR	6.6	4.8-NBCR	None
Schiller Pond	Cook	Schiller Park	3 DCEL-2011	10.1	7.1-NBCR	None
Elliot Lake	DuPage	Wheaton	NR	25.7	14.5-CSSC	None
Community Park Pond	Lake	Mundelein	NR	9.2	22.7-NSC	None

Post-cleithra analysis indicated the two bighead carp from Columbus Park Lagoon were age-6. These fish ranged in total length from 44.5-45.3 inches. Growth of these fish was rapid compared to growth trajectories of bighead carp from other waters (Schrank and Guy 2002; Nuevo et al. 2004; Irons et al. 2011). Rapid growth may have occurred because food resources were abundant and the density of bighead carp was low in Columbus Park Lagoon. However, recent information suggests that ages of very large (and likely old) Asian carp may be underestimated with post-cleithra bones and that vertebrae may be a more accurate structure for aging large Asian carp (Duane Chapman, personal communication). Based on this information, we plan to include sectioned vertebrae in future age analyses of large Asian carp.

Sources of Bighead Carp in Ponds

The source of bighead carp in urban fishing ponds has not been confirmed to date and identifying a specific source may prove impossible. However, there is building evidence that young bighead carp may have been unintentionally stocked in urban fishing ponds with shipments of desirable fish species. To date, potential suppliers of contaminated shipments of fish have been found to be out of business or unreachable, although anecdotal evidence has identified occurrences of bighead carp in shipments reaching other parts of Illinois. From his analysis of otolith microchemistry data, Dr. Whitledge concluded that Sr:Ca data from bighead carp in Chicago area ponds were not consistent with transplanted adult fish or bait bucket introductions of juveniles from nearby rivers. The most plausible explanation for these data is that the fish were contaminants in shipments of other fish stocked in the lagoons. Furthermore, there may have been contaminated shipments from multiple sources because a higher otolith core Sr:Ca was found in one carp compared to the others.

The fact that all bighead carp obtained from Chicago area ponds to date have been very large fish of similar size and age also points towards stocking as a potential source. These demographics indicate that stocking probably occurred during a limited number of events sometime before 2005 and likely before the State of Illinois banned transport of live bighead carp in 2002-2003. This corresponds to a time when bighead carp were raised for market in ponds with channel catfish in certain regions of the U.S. (Kolar et al. 2007). Shipments of channel catfish may be the most likely source of contamination in Illinois urban fishing ponds because catchable-sized catfish are stocked frequently and extensively in these waters throughout the State (IDNR 2010).

Examination of urban fishing program stocking records by IDNR has indicated that channel catfish have been purchased from in-state and out-of-state suppliers over the years. Any producers rearing catfish and carp together in culture ponds could be a potential source of bighead carp in Chicago area urban fishing ponds, as well as in ponds from other states that purchased catchable-sized channel catfish from suppliers that practiced catfish/carp polyculture. Indeed, records of bighead carp in lakes, ponds, and lagoons exist across the state of Illinois, and are not just limited to the Chicago area (Table 2).

Regulations preventing live transport of bighead carp in Illinois and nationally (2011) appear to have had the desired effect of reducing the spread of invasive carp by unintentional stocking, at least in the case of Illinois urban fishing ponds. The capture of only very large adults in these ponds and results of otolith microstructure analysis of captured carp to date are consistent with introductions from years ago when live transport of bighead carp was permitted. Similarly, an absence of young bighead carp in recent samples from Chicago urban fishing ponds may reflect the prevention of live transport after the Illinois law was enacted in 2002-2003. The 2011 Lacey Act listing of bighead carp may have further reduced the threat of introduction by preventing live transport across state borders, which had the effect of preventing legal use of these fish in live fish markets throughout the U.S. and Canada. With live fish markets inaccessible, catfish farmers from at least one state are no longer rearing bighead carp in ponds with channel catfish (Anita Kelly, personal communication). If widespread, this change in catfish farming would eliminate one possible source of bighead carp from stocked fishing ponds in Illinois and elsewhere.

Future Monitoring and Removal Plans

We have identified Chicago area urban fishing ponds as a possible source of live bighead carp or bighead carp eDNA in CAWS waterways, Lake Michigan, and the upper Des Plaines River.

Table 2. A list of urban fishing ponds in Illinois located outside of the Chicago Metropolitan Area and reported occurrence of bighead carp (all were large adults removed by indicated methods). Silver carp have not been captured in any urban fishing ponds. NR indicates none reported or observed/captured during routine sampling.

Urban Fishing Pond	Region	County	Town	Presence of bighead carp (number-year)
Lovings Lake	Northwest	Winnebago	Rockford	NR
Belvidere Park District Pond	Northwest	Boone	Belvidere	NR
Boone County Conservation District Pond	Northwest	Boone	Belvidere	NR
Riverside Park Lagoon	Northwest	Rock Island	Moline	NR
Glen Oak Park Lagoon	Northwest	Peoria	Peoria	NR
Crystal Lake	Central	Champaign	Urbana	NR
Kaufman Lake	Central	Champaign	Champaign	NR
Washington Park Lagoon	Central	Sangamon	Springfield	15-20 AC electrofishing - 2004
Dreamland Pond	Central	Macon	Decatur	2 pond draining - 2004
Miller Park Pond	Central	McLean	Bloomington	NR
Holiday Park Pond	Central	McLean	Bloomington	NR
North Point Park Pond	Central	McLean	Bloomington	NR
Moore Community Park Pond	Southern	Madison	Alton	NR
LeClair Pond	Southern	Madison	Edwardsville	NR
Jones Lake	Southern	St. Clair	East St. Louis	NR
St. Ellen Park Pond	Southern	St. Clair	O‟Fallon	NR
SIUC Campus Lake	Southern	Jackson	Carbondale	NR
SIUC Touch of Nature Pond	Southern	Jackson	Carbondale	NR
Veteran‟s Park Lake	Southern	Jefferson	Mt. Vernon	1 AC electrofishing 1997
Foundation Park Lake	Southern	Marion	Centralia	NR
Eldon Hazlet State Park Pond	Southern	Clinton	Carlyle	NR

Recent sampling and examination of pond location and hydrology relative to targeted waters suggest the present threat of Asian carp contamination from these ponds is low. Regardless, the following actions will be taken to further evaluate contamination in these urban fishing ponds, eliminate any present risk of contamination, and prevent future contamination from occurring.

<u>Sample Ponds for Asian Carp eDNA</u> – Collecting water samples from urban ponds and analyzing them for Asian carp eDNA may be a quick method of determining presence of bighead or silver carp. Chris Jerde of University of Notre Dame has an ongoing study monitoring eDNA in Chicago area fishing ponds. Samples were taken in fall 2010 and spring/summer 2011. Results are pending and may be available in January 2012.

<u>Sample Ponds with Conventional Gear</u> – All fishing ponds supported by the urban fishing program will be sampled with DC electrofishing gear and trammel or gill nets during fall 2011 and spring 2012. Sampling will begin with ponds in closest proximity to Lake Michigan and CAWS waterways upstream of the Dispersal Barrier, followed by those that have had reports of Asian carp in the past. The first seven ponds to be targeted will be Gompers Park Lagoon, Commissioners Park Pond, Jackson Park Lagoon, Washington Park Lagoon, Garfield Park Lagoon, McKinley Park Lagoon, and Humboldt Park Lagoon. Other ponds with positive detections of bighead or silver carp eDNA will be given highest priority.

<u>Otolith Microanalysis and Aging</u>-We will continue to work with SIUC to obtain additional life history information on any Asian carp captured from urban fishing ponds or waters upstream of

the Dispersal Barrier. Heads, vertebrae, and post-cleithra will be removed and sent to SIUC for otolith microchemistry analysis and aging. Disposition of samples will be tracked with chain-of-custody forms as outlined in the 2011 Asian Carp Monitoring and Rapid Response Plan (MRRWG 2011).

Future Fish Purchases – IDNR will formalize a policy to ensure that future fish contracts for the urban fishing program will be made only with producers that can guarantee that no Asian carp are stocked in rearing ponds for channel catfish or other species.

Urban Fishing Programs in Other States – We recommend that other states evaluate urban fishing ponds for the presence of Asian carp, especially if channel catfish or other species are known to have been purchased from producers that practice(d) catfish/carp polyculture. States with urban fishing ponds located within the Great Lakes basin require immediate attention. Pay fishing lakes where stockings may have occurred from co-mingled populations of catfish and Asian carps should also be evaluated throughout the Great Lakes and Mississippi River basins.

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Appendix E. Electrofishing Taxis Study for Bighead and Silver Carp (Dean 2011).

Electrofishing Taxis Study for Bighead and Silver Carp

Prepared by: Jan Dean

Tank Study

Dr. Tracy Hill and Wyatt Doyle of the Columbia Fish and Wildlife Conservation Office met with Shawn Banks and Tom Lehman of Midwest Lake Electrofishing Systems and with Jan Dean of the Natchitoches LA National Fish Hatchery to investigate electrical waveforms and power setting for attraction and immobilization of small Asian carp – Silver carp (SC) and Bighead carp (BHC). A tank study was conducted at the USGS CERC lab in Columbia, MO. Duane Chapman, USGS Asian carp expert, allowed us use of the CERC lab and some small Asian carp for this portion of the study.

The tank was 366 cm long x 46 cm wide and was filled to a water depth of 19 cm. Metal screen material was used to construct electrodes at each end of the tank. The screens were 345 cm apart and covered the flooded surface area of each tank end so as to produce a homogeneous electrical field within the test tank between the electrodes. A homogeneous electrical field is one in which the voltage gradient (V/cm) and power density (μW/cc) is the same anywhere inside the electrified area of the tank. Constant voltage gradient and power density values are needed for conducting quantitative electrical field studies to describe the effects of electricity on fish. The homogeneous electrical field was verified with a voltage gradient probe connected to a Fluke scopemeter. The calculated voltage gradient with 148 peak volts applied to electrodes 345 cm apart was $148 \div 345 = 0.43$ V/cm. The voltage across the voltage gradient probe electrodes was 2.4 volts, and the probe electrodes were 5.35 cm apart. Therefore, the voltage gradient at the same 148 volts applied was $2.4 \div 5.35 = 0.45$ V/cm. Because of the close agreement between the two methods of measuring voltage gradient, the results during the study were calculated from the input peak voltage, which was measured with another Fluke scopemeter, divided by the 345 cm between the tank electrodes.

Electrical power for the tank study was supplied by a Midwest Lake Electrofishing Systems Infinity pulsator connected to line voltage through an isolation transformer. Frequencies, duty cycles and peak voltages were monitored with a Fluke scopemeter by Tom Lehman who set the controls as requested for each fish test. The test protocol was to shock each fish for four seconds at a time using a selected frequency, duty cycle and peak voltage and while observing fish response. Some fish had to be shocked a few (2-4) times because of the small number of test subjects. The first tests were designed to evaluate Asian carp taxis to the anode; later tests were for immobilization.

Specific conductivity was measured as 717 μS/cm at 17.6°C. Therefore, the ambient conductivity (the measure important for electrofishing) was calculated as 619 μS/cm using the formula: $Ca = Cs \times (1.02)^{(T-25)}$, where T is the water temperature in °C. Power density in $\mu W/cc = (V/cm)^2 \times Ca$, ambient conductivity.

At 619 μS/cm, ~200 mm TL BHC and SC exhibited some anodic taxis at 0.14-0.19 V/cm using 60-80 Hz pulsed direct current with duty cycles of 27-35%. This equates to power densities of 12-22 μW/cc. There were limited fish and time for accurate determination of threshold values, and assessment of taxis is subjective. However, we feel that these results are close to threshold values for this size Asian carp under these conditions. Smaller fish (65-110 mm TL) required about 0.29-0.36 V/cm when exposed to similar waveforms, and this equates to power densities of 52-81 µW/cc.

Asian carp immobilization was found at similar voltage gradients and power densities as for taxis (Table 1), and assessment of immobilization is less subjective than is assessment of taxis. With more fish and time, we may have been able to detect a larger difference between voltage gradient needed for immobilization vs. taxis by using smaller intervals between voltage settings so as to determine more accurate threshold values for both fish responses.

There was some size difference between the two groups of Asian carp, and smaller fish are known to require a higher voltage gradient to elicit a response such as taxis or immobilization. This phenomenon may be related to the "whole body" voltage or power to which a fish is subjected. One way to describe this is to calculate the head-to-tail voltage which may enter a fish if it is oriented parallel to the electrical current. The H-T voltage is the product of the voltage gradient in V/cm times the total length of the fish in cm. Fish orientation in the electrical field is important, and we did observe the fish "tacking" toward the anode. This tacking movement side to side as they progressed toward the anode presumably lessens the voltage passing through the fish body versus the full voltage exposure if the fish were parallel to the current flow, i.e. if they were facing directly toward the anode. The estimated H-T voltage for immobilization of the smaller (65-110 mm TL) carp was approximately 3 volts when using waveforms of 3.3-8.8 ms pulse width, i.e. the on time for a single pulse of direct current (Table 1). Most of the effective waveforms for the smaller carp had pulse widths of 3.4-5.8 ms at 40-80 Hz with duty cycles of 20-35%. Larger BHC (236 mm TL) were immobilized with approximately 3.4-3.8 H-T volts using 60-80 Hz and a 35% duty cycle; the voltage gradients and power densities were 0.14-0.16 V/cm and 13-16 µW/cc, respectively. Investigations with other fish of various sizes have revealed a similar pattern of threshold H-T voltage increase before leveling off in a hyperbolic fashion. There were too few fish and fish sizes to describe and quantify this size-voltage relationship.

Boat Testing

Results from the tank study were used to select waveforms for testing in a stream known to contain Asian carp. The objective was to increase the boat electrofishing capture efficiency of Asian carp versus largely unsuccessful past attempts. Adam McDaniel of the Columbia FWCO joined Wyatt Doyle and Jan Dean for the stream boat testing and electrofishing parts of the study. The Midwest Lake Electrofishing Systems Infinity pulsator was the power supply in the Columbia FWCO electrofishing boat, Roman 6, outfitted with a spider array having six droppers for each of two identical boom anodes and using the boat hull as the cathode. A power-on resistance (peak voltage divided by peak current) check using one anode array and two anode arrays was conducted September 22 in a stream of 587 µS/cm ambient conductivity using 60 Hz pulsed direct current and a 20% duty cycle. About 2-3 cm of the anode droppers were exposed above the water. The resistance values were transformed to those at a standard ambient conductivity of 100 µS/cm for ease of comparison with other results. The resistance of each anode array was 60 ohms, the boat hull was 10 ohms, and the overall resistance with both anode arrays wired in parallel, i.e. for the typical electrofishing configuration, was 40 ohms. Therefore, the resistance (and the power) to the anodes was 75% of the total. All of these values are among the best results ever seen as compared to those from boats measured during multiple FWS electrofishing classes in recent years. Roman 6 should perform very well as an electrofishing boat with these electrodes. The overall power demand and power distribution to the anodes are excellent.

A field map of voltage gradients around the anodes and boat hull of Roman 6 was made using a shop-made voltage gradient probe and a simple digital multimeter (Table 2). It was possible to do this with a simple multimeter because the Infinity pulsator was set to 100% duty cycle, i.e. to continuous direct current. One could also make a voltage gradient map with a simple digital multimeter if the power supply provided a sinusoidal alternating current waveform. One would need an accurate peak-reading digital multimeter (such as a Fluke 87 V) or a scopemeter to measure peak voltage gradients using pulsed direct current. Voltage gradient maps are independent of water conductivity if the applied voltage does not change. It is desirable to change voltage as water conductivity changes so as to transfer the same amount of electrical power into a fish. The shape of the voltage gradient map for a given boat will remain the same if the electrode configuration remains unchanged. The voltage gradients at a given point are directly proportional to the applied voltage. If the applied voltage is doubled versus when the map was made, then the voltage gradient at a given point doubles, and so forth. Thus, one only needs to make a voltage gradient map once for a given electrode configuration in order to determine future voltage gradients when applied voltages are changed. The voltage gradients were measured at 50 cm intervals from the port anode array center or from the boat hull at various points. The applied voltage was 100 volts continuous direct current. Thus, there were no frequency or duty cycle components to this waveform. The ambient water conductivity was 587 µS/cm, but water conductivity does not affect the voltage gradient map. Water conductivity does affect the map of power densities because power density equals voltage gradient squared times ambient water conductivity, as described above in the Tank Study section.

Stream Shocking

Asian carp sampling via boat electrofishing was conducted in a stream, Petite Saline, off the Missouri River near Columbia, MO September 23. Ambient water conductivity values ranged from 608 µS/cm at the mouth to 520 µS/cm further upstream to 295 µS/cm well upstream in clearer water.

Most waveforms evaluated were 40-80 Hz with duty cycles of 20-40%. The 2:1 ratio of frequency in Hz to duty cycle in percent resulted in a constant 5 ms pulse width. Examples are 70 Hz and 35% duty cycle or 40 Hz and 20% duty cycle. Using such waveforms -- often about 70 Hz and 35% duty cycle – there was limited success at 100 peak volts applied and more success at 120 peak volts. Initially, we were trying to induce taxis to the anode, and that generally occurs at a lesser power than does immobilization. Later in the day, it was decided that 200 peak volts resulted in greater attraction of fish to the anode and increased immobilization near the anodes for capture success. We were using the anode droppers more fully submerged than for the initial resistance measurement, so a quick resistance check revealed that the overall resistance had dropped slightly from 40 ohms to 37 ohms at the standard water conductivity of

100 µS/cm. At a water conductivity of 520 µS/cm for much of the test, the ambient total resistance was therefore 7.1 ohms. Using the 200 peak volt value for successful capture of Asian carp, the associated power demand was $(200\ V)^2 \div 7.1$ ohms = 5634 peak watts at 520 µS/cm ambient conductivity.

Juvenile or sub-adult shortnose and longnose gar were effectively captured using 115 peak volts in 608 µS/cm ambient conductivity at the mouth of the Petite Saline. The waveform was 70 Hz and a 35% duty cycle. The associated power demand was $(115\ V)^2 \div 6.1$ ohms = 2168 peak watts at 608 µS/cm. That is a potentially important finding for those wanting to capture juvenile alligator gar, which have been difficult to capture with electrofishing.

A maximum loading test was conducted for a few seconds with the Infinity pulsator using a 70 Hz, 35% duty cycle waveform. The applied voltage was increased until the pulsator could no longer produce the voltage for 30 seconds. The loading test was done near the stream mouth in ambient conductivity of 608 µS/cm. The maximum sustained peak voltage, current and power (as indicated on the Infinity pulsator meters) were 233 Vp, 38.0 Ap and 8870 Wp. The peak power calculated from the voltage and current was 8854 Wp. The generator power supply was rated for 7000 watts. The output was in peak watts, not in average watts as for generator ratings.

Conclusions and Recommendations

Results from the combined tank and stream study provided information useful to increasing the capture efficiency of wild Asian carp. Pulsed direct current waveforms of 40-80 Hz with duty cycles of 20-40%, especially in a near 2:1 ratio of frequency to percent duty cycle, which results in pulse widths of 5 ms, appeared to be effective for producing anodic attraction and immobilization leading to capture while boat electrofishing. Applied peak voltage and power goals were developed for the Columbia FWCO electrofishing boat “Roman 6” when configured as described herein, i.e. with two identical six-dropper anode arrays wired in parallel and with the boat hull as the cathode (Table 3). These goals are for ambient water conductivities of 50 to 5000 µS/cm and are based upon the power transfer theory of Larry Kolz and an Asian carp effective fish conductivity of 90 µS/cm as determined by Mike Holliman. These voltage and power goals are presented herein as guidelines for future efforts at capturing sub-adult and adult Asian carp in waters of various conductivities. The goal values are subject to change as new information is gained from future capture experiences.

Table 1. Results of Asian carp tank study at CERC lab 9/21/2011. Ambient conductivity 619 µS/cm. Values near threshold for immobilization of Silver carp (SC) and Bighead carp (BHC). Results shown in blue highlight are for more efficient waveforms; those which required less voltage and power for fish immobilization.

Species	TL (mm)	Frequency	Duty cycle	V setting	V/cm	µW/cc	H-T Volts	PW (ms)
initial waveforms:								
BHC	65	15	10	300	0.87	468	5.7	6.7
BHC	65	15	10	275	0.80	393	5.2	6.7
SC	103	15	10	200	0.58	208	6.0	6.7
SC	99	50	95	150	0.43	117	4.3	19.0
SC	105	240	80	100	0.29	52	3.0	3.3
SC	87	120	2	200	0.58	208	5.0	0.2
BHC	59	120	2	200	0.58	208	3.4	0.2
BHC	59	120	2	250	0.72	325	4.3	0.2
more efficient waveforms:								
BHC	74	40	20	100	0.29	52	2.1	5.0
BHC	69	60	15	150	0.43	117	3.0	2.5
BHC	79	80	35	125	0.36	81	2.9	4.4
BHC	79	60	35	125	0.36	81	2.9	5.8
BHC	79	40	35	125	0.36	81	2.9	8.8
BHC	82,91,93	80	27	125	0.36	81	~3.2	3.4
BHC	76,85,95	80	27	125	0.36	81	~3.1	3.4
SC	87,112	70	35	100	0.29	52	~2.9	5.0
SC	87,110	70	27	100	0.29	52	~2.9	3.9
SC	95,101	60	35	125	0.36	81	~3.5	5.8
larger fish:								
BHC	236	60	35	50	0.14	13	3.4	5.8
BHC	236	80	35	56	0.16	16	3.8	4.4

Note: less volts/cm and µW/cc are required for the larger fish, but head-tail voltage slightly higher

Table 2. Voltage gradient (V/cm) values at specified distances from anode array centers or from the hull of Columbia FWCO electrofishing boat "Roman 6" with 100 volts of continuous direct current applied to the electrodes. The anodes were typical spider arrays of six droppers from each of two identical booms wired in parallel. The boat hull served as the cathode. Ambient water conductivity was 587 µS/cm.

Distance (cm)	**Port array to port side**	**Port array to bow**	**Port array forward**	**Mid bow forward**	**Boat hull to port side**
50				0.17	0.11
100	0.37	0.27	0.31	0.18	0.09
150	0.20	0.16	0.16	0.20	0.07
200	0.10	0.13	0.10	0.23	
250	0.05	0.14	0.06	0.10	
300	0.03		0.05	0.14	
350				0.13	
400				0.11	

Note: value highlighted in blue taken midway between anode arrays

Table 3. Applied voltage and power goals for waters of different ambient conductivity for capturing Asian carp with Columbia FWCO electrofishing boat "Roman 6" as set up for test with two identical spider anode arrays in parallel and with the boat hull as the cathode. Electrical waveforms are 40-80 Hz with duty cycles of 20-40% in a 2:1 ratio of frequency to percent duty cycle square-wave pulsed direct current such that the pulse width is 5 ms in each case. Effective fish conductivity 90 µS/cm in calculations. Total resistance 37 ohms at 100 µS/cm ambient conductivity.

Ambient Conductivity (µS/cm)	**Peak Voltage (Vp)**	**Peak Power (Wp)**
50	477	3,086
100	324	2,842
200	247	3,311
300	222	3,992
400	209	4,726
500	201	5,481
600	196	6,248
700	192	7,020
800	190	7,796
900	188	8,574
1000	186	9,354
1500	181	13,270
2000	178	17,196
2500	177	21,126
3000	176	25,059
3500	175	28,992
4000	174	32,927
4500	174	36,862
5000	174	40,797

Figure 4. Midwest Lake Electrofishing Systems Infinity pulsator used for all electrofishing trials and Fluke scopemeter used to monitor frequencies, duty cycles and peak voltages