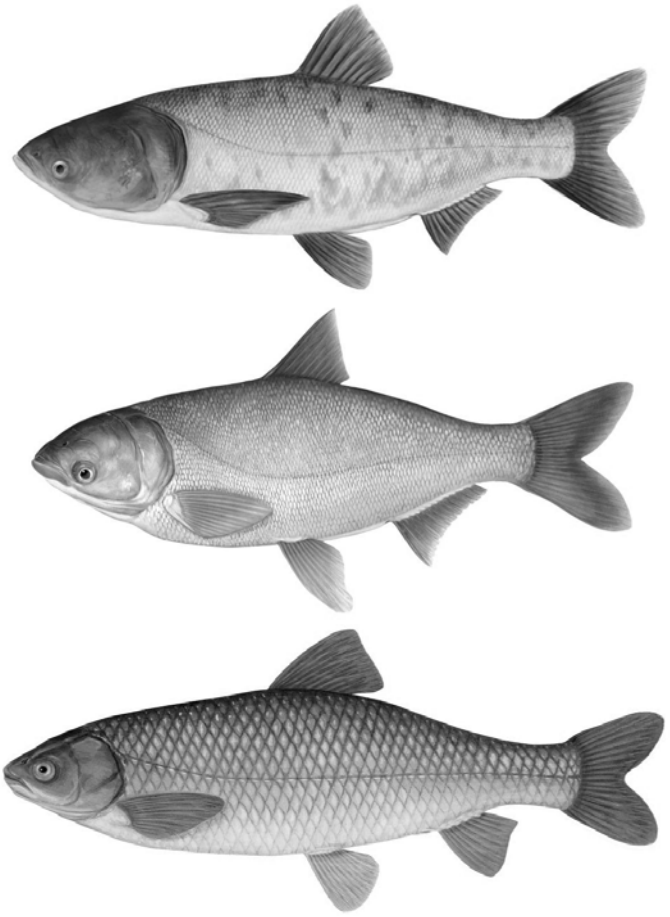
INVASIVE CARP SAMPLING REPORT

JANUARY – DECEMBER 2019

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, 2020

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 currently found in the United States. These species were 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 have the potential to devastate local ecosystems by competing with native planktivores and overcrowding other native species. With high fecundity and the ability to populate new areas quickly, 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 with invasive carp for food resources. 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, standard invasive carp sampling occurred in approximately 76 miles of water from St. Anthony Falls Lock and Dam in Minneapolis, MN to Pool 9 near

Jefferson Township, MN. In the St. Croix River, standard 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, 2019 and December 31, 2019. 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) 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 fishermen were contracted to target invasive carp with gill nets and seines for sampling and response efforts. Minnesota Department of Natural Resources (MN DNR) personnel accompanied contracted commercial fishermen 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 fishermen for both gill netting and seining operations.

Invasive Carp Acoustic Tagging and Tracking

In Minnesota, Statute 84D.05, Subdivision 1 stated, "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, MN DNR 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.

Based on the tagging results, MN DNR 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.

The DNR was permitted to tag up to two invasive carp at a time with acoustic transmitters. The DNR 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. From above the Coon Rapids Dam to Lock and Dam 5 in the Mississippi River, from the Mississippi River

confluence at Prescott, WI to Taylor's Falls in the St. Croix River, and from the Mississippi River confluence to the County Road 6 bridge north of Delhi, MN, in the Minnesota River (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 tagging a limited number of 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 fishermen, 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 MN DNR 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. Comprehensive removal efforts will be employed to remove tagged and un-tagged invasive fish from Minnesota waters.

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, MN DNR 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 presence front. Finally, Minnesota is remaining conservative with only one or two fish permitted to be tagged and released at a time, with all other invasive carps euthanized however, Fisheries staff are proposing to increase the maximum number of tagged invasive carp from two to six in 2020.

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), 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 is to use stable isotope analysis to examine the aquatic food web within Pool 2 and provide baseline trophic data before invasive carp establishment. The results of this study are currently being compiled for peer-reviewed publication.

Larval Trawling

Larval trawling was conducted in the Mississippi River Pools 2 and 3 and the St. Croix River to target early life stages of invasive carp. Two standardized sites were sampled in Pool 2, two in Pool 3 (Figure 2), and two on the St. Croix (Figure 3). A bow mounted icthyoplankton net (0.75 m x 3 m) consisting of 500 µm mesh was pushed near the surface into the current so that the velocity of the water entering the net was between 1.0 to 1.5 m/s. A mechanical flow meter was placed in the mouth of the net to determine the volume of water sampled. A total of two locations were sampled in each system, approximately 10 and 15 miles downstream of sites determined by Fluvial Egg model (Kasprak et al., in preparation) with two, 5-minute pushes conducted at each location. For all samples, contents were placed in containers labeled with

sample location, name of the water body, and date, and preserved. For preservation, samples were placed into 10% buffered formalin for 24-48 hours and then the formalin was removed and replaced by 90% alcohol. All samples were sifted to remove all excess material, with only eggs and fish kept for later identification. Fish and eggs were examined to determine if any invasive carp species were collected and to identify specimens to the lowest possible taxonomic level. Samples are sent to an external researcher for verification in order to create a reference collection of the species captured. 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 site.

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. As a result this species is being studied to serve as a surrogate for tagging additional Bighead or Silver carp. During the 2019 field season, this project was not a large priority as other higher priorities were encountered that had to be addressed.

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 sampling locations were selected based on habitats invasive carp are likely to occupy and are 1/3 mile (500 meters) in length. 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 conducted on Pool 2 of the Mississippi River in 2019 using standard and mini-fyke nets June 24-28, 2019. Trap netting was not conducted in the St. Croix River this field season due to high water conditions. The mini-fyke nets consist of a double frame (27 in. x 39 in.), 4 hoops (2 ft.), a single throat, and a 25 ft. lead, with a square mesh size of 0.125 in. throughout. All fish were identified and enumerated in the field.

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 18 seine hauls completed over 5 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.

Fish 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 2019, 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. During the 2015, 2016, 2017, and 2018 field seasons, 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. The results of this study are presented in an annual MN DNR tagging report (Waters, 2017).

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. Trammel nets with outside

wall bar mesh sizes of 14 inches and inner bar mesh sizes of 4 inches were also 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.

Results and Discussion

Sampling Results

In total, 102 days were spent sampling between January and December 2019 on the Mississippi River Pools 2, 3, 4, 5A, and 6, 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 2 and the St. Croix River, because invasive carp were found above Lock and Dam 2 on the Mississippi River in 2014 and multiple Bighead Carp captured at the Allen S. King Plant discharge on the St. Croix in 2015. A total of 18 invasive carp were caught in Minnesota waters and Minnesota-Wisconsin boundary waters in 2019 (Table 2). We believe this is due to a surge in upstream movement made possible by extended periods of high water. Minnesota's population is still considered low density. Follow up sampling was conducted after invasive carp captures when possible. Follow up sampling occurred at the Lake Bella Outlet in Nobles county after a report and capture of a Silver Carp resulting in an additional Silver Carp captured. Capture data and response actions were shared with multiple agencies including the Wisconsin Department of Natural Resources, USGS, and Western Illinois University.

On May 17, 2019 the newly purchased real-time receiver detected the tagged Bighead Carp within Andersen bay on the St. Croix River. MN DNR personnel set gill nets across the bay from shoreline to shoreline to block the bay off. This set yielded one mature female Bighead Carp. Andersen Bay produced two fish in 2018 as well; none of these fish would have been caught without the tagged fish leading MN DNR crews to that location. On June 20, 2019 while

tracking the tagged Bighead Carp, MN DNR crews located the tagged fish near the Allen S. King Plant discharge. MN DNR personnel set nets across the mouth of the outlet and caught a mature female Bighead Carp. Another product of the tagged invasive carp and MN DNR crews use of the traitor fish technique. Additionally, on July 12, 2019, MN DNR crews tracked the tagged Bighead Carp in upper Pool 3 near the Lock and Dam 2 auxiliary lock chamber. Crews set nets in the chamber and caught a mature female Bighead Carp. This is the second consecutive year the tagged invasive carp has made such a movement to Lock and Dam 2 in the mid-summer months.

On September 10, 2019 while using the newly acquired 2,000 foot purse seine, MN DNR crews in cooperation with a commercial fisherman caught and tagged a Silver Carp near Lakeland, MN on the St. Croix River. The Silver Carp was tagged but was confirmed deceased two weeks later. Transmitter retrieval is ongoing.

Contracted commercial fishermen were hired to use large mesh gill nets and seines to sample in the Mississippi River in Pools 2, 4, 5A, and 6, and in the St. Croix River from Andersen Bay in Bayport to the confluence with the Mississippi River near Prescott, WI. Contracted commercial fishermen set approximately 64,900 feet of gill nets during 10 days of effort and conducted six seine hauls between January and December 2019. Gill nets were set short term (2-3 hours) and fish were chased towards the net with boats, typically in large backwater areas. In 2019, six regular commercial fishing operations were also monitored for the presence of invasive carp. In total, the purse seine was used for three pursing hauls and five beach hauls.

Larval trawling was conducted for a total of 152 total trawls during 12 days by the invasive carp fisheries personnel. All samples were sifted by invasive carp fisheries personnel

and all samples with fish larvae or eggs were preserved and have been sent to Colorado State University for expert analysis to determine the species caught and their respective number (Table 3).

Both random and standardized electrofishing sampling was conducted on Pool 2 of the Mississippi, the Minnesota and the St. Croix rivers. A total of 1,840 minutes of "on time" over 28 days were spent electrofishing between January and December 2019. In 2019, 23 standardized electrofishing sites were sampled once for a total of 440 minutes. Random electrofishing was used to monitor for invasive carp and for collection of individual native fish for age and growth.

Trap netting was conducted using fyke nets over June 24-28 for a total of 40 net nights on Pool 2 of the Mississippi River. All fish were counted and measured in mini-fyke nets, except Spottail Shiners *Notropis hudsonius* and young-of-the-year Bigmouth Buffalo due to large numbers captured.

Gill nets and trammel nets set by MN DNR personnel were often used to sample behind wing dikes and in smaller side channel and backwater areas where it wasn't feasible for commercial fishermen to target with their larger operations. In 2019, a total of 51,700 feet of gill and trammel nets were set in Pools 2, 3, and 4, and the St. Croix River over 29 days, with most net sets being short-term sets (2-5 hours).

Numerous unique or rare native fishes worth mentioning were encountered during these sampling events. Three new species were added to our on-going species list from Pool 2 and the St. Croix: Trout-Perch *Percopisi omiscomaycus*, Silver Chub *Macrhybopsis storeriana*, and Golden Shiner *Notemigonus crysoleucas*. Also, from past experiences and in conjunction with tracking the tagged Bighead Carp, a large number of Paddlefish and Lake Sturgeon were caught.

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 2019, has been compiled (Table 4).

Determining if invasive carp seen in Minnesota are pioneering individuals or are indicative of a population is a key question for managers. While it is likely there are additional invasive carp present in Minnesota waters of the monitored rivers, the level of effort invested and resulting capture data support the hypothesis that the carp currently present are individual wandering adults and not part of a larger population present in Minnesota waters. A larger number of invasive carp were captured in 2019 due to frequent high water. It is still believed that these fish are individual, wandering adults and not part of a larger population present in Minnesota waters. The lack of invasive carp in targeted backwaters and absence of larval invasive carp (as of 2018) further support this hypothesis.

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 MN DNR 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 September 14, 2018 and the last detection using active tracking and the VR100 occurring on November 20, 2018. Details of when and where this fish were located can be found in Figure 6. In 2017, we received 54,264 data points from the VR2W array up until the end of the year. In 2018, we received 166,837 data points from the VR2W array. In 2019 we received 107,749 data points from the VR2W array with the last download on September 19. There are a total of 2,681 data points from the VR100 since the fish was tagged.

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 and entered Pool 3 and traveled 2.5 miles from the confluence to Lock and Dam #2 (Figure 6). Over the course of this second field season, the tagged carp started showing site fidelity within the St. Croix River. In general, the tagged Bighead Carp was observed to remain between the Interstate 94 Bridge and Afton, MN (here after referred to as the Lakeland area) from August to April. In 2019 the tagged fish started showing more site fidelity, returning to Anderson Bay in Bayport, MN in the spring, running downstream to Lock & Dam 2 midsummer, and Lakeland area in the fall. Based on the first two field seasons, this fish spends over 80% of its time within the Lakeland area.

From temperature and depth data, this fish comes to the water's surface often and inhabits a wider range of depths, 0 to 68.6 feet, than believed (Figure 7) and tolerates temperatures ranging from 33 to 88 degrees Fahrenheit (Figure 8). (See MN DNR 2018 and MN DNR 2019 for data collected from the previous two filed seasons.)

In 2019, recapture efforts began in May as soon as ice was off the river. Ten days of concerted effort to recapture the tagged fish or capture fish schooling near the tagged individual included: 16,700 feet of gill net, 1.7 hours of electrofishing, and 3,000 feet of large mesh commercial gill nets and two commercially deployed seines. The tagged fish was not recaptured; however, on May 17, 2019 while tracking and attempting to recapture the tagged bighead an additional Bighead Carp was caught. Unfortunately, due to flooding conditions, the tagged bighead was able to escape. From July 5 through July 12, 2019 the tagged fish was observed to move into Pool 3 and approach the downstream side of Lock and Dam #2. Nets were deployed on July 12 in the auxiliary chamber resulting in the capture of a mature female Bighead Carp. While the fish had been residing within the St. Croix River, the timing of the fish's movement to Lock and Dam #2 corresponded to periods of high flow and discharge through the dam. Flows reached open river conditions on June 26 and remained open-river until July 6 and again on July 13 through July 14 (Figure 9). In total, the dam experienced open-river conditions above 61,000 cubic feet per second (cfs) four times in 2019. From research conducted in other states, movements below a lock and dam are often associated with discharges when flows are at their greatest. Continued monitoring in the St. Croix and Pool 3 will be conducted in 2020 to ensure no reproduction occurred in 2019.

Again in 2019, the tagged bighead spent a large majority of its time within Lake St. Croix between Hudson, WI and Afton, MN suspended on average 8.6 feet below the surface which proved difficult to sample when the depth ranged from 50-60 feet deep in the area. Standard gill nets reach less than 25 feet from the surface or bottom and even commercial seines only reach 30-40 feet of water. From these experiences, MN DNR purchased additional 24 foot deep large mesh gill nets to better sample Lake St. Croix and deeper St. Croix River habitats. In addition,

the DNR also purchased a 2,000 foot long and 40 foot deep purse seine to better sample these deep water habitats. In 2019 a real-time receiver was built and deployed on the St. Croix River. This receiver allowed for rapid response action allowing fisheries staff to view daily reports of fish movement in the area. During the 2019 field season, use of the real time receiver allowed for three recapture attempts of the tagged Bighead Carp. Lastly, a crew of two temporary staff will continue through 2020 to track the tagged Bighead Carp and set nets if possible to attempt to recapture the tagged bighead or catch additional fish for tagging and/or removal.

From this 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. Based on information from other areas tracking carp and historic sightings in Minnesota, the hypothesis was that 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 with the most likely location being at Point Douglas, near Prescott, WI. From the tracking data collected, 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 inhabiting 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. These locations will be sampled extensively during the 2020 field season to determine if other invasive carp also use these areas and if this tagged Bighead Carp can continue to reveal the locations of other invasive carp using the traitor, or “Judas” fish technique.

The tagged Bighead Carp has been critical to the capture of two additional Bighead Carp in 2018 and the capture of four additional invasive carp in 2019. Without the tagged carp, DNR

personnel would not have fished that area at that time. From previous captures and the understanding of invasive carp movements and biology, the DNR had focused efforts on a relatively few areas (including the Allen S. King Plant, Andersen Bay and Point Douglas on the St. Croix River). Finally, timing of sampling is critical for effective management and removal. This tagged fish has shown significant movements and has inhabited confined areas suitable for complete sampling for short periods of time. As a result, the ability to track a tagged individual to better understand additional habitat preferences and the duration of residence will be invaluable into the future.

On September 10, 2019 while attempting to capture the tagged bighead, a Silver Carp was captured. The fish was surgically implanted with 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. The fish was tracked for one week. On September 16, 2019, the fish was located near Lakeland and was detected in the same location for 5 days. After detecting the fish at the same depth for consecutive days, it was determined that the fish was deceased. On October 4, 2019 a dive team attempted to recover the Vemco acoustic transmitter which was unsuccessful, but one external Floy tag from that fish was recovered. As of November 7, 2019 the transmitter was in the same location. Given the opportunity, we will continue attempts to retrieve this transmitter. Its current location is within detection range of a passive receiver. Due to the high transmission frequency, this transmitter will interfere with other transmitters in the area resulting in a loss of valuable data based on the findings of 2019. Tracking methods and field sampling will be adjusted accordingly for 2020. MN DNR staff will continue to track tagged fish and analyze 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 MN DNR Invasive Carp Report (MN DNR 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 for peer review publication.

Recommendations

Continued monitoring and removal of invasive carp from Minnesota waters is recommended for the near future. This project is funded in part by the current Minnesota Environment and Natural Resources Trust Fund grant through June, 2020. MN DNR staff secured funding for another 3 years until 2023, which is also funded by the Minnesota Environment and Natural Resources Trust Fund. It is recommended this project continue beyond that date to ensure invasive carp do not establish populations or if they do, adequately document the effects of invasive carp to native fish populations. Further, it is recommended that invasive carp acoustic tagging continue and that the project expand the number and duration of tagged fish at liberty in Minnesota waters. At this time, only two invasive carp can be at liberty at one time however, a change in tagging protocol is being submitted to increase that number to six (two Bighead Carp, two Silver Carp, and two Grass Carp).

Continued age and growth analysis as well as population dynamics validation (including fecundity and recruitment) is recommended for commercially valuable Bigmouth and

Smallmouth Buffalo, which may be in direct competition for food resources with invasive carp. Resource agencies would benefit from a greater understanding of the population dynamics of our commercially important native fishes. In addition to age and growth analyses, over 4,000 Bigmouth Buffalo and Smallmouth Buffalo have been tagged in Pool 2 during 2015, 2016, 2017, and 2018 as part of a study investigating movement, exploitation, age and growth, and other key population dynamics of these commercially important species. It is recommended that this tagging project continue to better understand movement patterns and approximate the numbers of individuals present in Pool 2 of the Mississippi River via mark-recapture techniques.

Paddlefish are another native planktivore that may compete for food resources with invasive carp and therefore may be negatively affected. 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 would be further stressed. Being a state threatened species, non-lethal means of studying Paddlefish populations are also recommended including continued tagging of encountered Paddlefish using jaw and acoustic tags. Efforts to tag and release Paddlefish are invaluable to gain more information about their populations and life history, as well as provide a population estimate for management purposes. Further effort should also be used to encourage boaters to report any deceased Paddlefish for age and growth analysis and other MN DNR 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 2019. Number of Invasive Carp Captured represents the number of individuals caught by MN DNR, contracted commercial fishermen, or monitored commercial fishing.

Invasive Carp Sampling Summary January – December 2019			Days
Random Sampling Effort			
Gill/Trammel Netting	51700	feet	29
Electrofishing	1400	minutes	20
Trap Netting	40	net/nights	5
Standardized Sampling Effort			
Electrofishing	440	minutes	13
Larval trawling	152	trawls	12
Targeted Commercial Fishing Effort			
Gill Netting	64900	feet	10
Seining	7	hauls	6
Monitored Commercial Fishing Effort			
Seining	6	hauls	6
Tracking			
2-person crew	290	hours	
Number of Invasive Carp Captured	18	fish	
Total Number of Days Sampled			101

Table 2. Invasive Carp caught from January through December 2019 in Minnesota and Wisconsin boundary waters.

Date	Species	Water Body	Location	Length (mm)	Weight (grams)	Sex	Maturity	Capture Method	Captured By	Age
4/3/2019	Silver Carp	St. Croix River	Pt. Douglas	666	3200	Male	Mature	Commercial Seine	Commercial Fisherman	
5/17/2019	Bighead Carp	St. Croix River	Andersen Bay	1254	18500	Female	Mature	Gill Net	MN DNR	
5/22/2019	Silver Carp	Mississippi River	Pool 9	863	7150	Male	Mature	Commercial Gill Net	Commercial Fisherman	
5/24/2019	Silver Carp	Mississippi River	Pool 4	668	3500	Male	Mature	Snagged	Angler	
6/4/2019	Silver Carp	Mississippi River	Lake Pepin	655	3600	Male	Mature	Electrofishing	Xcel Energy	
6/20/2019	Bighead Carp	St. Croix River	King Plant	1175	28000	Female	Mature	Gill Net	MN DNR	
6/25/2019	Silver Carp	Mississippi River	Pool 6	635	3500	Male	Mature	Jumped into boat	Boater	
6/29/2019	Silver Carp	Mississippi River	Pool 5a	661	4400	Female	Mature	Jumped into boat	Boater	
6/29/2019	Grass Carp	Mississippi River	Pool 8	1023	13500	Male	Mature(tri)	Bow fishing	Bowfisherman	
6/30/2019	Grass Carp	Mississippi River	Pool 6	817	8050	Male	Mature	Bow fishing	Bowfisherman	
7/12/2019	Bighead Carp	Mississippi River	Pool 3	1249	27800	Female	Mature	Gill Net	MN DNR	
9/10/2019	Silver Carp	St. Croix River	Lakeland	675	4190	- -	- -	Purse Seine	MN DNR	
11/19/2019	Silver Carp	Mississippi River	Pool 6	714	4100	Male	Mature	Commercial Seine	Commercial Fisherman	
11/19/2019	Silver Carp	Mississippi River	Pool 6	714	4050	Male	Mature	Commercial Seine	Commercial Fisherman	
11/19/2019	Grass Carp	Mississippi River	Pool 6	800	7200	Male	Mature	Commercial Seine	Commercial Fisherman	
12/4/2019	Silver Carp	Mississippi River	Pool 5a	700	3800	Male	Mature	Commercial Seine	Commercial Fisherman	
12/17/2019	Silver Carp	Lake Bella Outlet	Bigelow, MN	733	4250	Male	Mature	Gill Net	MN DNR	
12/19/2019	Silver Carp	Lake Bella Outlet	Bigelow, MN	662	3500	Male	Mature	Seine	MN DNR	

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 and/or Eggs
2013	**22**	**44**	**39**
2014	**16**	**141**	**72**
2015	**16**	**301**	**162**
2016	**16**	**156**	**116**
2017	**16**	**143**	**93**
2018	**16**	**134**	**81**
2019	**12**	**101**	**101**
Total:	***114***	***1071***	***664***

Table 4. Species list for the Minnesota, St. Croix and Mississippi (Pool 2, Pool 3 and Pool 4) Rivers from January 2013 through December 2019, 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 ShinerPaddlefish	*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
Pumpkinseed	*Lepomis gibbosus*	x			x	
Quillback	*Carpiodes cyprinus*	x	x		x	x
Rainbow Darter	*Etheostoma caeruleum*				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 2019, including 89 native and invasive species.

Common Name	Genus Species	Pool 2	Pool 3	Pool 4	St. Croix River	Minnesota River
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

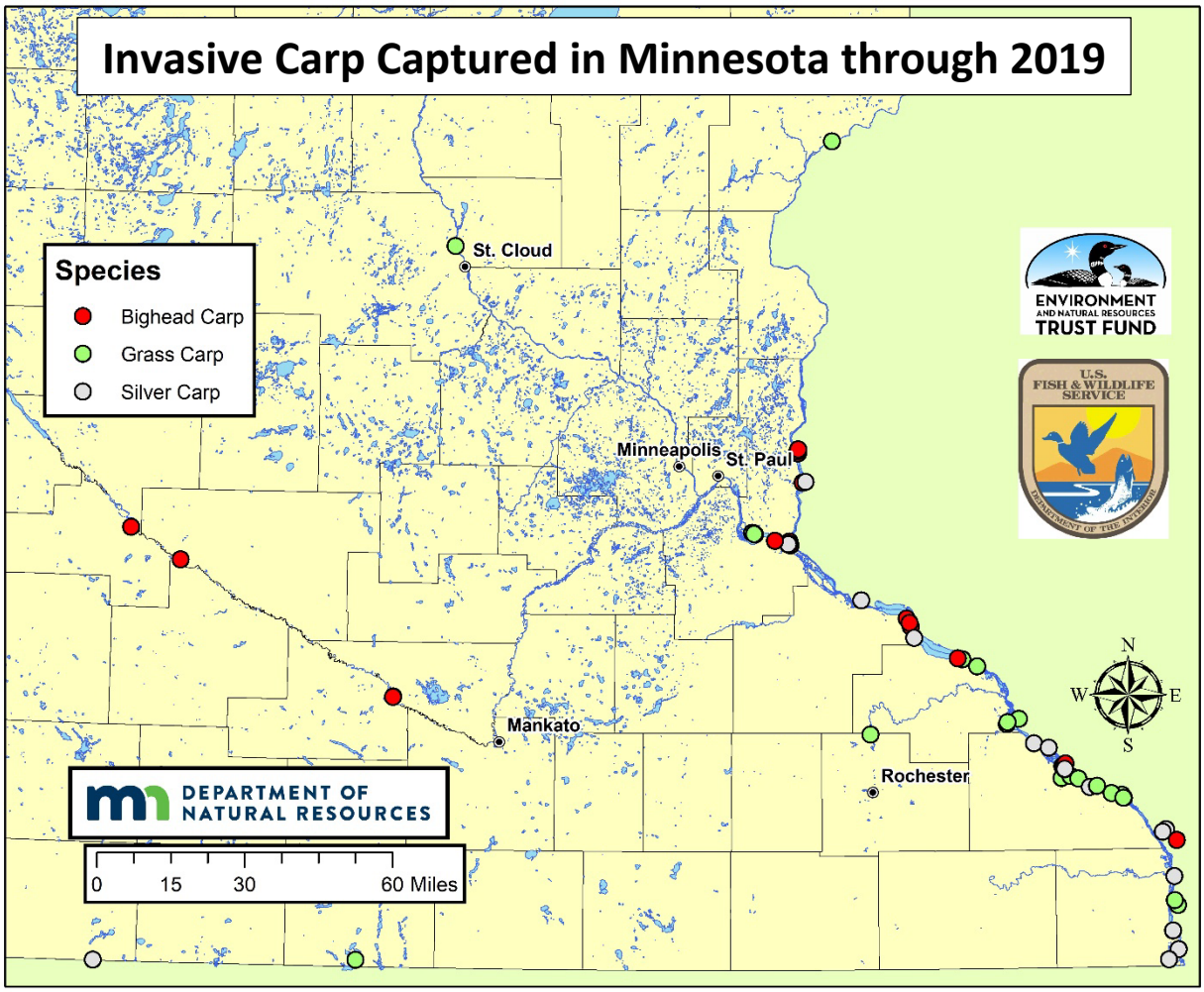

Figure 1. Locations of all known invasive carp captured in Minnesota waters through 2019.

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.

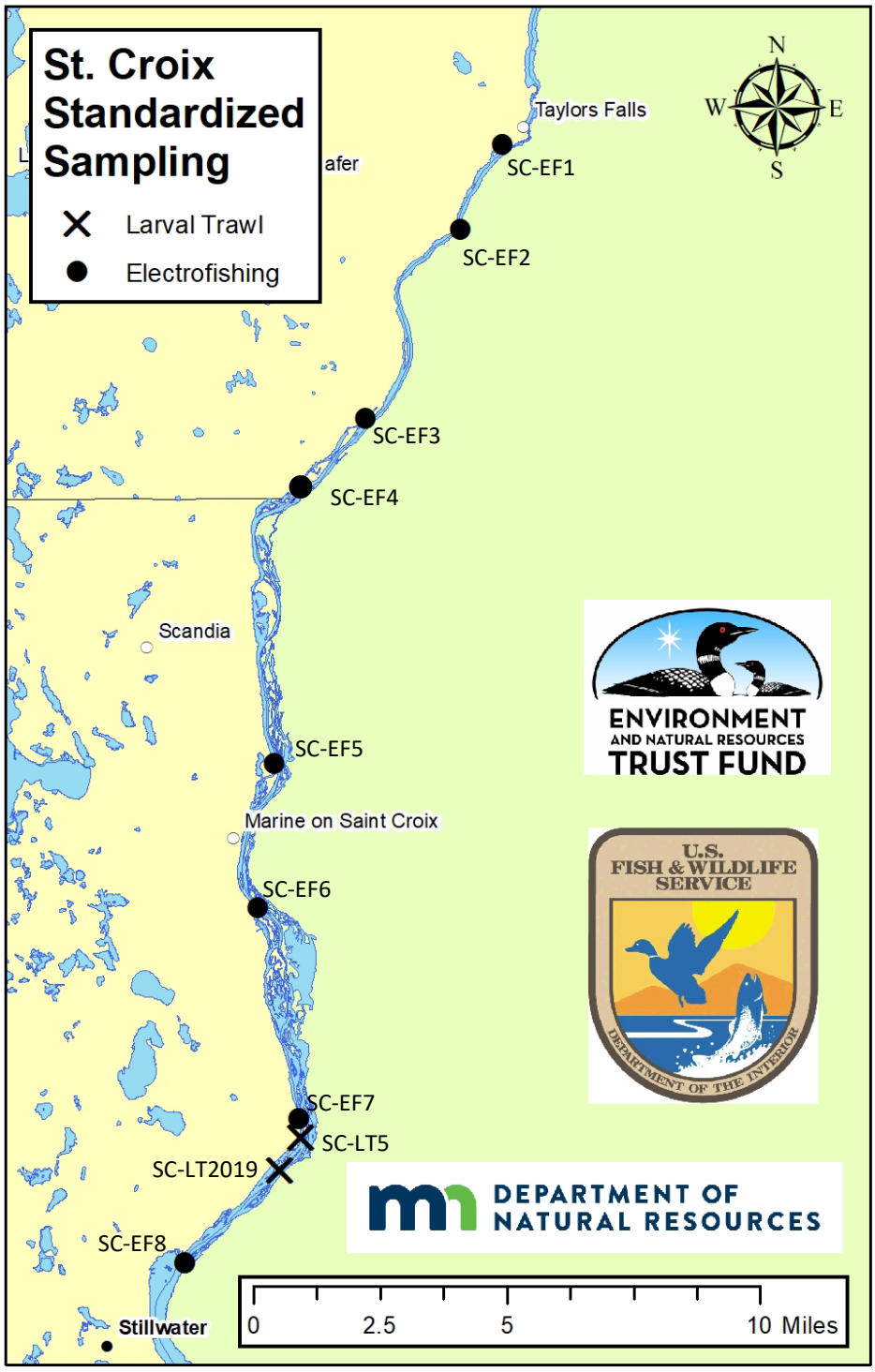

Figure 3. Standardized electrofishing (dark circle, EF1 – EF8) and larval fish trawling (dark cross, SC-LT5 and SC-LT2019) locations on the St. Croix River (SC).

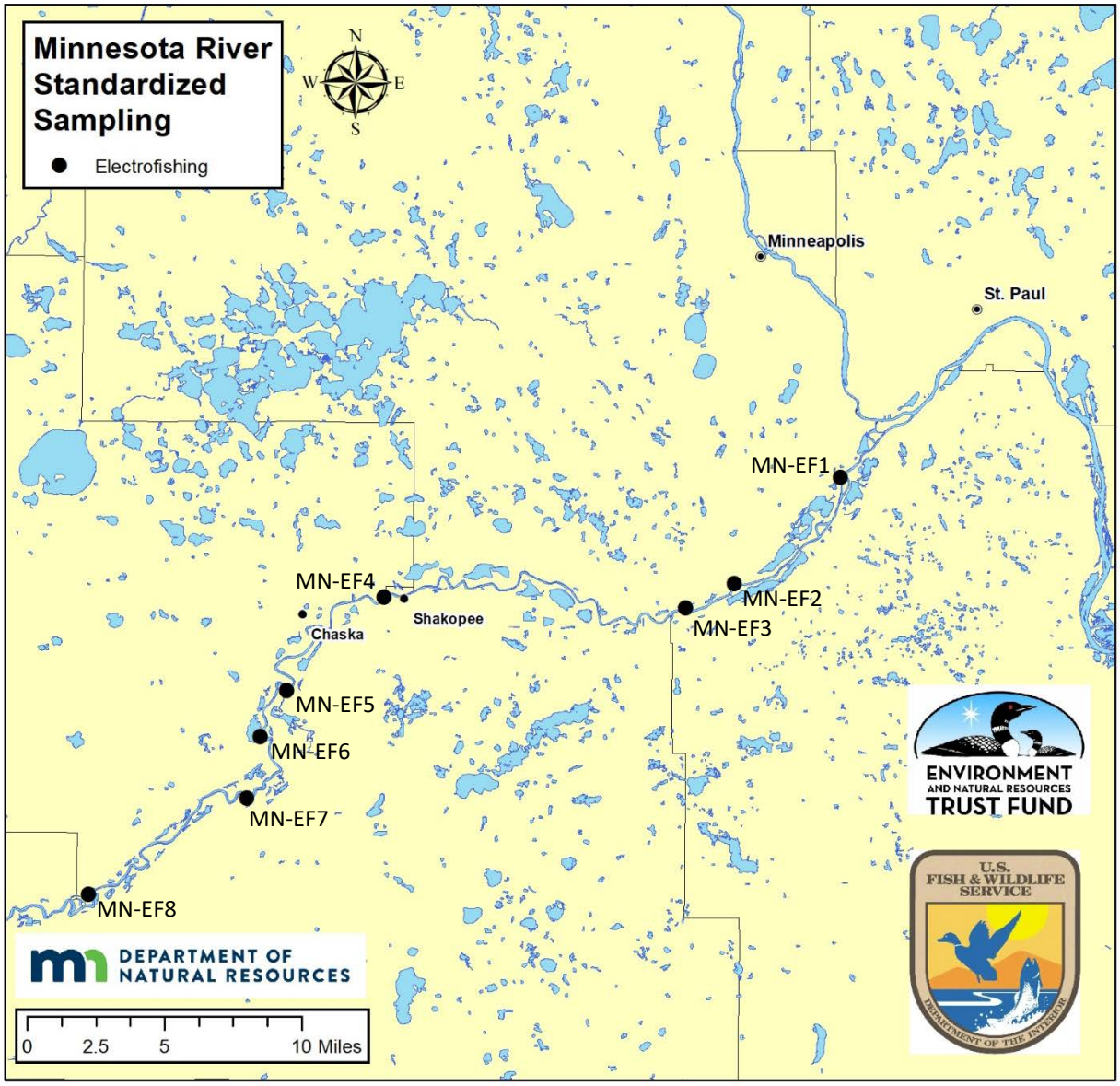

Figure 4. Standardized electrofishing (dark circle, EF1 – EF8) locations on the Minnesota River.

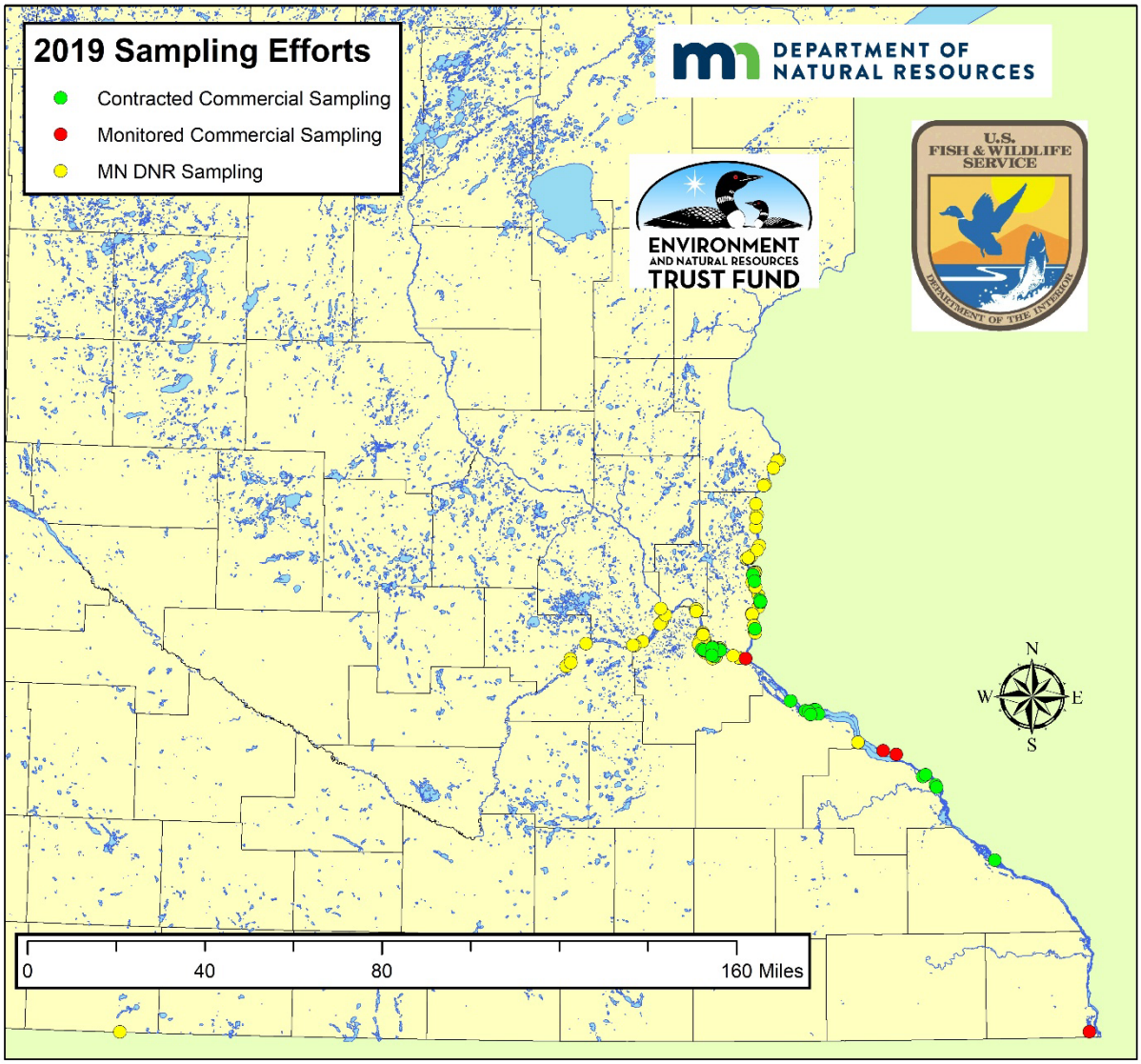

Figure 5. All sampling locations for contracted commercial sampling and MN DNR sampling on the Mississippi, St. Croix, and Minnesota Rivers during 2019.

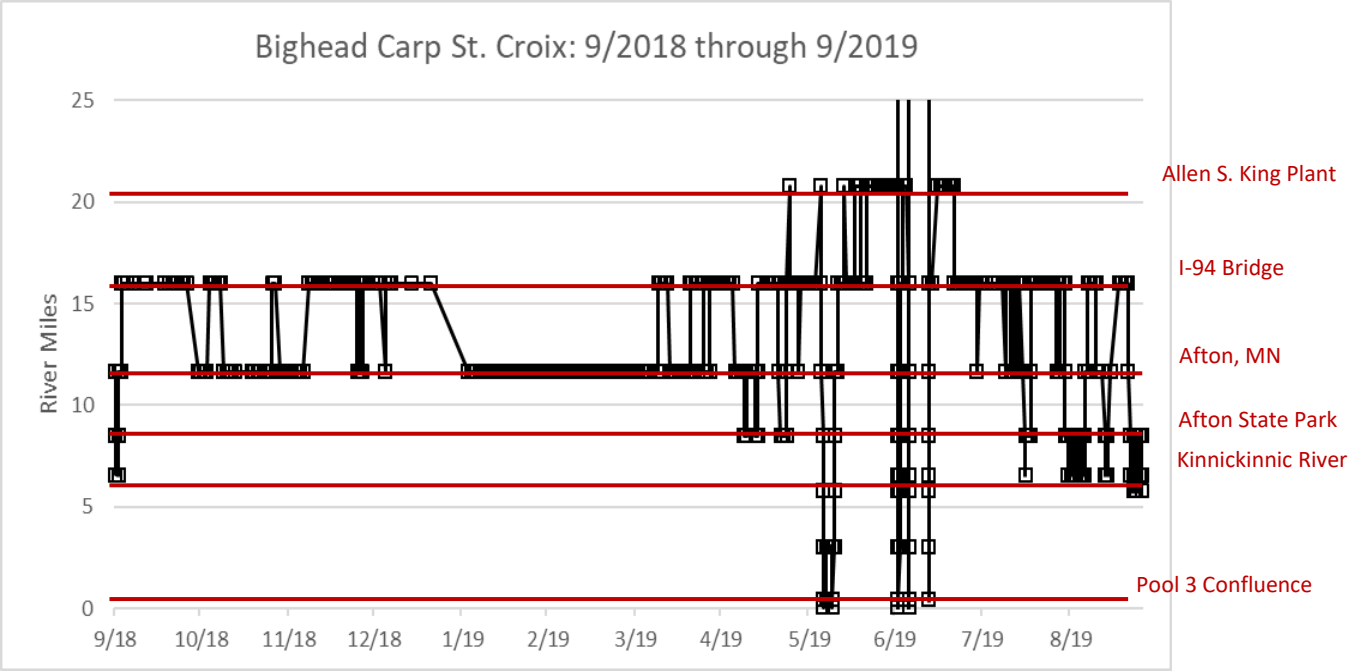

Figure 6. Movement patterns by River Mile over time of a tagged Bighead Carp from January 1, 2019 through the last receiver download for 2019 on September 26, 2019. The tagged Bighead Carp left the St. Croix River and entered Pool 3 of the Mississippi River July 5 through July 12, 2019, approaching the downstream side of Lock and Dam #2 before returning to the St. Croix River.

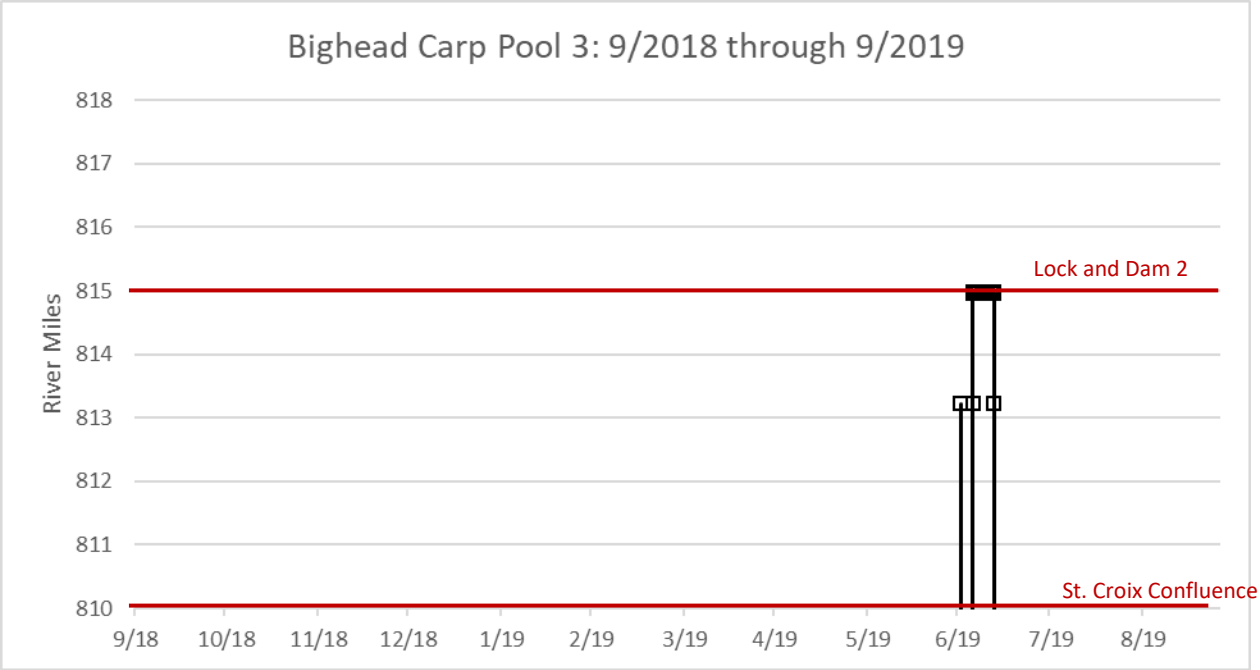

Figure 6 (continued). Movement patterns by River Mile over time of a tagged Bighead Carp from January 1, 2019 through the last receiver download for 2019 on September 26, 2019. The tagged Bighead Carp left the St. Croix River and entered Pool 3 of the Mississippi River July 5 through July 12, 2019, approaching the downstream side of Lock and Dam #2 before returning to the St. Croix River.

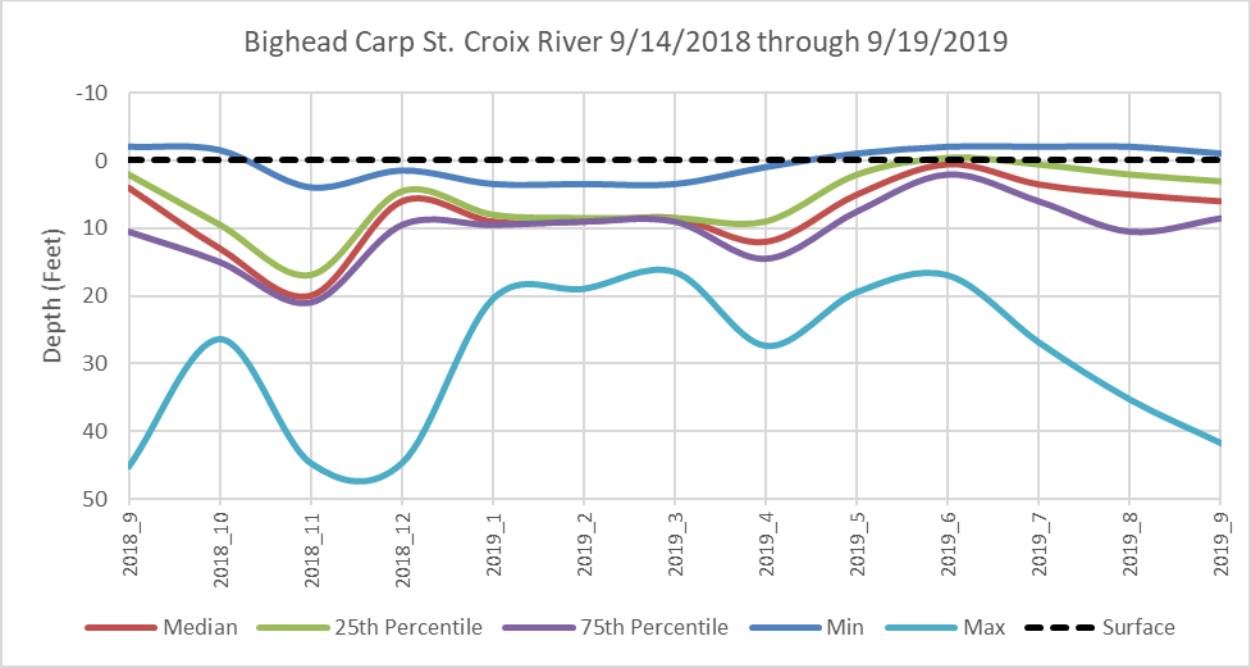

Figure 7. Depth patterns of tagged Bighead Carp from September 14, 2018 through the last receiver download for 2019 on September 19, 2019. Depths ranged from the surface (0 feet) to a maximum depth of 41.8 feet. Average depth occupied was 8.2 feet below the surface.

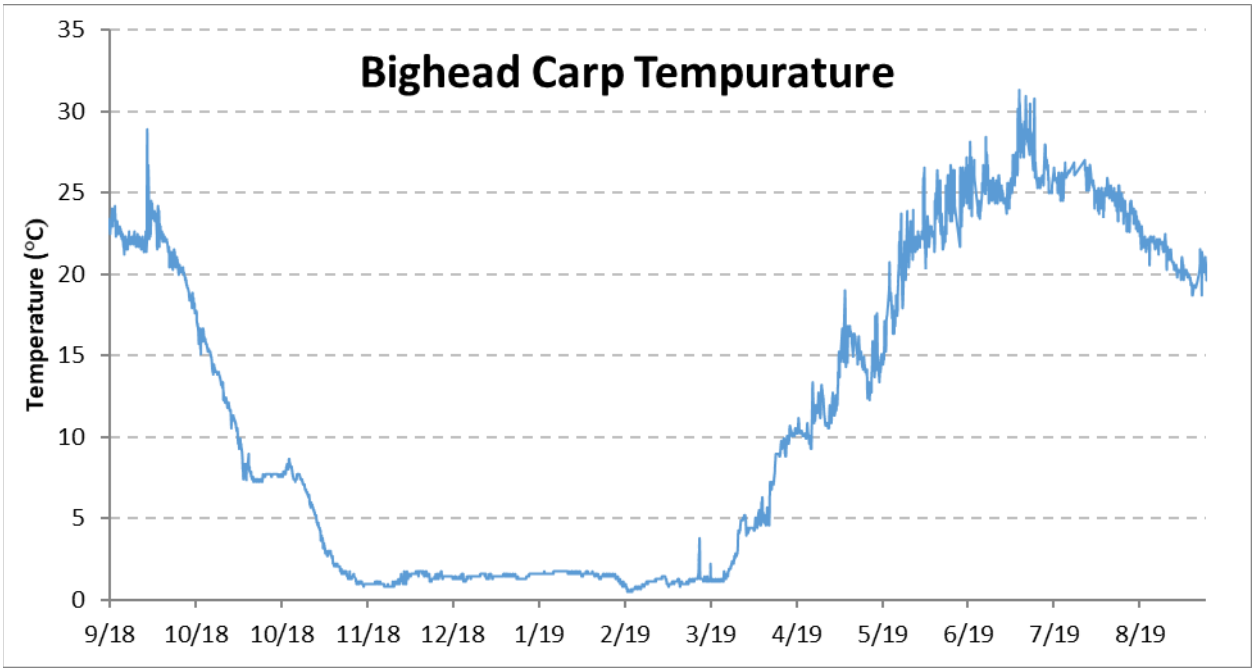

Figure 8. Temperature patterns of tagged Bighead Carp from September 14, 2018 through the last receiver download for 2019 on September 19, 2019.

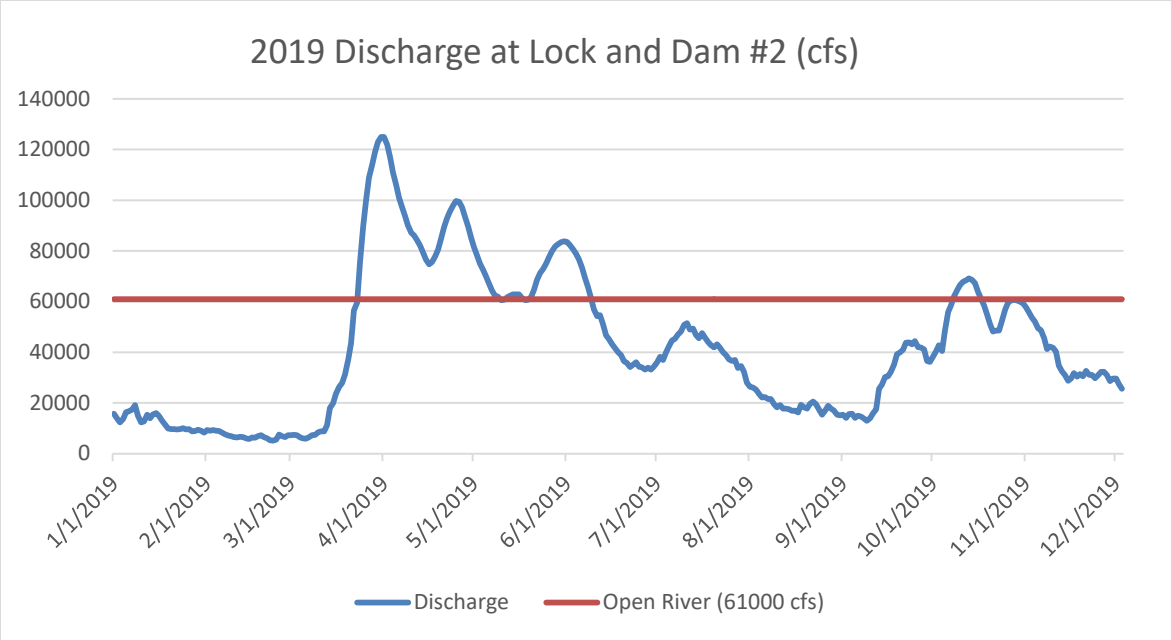

Figure 9. Discharge patterns of USGS gauge (05331580) at Hastings, MN in Pool 3 of the Mississippi River from January 1, 2019 through December 4, 2019. The tagged Bighead Carp was detected in the vicinity of the Lock and Dam July 5 through July 12, 2019 when flows were approaching open river conditions or 61,000 cubic feet per second (cfs). In total, the gauge shows four open river high flow events occurring in 2019.

Field work and report by:

Ben J. Larson, Invasive Carp Statewide Field Lead

Approved by:

Area Fisheries Supervisor:

Regional Fisheries Supervisor:

Date: