Pallid and Shovelnose Sturgeon in the Lower Missouri and Middle Mississippi Rivers

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Abstract

The cooperative MICRA pallid sturgeon project covered sections of 1000 river miles in the Lower Missouri and Middle Mississippi Rivers and included sampling efforts by the Nebraska Game & Parks Commission, Iowa Department of Natural Resources, U. S. Fish & Wildlife Service - Columbia Fishery Resources Office, Southern Illinois University, and Missouri Department of Conservation's Long Term Resource Monitoring Program station. Field sampling began in November 1997 and was completed in April 2000. In total, 5400 fish of 39 species were collected in 1033 nets and lines. Sturgeon catch data provided by Missouri Department of Conservation – Central Regional Office were added to the sturgeon data analysis where appropriate.

Seven presumed wild origin pallid sturgeon and 2 recaptured hatchery pallid sturgeon were collected in the Lower Missouri River. Seven hatchery origin pallid sturgeon were collected in the Middle Mississippi River. The ratio of wild pallid sturgeon to all river sturgeon collected dropped from 1 in 398 (0.25%) collected by Carlson et al (1985) to 1 in 633 (0.16%). The contribution of hatchery raised fish can be seen when examining the total number of pallid sturgeon collected. Wild and hatchery raised pallid sturgeon accounted for 1 in 277 (0.36%) of all river sturgeons.

All but one of the pallid sturgeon were collected in deep holes associated with wing dikes. The remaining fish was collected in a side channel border habitat.

Six pallid-shovelnose sturgeon hybrids were collected in the Middle Mississippi River while 15 were collected in the Lower Missouri River. The rate of hybridization increased from 1 in 365 (0.27%) river sturgeons in the late 1970s to 1 in 211 (0.47%) in the 1990s (Carlson et al 1985).

The shovelnose sturgeon data (4391 fish) were also examined to determine if the long-feared increases in exploitation caused by the decline of Russian sturgeon stocks was impacting the shovelnose population. There was no apparent decline in mean shovelnose lengths, percent of fish greater than 50 cm (minimum male reproductive size) or percent of fish greater than 60 cm (minimum female reproductive size) from late 1970s values (Carlson et al 1981). In addition, the average length (590-mm) of shovelnose sturgeon collected in the Middle Mississippi River was similar to that reported by Barnickol and Starrett in 1951 (589-mm).

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Introduction

The pallid sturgeon, *Scaphirhynchus albus,* was first recognized as a species by Forbes and Richardson (1905). The historical distribution of the pallid sturgeon extended from Great Falls, Montana along the Missouri and Mississippi Rivers to New Orleans and in the Kansas River upstream to Lawrence, Kansas (Kallemeyn 1983, Bailey and Cross 1954). A population has also recently been reported from the Atchafalaya River in Louisiana downriver from its connection with the Mississippi River (Keenlyne and Evenson 1993). Early commercial landings of sturgeon did not differentiate between sturgeon species. The pallid sturgeon was never very common; it represented 1 in 500 sturgeon at the mouth of the Illinois River and 1 in 5 river sturgeon in the Lower Missouri River in 1905 (Forbes and Richardson).

The pallid sturgeon was listed as an endangered species because of habitat alteration and the threat of hybridization with shovelnose sturgeon *S. platorynchus* (Federal Register 55 [September 6, 1990]: 36641-36647). Pallid sturgeon were still fairly common in many parts of the Missouri and Mississippi River systems as of 1967 but have declined with development of the river systems for flood control and navigation (Keenlyne 1989). Seventy-six percent of pallid sturgeon reported to Kallemeyn (1983) were collected from the Missouri River in Montana and the Dakotas; most were collected in the five mainstem reservoirs. The next most frequent collection sites were reported from the Missouri and Mississippi Rivers in or adjoining Missouri (Kallemeyn 1983). Pallid sturgeon were 1 in every 398 river sturgeons collected in the Lower Missouri and Middle Mississippi Rivers in the late 1970s (Carlson et al 1985). A recent survey of sturgeon biologists indicates that pallid sturgeon may have been eliminated from 47.6% of the lakes and streams they were reported to have lived in (Hesse and Carreiro 1997).

The pallid sturgeon's preferred habitat is the main channel of large, turbid rivers (Kallemeyn 1983). This bottom dwelling species usually occurs in faster water than shovelnose sturgeon (Forbes and Richardson 1905). Carlson et al (1985) captured pallid sturgeon in the late 1970s in the main channel of the Missouri River along sandbars at the inside of river bends and behind wing dikes with deeply scoured trenches. Long Term Resource Monitoring program staff collected three pallid sturgeon in stationary gill nets in the Middle Mississippi River in 1994 (Dave Herzog, pers. comm.)

Pallid sturgeon avoid areas without turbidity and current (Erickson 1992). Pallid sturgeon in the Upper Missouri River are reported to occupy a wide range of bottom velocities from 0 to 1.37 m/s (Bramblett 1996, Clancey 1990, Erickson 1992). Sheehan (1998) found pallid sturgeon in the Middle Mississippi River did not shift habitat selection or avoidance under different velocity regimes. Sandy substrates were preferred by pallid sturgeon in the Upper Missouri River (Bramblett 1996) and Atchafalaya Rivers (Constant et al 1997). However, spawning is believed to occur over gravel or cobble substrates. The range of water depths used by pallid sturgeon varies across studies and is probably related to the habitat available within the area (Steve Krentz, pers. comm.).

Hybridization of pallid and shovelnose sturgeons was first reported in Carlson et al (1985). Sturgeon hybrids were just as prevalent as pallid sturgeon in their samples. Hybrids identified in the field were intermediate in several morphometric and meristic characters as well as in growth rate. Previous failure to report hybrid sturgeon catch seem to indicate it is a recent phenomenon, resulting from changes to the Missouri and Mississippi Rivers.

The Missouri Department of Conservation's Blind Pony Hatchery stocked 7,200 juvenile pallid

sturgeon (16-20 inch) and 20,000 lake sturgeon (9-11 inch) fingerlings in the Lower Missouri and Middle Mississippi Rivers in 1994. An additional 3000 pallid sturgeon fingerlings were stocked in 1997. Since the 1994 stocking, 86 pallid sturgeon returns have been reported, mostly in the Mississippi River downstream of St. Louis (Graham 1999). The larger number of reports from the Mississippi River is likely due to the higher number of commercial fishermen.

The objective of this project was to document relative abundance, distribution, and habitat association characteristics of pallid sturgeon and associated fish species in the Lower Missouri and Middle Mississippi Rivers. No concerted effort to sample pallid sturgeon had been conducted in the Lower Missouri River since the late 1970s (Carlson et al 1985).

Methods

Field sampling was conducted in the Lower Missouri River below Gavins Point Dam and in the middle Mississippi River from the Missouri River confluence to the Arkansas border. Sampling was also conducted in the Missouri River adjacent to the Niobrara River confluence, upstream of Gavins Point Dam. Five agencies sampled for pallid sturgeon including: Iowa Department of Natural Resources (IA), Nebraska Game and Parks Commission (NE), Missouri Department of Conservation - LTRM Open River Station (LTRM), Southern Illinois University (SIU) and U.S. Fish and Wildlife Service - Columbia Fishery Resources Office (FWS). Each agency sampled three to five sites. Sampling sites were assigned on the basis of historic pallid sturgeon collections or recaptures of juvenile pallid sturgeon stocked by the Missouri Department of Conservation. Actual sampling sites were chosen by field biologists based on familiarity and experience with the local area (Figure 1). Each agency completed two sampling periods. Original project protocol called for one fall (October-December) and one spring (February-April) sample when water temperatures ranged from 35-65^{o} F and water stages were near normal flow. Sturgeon sampling conducted by the Missouri Department of Conservation – Central Regional Office (MDC) began after the design of this project. Data from their work was incorporated where appropriate.

Sampling gears included large and small hoop nets, set lines, and drifting and stationary gill nets. Efforts were made to standardize gear among the agencies according to the following specifications:

<u>Large Hoop Nets</u>
- 16 ft. long (4.8 m)
- 7 fiberglass hoops
- first hoop 4 ft. diameter (1.2 m)
- all remaining six hoops decrease 1 in. diameter (2.5 cm) successively to rear
- #15 nylon netting, 1 1/2 in. bar mesh (3.7 cm)
- 2 finger style throats attached to second and fourth hoops
- 8 ft. long 3 in. braided nylon drawstring at rear

<u>Small Hoop Nets</u>
- 10 ft. long (3 m)
- 7 fiberglass hoops
- first hoop 2 ft. diameter (0.6 m)
- all remaining six hoops decrease 1 in. diameter successively to rear

- #12 nylon netting, 3/4 in. bar mesh (1.8 cm)
- 2 finger style throats attached to second and fourth hoops
- 8 ft. long 1/4 in. braided nylon drawstring at rear

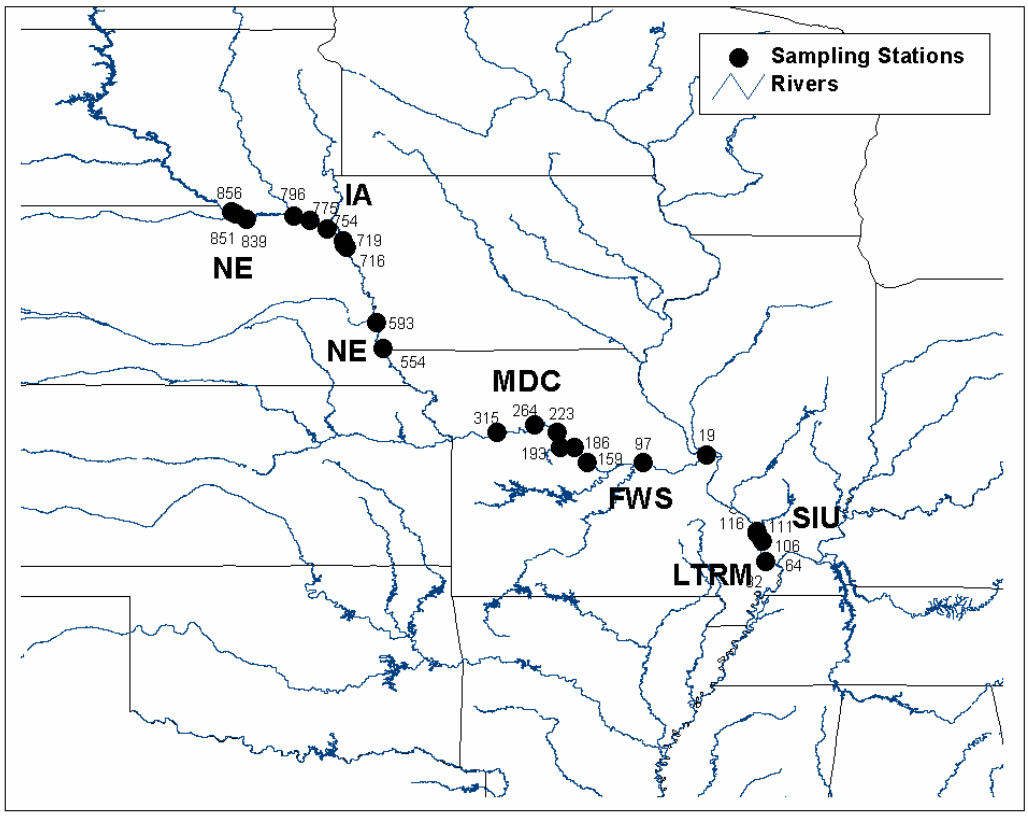

Figure 1. Sampling station locations in the Lower Missouri and Middle Mississippi Rivers.

Set Lines

- Preferred hooks size 2 Eagle Claw O'Shaughnessy stainless steel
- Staging of size 60 green braided nylon twine
- 3/0 Champion swivels threaded on staging and anchored at 3 foot intervals with trot line brads Minimum of 6 hooks per line (on Missouri River, may use more in Mississippi)
- Droppers of size 15 green braided nylon twine, 15 to 18 inches long with hook on one end and the other end tied to 3/0 staging line swivel

Gill Nets

- Multifilament experimental gill nets
- Nets 100 feet (33.3 yds) long and 6 feet deep
- Alternating 25' panels of 1" and 2" square mesh (No. 139 twine)
- Polycore float line and No. 50 leadcore line (for driftnetting/current holding)

However, sampling gears were adapted to local conditions and supplies where appropriate. NE used small hoop nets of the same dimensions as the large hoop nets with a 1-in mesh. SIU used drifted trammel nets 150-ft long with a 1.5-in inner mesh and a 10-in outer mesh in

their spring 2000 sample. MDC used 150-ft long stationery gill nets with 2-in or 3-in panels and 200-ft long experimental gill nets with incrementing panels of 1 to 3-in or 1 to 4 inches. The sampling effort expended and gears utilized by each crew are listed in Table 1.

All fish were measured to the nearest mm and most were weighed to the nearest gram in anticipation of assessing pallid sturgeon species assemblage information. (MDC's dataset only includes lengths for sturgeon species.) Morphometric measurements and meristic counts were made on all pallid sturgeon, suspected pallid-shovelnose sturgeon hybrids, and a subsample of shovelnose sturgeon to verify species identification. Measurements included: head length, snout to outer barbel length, mouth to inner barbel length, inner barbel length, outer barbel length, anal fin ray count and dorsal fin ray count (Sheehan et al 1999). Pallid sturgeon were tagged with Passive Integrated Transponder (PIT) tags along the base of the dorsal fin in accordance with Recovery Team guidelines. Barbel samples were removed from the left outer barbel of pallid sturgeon, suspected pallid-shovelnose hybrids, and a subsample of shovelnose sturgeon and sent to Southern Illinois University for future genetic analysis.

Habitat data were collected at each net set where gear and conditions allowed. Biologists recorded the river stage at the nearest upstream gage, habitat type, substrate, depth, turbidity, water temperature, conductivity, and water velocity. Net locations were recorded with GPS units or marked on paper maps.

Statistical analyses were conducted using the Statistical Analysis System (SAS 1990). The Shapiro-Wilk test was used to determine if fish numbers represented random samples from normal distributions (SAS Institute Inc. 1991, Zar 1984). The Kolmogorov-Smirnov test was used to examine potential differences in sturgeon length distributions between rivers. The Mann-Whitney Rank Sum Test was used to test for differences in median relative weights between rivers and median fish lengths between two sampling sites. A Kruskal-Wallis non-parametric analysis of variance (ANOVA) test was used to determine if there were significant differences in catch rates of sturgeon species with respect to mean depth and bottom velocity and to determine if their were significant differences in median sturgeon lengths between three or more sites.

The chi-square statistic was used on binary presence/absence data to determine if pallid sturgeon, pallid sturgeon hybrids, and shovelnose sturgeon were independent of, or not associated with, other large river fish species. The Jaccard index was calculated to determine the degree of species association between sturgeon species and other large river fish species found to be associated with the chi-square statistic. The Jaccard Index, with a scale of 0 to 1, is the proportion of the number of sampling units where both species occur to the total number of sampling units where at least one of the species is found (Ludwig and Reynolds 1988):

$$JI = a/(a+b+c)$$

where a = the number of sampling units where both species occur
b = the number of sampling units where species A occurs, but not species B
c = the number of sampling units where species B occurs, but not species A.

The Spearman correlation coefficient was used to determine the covariation in abundance between pallid sturgeon, hybrid sturgeon, and shovelnose sturgeon and other large river fish species found to be associated with the chi-square statistic (Ludwig and Reynolds 1988).

Table 1. Sampling dates, locations (MOR = Missouri River, MSR = Mississippi River) and gears (SHN = small hoop net, LHN = large hoop net, SL-# = set line with number of hooks, SGN = stationary gill net, DGN = drifting gill net, DTN = drifting trammel net) used by each crew.

Crew	Date	River	River Mile	Site name	Gear
NE	05/25-26/99, 06/01-02/99	MOR	845	Verdel	SGN
NE	05/10-13/99	MOR	851	Verdel	SHN, LHN, SGN
NE	09/27-30/99	MOR	845	Verdel	SHN, LHN, SL
NE	10/04-07/99	MOR	845	Verdel	SGN
NE	05/26-27/99, 06/02-03/99	MOR	841	Niobrara	SGN
NE	05/17-20/99	MOR	839	Niobrara	SHN, LHN, SGN
NE	06/02-04/98	MOR	796	St. Helena	SHN, LHN, SL-30, SGN
NE	09/21-24/98	MOR	796	St. Helena	SHN, LHN, SGN
NE	06/08-11/98	MOR	775	Mulberry	SHN, LHN, SGN
NE	09/14-17/98	MOR	775	Mulberry	SHN, LHN, SL-10, SGN
NE	06/08-11/98	MOR	754	Ponca	SHN, LHN, SGN
NE	09/14-17/98	MOR	754	Ponca	SHN, LHN, SGN
IA	05/14-15,18-19/98	MOR	725.0	Upper Dakota Bend	SHN, LHN, SL, DGN
IA	09/16-18/98	MOR	725.0	Upper Dakota Bend	SHN, LHN, SL
IA	05/14-15,18-19/98	MOR	719.0-719.5	Omaha Bend	SHN, LHN, SL, DGN
IA	09/16-18/98	MOR	719.0	Omaha Bend	SHN, SL, DGN
IA	05/14-15,18-19/98	MOR	716.0	Snyder Bend	SHN, LHN, SL, DGN
IA	09/16-18/98	MOR	716.0	Snyder Bend	SHN, LHN, SL
NE	05/26-28/98	MOR	593	Plattsmouth	SHN, LHN, SL-15, SGN
NE	09/08-11/98	MOR	593	Plattsmouth	SHN, LHN, SL-15, SGN
NE	05/18-21/98	MOR	554	NE City	SHN, LHN, SL-10, SGN
NE	09/08-11/98	MOR	554	NE City	SHN, LHN, SL-10, SGN
MDC	03/20-22/00	MOR	315-322	None	SGN
MDC	03/06-07/00	MOR	264-272	None	SGN
MDC	02/07-09/00	MOR	223-226	None	SGN
MDC	12/07-08/99	MOR	193-197	None	SGN
MDC	03/30-04/01/99	MOR	186-191	None	SGN
MDC	11/08-10/99	MOR	186-191	None	SGN
MDC	01/10-13/00	MOR	186-190	None	SGN
FWS	02/24-27/99	MOR	186-186.7	Rocheport	SL-20, SGN
FWS	11/01-04/99	MOR	186.4-186.9	Rocheport	SGN
FWS	07/26-29/99	MOR	185.8-186.7	Rocheport	SHN, LHN, SL-20, SGN
FWS	02/24-27/99	MOR	157.5-159.2	Hartsburg	SL-20, SGN
FWS	07/26-29/99	MOR	154.4-159.2	Hartsburg	SHN, LHN, SL-20, SGN
FWS	11/01-04/99	MOR	157.9-159.8	Hartsburg	SGN
FWS	03/01-04/99	MOR	95.4-97.8	Hermann	SHN, LHN, SL-20, SGN
FWS	08/03-06/99	MOR	91.6-97.5	Hermann	SL-20, SGN
FWS	01/11-14/00	MOR	95.6-98.2	Hermann	SGN
FWS	03/22-25/99	MOR	19.2-26.4	St. Charles	SL-20, SGN
FWS	08/09-12/99	MOR	19.1-26.4	St. Charles	SGN
FWS	12/27-30/99	MOR	19.2-26.4	St. Charles	SGN
SIU	11/18-21/97	MSR	105.8-106.7	Site 1	SHN, LHN, SL, DGN
SIU	11/18-21/97	MSR	110.3-111.2	Site 2	SHN, LHN, SL, DGN
SIU	11/18-21/97	MSR	115.6-116.5	Site 3	SHN, LHN, SL, DGN
SIU	04/16-19/00	MSR	106.4-117.3	None	LHN, DTN
LTRM	12/15-18/97	MSR	48.9-64.0	Station2	SGN
LTRM	02/02-05/98	MSR	48.0-64.0	Station2	SGN
LTRM	02/10-12/98	MSR	31.6-43.9	Station3	SGN

Crew	Date	River	River Mile	Site name	Gear
LTRM	03/27-28/96	MSR	32.0E-42.1E		SGN
LTRM	04/04-04/96	MSR	68.5E-77.8W		SGN
LTRM	04/10-12/96	MSR	55.9E-63.4W		SGN
LTRM	04/16-18/96	MSR	31.2E-41.8E		SGN
LTRM	04/23-24/96	MSR	72.9E		SGN
LTRM	12/03-05/96	MSR	53		SGN,SL,DGN
LTRM	11/15-17/99	MSR	75.1L-77.8L		SGN
LTRM	11/01-03/99	MSR	52.5L-64.0R		SGN
LTRM	11/08-09/99	MSR	32.1L-44.5R		SGN
LTRM	11/29-12/01/99	MSR	1.0R-6.6L		SGN
LTRM	12/06-07/99	MSR	934.1L		SGN
LTRM	01/19-20/00	MSR	53.1E		SGN
LTRM	02/14-15/00	MSR	53.0E-62.8W		SGN

Bathymetric Habitat Assessment

The USGS-BRD-Columbia Environmental Research Center (CERC) conducted bathymetric surveys on five dike pairs in the lower Missouri River. Four dike pairs included one dike where pallid sturgeon were collected and one dike without pallid sturgeon. One dike pair included one dike where many shovelnose sturgeon were collected and one dike without shovelnose sturgeon. Each dike area consisted of the area downstream of a wing dike to the next wing dike or to a distance of 250-m, whichever was shorter, extending laterally to the bank, and laterally approximately 50-m into the navigation channel. The area surveyed included all parts of the area 1 m or greater in depth that could be accessed safely at the prevailing river stage.

Habitat assessment included the following:

1. Mapping bathymetry of the dike areas to produce maps of depth at nominal 0.5 contour intervals.
2. Mapping substrate using an acoustic classification system, yielding maps of hardness, roughness, and classified substrate material.
3. Collection of velocity transects using acoustic Doppler velocimetry.

Results of the USGS-CERC habitat mapping work and area maps will be printed in a separate USGS report.

Results

In total, 6554 fish of 42 species were collected by original project participants. Fifty-five percent of all fish collected were sturgeon species. This was followed by 15% catfish species and 13% catostomids. Some regional and gear differences were observed. The majority (75%) of the 62 centrarchids collected were caught above Gavins Point Dam. Catch per unit effort was highest for stationery gill nets for both the LTRM and FWS crews (Table 2). NE was most successful collecting fish with large hoop nets, while IA was most successful with small hoop nets. SIU's highest CPUE occurred with drifting trammel nets. Species catch appears to be largely connected to gear choice. Iowa fished primarily hoop nets and collected 82% catfish (Table 3). FWS and LTRM fished primarily stationery gill nets while SIU fished primarily drifting trammel nets to catch 56 to 79 percent sturgeon (Tables 4 and 5).

Table 2. Catch-per-unit-effort (CPUE) as catch per hour for total fish catch and total sturgeon catch in each net type for each sampling crew.

Nets	NE						FWS						IA					
	Nets	Hours	Fish	CPUE	Sturgeon	CPUE	Nets	Hours	Fish	CPUE	Sturgeon	CPUE	Nets	Hours	Fish	CPUE	Sturgeon	CPUE
DGN	---	---	---	---	---		---	---	---	---	---	---	10	0.63	2	3.17	0	---
SGN	193	990.0	730	0.74	167	0.17	213	4976.3	1300	6.1	967	0.19	---	---	---	---	---	---
DTN	---		---	---	---		---	---	---	---	---	---	---	---	---	---	---	---
SHN	135	2722.2	472	0.17	3	0.001	9	210.4	11	1.2	0		12	278.3	72	0.26	0	---
LHN	135	2673.4	785	0.29	9	0.003	9	210.0	42	4.7	0		10	209.8	19	0.09	2	0.01
SL	57	1142.6	5	0.04	0	---	76	1970.0	125	1.6	46	0.02	12	277.8	2	0.01	1	0.004
Total	520		1965		179		307		1478		1013		44		95		3	

Nets	LTRM						SIU					
	Nets	Hours	Fish	CPUE	Sturgeon	CPUE	Nets	Hours	Fish	CPUE	Sturgeon	CPUE
DGN	2	0.5	0	---	---	---	27	1.07	7	6.54	3	2.80
SGN	136	3283.7	2890	0.88	2309	0.70	---	---	---	---	---	---
DTN	---	---	---	---	---	---	13	0.57	55	9.649	35	61.40
SHN	---	---	---	---	---	---	9	211.5	0	0	0	---
LHN	---	---	---	---	---	---	16	304.3	25	0.08	2	0.01
SL	19	441.3	29	0.07	0	---	24	500.4	10	0.02	0	---
Total	157		2919		---	---	90		97		40	

Table 3. Total catch (TC) and relative abundance (RA) of fish species collected by each crew in the Missouri River (river miles 554-856).

Species	Nebraska (RM 841-845)		Nebraska (RM 754-796)		Iowa (RM 716-725)		Nebraska (RM 554-593)	
	TC	RA	TC	RA	TC	RA	TC	RA
Lamprey								
Lake Sturgeon								
Shovelnose Sturgeon	65	6.7%	129	23.0%	3	3.2%	50	11.8%
Pallid Sturgeon								
Pallid Hybrid								
Paddlefish								
Shortnose Gar	27	2.8%	12	2.1%			11	2.6%
Longnose Gar			21	3.7%			34	8.0%
American Eel			1	0.2%				
Gizzard Shad	1	0.1%						
Goldeye			53	9.4%			9	2.1%
Mooneye					2	2.1%		
Northern Pike	11	1.1%	1	0.2%				
Common Carp	28	2.9%	10	1.8%	3	3.2%	20	4.7%
Bighead Carp							1	0.2%
Grass Carp								
Blue Sucker	3	0.3%	102	18.1%	4	4.2%	8	1.9%
Bigmouth Buffalo	11	1.1%	3	0.5%	1	1.1%	3	0.7%
Black Buffalo								
Smallmouth Buffalo	247	25.3%	5	0.9%	2	2.1%	8	1.9%
River Carpsucker	162	16.6%	20	3.6%			7	1.7%
Quillback Carpsucker								
Highfin Carpsucker								
River Redhorse					1	1.1%		
Shorthead Redhorse	46	4.7%	35	6.2%				
Channel Catfish	154	15.8%	116	20.6%	75	78.9%	167	39.4%
Blue Catfish								
Flathead Catfish	15	1.5%	14	2.0%	3	3.2%	86	20.3%
Black Bullhead	25	2.6%						
Stonecat					1	1.1%		
Smallmouth Bass	11	1.1%	4	0.7%				
Bluegill	8	0.8%	4	0.7%				
Rock Bass	16	1.6%	2	0.4%				
White Crappie	2	0.2%					2	0.5%
Black Crappie	9	0.9%	2	0.4%			1	0.2%
Walleye	33	3.4%	3	0.5%				
Sauger	97	9.9%	7	1.2%				
Striped Bass								
White Bass	1	0.1%	2	0.4%				
Yellow Bass			3	0.5%				
Yellow Perch			2	0.4%				
Freshwater Drum	5	0.5%	11	2.0%			17	4.0%
Total Catch	952		562		95		424	

Table 4. Total catch (TC) and relative abundance (RA) of fish species collected by each crew in the Lower Missouri River (river miles 19.1-186.7).

Species	FWS - Rocheport (RM 185.8-186.9)		FWS - Hartsburg (RM 154.4-159.8)		FWS - Hermann (RM 91.6-97.8)		FWS - St. Charles (RM 19.1-26.4)	
	TC	RA	TC	RA	TC	RA	TC	RA
Lamprey	1	0.4%	1	0.4%	1	0.2%		
Lake Sturgeon	1	0.4%					1	0.3%
Shovelnose Sturgeon	138	54.5%	183	68.8%	434	75.3%	258	68.3%
Pallid Sturgeon	1	0.4%			2	0.3%	3	0.8%
Pallid Hybrid					8	1.4%	6	1.6%
Paddlefish							2	0.5%
Shortnose Gar	2	0.8%	2	0.8%	1	0.2%	3	0.8%
Longnose Gar	7	2.8%	2	0.8%	5	0.9%	4	1.1%
American Eel								
Gizzard Shad			2	0.8%				
Goldeye	3	1.2%	6	2.3%	11	1.9%	11	2.9%
Mooneye			4	1.5%			2	0.5%
Northern Pike	1	0.4%						
Common Carp	20	7.9%	6	2.3%	3	0.5%	4	1.1%
Bighead Carp	1	0.4%						
Grass Carp	2	0.8%	1	0.4%				
Blue Sucker								
Bigmouth Buffalo								
Black Buffalo								
Smallmouth Buffalo			3	1.1%	4	0.7%	2	0.5%
River Carpsucker	20	7.9%	14	5.3%	32	5.6%	9	2.4%
Quillback Carpsucker	1	0.4%			1	0.2%		
Highfin Carpsucker					1	0.2%		
River Redhorse	2	0.8%	2	0.8%	1	0.2%	1	0.3%
Shorthead Redhorse			2	0.8%	10	1.7%	2	0.5%
Channel Catfish	14	5.5%	16	6.0%	4	0.7%	14	3.7%
Blue Catfish	17	6.7%	12	4.5%	39	6.8%	35	9.3%
Flathead Catfish	1	0.4%			2	0.3%	1	0.3%
Stonecat								
Smallmouth Bass								
Bluegill								
Rock Bass								
White Crappie	1	0.4%						
Black Crappie								
Walleye								
Sauger	8	3.2%	2	0.8%	7	1.2%	13	3.4%
Striped Bass			1	0.4%				
White Bass			1	0.4%	1	0.2%		
Yellow Bass								
Yellow Perch								
Freshwater Drum	12	4.7%	6	2.3%	9		7	1.9%
Total Catch	253		266		576		378	

Table 5. Total Catch (TC) and relative abundance (RA) of fish species collected by each crew in the Middle Mississippi River (river miles 31.6-116.5).

Species	SIU (RM 105.8-116.5)		LTRM (RM 31.6-64.0)	
	TC	RA	TC	RA
Lamprey				
Lake Sturgeon			1	0.06%
Shovelnose Sturgeon	54	55.7%	1547	87.6%
Pallid Sturgeon			7	0.4%
Pallid Hybrid	1	1.0%	5	0.3%
Paddlefish			3	0.2%
Shortnose Gar			27	1.5%
Longnose Gar			24	1.4%
American Eel				
Gizzard Shad				
Goldeye	1	1.0%	1	0.06%
Mooneye				
Northern Pike				
Common Carp	6	6.2%	1	0.06%
Bighead Carp	1	1.0%		
Grass Carp				
Blue Sucker	4	4.1%		
Bigmouth Buffalo				
Black Buffalo	1	1.0%		
Smallmouth Buffalo	1	1.0%	1	0.06%
River Carpsucker	7	7.2%	1	0.06%
Quillback Carpsucker	2	2.1%		
Highfin Carpsucker				
River Redhorse				
Shorthead Redhorse				
Channel Catfish	9	9.3%		
Blue Catfish	1	1.0%	86	4.9%
Flathead Catfish	3	3.1%	2	0.1%
Black Bullhead				
Stonecat				
Smallmouth Bass				
Bluegill				
Rock Bass				
White Crappie				
Black Crappie				
Walleye				
Sauger			35	2.0%
Striped Bass				
White Bass	3	3.1%	6	0.3%
Yellow Bass				
Yellow Perch				
Freshwater Drum	3	3.1%	18	1.0%
Total Catch	97		1765	

Sturgeon Character Indices

A series of morphometric measurements and meristic counts were made on all pallid sturgeon, pallid sturgeon hybrids, and a subsample of shovelnose sturgeon. These measurements were used to calculate the Character Index (CI) and Morphometric Character Index (mCI) in order to confirm field identification of the three sturgeon species (Sheehan et al 1999). The CI uses all the morphometric measurements and both meristic counts while the mCI eliminates the anal and dorsal fin ray counts as they are sometimes difficult to obtain in live specimens. CI values for field-identified sturgeon fell largely within the ranges identified for each species (Figure 2). The mCI has a much wider range of value overlap, more fish identified as shovelnose sturgeon had values within the hybrid sturgeon range. Sheehan et al (1999) recommend using the CI whenever possible because it is a stronger predictive equation. One fish field-identified in Nebraska as a shovelnose sturgeon was classified as a pallid sturgeon hybrid by both indices (Figure 2). This indicates this specimen was either misidentified or had one or more erroneous measurements. Due to the large agreement between species field-identifications and index values all sturgeon species were presumed to be correctly identified in the following analyses.

Shovelnose sturgeon (top) and pallid sturgeon (bottom) collected in the Lower Missouri River/FWS Photo

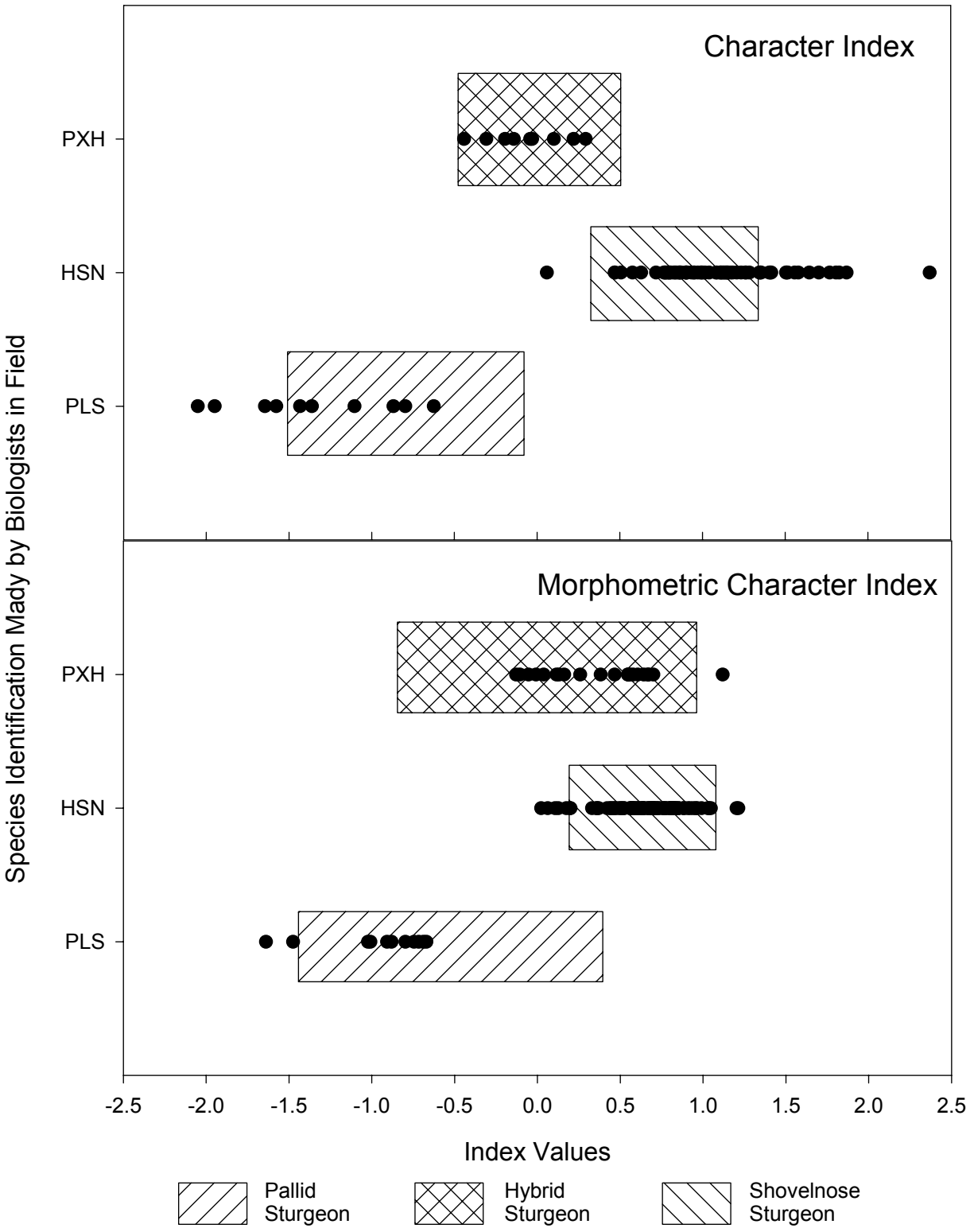

Figure 2. Character Index (CI) and Morphometric Character Index (mCI) values calculated for sturgeon collected in the Lower Missouri and Middle Mississippi Rivers. Boxes indicate the range of values derived from the original formulas (Sheehan et al 1999) based on data collected by Carlson and Pflieger (1981).

Pallid Sturgeon

Twenty-one pallid sturgeon were collected through the combined efforts of all 6 crews (Table 6). The average fork length was 660-mm while the average weight was 2541-g. The fish were in good condition with an average Wr of 99.5. Seven presumed wild origin pallid sturgeon and 2 recaptured hatchery pallid sturgeon were collected in the Lower Missouri River. Eleven hatchery reared pallid sturgeon and two presumed wild origin pallid sturgeon were collected in the Middle Mississippi River. The ratio of wild pallid sturgeon to all river sturgeon collected dropped from 1 in 398 (0.25%) collected by Carlson et al (1985) to 1 in 647 (0.15%). The contribution of hatchery raised fish can be seen when examining the total number of pallid sturgeon collected. Wild and hatchery raised pallid sturgeon accounted for 1 in 247 (0.41%) of all river sturgeons.

Table 6. Pallid sturgeon collected in the Lower Missouri (MOR) and Middle Mississippi (MSR) Rivers, 1996-2000.

Crew	River	River Mile	Depth (m)	Date	Fork Length (mm)	Weight (g)	Wr	PIT #	Source
MDC	MOR	186.5L	12.2	11/10/99	953	4990	119.2	none	wild fish
MDC	MOR	196.5R	10.4	12/08/99	983	6532	140.6	none	wild fish
MDC	MOR	186.5L	13.1	01/12/00	927	3629	95.1	unknown	wild fish
FWS	MOR	186.4L	---	02/26/99	924	3191	84.5	115668221A	wild fish
FWS	MOR	95.5	---	03/02/99	759	1565	80.2	115526524A	wild fish
FWS	MOR	19.2	---	03/24/99	862	3035	101.5	116162225A	wild fish
FWS	MOR	20.1	---	03/24/99	550	572	86.5	115709574A	wild fish
FWS	MOR	23.8	2.1	03/24/99	536	492	81.1	115717251A	MDC fish
FWS	MOR	93.7L	2.8	08/06/99	522	550	99.1	115672123A	MDC fish
LTRM	MSR	63.2L	10.2	02/03/98	584	---	---	//554645	MDC fish
LTRM	MSR	64.0R	10.9	02/03/98	554	---	---	11567469	MDC fish
LTRM	MSR	63.2L	6.9	02/05/98	580	850	107.5	11552865	MDC fish
LTRM	MSR	43.9R	6.1	02/11/98	560	---	---	11621844	MDC fish
LTRM	MSR	32.1L	9.8	02/12/98	574	---	---	11552623	MDC fish
LTRM	MSR	64.0R	8.1	12/16/97	518	---	---	none	MDC fish
LTRM	MSR	48.9L	12.4	12/17/97	549	---	---	1151175	MDC fish
LTRM	MSR	32.2E	10	03/28/96	712	---	---	none	wild fish
LTRM	MSR	75.0E	7.2	04/03/96	516	---	---	none	MDC fish
LTRM	MSR	61.2W	12.5	04/11/96	532	---	---	none	MDC fish
LTRM	MSR	32.2L	14.5	11/10/99	526	---	---	115551567A7	MDC fish
LTRM	MSR	44.5R	8	11/10/99	645	---	---	115677130A7	MDC fish

Species Associations

Pallid sturgeon were collected with shovelnose sturgeon, blue catfish, sauger, freshwater drum, paddlefish, shortnose gar, goldeye, longnose gar, river carpsucker, and smallmouth buffalo in the Middle Mississippi River. They were collected with shovelnose sturgeon, sauger, river carpsucker, freshwater drum, goldeye, blue catfish, and common carp in the Lower Missouri River. The chi-square statistic was used to test for independence of pallid sturgeon and other large river species. There were no significant associations found with the chi-square statistic between pallid sturgeon and any other species in the Lower Missouri River. Therefore,

there was no need to perform either the Jaccard index or the Spearman correlation coefficient to measure either the degree of association or the covariation of abundance between pallid sturgeon and any other fish species in the Lower Missouri River. In the Mississippi River, pallid sturgeon were associated with sauger (df=1, X^2=5.0361, a=0.05) with a low Jaccard Index value of 0.26. The Spearman correlation coefficient was not significant.

Habitat Use

Fifteen of the sixteen pallid sturgeons collected were caught in main channel border habitat with wing dikes. One pallid sturgeon was collected in a side channel border habitat. Most were collected December through April. One was caught as early as November while one was caught as late as August. No significant differences between pallid sturgeon, pallid hybrids and shovelnose sturgeon were found for water velocities or depths. This may be due to the small sample sizes of pallid sturgeon and sturgeon hybrids. Pallid sturgeon were collected in water depths of 2.14 to 13.1-m in the Lower Missouri River and water depths of 6.1 to 14.5-m in the Middle Mississippi River.

Hybrid Sturgeon

Seven pallid-shovelnose sturgeon hybrids were collected in the Middle Mississippi River while 15 were collected in the Lower Missouri River. The rate of hybridization increased from 1 in 365 (0.27%) river sturgeons in the late 1970s (Carlson et al 1985) to 1 in 235 (0.42%) in the 1990s. The average fork length was 656-mm while the average weight was 1003-g.

Species Associations

Pallid sturgeon hybrids were collected with shovelnose sturgeon, shorthead redhorse, goldeye, river carpsucker, sauger, channel catfish, blue catfish, freshwater drum, and longnose gar in the Lower Missouri River. Sturgeon hybrids were collected with shovelnose sturgeon, blue catfish, freshwater drum, blue sucker, sauger, shortnose gar, and common carp in the Middle Mississippi River. Significant associations were found with the chi-square statistic for pallid sturgeon with shorthead redhorse (df=1, X^2=15.6793, a=0.05) in the Lower Missouri River and with goldeye (df=1, X^2=7.1538, a=0.05) and longnose gar (df=1, X^2=4.1964, a=0.05) in the Middle Mississippi River. The Jaccard index was used to measure the degree of association between pallid sturgeon hybrids and each of these species. Jaccard Index values did not indicate a large degree of association for pallid sturgeon hybrids and shorthead redhorse (0.16) in the Lower Missouri River or for sturgeon hybrids and goldeye (0.13) or longnose gar (0.0) in the Middle Mississippi River. No significant correlations in species abundance were found for hybrid sturgeon and any other species with the Spearman correlation coefficient.

Habitat Use

Hybrid sturgeon were collected in water depths of 4.3 to 16.5-m (average 9.5-m) in the Middle Mississippi River and 0.7 to 13.7-m (average 4.8-m) in the Lower Missouri River. Most of the hybrid sturgeon were collected in main channel border areas associated with wing dikes. One was collected in a side channel border area and one was collected on the channel side of a channel bar. They were collected in water velocities ranging from 0.01 m/s to 0.42 m/s (average 0.14 m/s).

Shovelnose Sturgeon

The combined efforts of the six crews resulted in 2792 shovelnose sturgeon in the Lower Missouri River and 2344 in the Middle Mississippi River. Fork length and body weight measurements were examined for differences where available (Table 7). When examined with the Mann Whitney Rank Sum Test, shovelnose sturgeon were significantly larger in the Middle Mississippi River (N=2335, median=602 mm) than in the Lower Missouri River (N=2649, median=584 mm) (T=6577442.0, P<0.001). Median relative weights (Wr) of shovelnose sturgeon were also significantly larger in the Middle Mississippi River (N=384, median=104.4) than in the Lower Missouri River (N=1137, median=87.4) (T=417542.0, P<0.001). Significant differences in the distribution of shovelnose sturgeon lengths were also found with the Kruskal-Wallis Analysis of Variance on ranks between Nebraska sites in the Lower Missouri River (H=74.2206, df =2, P<0.0001). Shovelnose sturgeon were significantly larger in the upper unchannelized river reach above Gavins Point Dam (RM 839-845) while the smallest Nebraska shovelnose were collected in the lower unchannelized river reach below Gavins Point Dam (RM 754-796) (Figure 3). Fish collected in the lower channelized reach (RM 554-593) were intermediate in length distribution. There were also significant differences found between sites sampled by MDC (N=1532. median=587 mm) and FWS (N=1013, median=577 mm), with MDC sites generally having larger shovelnose sturgeon (T=1193322.50, P<0.001) (Figure 4). However, MDC fished nets with a maximum of 4-inch mesh panels while FWS fished a maximum of 2-inch mesh panels, so it is unclear if differences were a result of sampling locations or gears. Significant differences were also found between MDC sites and between FWS sites. However, there was no clear trend in sturgeon lengths either increasing or decreasing with river mile. There was a significant difference in shovelnose sturgeon lengths between LTRM and SIU samples on the Middle Mississippi River (Figure 5). However, this difference may be largely due to the difference in sample sizes (Table 7).

Table 7. Mean Fork Length and fork length range of shovelnose sturgeon collected in the Lower Missouri and Middle Mississippi Rivers, 1996-2000.

Crew and Site	N	Mean Fork Length	Fork Length Range
NE			
RM 839-851	66	626	538-718
RM 754-796	77	551	349-676
RM 554-593	45	582	460-705
MDC			
RM 186-191	653	586	290-752
RM 193-197	113	601	439-747
RM 223-226	376	582	366-729
RM 264-272	165	563	361-714
RM 315-322	220	585	333-719
FWS			
RM 185.8-186.9	120	551	258-670
RM 154.4-159.8	183	558	281-734
RM 91.6-98.2	434	574	247-790
RM 19.1-26.4	257	558	265-762
IA	1	519	519
SIU	54	557	343-676
LTRM	2990	597	305-793

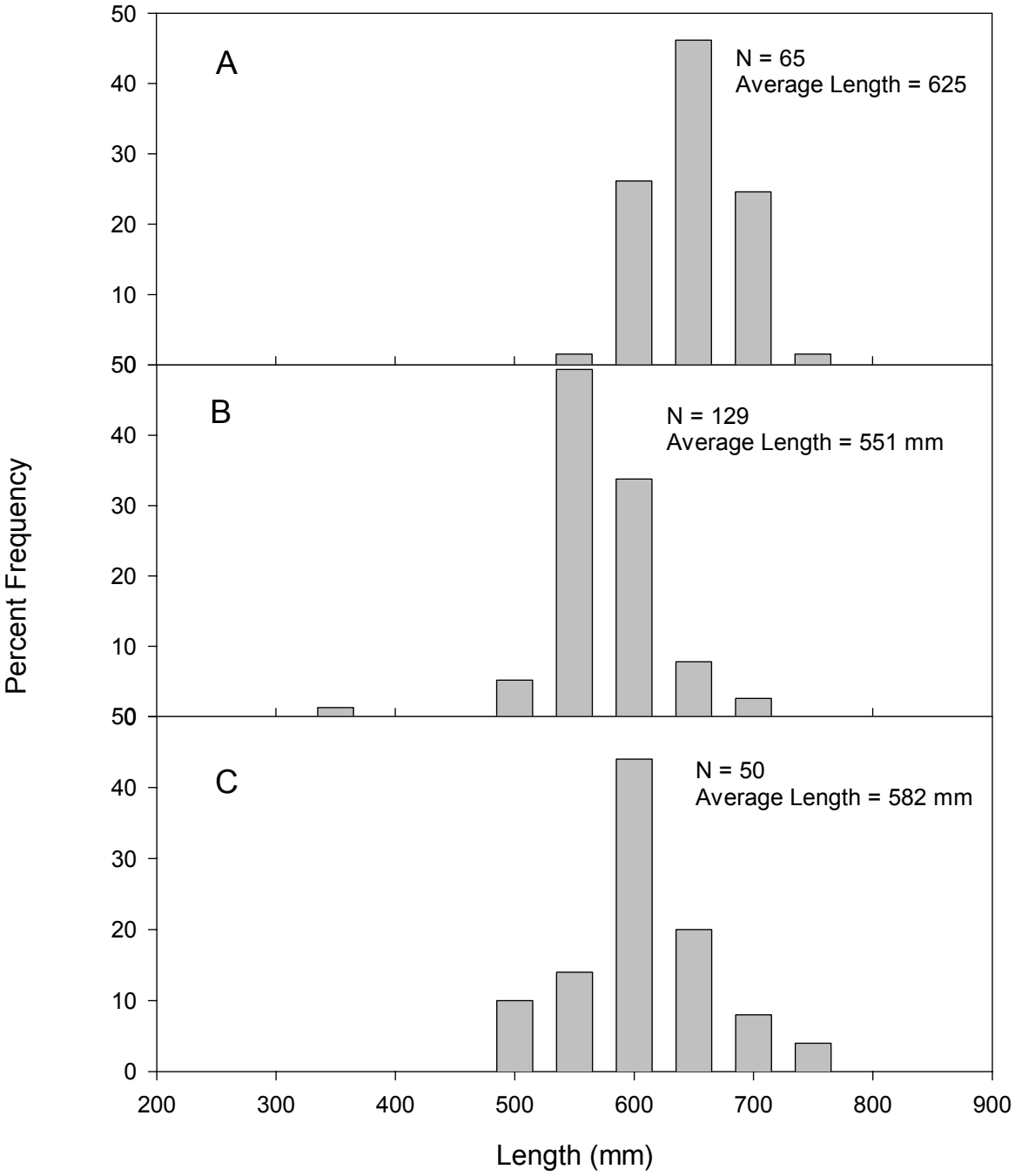

Figure 3. Length frequency distributions of shovelnose sturgeon caught by Nebraska Game and Parks Commission at Missouri River miles A) 839-845, B) 754-796 and C) 554-593.

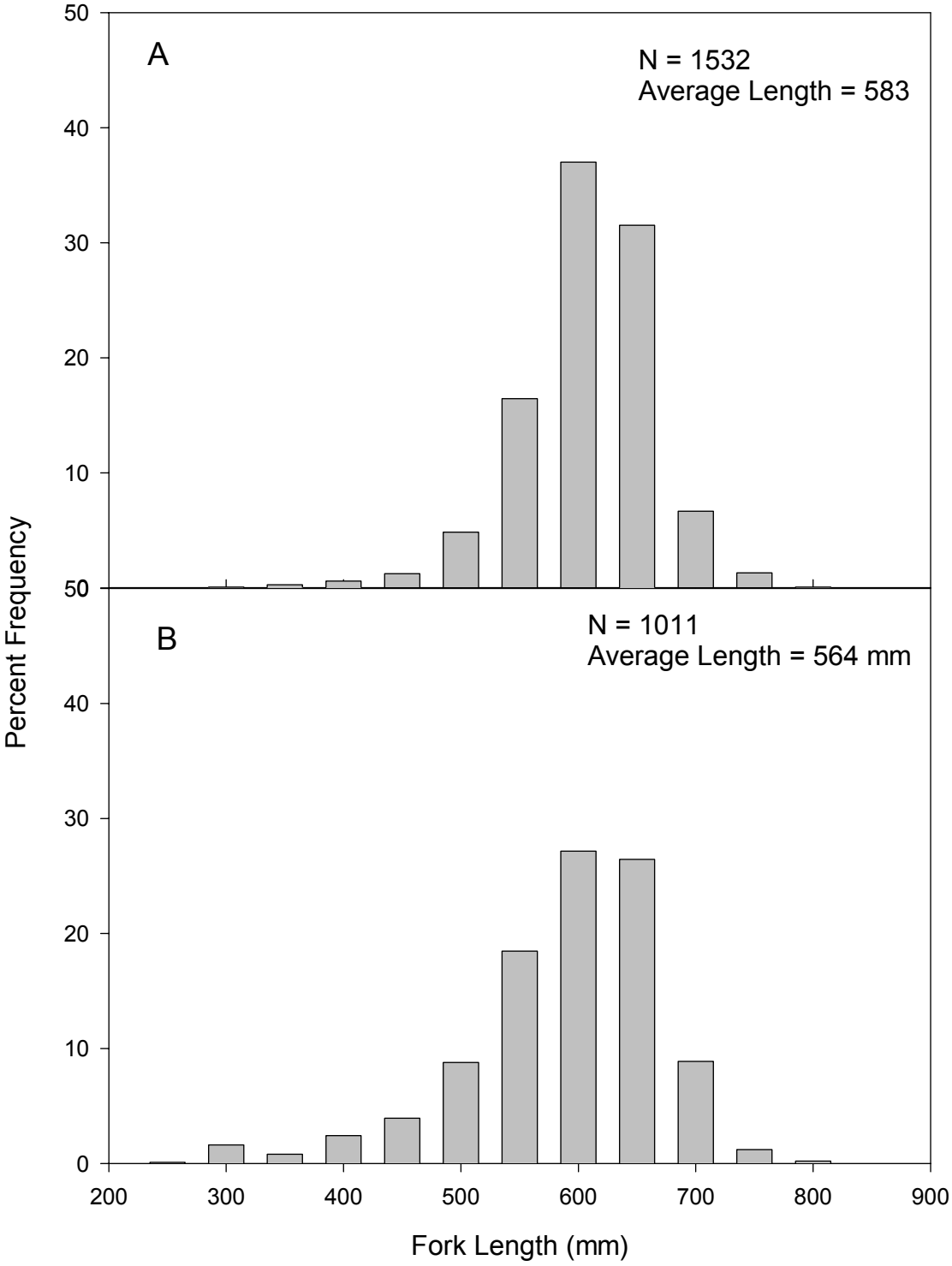

Figure 4. Percent length frequency of shovelnose sturgeon caught by A) Missouri Department of Conservation at Missouri River miles 322-186 and B) U.S. Fish & Wildlife Service at Missouri River miles 186-19.

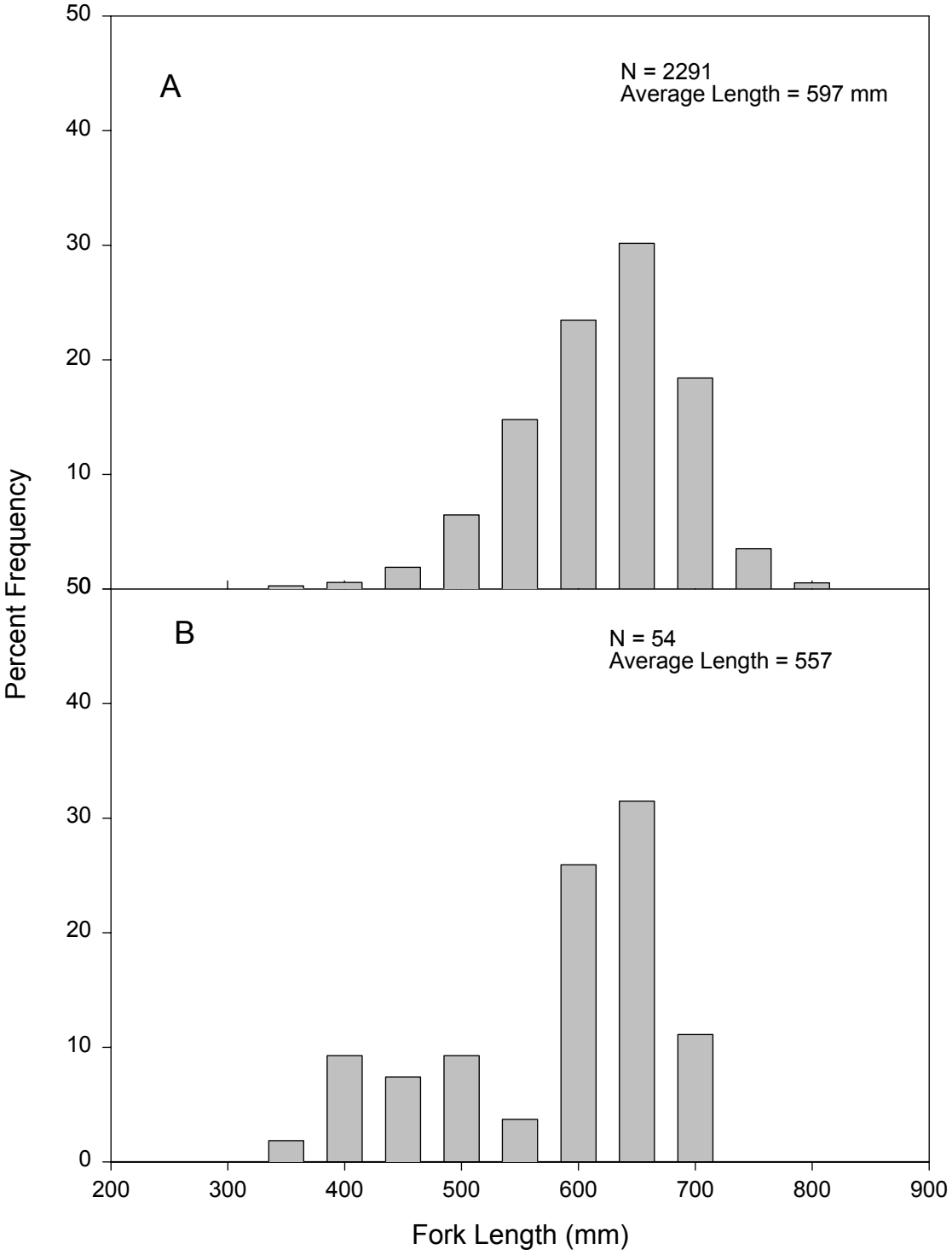

Figure 5. Percent length frequency of shovelnose sturgeon caught on the Middle Mississppi River by A) Long Term Resource Monitoring Program at river miles 934.1-77.8 and B) Southern Illinois Univeristy at river miles 105.8-116.5.

Species Associations

Shovelnose sturgeon were collected with blue catfish, sauger, shortnose gar, gizzard shad, freshwater drum, longnose gar, white bass, paddlefish, skipjack herring, river carpsucker, common carp, smallmouth buffalo, channel catfish, pallid sturgeon, flathead catfish, goldeye, quillback carpsucker, striped bass, lake sturgeon, pallid sturgeon hybrid, freckled madtom, bigmouth buffalo, black buffalo, and blue sucker in the Middle Mississippi River. They were collected with river carpsucker, channel catfish, blue catfish, goldeye, freshwater drum, common carp, sauger, shorthead redhorse, longnose gar, pallid sturgeon hybrid, flathead catfish, blue sucker, shortnose gar, smallmouth buffalo, pallid sturgeon, river redhorse, mooneye, walleye, lamprey, lake sturgeon, bigmouth buffalo, highfin carpsucker, northern pike, paddlefish, quillback carpsucker, striped bass, white bass, and white crappie in the Lower Missouri River. Shovelnose sturgeon and blue catfish collected in the Lower Missouri River were not independent (df=1, X^2=9.7287, a=0.05). The Jaccard index and Spearman correlation coefficient were used to measure the degree of association and covariation of abundance between shovelnose sturgeon and each of these species. The Jaccard Index value (0.18) did not indicate a large degree of association. The Spearman correlation coefficient was also not significant.

Habitat Use

Shovelnose sturgeon were collected in water depths of 0.8 to 20.1-m (average 10.3-m) in the Middle Mississippi River and 0.6 to 13.5-m (average 4.2-m) in the Lower Missouri River. Potential preferences in shovelnose sturgeon depths were examined per Mestl (1999). Figures 6 through 8 present the percentage of shovelnose sturgeon collected at various depths and the availability of each depth interval sampled. Preferences varied by river and reach. In the upper unchannelized Missouri River above Gavins Point Dam, shovelnose sturgeon were collected across a range of depths and were collected in higher percentages than were sampled at 2, 2.5, 3.5, 5.5, and 9-m. In the lower unchannelized Missouri River 85% of shovelnose sturgeon were collected in 1.5 m of water while only 16% of Nebraska's sampling was conducted at this depth (Figure 7). Likewise, in the lower channelized Missouri River 64% of shovelnose sturgeon were collected in 5-m of water while only 4% of the samples were collected there. Trends in potential sturgeon preference were not as clear in the lower 200 miles of the Missouri River. Shovelnose sturgeon were collected at every depth interval sampled by the FWS crew and in percentages greater than were sampled in water 6-m deep or deeper (Figure 8). Shovelnose sturgeon were also collected across a range of depths in the Middle Mississippi River. They were collected in percentages greater than were sampled for most depth categories deeper than 7-m (Figure 8).

Although the range of water velocities in which shovelnose sturgeon were collected was greater in the Lower Missouri River (-0.25 to 1.31 m/s) than in the Middle Mississippi River (0.08 to 0.42 m/s), averages were similar at 0.18 and 0.15 m/s respectively. Potential preferences in shovelnose sturgeon water velocities were also examined per Mestl (1999). Figures 9 through 11 present the percentage of shovelnose sturgeon collected at various water velocities measured at 0.2 of the water column and the availability of each velocity interval sampled. Shovelnose sturgeon appeared to prefer faster water above Gavins Point Dam as they were collected in larger proportions than the available velocity samples at 0.4, 0.5, 0.8, and 0.9 m/s. In the lower unchannelized Missouri River 81% of shovelnose sturgeon were collected in water velocities of 0.3 m/s while 16% of the samples were collected there. In the lower channelized Missouri River 56% of shovelnose were collected in water velocities of 0.2

m/s while 10% of the sampling was conducted at this velocity (Figure 9). Preferences were also exhibited at 0.4 and 0.8 m/s in this river reach. Shovelnose sturgeon in the lower 200 miles of the Missouri River appeared to prefer water velocities of 0.1-0.2 m/s (Figure 10). Sampling for shovelnose sturgeon in the Middle Mississippi River occurred in a narrower range of water velocities. Shovelnose sturgeon exhibited a preference at 0.2 m/s but were caught in similar proportions to availability for most other velocities (Figure 11).

Table 8. Depths and water velocities at 2/10 of the water depth sampled by each crew and depths and water velocities at which shovelnose sturgeon were collected in the Lower Missouri and Middle Mississippi Rivers, 1996-2000.

Crew and RM	Depth Sampled (m)		Depth Collected (m)		Velocity Sampled (2/10 of depth) m/s		Velocity Collected (2/10 of depth) m/s	
	mean	range	mean	range	Mean	range	mean	range
NE								
RM 839-851	3.8	0.94-8.9	3.64	1.55-8.93	0.55	0-1.31	0.55	0-1.10
RM 754-796	2.3	0.98-7.44	1.61	1.13-3.11	0.56	0-1.14	0.43	0.15-0.95
RM 554-593	2.5	0.85-6.16	3.87	1.68-4.69	0.61	0-1.48	0.29	0-1.04
MDC								
RM 186-191	NA	NA	12.4	6.1-15.6	NA	NA	NA	NA
RM 193-197	NA	NA	10.1	6.1-11.3	NA	NA	NA	NA
RM 223-226	NA	NA	10.0	7.6-13.7	NA	NA	NA	NA
RM 264-272	NA	NA	10.4	8.5-13.7	NA	NA	NA	NA
RM 315-322	NA	NA	10.6	6.1-13.7	NA	NA	NA	NA
FWS								
RM 185.8-186.9	5.1	1.5-13.5	6.4	1.68-13.5	0.14	-0.10-0.58	0.09	-0.10-0.50[1]
RM 154.4-159.8	3.1	0.6-8.5	4.1	0.61-8.54	0.32	-0.25-1.17	0.11	-0.25-0.96[1]
RM 91.6-98.2	5.2	1.8-11.4	5.6	1.83-11.4	0.21	-0.11-1.30	0.19	-0.11-1.15[1]
RM 19.1-26.4	3.4	0.6-7.6	3.3	0.61-7.63	0.24	-0.20-1.31	0.20	-0.16-1.31[1]
IA	2.7	1.2-5.5	NA	NA	0.79	0.30-1.37	NA	NA
SIU	4.9	0.8-15.3	4.7	0.84-12.2	0.39	0.32-0.42	0.39	0.32-0.42
LTRM	10.0	2.1-20.1	10.5	3.4-20.1	0.13	0-0.61	0.13	0-0.45

[1] Negative velocities were recorded in eddies where water moved upstream.

FWS biologists observed that shovelnose sturgeon and river carpsucker appeared to prefer different water velocities in the Lower Missouri River. One obvious example was a gillnet set behind an L-dike in which shovelnose sturgeon were collected in the flowing water while river carpsucker were collected in the still water directly behind the dike (Figure 12). An examination of the data showed that shovelnose sturgeon were indeed collected under faster water than river carpsucker. There were significant differences in median water velocity use of collected shovelnose sturgeon and river carpsucker at 0.2 the water depth (T=23902.5, P=0.023) and 0.8 the water depth (T=22179.5, P=0.002) in the Lower Missouri River using the Mann Whitney Rank Sum test. There were no significant differences found in water velocities at the river bottom.

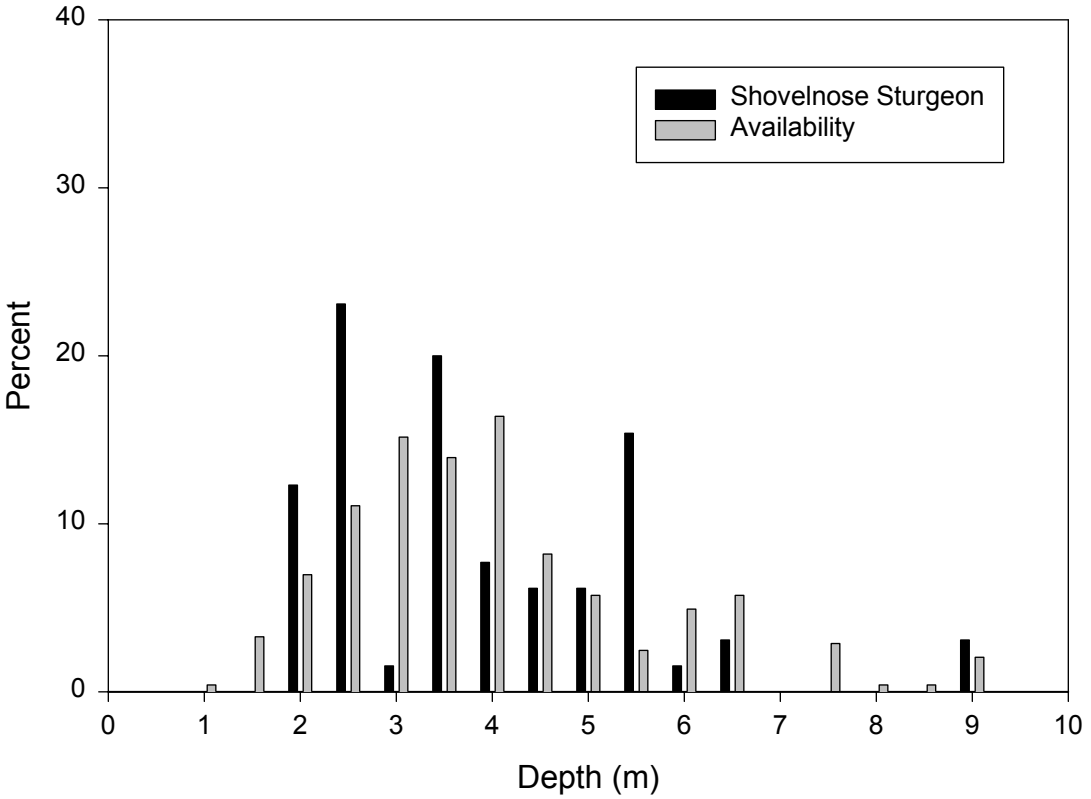

Figure 6. Percent of shovelnose sturgeon collected by Nebraska Game and Parks Commission at various depths and percent of samples taken at each depth from the upper unchannelized Missouri River, Nebraska (RM 839-851).

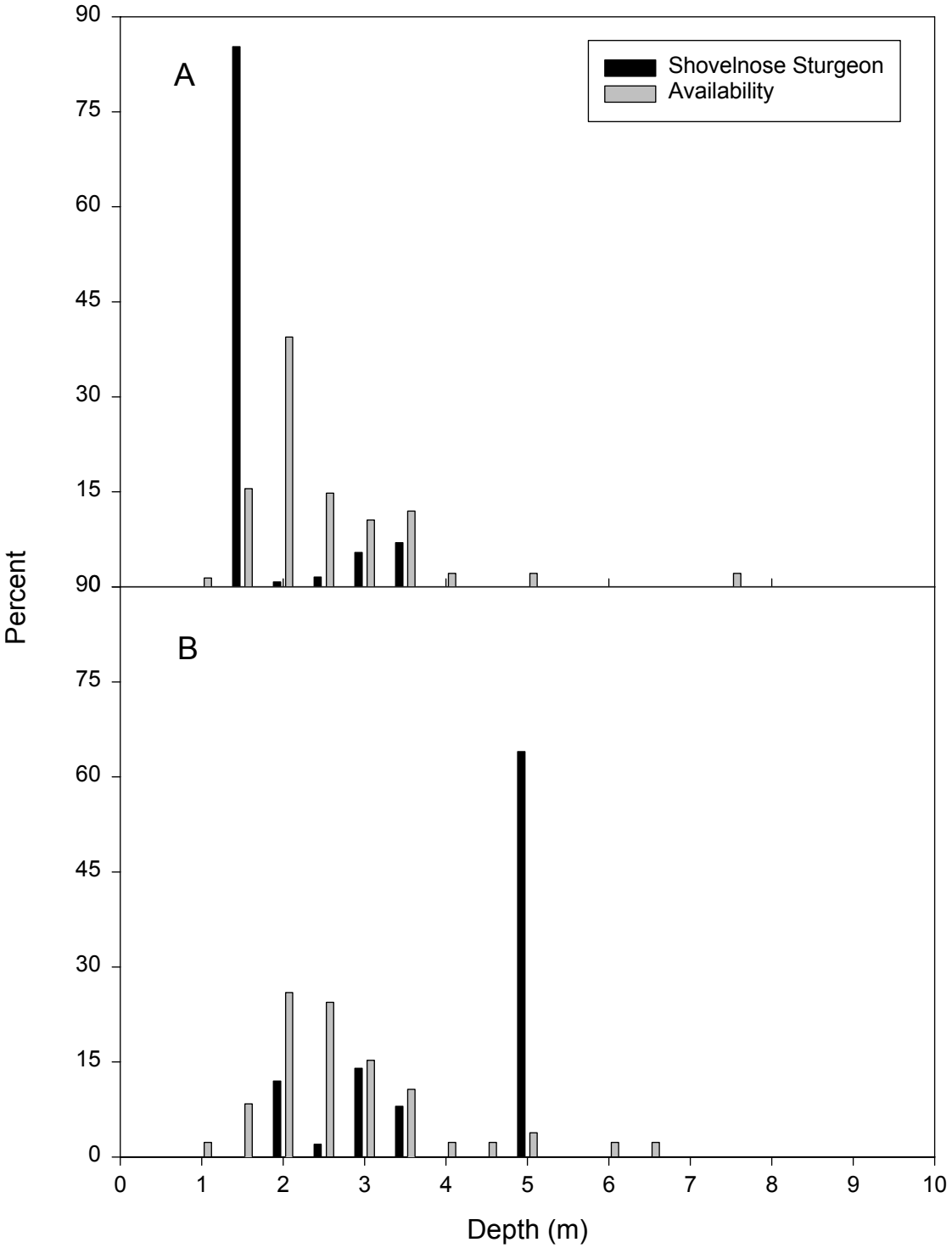

Figure 7. Percent of shovelnose sturgeon collected at various depths and percent of samples taken at each depth by the Nebraska Game and Parks Commission in the A) lower unchannelized Missouri River (RM 754-796) and B) the lower channelized Missouri River (RM 554-593).

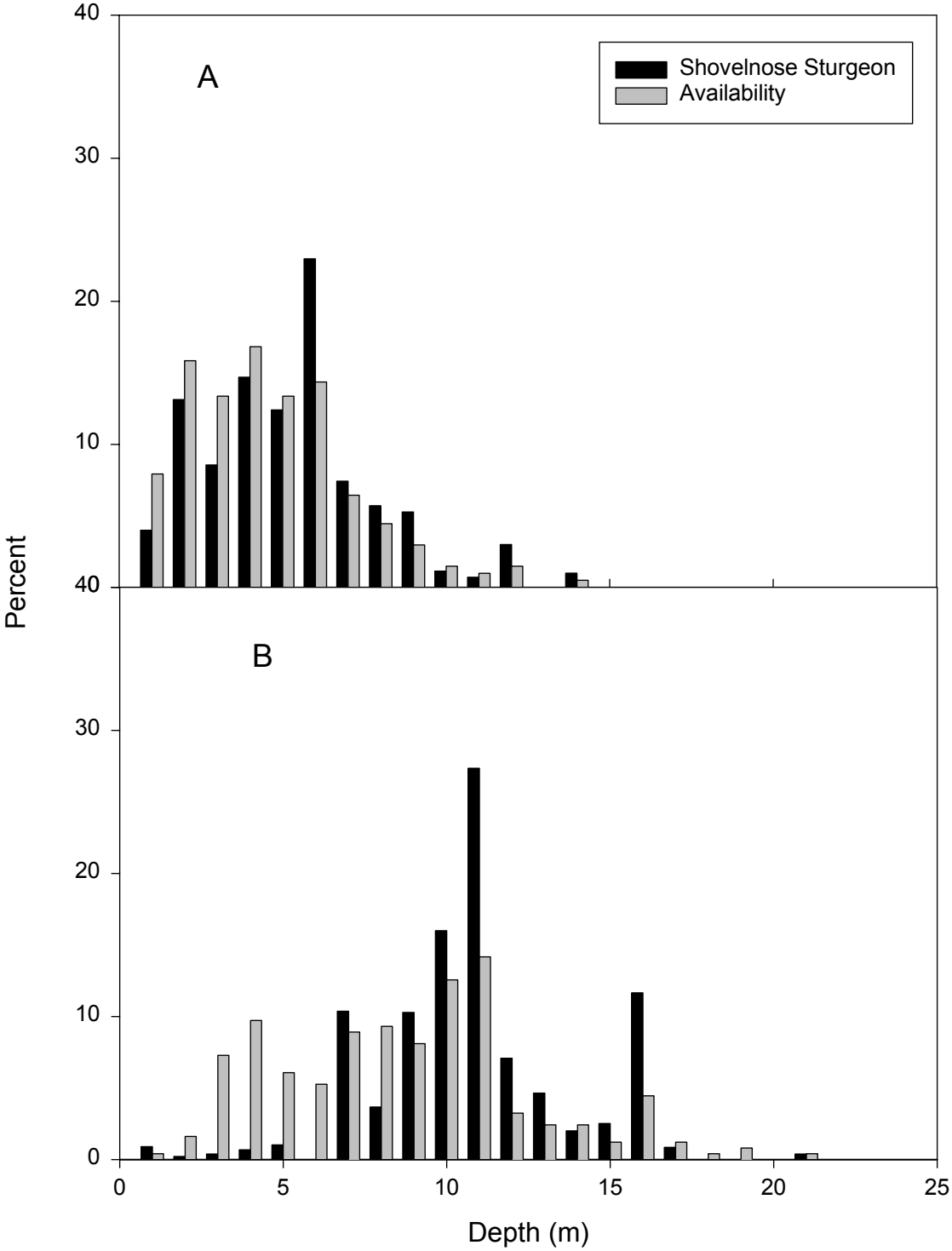

Figure 8. Percent of shovelnose sturgeon collected at various depths and percent of samples taken at each depth by A) FWS on the Lower Missouri River (RM 19.1-186.9) and B) LTRM (RM 31.6-64.0) and SIU (RM 105.8-116.5) on the Middle Mississippi River

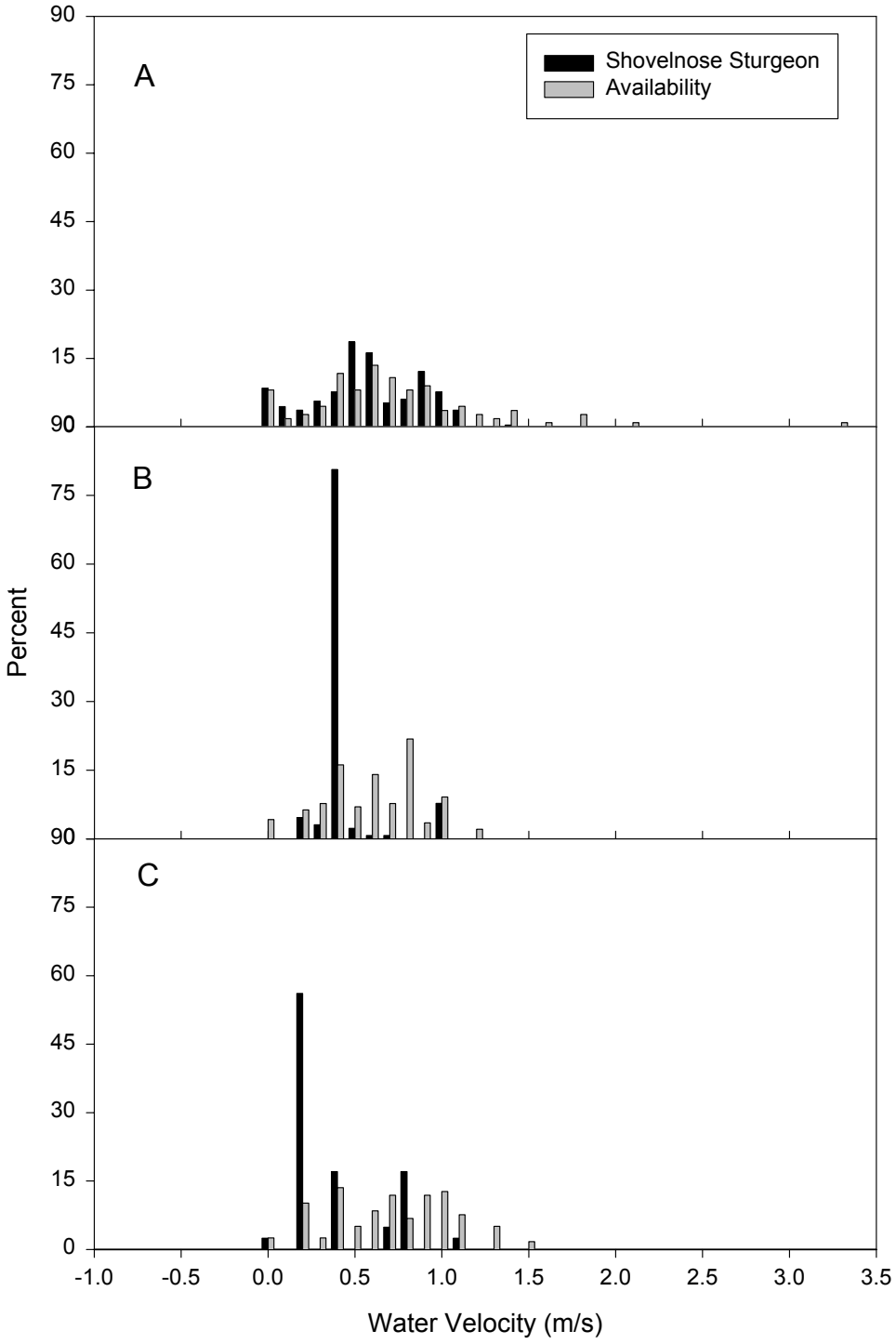

Figure 9. Percent of shovelnose sturgeon collected at water velocities measured at 0.2 the depth of the water column and percent availability of water velocities from Nebraska Game and Parks Commission samples taken from A) upper channelized river (rm 839-851), B) lower unchannelized river (rm 754-796), and C) lower channelized river (rm 554-596).

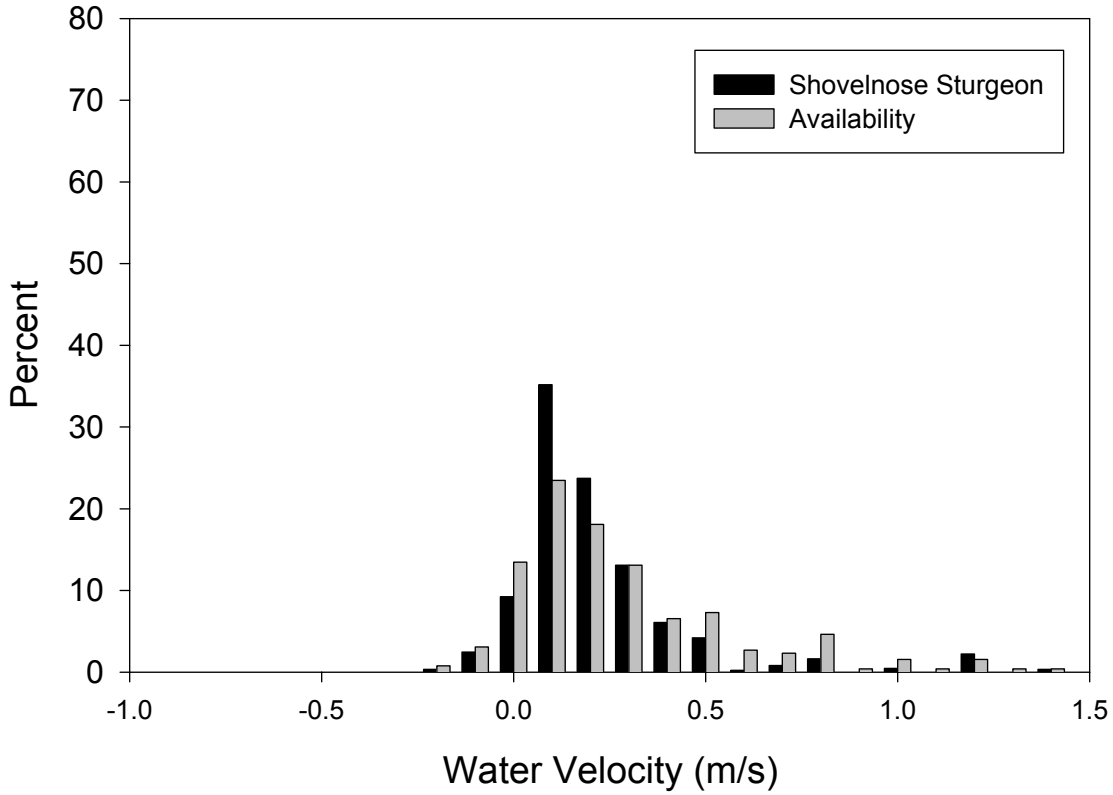

Figure 10. Percent of shovelnose sturgeon collected at water velocities measured at 0.2 the depth of the water column and percent availability of water velocities from FWS samples taken in the Lower Missouri River (RM 19.1-186.9).

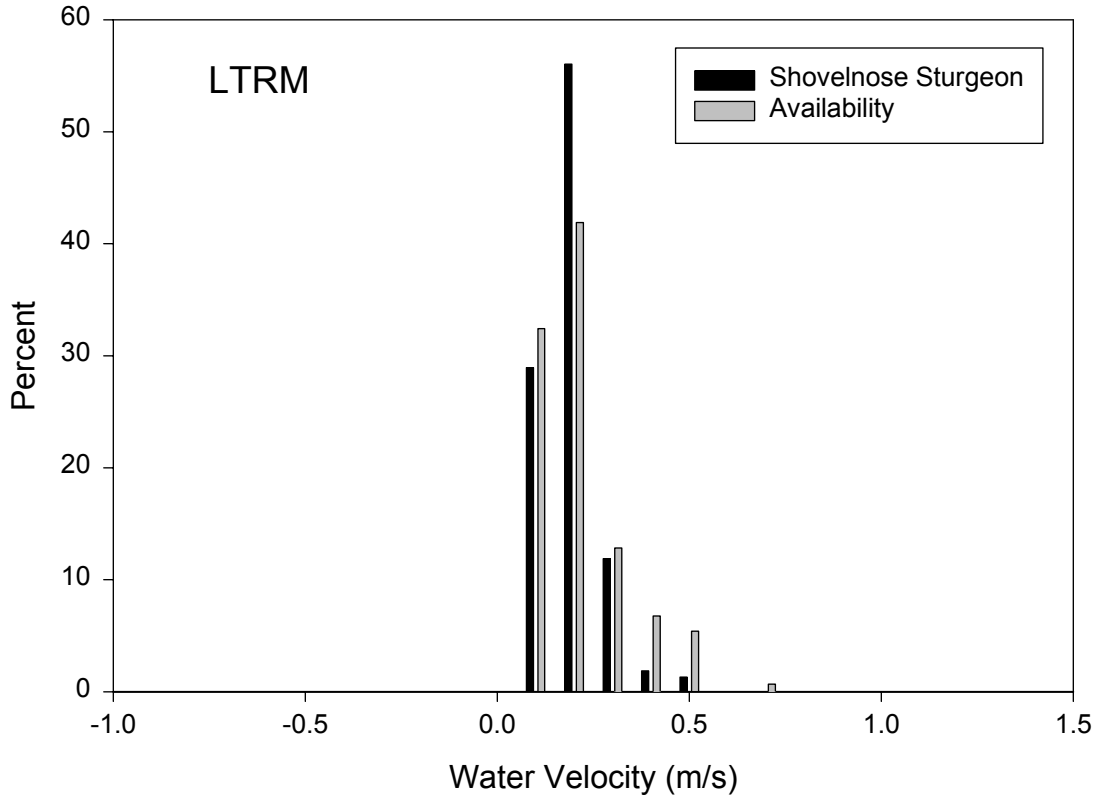

Figure 11. Percent of shovelnose sturgeon collected at water velocities measured at 0.2 the depth of the water column and percent availability of water velocities from LTRM samples (RM 31.6-64.0) and SIU samples (RM 105.8-116.5) taken in the Middle Mississippi River.

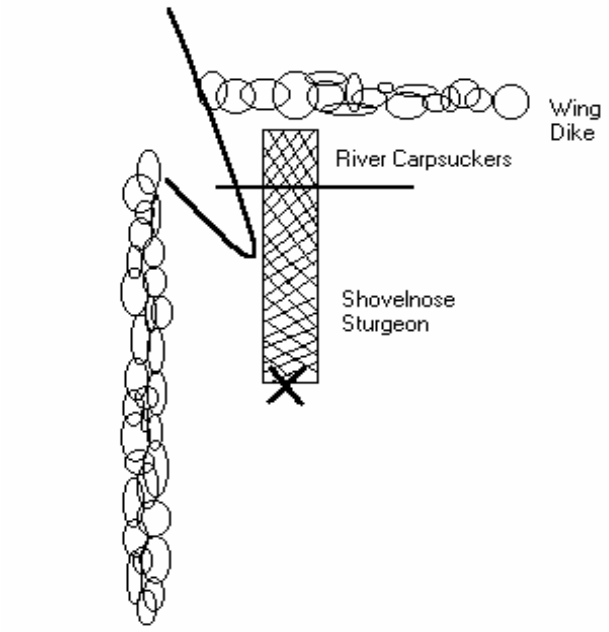

Figure 12. Example of gill net set behind notched dike in the Lower Missouri River. This gill net caught exclusively shovelnose sturgeon where water flowed through the dike notch and exclusively river carpsucker in the protected water directly behind the dike.

Discussion

Fish Sampling

Although the SIU crew on the Middle Mississippi River was very successful in collecting sturgeon species with drifting trammel nets, stationary gillnets were the most effective means of collecting sturgeon for most crews in the Lower Missouri and Middle Mississippi Rivers. Drifting nets have been utilized by Lower Missouri River field crews with little success and expensive net replacement rates.

One of the primary concerns in sturgeon sampling is fish misidentification. The morphological similarities between pallid sturgeon and shovelnose sturgeon make it difficult for untrained observers to distinguish between them. Results of character index values obtained in this project indicate that field biologists can be confident in their abilities to identify pallid sturgeon, shovelnose sturgeon and their hybrids.

Pallid Sturgeon Populations

Pallid sturgeon populations in the Lower Missouri and Middle Mississippi Rivers appear to have declined. The ratio of wild pallid sturgeon to all river sturgeon collected dropped from 1 in 398 (0.25%) collected by Carlson et al (1985) to 1 in 647 (0.15%). The contribution of hatchery raised fish can be seen when examining the total number of pallid sturgeon collected. Wild and hatchery raised pallid sturgeon accounted for 1 in 247 (0.41%) of all river sturgeons.

The rate of hybridization between pallid sturgeon and shovelnose sturgeon has increased. Six pallid-shovelnose sturgeon hybrids were collected in the Middle Mississippi River while 15 were collected in the Lower Missouri River. The rate of hybridization increased from 1 in 365 (0.27%) river sturgeons in the late 1970s (Carlson et al 1985) to 1 in 235 (0.42%) in the 1990s.

Commercial Harvest of Shovelnose Sturgeon

Recent concerns about sturgeon caviar harvest have led to an examination of long-term trends in shovelnose sturgeon numbers. Excessive exploitation of shovelnose sturgeon may be evident in reduced numbers of large reproductive fish. Although large historic datasets for shovelnose sturgeon are not available for statistical testing, average length of shovelnose sturgeon can be compared over time. Evermann (1902) reported females in Ohio River commercial harvest averaged 645 mm and 1.5 kg while males averaged 551 mm and 0.9 kg. Barnickol and Starrett (1951) collected shovelnose sturgeon in the Mississippi River that averaged 589-mm in length and 0.6-kg in weight.

The minimum reproductive size for female and male shovelnose sturgeon appears to vary by study location. In the Missouri River in South Dakota the minimum sizes were 48 cm for females and 44 cm for males. In the Lower Missouri, Carlson and Pflieger (1981) found minimum sizes of 51 and 45 cm, respectively. In the Upper Mississippi River, the smallest sexually mature females were 60-64 cm while males were 47-56 cm (Monson and Greenback 1947, Helms 1974).

Carlson and Pflieger (1981) reported average lengths, percent of catch over 50 cm and percent of catch over 60 cm for shovelnose sturgeon collected in the Lower Missouri and

Middle Mississippi River from 1978-1979. These values were compared with recent statistics in Tables 7 and 8. With the exception of the St. Louis site, values for mean lengths, % over 50 cm (minimum male reproductive size), and % over 60 cm (minimum female reproductive size) increased for shovelnose sturgeon in most locations in the Lower Missouri and Middle Mississippi Rivers. The largest increase in mean size was found near Brownsville, Nebraska. While Carlson and Pflieger (1981) found shovelnose sturgeon increased in size as moving downstream in the Missouri River, this trend no longer appears evident.

Work currently being completed on Ohio River shovelnose sturgeon indicates a significant decline in shovelnose sturgeon lengths between 1999 and 2000 and has raised concerns about shovelnose sturgeon exploitation rates (Chad Stinson, FWS pers. comm.). Shovelnose sturgeon lengths were compared at Hermann, Missouri between March 1999 and March 2000. No significant differences were found in length distributions or relative weights between the two sample years (Joanne Grady, FWS pers. comm.).

In summary, over-exploitation of shovelnose sturgeon stocks does not seem to be a problem yet in the Lower Missouri and Middle Mississippi Rivers. These numbers should be reviewed with some caution as there are likely to be some size frequency differences due to sampling gear and other causative factors. Fish caught in the Mississippi River during the late 1970s were contaminated with high levels of pollutants that may have impacted growth, longevity and marketability (Robert Sheehan, pers. comm.). Sturgeon populations are sensitive to fishing mortality and the 2000 Russian sturgeon harvest was 60% lower than in 1999 (Boreman 1997, The Russian Environmental Digest 2000). Sturgeon populations in the Missouri and Mississippi Rivers should continue to be monitored for potential overharvest.

Table 7. Comparisons of Missouri River shovelnose sturgeon mean lengths, percent of catch over 50 cm, and percent of catch over 60 cm between fish collected in this study and fish collected by Carlson and Pflieger (1981) in the late 1970s.

Site Name and River Miles		Brownsville RM 535	Brunswick RM 250		Easley RM 165		St. Louis
1970s	Sample Size	441	194		426		134
	Mean Length	47	50		51		58
	% over 50 cm	30	56		63		83
	% over 60 cm	1	8		14		41
Site Name and River Miles		NGPC RM 554-593	MDC RM 264-272	MDC RM 223-226	FWS RM 185-187	FWS RM 154-159	FWS RM 19-26
1990s	Sample Size	50	166	377	120	183	257
	Mean Length	58	56	58	55	56	56
	% over 50 cm	100	92	94	98	79	80
	% over 60 cm	32	26	37	31	33	37

Table 8. Comparisons of Mississippi River shovelnose sturgeon mean lengths, percent of catch over 50 cm, and percent of catch over 60 cm between fish collected in this study and fish collected by Carlson and Pflieger (1981) in the late 1970s.

Site Name & River Miles		St. Genevieve RM 125	Cairo RM 6
1970s	Sample Size	97	112
	Mean Length	57	58
	% over 50 cm	82	89
	% over 60 cm	32	56
Site Name & River Miles		SIU samples RM 106-116	LTRM samples RM 32-64
1990s	Sample Size	54	2281
	Mean Length	56	60
	% over 50 cm	72	92
	% over 60 cm	43	53

Recommendations

- Need to continue pallid sturgeon monitoring to assess rates of decline and hybridization.
- Need to continue/expand shovelnose sturgeon monitoring to assess population characteristics and potential impacts of commercial harvest.
- Monitoring needs to expand to include areas between river miles 300 and 500 on the lower MOR.
- Sampling should be expanded to include all life stages.
- Cooperative pallid sturgeon habitat modeling should continue.

Acknowledgements

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Appendix A.
Additional Fish Information

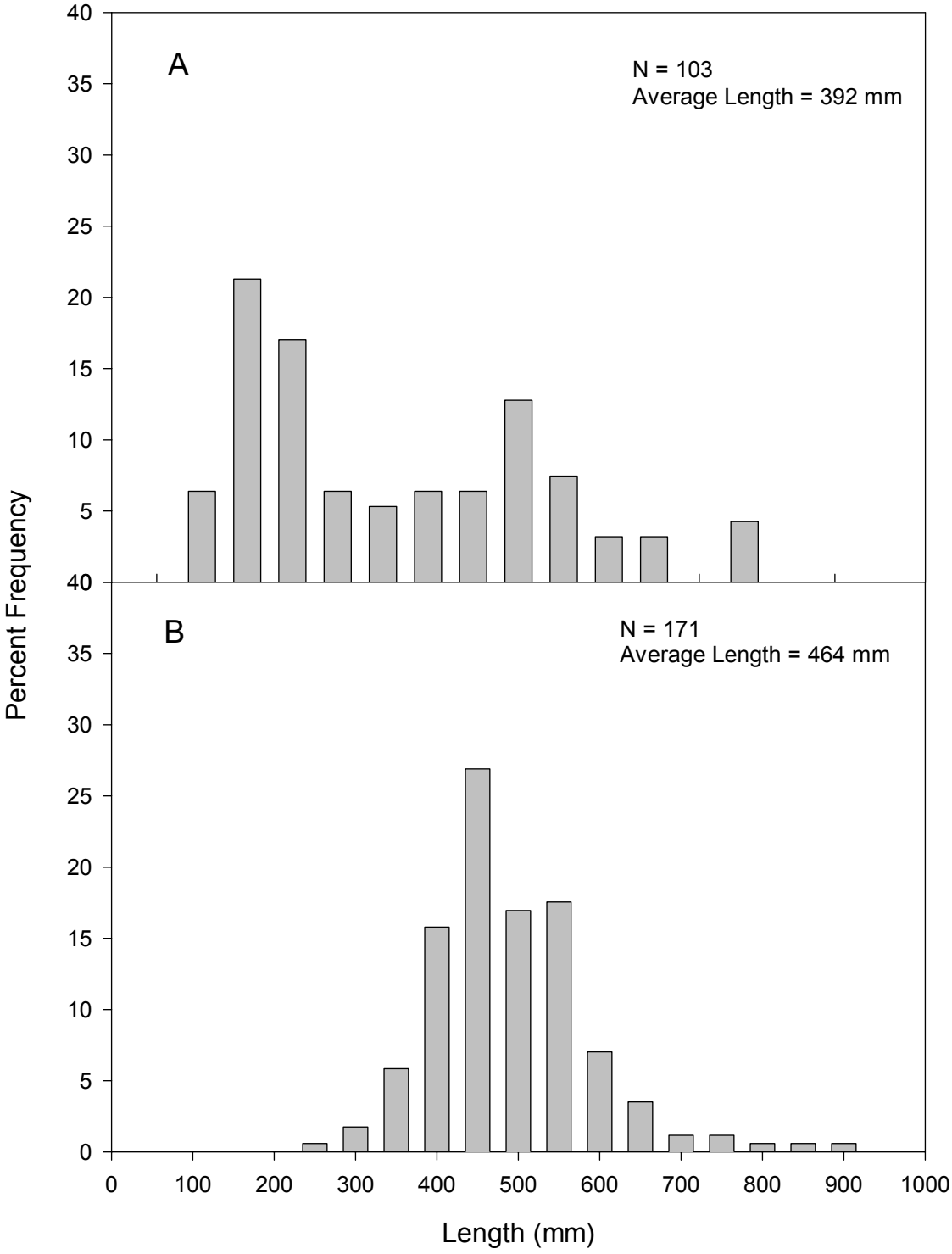

Figure A1. Percent length frequency distribution of blue catfish collected by A) U.S. Fish & Wildlife Service, Missouri River, river miles 186-19 and B) Long Term Resource Monitoring Program, Mississippi River, river miles 32-64.

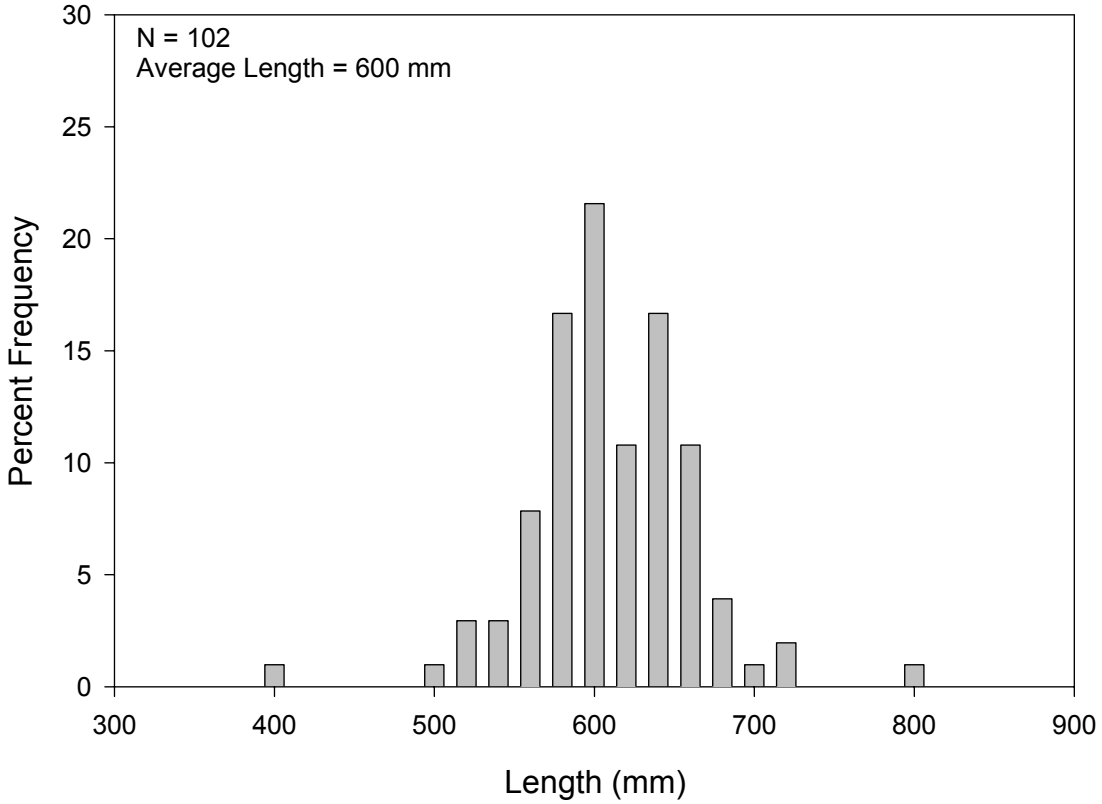

Figure A2. Length frequency of blue sucker caught in the Missouri River by Nebraska Game and Parks Commission at river miles 754-796.

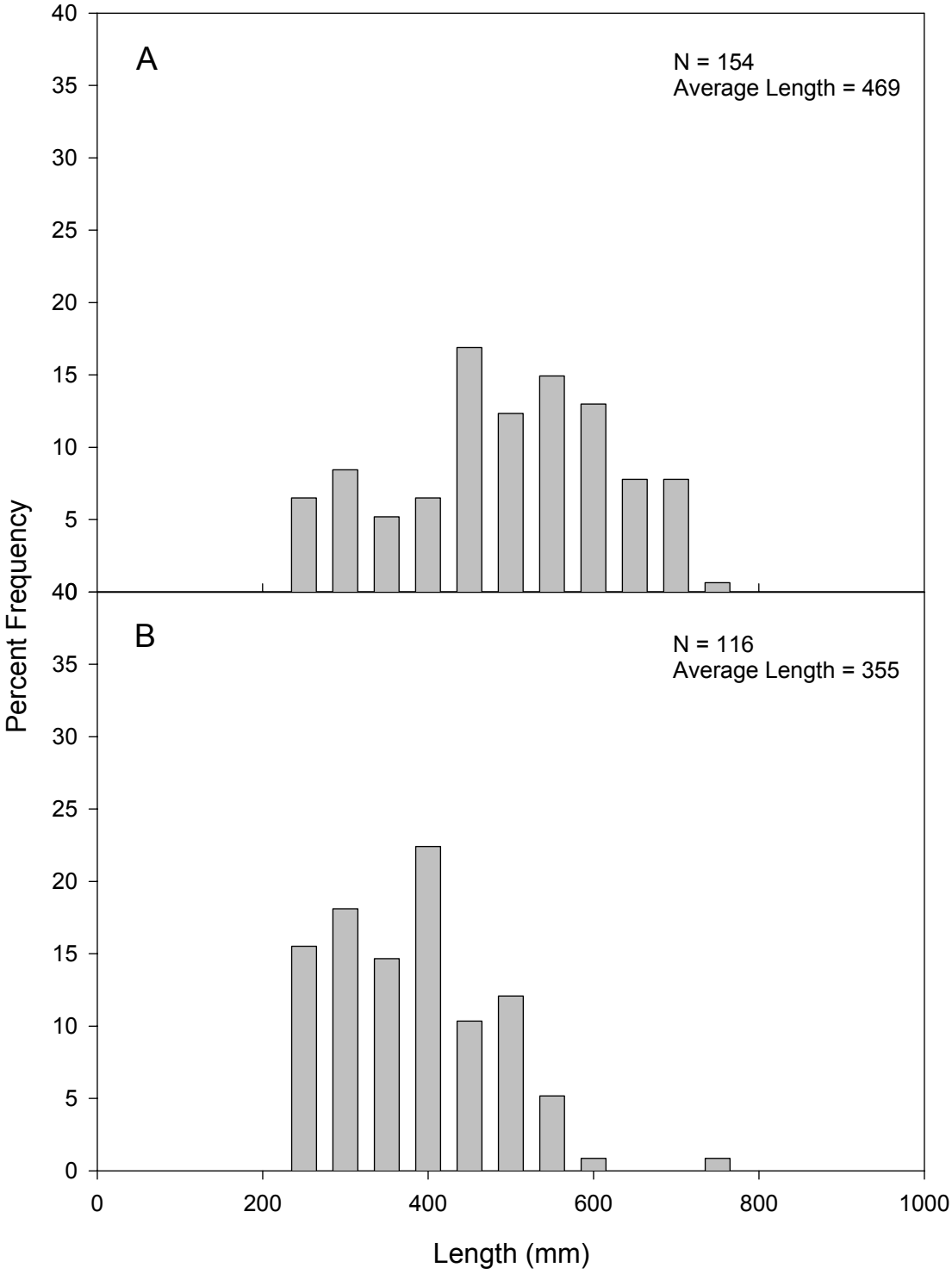

Figure A3. Percent length frequency of channel catfish caught by Nebraska Game and Parks Commission in the Missouri River at A) river miles 836-851 and B) river miles 754-796.

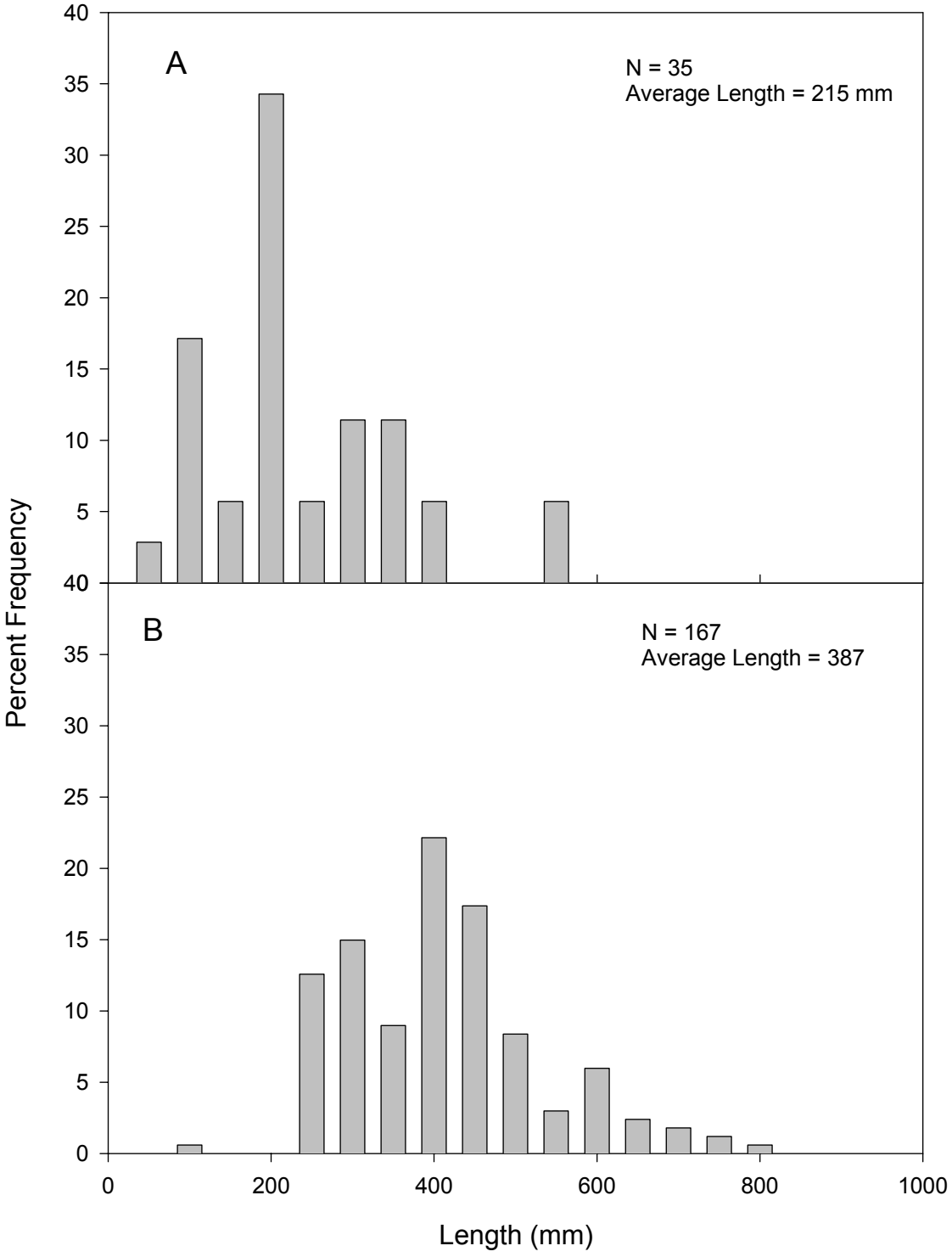

Figure A4. Percent length frequency distributions of channel catfish collected in the Missouri River by A) Iowa Department of Natural Resources at river miles 716-725 and B) Nebraska Game and Parks Commission at river miles 543-596.

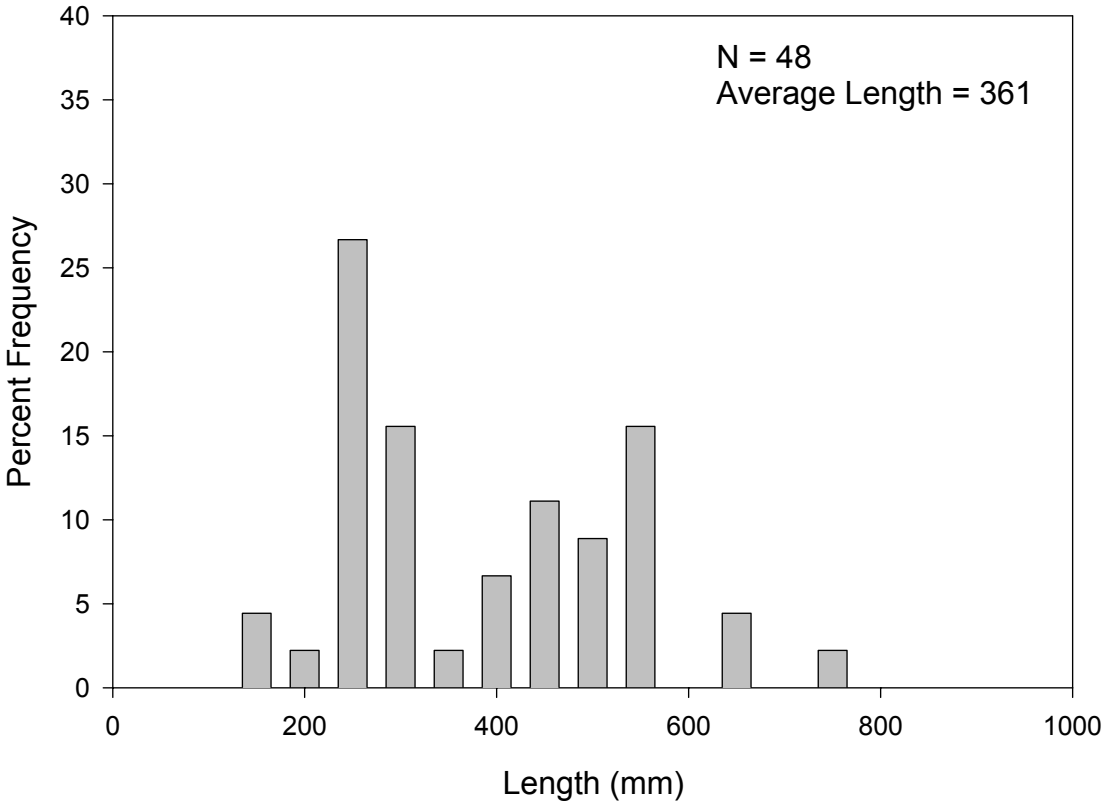

Figure A5. Percent length frequency of channel catfish caught in the Missouri River by U.S. Fish & Wildlife Service at river miles 19-186.

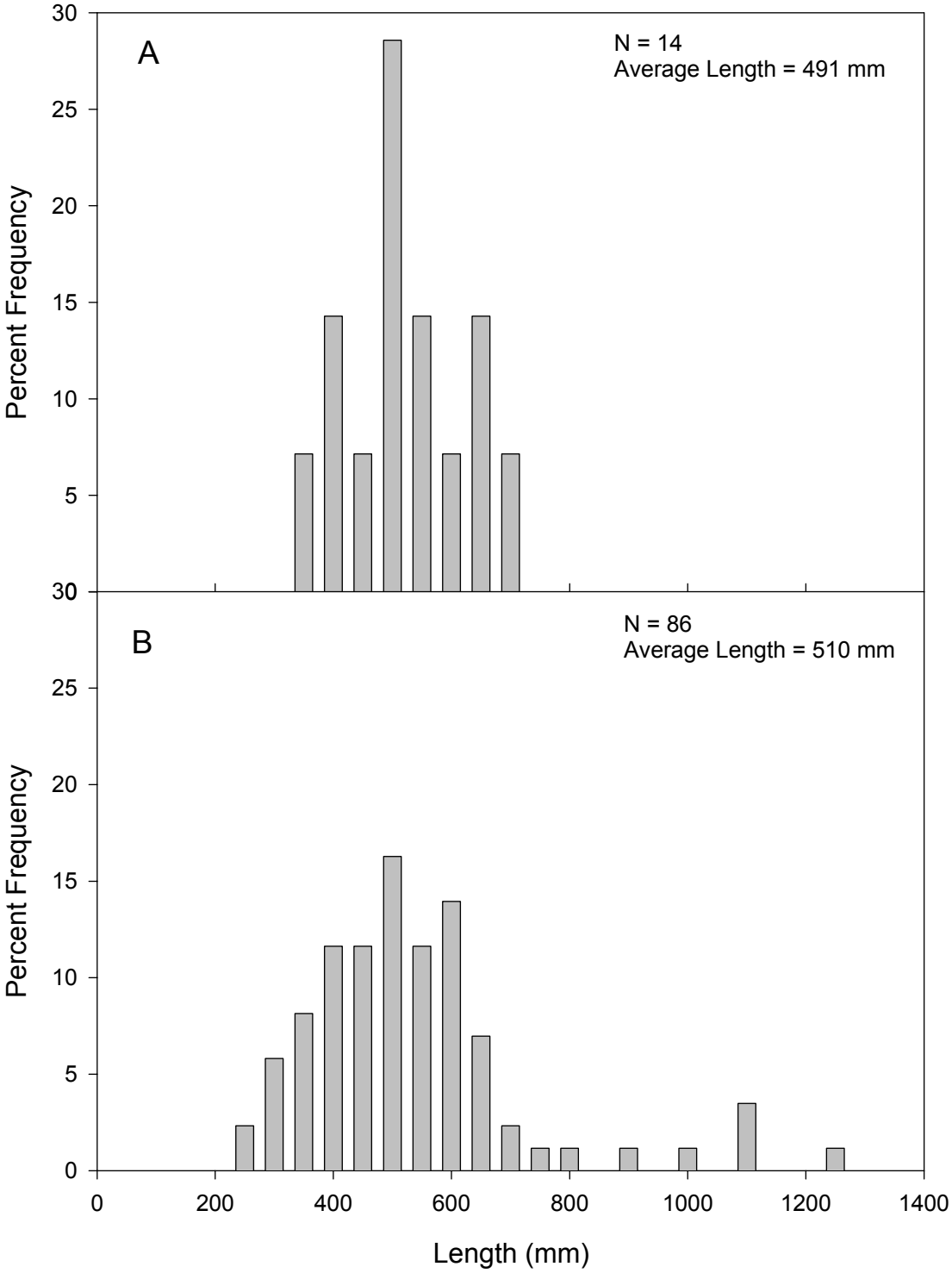

Figure A6. Percent length frequency of flathead catfish caught in the Missouri River by Nebraska Game and Parks Commission at A) river miles 754-796 and B) river miles 554-593.

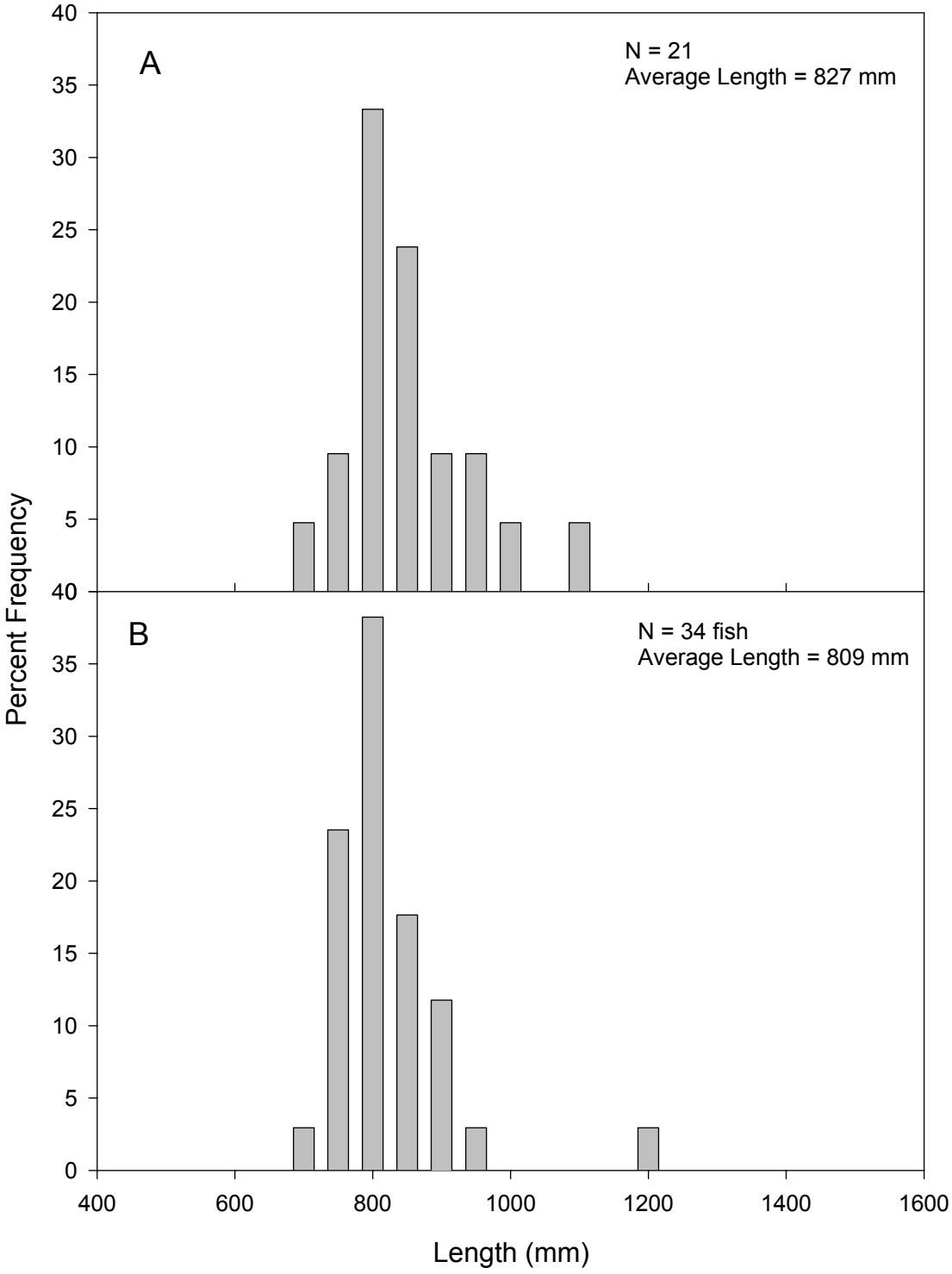

Figure A7. Percent length frequency of longnose gar caught by the Nebraska Game and Parks Commission on the Missouri River at A) river miles 754-796 and B) river miles 554-593.

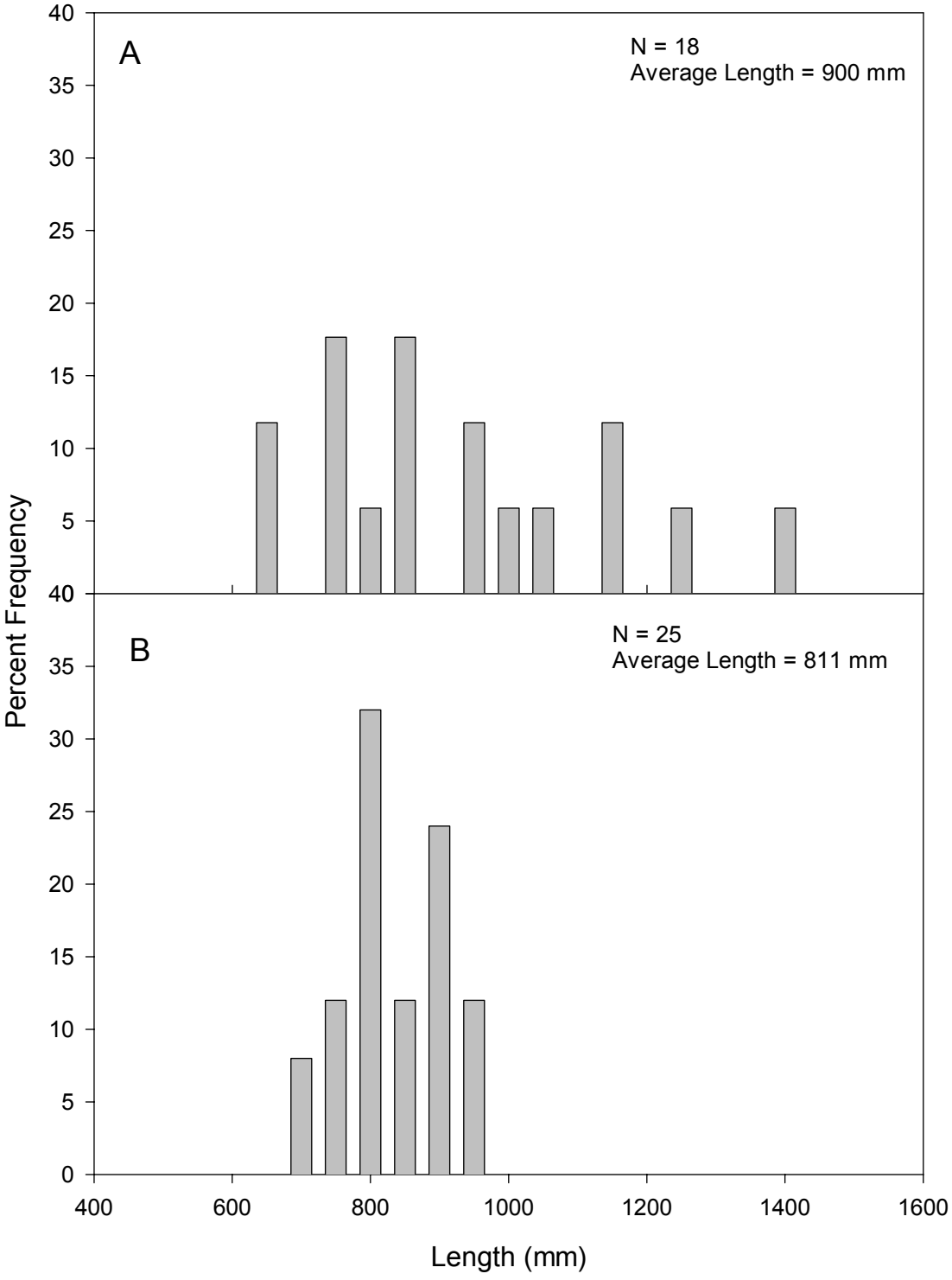

Figure A8. Percent length frequency of longnose gar collected by A) U.S. Fish & Wildlife Service, Missouri River, river miles 19-186 and B) Long Term Resource Monitoring Program, Mississippi River, river miles 32-64.

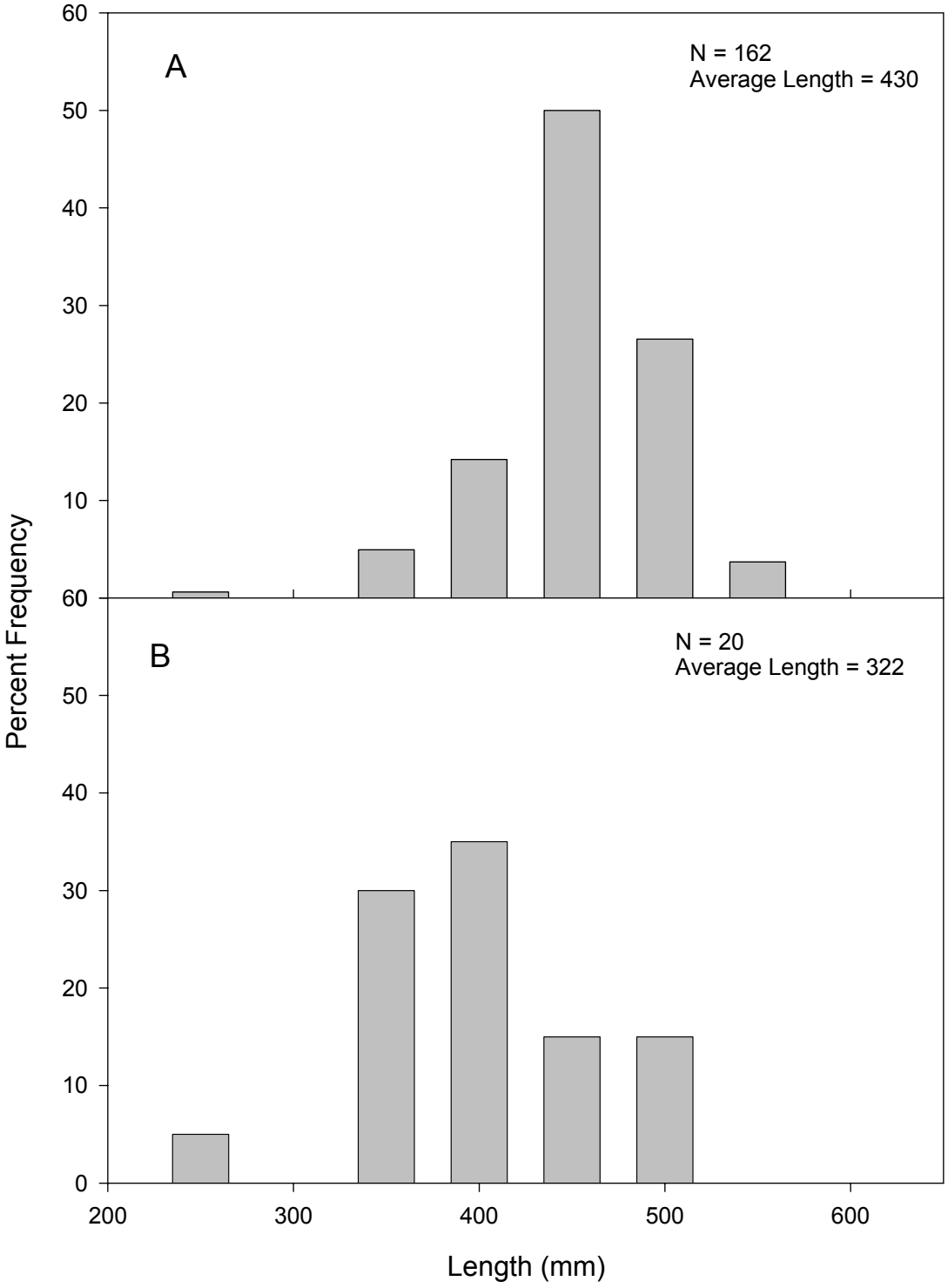

Figure A9. Percent length frequency of river carpsuckers caught in the Missouri by the Nebraska Game and Fish Commission at A) river miles 836-851 and B) river miles 754-796.

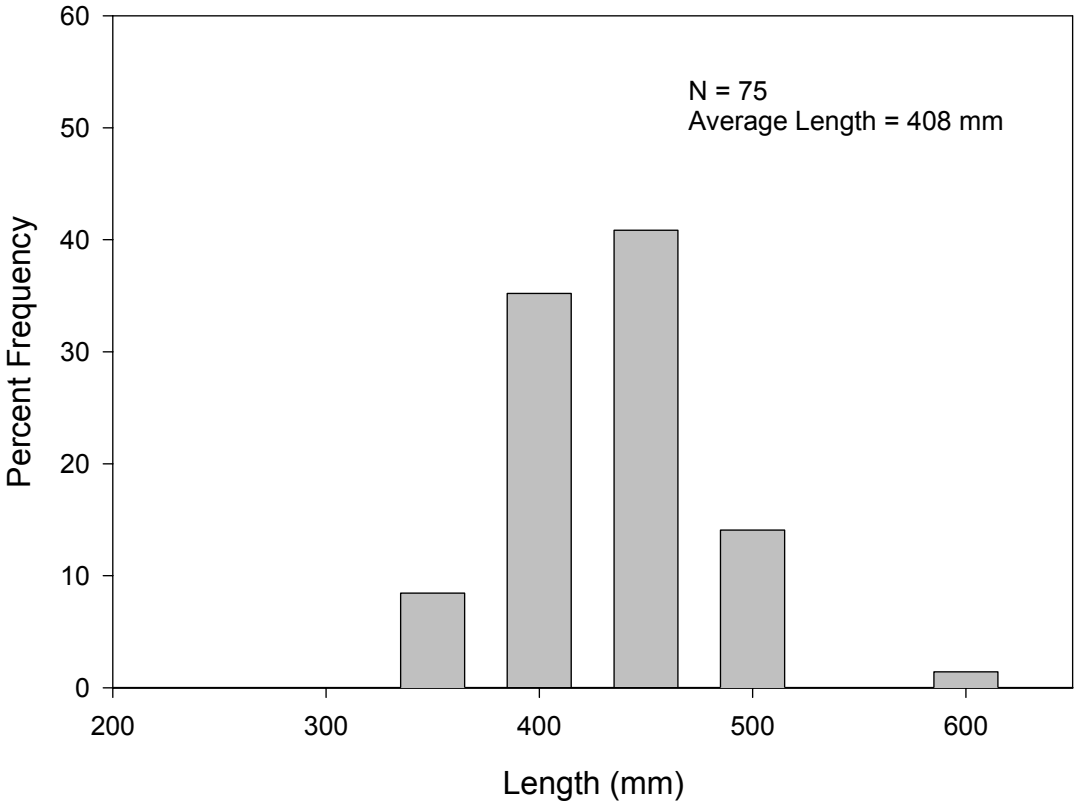

Figure A10. Percent length frequency of river carpsucker caught by U.S. Fish &Wildlife Service at river miles 19-186, Missouri River.

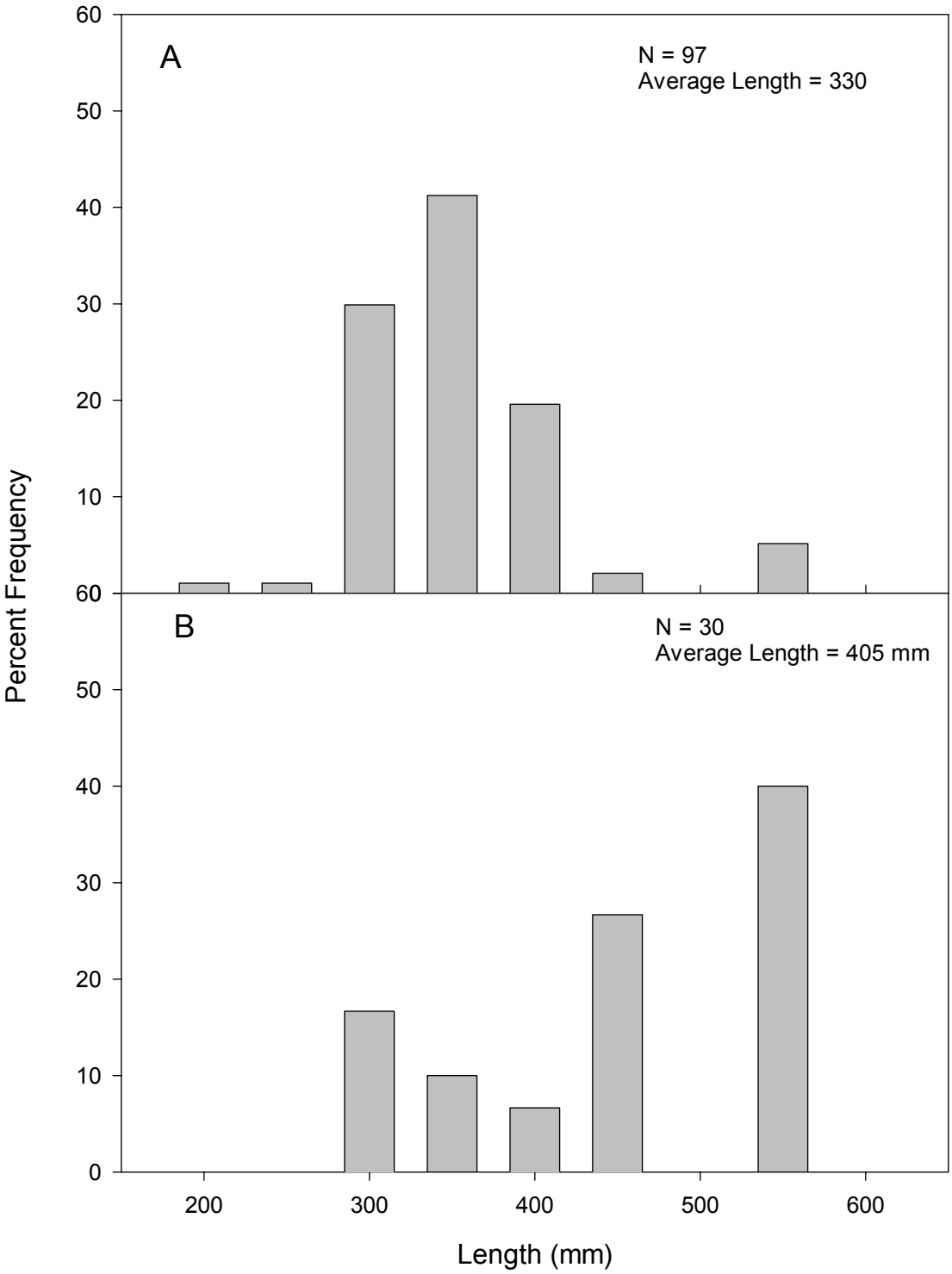

Figure A11. Percent length frequency of sauger caught in the Missouri River by A) Nebraska Game and Parks Commission at river miles 836-851 and B) U.S. Fish & Wildlife Service at river miles 19-186.

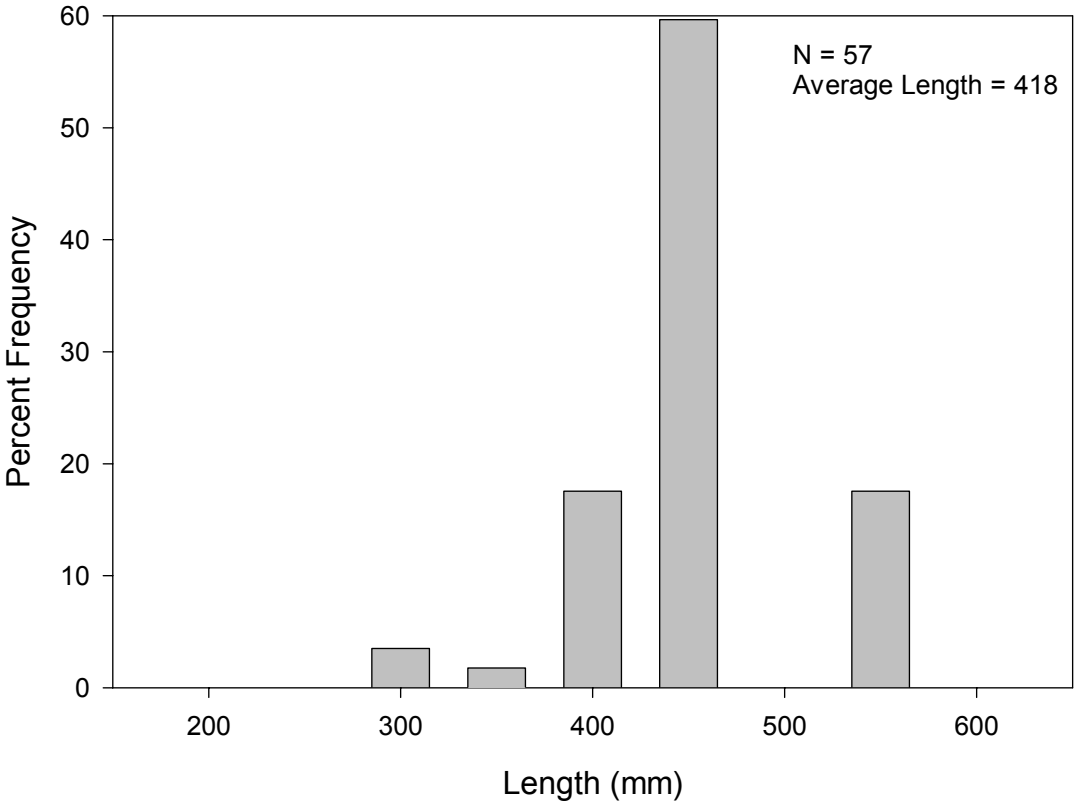

Figure A12. Percent length frequency of sauger collected by Long Term Resource Monitoring Program, Mississippi River, river miles 32-64.