

State Wildlife Grants Program Project

Final report for:

Status and critical habitat of threatened, special concern, and rare fish species in nonwadeable portions of the Minnesota River.

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Introduction

In 2005, a survey of the nonwadeable portions of the Minnesota River was completed to document occurrences and critical habitats for fish species that are rare or categorized as threatened or special concern (Table 1). Surveys were separated into two major categories based on methodology; standardized whole fish community assessments using a boat-mounted electrofisher (boom shocker) and non-standardized methods utilizing various fish capturing equipment. Additional rare fish surveys were completed on the St. Croix River to follow up on work done in 2004 as part of this State Wildlife Grant's original proposal.

Methods

The standardized whole fish community assessments consist of electrofishing the main-channel-border habitats near a randomly selected bank for one mile (1600 m) of river. At each station, all fish were collected, identified down to the species level, weighed, and measured. This information will be used in a large river Index of Biotic Integrity (IBI), described by Lyons (2001), and to list common associated species. An IBI is created by using fish species characteristics and abundance at a given site, which will in turn be used as an indicator of community health for that stretch of river. An IBI will give resource managers additional information by locating least and most impacted river sections and guide future protection and/or restoration activities. Continued monitoring can also provide trend information, which is useful in assessing management efforts. A total of 36 surveys were completed on 32 different stations (Figure 1 and Table 2). Four of those surveys were repeated to verify the IBI. Raw data are available upon request and are summarized in Appendix A.

The non-standardized methods were used to enhance and test the capture rate of rare fish, which will increase our knowledge of their distribution. Methods included in this sampling effort were trawling, nocturnal snorkeling (St. Croix only), and electrofishing preferred fish habitats. The Missouri trawl, which was recently developed by Fisheries Biologists at the Missouri Department of Conservation (DOC) (Herzog et al 2004), is designed to sample small benthic fishes that are ineffectively sampled with other methods. In addition to the trawling, a backpack electrofisher and a boat-mounted electrofisher were used to sample unique habitats, such as the confluences of tributaries. The nonstandardized work was scheduled for the late summer, early fall of 2005. During that time period, excessive rainfall resulted in near flood conditions in the Minnesota River, which hindered much of the planned nonstandardized surveys. As a result, only a fraction of the targeted sites were completed (Figure 1).

To effectively use the remaining 2005 resources for sampling targeted species, survey efforts were redirected to expand on some of the 2004 SWG funded surveys in the St. Croix River (Proulx 2005). Two fish were targeted for these brief surveys, the pugnose minnow (*Opsopoeodus emiliae*) and crystal darter (*Crystallaria asprella*). The crystal darters were best sampled at night on shallow gravel bars and the pugnose minnows were found in backwater habitats. Both habitats were not extensively sampled in 2004.

Table 1. List of the targeted threatened, special concern, and rare fish species for the Minnesota River Basin.

Species	Threatened	Special Concern	Rare/ Uncommon	Delisted	Historical	**Sampled (2005)
<i>Polyodon spathula</i> (Paddlefish)	X					
<i>Acipenser fulvescens</i> (lake sturgeon)		X				
Cypleptus elongatus (blue sucker)		X				S/NS
<i>Etheostoma microperca</i> (least darter)		X				
Ictiobus niger (black buffalo)		X				S
<i>Notropis anogenus</i> (pugnose shiner)		X				
<i>Ammocrypta clara</i> (western sand darter)			X			
<i>Anguilla rostrata</i> (American eel)			X			
<i>Campostoma oligolepis</i> (largescale stoneroller)			X			
<i>Etheostoma caeruleum</i> (rainbow darter)			X			
Etheostoma zonale (banded darter)			X			S
<i>Fundulus diaphanus</i> (banded killifish)			X			
<i>Ichthyomyzon unicuspis</i> (silver lamprey)			X			
Lepisosteus osseus (longnose gar)			X			S
<i>Lota lota</i> (burbot)			X			
Macrohybopsis hyostoma (shoal chub)			X			NS
*Macrohybopsis aestivalis (speckled chub)			X			
Macrhybopsis storeriana (silver chub)			X			S/NS
<i>Margariscus margarita</i> (pearl dace)			X			
<i>Minytrema melanops</i> (spotted sucker)			X			
<i>Moxostoma valenciennesi</i> (greater redhorse)			X			
<i>Notropis blennioides</i> (river shiner)			X			
Notropis heterodon (blackchin shiner)			X			S
<i>Notropis heterolepis</i> (blacknose shiner)			X			
<i>Notropis percobromus</i> (carmine shiner)			X			
*Notropis rubellus (rosyface shiner)			X			
<i>Notropis texanus</i> (weed shiner)			X			
Notropis volucellus (mimic shiner)			X			S/NS
Percina caprodes (logperch)			X			S
Percina shumardi (river darter)			X			NS
<i>Percopsis omiscomaycus</i> (trout-perch)			X			
<i>Phoxinus eos</i> (northern redbelly dace)			X			
Pimephales vigilax (bullhead minnow)			X			S
<i>Lampetra appendix</i> (American brook lamprey)				X		
Scaphirhynchus platyrhynchus (shovelnose sturgeon)				X		S
<i>Alosa chrysochloris</i> (skipjack herring)					X	
<i>Moxostoma carinatum</i> (river redhorse)					X	
<i>Hybopsis amnis</i> (pallid shiner)					X	
*Notropis amnis (pallid shiner)					X	

* Scientific and common name change (Nelson et al., 2004)

** S = standardized electrofishing surveys and NS = nonstandardized surveys

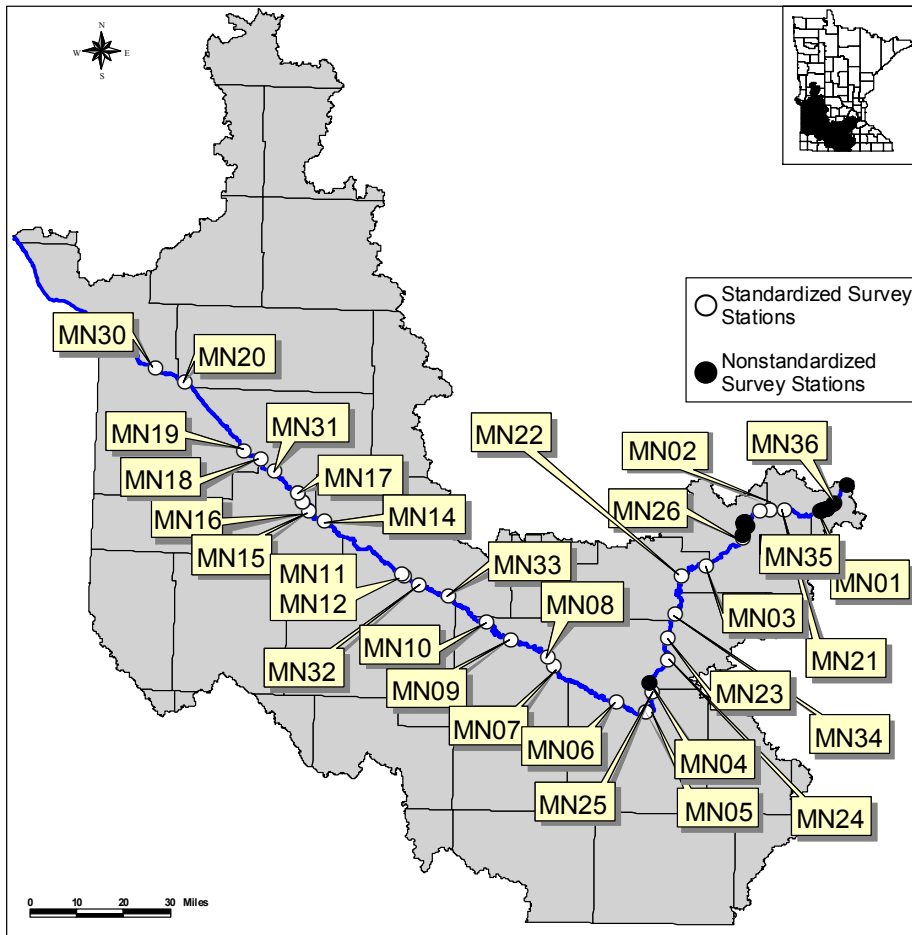


Figure 1. Standardized (site numbers included) and nonstandardized survey station locations within the Minnesota River in 2005.

Table 2. Standardized survey locations with GPS coordinates that indicate the start of a station.

Station ID	UTM X	UTM Y	Nearest City & River Mile	Station ID	UTM X	UTM Y	Nearest City & River Mile
MN01	476916	4960790	Bloomington- 10	MN18	284652	4978938	Montevideo – 275
MN02	459680	4961403	Shakopee – 25	MN19	278468	4982094	Montevideo – 277.5
MN03	437546	4942100	Belle Plaine – 55	MN20	258149	5006019	Appleton – 300
MN04	418054	4901165	St. Peter – 105	MN21	464794	4961410	Shakopee – 21
MN05	417099	4890675	Mankato – 112	MN22	429154	4938228	Henderson – 64
MN06	406670	4894087	Judson – 125.5	MN23	424465	4916754	St. Peter – 88
MN07	385209	4907089	New Ulm – 150	MN24	424592	4909114	St. Peter – 97
MN08	383229	4909958	New Ulm – 157.5	MN25	418879	4897792	North Mankato – 109
MN09	370467	4915828	Essig – 166	MN26	450446	4951553	Jordan – 39
MN10	362237	4922235	Fort Ridgely – 182	MN30	248176	5011091	Odessa – 311
MN11	333938	4938112	N. Redwood Falls – 218	MN31	289156	4974861	Wegdahl – 263.5
MN12	333179	4938890	N. Redwood Falls – 217	MN32	339106	4935338	Redwood Falls – 206
MN14	306393	4957355	Upper Sioux Agency – 240.5	MN33	349104	4931428	Franklin – 193
MN15	300772	4960720	Minnesota Falls – 245	MN34	426915	4924877	Le Sueur – 80
MN16	298750	4964295	Granite Falls – 251	MN35	456270	4960744	Chaska – 27.5
MN17	297089	4967377	Granite Falls - 254	MN36	482024	4963939	Eagan – 7.5

Results

Standardized Fish Survey Results

Thirty-two stations with four repeat surveys were completed on the Minnesota River in 2005 capturing a total of 22,550 fish, representing 60 species and 38 families. The standardized fish surveys captured ten targeted fish species, which at least one occurred at 19 out of 32 stations and totaled 202 individuals (Table 3). Two special concern species occurred at four stations and totaled eight individuals (Table 3 and Figure 2). The two special concern species sampled, the black buffalo (*Ictiobus niger*) and blue sucker (*Cycleptus elongatus*), were both sampled in the bottom third of the Minnesota River and the black buffalo outnumbered the blue sucker four to one (Figures 2, 3). Out of all the targeted fish, the mimic shiner (*Notropis volucellus*) was sampled the most, totaling 165 individuals at 15 stations and the silver chub (*Macrhybopsis storeriana*) was the second with 17 fish at eight locations (Table 3 and Figure 4).

Table 3. The number of fish, their batch weight, number of stations and sites, percent of the catch, frequency of the catch, and catch per unit effort (fish per hour – relative abundance) for each targeted fish sampled in the Minnesota River standardized survey.

Species	Stations	# of Times Sampled	Total Catch	Total Weight (g)	Length Range (mm)	% composition	% frequency	Median CPUE (fish/hour)
<i>Cycleptus elongatus</i> (blue sucker)	1	1	1	1,800	585	0.004%	3%	0.96
<i>Ictiobus niger</i> (black buffalo)	3	4	7	30,555	558-756	0.031%	11%	1.70
<i>Etheostoma zonale</i> (banded darter)	1	1	1	1	49	0.004%	3%	1.04
<i>Lepisosteus osseus</i> (longnose gar)	1	1	1	22	250	0.004%	3%	1.07
<i>Macrhybopsis storeriana</i> (silver chub)	8	8	17	295	100-146	0.075%	22%	2.17
<i>Notropis heterodon</i> (blackchin shiner)	1	1	1	1	40	0.004%	3%	1.30
<i>Notropis volucellus</i> (mimic shiner)	15	18	165	104	32-66	0.732%	50%	11.97
<i>Percina caprodes</i> (logperch)	3	3	3	6	36-83	0.013%	8%	0.91
<i>Pimephales vigilax</i> (bullhead minnow)	1	1	2	2	32-53	0.009%	3%	3.19
<i>Scaphirhynchus platyrhynchus</i> (shovelnose sturgeon)	4	4	5	5,979	528-860	0.022%	11%	1.27
Total	19	21	202	38,765				
Total number to fish captured for all species = 22,550								
Total stations = 32, Total surveys = 36								

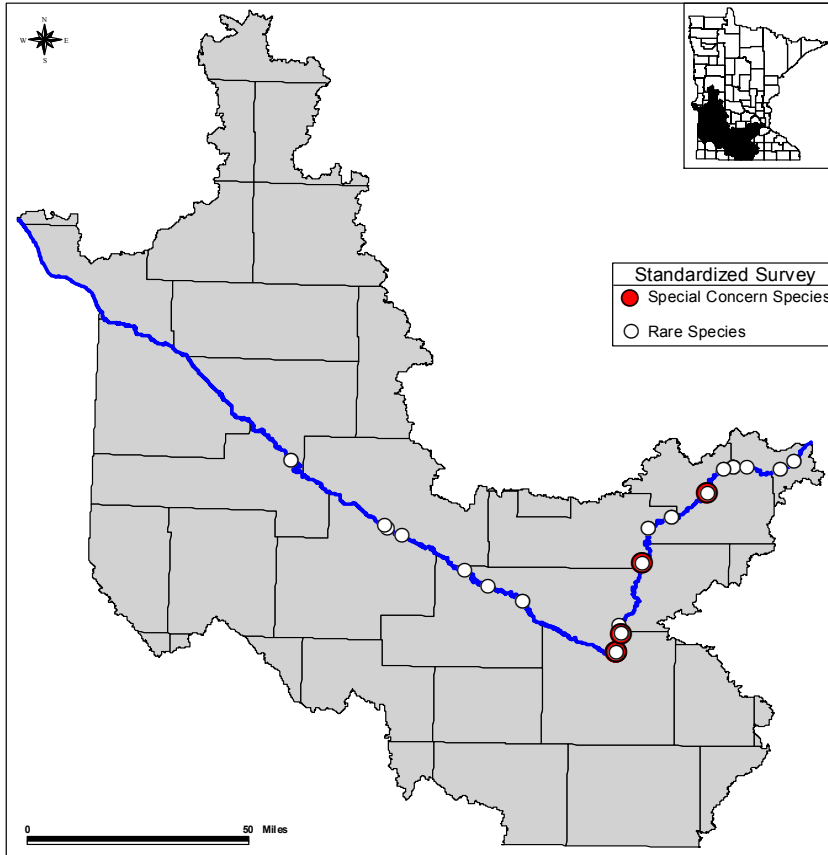


Figure 2. Locations of special concern and rare species captured during standardized sampling in 2005.



Figure 3. Black buffalo (*Ictiobus niger*) (left) and blue sucker (*Cycoreus elongates*) (bottom).



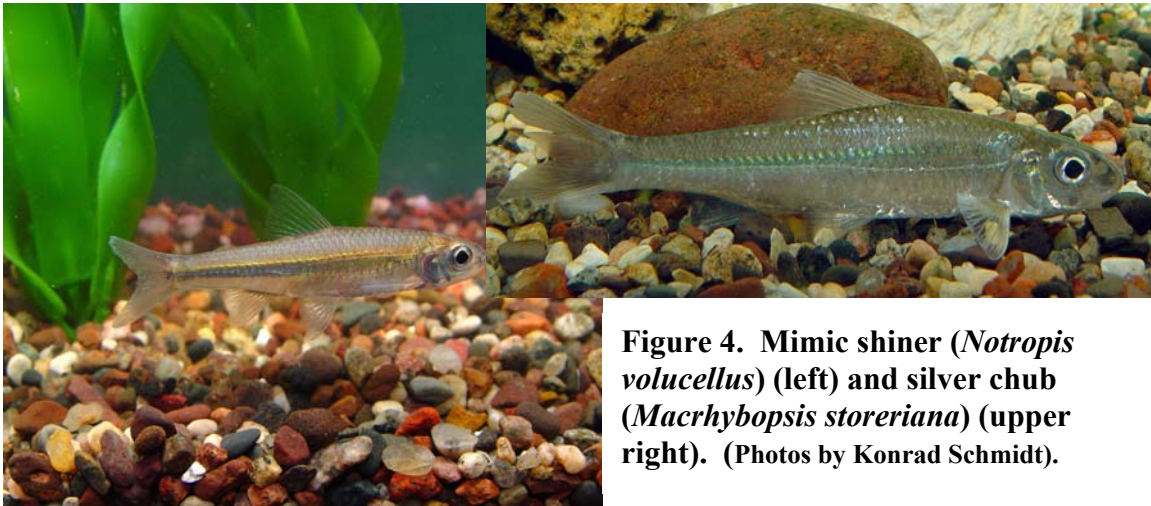


Figure 4. Mimic shiner (*Notropis volucellus*) (left) and silver chub (*Macrhybopsis storeriana*) (upper right). (Photos by Konrad Schmidt).

Associated Species

One of the values of collecting whole fish community information is the ability to list species that are typically found with rare fish. These species lists can assist with evaluating potential rare fish habitat based on other fish community survey information and provide opportunities to explore poorly known inter-relationships with common species that may exist. Table 4 summarizes the top ten associated species found with five targeted species. The remaining five targeted species were excluded because they were all sampled only once. Given the relatively low number of occurrences for most targeted species (Table 3), the associated species information for these community surveys are not as useful in detecting inter-relationships as anticipated.

Table 4. The frequency of the top ten associated species found at the same station as five targeted species (additional non-target species were included if frequencies matched the lowest percentage).

Associated Species	black buffalo % associated n = 4	silver chub % associated n = 8	mimic shiner % associated n = 18	loggerch % associated n = 3	shovelnose sturgeon % associated n = 4
Bluegill	100				
Bluntnose minnow	100				
Channel catfish		88	78	100	100
Common carp	100	100	100	100	100
Emerald shiner	100	100	100	100	100
Flathead catfish	100	100	83	100	100
Freshwater drum	100	100	94	100	100
Gizzard shad		100	88	100	100
Green sunfish				100	
Mimic shiner	100	88		100	
Orangespotted sunfish				100	
River carpsucker	100				100
Sand shiner		88	78	100	
Sauger	100	88			
Shorthead redhorse					100
Shortnose gar				100	100
Smallmouth buffalo	100	100	78	100	100
Spotfin shiner	100	100	100	100	100
White bass		100	78	100	

Non-standardized Fish Survey Results

As noted earlier, the non-standardized fish surveys for the Minnesota River were cut short due to high flow conditions in mid-September through October of 2005. As a result only 14 stations were completed and most were located in the lower 39 miles of the river (Figure 5). Two methods were attempted, bottom trawling and electrofishing unique habitats. Of the 14 stations, 10 contained targeted fish (Table 5). Two species, shoal chub (*Macrohybopsis storeriana*) and river darter (*Percina shumardi*), were not sampled during the standardized surveys, but were captured using the trawl (Figure 6). Although the nonstandardized surveys were limited, the return on the effort was high. These surveys took approximately one week to complete and captured 1,444 individual targeted species (Table 5). The standardized surveys were completed in five weeks and captured only 202 targeted species (Table 3).

Table 5. The targeted fish species surveyed using non-standardized methods.

Species	Total Catch	Stations	Method	Conservation Category
Blue sucker (<i>Cycleptus elongates</i>)	4	1	Electrofishing	Special concern
Bullhead minnow (<i>Pimephales vigilax</i>)	1	1	Trawl	Rare
Logperch (<i>Percina caprodes</i>)	2	2	Trawl/electrofishing	Rare
Mimic shiner (<i>Notropis volucellus</i>)	774	7	Trawl/electrofishing	Rare
River darter (<i>Percina shumardi</i>)	2	1	Trawl	Rare
Shovelnose sturgeon (<i>Scaphirhynchus platyrhynchus</i>)	4	3	Trawl/electrofishing	Historically Rare
Silver chub (<i>Macrohybopsis storeriana</i>)	5	3	Trawl/electrofishing	Rare
Shoal chub (<i>Macrohybopsis hyostoma</i>)	652	9	Trawl	Rare
Total Targeted Species	1444	10		

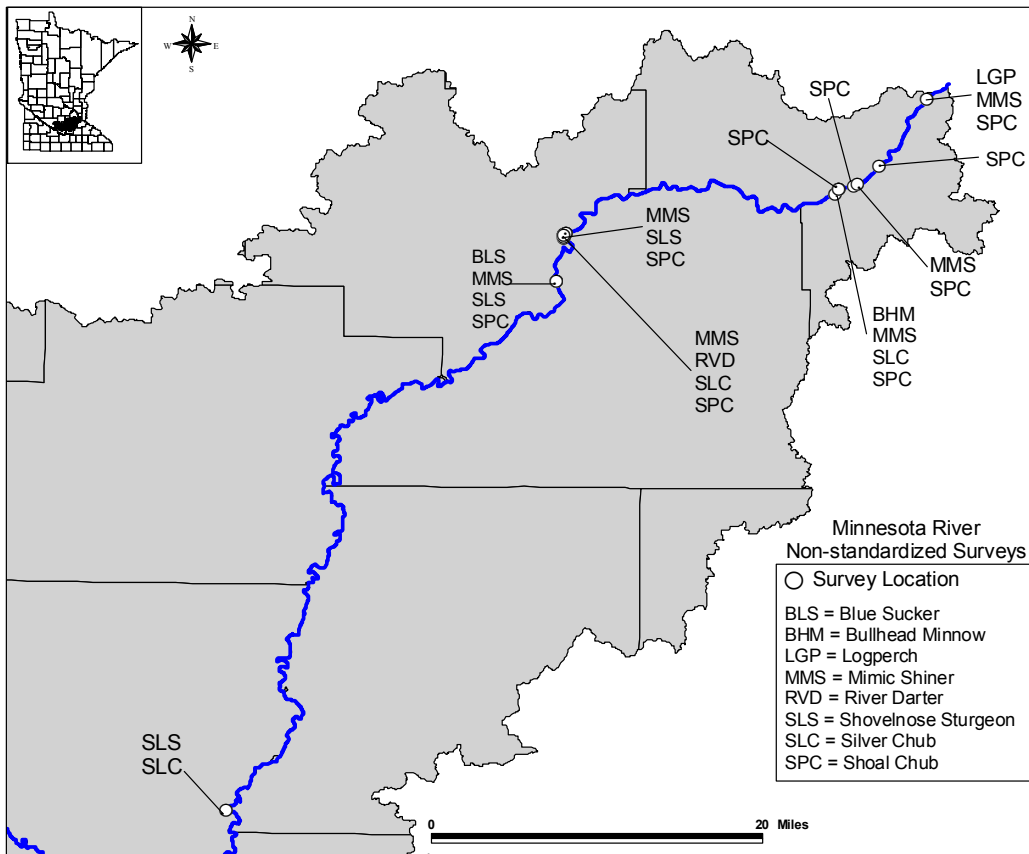


Figure 5. Nonstandardized sampling sites and locations of targeted fish.



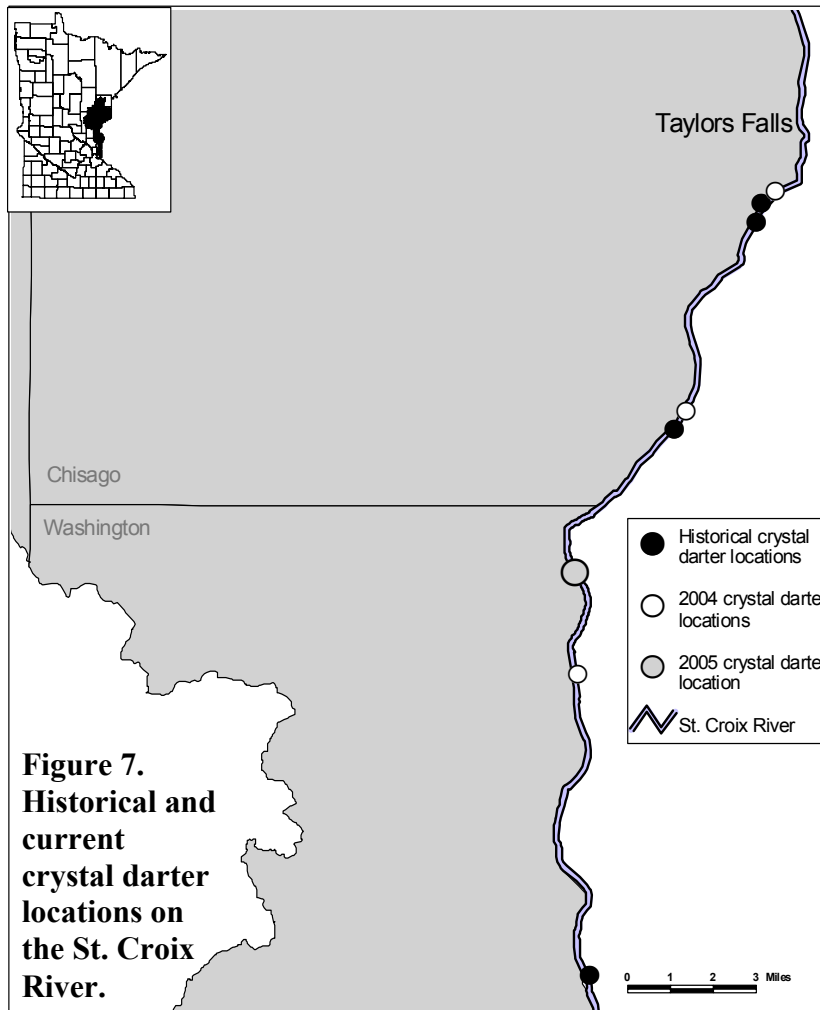
Figure 6. Shoal chub (left) (*Macrhybopsis hyostoma*) and river darter (bottom right) (*Etheostoma shumardi*). (Photos by Konrad Schmidt)



St. Croix River Survey Results

Several backwater areas were electrofished to target pugnose minnows. In one backwater site across from Marine on the St. Croix, 40 pugnose minnows were sampled. Up until that survey, only two

occurrences in the last 20 years of this species were noted in the St. Croix River.



In 2004, crystal darters were observed swimming onto a shallow gravel bar during the night in the St. Croix River at Interstate Park. Reconnaissance surveys were conducted on the river to note habitats that were similar to the Interstate Park location. Several areas were identified in the lower St. Croix and one was surveyed at night on August 30th, 2005. One crystal darter was found at this new location (Figure 7). Additional nocturnal surveys were planned, but abandoned when water levels increased due to several rain events.

Status of selected targeted fish species

Standardized Surveys

During the years of 1980 through 1982 the Major River Surveys (MRS) Program within MnDNR Ecological Services conducted whole fish community assessments using similar techniques on the Minnesota River. The MRS completed 60 surveys at 53 stations and captured 54 different species, representing 36 families. Six targeted fish species were sampled during these surveys, while 10 species were sampled in 2005 (Table 6). Only two species overlapped between the two sampling efforts, silver chub (*Macrohybopsis storeriana*) and shovelnose sturgeon (*Scaphirhynchus platyrhynchus*). In the earlier survey effort, no listed fish species were sampled, but two American eels (*Anguilla rostrata*) were captured, which are currently under review for Federal listing. In 1980-82, MRS conducted 24 more surveys than in 2005, but captured less than half the total number of fish (Table 6). However the total targeted fish sampled is similar if you exclude the mimic shiner.

Table 6. Comparison of the standardized 2005 SWG surveys with Ecological Services, MRS Program's surveys of the early 1980's of the Minnesota River. The number of fish, their batch weight, number of stations and sites, percent of the catch, frequency of the catch, and catch per unit effort (fish per hour - relative abundance) for each targeted fish sampled in the Minnesota River.

Species	Number		Stations		# of times Sampled		% Composition		% Frequency		Median CPUE (fish/hour)	
	MRS	SWG	MRS	SWG	MRS	SWG	MRS	SWG	MRS	SWG	MRS	SWG
MRS = 80-82 survey SWG = 2005 survey												
blue sucker	-	1	-	1	-	1	-	.004%	-	3%	-	1.0%
black buffalo	-	7	-	3	-	4	-	.03%	-	11%	-	1.7%
American eel	2	-	2	-	2	-	.02%	-	3.3%	-	2.0%	-
banded darter	-	1	-	1	-	1	-	.004%	-	3%	-	1.0%
longnose gar	-	1	-	1	-	1	-	.004%	-	3%	-	1.1%
burbot	1	-	1	-	1	-	.01%	-	1.7%	-	1.4%	-
shoal chub	2	-	2	-	2	-	.02%	-	3.3%	-	1.4%	-
silver chub	3	17	3	8	3	8	.03%	.08%	5.0%	22%	1.5%	2.2%
greater redhorse	4	-	2	-	2	-	.02%	-	3.3%	-	4.0%	-
blackchin shiner	-	1	-	1	-	1	-	.004%	-	1%	-	1.3%
mimic shiner	-	165	-	15	-	18	-	.73%	-	50%	-	12.0%
Logperch	-	3	-	3	-	3	-	.01%	-	8%	-	0.9%
bullhead minnow	-	2	-	1	-	1	-	.01%	-	3%	-	3.2%
shovelnose sturgeon	21	5	10	4	11	4	.11%	.02%	18.3%	11%	3.8%	1.3%
Total	33	202	18	19	19	21	-	-	-	-	-	-
MRS 1980-1982 number of fish captured = 9,908, Stations = 53, Total surveys = 60												
SWG 2005 - number of fish captured = 22,550, Stations = 32, Total surveys = 36												

Non-standardized Surveys

The results from the non-standardized surveys for 2005 were not as impressive as the 2004 because of the reduced effort, but nonetheless a few highlights have emerged. As in 2004, the trawling technique proved to be successful at sampling benthic fishes that may not be easily sampled with standardized electrofishing gear. One example of this is the shoal chub, which has been sampled in the Minnesota River periodically and in low numbers. According to the database assembled for the book "Fishes of Minnesota", the shoal chub started showing up in surveys of the Minnesota in the early sixties and since that point, it has been collected at 26 locations and number 136 individuals. In 2005, the

trawl captured 652 shoal chubs at all nine trawling locations. Also of interest are the two river darters sampled using the trawl, which extended the species' range approximately 30 miles upstream (Figure 8).

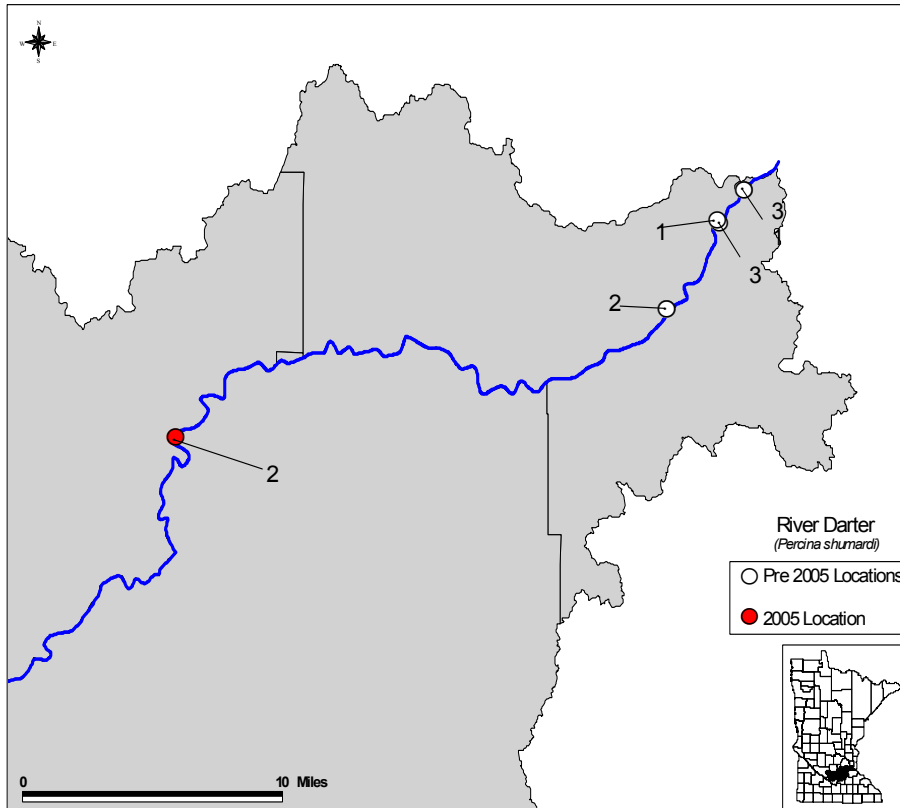


Figure 8. River darter (*Percina shumardi*) locations and numbers collected on the mainstem Minnesota River.

Recent Changes in Distribution of Selected Target Fish Species

In the last 25 years, several surveys of varying degree in the Minnesota River were completed. In 1980-1982, MRS Program completed a comprehensive look at the mainstem Minnesota (Table 6) and in 1990-1992 returned to survey a handful of mainstem stations. Although no survey effort, in terms of number of sites, has ever matched the MRS Programs 1980-1982 assessment, other agencies have also surveyed the river in the last 25 years. MnDNR Fisheries (1998 and 2004) and MnPCA Environmental Outcomes (2001, and 2003) have surveyed approximately 20 stations for each year indicated. Other agencies, such as USGS and USFWS, have also completed fish surveys recently, but were of limited scope.

Given the recent survey activity on the Minnesota River, rare fish distribution trends can be assessed within the past 25 years with relative certainty. Specifically, within the last decade, the distribution of intolerant or indicator fish species within the Minnesota River has expanded. The 2005 surveys reinforce some of the trends that are slowly emerging within the basin. For example, the mimic shiner, which was absent from the Minnesota River for close to 50 years, has returned within the last seven years. In 2005, close to 1000 mimic shiners were sampled at 21 sites (Figure 9).

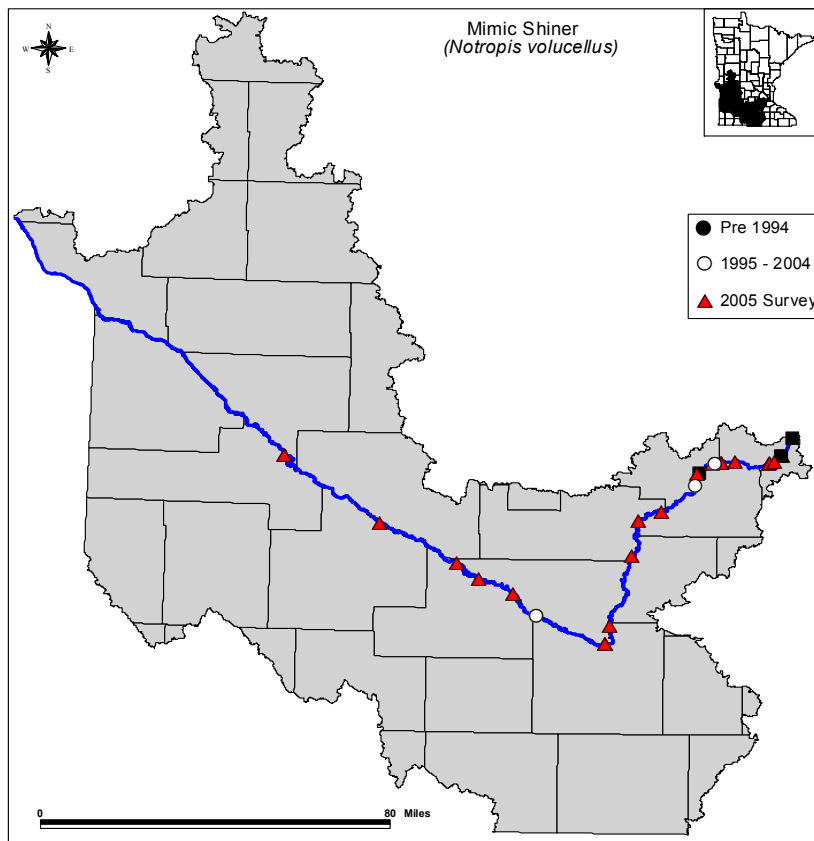


Figure 9. Recent changes in distribution of the mimic shiner.

Two other examples of intolerant species range expansions into the Minnesota River are the blue sucker and black buffalo, both of which have not been documented in the Minnesota until recently (Figure 10). The first record of the blue sucker in the Minnesota River was 1989 and the black buffalo was sampled in 1997. The black buffalo was likely present before 1997, based on a 1990 record in the Cottonwood River by an angler.

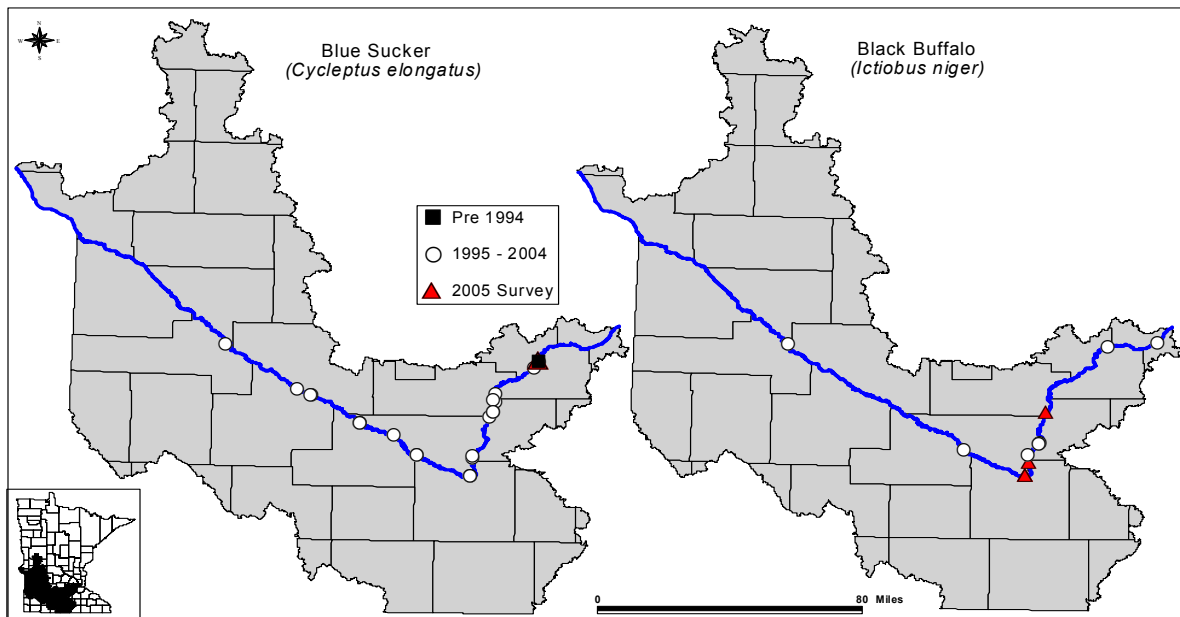


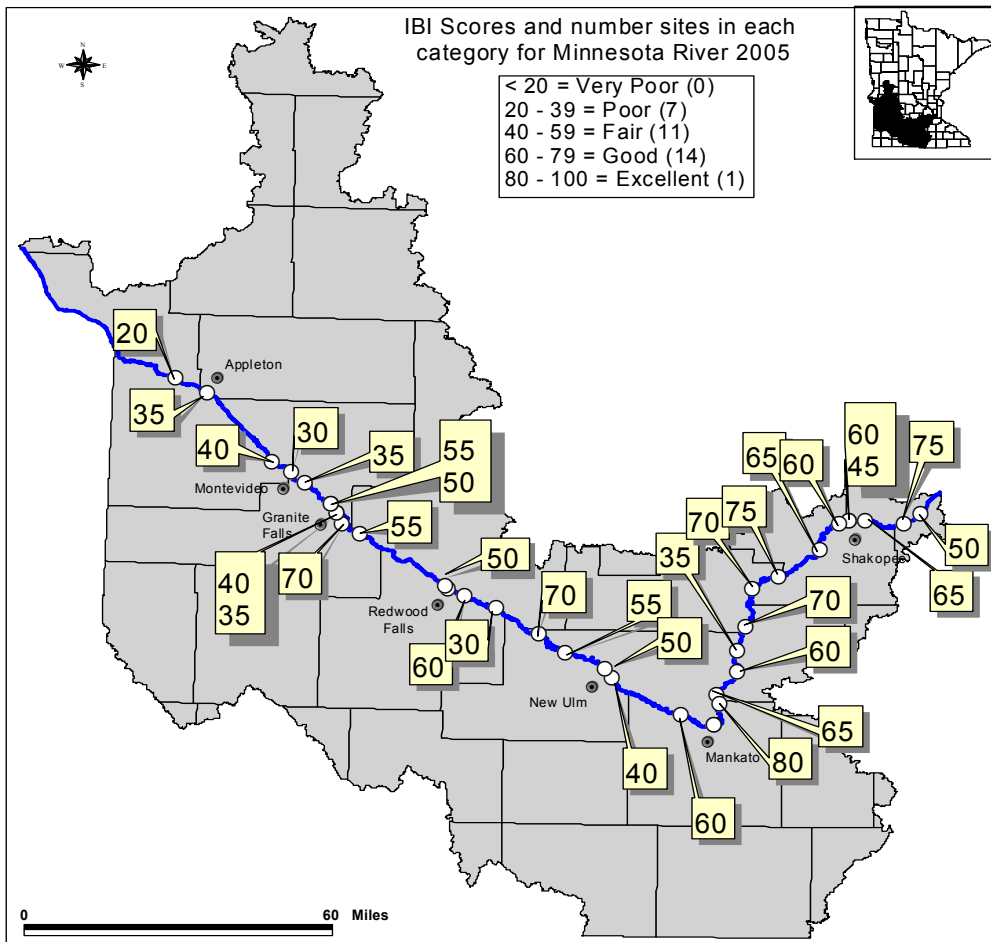
Figure 10. The blue sucker and black buffalo expansion into the Minnesota River.

Although not a targeted fish for this survey, the smallmouth bass is classified as an intolerant fish and has the potential to be an important recreational fishing opportunity on the Minnesota River. Like the other intolerant species in the Minnesota River, the smallmouth bass was rarely sampled within the mainstem Minnesota for close to 30 years (1950 – 1976). Historical accounts indicate healthy populations within the basin, specifically in the Upper Cottonwood River, as late as 1948 (Kuehn 1948). Beginning in the early eighties, the smallmouth bass was again present in the Minnesota River. In 2005, 11 smallmouth bass were captured at six locations.

Index of Biotic Integrity Scores

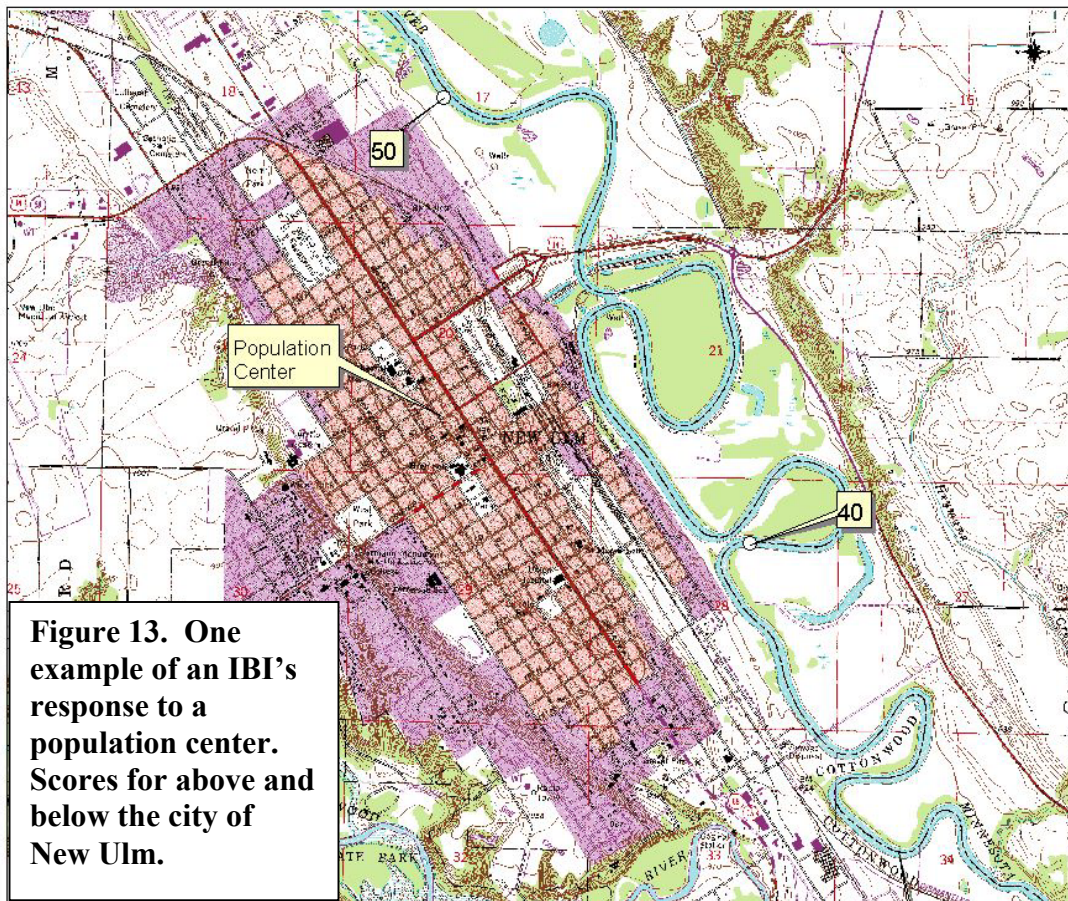
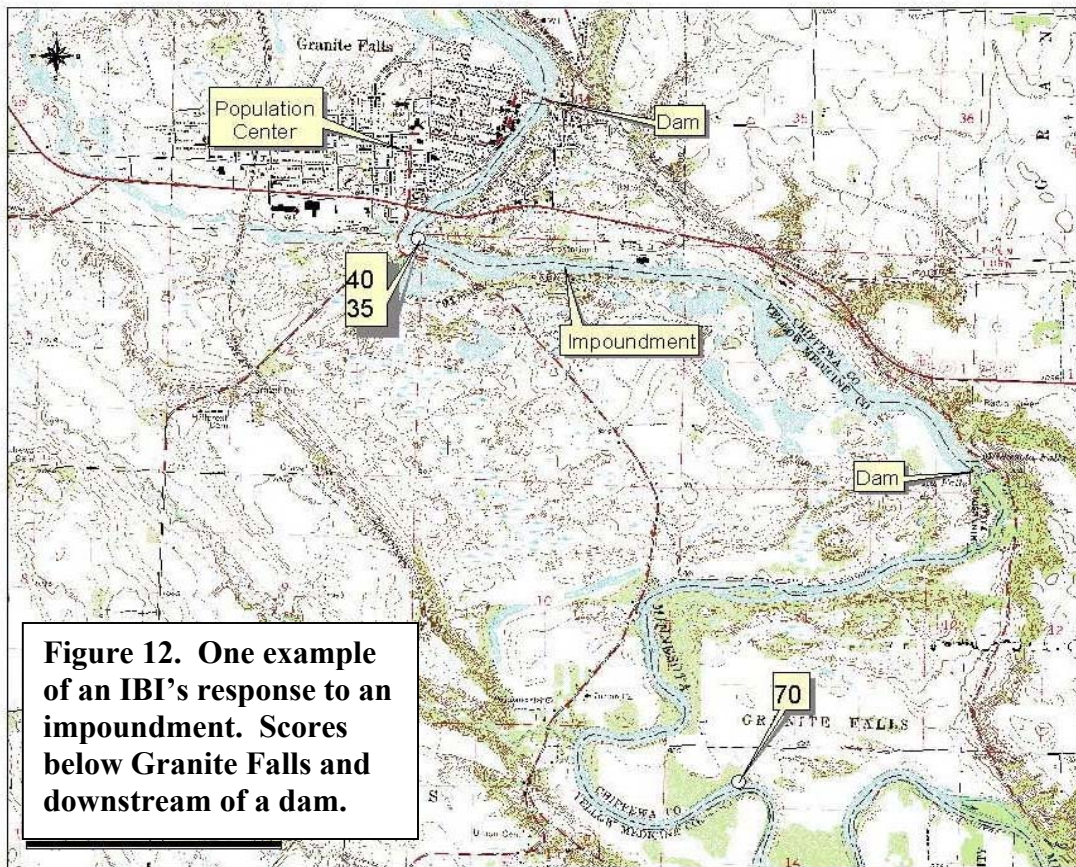
For this report, the metrics used to calculate an IBI are described in Lyons (2001). The metrics have not been validated for the Minnesota River, but for the purpose of this report and its time constraints, they were used. As a result, the scores may fluctuate in the future when the validation process is complete, but this exercise should allow for cursory comparisons of river sections within this sampling period using the standardized survey results.

An IBI can score between 0 – 100, with the following qualitative rankings: ≥ 80 = excellent, 60 – 79 = good, 40 – 59 = fair, 20 – 39 = poor, and < 20 = very poor. In the Minnesota River the calculated IBI ranged from a low of 20 to a high of 80 and averaged 55 (Figure 11, Appendix B). The Minnesota River has many stressors that will impact an IBI score; such as impoundments (Figure 12), population centers (Figure 13), point and non-point source pollution, particularly sediment loads during periods of high surface



runoff and the resulting lack of aquatic vegetation.

Figure 11. IBI scores for the Minnesota River standardized survey sites in 2005.



Discussion

In recent years, the Minnesota River fish community has been changing. The improvements in water quality for pool 2 in the Mississippi River may be responsible for allowing species, such as blue sucker and black buffalo to colonize their historical range within the Minnesota River. The Minnesota itself has seen overall improvements in water quality over the last thirty-five years, due mainly to improvements in point and nonpoint source controls (Metropolitan Council, 2004). The 2005 surveys show these subtle changes in the fish community, mainly the increase of target or indicator species such as the ones above.

Overall 12 out of 36 targeted fish species were sampled using all gear types during this survey period. When comparing the standardized fish surveys done in the early eighties by the MRS Program to the 2005 effort, the total number of fish captured has increased and the distribution of rare fish has expanded. The non-standardized surveys, especially the Missouri trawl, demonstrated its utility as a method for sampling small benthic fishes and have increased our knowledge of the distribution of these fishes.

The IBI scores indicate a separation between the lower (Mankato to the Mississippi River) and the upper Minnesota River. The scores are much higher in the lower portion with only one site scoring in the poor range. In the upper Minnesota, eight out of 17 sites scored in the poor range, which could be due to a number of factors, both directly related to habitat or a result of an IBI not fully validated statistically. However this information is consistent with locations of the majority of the targeted fish species, such as the black buffalo, silver chub, and mimic shiner.

As reported by the Metropolitan Council (2004), water quality has improved, but the improvements have taken place primary in the late seventies to early nineties and in recent years, some of the water quality metrics have trended in the negative direction. If we are to see these targeted fish remain and expand within the Minnesota River, continuing to monitor point sources and increase conservation efforts that address nonpoint source pollution need to be maintained and extended. To assess these protection efforts, long term monitoring utilizing an IBI, should be completed at regular intervals.

Acknowledgements

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References Cited

- Herzog, D.P., V.A. Barko, J.S. Scheibe, R.A. Hrabik, and D.E. Ostendorf 2005. Efficacy of a benthic trawl for sampling small-bodied fishes in large river systems. *North American Journal of Fisheries Management* 25:594-603.
- Kirsch, N.A., S.A. Hanson, P.A. Renard, and J.W. Enblom. 1985. Biological Survey of the Minnesota River. Minnesota Department of Natural Resources, Special Publication, #139. pp107.
- Kuehn, J.H., 1948. A Reconnaissance of the Cottonwood River to Determine Present Status of Smallmouth Bass. Minnesota Department of Conservation, Division of Game and Fish, Fisheries Research Unit. pp5.
- Lyons, J. 1992. Using the index of biotic integrity (IBI) to measure environmental Quality in warmwater streams of Wisconsin. Gen. Tech. Rep. NC-149. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. p 51.
- Lyons, J., R.R. Piette, and K.W. Niermeyer 2001. Development, Validation, and Application of a Fish-Based Index of Biotic Integrity for Wisconsin's Large Warmwater Rivers. *Transactions of the American Fisheries Society* 130:1077-1094.
- Metropolitan Council, June 2004. Regional Report. Regional Progress in Water Quality, Analysis of Water Quality Data form 1976 to 2002 for the Major Rivers in the Twin Cities. St. Paul, MN pp.75.
- Nelson, J. S., E. J. Crossman, H. Espinosa-Perez, L. T. Findley, C. R. Gilbert, R. N. Lea, and J. D. Williams. 2004. Common and scientific names of fishes from the United States, Canada, and Mexico. American Fisheries Society, Special Publication 29, Bethesda, Maryland.
- Proulx, N.A., 2005. Status and critical habitat of threatened, special concern, and rare fish species in nonwadeable portions of the St. Croix River Basin. Final Report for State Wildlife Grant Program. Pp. 20.

Appendix A

Table of all species sampled, their total catch, number of times sampled, total weight, percent composition of catch, and percent frequency sampled. Top five species in abundance and frequency highlighted.

common name	total catch	# of times sampled	total biomass (g)	% composition	% frequency
banded darter	1	1	1	0.00%	3%
bigmouth buffalo	92	14	82485	0.41%	39%
bigmouth shiner	2	2	2	0.01%	6%
black buffalo	7	4	30555	0.03%	11%
black bullhead	63	4	180	0.28%	11%
black crappie	11	10	928	0.05%	28%
blackchin shiner	1	1	1	0.00%	3%
blackside darter	11	4	39	0.05%	11%
blue sucker	1	1	1800	0.00%	3%
bluegill	50	19	1777	0.22%	53%
bluntnose minnow	173	26	325	0.77%	72%
bowfin	3	2	5584	0.01%	6%
brassy minnow	32	12	47	0.14%	33%
bullhead minnow	2	1	2	0.01%	3%
central mudminnow	1	1	4	0.00%	3%
central stoneroller	1	1	1	0.00%	3%
channel catfish	134	29	60514	0.59%	81%
common carp	1101	36	1874986	4.88%	100%
common shiner	53	8	230	0.24%	22%
emerald shiner	14138	33	20265	62.70%	92%
fantail darter	1	1	1	0.00%	3%
fathead minnow	84	22	95	0.37%	61%
flathead catfish	75	23	94047	0.33%	64%
freshwater drum	598	35	60339	2.65%	97%
gizzard shad	2784	27	20031	12.35%	75%
golden redhorse	25	11	5565	0.11%	31%
golden shiner	5	4	15	0.02%	11%
goldeye	1	1	735	0.00%	3%
green sunfish	102	23	897	0.45%	64%
highfin carpsucker	11	7	3260	0.05%	19%
hornyhead chub	1	1	4	0.00%	3%
iowa darter	1	1	2	0.00%	3%
johnny darter	6	5	5	0.03%	14%
largemouth bass	25	10	890	0.11%	28%
logperch	3	3	6	0.01%	8%
longnose gar	1	1	22	0.00%	3%
mimic shiner	165	18	104	0.73%	50%
northern hog sucker	2	2	169	0.01%	6%
northern pike	24	6	5176	0.11%	17%
orangespotted sunfish	48	18	152	0.21%	50%
quillback	8	4	3285	0.04%	11%

river carpsucker	145	24	150614	0.64%	67%
sand shiner	429	22	612	1.90%	61%
sauger	35	18	15198	0.16%	50%
shorthead redhorse	117	28	29360	0.52%	78%
shortnose gar	99	20	74371	0.44%	56%
shovelnose sturgeon	5	4	5979	0.02%	11%
silver chub	17	8	295	0.08%	22%
silver redhorse	14	11	5832	0.06%	31%
slenderhead darter	76	11	162	0.34%	31%
smallmouth bass	11	6	2770	0.05%	17%
smallmouth buffalo	49	21	60952	0.22%	58%
spotfin shiner	1371	36	2247	6.08%	100%
spottail shiner	11	3	14	0.05%	8%
walleye	15	8	5280	0.07%	22%
white bass	270	28	33929	1.20%	78%
white crappie	4	3	194	0.02%	8%
white sucker	19	7	2346	0.08%	19%
yellow bullhead	2	2	422	0.01%	6%
yellow perch	13	3	391	0.06%	8%

Appendix B

Table of Index of Biotic Integrity scores for each station and survey.

River Station	Field Survey Number	IBI Score	River Station	Field Survey Number	IBI Score
Minnesota 36	LR05-005	50	Minnesota 09	LR05-022	55
Minnesota 01	LR05-004	75	Minnesota 10	LR05-021	70
Minnesota 21	LR05-006	65	Minnesota 33	LR05-034	30
Minnesota 02	LR05-002	45	Minnesota 32	LR05-035	60
Minnesota 02	LR05-015 (repeat with different crew and boat)	60	Minnesota 11	LR05-028 (pulled – crossed tributary)	80
Minnesota 35	LR05-003	60	Minnesota 12	LR05-033	50
Minnesota 26	LR05-014	65	Minnesota 14	LR05-020	55
Minnesota 03	LR05-013	75	Minnesota 15	LR05-018	70
Minnesota 22	LR05-012	70	Minnesota 16	LR05-016	40
Minnesota 34	LR05-011	70	Minnesota 16	LR05-031 (repeat)	35
Minnesota 23	LR05-010	35	Minnesota 17	LR05-017	55
Minnesota 24	LR05-009	60	Minnesota 17	LR05-032 (repeat)	50
Minnesota 04	LR05-007	65	Minnesota 31	LR05-019	35
Minnesota 25	LR05-008	80	Minnesota 18	LR05-024	30
Minnesota 05	LR05-001 (pulled – water too high)	60	Minnesota 19	LR05-025	40
Minnesota 05	LR05-036 (pulled – crossed tributary)	90	Minnesota 20	LR05-026	35
Minnesota 06	LR05-029	60	Minnesota 30	LR05-027	20
Minnesota 07	LR05-030	40			
Minnesota 08	LR05-023	50			