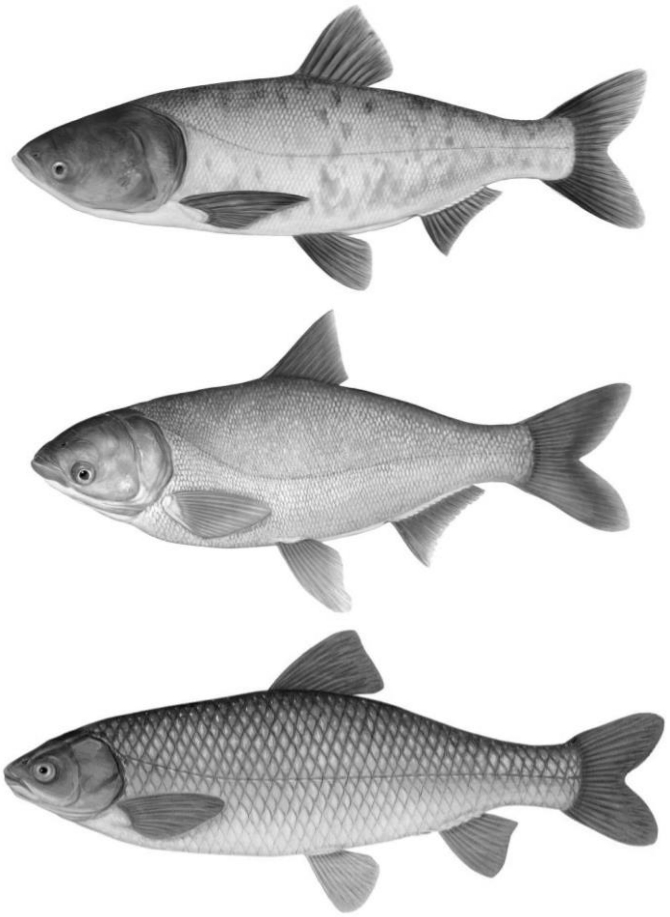
INVASIVE CARP SAMPLING REPORT

JANUARY – DECEMBER 2020

MINNESOTA DEPARTMENT OF NATURAL RESOURCES

DIVISION OF FISH AND WILDLIFE

SECTION OF FISHERIES



UPPER MISSISSIPPI RIVER, POOLS 1-9

LOWER ST. CROIX RIVER, BELOW ST. CROIX FALLS

MINNESOTA RIVER, BELOW GRANITE FALLS

March 19th, 2021

DEPARTMENT OF NATURAL RESOURCES

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Introduction

Bighead carp *Hypophthalmichthys nobilis*, Silver Carp *H. molitrix*, Grass Carp *Ctenopharyngodon idella*, and Black Carp *Mylopharyngodon piceus* (hereafter collectively referred to as invasive carp) are invasive species introduced into the United States during the early 1970's as aids in fish aquaculture operations (Henderson 1976). Large flood events allowed these species to escape into the Mississippi River drainage, where they began reproducing and spreading (Freeze and Henderson 1982). Invasive carp have migrated up the Mississippi River and adjoining tributaries, quickly establishing populations in newly invaded areas. In Minnesota, Bighead and Grass carp have been collected in the Minnesota, Mississippi, and St. Croix rivers, while Silver Carp have only been captured in the Mississippi and St. Croix rivers (Figure 1). Black Carp have never been collected in Minnesota or Wisconsin waters. Currently, there is no evidence of invasive carp reproduction in Minnesota waters.

Invasive carp can radically alter local ecosystems by competing with native planktivores and overcrowding other native species. With high fecundity and the ability to disperse great distances, invasive carp can reach substantial populations, sometimes comprising most of the fish biomass in certain systems (MICRA 2002). Bighead and Silver carp have a voracious appetite, and coupled with their large size (>70 pounds), have the ability to consume large amounts of food by filtering zooplankton, phytoplankton, and organic particles out of the water column (Jennings 1988; Smith 1989; Voros 1997). If invasive carp populations establish in Minnesota, native planktivores such as Paddlefish *Polyodon spathula*, Bigmouth Buffalo *Ictiobus cyprinellus*, Gizzard Shad *Dorosoma cepedianum*, and the larval stages of many other native fishes may be in direct competition for food resources with invasive carp. Evidence from the Illinois River suggests that competition with invasive carp resulted in reduced condition factors

for Bigmouth Buffalo and Gizzard Shad (Irons et al. 2007). Worldwide, introductions of invasive carp have led to declines in fish species diversity and abundance of commercially desirable species (Spatura and Gophen 1985; Petr 2002).

With the continuing progression of invasive carp up the Mississippi River, Minnesota waters are threatened by a potential invasion. A better understanding to the current status of individual invasive carp and their populations in Minnesota will allow for more effective efforts to prevent their spread and/or eradicating them. Although standard fish sampling assessments have been ongoing in Minnesota's major rivers, and have the potential to catch invasive carp, the gear and methods used in the standard assessments are not the most efficient methods for capturing invasive carp. The purpose of this sampling effort is to use more carp-specific gear and techniques to monitor all life stages of invasive carp and associated native fishes in Minnesota waters.

Objectives

- Detect and monitor all life stages of invasive carp to:
    - Inform management efforts in Minnesota.
    - Provide current information for Upper Mississippi River managers on carp population changes.
- Monitor native fish species that may be affected by the establishment of invasive carp.
- Implement innovative monitoring and removal techniques of invasive carp to increase removal efficiency.

Sampling Sites

In the Mississippi River, invasive carp sampling occurred in approximately 200 miles of water from St. Anthony Falls Lock and Dam in Minneapolis, MN to Pool 9 near Jefferson

Township, MN on the MN-IA boarder. In the St. Croix River, effort focused on a 52-mile stretch from the dam near Taylors Falls, MN to the confluence with the Mississippi River near Prescott, WI. In the Minnesota River standard effort focused on a 48-mile stretch from Belle Plaine, MN to the confluence with the Mississippi River in St. Paul, MN.

Sampling Methods

Sampling for invasive carp took place between January 1, 2020 and December 31, 2020. Gear types, methods, and targeted locations were derived from personal communications with biologists who have been sampling invasive carp (V. Santucci, Illinois Department of Natural Resources, personal communication; J. Lamer, Western Illinois University, personal communication, Duane Chapman, USGS, personal communication) and conducting research on the most efficient gear to sample invasive carp (M. Diana, Illinois Natural History Survey, personal communication), literature review of sampling techniques and habitat preferences (Lohmeyer and Garvey 2009; Williamson and Garvey 2005; Dettmers et al. 2001; DeGrandchamp et al. 2007; Kolar et al. 2007; DeGrandchamp et al. 2008; Wanner and Klumb 2009; ACRCC 2012), and experience from prior field seasons.

Commercial Fishing

Commercial anglers were contracted to target invasive carp with gill nets and seines for sampling and response efforts. Minnesota Department of Natural Resources (MNDNR) personnel accompanied contracted commercial anglers to direct sampling locations and monitor efforts. The number of fish caught by species was estimated during gill netting operations and total weight harvested was requested from the commercial anglers for both gill netting and seining operations.

Invasive Carp Acoustic Tagging and Tracking

In Minnesota, Statute 84D.05, Subdivision 1 states, "A person may not possess, import, purchase, sell, propagate, transport, or introduce a prohibited invasive species." In 2017, the legislature passed and the governor signed an amendment to this statute: *Subd. 1a.* ***Permit for invasive carp.*** *The commissioner may issue a permit to departmental divisions for tagging bighead, black, grass, or silver carp for research or control. Under the permit, the carp may be released into the water body from which the carp was captured. This subdivision expires December 31, 2021.* As part of the permitting process, MNDNR fisheries developed a protocol to characterize and minimize potential risk while maximizing the amount of information gained. For further information regarding the tagging and tracking procedures, please see the permit issued by the Minnesota Department of Natural Resource's Division of Ecological and Water Resources.

The MNDNR was permitted to tag up to six invasive carp at a time with acoustic transmitters. The MNDNR utilized both passive telemetry (a stationary receiver array already in place) and active tracking (using a portable receiver) to determine preferred habitats, longitudinal movement patterns, depth preferences, and specific locations for capture efforts.

There are 80 stationary receivers placed throughout the state of Minnesota. They are located on the Mississippi River above the Coon Rapids Dam to Lock and Dam #5, on the St Croix River from the Mississippi River confluence at Prescott, WI to Taylor's Falls, and on the Minnesota River from the Mississippi River confluence to the County Road 6 bridge north of Delhi, MN (river mile 209). Sixty-one receivers are maintained by the East Metro fisheries office, nine are maintained in the Minnesota River by the Hutchinson fisheries office (from river mile 18.7 to river mile 209), and ten are maintained by the Lake City office in the Chippewa

River and Pools 4 and 5 of the Mississippi River. In addition, the U.S. Fish and Wildlife Service maintains seven receivers in Minnesota waters and 47 additional receivers that extend downstream to Pool 19 near Keokuk, IA. Additional receivers are maintained outside of Minnesota that include, but are not limited to, 11 receivers maintained by the Missouri Department of Conservation from Pool 19 to the confluence with the Ohio River.

By tracking tagged invasive carp, we expect to capture additional invasive carp if they are present. Recapture actions will continue to be taken, including the use of commercial anglers, when tagged fish are in jeopardy of being un-trackable due to tag life nearing completion, leaving the passive array network, or to support removal of other conspecifics. The MNDNR will take all reasonable measures to ensure all tagged fish are tracked and their locations known through active tracking and an extensive passive tracking network.

The impacts of releasing wild-caught invasive carp back into the wild have been considered and are believed to be minimal when compared to the potential information gained from this project. As outlined in this report, MNDNR maintains an extensive monitoring and removal program to ensure populations are adequately sampled and document if reproduction is occurring in Minnesota waters to provide accurate information for Upper Mississippi River managers on carp population changes in the present front. MNDNR is strategic in both the species and locations where tagged invasive carp are released, so as to maximize the information we gain through their tracking. Most captured invasive carp are removed and euthanized.

Based on the tagging results, MNDNR staff have gained a better understanding of movement patterns and habitat preferences, while posing a very low risk to native fish populations or risk of increasing invasive carp populations. Other states have already begun work of this nature in riverine environments and have shown significant results and ability to remove

additional fish with this tagging method. This information will help to improve sampling and removal efforts.

Pool 2 Stable Isotope Analysis

With the financial support of the Minnesota Environment and Natural Resources Trust Fund (ENRTF) from the Legislative-Citizens Commission on Minnesota Resources (LCCMR), freshwater invertebrae, fish, and phytoplankton samples were collected from Pool 2 of the Mississippi River for Carbon (C^{13}) and Nitrogen (N^{15}) stable isotope analysis during the 2017 field season. The purpose of this project was to use stable isotope analysis to examine the aquatic food web within Pool 2 and provide baseline trophic data before invasive carp establishment.

Larval Trawling

Larval trawling was not conducted during the 2020 field season. Sampling could not be performed safely using the protocols in place for larval trawl due to the Covid-19 pandemic and social distancing requirements. Historic data can be found in Table 3.

Buffalo Tagging

This study will provide information on population dynamics and movements of Smallmouth Buffalo and Bigmouth Buffalo in Pool 2 of the Mississippi River. From the literature and previous experience, Bigmouth Buffalo are often found with Bighead and Silver carp. During the 2020 field season where COVID-safety protocols and reduced staffing limited our capacity, higher priority work was completed and additional buffalo tagging was not performed.

Beginning in the spring of 2015, buffalo sampled in Pool 2 of the Mississippi River were collected using large mesh gill net, seine commercial fishing operations, trammel nets, and electrofishing. Buffalo were tagged externally with a yellow Floy t-bar tag, along with a secondary mark by removing one pelvic fin. This allows recaptured buffalo to be identified for as long as the tags are retained (>4 years) and to assess tag retention. Pelvic fin rays are being used for aging purposes to determine variation in movement patterns by age as well as validate aging techniques by re-aging recaptured fish using the original fin from when the fish was tagged and the fin clip when the fish is re-captured in subsequent years. To date, no known studies have validated buffalo aging techniques.

As one of the United States' most prolific and valuable freshwater commercial fisheries, it is also imperative that fisheries managers develop management plans and quotas to ensure populations are sustainably harvested and do not become overfished. Further, buffalo are native to the United States, occupying a distinct ecological niche that may ultimately be filled by invasive carp species should buffalo populations become overfished. Bighead and Silver carp have adverse effects on all life stages of native fish species because they feed on plankton, the primary food source of several adult fish (Irons et al. 2007), all larval fish (Schrank et al. 2003), as well as all mussel species (Kolar et al. 2007), creating cascading trophic effects throughout the food web. The full impacts of invasive carp, should they become established in Minnesota, cannot be well documented without this biological data from commercial fish species.

Electrofishing

Electrofishing occurred in a variety of habitats including backwaters, side channels, main channel borders, and over wing dikes. Sampling locations consisted of eight standardized

sampling locations in Pool 2 (Figure 2), the St. Croix River (Figure 3) and Minnesota River (Figure 4), and all other sampling events occurred at non-standardized locations in the aforementioned habitats at the discretion of the sampler. Standardized electrofishing sampling locations were selected based on habitats invasive carp are likely to occupy. Sites averaged 968 seconds of on-time. At these set sampling locations, all observed fish were collected, identified, measured and weighed, and aging structures were taken from fish included in the age and growth analysis. If positive identification was not possible, voucher specimens were kept, labeled, and preserved in 90% ethanol for later identification. At non-standardized sampling sites, fish were identified in the water and only invasive carp were collected. This reduced unnecessary processing time and allowed for greater sampling effort. Sampling site locations, sampling dates, gear description, effort, habitat type (main channel border, backwater, wing dike, etc.), water depth, and crew details were recorded for each electrofishing run.

Trap Netting

Trap netting was not conducted during the 2020 field season. Sampling could not be performed safely using the protocol in place for trap netting due to the Covid-19 pandemic.

Seining

A small 35-foot seine was used to sample shallow water habitats for young fish from July through August on Pool 2 of the Mississippi River with 20 seine hauls completed over 6 days. The seine measure 35 ft. long and 6 ft. deep with 3 ft. square bag (3 ft. x 3 ft. x 3 ft.) located at the center of the net, consisting of a knotless "Ace"-type nylon netting 1/8 in. mesh, with a mudline. No invasive carp were captured during 2020 using the shallow seine.

Fish Acoustic Tagging Efforts

Several species of fish in the Mississippi River Pool 2 and the St. Croix River have been tagged according to study guidelines as part of tagging studies. These species included Flathead Catfish *Pylodictis olivaris*, Channel Catfish *Ictalurus punctatus*, Smallmouth Buffalo *Ictiobus bubalus*, and Bigmouth Buffalo in Pool 2. In the St. Croix River, Lake Sturgeon *Acipenser fulvescens*, Muskellunge *Esox masquinongy*, White Bass *Morone chrysops*, Flathead Catfish, and Channel Catfish have been tagged. In both Pool 2 and the St. Croix River, Paddlefish have also been tagged.

Age and Growth Analysis

In 2020, age and growth analyses were limited to Smallmouth Buffalo and Bigmouth Buffalo recaptures. Bigmouth Buffalo are native planktivores that may be in direct competition with Bighead and Silver carp. Smallmouth Buffalo, as well as Bigmouth Buffalo, are commercially important and a better understanding of these species will be useful to determine effects from commercial fishing and/or the presence of invasive carp. Since 2015, nearly 4,500 Smallmouth and Bigmouth Buffalo (2,140 Smallmouth Buffalo and 2,220 Bigmouth Buffalo) were tagged with Floy tags and their pelvic fins were removed for aging and to validate aging analyses using re-captured fish in the future as part of another study. Since 2015, there have been a total of 271 recaptures of tagged fish (98 recaptures of Smallmouth Buffalo and 173 recaptures of Bigmouth Buffalo). Fin rays were dried and cut using a low-speed isomet saw. Two independent readers counted each opaque band as an annulus under a dissecting microscope, using both reflected and transmitted light sources. If counts differed between readers, the readers

re-examined the structure independently a second time. If readings differed the second time, the readers conferred until a consensus was reached.

Gill and Trammel Netting

Gill netting and trammel netting occurred during multiple sampling events on each system. Large mesh gill nets of depths from 8 to 24 feet and lengths of 150 to 300 feet with bar mesh sizes of 4 to 6 inches were used to target adult invasive carp. Nets were set either short-term or overnight, with short-term sets favored when water temperatures were greater than 60º F. All fish caught were identified caught were identified.

Trammel nets were not used during 2020 due to the shortened field season due to the Covid-19 pandemic.

Results and Discussion

Sampling Results

In total, 73 days were spent sampling between January and December 2020 on the Mississippi River Pools 2, 3, 4, 5, 5A, 6, 8 and 9, and the Minnesota and St. Croix rivers with gear appropriate for sampling invasive carp (Table 1; Figure 5). A greater amount of effort was focused on Pool 8 in 2020. In March 2020 during a commercial fishing seine haul, 51 invasive carp were caught including 39 Silver Carp and 12 Grass Carp. Follow-up sampling was conducted by a contracted commercial angler as well as private commercial anglers in Pool 8 and Pool 7. No additional invasive carp were caught during the spring in Pool 8. Follow up sampling was conducted after invasive carp captures when possible. Follow up sampling occurred at the Illinois Lake Outlet in Jackson County, MN after confirmed sightings of invasive carp below an electrical barrier. The sampling event resulted in the capture of 18 invasive carp

(12 Bighead Carp, 5 Grass Carp, and 1 Silver Carp). Capture data and response actions were shared with multiple agencies including the Wisconsin Department of Natural Resources, USGS, and Western Illinois University.

Intensive fall sampling occurred in Pool 8 of the Mississippi River. This sampling resulted in the capture of a total of six Silver Carp. These fish were caught by contracted commercial anglers in back waters and side channels, and five of the silver carp were tagged in conjunction with USFWS. Capture data and response actions were shared with multiple agencies including the Wisconsin Department of Natural Resources, USGS, and Western Illinois University. A total of 83 invasive carp were caught in Minnesota waters and Minnesota-Wisconsin boundary waters in 2020 (Table 2).

Contracted commercial anglers were hired to use large mesh gill nets and seines to sample in the Mississippi River in Pools 2, 3, 4, 5, 6, and 8, and in the St. Croix River from Andersen Bay in Bayport to the confluence with the Mississippi River near Prescott, WI. Contracted commercial anglers set approximately 78,850 feet of gill nets during 21 days of effort and conducted six seine hauls between January and December 2020. Gill nets were set short term (2-3 hours) and fish were chased towards the net with boats, typically in large backwater areas. In 2020, two regular commercial fishing operations were also monitored for the presence of invasive carp.

Both random and standardized electrofishing sampling was conducted on Pool 2 of the Mississippi, the Minnesota and the St. Croix rivers. A total of 1,290 minutes of "on time" over 19 days was spent electrofishing between January and December 2020. In 2020, twenty-two standardized electrofishing sites were sampled once, for a total of 355 minutes. Random

electrofishing was used to monitor for invasive carp and for collection of individual native fish for age and growth.

Gill nets set by MNDNR personnel were often used to sample behind wing dikes and in smaller side channel and backwater areas where it wasn't feasible for commercial anglers to target with their larger operations. In 2020, a total of 12,550 feet of gill net were set in Pools 2, 3, and 8, and the St. Croix River over 10 days, with most net sets being short-term sets (2-5 hours). In 2020, no invasive carp were captured during routine gill netting operations, seining or electrofishing.

Although no new species were added to the list in 2020, numerous unique or rare native fishes were encountered during these sampling events. A complete species list of species caught and observed on Pools 2, 3, and 4, the Minnesota River and the St. Croix River, from January 2013 through December 2020, has been compiled (Table 4).

Determining if invasive carp captured in Minnesota are pioneering individuals or are indicative of established populations is a key question for MNDNR managers. While it is likely there are additional invasive carp present in Minnesota's monitored rivers based on the previously mentioned captures of larger congregations of fish, the degree to which invasive carp populations have change is unclear. The increase in captures could be attributed to a successful year class migrating upstream during extended periods of high water in 2019, but it remains to be seen what the implications will be for the future abundance of invasive carp in Minnesota waters.

Invasive Carp Acoustic Tagging and Tracking

On July 28, 2017 during routine monitoring at the Allen S. King Plant on the St. Croix River, a Bighead Carp was caught by MNDNR staff in a large mesh gill net. The fish was then

tagged using a VEMCO V16TP-6H (VEMCO Ltd., Nova Scotia, 69 kHz) coded acoustic transmitter containing sensors to measure pressure (depth) and temperature, transmitting every 60 seconds on average (minimum transmission delay of 30 seconds, maximum delay of 90 seconds) and released. This fish was actively tracked using a VEMCO VR100 every day for a week after release, followed by actively locating the fish once a week every week until September 5, 2017. After September 5, 2017 the fish was located routinely until the last day in the field on November 20, 2017. In 2018, the fish was routinely tracked except when found in areas where sampling was too difficult, at which time tracking resumed within two weeks to ensure the fish did not make large-scale movements or leave the St. Croix River. In addition, this fish was routinely identified and data recorded by the passive VEMCO VR2W receiver array in place, with the last VR2W downloaded on October 20, 2020. The last detection using active tracking with the VR100 occurred on November 6, 2020 (Figure 6). Since the fish was tagged, we have received an average of 15,000 data points per month with a total of 585,093 data points from July 28, 2017 to October 20, 2020.

This fish was observed on the St. Croix River to range over an extent of 23.3 river miles from Stillwater, MN to the confluence with Pool 3 of the Mississippi River. The tagged fish did not travel into Pool 3 of the Mississippi River in 2020, unlike the last two open-water seasons (Figure 6). In 2018 and 2019, runs downstream coincided with a spike in the hydrograph at Lock & Dam #3 in Hastings, MN. In 2020, the spike in the hydrograph occurred early in the season when temperatures were low (Figure 7) compared to previous years, where spikes coincided with a downstream migration when water temperatures were higher. Over the course of its third field season, the tagged carp continued showing site fidelity within the St. Croix River. In general, the tagged Bighead Carp remained between the Interstate 94 Bridge and Afton,

MN (here after referred to as the Lakeland area) from August to April. The tagged fish returned to the King Plant in Bayport, MN and continued upstream to Stillwater, MN in the spring and early summer. The fish then returned downstream to the Lakeland area.

According to temperature and depth data, this fish comes to the water's surface often, inhabits a wider range of depths (0 to 68.6 feet) than believed (Figure 8), and tolerates temperatures ranging from 33 to 88 degrees Fahrenheit (Figure 9). (See MNDNR 2018, MNDNR 2019, and MNDNR 2020 for data collected from the previous three field seasons.) In 2020, due to the Covid-19 pandemic there were no direct recapture efforts during the field season.

From our tagged invasive carp, we have learned of additional areas where this fish has resided for prolonged periods of time, including an overwintering site in the Lakeland area. Therefore, additional VR2Tx receivers were added in the fall of 2020 to the Lakeland area to investigate how the tagged fish uses the bathymetry in the area for overwintering and feeding, while learning about additional environmental preferences to further inform sampling efforts. Based on information from other areas tracking carp and historic sightings in Minnesota, the hypothesis was this fish would inhabit the King Plant discharge periodically with forays to Lake St. Croix and overwinter near a natural point where flow is constricted on the river (most likely Point Douglas, near Prescott, WI). Based on tracking data, the fish was never observed within the King Plant discharge despite continued monitoring within the discharge. Data from the real-time receiver and main channel receivers showed the tagged carp inhabited the mouth of the King Plant discharge as well as an adjacent bay for several weeks during the spring. Over nearly three full field seasons, the fish has exhibited some site fidelity, inhabiting several key locations for prolonged periods of time.

On May 26, 2020, a Silver Carp was captured in Anderson Bay on the St. Croix River in a contracted commercial gill net. Although the tagged Bighead Carp was not in the bay at the time of the capture, this capture event provides additional habitat information from the tagged fish. The reason that sampling took place at that location and time was because of past movement patterns of our tagged fish. This capture is one of many examples how the tagged Bighead Carp aided in the removal of additional conspecifics.

During the fall of 2020, six Silver Carp were captured in Pool 8 of the Mississippi River, and five of the Silver Carp were tagged and released near the capture site. The three fish tagged on October 13, 2020 were captured by gillnet in a backwater bay, 1.35 miles downstream of Lock & Dam #7. The Silver Carp were released in an adjacent bay, 0.68 miles from the original capture location. The fish were tracked every day for 5 days. One of the fish stayed in the release bay for 4 days then returned to the capture bay, while the other two fish remained in the release bay for 2 days before traveling downstream to the east of Taylor Island. On October 21st, one Silver Carp was captured in Bluff Slough, south of the 7th Street landing in La Crosse, WI and was tagged and released at the capture site. The fish stayed in the slough through the first five days of tracking. Additional sampling in Bluff Slough on October 23rd resulted in the capture of one additional Silver Carp, which was tagged and released. Crews tracked the fish for 5 consecutive days, the fish remained in Bluff Slough during that time (Figure 10).

During the 2021 field season these tagged fish will be used as traitor fish to guide removal efforts. The Silver Carp in Pool 8 of the Mississippi River will be used to direct commercial fishing efforts in the future, including spring 2021 using the Modified Unified Method in collaboration with USFWS, USGS, WI DNR, NPS, USACE, and The Upper Mississippi National Wildlife and Fish Refuge.

The tagged Bighead Carp was vital in the capture of two Bighead Carp in 2018, four additional invasive carp in 2019, and one Silver Carp in 2020. Without tracking information from the tagged carp, MNDNR personnel would not have fished certain location over the last three years. From previous captures and the understanding of invasive carp movements and biology, MNDNR had focused efforts on relatively few areas (e.g. the Allen S. King Plant, Andersen Bay, and Point Douglas on the St. Croix River), with sporadic sampling in areas considered less suitable to invasive carp. While the data collected only represents the movements of one individual, areas that were considered less suitable may be frequented as often as areas of primary focus in previous years. Because this tagged fish has shown relatively large movements and has inhabited confined areas suitable for complete sampling for short periods of time, timing of sampling is critical for effective management and removal. The ability to track a tagged individual will allow biologist to better understand additional habitat preferences and the duration of residence preferences.

Tracking methods and field sampling will be adjusted accordingly for 2021. MNDNR staff will continue to track tagged fish while analyzing the data to increase sampling and removal efficiencies.

Pool 2 Stable Isotope Analysis

During the 2017 field season fish, invertebrates, and environmental samples were collected as part of a stable isotope analysis of the complex Pool 2 ecosystem. For more information on the samples collected and project design, please see the 2017 MNDNR Invasive Carp Report (MNDNR 2018).

Mass spectrometry was contracted with the University of Minnesota for Carbon (C^{13}) and Nitrogen (N^{15}) stable isotope analysis. Due to problems with the mass spectrometer, the University of Minnesota could not complete analysis and samples were subsequently sent to Cornell University. Results are currently being compiled.

Recommendations

Continued monitoring and removal of invasive carp from Minnesota waters is recommended. This project is funded in part by the current Minnesota Environment and Natural Resources Trust Fund grant through June, 2021. MNDNR is recommended for an additional 3 years of funding by the Minnesota Environment and Natural Resources Trust Fund. We recommend this project continue beyond that grant to ensure invasive carp do not establish spawning populations and adequately document the effects of invasive carp to native fish populations. Lastly, we recommend the invasive carp acoustic tagging project continue to expand beyond the limit of six fish in Minnesota waters so that we can learn more from different species tagged in different locations, and to guide additional removal efforts.

Paddlefish are a native planktivore that may compete for food resources with invasive carp. Currently, Paddlefish are a threatened species in Minnesota and populations across their range have suffered due to commercial navigation projects (that impede movement and alter habitats), pollution, and overexploitation (Jennings and Zigler 2000). If invasive carp become established in Minnesota rivers, local Paddlefish populations could be further stressed. Non-lethal means of studying Paddlefish populations are recommended, including continued tagging of encountered Paddlefish using jaw and acoustic tags. Tagging and releasing Paddlefish will inform biologists of their populations and life history, as well as provide a population estimate for management purposes. MNDNR should increase effort to encourage boaters to report any

deceased Paddlefish for age and growth analysis. Other MNDNR offices should collect all deceased Paddlefish for analysis.

Acknowledgements

The monitoring and removal of invasive carp in Minnesota is a collaborative program funded by the Minnesota Department of Natural Resources, U.S. Fish and Wildlife, and the Minnesota Environment and Natural Resources Trust Fund. Technical support from USGS and financial support from the Interstate Grant was crucial in building, troubleshooting and deploying a real-time acoustic receiver on the St. Croix River.

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Tables

Table 1. Invasive Carp sampling summary for the Mississippi River Pools 1, 2, 3, 5A, 6, 8 and 9 and the St. Croix and Minnesota Rivers for January through December 2020. Number of Invasive Carp Captured represents the number of individuals caught by MNDNR, contracted commercial anglers, or monitored commercial fishing.

Invasive Carp Sampling Summary January – December 2020			Days
Random Sampling Effort			
Gill/Trammel Netting	12,550	feet	10
Electrofishing	935	minutes	16
Small Seine	20	Hauls	6
Standardized Sampling Effort			
Electrofishing	355	minutes	12
Targeted Commercial Fishing Effort			
Gill Netting	82,450	feet	21
Seining	10	hauls	9
Monitored Commercial Fishing Effort			
Seining	2	hauls	2
Tracking*			
2-person crew	98	hours	
Number of Invasive Carp Captured	83	fish	
Total Number of Days Sampled			73

***Does not include tracking by real-time receivers (MNDNR, USFWS) in the St. Croix River and Pool 8.**

Table 2. Invasive Carp caught from January through December 2020 in Minnesota and Wisconsin boundary waters.

Date	Species	Water Body	Location	State	Length (mm)	Weight (grams)	Sex	Maturity	Capture Method	Captured By
3/8/2020	Silver Carp	Mississippi River	Pool 6	WI	890	6600	Female	Mature	Commercial Seine	Commercial Angler
3/9/2020	Grass Carp	Mississippi River	Pool 8	WI	824	7565	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Grass Carp	Mississippi River	Pool 8	WI	930	10003	Female	Mature	Commercial Seine	Commercial Angler
3/9/2020	Grass Carp	Mississippi River	Pool 8	WI	830	6873	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Grass Carp	Mississippi River	Pool 8	WI	854	7530	Female	Mature	Commercial Seine	Commercial Angler
3/9/2020	Grass Carp	Mississippi River	Pool 8	WI	829	7660	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Grass Carp	Mississippi River	Pool 8	WI	945	9330	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Grass Carp	Mississippi River	Pool 8	WI	877	8820	Female	Mature	Commercial Seine	Commercial Angler
3/9/2020	Grass Carp	Mississippi River	Pool 8	WI	824	7900	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Grass Carp	Mississippi River	Pool 8	WI	800	6640	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Grass Carp	Mississippi River	Pool 8	WI	919	9750	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	710	4196	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	675	3615	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	690	3704	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	702	4055	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	723	4038	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	750	4699	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	716	4157	Male	Mature	Commercial Seine	Commercial Angler

Table 2 (continued). Invasive Carp caught from January through December 2020 in Minnesota and Wisconsin boundary waters.

Date	Species	Water Body	Location	State	Length (mm)	Weight (grams)	Sex	Maturity	Capture Method	Captured By
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	730	4471	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	700	3591	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	731	4480	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	698	4093	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	734	4962	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	704	3957	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	697	4028	Female	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	704	4179	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	727	4253	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	689	3988	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	735	4291	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	735	4269	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	726	4686	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	690	3302	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	722	4185	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	764	6034	Female	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	700	3528	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	704	3658	Female	Immature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	731	4835	Female	Mature	Commercial Seine	Commercial Angler

Table 2 (continued). Invasive Carp caught from January through December 2020 in Minnesota and Wisconsin boundary waters.

Date	Species	Water Body	Location	State	Length (mm)	Weight (grams)	Sex	Maturity	Capture Method	Captured By
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	736	4699	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	765	4987	Female	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	735	4168	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	684	3273	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	700	3635	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	720	3929	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	705	4060	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	674	3473	Male	Mature	Commercial Seine	Commercial Angler
3/9/2020	Silver Carp	Mississippi River	Pool 8	WI	703	3773	Male	Mature	Commercial Seine	Commercial Angler
3/12/2020	Grass Carp	Mississippi River	Pool 8	WI	915	11440	Male	Mature	Commercial Seine	Commercial Angler
3/12/2020	Grass Carp	Mississippi River	Pool 8	WI	960	11970	Male	Mature	Commercial Seine	Commercial Angler
3/12/2020	Hybrid Silver-Bighead	Mississippi River	Pool 8	WI	695	3427	Male	Mature	Commercial Seine	Commercial Angler
3/12/2020	Hybrid Silver-Bighead	Mississippi River	Pool 8	WI	745	4176	Male	Mature	Commercial Seine	Commercial Angler
3/12/2020	Hybrid Silver-Bighead	Mississippi River	Pool 8	WI	696	3507	Male	Mature	Commercial Seine	Commercial Angler
3/12/2020	Silver Carp	Mississippi River	Pool 8	WI	730	4665	Female	Mature	Commercial Seine	Commercial Angler
3/25/2020	Bighead Carp	St. Croix River	Pt. Douglas	MN	1179	21550	Male	Mature	Commercial Seine	Commercial Angler
5/26/2020	Silver Carp	St. Croix River	Andersen Bay	MN	751	6500	Female	Mature	Commercial Gillnet	Contracted Commercial Angler
7/8/2020	Bighead Carp	Illinois Lake Drainage	Round Lake, MN	MN	621	3400	Male	Mature	Seine	MNDNR

Table 2 (continued). Invasive Carp caught from January through December 2020 in Minnesota and Wisconsin boundary waters.

Date	Species	Water Body	Location	State	Length (mm)	Weight (grams)	Sex	Maturity	Capture Method	Captured By
7/8/2020	Bighead Carp	Illinois Lake Drainage	Round Lake, MN	MN	632	3450	Female	Mature	Seine	MNDNR
7/8/2020	Silver Carp	Illinois Lake Drainage	Round Lake, MN	MN	659	3300	Male	Mature	Seine	MNDNR
7/8/2020	Silver Carp	Illinois Lake Drainage	Round Lake, MN	MN	425	900	Male	--	Seine	MNDNR
7/8/2020	Silver Carp	Illinois Lake Drainage	Round Lake, MN	MN	473	1400	Male	--	Seine	MNDNR
7/8/2020	Silver Carp	Illinois Lake Drainage	Round Lake, MN	MN	484	1500	Male	--	Seine	MNDNR
7/8/2020	Silver Carp	Illinois Lake Drainage	Round Lake, MN	MN	467	1300	Male	--	Seine	MNDNR
7/8/2020	Grass Carp	Illinois Lake Drainage	Round Lake, MN	MN	474	1500	Male	Mature	Seine	MNDNR
7/8/2020	Bighead Carp	Illinois Lake Drainage	Round Lake, MN	MN	779	6300	Male	Mature	Seine	MNDNR
7/8/2020	Bighead Carp	Illinois Lake Drainage	Round Lake, MN	MN	680	4200	Female	Mature	Seine	MNDNR
7/8/2020	Bighead Carp	Illinois Lake Drainage	Round Lake, MN	MN	770	6100	Female	Mature	Seine	MNDNR
7/8/2020	Bighead Carp	Illinois Lake Drainage	Round Lake, MN	MN	850	8200	Female	Mature	Seine	MNDNR
7/8/2020	Bighead Carp	Illinois Lake Drainage	Round Lake, MN	MN	747	5500	Male	Mature	Seine	MNDNR
7/8/2020	Bighead Carp	Illinois Lake Drainage	Round Lake, MN	MN	689	3900	Female	Mature	Seine	MNDNR
7/8/2020	Bighead Carp	Illinois Lake Drainage	Round Lake, MN	MN	720	4300	Female	Mature	Seine	MNDNR
7/8/2020	Bighead Carp	Illinois Lake Drainage	Round Lake, MN	MN	691	5000	Female	Mature	Seine	MNDNR
7/8/2020	Bighead Carp	Illinois Lake Drainage	Round Lake, MN	MN	577	2700	Male	Mature	Seine	MNDNR
7/8/2020	Bighead Carp	Illinois Lake Drainage	Round Lake, MN	MN	438	1200	Male	Mature	Seine	MNDNR
8/21/2020	Silver Carp	Mississippi River	Pool 5A	MN	775	5900	Female	Mature	Bow fishing	Bow-fisher

Table 2 (continued). Invasive Carp caught from January through December 2020 in Minnesota and Wisconsin boundary waters.

Date	Species	Water Body	Location	State	Length (mm)	Weight (grams)	Sex	Maturity	Capture Method	Captured By
10/13/2020	Silver Carp	Mississippi River	Upper Pool 8	MN	859	10300	Tagged	--	Gillnet	Contracted Commercial Angler
10/13/2020	Silver Carp	Mississippi River	Upper Pool 8	MN	770	5700	Tagged	--	Gillnet	Contracted Commercial Angler
10/13/2020	Silver Carp	Mississippi River	Upper Pool 8	MN	795	6800	Tagged	--	Gillnet	Contracted Commercial Angler
10/21/2020	Silver Carp	Mississippi River	Upper Pool 8	MN	840	8500	Tagged	--	Gillnet	Contracted Commercial Angler
10/23/2020	Silver Carp	Mississippi River	Upper Pool 8	MN	818	8500	Tagged	--	Gillnet	Contracted Commercial Angler
10/29/2020	Silver Carp	Mississippi River	Upper Pool 8	MN	721	5390	Female	Mature	Seine	Contracted Commercial Angler
11/3/2020	Silver Carp	Mississippi River	Lower Pepin	WI	--	--	--	--	Seine	Contracted Commercial Angler
11/23/2020	Grass Carp	Lake Okaman-peedan	Lake Okaman-peedan	MN	--	--	--	--	Seine	Commercial Angler
11/24/2020	Silver Carp	Mississippi River	Pool 7	WI	--	--	--	--	Seine	Commercial Angler
11/24/2020	Silver Carp	Mississippi River	Pool 7	WI	--	--	--	--	Seine	Commercial Angler

Values that are unknown are marked with "--".

Table 3. Larval trawl sampling for the St. Croix and Mississippi Rivers from 2013 to 2019.

Year	Number of Sites		Total number of Samples		Number of Samples with Larval Fish		Number of Larval Invasive carp	
	St. Croix River	*Mississippi River*	*St. Croix River*	*Mississippi River*	*St. Croix River*	*Mississippi River*	*St. Croix River*	*Mississippi River*
2013	8	8	16	28	6	16	0	0
2014	9	13	28	44	17	28	0	0
2015	8	18	52	253	23	139	0	0
2016	9	16	46	102	25	83	0	0
2017	7	17	20	73	20	73	0	0
2018	8	8	66	68	37	44	0	0
2019	2	4	52	100	37	64	0	0

Table 4. Species list for the Minnesota, St. Croix and Mississippi (Pool 2, Pool 3 and Pool 4) Rivers from January 2013 through December 2020, including 89 native and invasive species.

Common Name	Genus Species	Pool 2	Pool 3	Pool 4	St. Croix River	Minnesota River
American Eel	*Anguilla rostrata*	x				
Bighead Carp	*Hypophthalmichthys nobilis*	x	x		x	x
Bigmouth Buffalo	*Ictiobus cyprinellus*	x	x	x	x	x
Bigmouth Shiner	*Notropis dorsalis*	x				
Black Buffalo	*Ictiobus niger*	x				
Black Bullhead	*Ameiurus melas*				x	
Black Crappie	*Pomoxis nigromaculatus*	x	x		x	x
Black Redhorse	*Maoxostoma duquesnei*				x	
Blackchin Shiner	*Notropis heterodon*				x	
Blacknose Shiner	*Notropis heterolepis*	x				
Blackside Darter	*Percina maculata*	x			x	
Blue Sucker	*Cycleptus elongatus*	x			x	x
Bluegill	*Lepomis macrochirus*	x			x	x
Bluntnose Minnow	*Pimephales notatus*	x			x	
Bowfin	*Amia calva*	x		x	x	x
Brassy Minnow	*Hybognathus hankinsoni*				x	
Brook Silverside	*Labidesthes sicculus*	x			x	
Brook Stickleback	*Culaea inconstans*	x				
Brown Trout	*Salmo trutta*				x	
Bullhead Minnow	*Pimephales vigilax*	x				
Burbot	*Lota lota*				x	
Central Mudminnow	*Umbra limi*	x				
Central Stoneroller	*Campostoma anomalum*				x	
Channel Catfish	*Ictalurus punctatus*	x		x	x	x
Channel Shiner	*Notropis wickliffi*	x				
Common Carp	*Cyprinus carpio*	x	x	x	x	x
Common Shiner	*Luxilus cornutus*	x			x	
Creek Chub	*Semotilus atromaculatus*	x				
Crystal Darter	*Crystallaria asprella*				x	
Emerald Shiner	*Notropis atherinoides*	x	x		x	x
Fathead Minnow	*Pimephales promelas*	x			x	x
Flathead Catfish	*Pylodictis olivaris*	x	x	x	x	x
Freshwater Drum	*Aplodinotus grunniens*	x	x	x	x	x
Gilt Darter	*Percina evides*				x	
Gizzard Shad	*Dorosoma cepedianum*	x	x		x	x
Golden Redhorse	*Moxostoma erythrurum*	x			x	x
Golden Shiner	*Notemigonus crysoleucas*	x			x	
Goldeye	*Hiodon alosoides*	x	x			x
Grass Carp	*Ctenopharyngodon idella*	x				
Greater Redhorse	*Moxostoma valenciennesi*	x			x	
Green Sunfish	*Lepomis cyanellus*	x			x	x
Highfin Carpsucker	*Carpiodes velifer*	x			x	x
Hornyhead Chub	*Nocomis biguttatus*	x			x	
Hybrid Sunfish	*Lepomis microlophus* x *L.*	x			x	
Iowa Darter	*Etheostoma exile*				x	
Johnny Darter	*Etheostoma nigrum*	x			x	
Lake Sturgeon	*Acipenser fulvescens*	x	x	x	x	
Largemouth Bass	*Micropterus salmoides*	x			x	x
Logperch	*Percina caprodes*	x			x	
Longnose Gar	*Lepisosteus osseus*	x	x		x	x
Mimic Shiner	*Notropis volucellus*	x			x	
Mooneye	*Hiodon tergisus*	x			x	x
Muskellunge	*Esox masquinongy*	x			x	
Northern Hogsucker	*Hypentelium nigricans*				x	
Northern Pike	*Esox lucius*	x	x	x	x	x
Orangespotted Sunfish	*Lepomis humilis*	x			x	
Paddlefish	*Polyodon spathula*	x	x	x	x	x

Table 4 (continued). Species list for the Minnesota, St. Croix and Mississippi (Pool 2, Pool 3 and Pool 4) Rivers from January 2013 through December 2020, including 89 native and invasive species.

Common Name	Genus Species	Pool 2	Pool 3	Pool 4	St. Croix River	Minnesota River
Pumpkinseed	*Lepomis gibbosus*	x			x	
Quillback	*Carpiodes cyprinus*	x	x		x	x
Rainbow Darter	Etheostoma caeruleum				x	
River Carpsucker	*Carpiodes carpio*	x	x	x	x	x
River Darter	*Percina shumardi*	x			x	
River Redhorse	*Moxostoma carinatum*	x			x	
Rock Bass	*Ambloplites rupestris*	x	x		x	
Sand Shiner	*Notropis stramineus*	x			x	x
Sauger	*Sander canadensis*	x	x		x	x
Shoal Chub	*Macrhybopsis hyostoma*	x				
Shorthead Redhorse	*Moxostoma macrolepidotum*	x	x	x	x	x
Shortnose GarSmallmouth	*Lepisosteus platostomus*	x	x		x	x
Silver Carp	*Hypophthalmichthys molitrix*	x		x	x	
Silver Chub	*Macrhybopsis storeriana*	x			x	
Silver Lamprey	*Ichthyomyzon unicuspis*	x			x	
Silver Redhorse	*Moxostoma anisurum*	x	x		x	x
Skipjack Herring	*Alosa chrysochloris*	x				
Slenderhead Darter	*Percina phoxocephala*	x			x	
Smallmouth Bass	*Micropterus dolomieu*	x		x	x	x
Smallmouth Buffalo	*Ictiobus bubalus*	x	x	x	x	x
Spotfin Shiner	*Cyprinella spiloptera*	x			x	x
Spottail Shiner	*Notropis hudsonius*	x			x	x
Spotted Sucker	*Minytrema melanops*	x			x	
Tadpole Madtom	*Noturus gyrinus*	x				
Trout Perch	*Percopsis omiscomaycus*	x			x	
Walleye	*Sander vitreus*	x	x	x	x	x
Weed Shiner	*Notropis texanus*	x				
White Bass	*Morone chrysops*	x	x		x	x
White Crappie	*Pomoxis annularis*	x			x	x
White Sucker	*Catostomus commersonii*	x			x	x
Yellow Bullhead	*Ameiurus natalis*	x				
Yellow Perch	*Perca flavescens*	x			x	

Figures

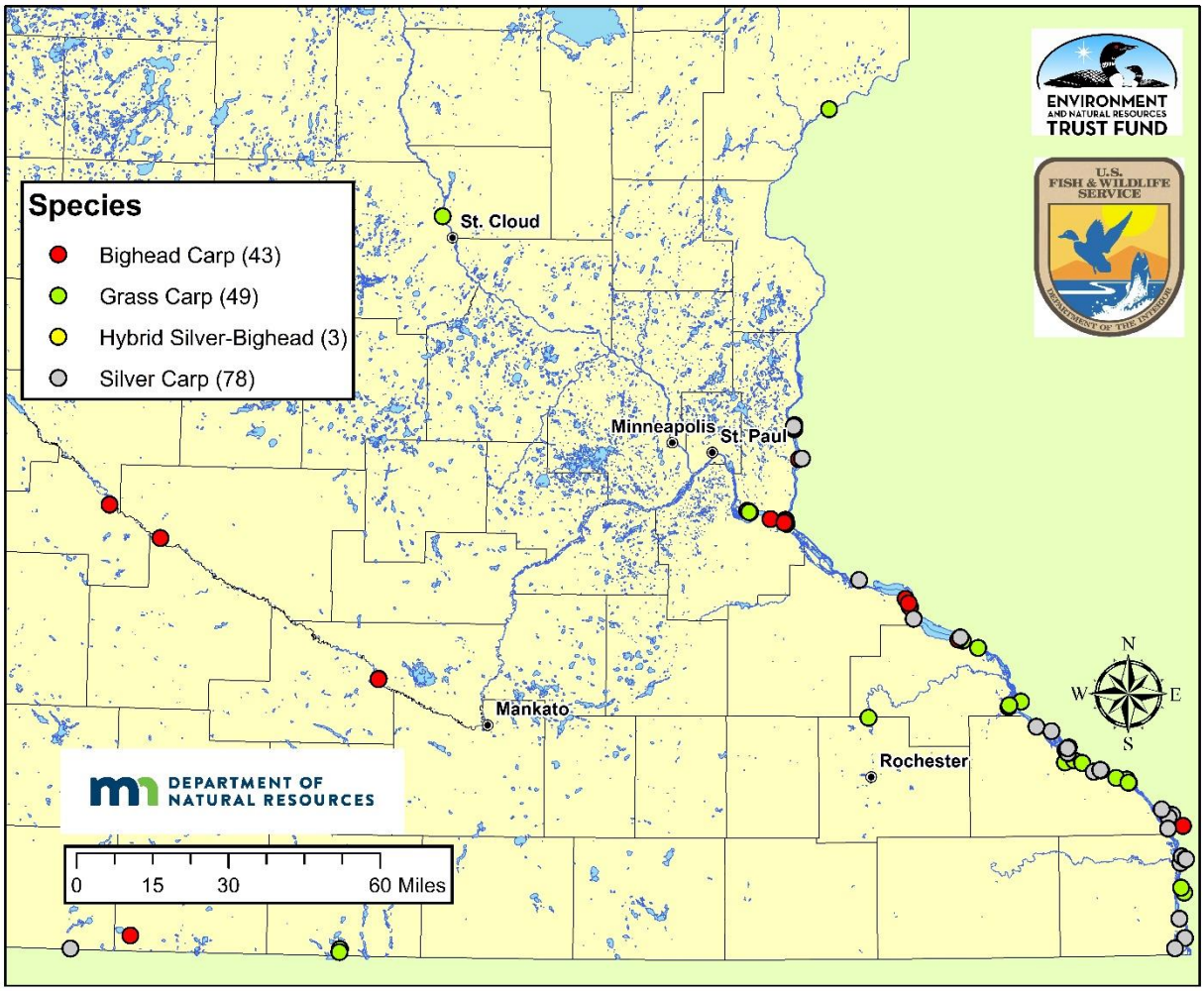

Figure 1. Locations of all known invasive carp captured in Minnesota waters through 2020.

Figure 2. Standardized electrofishing (dark circle, EF1 – EF8) and larval fish trawling (dark cross, P2-LT6 and P2-LT2019) locations on Pool 2 (P2) and larval fish trawling (dark cross, P3-LT4 and P3-LT2019) locations on Pool 3 (P3) of the Mississippi River.

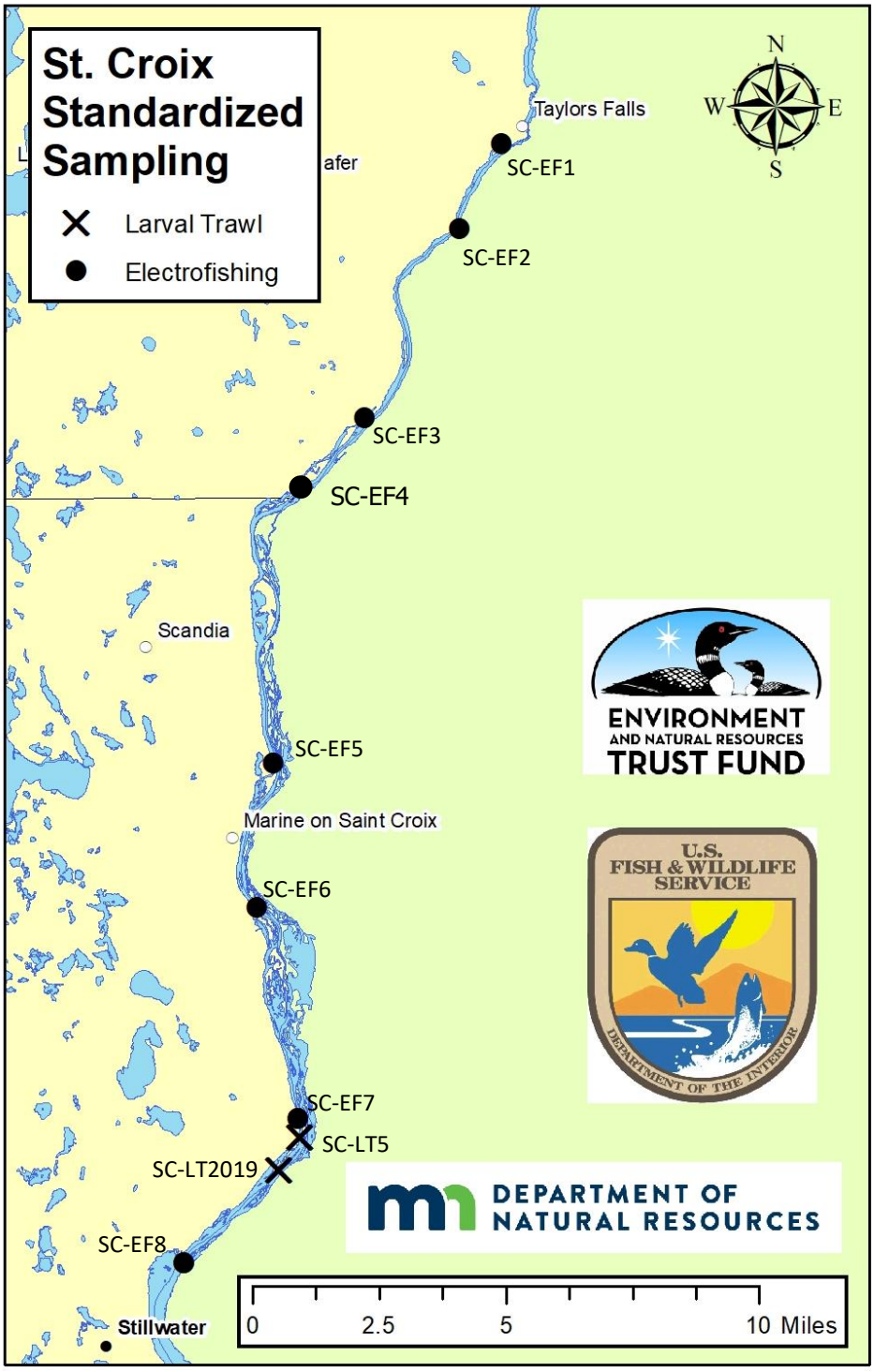

Figure 3. Standardized electrofishing (dark circle, EF1 – EF8) and larval fish trawling (dark cross, SC-LT5 and SC-LT2019) locations on the St. Croix River (SC).

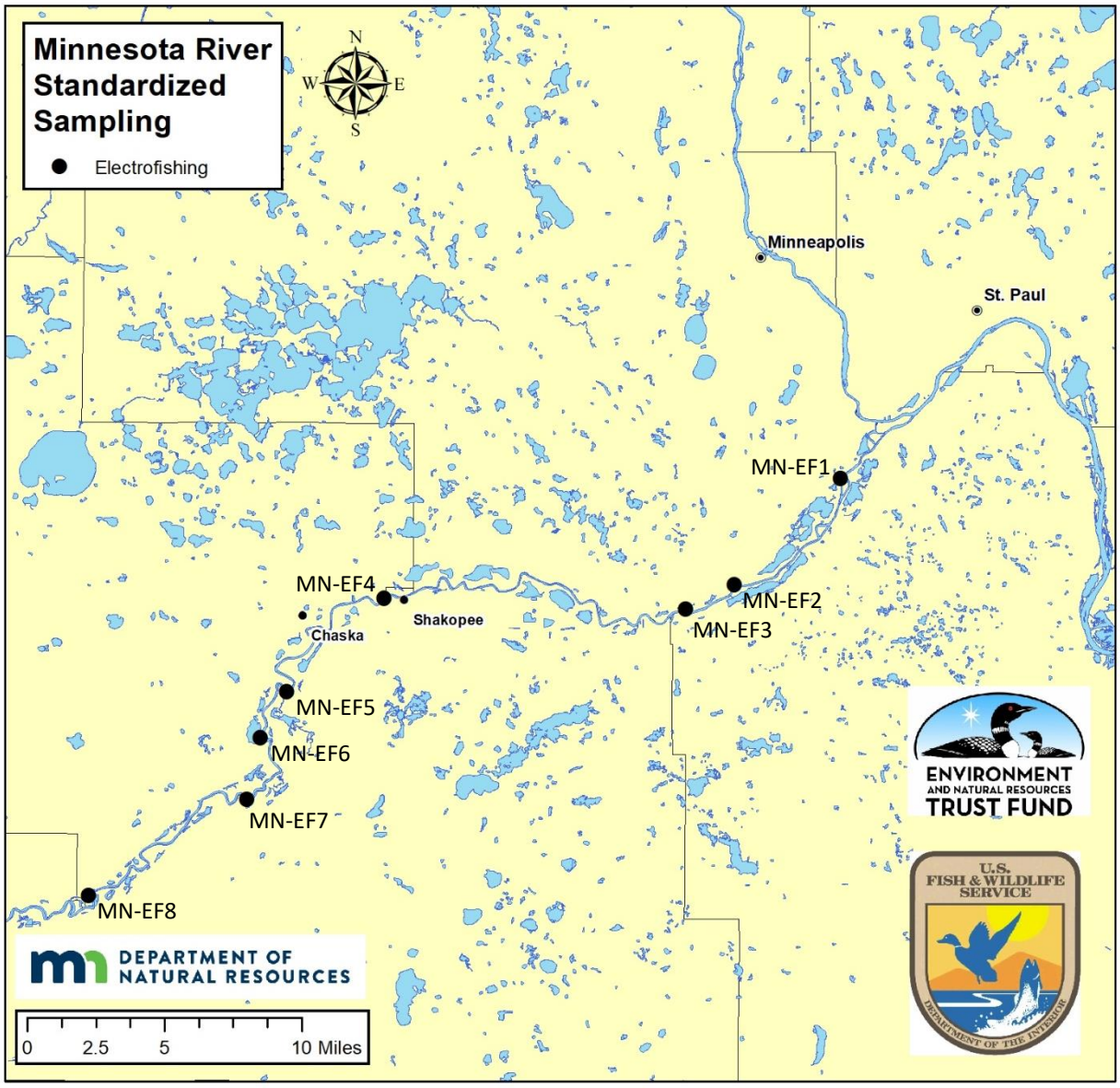

Figure 4. Standardized electrofishing (dark circle, EF1 – EF8) locations on the Minnesota River.

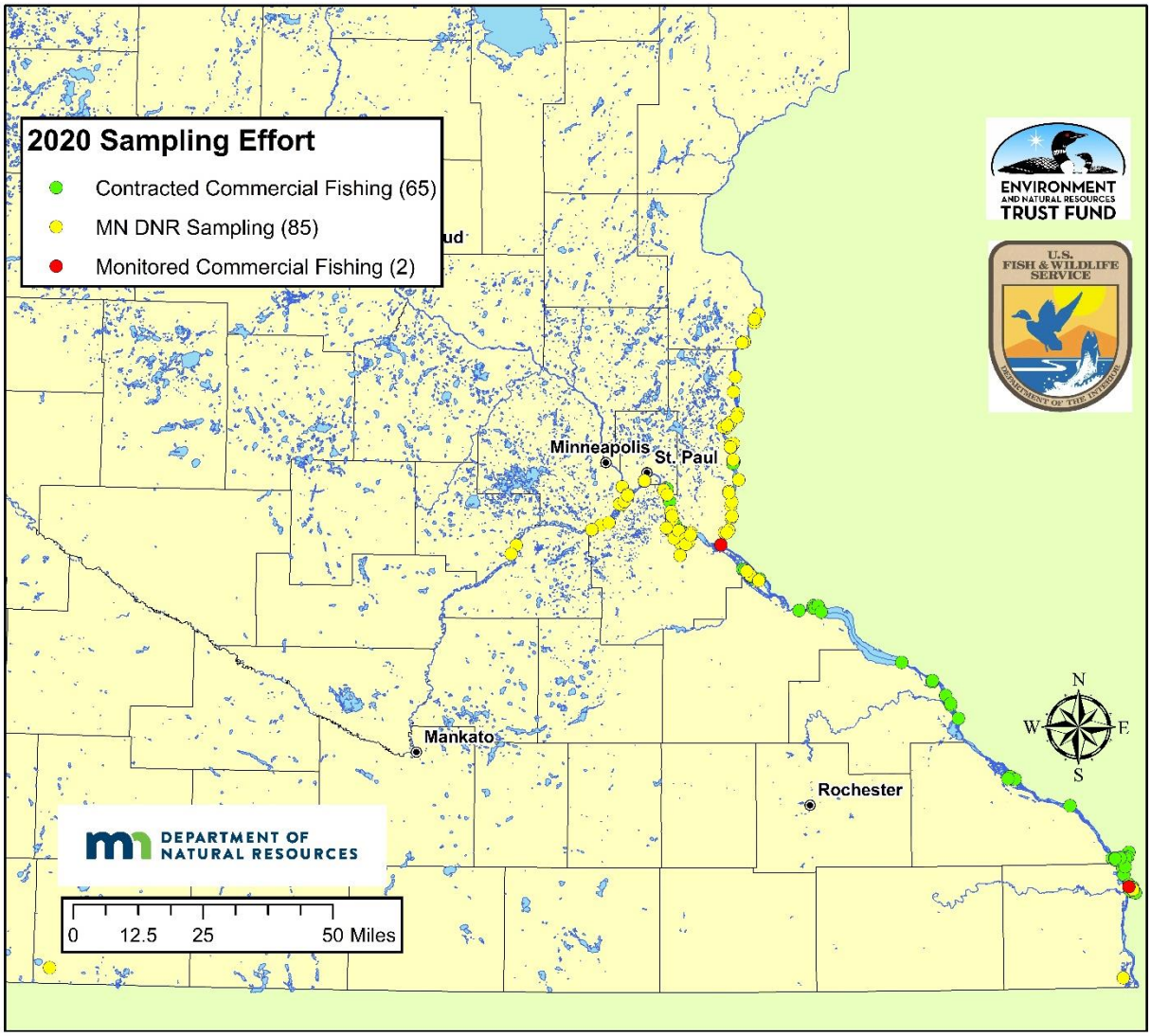

Figure 5. All sampling locations for contracted commercial sampling and MDNR sampling on the Mississippi, St. Croix, and Minnesota Rivers during 2020.

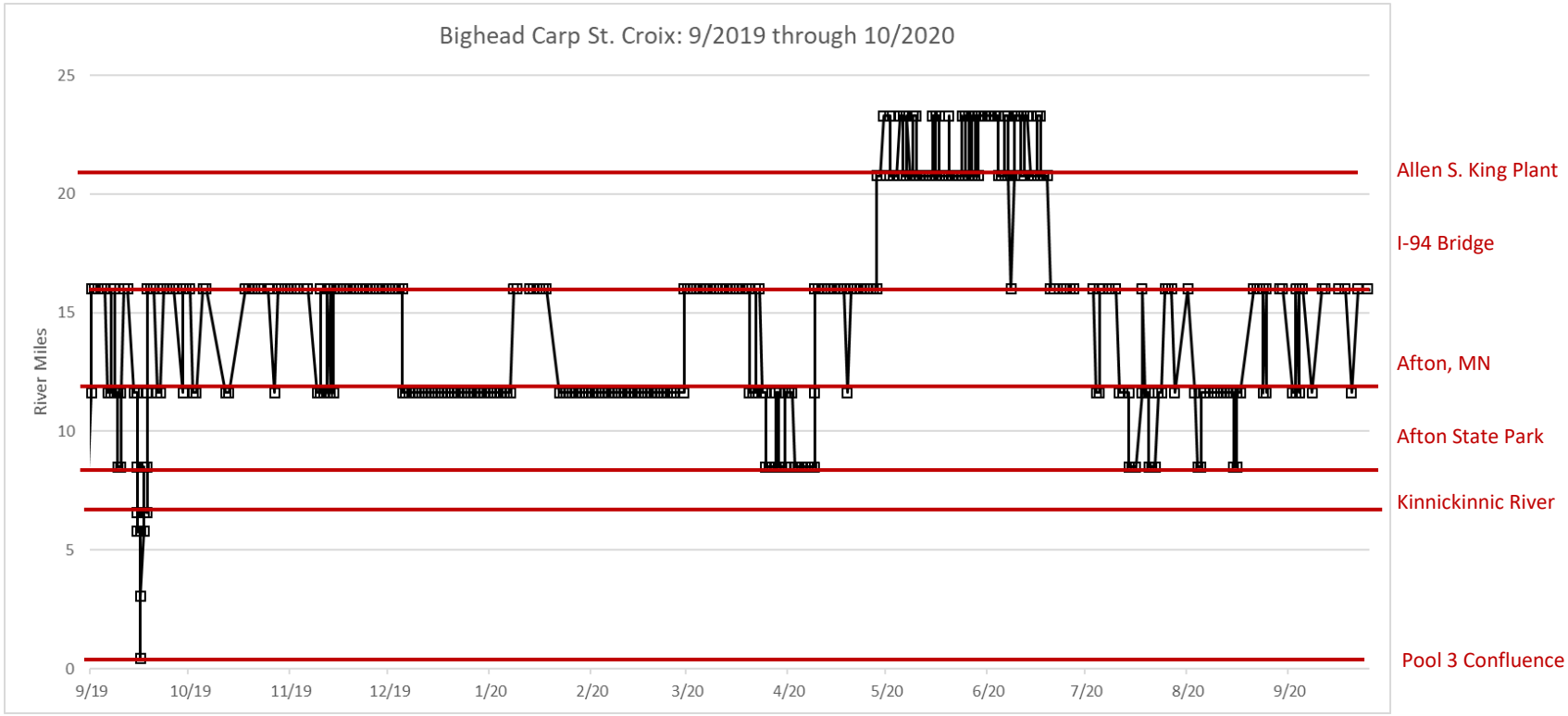

Figure 6. Movement patterns by River Mile over time of a tagged Bighead Carp from September 26, 2019 through the last receiver download for 2020 on October 20, 2020. The tagged Bighead Carp.

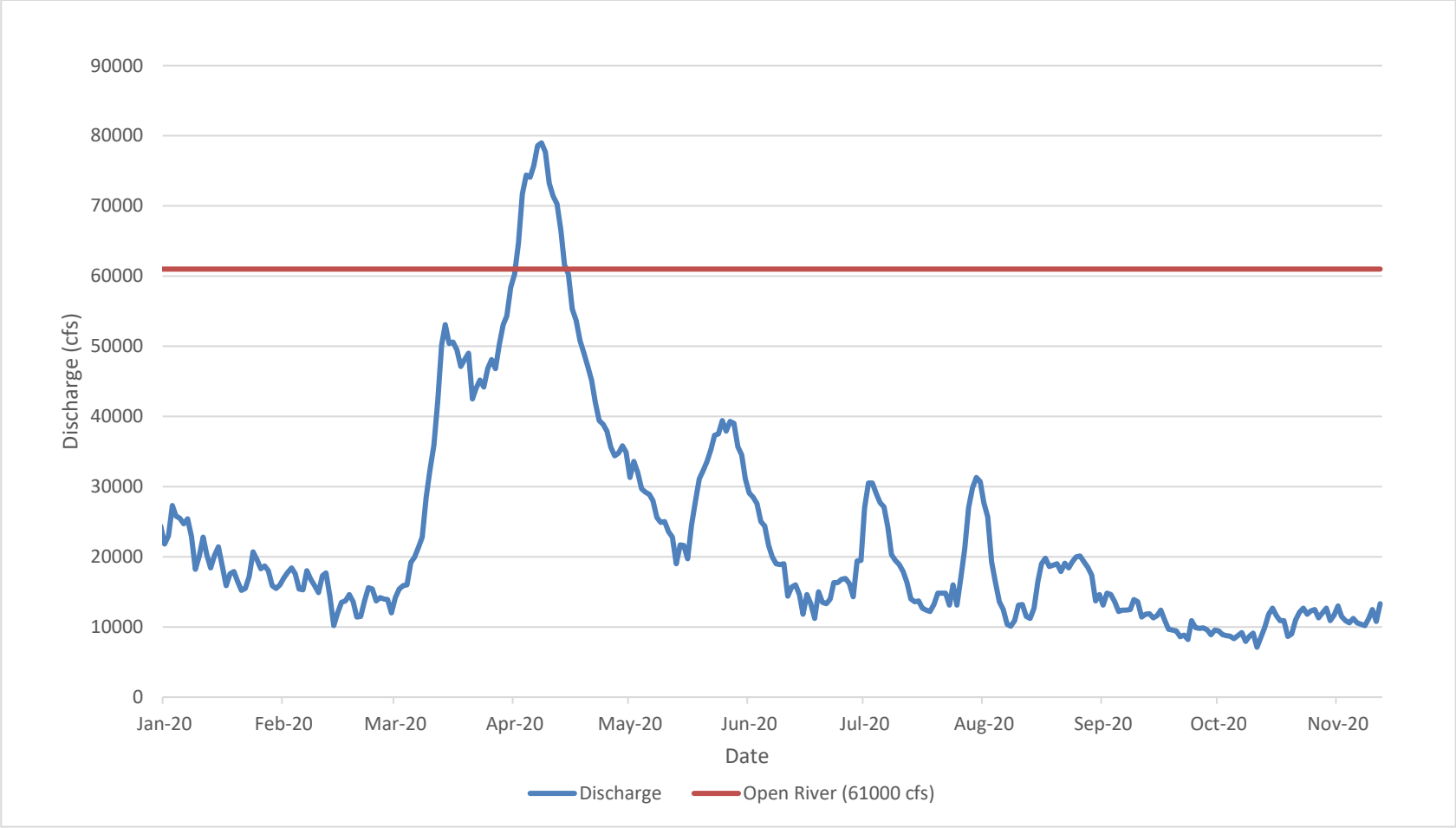

Figure 7. Discharge patterns of USGS gauge (05331580) at Hastings, MN in Pool 3 of the Mississippi River from January 1, 2020 through November 12, 2020. The tagged Bighead Carp was not detected in the vicinity of the Lock and Dam #2 during this time. The gauge reached open river conditions or 61,000 cubic feet per second (cfs) once during 2020.

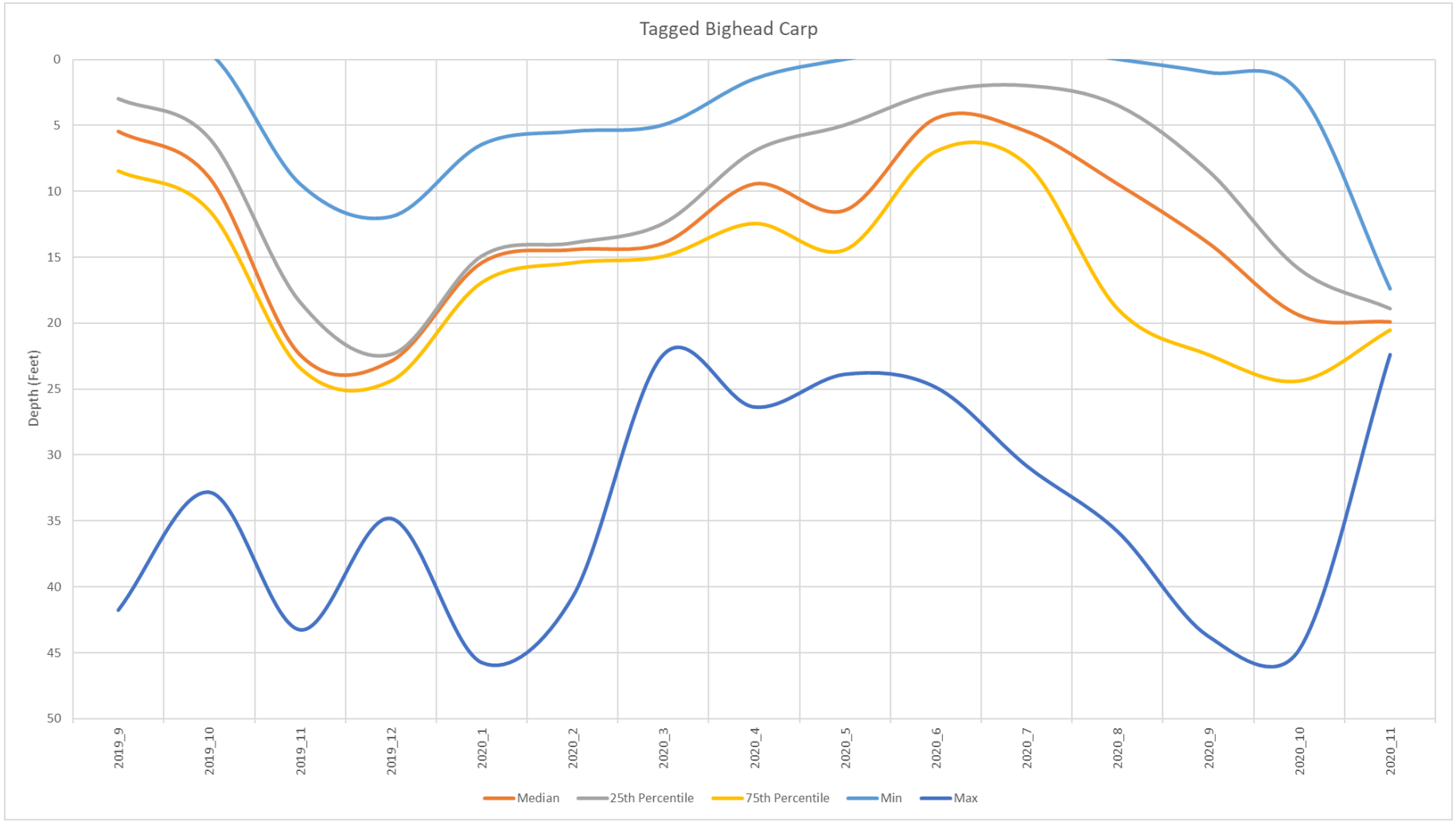

Figure 8. Depth patterns of tagged Bighead Carp from September 19, 2019 through the last receiver download for 2020 on October 20, 2020. Depths ranged from the surface (0 feet) to a maximum depth of 41.8 feet. Average depth occupied was 8.2 feet below the surface.

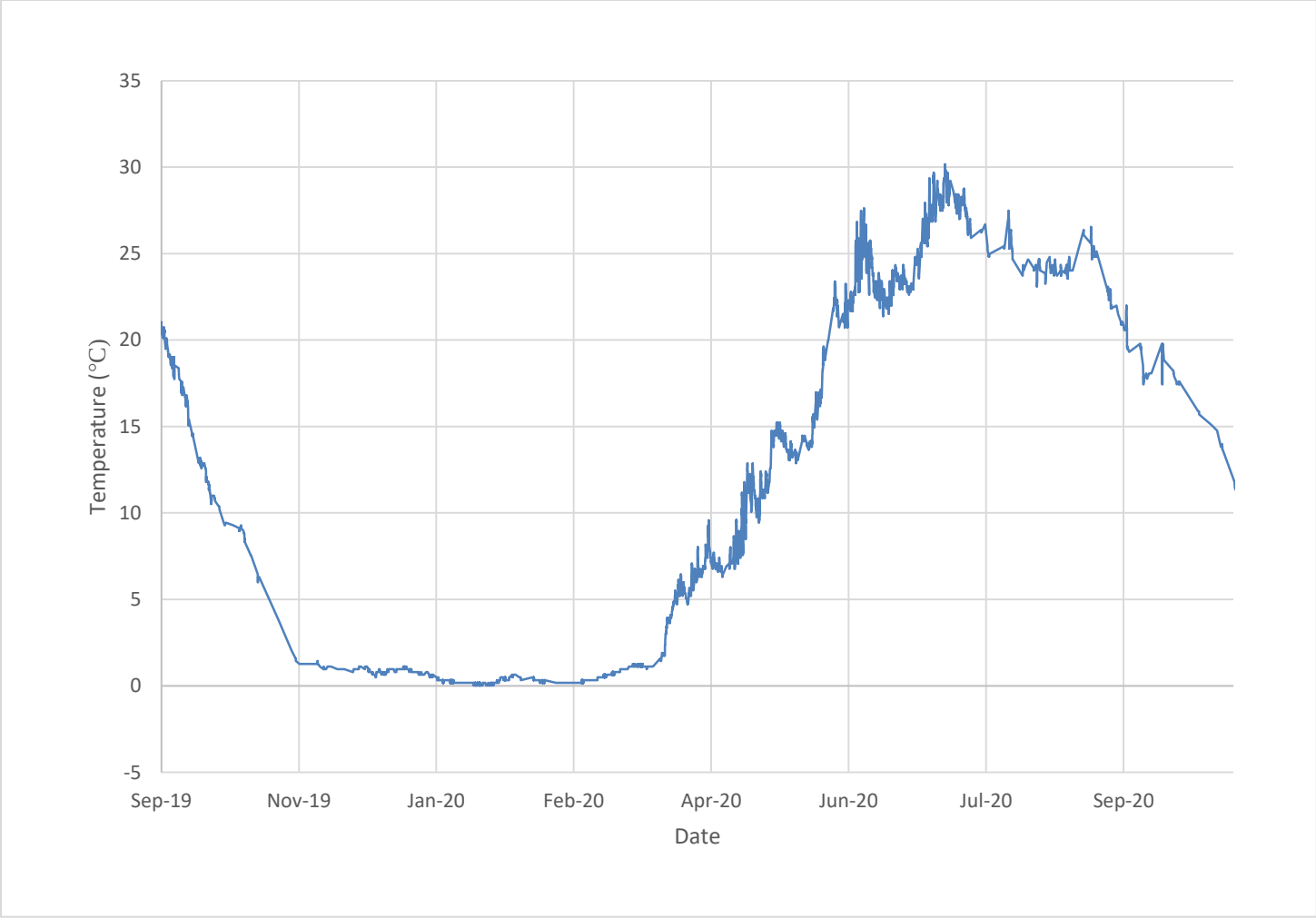

Figure 9. Temperature patterns of tagged Bighead Carp from September 26, 2019 through the last receiver download for 2020 on October 20, 2020.

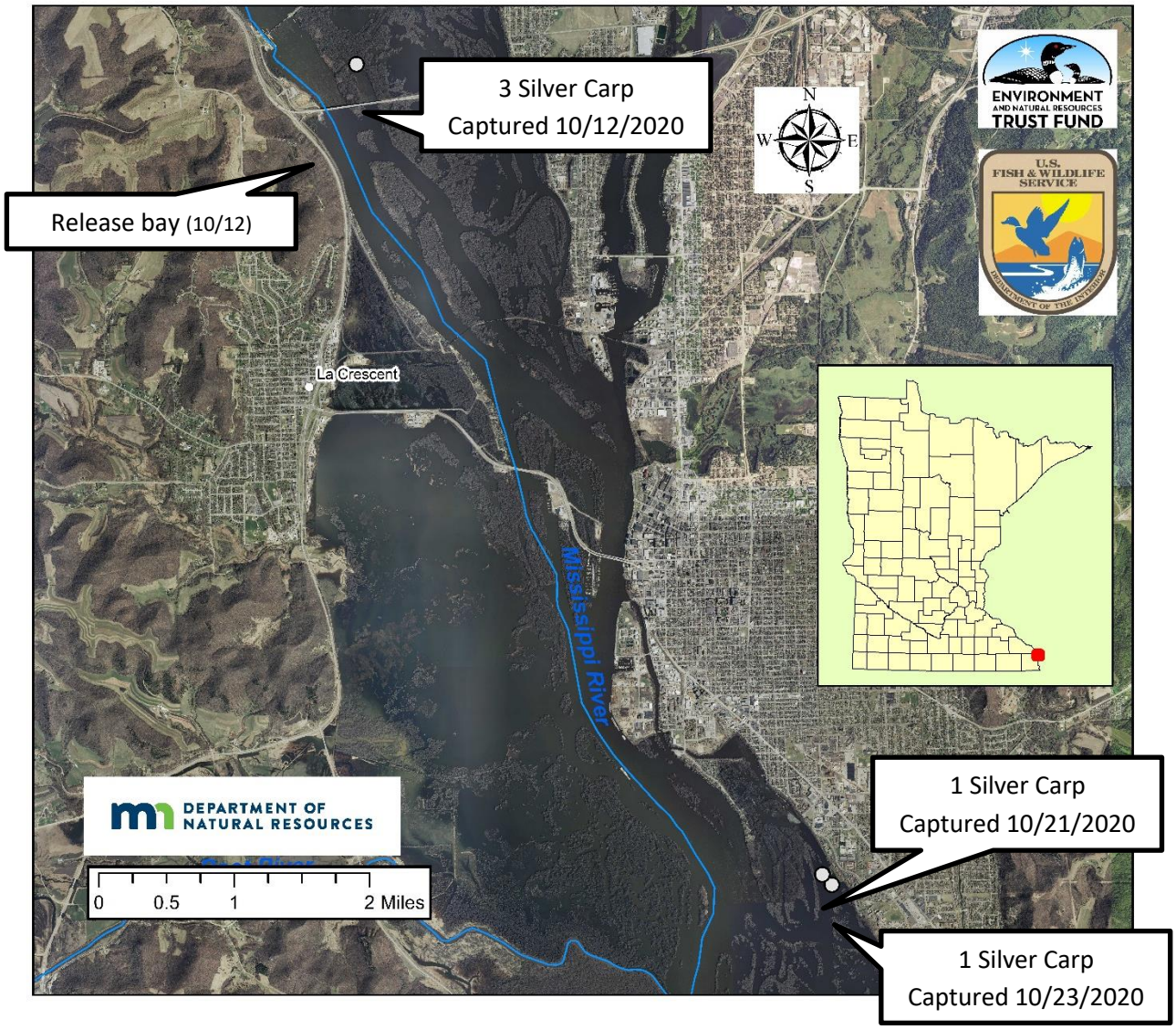

Figure 10. Capture location of tagged Silver Carp, October 2020.

Field work and report by:

Ben J. Larson, Invasive Carp Statewide Field Lead

Approved by:

Area Fisheries Supervisor:

/s/ TJ DeBates date: 05/31/2022

Regional Fisheries Supervisor:

/s/ Brian Nerbonne date: 05/31/2022

Date: