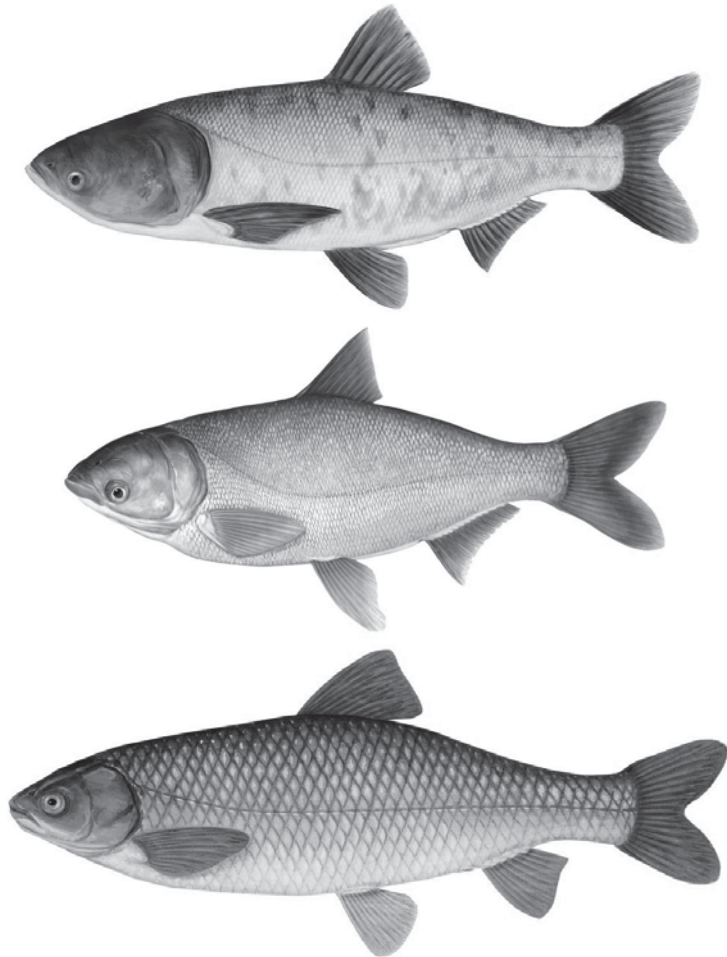


INVASIVE CARP SAMPLING REPORT
JANUARY – DECEMBER 2015
MINNESOTA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF FISH AND WILDLIFE
SECTION OF FISHERIES



UPPER MISSISSIPPI RIVER, POOL 2
LOWER ST. CROIX RIVER, BELOW ST. CROIX FALLS

April 21st, 2016



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.....	17
References.....	18

LIST OF TABLES

Table 1. Invasive Carp sampling summary for the Mississippi River Pools 1, 2, 3, 4, 6, 8 and the St. Croix River for January through December 2015. Number of Invasive Carp Captured represents the number of individuals caught by MN DNR, contracted commercial fishermen, or monitored commercial fishing.....21

Table 2. Invasive Carp caught from January through December 2015 in Minnesota waters. 21

Table 3. Species list for the Mississippi River Pool 2 and the St. Croix River from January 2013 through December 2015, including 73 native and invasive species.22

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.24

Figure 2. Standardized electrofishing (dark circle, E1 – E8) and larval fish trawling (dark cross, LT1 - LT 6) locations on the St. Croix River (SC).25

Figure 2 (Continued). Standardized electrofishing (dark circle, E8) and larval fish trawling (dark cross, LT 6 - LT 8) locations on the St. Croix River (SC).26

Figure 3. Standardized larval fish trawling (LT1-LT8) locations on Pool 3. Site P3-LT3 was moved in 2015 due to the site becoming too shallow to trawl.27

Figure 4. Standardized larval fish trawling (dark cross, MC 1-3 and BW 1-3) locations on upper Pool 4.28

Figure 5. Standardized larval fish trawling (dark cross, MC 4-6 and BW 4-6) locations on lower Pool 4.28

Figure 6. Standardized larval fish trawling (dark cross, Pool 8) location in Pool 8.29

Figure 7. All sampling locations for contracted commercial sampling and MN DNR sampling on the Mississippi River and the St. Croix River during 2015.30

Figure 8. Catch by weight in pounds of all fish caught using seines and gill nets during contracted commercial fishing efforts on the Mississippi River Pool 2-6 and the St. Croix River during 2015.31

Figure 9. Catch by number of individuals of all fish caught using large fyke nets on the Mississippi River Pool 2 during 2015. “Other species” caught included Shorthead Redhorse, Flathead Catfish, White Crappie, Northern Pike, Smallmouth Buffalo, Bigmouth Buffalo, Channel Catfish, and Sauger.....31

Figure 10. Catch by number of individuals of all fish caught using minitature fyke nets on the Mississippi River Pool 2 during 2015. Other species caught included Silver Redhorse, Bluegill, Logperch, Bigmouth Buffalo, River Carpsucker, Tadpole Madtom, Largemouth Bass, Gizzard Shad, Freshwater Drum, Smallmouth Bass, Pumpkinseed, Bowfin, Golden Redhorse, Mimic Shiner, Rock Bass, Shorthead Redhorse, Shortnose Gar, and Yellow Bullhead.....32

Figure 11. The percent catch by number of fish caught during standardized electrofishing on the Mississippi River Pool 2 during 2015. “Other species” represents 25 species, including: Smallmouth Bass, Sauger, Walleye, Smallmouth Buffalo, River Carpsucker, Golden Redhorse, Largemouth Bass, Channel Catfish, White Bass, Highfin, Pumpkinseed, Quillback, Black Crappie, Spotfin Shiner, Flathead Catfish, Orange Spotted Sucker, Bigmouth Buffalo, Bluntnose Minnow, White Crappie, Yellow Perch, Bowfin, Rock Bass, River Redhorse, and Spottail Shiner.....32

Figure 12. The percent catch by number of fish caught during standardized electrofishing on the St. Croix River during 2015. “Other species” represents 27 species, including: Bluegill, River Redhorse, Spotted Sucker, Yellow Perch, Logperch, Emerald Shiner, Smallmouth Bass, Rock Bass, Spotfin Shiner, Highfin, Northern Pike, Walleye, Burbot, Bowfin, Largemouth Bass, Northern Hogsucker, Black Crappie, Channel Catfish, Spottail Shiner, Blue Sucker, Greater Redhorse, Green Sunfish, Hybrid Sunfish, Muskie, Orangespotted Sunfish, Shortnose Gar, and Tiger Muskie.....33

Figure 13. The percent catch by number of fish caught during standardized larval sampling on Pool 2 of the Mississippi River during 2013 and 2014.....34

Figure 14. The percent catch by number of fish caught during standardized larval sampling on Pool 3 of the Mississippi River during 2013 and 2014.....34

Figure 15. The percent catch by number of fish caught during standardized larval sampling on Pool 6 of the Mississippi River during 2014. A total of 12 fish, 4 species, were caught in 3 samples collected on May 19, 2014, including 2 Grass Pickerel.....35

Figure 16. The percent catch by number of fish caught during standardized larval sampling on Pool 6 of the Mississippi River during 2014. Of the 472 total fish sampled, the “other species” represented 6 species with numbers ranging from 1 to 4 individuals.....36

Figure 17. The percent catch by number of fish caught during standardized larval sampling on the St. Croix River during 2013 and 2014. Of the 1806 total fish sampled, the “other species” represented 17 species with numbers ranging from 1 to 15 individuals.....36

Figure 18. 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 and 2015.....37

Figure 19. Length distribution for Freshwater Drum collected for age and growth analyses from Pool 2 of the Mississippi River and the St. Croix River from 2012 through 2015.....37

Figure 20. Length distribution of Smallmouth Buffalo collected for age and growth analyses in Pool 2 of the Mississippi River and the St. Croix River 2013-2015.....38

Figure 21. Length distribution of Bigmouth Buffalo collected for age and growth analyses from Pool 2 of the Mississippi River and the St. Croix River 2013-2015.....38

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 on the St. Croix River as far north as Lake St. Croix, near Prescott, WI, and on the Mississippi River Silver Carp had been found as far north as Pool 2, near Hastings, 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 the ability to populate new areas quickly, Invasive Carps can reach high abundances, sometimes comprising most of the fish biomass in certain systems (MICRA 2002). Invasive Carps 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 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. Before this year, Invasive Carps in Minnesota had 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 6, including approximately 89 km of water from St. Anthony Falls Lock and Dam in Minneapolis, MN to Lock and Dam 4 south of Wabasha MN near Alma, WI. 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 were hired to use large mesh gillnets and seines to sample in the Mississippi River from Pool 2 to Pool 6 near Trempealeau, WI, in the St. Croix River from the dam near Taylors Falls, MN to the confluence with the Mississippi River near Prescott, WI, and in a backwater off the Minnesota River at Blackdog Lake in Burnsville, MN.

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, 2015 and December 31, 2015.

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*, Channel Catfish *Ictalurus punctatus*, Smallmouth Buffalo *Ictiobus bubalus*, and Bigmouth Buffalo *Ictiobus cyprinellus* in Pool 2 and Lake Sturgeon *Acipenser fulvescens*, Muskellunge *Esox masquinongy*, White Bass *Morone*

chrysops, Flathead Catfish, and Channel Catfish in the St. Croix River. 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 feet and lengths of 150 to 300 feet with square mesh sizes of 4 to 6 inches were used to target adult Invasive Carps. Trammel nets with outside wall square mesh sizes of 14 inches and inner square mesh sizes of 4 inches were also used to target adult Invasive Carps. Experimental gill nets 250 feet in length and 6 feet deep consisting of 50 foot complements of net with square mesh sizes 0.75, 1, 1.25, 1.5, 2 inches 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 60° F. All fish caught were identified and measured.

Commercial Fishing

Commercial fishermen were contracted to target Invasive Carp with 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.

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. On several occasions, over 2,000 Common Carp were caught and counts were discontinued after counting 2,000 individuals.

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 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 2015, 15 standardized electrofishing sites were sampled for a total of 267 minutes. Standardized sampling locations were selected based on habitats Invasive Carps 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 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, Pool 4, Pool 8, and the St. Croix River to target early life stages of Invasive Carps. Eight standardized sites were sampled in Pool 2 (Figure 1), the St. Croix (Figure 2 and 3), and Pool 3 (Figure 4) and 12 sites were sampled in Pool 4 (Figures 5 and 6). A bow mounted ichthyoplankton net (0.75 m x 3 m) consisting of 500 μ m 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. In Pool 2, Pool 3 and the St. Croix River sampling locations were located in the following macro habitats: 4 main channel, 2 side channel, and 2 backwater locations in each system. In Pool 4, 6 sites were sampled upstream of

Lake Pepin (Figure 5) and 6 were sampled downstream of Lake Pepin (Figure 6), with 3 main channel sites and 3 backwater sites, respectively. Several samples were also collected from Mississippi River Pool 8 (Figure 7). 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 Smallmouth Buffalo 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.

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 ageing 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 Smallmouth and Bigmouth Buffalo, lapillus otoliths and pelvic fin rays were extracted and compared. As part of another study, 2,000 Smallmouth and Bigmouth Buffalo were tagged with Floy tags and their pelvic fins were removed for ageing and to validate ageing analyses using re-captured fish in the future. Otoliths were baked, embedded in epoxy, and subsequently cut using an isomet saw. 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, 66 days were spent sampling between January and December 2015 on the Mississippi River Pool 1, 2, 3 and St. Croix River with gears appropriate for sampling Invasive Carps (Table 1), as well as additional days spent by the Lake City office larval sampling in Pool 4 (13 days) and the U.S. Fish and Wildlife Service larval sampling in Pool 8 (7 days). A greater amount of effort was focused on Pool 2 and the St. Croix River (Figure 7), because Invasive Carps were found above Lock and Dam 2 on the Mississippi River in 2014 and due to the finding of Bighead Carp at the Allen S. King Plant discharge on the St. Croix in 2015. Determining whether there were individuals or populations of Invasive Carps in Pool 2 and the St. Croix 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.

In 2015, a total of 4 Grass Carp, 6 Bighead Carp, and 0 Silver Carp were caught in Minnesota waters (Table 2). One gravid female Grass Carp was collected in Pool 6 near Pol Mar campground by contracted commercial seine fishermen on January 15, 2015, one gravid female Grass Carp was collected in Pool 4 near Wabasha, MN by commercial gill net fishermen on January 22, 2015, and one mature male Grass Carp was collected in Pool 2 in Grey Cloud Slough by contracted commercial gill net fishermen on April 28, 2015. On December 10, 2015 one Grass Carp was caught on the Minnesota River near New Ulm, MN by a commercial fisherman. This represents the furthest upstream this species has ever been observed in the Minnesota River. All 4 Grass Carp were found to be diploid by the USGS' Whitney Genetics Laboratory. Biologists from the USGS Columbia Environmental Research Center in Missouri aged all sampled Invasive Carp, removed otoliths for microchemistry analysis, examined samples of the reproductive tract for sex and maturity, and stored genetic samples for later analysis. The Grass Carp caught in Pool 6 was aged at 6 years, the Grass Carp caught in Pool 4 was aged at 4 years, and the Grass Carp caught in Pool 2 was aged at 6 or 7 years. The Minnesota River Grass Carp has not been aged at the time of this report. Though two female Grass Carp had eggs, they showed no visible signs of mating or ovulation.

On May 27, 2015 a Bighead Carp was caught by a shore angler and reported to the DNR Information hotline from the discharge of the Allen S. King Plant on the St. Croix River. DNR personnel contacted the individual to attain the fish but the fish had already been consumed. The following day, May 28, 2015, DNR personnel used deep gill and trammel nets to block off the

discharge and deployed an electrofishing boat to electrofish and push fish in the discharge towards the nets. As a result, a gravid female Bighead Carp was caught in the gill nets. In total, 6 Bighead Carp were positively identified and confirmed to have been caught in the Allen S. King Plant discharge between May 26, 2015 and June 8, 2015. Of the five Bighead Carp caught by shore anglers, one mature female was donated to DNR personnel for analysis. Both individuals that were able to be analyzed were aged at least 5 years old and neither showed signs of mating or ovulation. After the first report of a Bighead Carp, DNR monitoring efforts were deployed in the area of the discharge as well as upstream and downstream, including contracting with a commercial gill net fisherman to determine if more were in the area. These efforts did not produce any additional individuals. The six Bighead Carp at the King Plant represent the furthest upstream this species has ever been observed on the St. Croix River.

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 2015, a total of 14,700 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 hours).

Contracted commercial fishermen set approximately 75,700 feet of gill and trammel nets during ten days of effort and conducted eight seine hauls between January and December 2015. Gill nets were set short term (2-3 hours) and fish were chased towards the net with boats, typically in large backwater areas. By weight, Common Carp *Cyprinus carpio* (56%) dominated the commercial catches, followed by Buffalo (Smallmouth (26%) and Bigmouth (15%)), Freshwater Drum (1.5%), and 1 Grass Carp (0%) (Figure 9). The commercial fishermen harvested a total of 109,647 pounds of fish during the 18 days of effort.

A small 35 foot seine was used by MN DNR personnel to sample shallow water habitats for young fish. A total of 6 seines were used over 4 days. A total of 20 species were caught in Pool 2 and the St. Croix River, with over 2,000 individuals caught. The use of this gear allowed us to confirm presence of young of the year Common Carp and Buffalo species in Pool 2 to better determine where to monitor for young Invasive Carp, collect young of the year Gizzard Shad and Freshwater Drum for age and growth analyses, as well as document smaller species including Johnny Darters *Etheostoma nigrum*, Pumpkinseeds *Lepomis gibbosus*, Bluntnose Minnows *Pimephales notatus*, and Tadpole Madtoms *Noturus gyrinus*.

Trap netting was conducted using fyke nets for a total of 27 net nights. All fish were counted and measured and weighed in large fyke nets; however, several mini fyke nets caught so many Common Carp that counts were stopped after 2,000 individuals were counted in a single net. Large fyke nets caught mostly Black Crappie *Pomoxis nigromaculatus* (20.9%), followed by Silver Redhorse *Moxostoma anisurum* (12.1%), Freshwater Drum (11.0%), White Bass *Morone chrysops* (11.0%), Bluegill *Lepomis macrochirus* (9.9%), Common Carp (8.8%), and Walleye *Sander vitreus* (7.7%)(Figure 10). Other species caught included Shorthead Redhorse *Moxostoma macrolepidotum*, Flathead Catfish *Pylodictis olivaris*, White Crappie *Pomoxis annularis*, Northern Pike *Esox lucius*, Smallmouth Buffalo, Bigmouth Buffalo, Channel Catfish *Ictalurus punctatus*, and Sauger *Sander canadensis*. Mini fyke nets caught mostly Common Carp (65.1%), followed by Emerald Shiner *Notropis atherinoides* (13.5%), Spottfin Shiner *Cyprinella spiloptera* (6.5%), Johnny Darter (4.9%), Spottail Shiner *Notropis hudsonius* (4.1%), Bluntnose Minnow (1.6%), and Black Crappie (1.3%). Other species caught included Silver Redhorse, Bluegill, Logperch *Percina caprodes*, Bigmouth Buffalo, River Carpsucker *Carpionodes carpio*, Tadpole Madtom, Largemouth Bass *Micropterus salmoides*, Gizzard Shad, Freshwater Drum,

Smallmouth Bass *Micropterus dolomieu*, Pumpkinseed, Bowfin *Amia calva*, Golden Redhorse *Moxostoma erythrurum*, Mimic Shiner *Notropis volucellus*, Rock Bass *Ambloplites rupestris*, Shorthead Redhorse, Shortnose Gar *Lepisosteus platostomus*, and Yellow Bullhead *Ameiurus natalis* (Figure 11).

Both random and standardized electrofishing sampling was conducted on Pools 1 and 2 of the Mississippi and the St. Croix rivers. A total of 971 minutes of “on time” over 18 days were spent electrofishing between January and December 2015. 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. On Pool 2, 31 species were sampled. The most common species caught were Emerald Shiner (18.3%), followed by Bluegill (16.1%), Common Carp (7.4%), Silver Redhorse (7.0%), Shorthead Redhorse (6.0%), and Freshwater Drum (4.8%), with the other 25 species representing 40.2% of the catch (Figure 12). On the St. Croix River, 32 species were sampled. The most common species were Golden Redhorse (39.0%), followed by Shorthead Redhorse, Freshwater Drum, Quillback *Carpionodes cyprinus* (5.0%), and Common Carp (4.4%), with the other 27 species representing 36.0% of the catch (Figure 14).

Larval trawling was conducted for 159 total trawls during 19 days by the Invasive Carp fisheries personnel, as well as 132 trawls over 13 days in Pool 4 by Lake City fisheries personnel and 14 trawls over 7 days in Pool 8 by U.S. Fish and Wildlife Service personnel. A total of 305 samples were sifted by Invasive Carp fisheries personnel and all samples with fish larvae or eggs are preserved and awaiting expert analysis to determine the species caught and their respective number. Zero samples were found to contain Invasive Carp larvae or eggs.

In early 2015, we received the expert identification of larval samples collected during the 2013 and 2014 field seasons. From these two field seasons, a total of 4,269 specimens were collected and examined from 120 samples containing larval fish or eggs, representing at least 36 species. Several species could not be determined to species level including Walleye/Sauger, Black Crappie/White Crappie, Sunfish, Suckers, Darters, and Shiners. Though species specific identification of Emerald Shiner, Golden Shiner *Notemigonus crysoleucas*, Sand Shiner *Notropis stramineus*, and Mimic Shiner were possible, several samples were identified as un-described or poorly described species of Shiners and species could not be determined. Several species had not been collected using other gears including Brook Stickleback *Culaea inconstans*, Skipjack Herring *Alosa chrysochloris*, Grass Pickerel *Esox americanus vermiculatus*, Sand Shiner, Golden Shiner, and White Sucker *Catostomus commersonii*. Most notably, expert identification found the first signs of Skipjack Herring reproduction in Pool 2 of the Mississippi River from 3 individuals identified in 2 samples collected on July 8 and 9, 2013 from Upper Pool 2 near Pigs Eye Lake and lower Pool 2 near Spring Lake.

In Pool 2, a total of 28 species were identified in the larval samples with presence varying by species from one individual up to 750 Gizzard Shad out of 1,247 total individuals collected from 53 samples with fish present. In 2013, larval White Bass and Black/White Crappie were found in samples from July 8 through August 28, and Freshwater Drum and Common Carp were found in samples from all dates in which larval fish were collected in 2013, from June 27 to August 28. In 2014, only Common Carp were found across nearly all sampling dates in which larval fish were collected, from June 5 to July 10, 2014. Shiner species were found at varying life stages through many of the samples in both years. Based on the number of eggs and larvae present, the most common species found in Pool 2 was Gizzard Shad (60.1%), followed by

Emerald Shiner (8.4%), Mimic Shiner (6.4%), Common Carp (3.7%), and White Sucker (3.6%). “Other species” accounted for 17.5% representing 24 species, including Unknown Shiner species, Golden Shiner, Unknown species, Suckers, Spotfin Shiner, Freshwater Drum, Sand Shiner, Sunfish, White Bass, Black/White Crappie, Skipjack Herring, Bluntnose Minnow, Brook Silverside *Labidesthes sicculus*, Brook Stickleback, Longnose Gar *Lepisosteus osseus*, River Carpsucker, Pumpkinseed, Rock Bass, Quillback, Northern Pike, Shorthead Redhorse, Bluegill, Walleye/Sauger, and Bigmouth Buffalo (Figure 13).

In Pool 3, a total of 12 species were identified in the larval samples with presence varying by species to one individual up to 325 unidentified species samples out of 732 total individuals collected from 22 samples collected with fish present. Gizzard Shad were found on all sample dates in which larval fish were collected from June 2 to August 11, 2014 (Figure 14). Based on the number of eggs and larvae present, the most common species found in Pool 3 was an unknown species (44.4%), followed by Gizzard Shad (17.8%), White Bass (16.5%), Freshwater Drum (9.2%), Common Carp (4.4%), and Emerald Shiner (4.2%). “Other species” accounted for 3.6% representing 7 species, including White Sucker, Unknown Shiner species, Suckers, Sunfish, Black/White Crappie, Walleye/Sauger, and Spotfin Shiner (Figure 14).

In Pool 6, a total of 4 species were identified in the larval samples with presence varying by species from one individual up to 8 Yellow Perch of out 12 total individuals collected from 3 samples with fish present collected on May 19, 2014. Based on the number of eggs and larvae present, the most common species found in Pool 3 was Yellow Perch (66.7%), followed by Grass Pickerel (16.7%), Walleye/Sauger (8.3%), and Suckers (8.3%) (Figure 15).

In Pool 8, a total of 10 species were identified in the larval samples with presence varying by species from one individual up to 286 Freshwater Drum out of 472 total individuals collected

from 10 samples with fish present. Freshwater Drum and Common Carp were found on nearly all sample dates in which larval fish were collected from June 12 to July 29, 2014. Bluegill were found through July 2, 2014. White Bass were found between June 24 and July 2, 2014. Based on the number of eggs and larvae present, the most common species found in Pool 3 was Freshwater Drum (60.6%), followed by unknown species (32.0%), Common Carp (3.6%), Bluegill (1.3%). “Other species” accounted for 2.5% representing 6 species, including Emerald Shiner, Gizzard Shad, White Bass, Suckers, Mooneye, and Largemouth Bass (Figure 16).

In the St. Croix River, a total of 21 species were identified in the larval samples with presence varying by species from one individual up to 1,131 Freshwater Drum out of 1,806 total individuals collected from 32 samples with fish present. In 2013, most larval fish were found on single sampling days, with only Shiner species found on multiple days. In 2014, Common Carp were found on all sample dates in which larval fish were collected from June 18 to August 5, 2014. Freshwater Drum were found June 18 to June 25, 2014. Gizzard Shad were found between June 27 and July 2, 2014 and again between August 4 and August 5, 2014. Based on the number of eggs and larvae present, the most common species found in the St. Croix was Freshwater Drum (62.6%), followed by unknown species (15.6%), Emerald Shiner (12.3%), and an unknown Shiner species (5.0%). “Other species” accounted for 4.5% representing 17 species, including Gizzard Shad, Common Carp, Suckers, Darters, Sunfish, Walleye/Sauger, Spottfin Shiner, Black/White Crappie, Bluegill, Blackside Darter *Percina maculata*, Logperch, Brook Stickleback, Rock Bass, White Bass, White Sucker, Yellow Perch, and Smallmouth Bass (Figure 17).

Numerous unique or rare native fishes worth mentioning were encountered during these sampling events. Numerous Blue Suckers *Cycleptus elongatus* and several Goldeyes *Hiodon*

alosooides, Mooneyes *H. tergisus*, and Shortnose Gar were observed in Pool 2. Further, three larval Skipjack Herring were found in larval samples in Pool 2. Several Paddlefish, Northern Hogsuckers *Hypentelium nigricans*, Spotted Sucker *Minytrema melanops*, Longnose Gar, 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 2015 has been compiled (Table 3). Grass Pickerel were also found in larval samples from Pool 6 on May 19, 2014.

Age and growth analysis was completed for the four species of interest by two readers. A total of 67 Gizzard Shad were aged from Pool 2 and 112 from the St. Croix. The number of annuli observed ranged from 0 to 7 in Pool 2 and 0 to 7 in the St. Croix River from fish measuring 58 to 504 mm (Figure 18). From Pool 2, 160 Freshwater Drum were aged and 253 from the St. Croix River. In Freshwater Drum, the number of annuli observed ranged from 0 to 39 in Pool 2 and 0 to 36 in the St. Croix River from fish measuring 103 to 825 mm (Figure 19). 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. Fifty-four Smallmouth Buffalo and 46 Bigmouth Buffalo were collected from Pool 2 and 45 Smallmouth Buffalo and 19 Bigmouth Buffalo from the St. Croix. In Smallmouth Buffalo, the number of annuli observed ranged from 1 to 12 in Pool 2 and 0 to 12 in the St. Croix River from fish measuring 321 to 678 mm (Figure 20). In Bigmouth Buffalo, the number of annuli observed ranged from 2 to 11 in Pool 2 and 3 to 14 in the St. Croix River from fish measuring 316 to 808 mm (Figure 21). Comparisons between fin rays and otoliths have been completed and it has been determined that pelvic fin rays are the easiest to read and produce significantly similar results to otoliths. Further,

in 2015, over 2,000 Buffalo were tagged and pelvic fin rays were removed. These fin rays will be aged and fish re-captured in 2016 will be euthanized and the other pelvic fin ray and otoliths will be compared.

RECOMMENDATIONS

Further 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 Carps. 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 negatively affect native species. Resource agencies would benefit from a greater understanding of the population dynamics of our commercially important native fishes. While many ageing structures have been collected in 2013, 2014, and 2015 field seasons, a greater number is required to make management decisions and accurately determine population dynamic measures. In addition to age and growth analyses, over 2,000 Bigmouth Buffalo and Smallmouth Buffalo were 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. It is recommended that this tagging project continue to better understand movement patterns and approximate the numbers of individuals present in the Pool 2 of the Mississippi River via mark-recapture techniques.

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 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 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.

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Table 1. Invasive Carp sampling summary for the Mississippi River Pools 1, 2, 3, 4, 6, 8 and the St. Croix River for January through December 2015. 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 2015			
Gear	Measure	Unit	Days
<i>Random Sampling Effort</i>			
Gill/Trammel Netting	16,400	feet	10
Electrofishing	704	minutes	12
Hoop Netting	12	net/nights	2
Trap Netting	27	net/nights	3
Seining	6	hauls	3
<i>Standardized Sampling Effort</i>			
Electrofishing	267	minutes	6
Larval trawling	159	trawls	19
<i>Targeted Commercial Fishing Effort</i>			
Gill Netting	75,700	feet	10
Seining	8	hauls	8
<i>Number of Invasive Carp Captured</i>	4	fish	
<i>Total Number of Days Sampled</i>			66

Table 2. Invasive Carp caught from January through December 2015 in Minnesota waters.

Date	Species	Water Body	Location	River Mile	Length (mm)	Weight (grams)	Sex	Maturity	Capture Method	Age
1/15	Grass Carp	Mississippi River	Pool 6 - Forest River Campground	717.4	926	9700	Female	Mature	Commercial Seine	6
1/22	Grass Carp	Mississippi River	Pool 4 - Near Wabasha	760.6	920	11300	Female	Mature	Commercial Gill Net	4
4/28	Grass Carp	Mississippi River	Pool 2 - Lower Grey Cloud Slough	~823	874	8200	Male	Mature	Commercial Gill Net	6 or 7
5/26	Bighead Carp	St. Croix River	King Plant Discharge	20.9	~914.4				Shore Angler	
5/27	Bighead Carp	St. Croix River	King Plant Discharge	20.9	~914.4				Shore Angler	
5/28	Bighead Carp	St. Croix River	King Plant Discharge	20.9	930	11000	Female	Mature	DNR Gill Net	5
5/30	Bighead Carp	St. Croix River	King Plant Discharge	20.9	~914.4				Shore Angler	
5/31	Bighead Carp	St. Croix River	King Plant Discharge	20.9	908	14250	Female	Mature	Shore Angler	5
6/8	Bighead Carp	St. Croix River	King Plant Discharge	20.9			Female	Mature	Shore Angler	
12/10	Grass Carp	Minnesota River	Near New Ulm	149.2	946	9150	Male	Immature	Commercial Seine	?

Table 3. Species list for the Mississippi River Pool 2 and the St. Croix River from January 2013 through December 2015, including 73 native and invasive species.

Species	Pool 2	St. Croix River
American Eel	x	
Bighead Carp	x	x
Bigmouth Buffalo	x	x
Black Bullhead		x
Black Crappie	x	x
Blackside Darter	x	x
Blue Sucker	x	x
Bluegill	x	x
Bluntnose Minnow	x	x
Bowfin	x	x
Brook Silverside	x	
Brook Stickleback	x	
Bullhead Minnow	x	
Burbot		x
Channel Catfish	x	x
Common Carp	x	x
Channel Shiner	x	
Crvstal Darter		x
Emerald Shiner	x	x
Fathead Minnow	x	
Flathead Catfish	x	x
Freshwater Drum	x	x
Gilt Darter		x
Gizzard Shad	x	x
Goldeve	x	
Golden Redhorse	x	x
Golden Shiner	x	
Grass Carp	x	
Greater Redhorse	x	x
Green Sunfish	x	x
Hornvhead Chub	x	
Hybrid Sunfish	x	x
Iowa Darter		x
Johnny Darter		x
Lake Sturgeon		x
Largemouth Bass	x	x
Logperch	x	x
Longnose Gar	x	x
Mimic Shiner	x	x
Mooneve	x	x
Muskellunge	x	x
Northern Hog Sucker		x
Northern Pike	x	x
Orangespotted	x	x
Paddlefish	x	x
Pumpkinseed	x	x
Ouillback	x	x
River Carnsucker	x	x
River Darter	x	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
Skinjack Herring	x	
Slenderhead Darter	x	
Smallmouth Bass	x	x
Smallmouth Buffalo	x	x
Spotfin Shiner	x	x

Table 3 (continued). Species list for the Mississippi River Pool 2 and the St. Croix River from January 2013 through December 2015, including 73 native and invasive species.

Species	Pool 2	St. Croix River
Spottail Shiner	x	
Spotted Sucker	x	x
Tadpole Madtom	x	
Trout Perch		x
Walleye	x	x
White Bass	x	x
White Crappie	x	x
White Sucker	x	x
Yellow Bullhead	x	
Yellow Perch	x	x

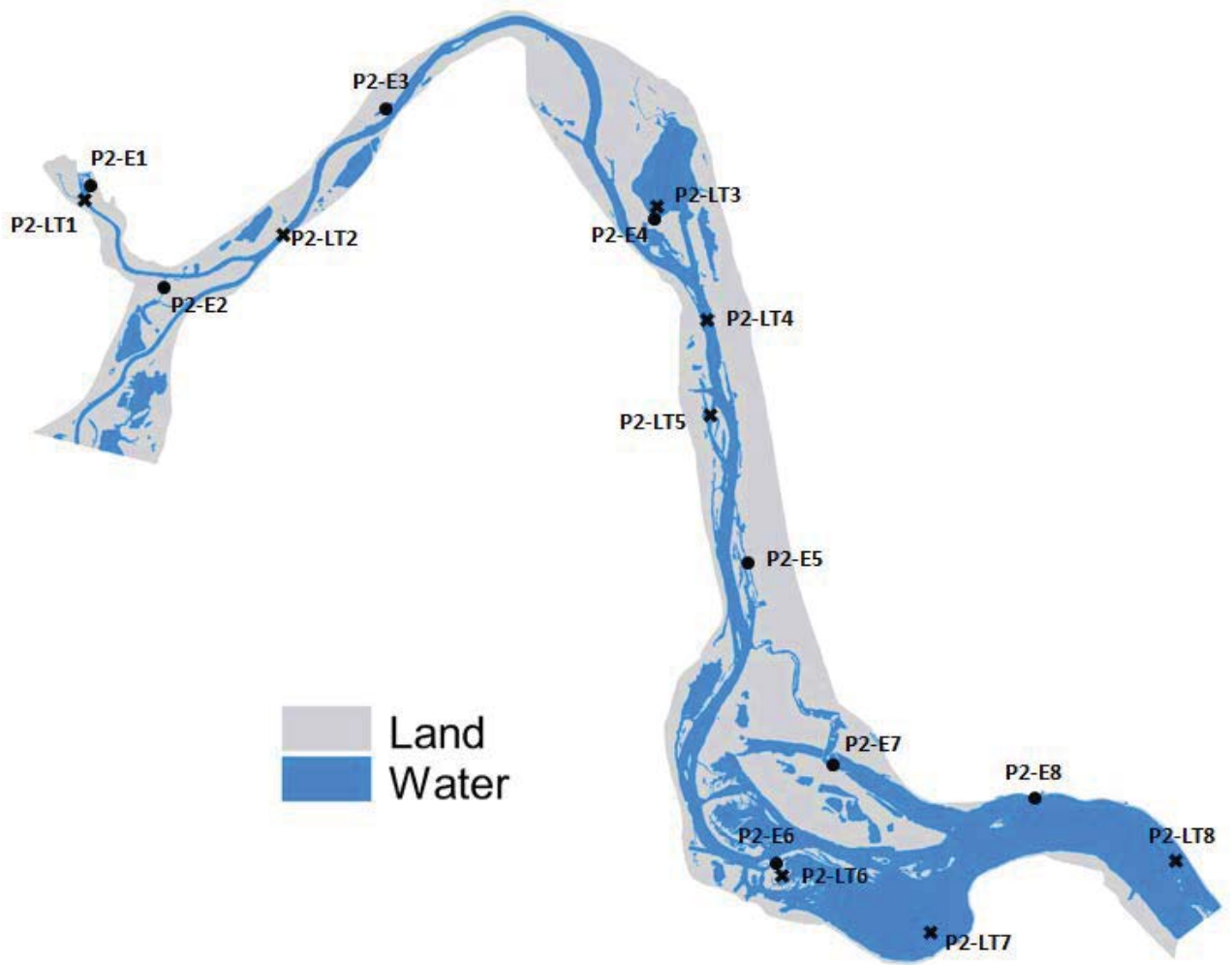


Figure 1. Standardized electrofishing (dark circle, E1 – E8) and larval fish trawling (dark cross, LT1 - LT 8) locations on Pool 2 (P2) of the Mississippi River.

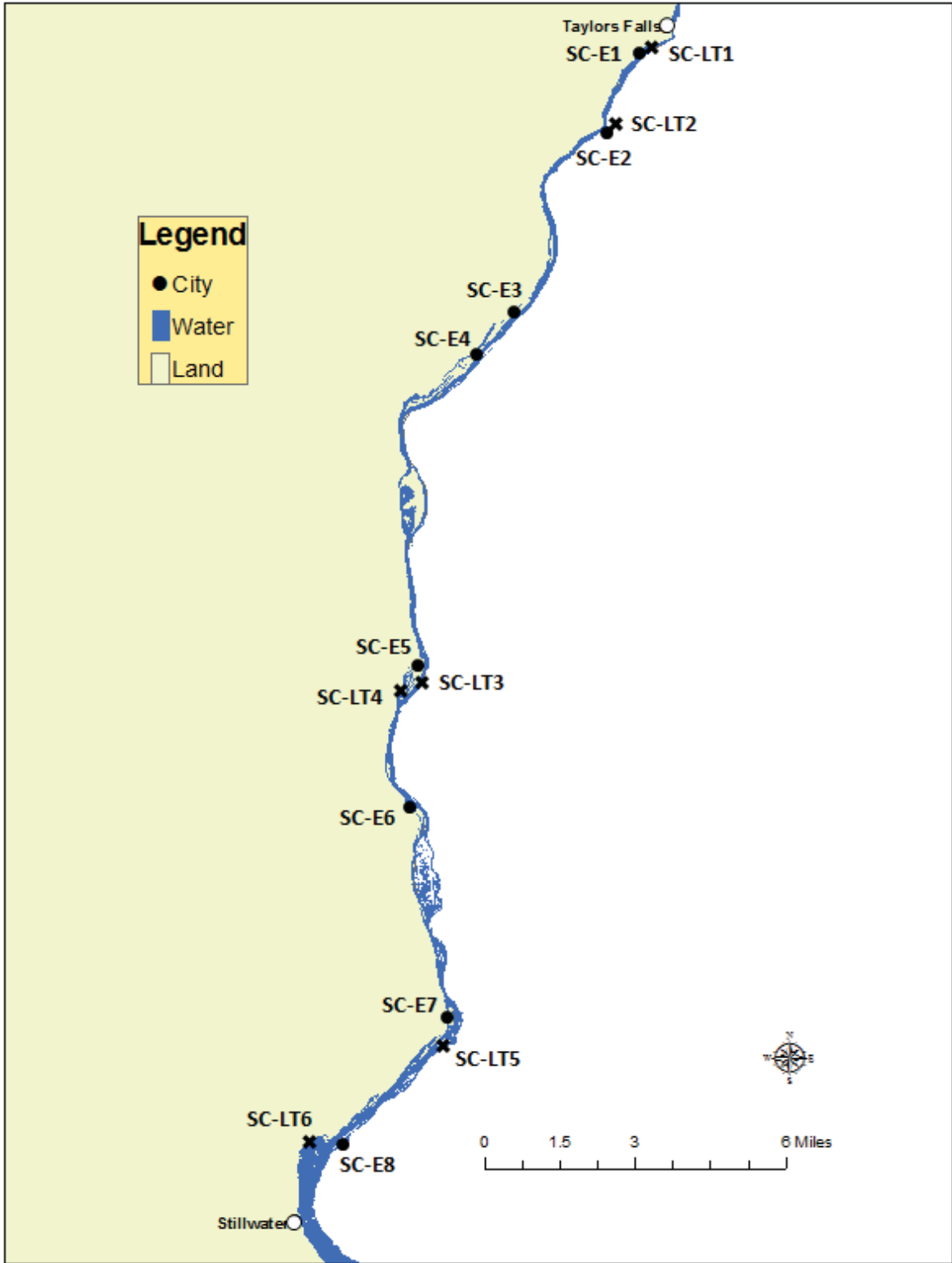


Figure 2. Standardized electrofishing (dark circle, E1 – E8) and larval fish trawling (dark cross, LT1 - LT 6) locations on the St. Croix River (SC).

St. Croix River Electrofishing and Trawling Sampling Map



Figure 2 (Continued). Standardized electrofishing (dark circle, E8) and larval fish trawling (dark cross, LT 6 - LT 8) locations on the St. Croix River (SC).

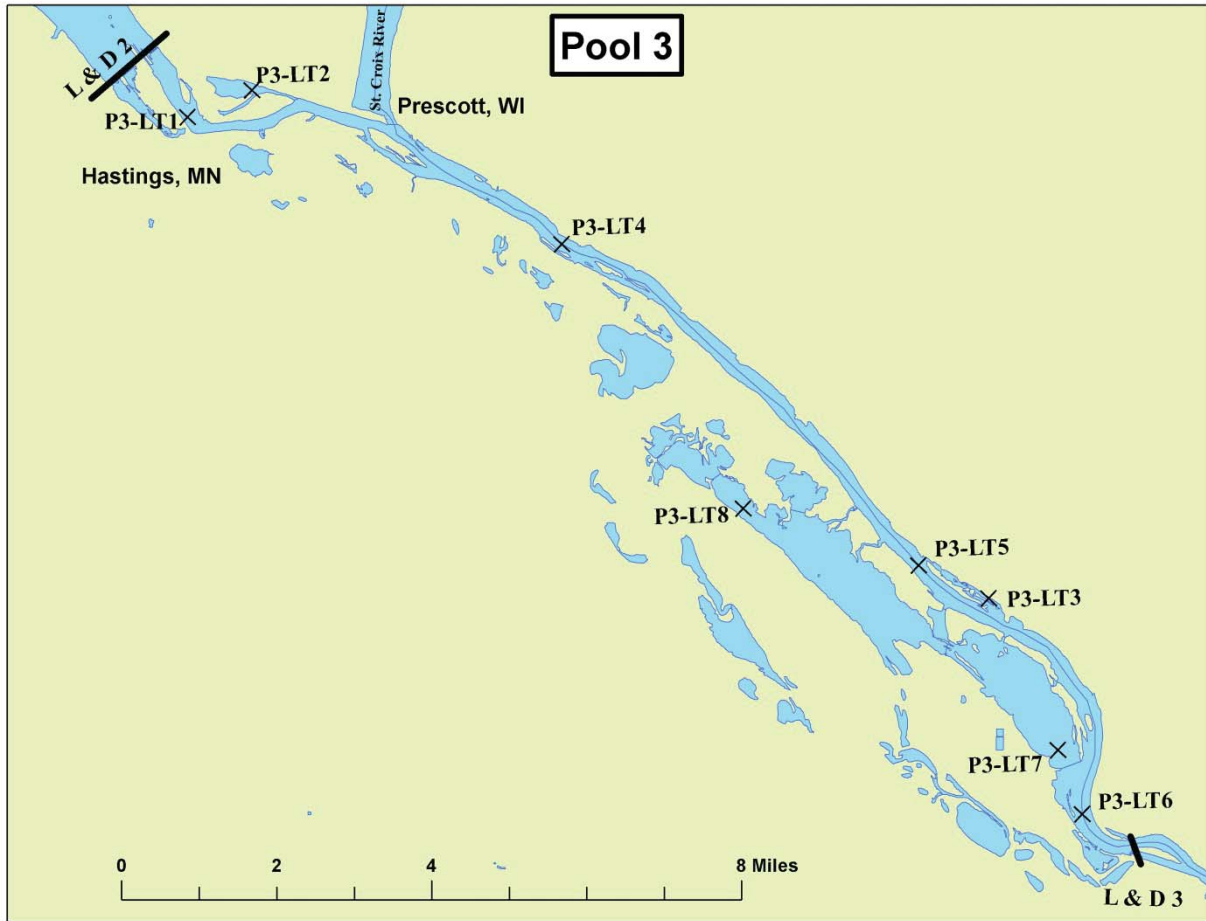


Figure 3. Standardized larval fish trawling (LT1-LT8) locations on Pool 3. Site P3-LT3 was moved in 2015 due to the site becoming too shallow to trawl.

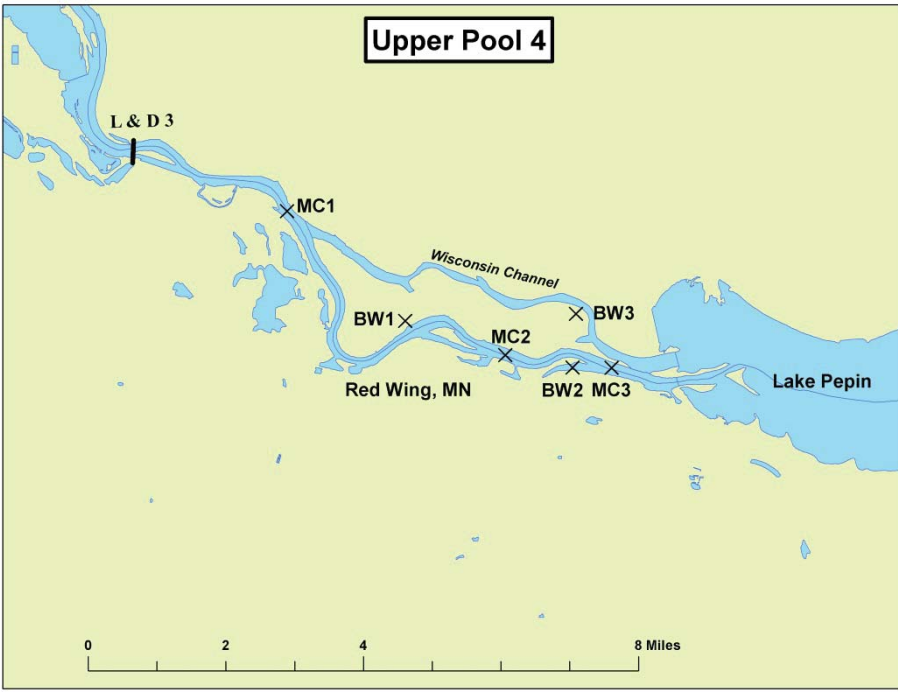


Figure 4. Standardized larval fish trawling (dark cross, MC 1-3 and BW 1-3) locations on upper Pool 4.

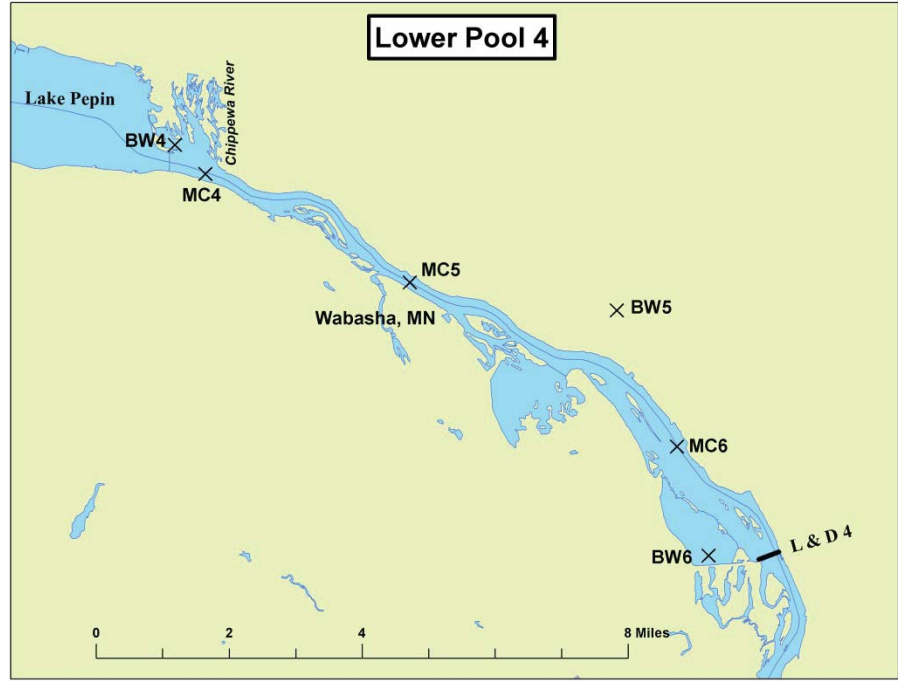


Figure 5. Standardized larval fish trawling (dark cross, MC 4-6 and BW 4-6) locations on lower Pool 4.



Figure 6. Standardized larval fish trawling (dark cross, Pool 8) location in Pool 8.



Figure 7. All sampling locations for contracted commercial sampling and MN DNR sampling on the Mississippi River and the St. Croix River, as well as Blackdog Lake a backwater of the Minnesota River, during 2015.

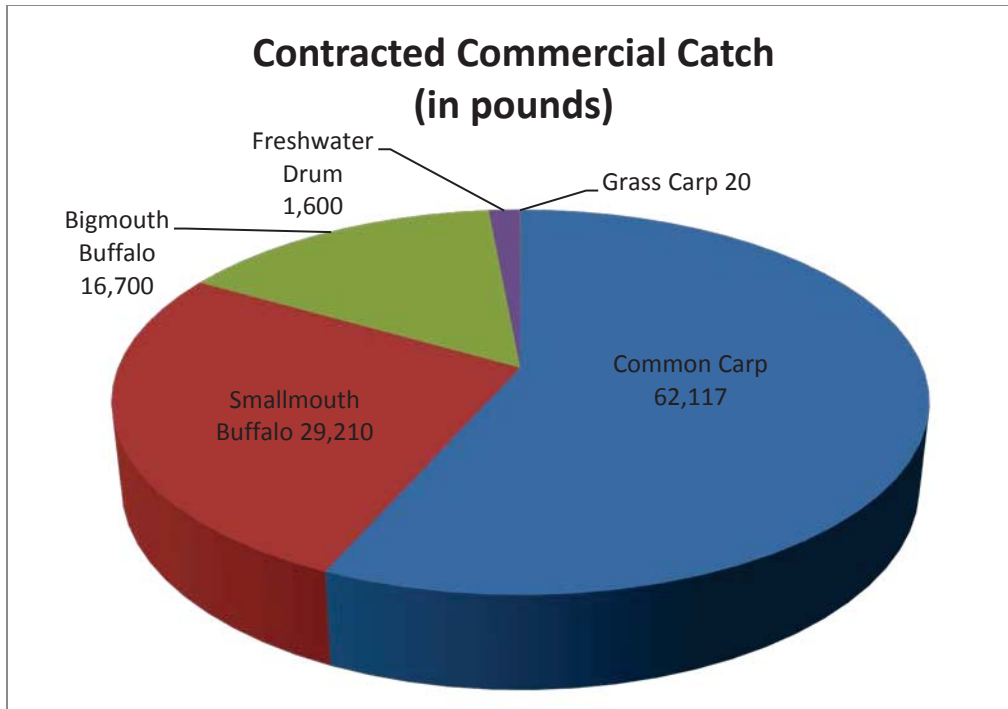


Figure 8. Catch by weight in pounds of all fish caught using seines and gill nets during contracted commercial fishing efforts on the Mississippi River Pool 2-6 and the St. Croix River during 2015.

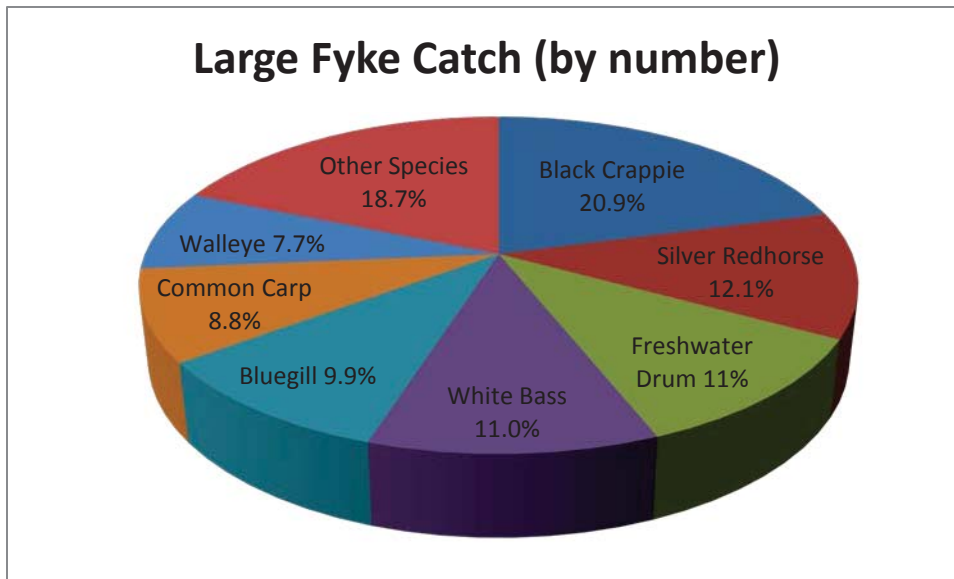


Figure 9. Catch by number of individuals of all fish caught using large fyke nets on the Mississippi River Pool 2 during 2015. "Other species" caught included Shorthead Redhorse, Flathead Catfish, White Crappie, Northern Pike, Smallmouth Buffalo, Bigmouth Buffalo, Channel Catfish, and Sauger.

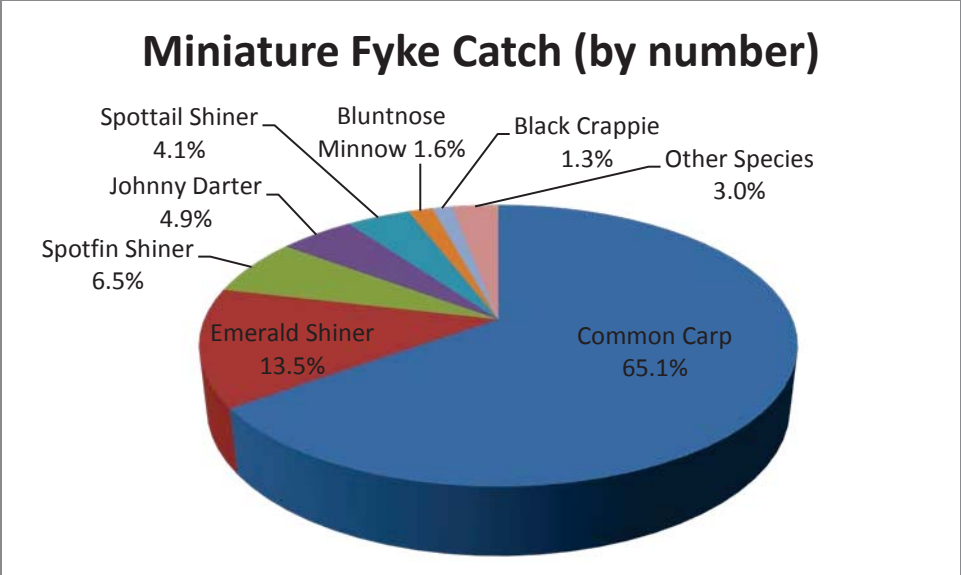


Figure 10. Catch by number of individuals of all fish caught using minitaure fyke nets on the Mississippi River Pool 2 during 2015. Other species caught included Silver Redhorse, Bluegill, Logperch, Bigmouth Buffalo, River Carpsucker, Tadpole Madtom, Largemouth Bass, Gizzard Shad, Freshwater Drum, Smallmouth Bass, Pumpkinseed, Bowfin, Golden Redhorse, Mimic Shiner, Rock Bass, Shorthead Redhorse, Shortnose Gar, and Yellow Bullhead.

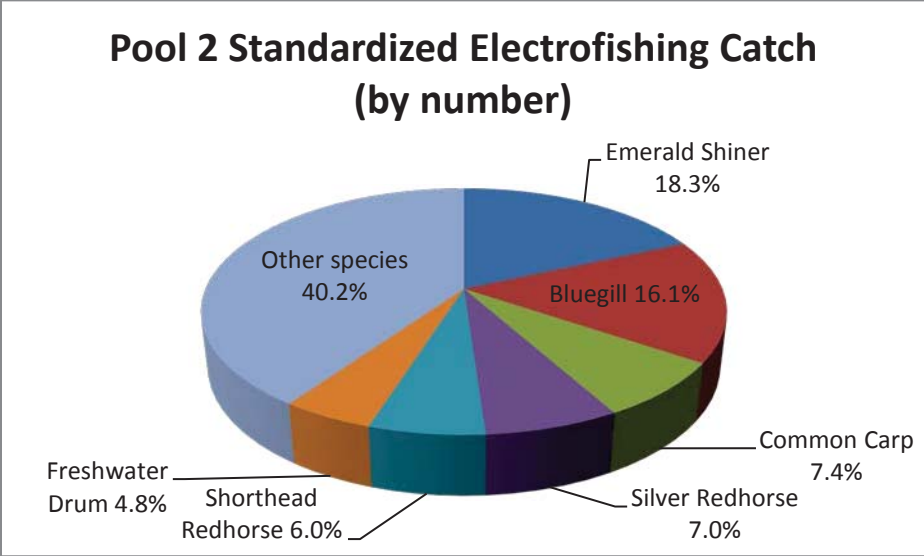


Figure 11. The percent catch by number of fish caught during standardized electrofishing on the Mississippi River Pool 2 during 2015. “Other species” represents 25 species, including: Smallmouth Bass, Sauger, Walleye, Smallmouth Buffalo, River Carpsucker, Golden Redhorse, Largemouth Bass, Channel Catfish, White Bass, Highfin, Pumpkinseed, Quillback, Black Crappie, Spotfin Shiner, Flathead Catfish, Orange Spotted Sucker, Bigmouth Buffalo, Bluntnose Minnow, White Crappie, Yellow Perch, Bowfin, Rock Bass, River Redhorse, and Spottail Shiner.

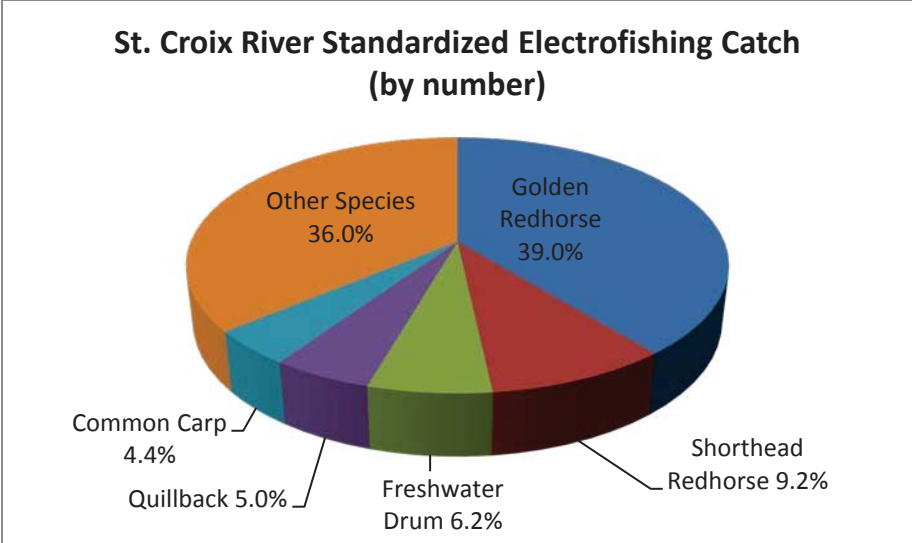


Figure 12. The percent catch by number of fish caught during standardized electrofishing on the St. Croix River during 2015. “Other species” represents 27 species, including: Bluegill, River Redhorse, Spotted Sucker, Yellow Perch, Logperch, Emerald Shiner, Smallmouth Bass, Rock Bass, Spottfin Shiner, Highfin, Northern Pike, Walleye, Burbot, Bowfin, Largemouth Bass, Northern Hogsucker, Black Crappie, Channel Catfish, Spottail Shiner, Blue Sucker, Greater Redhorse, Green Sunfish, Hybrid Sunfish, Muskie, Orangespotted Sunfish, Shortnose Gar, and Tiger Muskie.

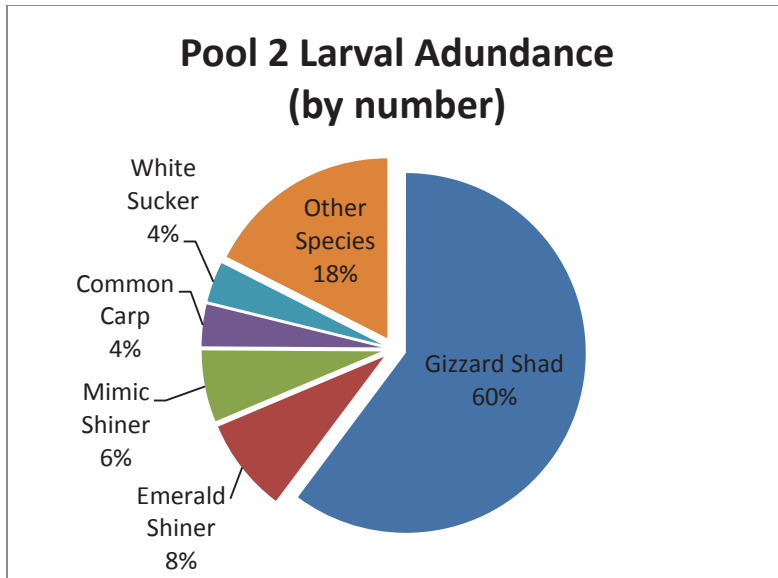


Figure 13. The percent catch by number of fish caught during standardized larval sampling on Pool 2 of the Mississippi River during 2013 and 2014.

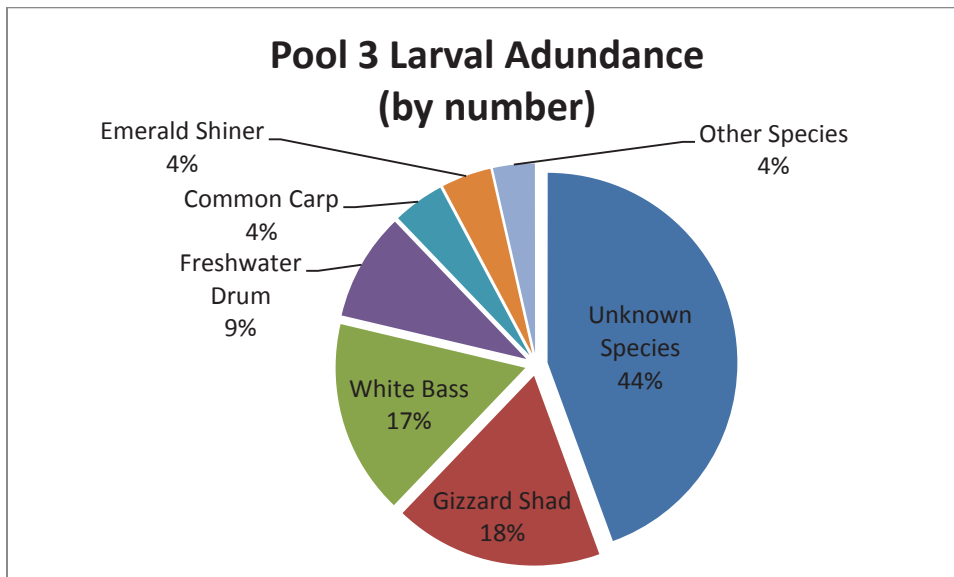


Figure 14. The percent catch by number of fish caught during standardized larval sampling on Pool 3 of the Mississippi River during 2013 and 2014.

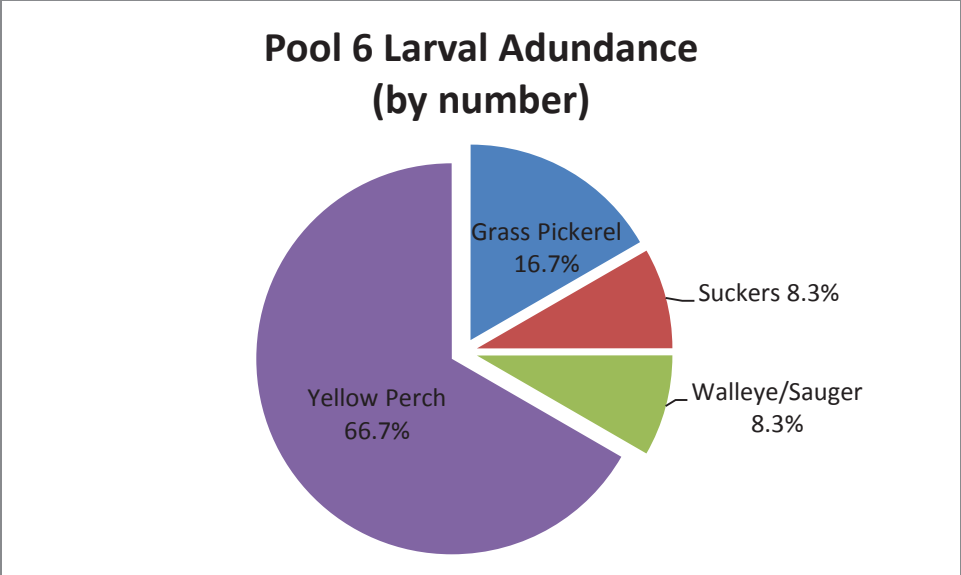


Figure 15. The percent catch by number of fish caught during standardized larval sampling on Pool 6 of the Mississippi River during 2014. A total of 12 fish, 4 species, were caught in 3 samples collected on May 19, 2014, including 2 Grass Pickerel.

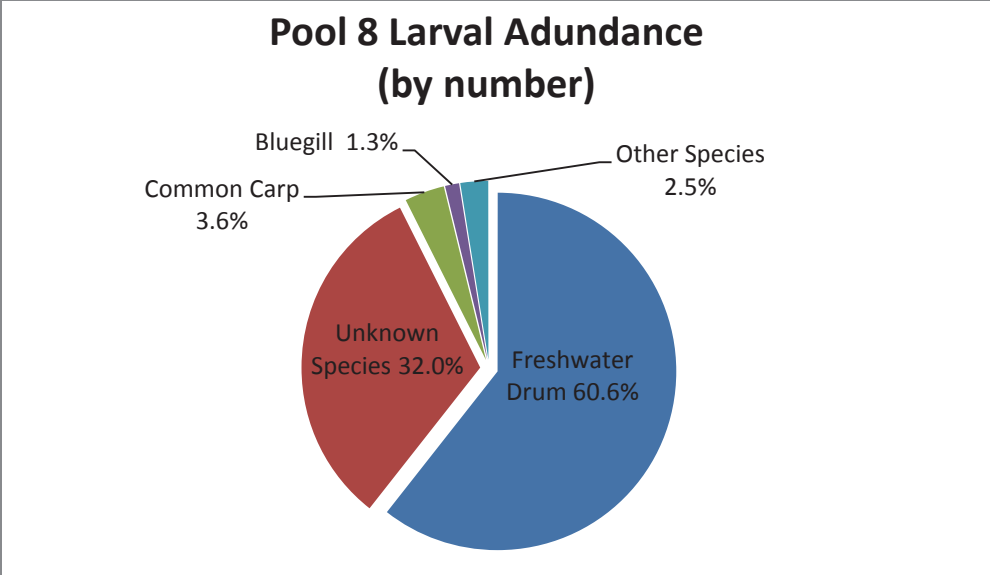


Figure 16. The percent catch by number of fish caught during standardized larval sampling on Pool 6 of the Mississippi River during 2014. Of the 472 total fish sampled, the “other species” represented 6 species with numbers ranging from 1 to 4 individuals.

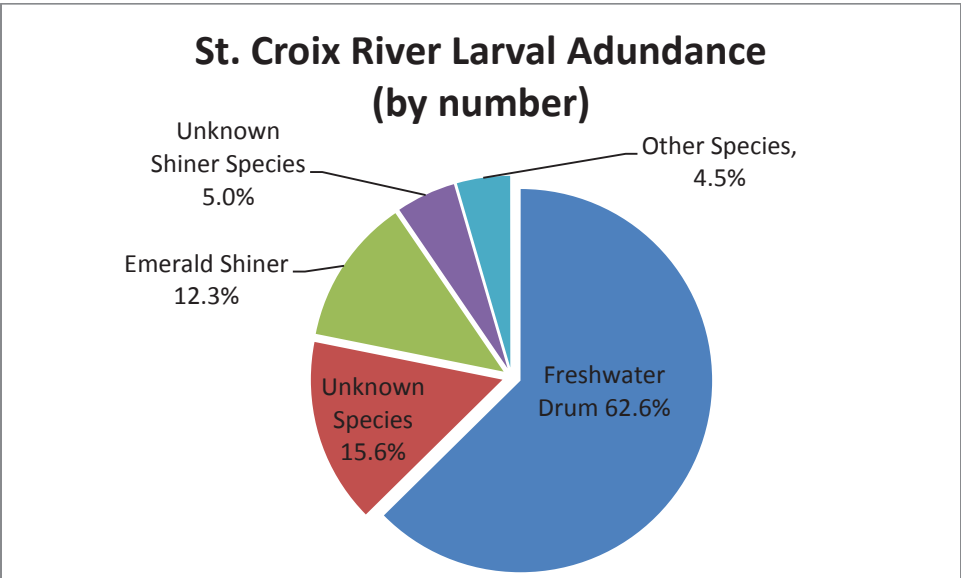


Figure 17. The percent catch by number of fish caught during standardized larval sampling on the St. Croix River during 2013 and 2014. Of the 1806 total fish sampled, the “other species” represented 17 species with numbers ranging from 1 to 15 individuals.

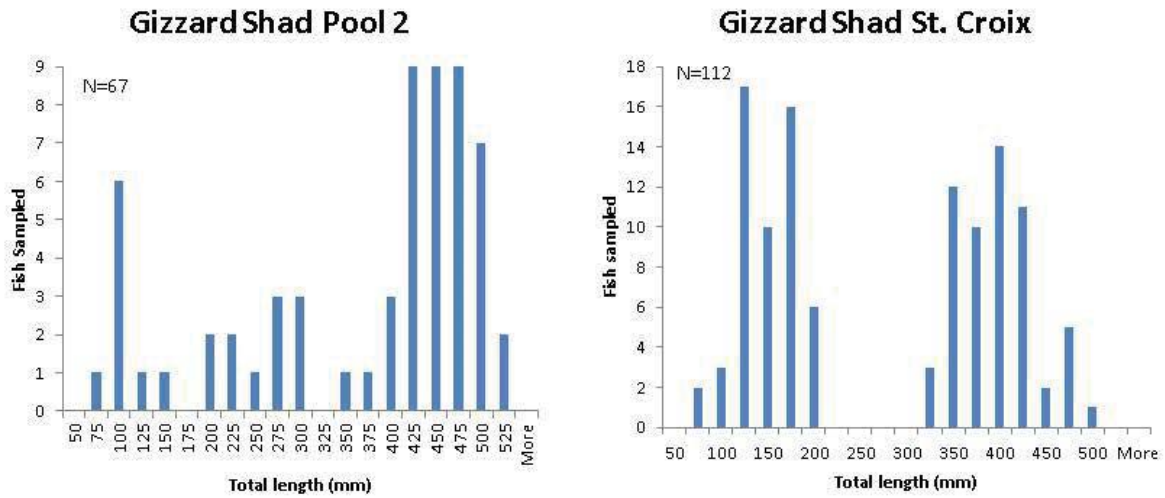


Figure 18. Length distribution for Gizzard Shad collected for age and growth analyses from Pool 2 of the Mississippi River and the St. Croix River during 2014 and 2015.

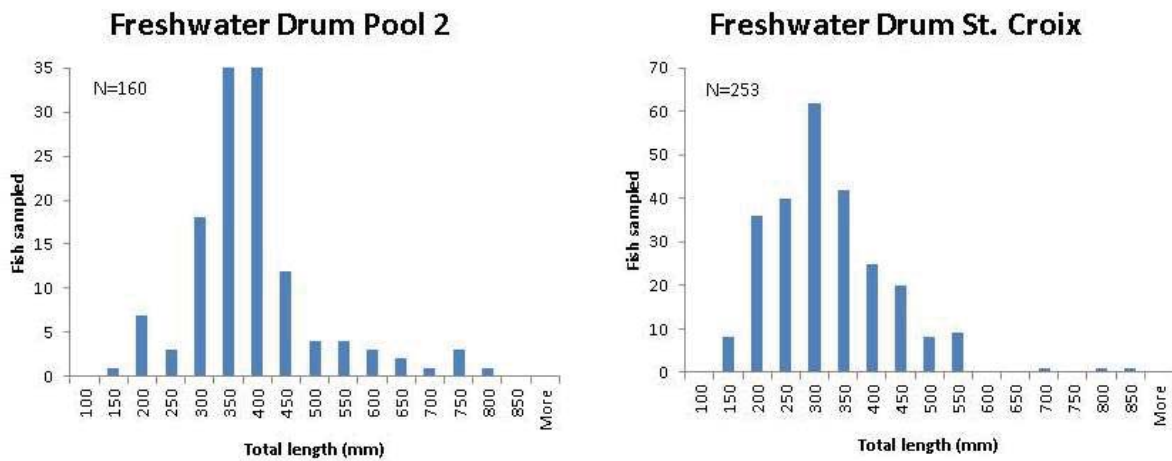


Figure 19. Length distribution for Freshwater Drum collected for age and growth analyses from Pool 2 of the Mississippi River and the St. Croix River from 2012 through 2015.

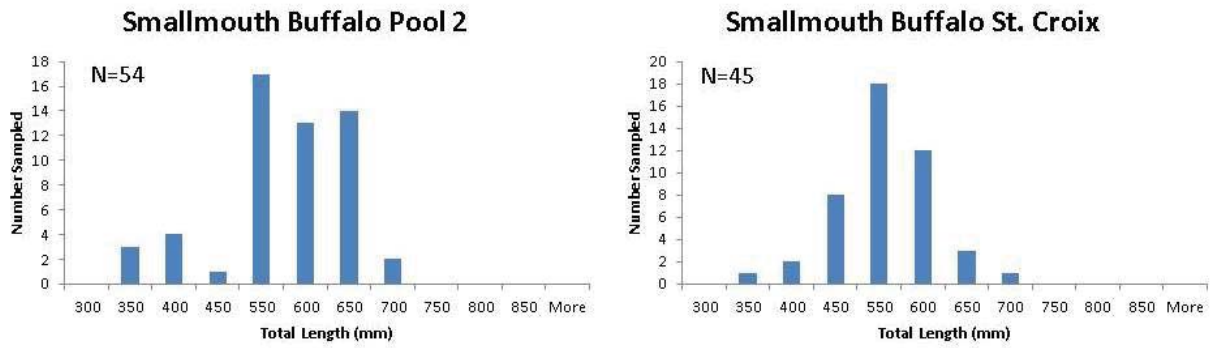


Figure 20. Length distribution of Smallmouth Buffalo collected for age and growth analyses in Pool 2 of the Mississippi River and the St. Croix River 2013-2015.

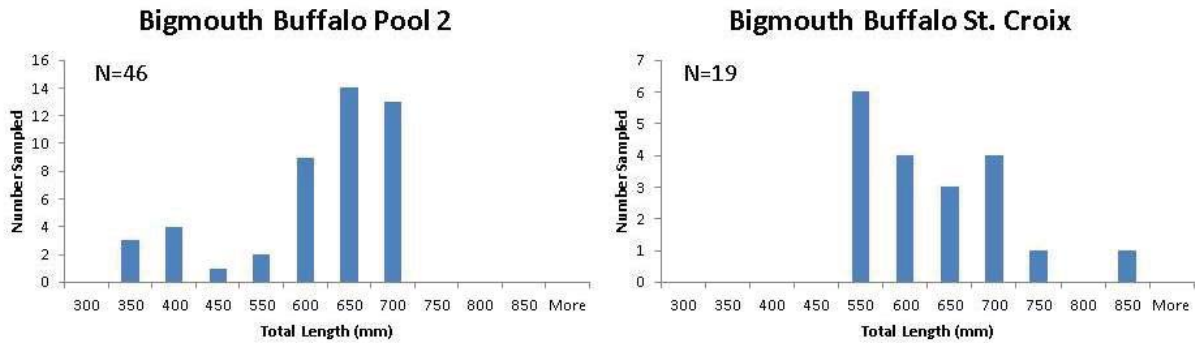


Figure 21. Length distribution of Bigmouth Buffalo collected for age and growth analyses from Pool 2 of the Mississippi River and the St. Croix River 2013-2015.