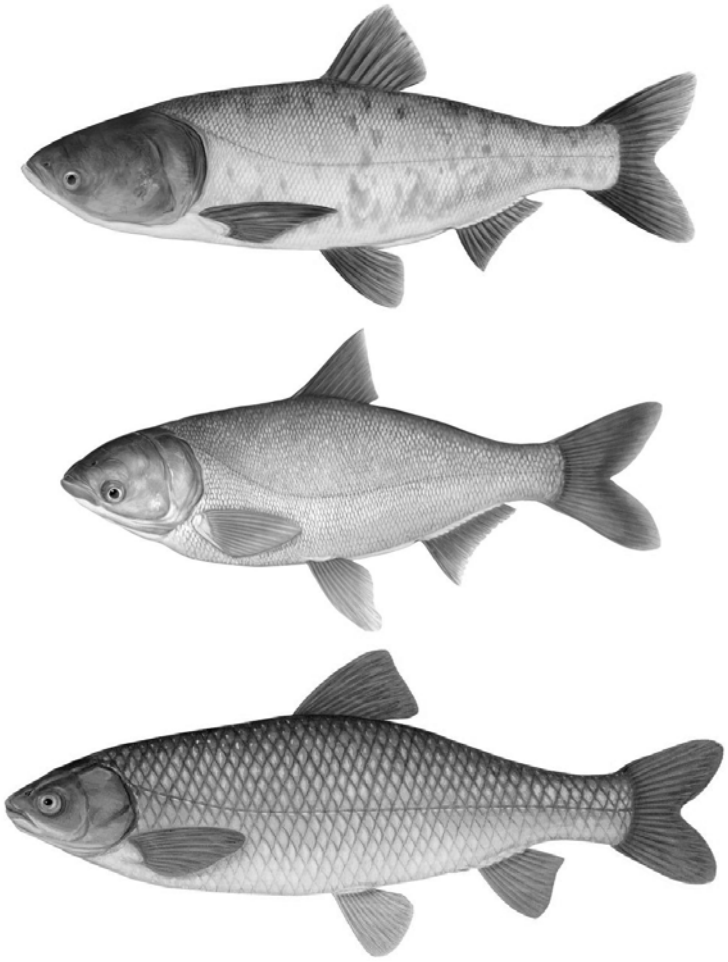
INVASIVE CARP SAMPLING REPORT

JANUARY – DECEMBER 2014

MINNESOTA DEPARTMENT OF NATURAL RESOURCES

DIVISION OF FISH AND WILDLIFE

SECTION OF FISHERIES



UPPER MISSISSIPPI RIVER, POOL 2

LOWER ST. CROIX RIVER, BELOW ST. CROIX FALLS

April 30th, 2015

TABLE OF CONTENTS

List of Tables……iii

List of Figures……iii

Introduction……1

Objectives……2

Sampling Sites……2

Sampling Methods……3

Results and Discussion……8

Recommendations……12

References……13

LIST OF TABLES

Table 1. Invasive Carp sampling summary for the Mississippi River Pools 1, 2, 3, 4, 5a, 6, 7 and the St. Croix River for January through December 2014.

Table 2. Species list for the Mississippi River Pool 2 and the St. Croix River for January 2013 through December 2014, including 62 native and invasive species.

LIST OF FIGURES

Figure 1. Standardized electrofishing (dark circle, E1 – E8) and larval fish trawling (dark cross, LT1 - LT 8) locations on Pool 2 (P2) of the Mississippi River.

Figure 2. Standardized electrofishing (dark circle, E1 – E8) and larval fish trawling (dark cross, LT1 - LT 6) locations on the St. Croix River (SC).

Figure 3. Standardized electrofishing (dark circle, E8) and larval fish trawling (dark cross, LT 6 - LT 8) locations on the St. Croix River (SC).

Figure 4. All sampling locations for contracted commercial sampling and MN DNR sampling on the Mississippi River and the St. Croix River during 2014.

Figure 5. Catch by weight in pounds of all fish caught using seines and gill nets during contracted commercial fishing efforts on the Mississippi River Pool 1-7 and the St. Croix River during 2014.

Figure 6. The percent catch by number of all fish caught in hoop nets by MNDNR personnel on the Mississippi River Pool 2 during 2014.

Figure 7. The percent catch by number of fish caught in large and small fyke nets by MNDNR personnel on the Mississippi River Pool 2 during 2014.

Figure 8. The percent catch by number of fish caught during standardized electrofishing on the Mississippi River Pool 2 and St. Croix River during 2014.

Figure 9. Length distribution of Smallmouth Buffalo collected for age and growth analyses in Pool 2 of the Mississippi River and the St. Croix River during 2014.

Figure 10. Length distribution of Bigmouth Buffalo collected for age and growth analyses from Pool 2 of the Mississippi River and the St. Croix River during 2014.

Figure 11. Length distribution for Gizzard Shad collected for age and growth analyses from Pool 2 of the Mississippi River and the St. Croix River during 2014.

Figure 12. Length distribution for Freshwater Drum collected for age and growth analyses from Pool 2 of the Mississippi River and the St. Croix River during 2014.

INTRODUCTION

Bighead Carp *Hypophthalmichthys nobilis*, Silver Carp *H. molitrix*, Grass Carp *Ctenopharyngodon idella*, and Black Carp *Mylopharyngodon piceus* (hereafter collectively referred to as Invasive Carps) 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). Subsequently, large flood events allowed these species to escape into the Mississippi River drainage, where they began reproducing and spreading (Freeze and Henderson 1982). Invasive Carps have migrated up the Mississippi River, and adjoining tributaries, quickly establishing populations in newly invaded areas. In Minnesota, individual Bighead Carp have been collected as far north as Lake St. Croix, near Prescott, WI, and Silver Carp had been found as far north as Pool 6 of the Mississippi River, near Winona, MN before this year (see Results and Discussion section). Currently, there is no evidence of Invasive Carp reproduction in Minnesota waters.

Invasive Carps have the potential to devastate local ecosystems by competing with native planktivores and overcrowding other native species. With high fecundity and an ability to populate new areas quickly, Invasive Carps can reach high abundances, sometimes making up most of the fish biomass in certain systems (MICRA 2002). Invasive Carps have a voracious appetite, and coupled with their large size (>70 lbs.), 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 fishes may be in direct competition with Invasive Carps for food resources. Evidence from the Illinois River, suggests that competition with Invasive Carps resulted in reduced condition factors for

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

With the continuing progression of Invasive Carps up the Mississippi River, Minnesota waters are threatened by a potential invasion. A better understanding of the current status of individual Invasive Carp and populations in Minnesota will allow for more effective efforts to prevent their spread and/or eradicating them if populations do exist. Standard fish sampling assessments have been ongoing in Minnesota's major rivers and have the potential to catch Invasive Carps. However, the gears and methods used in the standard assessments are not the most efficient methods for capturing Invasive Carps. To date, Invasive Carps in Minnesota have only been caught by commercial fishermen. The purpose of this sampling effort is to use gears more specific to Invasive Carps to monitor all life stages of Invasive Carps and associated native fishes in the Mississippi River and the Lower St. Croix River, including contracting commercial fishermen.

OBJECTIVES

- Detect and monitor all life stages of Invasive Carps.
- Monitor native fish species that may be affected by the establishment of Invasive Carps.

SAMPLING SITES

In the Mississippi River, standard Invasive Carp sampling occurred from Navigational Pools 1 through 3, including approximately 89 km of water from St. Anthony Falls Lock and Dam in Minneapolis, MN to Lock and Dam 3 near Red Wing, MN. In the St. Croix River, standard effort was focused on an 83 km stretch from the dam near Taylors Falls, MN to the

confluence with the Mississippi River near Prescott, WI. Contracted commercial fishermen we hired to use large mesh gillnets and seines to sample in the Mississippi River from Pool 1 to Pool 7 in Lake Onalaska just upstream of La Crosse, WI and in the St. Croix River from the dam near Taylors Falls, MN to the confluence with the Mississippi River near Prescott, WI.

SAMPLING METHODS

Gears, methods, and habitats where sampling was focused were derived from a collection of personal communications with biologists who have been sampling Invasive Carps (V. Santucci, Illinois Department of Natural Resources, personal communication; J. Lamer, Western Illinois University, personal communication) and conducting research on the most efficient gears to sample Invasive Carps (M. Diana, Illinois Natural History Survey, personal communication), along with a variety of literature that included 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). Sampling information for Invasive Carps included in this report took place between January 1, 2014 and December 31, 2014.

Fish Tagging Efforts

Currently several species of fish in the Mississippi River Pool 2 and the St. Croix River are tagged according to study guidelines as part of ongoing tagging studies when encountered. These species included Flathead Catfish *Pylodictis olivaris* and Channel Catfish *Ictalurus punctatus* in Pool 2 and Lake Sturgeon *Acipenser fulvescens*, Muskellunge *Esox masquinongy*, White Bass *Morone chrysops*, Flathead Catfish, and Channel Catfish in the St. Croix. In both Pool 2 and the St. Croix River, Paddlefish are also tagged.

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 14 ft. and lengths of 150 to 300 ft. with square mesh sizes of 4 to 6 in. were used to target adult Invasive Carps. Trammel nets with outside wall square mesh sizes of 14 in. and inner square mesh sizes of 4 in. were also used to target adult Invasive Carps. Experimental gill nets 250 ft. in length and 6 ft. deep consisting of 50 ft. complements of net with square mesh sizes 0.75, 1, 1.25, 1.5, 2 in. were used to target juvenile Invasive Carps. 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 and measured. Catch-per-unit-effort (CPUE) per 1000 feet of net was calculated for each net and averaged across nets.

Commercial Fishing

Commercial fishermen were contracted to target Invasive Carp with both gill nets and seines. 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.

Hoop Netting

Hoop netting was conducted during 3 separate sampling events. Two different sized hoop nets were used. Large 4 ft. diameter “buffalo” nets consisted of 9 tapered steel hoops and

three throats, with a tapered mesh size of 3 in. sq. mesh at the mouth, 2 in. sq. mesh in the middle, and 1.5 in. sq. mesh at the cod end. Small 3 ft. diameter hoop nets consisted of 7 tapered steel hoops and two throats, with either 1 in. or 2 in. sq. mesh throughout. All fish sampled were identified and measured. CPUE per net night was calculated for each net, and averaged across nets.

Trap Netting

Trap netting was conducted during four sampling events on Pool 2. Trap netting was not conducted in the St. Croix this field season. 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. The standard trap nets consist of a double frame (36 in. x 72 in.), 5 hoops (30 in.), two throats, and a 40 ft. lead, with a square mesh size of 0.75 in. throughout. All fish were identified and enumerated in the field.

Electrofishing

Electrofishing occurred in a variety of habitats including backwaters, side channels, main channel borders, and over wing dikes. Sampling locations consisted of 8 standardized sampling locations in both Pool 2 (Figure 1) and the St. Croix River (Figure 2 and 3), and all other sampling events occurred at random locations in the aforementioned habitats at the discretion of the sampler. In 2014, 18 standardized electrofishing sites were sampled for a total of 370 minutes. Standardized sampling locations were selected based on habitats Invasive Carps are likely to occupy and are 500 m in length. At these set sampling locations, all observed fish were collected, identified, measured and weights 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 random sampling sites, fish were identified in the water and only fish needed to collect aging structures and Invasive Carps 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.

Larval trawling

Larval trawling was conducted in Pool 2, Pool 3, and the St. Croix River to target early life stages of Invasive Carps. All eight sites were sampled twice in Pool 2 (Figure 1), Pool 3 and the St. Croix (Figure 2 and 3). A bow mounted icthyoplankton net (0.75 m x 3 m) consisting of 500 um mesh was pushed near the surface into the current so that the velocity of the water entering the net is between 1.0 to 1.5 m/s. At sampling locations where no water current exists (e.g. backwaters), sampling occurred towards a random direction that allowed for a complete sample to be taken in a relatively linear path. A mechanical flow meter was placed in the mouth of the net to determine the volume of water sampled. A total of eight locations were sampled in each system with two, 5-minute pushes conducted at each location. Sampling locations were located in the following macro habitats: 4 main channel, 2 side channel, and 2 backwater locations in each system. Several samples were also collected from Mississippi River Pool 6 and Pool 8. 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. 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 were also sent to an external researcher for verification and to create a reference collection of the species caught for future reference. 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.

Age and Growth Analysis

Gizzard Shad, Freshwater Drum *Aplodinotus grunniens*, and both Smallmouth *Ictiobus bubalus* and Bigmouth Buffalo were collected during sampling events and processed for age and growth analysis. Gizzard Shad and Bigmouth Buffalo are native planktivores that may be in direct competition with Bighead and Silver Carp. Paddlefish, another native planktivore, are currently a state listed threatened species in Minnesota; therefore low abundances and the lack of a non-lethal aging method for paddlefish make sacrificing fish to acquire ages unjustifiable. However, one individual did not survive capture in a commercial gillnet in Pool 2 and was subsequently aged using the dentary bone. Smallmouth Buffalo and Freshwater Drum, 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. For the previously mentioned species, lengths, weights and aging structures (except for Paddlefish) were collected as follows: for fish less than 300 mm, up to 5 individuals in each cm length group and for fish 300 mm and greater up to ten individuals in each 25 mm length group. For Freshwater Drum and Gizzard Shad, saggital otoliths were used for ageing. For both Smallmouth and Bigmouth buffalo, lapillus otoliths, and pelvic fin rays were extracted and

compared. Otoliths were embedded in epoxy and cut using an isomet saw and fin rays were dried and cut using the 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.

RESULTS AND DISCUSSION

Sampling Results

In total, 101 days were spent sampling between January and December 2014 on the Mississippi River Pool 1, 2, 3 and St. Croix River with gears appropriate for sampling Invasive Carps (Table 1). A greater amount of effort was focused on Pool 2 (Figure 4), because Invasive Carps had not been found above Lock and Dam 2 on the Mississippi River. Determining whether there were individuals or populations of Invasive Carps in Pool 2 was of high importance. With the results from this sampling effort, it is possible that more Invasive Carps are present in these systems. However, this increased sampling effort decreases the likelihood that populations of Invasive Carps do exist in these systems and reinforces assumptions that Invasive Carps previously caught in the area were only wandering individual adults.

One gravid female Silver Carp and one gravid female Bighead Carp were collected in Pool 2 in Grey Cloud Slough by contracted commercial gill net fishermen on July 17, 2014. Both fish were aged at 6 years and though both had eggs, they were found to be undergoing atresia where they are reabsorbed and no longer viable and no visible signs of mating or ovulation were present. On October 1, 2014 another gravid female Silver Carp was caught at this same site in Lower Grey Cloud Slough in Pool 2 by contracted commercial gill net fishermen. This individual was aged as 7-10 years old and similarly showed egg atresia and no signs of mating or

ovulation. The two Silver Carp and one Bighead Carp in Pool 2 represent the furthest upstream these species have ever been observed in the Mississippi River. On September 16, 2014 one mature male Bighead Carp was collected in the St. Croix River by contracted commercial seine fishermen. This individual was aged at over 4 years and the histology showed that it was in a post-spawn stage with residual spermatozoa present. The histology results were not conclusive enough to verify whether this individual had spawned but it seems to be unlikely from the presence of sperm after death. All Invasive Carp captured in Minnesota waters in 2014 in Pool 2 and the St. Croix River during 2014 were collected by MN DNR contracted commercial fishermen. In addition to the Silver and Bighead Carp caught by contracted fishermen, on October 23, 2014 a mature male Bighead Carp was caught in Lake Pepin in Pool 4 by a commercial seine fisherman aged to 8-11 years. Two diploid Grass Carp were also caught in a commercial seine on Pool 5A in Polander Lake on April 6, 2014.

Contracted commercial fishermen set approximately 115,000 feet of gill and trammel nets during 15 days of effort and conducted six seine hauls between January and December 2014. Gill nets were set short term (2-3 hours) and fish were chased towards the net with boats, typically in large backwater areas. Buffalo (both Bigmouth and Smallmouth) dominated the commercial catches, making up ~65% of the catch by weight, followed by Common Carp *Cyprinus carpio* (26%), "Carp Suckers" *Carpiodes* spp. (6%), and Freshwater Drum (3%) (Figure 5). The commercial fishermen harvested a total of 114,400 pounds of fish during the 21 days of effort.

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. A total of 16,750 feet of gill and

trammel nets were set in Pool 2 and the St. Croix River during 10 days, with most net sets being short-term sets (2-5 hrs.) (Table 1).

Hoop nets of varying sizes were typically set in side channel and main channel habitats with at least some flow. Hoop netting effort totaled 31 net nights during 2014. Freshwater Drum (22%, by number) dominated the hoop net catch, followed by Black Crappie *Pomoxis nigromaculatus* (17%), White Crappie *Pomoxis annularis* (14%), and Smallmouth Buffalo (11%) (Figure 6).

Trap netting was conducted using fyke nets for a total of 34 net nights. Fyke nets caught mostly Spottail Shiner *Notropis hudsonius* (22% by number), followed by Spotfin Shiner *Cyprinella spiloptera* (9%), Bluegill *Lepomis macrochirus* (8.0%), Black Crappie (6%) Common Carp (6%), and 32 other species (51% combined) (Figure 7).

Both random and standardized electrofishing sampling was conducted on Pools 1-3 of the Mississippi and the St. Croix rivers. A total of 3,667 minutes of "on time" over 33 days were spent electrofishing between January and December 2014. Random electrofishing was used to monitor for Invasive Carp and for collection of individuals for age and growth analyses. Standardized electrofishing sampled a total of 44 species. The most common species caught during standardized electrofishing sampling were Silver Redhorse *Moxostoma anisurum* (16.1%) and Shorthead Redhorse Moxostoma macrolepidotum (9.3%), followed by Common Carp (7.1%), Freshwater Drum (7.1%), Gizzard Shad (6.1%), Walleye *Sander vitreus* (5.7%), Golden Redhorse *Moxostoma erythrurum* (5.1%), White Bass *Morone chrysops* (5.0%), Bluegill *Lepomis macrochirus* (5.0%), Emerald Shiner *Notropis atherinoides* (5.0%), Smallmouth Bass *Micropterus dolomieu* (4.5%), Quillback *Carpiodes cyprinus* (4.1%), and Smallmouth Buffalo (2.6%), with the other 31 species representing 17.3% of the catch (Figure 8).

Larval trawling was conducted for 149 total trawls during 25 days. Samples are preserved and awaiting expert analysis to determine the species caught and their respective number.

Numerous other unique or rare native fishes worth mentioning were encountered during these sampling events. Numerous Blue Suckers *Cycleptus elongatus* and several Goldeyes *Hiodon alosoides*, Mooneyes *H. tergisus*, Shortnose Gar *Lepisosteus platostomus*, and an American Eel *Anguilla rostrata* were observed in Pool 2. Several Paddlefish, Northern Hogsuckers *Hypentelium nigricans*, Spotted Sucker *Minytrema melanops*, Longnose Gar *Lepisosteus osseus*, River Redhorse *Moxostoma carinatum*, and Greater Redhorse *M. valenciennesi* were observed in the St. Croix River. A complete species list of species caught and observed on Pool 2 and the St. Croix River from January 2013 through December 2014 has been compiled (Table 2).

Age and Growth Analysis

Age and growth analysis was completed for three of the species of interest and the one deceased paddlefish by two readers. A total of 10 Gizzard Shad were aged from Pool 2 and 50 from the St. Croix. The number of annuli observed ranged from 0 to 6 in Pool 2 and 0 to 7 in the St. Croix River from fish measuring 64 to 504 mm (Figure 14). From Pool 2, 80 Freshwater Drum were aged and 128 from the St. Croix River. In Freshwater Drum, number of annuli ranged from 0 to 39 from fish measuring 103 to 825 mm (Figure 15). Freshwater Drum age-at-length shows complex patterns with individuals of roughly equally length found to represent a wide range of ages. For both Smallmouth and Bigmouth buffalo, pectoral fin rays were found to produce the best results for analysis. Twenty nine Smallmouth Buffalo and 22 Bigmouth Buffalo were collected from Pool 2 and 46 Smallmouth Buffalo and 19 Bigmouth Buffalo from the St.

Croix from fish measuring 316 to 808 mm (Figure 16 and 17).The results of the Buffalo ageing are considered preliminary and will be further examined and augmented with future collections. A Paddlefish was found dead in a contracted commercial gill net in Pool 2 on July 17, 2014. The dentary bone was cleaned, preserved, and aged using methods similar to those used by Reed et al. (1992) and Hoxmeier and DeVries (1997). Two readers observed 12 annuli. The individual measured 33.5 inches (852 mm) eye-to-fork length and weighed 27.8 pounds (12.63 kg).

RECOMMENDATIONS

Further age and growth analysis is recommended for native planktivores, including Bigmouth Buffalo and Gizzard Shad, which may be in direct competition for food resources with Invasive Carps, as well as other native species such as Smallmouth Buffalo and Freshwater Drum that are commercially important and Common Carp which are also commercially important. In some states, current Invasive Carp population control efforts include increasing commercial fishing effort to decrease Invasive Carp abundance, although increased commercial effort in Minnesota would potentially affect native species. Resource agencies would benefit from a greater understanding of the population dynamics of our commercially important native fishes. Furthermore, the sex of specimens collected for age and growth analyses will be necessary to better understand the patterns found in these preliminary analyses. While many ageing structures have been collected in 2013 and 2014 field seasons, a greater number is required to make management decisions and accurately determine population dynamic measures. In addition to age and growth analyses, up to 2,000 Bigmouth Buffalo and Smallmouth Buffalo will be tagged in Pool 2 during 2015 as part of a study investigating movement, exploitation, age and growth, and other key population dynamics of these commercially important species.

Paddlefish are another native planktivore that may directly compete for food resources with Invasive Carps and therefore may be negatively affected. Currently, Paddlefish are a state threatened species in Minnesota, and populations across their range have suffered due to commercial navigation projects that impede movement and alter habitats, pollution, and over exploitation (Jennings and Zigler 2000). If Invasive Carps 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. 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.

REFERENCES

ACRCC (Asian Carp Regional Coordinating Committee). 2012. Monitoring and rapid response plan for Asian carp in the Upper Illinois River and Chicago Area Waterway System. Monitoring and Rapid Response Workgroup, Asian Carp Regional Coordinating Committee, Council on Environmental Quality. Washington. May 2012. <http://asiancarp.us/documents/2011Framework.pdf>

DeGrandchamp, K. L., J. E. Garvey, and L. A. Csoboth. 2007. Linking adult reproduction and larval density of invasive carp in a large river. Transactions of the American Fisheries Society 136:1327-1334.

DeGrandchamp, K. L., J. E. Garvey, and R. E. Colombo. 2008. Movement and Habitat Selection by Invasive Asian Carps in a Large River. Transactions of the American Fisheries Society 137:45-56.

Dettmers, J. H., D. H. Wahl, D. A. Soluk, and S. Gutreuter. 2001. Life in the fast lane: Fish and foodweb structure in the main channel of large rivers. Journal of the North American Benthological Society 20:255-265.

Freeze, M., and S. Henderson. 1982. Distribution and status of the bighead carp and silver carp in Arkansas. North American Journal of Fisheries Management 2:197-200.

Henderson, S. 1976. Observations on the bighead and silver carp and their possible application in pond fish culture. Arkansas Game and Fish Commission, Little Rock.

Hoxmeier, R. J. H., and D. R. DeVries. 1997. Habitat use, diet, and population structure of adult and juvenile paddlefish in the Lower Alabama River. Transactions of the American Fisheries Society 126:288-301.

Irons, K. S., G. G. Sass, M. A. McClelland, and J. D. Stafford. 2007. Reduced condition factor of two native fish species coincident with invasion of non-native Asian carps in the Illinois River, U.S.A. Is this evidence for competition and reduced fitness? Journal of Fish Biology 71 (Supplement D):258-273.

Jenning, D. P. 1988. Bighead carp (*Hypophthalmichthys nobilis*): a biological synopsis. U.S. Fish and Wildlife Service, Biology Report 88:1-35.

Jennings, C. A., and S. J. Zigler. 2000. Ecology and biology of paddlefish in North America: historical perspectives, management approaches, and research priorities. Reviews in Fish Biology and Fisheries 10:167–181.

Kolar, C. S., D. C. Chapman, W. R. Courtenay, Jr., C. M. Housel, J. D. Williams, and D. P. Jennings. 2007. Bigheaded carps: a biological synopsis and environmental risk assessment. American Fisheries Society, Special Publication 33, Bethesda, Maryland.

Lohmeyer A. M. and J. E. Garvey. 2009. Placing the North American invasion of Asian carp in a spatially explicit context. Biological Invasions 11:905-916.

MICRA. 2002. Asian carp threat to the Great Lakes. River Crossings: The Newsletter of the Mississippi Interstate Cooperative Resource Association 11:1-2.

Petr, T. 2002. Cold water fish and fisheries in the countries of the high mountain arc of Asia (Hindu Kush-Pamir-Karakoram-Himalayas): a review. *In* Cold Water Fisheries in the Trans-Himalayan Countries, eds. Petr, T. and Swar, D. B., pp. 1-38. FAO Fisheries Technical Paper 431.

Reed, B. C., W. E. Kelso, and D. A. Rutherford. 1992. Growth, fecundity, and mortality of paddlefish in Louisiana. Transactions of the American Fisheries Society 12:378-384.

Smith, D. W. 1989. The feeding selectivity of silver carp, *Hypophthalmichthys molitrix* Val. Journal of Fish Biology 34:819-828.

Spatura, P., and M. Gophen. 1985. Feeding behaviour of silver carp *Hypophthalmichthys molitrix* Val. and its impact on the food web in Lake Kinneret, Israel. Hydrobiologia 120:53-61.

Voros, L. 1997. Size-selective filtration and taxon-specific digestion of plankton and algae by silver carp (*Hypophthalmichthys molitrix* Val.). Hydrobiologia 342:223-228.

Wanner, G. A., and R. A. Klumb. 2009. Asian carp in the Missouri River: Analysis from multiple Missouri River habitat and fisheries programs. National Invasive Species Council materials. Paper 10.

Williamson, C. J., and J. E. Garvey. 2005. Growth, fecundity, and diets of newly established silver carp in the Middle Mississippi River. Transactions of the American Fisheries Society 134:1423-1440.

Table 1. Invasive Carp sampling summary for the Mississippi River Pools 1, 2, 3, 4, 5A, 6, 7 and the St. Croix River for January through December 2014.

Invasive Carps Sampling Summary January – December 2014			
Gear	**Measure**	**Unit**	**Days**
Random Sampling Effort			
Gill/Trammel Netting	16,750	feet	10
Electrofishing	3,667	minutes	33
Hoop Netting	31	net/nights	4
Trap Netting	34	net/nights	5
Standardized Sampling Effort			
Electrofishing	370	minutes	9
Larval trawling	133	trawls	19
Targeted Commercial Fishing Effort			
Gill Netting	115,300	feet	12
Seining	6	hauls	6
Number of Invasive Carp Captured	4	fish	
Total Number of Days Sampled			101

Table 2. Species list for the Mississippi River Pool 2 and the St. Croix River for January 2013 through December 2014, including 62 native and invasive species.

Species	Pool 2	St. Croix River
American Eel	x	
Bighead Carp	x	x
Bigmouth Buffalo	x	x
Black Crappie	x	x
Blue Sucker	x	x
Bluegill	x	x
Bluntnose Minnow	x	x
Bowfin	x	x
Brook Silverside	x	
Brook Stickleback	x	
Burbot		x
Channel Catfish	x	x
Common Carp	x	x
Crystal Darter		x
Emerald Shiner	x	x
Flathead Catfish	x	x
Freshwater Drum	x	x
Gilt Darter		x
Gizzard Shad	x	x
Golden Redhorse	x	x
Golden Shiner	x	
Grass Carp	x	
Greater Redhorse	x	x
Green Sunfish	x	x
Hybrid Sunfish	x	x
Johnny Darter		x
Lake Sturgeon		x
Largemouth Bass	x	x
Logperch	x	x
Longnose Gar	x	x
Mimic Shiner	x	x
Mooneye	x	x
Muskie	x	x
Northern Hog Sucker		x
Northern Pike	x	x
Paddlefish	x	x
Pumpkinseed	x	
Quillback	x	x
River Carpsucker	x	x
River Darter		x
River Redhorse	x	x
Rock Bass	x	x
Sand Shiner	x	
Sauger	x	x
Shorthead Redhorse	x	x
Shortnose Gar	x	x
Silver Carp	x	
Silver Lamprey	x	x
Silver Redhorse	x	x
Skipjack Herring	x	
Smallmouth Bass	x	x
Smallmouth Buffalo	x	x
Spotfin Shiner	x	x
Spottail Shiner	x	
Spotted Sucker	x	x
Tadpole Madtom	x	
Trout Perch	x	
Walleye	x	x
White Bass	x	x
White Crappie	x	x
Yellow Bullhead	x	
Yellow Perch	x	x

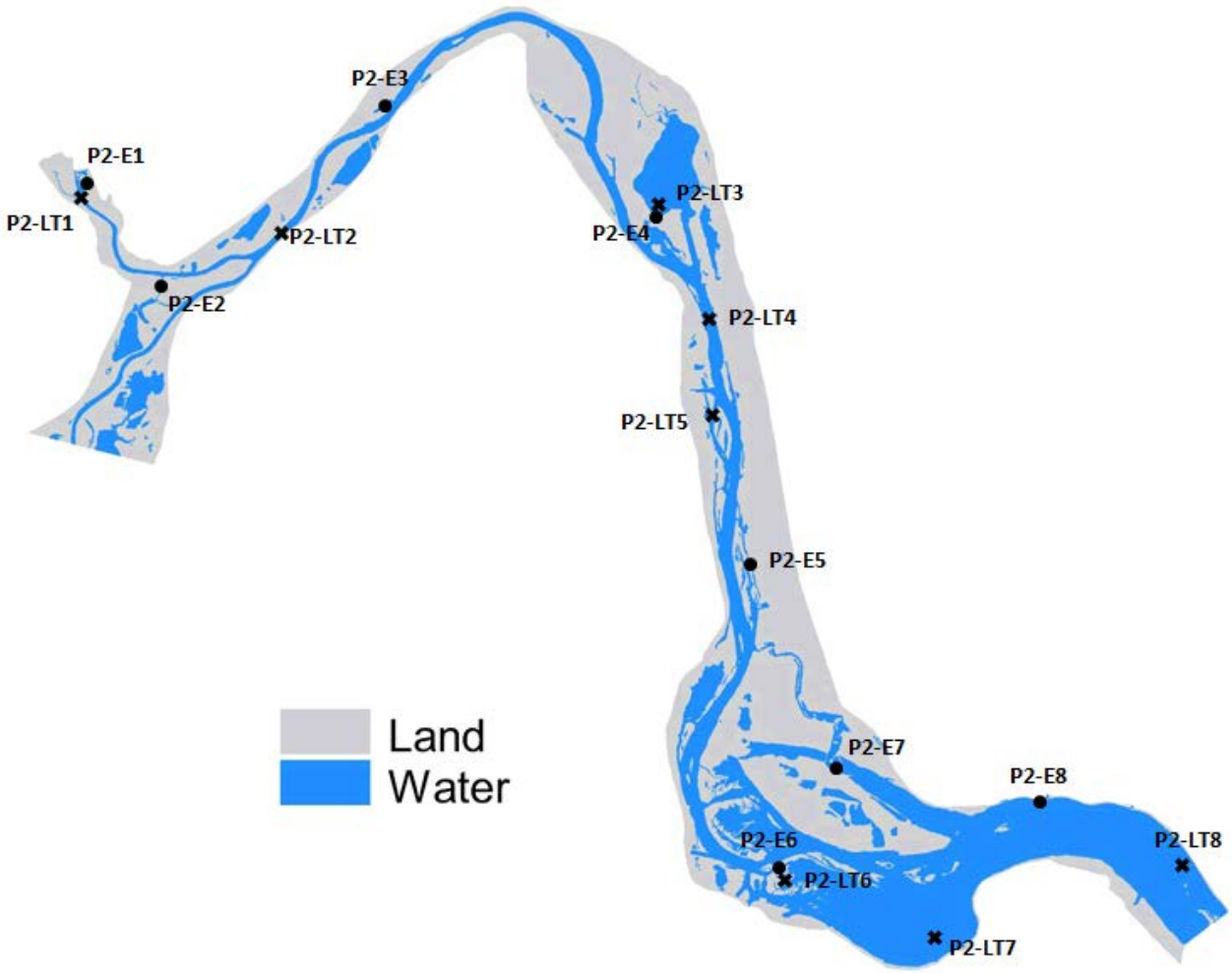


Figure 1. Standardized electrofishing (dark circle, E1 – E8) and larval fish trawling (dark cross, LT1 - LT 8) locations on Pool 2 (P2) of the Mississippi River.

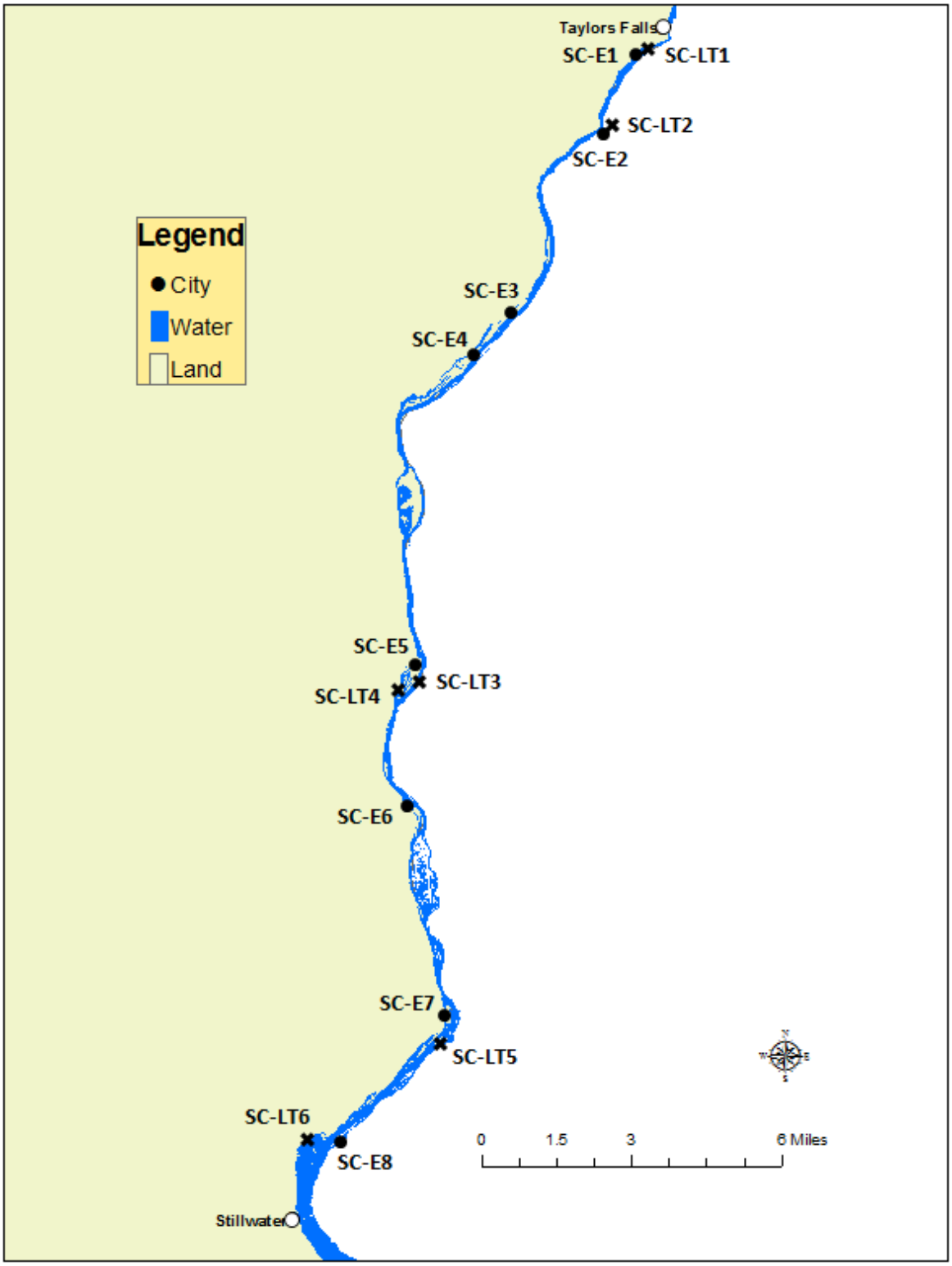


Figure 2. Standardized electrofishing (dark circle, E1 – E8) and larval fish trawling (dark cross, LT1 - LT 6) locations on the St. Croix River (SC).

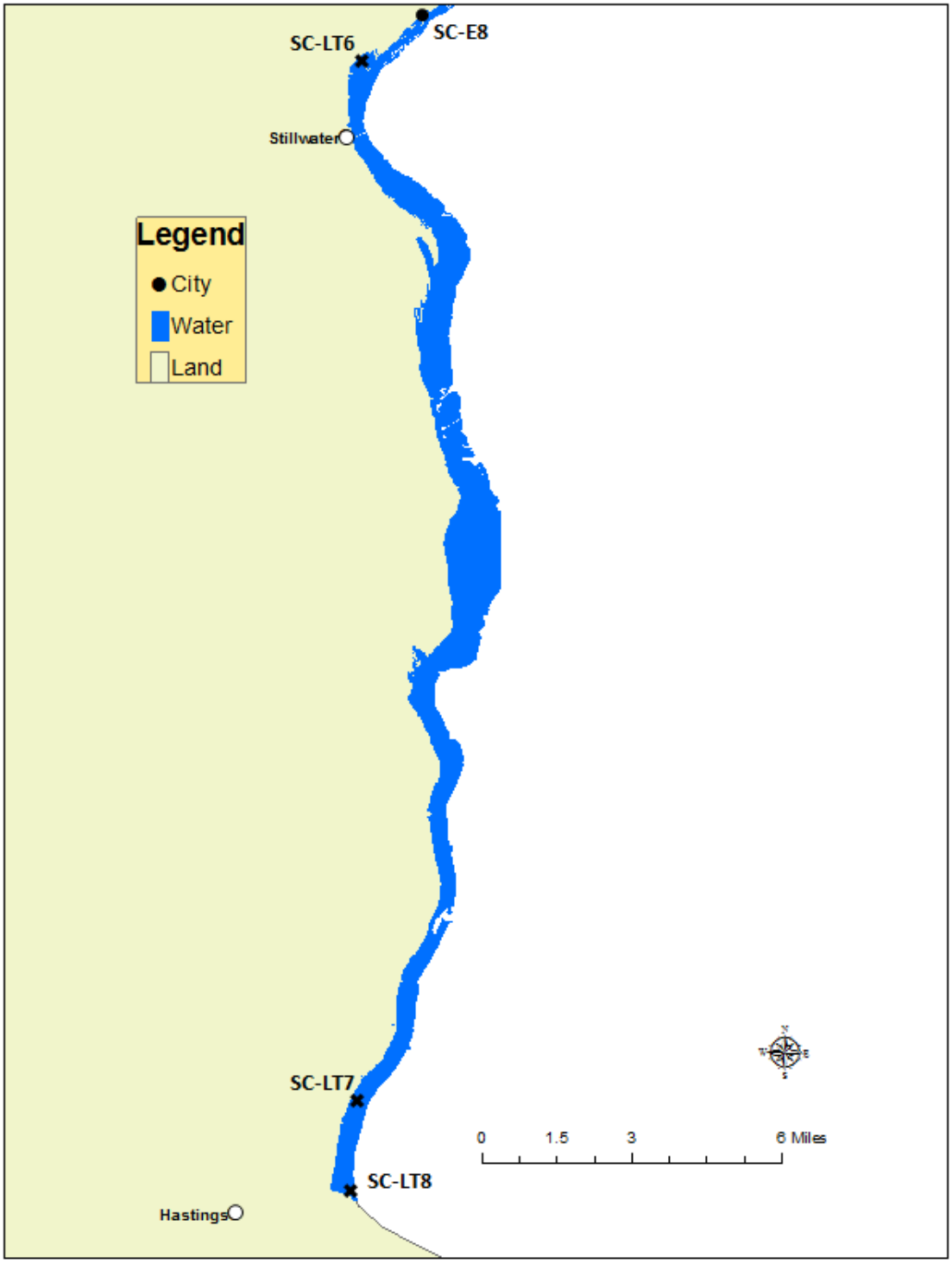


Figure 3. Standardized electrofishing (dark circle, E8) and larval fish trawling (dark cross, LT 6 - LT 8) locations on the St. Croix River (SC).

Figure 4. All sampling locations for contracted commercial sampling and MN DNR sampling on the Mississippi River and the St. Croix River during 2014.

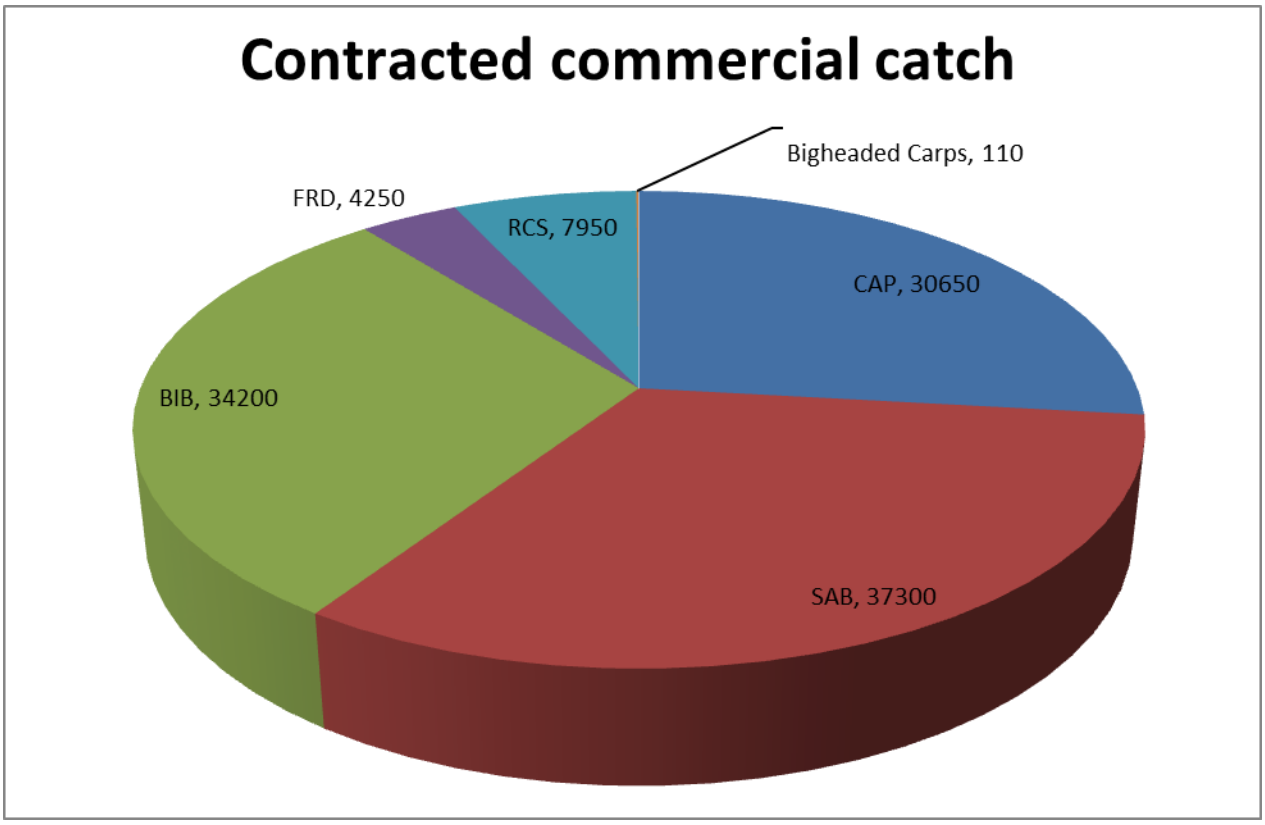


Figure 5. Catch by weight in pounds of all fish caught using seines and gill nets during contracted commercial fishing efforts on the Mississippi River Pool 1-7 and the St. Croix River during 2014. FRD- Freshwater Drum; RCS – River Carp Sucker; Bigheaded Carps – Bighead and Silver Carp; CAP – Common Carp; SAB – Smallmouth Buffalo; BIB – Bigmouth Buffalo.

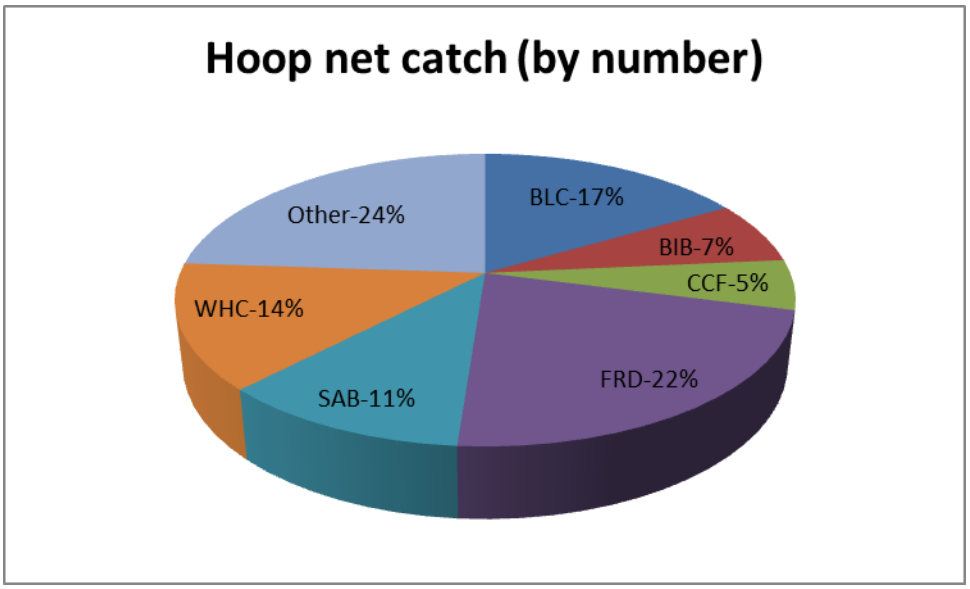


Figure 6. The percent catch by number of all fish caught in hoop nets on the Mississippi River Pool 2 during 2014. BLC – Black Crappie; BIB – Bigmouth Buffalo; CCF – Channel Catfish; FRD- Freshwater Drum; SAB – Smallmouth Buffalo; WHC – White Crappie.

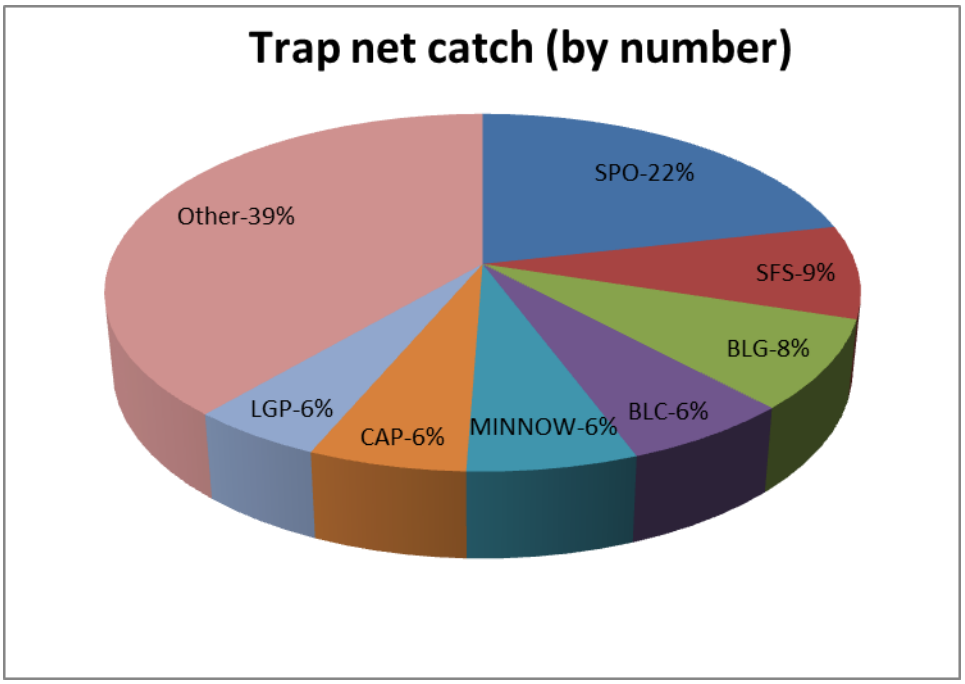


Figure 7. The percent catch by number of fish caught in large and small fyke nets on the Mississippi River Pool 2 during 2014. SPO – Spottail Shiner; SFS – Spotfin Shiner; BLG – Bluegill; BLC – Black Crappie; CAP – Common Carp; LGP – Logperch.

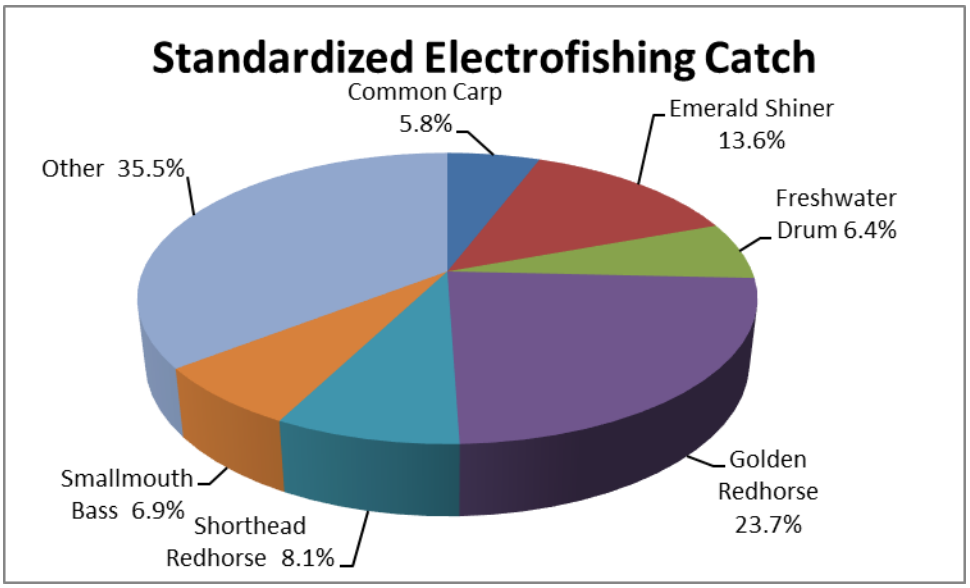


Figure 8. The percent catch by number of fish caught during standardized electrofishing on the Mississippi River Pool 2 and St. Croix River during 2014.

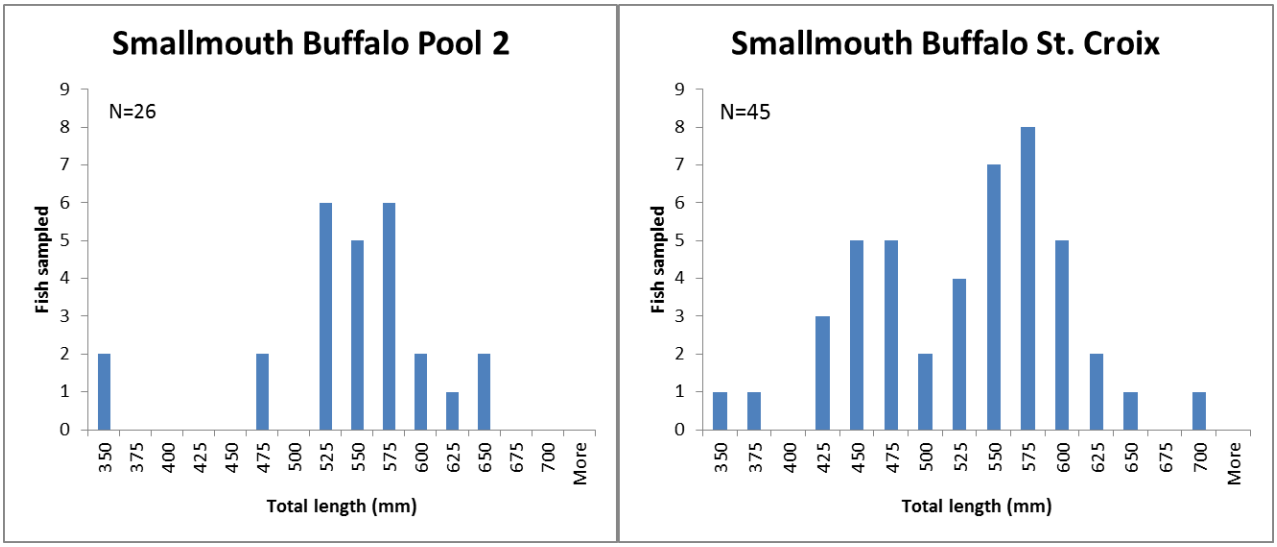


Figure 9. Length distribution of Smallmouth Buffalo collected for age and growth analyses in Pool 2 of the Mississippi River and the St. Croix River during 2014.

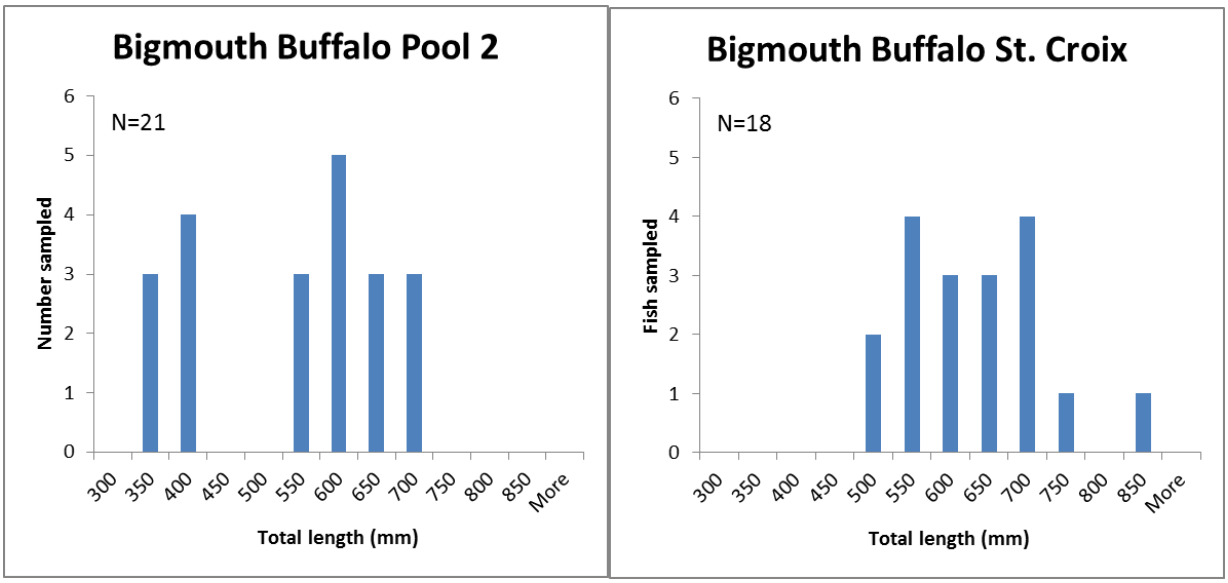


Figure 10. Length distribution of Bigmouth Buffalo collected for age and growth analyses from Pool 2 of the Mississippi River and the St. Croix River during 2014.

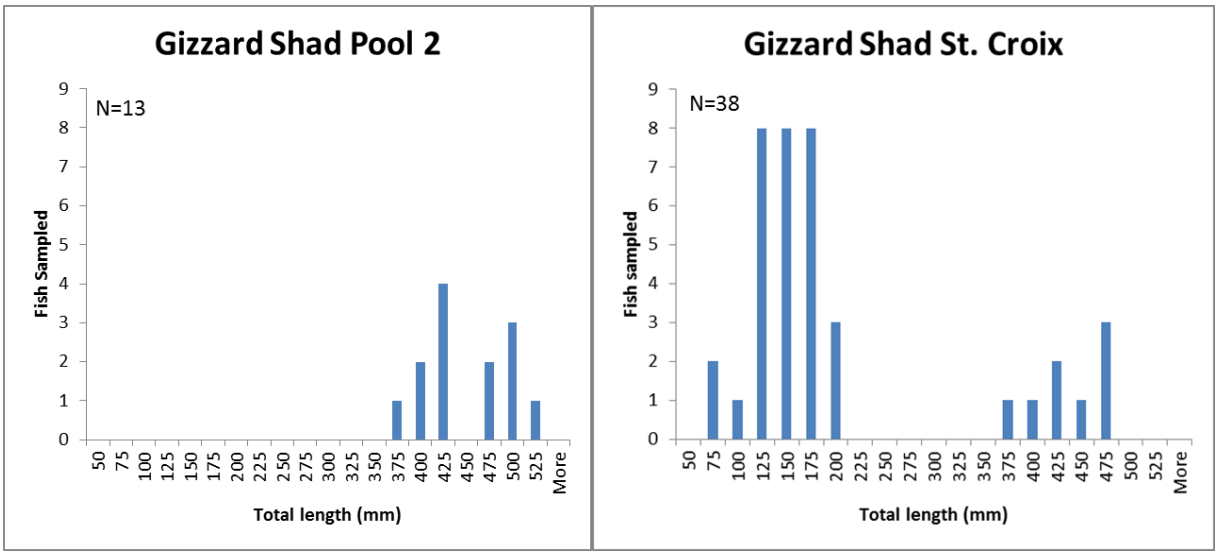


Figure 11. Length distribution for Gizzard Shad collected for age and growth analyses from Pool 2 of the Mississippi River and the St. Croix River during 2014.

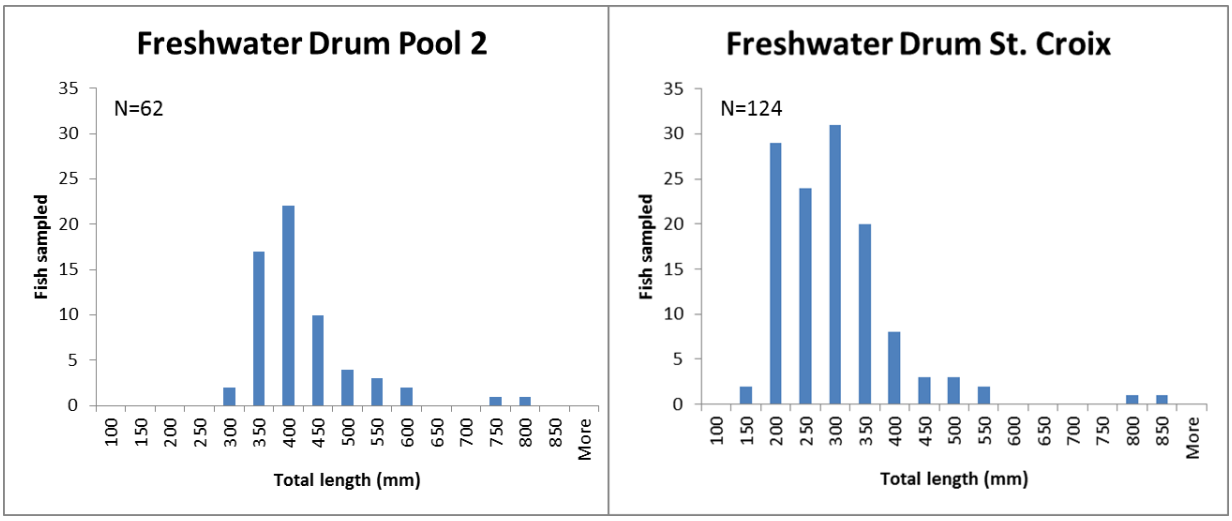


Figure 12. Length distribution for Freshwater Drum collected for age and growth analyses from Pool 2 of the Mississippi River and the St. Croix River during 2014.