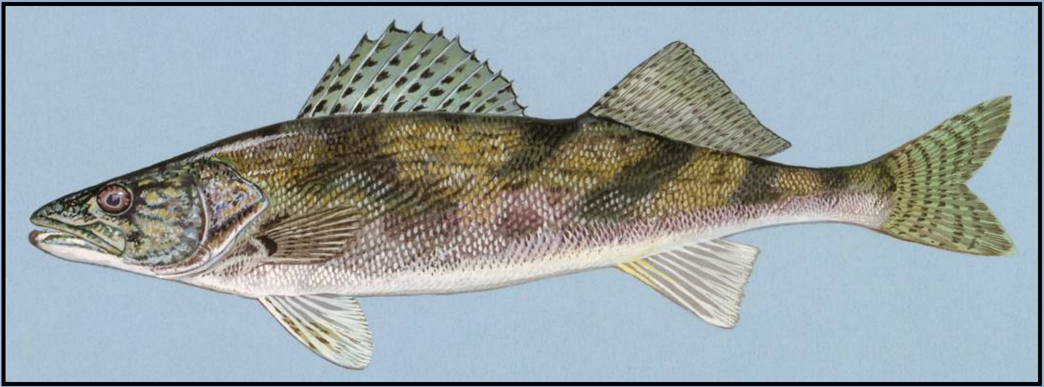
MISSISSIPPI INTERSTATE COOPERATIVE RESOURCE ASSOCIATION (MICRA)

SAUGER MANAGEMENT INVESTIGATION



Prepared for the
MICRA Gamefish Committee

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1.0 INTRODUCTION

Angler surveys from states within the Mississippi Interstate Cooperative Resource Association (MICRA) indicate that sauger (*Sander canadensis*) is a popular sportfish in many rivers and reservoirs. While the species is widespread in the Mississippi River basin, little is known about sauger life history, population trends, long-term sustainability, basin-wide management, and overall importance of the sauger fishery. Additionally, both the distribution and abundance of sauger have declined. To address these concerns, MICRA tasked the Watershed Institute, Inc. (TWI) to prepare a report on the life history, distribution, population status and trends, limiting factors, and management actions affecting sauger in MICRA states.

Initially, TWI conducted a literature search to identify and obtain published literature on sauger. Over 490 publications—including peer-reviewed journal articles, master's theses, doctoral dissertations, agency reports, electronic publications, and other gray literature—were identified through natural resource databases, library research, and personal contact with agency and academic sauger researchers. A full bibliography of identified literature is provided in Appendix A. Ebbers et al. (1988) developed an excellent bibliography on both walleye (*Sander vitreum*) and sauger. Most of the pre-1988 publications in Appendix A are also in the Ebbers document; however, the present work is not as comprehensive and should not be considered duplication of effort or as a replacement for Ebbers. Rather, this bibliography should be viewed as complementary because it lists pertinent and available research publications through 2006. Additionally, all literature obtained in electronic format is provided on the attached CD. Section 2.0 summarizes the status, life history, limiting factors, and management information reported in these publications.

Additionally, TWI surveyed agency personnel of all MICRA states to determine the current status and management actions affecting sauger. TWI contacted state fishery supervisors to identify the biologist(s) having specific sauger management responsibilities and sent electronic survey forms to the appropriate individual(s) within each state. Specifically, TWI solicited the following information:

- Current distribution, noting water body and habitat type.
- Strategies implemented to manage sauger.
- Effectiveness of implemented strategies.
- Equipment and procedures used to monitor sauger populations.
- Life history data.
- Importance to the state’s sportfishery.
- Research conducted on sauger populations.

Twenty five of 28 states returned completed surveys. To gather sauger information on the remaining three states, TWI used published literature (research reports, field guides, and fish distribution atlases) and websites (state natural resource agency and GAP programs) specific to the state. Appendix B contains all surveys received from MICRA states. Section 3.0 summarizes information reported by each state.

2.0 LITERATURE REVIEW

2.1 SPECIES ACCOUNT

2.1.1 Taxonomy

The Lewis and Clark expedition—1804-1806—were the first to formally document sauger, describing specimens from the Missouri River in what is now the state of Montana (Moring 1996; Galat et al. 2005). Rafinesque (1820), who described the genus *Stizostedion*, apparently did not distinguish between the sauger and walleye in his account of Ohio River "salmon perch", which contains diagnostic characteristics of both species. The original description of the species, *Lucioperca canadense*, was provided by Griffith and Smith (1834). Though sauger was known as *Stizostedion canadense* from 1880 (Scott and Crossman 1998), Nelson et al. (2003) recommended *Sander canadensis*, noting that the change is nomenclatural—*Sander* being a valid senior synonym for *Stizostedion*—and not taxonomic. Eschmeyer (1998)—referencing Gill (1903)—noted that *Sander* is Oken's (1817) Latinized "Les Sandres" of Cuvier (1816). The change from *canadense* to *canadensis* reflects agreement with the masculine gender of *Sander* (Nelson et al. 2003).

Saugers are members of the Order Perciformes and Family Percidae. The Percidae—which contains 152 species in Canada, United States, and Mexico—is one of the most speciose groups of freshwater fishes in North America (Bart and Page 1992). Collette and Banarescu (1977) recognized two subfamilies—Percinae and Luciopercinae—placing sauger in the latter. Berra (2001) and Nelson (2006) followed their arrangement, while Page (1985), Wiley (1992), and Coburn and Gaglione (1992) presented alternative interpretations of subfamily relationships. A more recent DNA sequence study divided the Percidae into three monophyletic subfamilies—Etheostomatinae, Percinae, and Luciopercinae—again placing sauger in the latter (Song et al. 1998). In the past, three subspecies have been recognized: *S. c. griseum* of the Great Lakes region, *S. c. boreum* from the Upper Missouri River, and *S. c. canadense* occurring elsewhere (Etnier and Starnes 1993; Scott and Crossman 1998). Though meristic differences exist among specimens representing these subspecies, most current authors do not consider subspecies justified (Smith 2002; Boschung and Mayden 2004). Genetic studies indicate walleye is a sister species of sauger (Billington et al. 1990; Faber and Stepien 1998; Stepien and Faber 1998).

Colloquial names for sauger include sand pickerel, sand pike, gray pike, jack, jack salmon, river pike, spotfin pike, pickering, horsefish, spotted trout, spotted jack, and rattlesnake pike (Tomelleri and Eberle 1990; Pflieger 1997; Ross 2001).

2.1.2 Current Description

The sauger is elongate and cylindrical, with two widely separated dorsal fins, a deeply forked caudal fin, and an average total length (TL) of 250-460 mm (Trautman 1981; Scott and Crossman 1998; Ross 2001; Smith 2002). There are 10-15 first dorsal spines, 1-2 second dorsal spines, and 16-21 second dorsal rays, 2 anal spines and 11-14 anal rays, 12-16 pectoral rays, 1 pelvic spine, and 5 pelvic rays (Trautman 1981; Etnier and Starnes 1993; Scott and Crossman 1998; Ross 2001; Smith 2002; Boschung and Mayden 2004). Both dorsal fins contain horizontal rows of discrete black spots on the anterior half of each membrane (Trautman 1981; Etnier and Starnes 1993; Smith 2002). The dorsal background color can range from sandy brown to olivaceous to dull gray, with 3-4 dark brown saddles extending down the sides (Scott and Crossman 1998; Ross 2001; Smith 2002; Boschung and Mayden 2004). The sides can also have several large, round spots (Scott and Crossman 1998). The ventral surface, anal fin, and pelvic fins are white; the pectoral fins are clear with a black spot at the base (Etnier and Starnes 1993; Scott and Crossman 1998; Smith 2002).

The lateral line is complete, and scales are present on the opercula, subopercle, cheek, breast, nape, and top of head (Etnier and Starnes 1993; Boschung and Mayden 2004; Stewart and Watkinson 2004). The species has a large terminal mouth with enlarged canine-type teeth (Ross 2001, Smith 2002). Teeth are also present on the premaxillaries, lower jaw, and palantines (Ross 2001). Internally, saugers have 3-9 pyloric caeca, 7-11 gill rakers, and 43-45 vertebrae (Trautman 1981; Etnier and Starnes 1993; Scott and Crossman 1998; Boschung and Mayden 2004; Stewart and Watkinson 2004).

2.2 SPECIES DISTRIBUTION

2.2.1 Historical

Historically, the sauger was considered one of the most widely distributed percid species in North America (see Figure 1). Sauger is native within a range bounded by the St. Lawrence-Great Lakes system, Hudson Bay, and Mississippi-Missouri River basins as far west as Alberta, Canada; east to the Appalachians and south to the Tennessee River in northern Alabama; southwest to northern Louisiana; northwest through eastern Oklahoma, Kansas, Nebraska, and South Dakota; west through northern South Dakota and Wyoming; and northwest through central Montana (Collette and Banarescu 1977; Page and Burr 1991; Scott and Crossman 1998). It has been introduced into the Atlantic, Gulf, and southern Mississippi River drainages (Page and Burr 1991). Though several texts—Hubbs and Lagler (1958), Moore (1968), Collette and Banarescu (1977)—mention that sauger occur in New Brunswick, Scott and Crossman (1998) noted that there was no evidence to support this statement. Pflieger (1971) suggested that the species invaded the Mississippi Valley from more northern drainages during the Pleistocene and inferred an origin in the western part of the ancestral Hudson Bay system based on a preference for large, turbid rivers.

2.2.2 Current

Researchers have documented declines in both the distribution and abundance of sauger populations from range-wide habitat fragmentation, habitat degradation, and overexploitation (Leach and Nezpy 1977; Nelson and Walburg 1977; Hesse 1994; Koonce et al. 1996; Pegg et al. 1996, 1997; Heidinger and Brooks 1998; McMahon and Gardner 2001; Galat et al. 2005). Declines have been reported from the Great Lakes (Rawson and Schell 1978), the Upper Missouri and Yellowstone Rivers in Montana

Sauger Management Investigation

Figure 1
Sauger Native Range

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Source: Adapted from Canada's Aquatic Environments: Fish 2002
U.S./Canada Boundary: USGS 2006

Date: 03/09/2007

Drawn By: BAE

(McMahon and Gardner 2001), the Middle Missouri River in South Dakota and Nebraska (Nelson and Walburg 1977; Hesse 1994), and the Tennessee and Cumberland Rivers of Tennessee and Kentucky (Yeager 1990; Pegg et al. 1996). Although Miller (1972) reported the species to be depleted in Kentucky and West Virginia, and rare in Ohio, and declines were reported from the Tennessee and Cumberland Rivers (Yeager 1990; Pegg et al. 1996), Warren et al. (2000) considered the species to be “currently stable” in the southern United States. In Mississippi, saugers are considered a species of “special concern” with regard to conservation status. Ross (2001) stated that sauger were uncommon in Mississippi, but it was not known whether their scarcity was due to the habitat conditions at the extreme southern end of their range or a decline from populations that were once more abundant. Table 1 displays the conservation status from natural heritage programs for each MICRA state.

Based on an analysis of fish collections from 1993–2002, Kirby and Ickes (2006) considered sauger to be widespread and common in the Upper Mississippi River (UMR). Pitlo et al. (2004) noted that, although estimates fluctuated, the annual surveys indicated the sauger fishery was thriving in the UMR. The Minnesota Department of Natural Resources, with 36 years of data from Pool 4, detected no discernible trends (Pitlo et al. 2004). Schell et al. (2004) considered sauger the most abundant and widely distributed percid in the Ohio River. Though once rare, populations had recovered steadily for several decades coincident with improved water quality over the previous 50 years, particularly with implementation of the 1972 Clean Water Act (Nielsen and Scott 1994; Thomas et al. 2004).

Similarly, though native to the Illinois River, saugers have inhabited the 117.9 km Peoria Pool only since the 1970s (Heidinger and Brooks 1988). Prior to 1970, pollution from municipal waste and nutrients in runoff from farmland caused frequent periods of low oxygen or anoxic conditions that prevented sportfish from surviving in the pool. Water quality improvements following implementation of wastewater treatment, soil conservation programs, and a municipal refuse disposal project allowed fish species diversity to increase (Heidinger and Brooks 1988). Saugers were among the first sportfish to proliferate and establish a fishery. A recent report noted that Illinois River sauger populations continued to expand, both in quality and quantity (Illinois Department of Natural Resources 2006). The major portion of the sauger population lies in the lower 371 km between the Mississippi River and Starved Rock Dam.

TABLE 1.
SAUGER CONSERVATION STATUS IN THE MISSISSIPPI RIVER BASIN

STATE	DESIGNATION [1]	STATE LISTING[2]	IMPORTANCE TO SPORTFISHERY[3]
Alabama	S5-Secure		2
Arkansas	S4- Apparently Secure		1.5
Colorado	Exotic		0.5
Georgia	Do Not Occur		0
Illinois	S4- Apparently Secure		-
Indiana	S4- Apparently Secure		3, 5[4]
Iowa	S4- Apparently Secure		4
Kansas	S2- Imperiled		3
Kentucky	S4- Apparently Secure		-
Louisiana	S4- Apparently Secure		0
Minnesota	Not Ranked		3
Missouri	Not Ranked		3
Mississippi	S3- Vulnerable	Special Concern	0
Montana	S2- Imperiled	Special Concern	3
Nebraska	S5- Secure		2
New York[5]	S1- Critically Imperiled	Species of Greatest Conservation Need	1
North Carolina	S2- Imperiled		0
North Dakota	Not Ranked		1
Ohio	Not Ranked		3
Oklahoma	S2- Imperiled		1
Pennsylvania	S4- Apparently Secure		3
South Dakota	S5- Secure		2
Tennessee	S5- Secure		4
Texas	Exotic		0
Virginia	S2- Imperiled	Special Concern	3
West Virginia	S5- Secure		-
Wisconsin	S4- Apparently Secure		3[6]
Wyoming	S3- Vulnerable		2

[1] From Nature Serve Explorer (http://www.natureserve.org/explorer/index.htm).
[2] From State Resource Agency.
[3] From State surveys; scale = 0 (no importance) to 5 (very important).
[4] 3 = interior waters, 5 = Ohio River
[5] Saugers do not occur in the Mississippi River Basin drainages.
[6] Where present, statewide = 0.5.

Historically, saugers thrived in the turbid waters of the Missouri River and were the predominant percid (Nelson and Walburg 1977; Fryda 2002). Due to declining abundance in the Missouri and Yellowstone Rivers, the State of Montana classified sauger as a "species of special concern" (McMahon and Gardner 2001; Montana Natural Heritage Program [MNHP] 2006). Berg (1981) reported sauger to be widely distributed above Lake Sakakawea; however, in the mid-1980s, sauger range declined 53% in Montana in both the Yellowstone River and middle Missouri River between Great Falls and Fort Peck Reservoir (McMahon and Gardner 2001). Penkal (1990) attributed the decline in both rivers to a drought and low flows. While increased flows in the 1990s corresponded to a rebound of the lower Yellowstone River population (Jaeger et al. 2005), the middle Missouri River population remained low (Gardner 2005). Jaeger (2005) reported that sauger catch rates in the Yellowstone River trended "steadily upwards" and improved to near pre-decline levels. McMahon and Gardner (2001) estimated a 22% range reduction of sauger in the main-stem Missouri River and a 75% reduction in occupancy of tributaries. Sauger populations at the peripheries of their distributions (i.e., tributary streams, upper and lower ends of their distributions) seem to have been most altered. Factors attributed to sauger declines over the past 20 years in Montana include low reservoir levels and river flows, migratory barriers—dams—and water diversions, hybridization and interspecific competition with nonnative walleye, interactions with introduced piscivorous smallmouth bass, and overfishing (McMahon and Gardner 2001; Jaeger et al. 2005; Bellgraph 2006).

In Wyoming, saugers are at the western extent of their range and native to the Big Horn-Wind, Tongue, Powder, and North Platte River drainages (Baxter and Stone 1995). However, sauger distribution and abundance in Wyoming has declined considerably since 1900 (Welker et al. 2001). While moderate populations existed in the Bighorn-Wind River drainage (Welker et al. 2001, 2002; Amadio et al. 2005), sauger were rare in the Powder and extirpated from the North Platte River (Hubert 1993; Baxter and Stone 1995). Sauger still occurred in the Tongue River drainage, but the extent of the distribution and the status of the population was largely unknown (Welker et al. 2001).

The strongest remaining population of sauger was within the Wind-Big Horn River drainage (Kuhn 2005).

A review of long-term fish collections from several states substantiated consistent population declines in sauger throughout the main channel of the Missouri River (Galat et al. 2005). Though sauger declined in number with closing of main-stem dams (Hesse et. al. 1993), they can be common in some lakes (Lewis and Clark, Sakakawea – Dakotas) and in the recreational fishery (Mestl et al. 2001). After the lake-like conditions fully developed in the main-stem reservoirs and spawning habitat was reduced, sauger declined in all of the reservoirs in South Dakota except Lewis and Clark Lake (Nelson and Walburg 1977). Sauger abundance remained relatively stable in Lewis and Clark Lake because, as the smallest of the four main-stem reservoirs in South Dakota, current velocities remained higher and turbidity was higher relative to the other reservoirs. Additionally, a 39-mile, relatively unaltered, inter-reservoir riverine stretch above Lewis and Clark Lake provided important habitat for spawning sauger (Nelson 1968). Recent annual population surveys showed that sauger populations in the three lower Missouri River reservoirs—Lewis and Clark, Francis Case, and Sharpe—remained relatively stable (Lott et al. 2002; Sorensen 2003; Wickstrom 2004).

Sauger populations have declined substantially in the Nebraska portion of the channelized Missouri river (Hesse 1994). In the lower Missouri River, saugers have declined both in catch per unit effort (CPUE) and percent composition (Galat et al. 2005). Hesse (1994) reported declining electrofishing catch rate in the unchannelized river between 1963 and 1991. These data showed the same sharp decrease following dam closure (1963–1975), with a less steep decline thereafter (1983–1991), as was observed for several riverine fishes in Lewis and Clark Lake. Similarly, a 93% reduction in sauger larvae was observed between 1974 and 1985–1991 from the channelized segment. Interestingly, Pflieger and Grace (1987), in a summary of fishery changes in the Missouri River, Missouri, from 1940 to 1983 indicated that sauger numbers might have increased.

Previous investigations revealed that there has been an overall decline in sauger populations in the Tennessee River since the mid-1980s (Scott 1984; Buchanan 1990; Ruane et al. 1990; Yeager and Shiao 1992). Saugers declined to low levels in several main-stem reservoirs of the upper Tennessee River in Tennessee, which prompted the Tennessee Wildlife Resources Agency to initiate a stocking program in 1990 (Maceina et al. 1998). In the lower Tennessee River, sauger stocks have persisted at low abundances (Maceina et al. 1998). Table 2 and Figure 2 provide the current distribution—HUC 8—and status of sauger from state survey data.

TABLE 2
CURRENT DISTRIBUTION FROM STATE SURVEYS

Waterbody	8-Digit HUC	Origin	State	Status
UPPER MISSISSIPPI RIVER BASIN				
Minnesota River	07020004	Native	Minnesota	Stable
	07020007	Native	Minnesota	Stable
	07020012	Native	Minnesota	Stable
St. Croix River	07030005	Native	Minnesota-Wisconsin	Stable
Mississippi River	07040001	Native	Minnesota-Wisconsin	Stable
	07040003	Native	Minnesota-Wisconsin	Stable
	07040006	Native	Minnesota-Wisconsin	Stable
Wisconsin River	07070005	Native	Wisconsin	Stable
Mississippi River	07060001	Native	Wisconsin-Iowa	Stable
	07060003	Native	Wisconsin-Iowa	Stable
	07060005	Native	Iowa-Illinois	Stable
Yellow River	07060001	Native	Iowa	Unknown
Upper Iowa River	07060002	Native	Iowa	Unknown
Turkey River	07060004	Native	Iowa	Unknown
Maquoketa River	07060006	Native	Iowa	Unknown
Mississippi River	07080101	Native	Iowa-Illinois	Stable
	07080104	Native	Iowa-Illinois	Stable
Wapsipinicon River	07080102	Native	Iowa	Unknown
	07080103	Native	Iowa	Unknown
Skunk River	07080107	Native	Iowa	Unknown
Des Moines River	07100009	Native	Iowa	Unknown
Mississippi River	07080201	Native	Iowa-Illinois	Stable
	07080204	Native	Iowa-Illinois	Stable
Cedar River	07080206	Native	Iowa	Unknown
Iowa River	07080209	Native	Iowa	Unknown
Rock River	07090005	Native	Illinois	Stable
Mississippi River	07110001	Native	Illinois-Missouri	Unknown

	07110004	Native	Illinois-Missouri	Unknown
	07110009	Native	Illinois-Missouri	Unknown
Fox River	07110001	Native	Missouri	Unknown
Fabius River	07110003	Native	Missouri	Unknown
South Fabius River	07110003	Native	Missouri	Unknown
South River	07110004	Native	Missouri	Unknown
Salt River	07110007	Native	Missouri	Unknown
Maple Slough	07110009	Native	Missouri	Unknown
Illinois River	07130001	Native	Illinois	Stable
	07130003	Native	Illinois	Stable
	07130011	Native	Illinois	Stable
Des Plaines River	07120004	Introduced	Illinois	Stable
Mississippi River	07140101	Native	Illinois-Missouri	Unknown
	07140105	Native	Illinois-Missouri	Unknown
Meramec River	07140102	Native	Missouri	Unknown
Big River	07140102	Native	Missouri	Unknown
Auxvasse River	07140105	Native	Missouri	Unknown
Mud Ditch	07140105	Native	Missouri	Unknown
Kaskaskia River	07140201	Native	Illinois	Increasing
	07140202	Native	Illinois	Increasing
	07140204	Native	Illinois	Increasing
OHIO RIVER BASIN				
Allegheny River	05010006	Native	Pennsylvania	Stable
	05010009	Native	Pennsylvania	Stable
Kiskiminetas River	05010008	Native	Pennsylvania	Increasing
Conemaugh River Lake	05010007	Introduced	Pennsylvania	Stable
Loyalhanna Lake	05010008	Introduced	Pennsylvania	Stable
Monongahela River	05020005	Native	Pennsylvania	Stable
Cheat River	05020004	Native	Pennsylvania	Increasing
Youghiogheny River	05020006	Native	Pennsylvania	Stable
Ohio River	05030101	Native	PA-Ohio-West Virginia	Stable
Raccoon Creek	05030101	Native	Pennsylvania	Increasing
Beaver River	05030103	Native	Pennsylvania	Increasing
Bessemer Lake	05030103	Introduced	Pennsylvania	Stable
Ohio River	05030201	Native	Ohio-West Virginia	Stable
	05030202	Native	Ohio-West Virginia	Stable
Elk River	05030201	Native	West Virginia	Unknown
Little Kanawha River	05030203	Native	West Virginia	Unknown
Kanawha River	05050006	Native	West Virginia	Unknown
	05050007	Native	West Virginia	Unknown
	05050008	Native	West Virginia	Unknown
Ohio River	05090101	Native	Ohio-WV-Kentucky	Stable
	05090103	Native	Ohio-Kentucky	Stable
Big Sandy River	05070204	Native	WV-Kentucky	Unknown
Ohio River	05090201	Native	Ohio-Kentucky	Stable

	05090203	Native	Ohio-Kentucky-Indiana	Stable
Licking River	05100101	Native	Kentucky	Unknown
Kentucky River	05100202	Native	Kentucky	Unknown
	05100205	Native	Kentucky	Unknown
Ohio River	05140101	Native	Kentucky-Indiana	Stable
	05140104	Native	Kentucky-Indiana	Stable
Salt River	05140102	Native	Kentucky	Unknown
Ohio River	05140201	Native	Kentucky-Indiana	Stable
	05140202	Native	Kentucky-Indiana	Stable
	05140203	Native	Kentucky-Illinois	Stable
	05140206	Native	Kentucky-Illinois	Stable
Wabash River	05120101	Native	Indiana	Stable
	05120104	Native	Indiana	Stable
	05120105	Native	Indiana	Stable
	05120108	Native	Indiana	Stable
	05120111	Native	Indiana-Illinois	Stable
	05120113	Native	Indiana-Illinois	Stable
Embarras River	05120112	Native	Illinois	Unknown
White River	05120201	Native	Indiana	Stable
	05120202	Native	Indiana	Stable
East Fork White River	05120204	Native	Indiana	Stable
	05120206	Native	Indiana	Stable
	05120207	Native	Indiana	Stable
	05120208	Native	Indiana	Stable
Patoka River	05120209	Native	Indiana	Stable
Cumberland River	05130101	Native	Kentucky	Stable
	05130102	Native	Kentucky	Stable
	05130103	Native	Tennessee	Stable
	05130106	Native	Tennessee	Stable
	05130108	Native	Tennessee	Stable
Cordell Hull Reservoir	05130106	Native	Tennessee	Stable
Old Hickory Reservoir	05130201	Native	Tennessee	Stable
Cheatham Reservoir	05130202	Native	Tennessee	Stable
Barkley Reservoir	05130205	Native	Kentucky-Tennessee	Increasing
TENNESSEE RIVER BASIN				
Tennessee River	06010101	Native	Tennessee	Stable
	06010104	Native	Tennessee	Stable
Cherokee Reservoir	06010104	Native	Tennessee	Stable
Upper French Broad River	06010105	Native	TN-North Carolina	Stable
Pigeon River	06010106	Native	TN-North Carolina	Stable
Douglas Reservoir	06010107	Native	Tennessee	Stable
Tennessee River	06010201	Native	Tennessee	Decreasing
	06010207	Native	Tennessee	Decreasing
Watts Bar Reservoir	06010201	Native	Tennessee	Decreasing
Little Tennessee River	06010204	Native	Tennessee	Stable
Tellico Reservoir	06010204	Native	Tennessee	Stable
Melton Hill Reservoir	06010207	Native	Tennessee	Stable

Clinch River	06010205	Native	Tennessee-Virginia	Decreasing
Powell River	06010206	Native	Tennessee-Virginia	Decreasing
Norris Reservoir	06010205	Native	Tennessee	Decreasing
	06010206	Native	Tennessee	Decreasing
Tennessee River	06020001	Native	Tennessee	Decreasing
	06020002	Native	Tennessee	Stable
Chickamauga Reservoir	06020001	Native	Tennessee	Decreasing
Hiwassee River	06020002	Native	Tennessee	Stable
Chickamauga Reservoir	06020002	Native	Tennessee	Stable
Tennessee River	06030001	Native	Alabama	Stable
	06030002	Native	Alabama	Stable
	06030005	Native	Alabama	Stable
Guntersville Reservoir	06030001	Native	Alabama	Stable
Wheeler Reservoir	06030002	Native	Alabama	Stable
Wilson Reservoir	06030002	Native	Alabama	Stable
Pickwick Lake	06030005	Native	Tennessee-AL-MS	Stable
	06030006	Native	Alabama-Mississippi	Stable
Tennessee River	06040001	Native	Tennessee	Stable
	06040005	Native	Tennessee-Kentucky	Stable
	06040006	Native	Kentucky	Stable
Kentucky Reservoir	06040001	Native	Tennessee	Stable
	06040005	Native	Tennessee-Kentucky	Stable
MISSOURI RIVER BASIN				
Missouri River	10030102	Native	Montana	Decreasing
Marias River	10030201	Native	Montana	Decreasing
	10030202	Native	Montana	Decreasing
	10030203	Native	Montana	Decreasing
Teton River	10030205	Native	Montana	Extirpated
Missouri River	10040101	Native	Montana	Stable
	10040104	Native	Montana	Stable
Judith River	10040103	Native	Montana	Decreasing
Musselshell River	10040205	Native	Montana	Extirpated
Milk River	10050001	Native	Montana	Decreasing
	10050002	Native	Montana	Decreasing
	10050004	Native	Montana	Decreasing
	10050012	Native	Montana	Decreasing
Missouri River	10060001	Native	Montana	Stable
	10060005	Native	Montana	Stable
Yellowstone River	10100001	Native	Montana	Stable
	10100004	Native	Montana	Stable
Bighorn River	10080015	Native	Montana	Decreasing
Wind River	10080001	Native	Wyoming	Stable
Little Wind River	10080002	Native	Wyoming	Stable
Popo Agie River	10080003	Native	Wyoming	Stable
Little Popo Agie River	10080003	Native	Wyoming	Stable
Boysen Reservoir	10080005	Native	Wyoming	Decreasing

Bighorn River	10080007	Native	Wyoming	Stable
Nowood River	10080008	Native	Wyoming	Stable
Greybull River	10080009	Native	Wyoming	Stable
Big Horn Lake	10080010	Native	Wyoming	Stable
Tongue River	10090101	Introduced	Wyoming	Unknown
	10090102	Native	Montana	Extirpated
Powder River	10090202	Native	Wyoming	Extirpated
	10090207	Native	Montana	Decreasing
	10090209	Native	Montana	Decreasing
Clear Creek	10090206	Native	Wyoming	Unknown
Lake Sakakawea	10110101	Native	North Dakota	Stable
Little Missouri River	10110201	Native	Montana-Wyoming	Unknown
	10110203	Native	North Dakota	Unknown
	10110205	Native	North Dakota	Unknown
Beaver Creek	10110204	Native	Wyoming	Extirpated
Little Beaver Creek	10110204	Native	Wyoming	Extirpated
Box Elder Creek	10110202	Native	Wyoming	Unknown
Cheyenne River	10120106	Native	South Dakota	Unknown
	10120209	Native	South Dakota	Unknown
	10120111	Native	South Dakota	Unknown
	10120112	Native	South Dakota	Unknown
Belle Fourche River	10120101	Native	Wyoming	Unknown
	10120102	Native	South Dakota	Unknown
Missouri River	10130101	Native	North Dakota	Stable
Lake Oahe	10130102	Native	North-South Dakota	Stable
	10130105	Native	South Dakota	Stable
Grand River	10130301	Native	South Dakota	Unknown
	10130302	Native	South Dakota	Unknown
	10130303	Native	South Dakota	Unknown
Moreau River	10130304	Native	South Dakota	Unknown
	10130305	Native	South Dakota	Unknown
	10130306	Native	South Dakota	Unknown
Lake Sharpe Lake Francis Case	10140101	Native	South Dakota	Stable
Bad River	10140102	Native	South Dakota	Unknown
White River	10140201	Native	South Dakota-Nebraska	Unknown
	10140202	Native	South Dakota	Unknown
	10140204	Native	South Dakota	Unknown
Missouri River	10170101	Native	South Dakota-Nebraska	Stable
Lewis and Clark Lake	10170101	Native	South Dakota-Nebraska	Stable
James River	10160001	Native	South Dakota	Unknown
	10160003	Native	South Dakota	Unknown
	10160006	Native	South Dakota	Unknown
	10160011	Native	South Dakota	Unknown
Vermillion River	10170101	Native	South Dakota	Unknown
Big Sioux River	10170202	Native	South Dakota	Unknown
	10170203	Native	South Dakota-Iowa	Stable

Rock River	10170204	Native	Iowa	Unknown
Niobrara River	10150007	Native	Nebraska	Stable
Cottonwood Lake	10150004	Introduced	Nebraska	Decreasing
Alkali Lake	10150004	Introduced	Nebraska	Decreasing
Missouri River	10230001 10230006	Native Native	Nebraska-Iowa Nebraska-Iowa	Stable Stable
Floyd Creek	10230002	Native	Iowa	Unknown
Monona-Harrison Ditch	10230005	Native	Iowa	Unknown
Maple Creek	10230005	Native	Iowa	Unknown
Boyer Creek	10230007	Native	Iowa	Unknown
Little Sioux River	10230003	Native	Iowa	Unknown
Platte River	10200203	Native	Nebraska	Stable
Pawnee Reservoir	10200203	Introduced	Nebraska	Decreasing
Willow Creek Reservoir	10220002	Introduced	Nebraska	Decreasing
Johnson Reservoir	10200101	Introduced	Nebraska	Increasing
Plum Creek Canyon Res	10200101	Introduced	Nebraska	Increasing
Gallagher Canyon Res	10200101	Introduced	Nebraska	Increasing
Midway Canyon Res	10200101	Introduced	Nebraska	Increasing
Blue Hole West Pit	10200101	Introduced	Nebraska	Stable
Phillips Canyon Res	10200101	Introduced	Nebraska	Increasing
G.I. Eagle Scout Pit	10200103	Introduced	Nebraska	Decreasing
Missouri River	10240001 10240005 10240011	Native Native Native	Nebraska-Iowa NE-Missouri-Kansas Missouri-Kansas	Stable Unknown Unknown
West Nishnabotna River	10240002	Native	Iowa	Unknown
Nishnabotna River	10240004	Native	Missouri	Unknown
Nodaway River	10240010	Native	Missouri	Unknown
Kansas River	10270104	Native	Kansas	Unknown
Perry Reservoir	10270103	Introduced	Kansas	Stable
Banner Creek Reservoir	10270103	Introduced	Kansas	Unknown
Missouri River	10300101 10300102	Native Native	Missouri Missouri	Unknown Unknown
Grand River	10280101 10280103	Native Native	Missouri Missouri	Unknown Unknown
Shoal Creek	10280201	Native	Missouri	Unknown
Blackbird Creek	10280201	Native	Missouri	Unknown
Moniteau Creek	10300102	N	Missouri	Unknown
Moreau River	10300102	N	Missouri	Unknown
Perche Creek	10300102	N	Missouri	Unknown
Osage River	10290111	N	Missouri	Unknown
Maries River	10290111	N	Missouri	Unknown
Melvern Reservoir	10290102	Introduced	Kansas	Stable
Gasconade River	10290203	Native	Missouri	Unknown
Missouri River	10300200	Native	Missouri	Unknown

LOWER MISSISSIPPI RIVER BASIN				
Mississippi River	08010100	Native	Missouri-Kentucky	Stable
	08010100	Native	Missouri-Tennessee	Stable
	08010100	Native	Arkansas-Tennessee	Stable
Hatchie River	08010208	Native	Tennessee	Unknown
Wolf--River	08010210	Native	Tennessee	Unknown
St John's Bayou	08020201	Native	Missouri	Unknown
St. Francis River	08020202	Native	Missouri-Arkansas	Unknown
	08020203	Native	Arkansas	Unknown
Mississippi River	08020100	Native	Arkansas-Mississippi	Unknown
Arkansas River	08020401	Native	Arkansas	Unknown
White River	08020301	Native	Arkansas	Unknown
	08020303	Native	Arkansas	Unknown
Mississippi River	08030100	Native	Arkansas-Mississippi	Unknown
	08030100	Native	Mississippi-Louisiana	Unknown
Mississippi River	08060100	Native	Mississippi-Louisiana	Stable
ARKANSAS RIVER BASIN				
White River	11010013	Native	Missouri-Arkansas	Unknown
Black River	11010007	Native	Missouri-Arkansas	Unknown
Current River	11010008	Native	Missouri-Arkansas	Unknown
Spring River	11010010	Native	Arkansas	Unknown
Eleven Point River	11010011	Native	Missouri-Arkansas	Unknown
Strawberry River	11010012	Native	Arkansas	Unknown
Little Red River	11010014	Native	Arkansas	Unknown
Horseshoe Reservoir	11020006	Introduced	Colorado	Increasing
Arkansas River	11060001	Native	Oklahoma	Stable
	11060006	Native	Oklahoma	Stable
Verdigris River	11070105	Native	Oklahoma	Unknown
Neosho River	11070209	Native	Oklahoma	Unknown
Webbers Falls Reservoir	11070109	Native	Oklahoma	Stable
Canadian River below Eufaula Dam	11090204	Native	Oklahoma	Stable
Illinois River below Tenkiller Dam	11110103	Native	Oklahoma	Stable
Arkansas River	11110104	Native	Oklahoma-Arkansas	Stable
R. S. Kerr Reservoir	11110104	Native	Oklahoma	Introduced
Poteau River	11110105	Native	Oklahoma	Unknown
Arkansas River	11110201	Native	Arkansas	Stable
	11110202	Native	Arkansas	Stable
	11110203	Native	Arkansas	Stable
	11110207	Native	Arkansas	Unknown

2.3 LIFE HISTORY

2.3.1 Reproduction and Recruitment

Age at maturity for saugers varies from 2 to 8 years, increasing from south to north (Carufel 1963; Vasey 1967; Gebken and Wright 1972; Carlander 1997). Although considerable variation is observed, it is thought that most male and female sauger mature at age II and age IV, respectfully (Pitlo et al. 2004). Length at maturity for either sex varies by geographic location and even by waterbody in similar areas. The Iowa Department of Natural Resources surveyed Pool 13—Upper Mississippi River—and found male sauger begin to mature at 292 mm TL and females at 330 mm TL, although some immature fish were 380 mm TL (Pitlo et al. 2004). In Lake Erie, Deason (1933) reported that male saugers were usually mature at 240 mm, while females did not begin to mature until they reached 267 mm.

During late winter, sauger begin congregating near spawning areas, with some fish making long-distance movements (Nelson 1968; Pitlo 1985; Freiermuth 1986; St. John 1990; Bulow et al. 1991; Pitlo 1992; Etnier and Starnes 1993; Pegg et al. 1997; Ickes et al. 1999; McMahon 1999; Welker et al. 2001; Jaeger et al. 2005; Kuhn 2005). For instance, a sauger tagged at Kentucky Dam was recaptured 11 days later 380 km upstream Tennessee River (Clay 1975). In the South Saskatchewan River drainage, Patalas et al. (1998) reported that one sauger moved downstream 90 miles to spawn, and then returned to near its original location within a 3-month period. Both upstream and downstream movements have been documented in other studies, with rising water temperature and discharge initiating spawning migration (Benson 1973; Hokanson 1977; Pitlo 1992; Siegwarth et al. 1993; Fryda 2002; Jaeger et al. 2005; Kuhn 2005).

Saugers belong to the simplest and most vulnerable reproductive guild of lithophils (Balon et al. 1977). Bergstedt et al. (2004) classified sauger as a lithopelagophilous spawner, which have buoyant, free-floating larvae that are carried in the water column. Adhesive eggs are broadcast and fertilized over firm substrate—sand, gravel, cobble, rubble, boulder, or bedrock—becoming non-adhesive and semi-buoyant as they water-harden, allowing wide dispersal by currents (Nord 1967; Balon et al. 1977; Pitlo 1992; Etnier and Starnes 1993; Siegwarth et al. 1993; Scott and Crossman 1998; Smith 2002; Boschung and Mayden 2004; Werner 2004; Kuhn 2005). Bart and Page (1992) noted that broadcast spawning in the large percids is the presumed ancestral mode of reproduction. This primitive mode of reproduction might account for the inability of sauger to tolerate high sedimentation and eutrophication (Leach et al. 1977). Spawning activity ranges from mid-March in the southern part of its range to early June in northern areas (Nelson and Paetz 1992; Boschung and Mayden 2004; Stewart and Watkinson 2004). Unlike walleye, which spawn in aggregations, sauger spawn in pairs or small groups (Collette et el. 1977; Roberts et al. 2003). Males arrive at spawning grounds first and are followed by females, which quickly disperse after spawning (Nelson 1968; Bulow et al. 1991; Scott and Crossman 1998; Roberts et al. 2003; Boschung and Mayden 2004). Spawning activity begins as water temperatures approach 11°C and can last for two weeks or more (Pitlo 1992; Etnier and Starnes 1993; Boschung and Mayden 2004). Sauger spawn at night, with several males attending each female (Gebken and Wright 1972; Seigwarth et al. 1993; Boschung and Mayden 2004). Nelson (1968) and Hesse (1994) reported most spawning action occurred in the first two hours following sunset, with activity decreasing through the night. The number of eggs produced by a single female varies with fish size, ranging from 9,000 to over 200,000 eggs annually (Etnier and Starnes 1993; Rohde et al. 1994; Ross 2001). No care is given to the eggs, which hatch in two to three weeks at temperatures of 9-15°C (Nelson 1968; Potter 1969; Koenst and Smith 1976; Smith 2002).

Saugers typically spawn in relatively small areas of habitat that meet their restrictive spawning requirements (Walburg 1972; Scott and Crossman 1998; Hesse 1994; McMahon 1999). Nelson (1978) reported that sauger spawned primarily, if not exclusively, in Missouri River tributaries because rock, rubble, and gravel substrates were not available along the shorelines of Lake Oahe, South Dakota. While surveying known walleye spawning locations, Rawson and Scholl (1978) discovered concentrations of mature sauger along shale bedrock ridges and sand-gravel substrate in the Sandusky River and along cobble-boulder riffles in the Maumee River, Ohio. Spawning sites have not been well documented in the Upper Mississippi River (Pitlo et al. 2004). A few locations have been associated near wing dams and side channel margins with sand substrates (Freiermuth 1986, 1987; Ickes et al. 2000). In Pool 7, sauger were found spawning over riprap in depths ranging from 1.0–4.5 feet (Gebken and Wright 1972). In Pool 13, Pitlo (1989) found sauger spawning over gravel or mussel bed substrate.

Crance (1987) described preferred sauger spawning habitat as cobble and rubble substrates (64 - 250 mm) in water with velocities ranging from 9.1 to 61.0 cm/s (0.3 to 2.0 ft/s). In a Tennessee reservoir, Hickman et al. (1989) reported sauger spawning habitat to be small, loosely imbedded gravel, with some areas dominated by large gravel, small and large cobble, and small boulders. Typically, sauger populations inhabiting large reservoirs spawn in large tributaries (Nelson 1978; McMahon 1999). For example, McMahon (1999) documented sauger spawning in the Montana portion of the Missouri River near the Milk River confluence above Lake Sakakawea, North Dakota. However, Gardner and Stewart (1987) reported that few saugers overwintered in those areas and speculated that adults migrated back to Lake Sakakawea after spawning. In a telemetry study conducted in Pool 16 of the upper Mississippi River, Siegwarth et al. (1993) determined that pre-spawn sauger used side-channel border habitats before moving to spawning habitat of shifting sand over solid bedrock, with current velocities ranging from 1.1 to 3.2 ft/sec. The Rock River was identified as the primary spawning area in Pool 16. Saugers spawned in the Ohio River on gravel and sand bars directly downstream from navigational dams (Vallazza et al. 1994). Advanced gravid sauger have been collected by Ohio Division of Wildlife electrofishing crews on gravel bars associated with the confluences of the Muskingum and Kanahwa Rivers, as well as the head and toe of Marietta and Muskingum Islands (Belleville Pool) (Schell et al. 2004).

Interestingly, Jaeger et al. (2005) reported that telemetered sauger spawned almost exclusively in main-stem habitats in Montana, whereas previous studies of sauger in the state suggested that most spawning occurred in tributaries (Penkal 1992; McMahon and Gardner 2001). Jaeger et al. (2005) reported the majority of spawning locations in the Yellowstone River were downstream from the Powder River confluence, a significant source of warm, turbid water. Similarly, Kuhn (2005) reported spawning saugers concentrated in the Little Wind River, Wyoming, downstream from the mouth of Beaver Creek, a source of warm, turbid water. Turbidity is considered an important cover type for sauger (Ali et al. 1977; Crance 1987; Welker et al. 2001, 2002; Amadio et al. 2005) and might play a substantial role in selection of spawning areas.

In a recent study of the Missouri River between Lewis and Clark Lake and Fort Randall Dam, Graeb (2006) reported sauger preferred secondary channels—despite an abundance of gravel substrate in the main channel—favoring locations with flowing water, warmer temperatures, and high physical turbidity. Though sauger historically spawned in the upper reaches of this system, near Fort Randall Dam, spawning habitat preferences shifted with the development of a delta habitat having abundant side channels, backwaters, warmer temperatures, and higher turbidities. Graeb (2006) reasoned that the delta habitat was more similar to the historical Missouri River channel (increased temperature, turbidity, active meandering, complex habitats, etc.), indicating that sauger prefer to spawn in areas with historical riverine features.

Other studies throughout the range of the species have documented spawning in both main channel habitats and tributaries (Willcock 1969; Hackney and Holbrook 1978; Nelson 1978; Siegwarth et al. 1993; Pegg et al. 1997). Several studies suggested that sauger used a broad diversity of substrates for spawning and that the relative use of any substrate type differed widely among pools of the Upper Mississippi River (Gebken and Wright 1972; Pitlo 1983; Freiermuth 1986, 1987; Brooks 1993; Siegwarth et al. 1993; Brooks and Weaver 1995; Gangl et al. 2000). The interpool variability in spawning habitat preference and availability makes it necessary to identify spawning habitat on a pool-by-pool basis (Ickes et al. 1999). Several studies documented the use of rocky substrates and bedrock reefs during the spawning season (Nelson 1968; St. John 1990; Hesse 1994; Jeffrey and Edds 1999). Other documented spawning areas include: main channel cobble-boulder riffles, side channel borders, shale bedrock ridges, bluff and terrace pools, and sand-gravel substrates (Rawson and Scholl 1978; Ickes et al. 1999; Jaeger et al. 2005); reservoir shoals, reefs, and tailwaters (Priegel 1969; Holland 1985; St.

John 1990; Stodola 1992; Stewart and Watkinson 2004); flooded riprap (Gebken and Wright 1972); sloughs, flats, and rock substrates between wing dams (Freiermuth 1986, 1987); shifting sand over bedrock (Siegwarth et al. 1993); and coarse sand, cobble, and gravel river margins (Welker et al. 2001; Kuhn 2005).

Spawning success of adult sauger is influenced by availability of spawning habitat and environmental conditions during spawning (Nelson 1968; Pitlo 1992). Benson (1968), in a review of fishery studies on six main-stem Missouri River reservoirs, noted that reproduction of bottom-spawning fishes—including sauger—was limited by substrate, wind action, and fluctuating water levels. Several studies noted the negative influence of water level fluctuation on sauger populations (Walburg 1972; Nelson and Walburg 1977; Nelson 1968). Nelson (1968b) reported that water level fluctuations in the Missouri River between Fort Randall Dam and Lewis and Clark Lake significantly influenced sauger reproductive success. Egg survival, larval abundance, and year-class strength were all higher when water level fluctuations were low. Walburg (1972) reported that water level fluctuation, reservoir water temperature, and water exchange rate accounted for 83% of the variability in adult sauger year-class strength in Lewis and Clark Lake, South Dakota. Cobble or gravel substrate, combined with stable water levels and temperatures during spawning and incubation, apparently provide optimal conditions for sauger reproduction. Thus, a combination of abiotic factors seem to influence spawning success of sauger.

Peak spawning can overlap that of walleye, and natural hybrids are known to occur (Stroud 1948; Uthe et al. 1966; Clayton et al. 1973; Nelson and Walburg 1977; Billington et al. 1988; Etnier and Starnes 1993; Ward and Berry 1995; White and Schell 1995; Van Zee et al. 1996; Billington et al. 2003; Billington et al. 2004). Billington and Palmer (2001) noted that the low level or absence of hybridization in many cases where the species co-occur suggested that either isolating mechanisms were sufficient where the two species have evolved in sympatry, or that selection against hybrids and backcrosses was likely occurring because they were less fit than the parental species. They also reported that human-induced effects tended to increase hybridization. Nelson and

Walburg (1977), who reported 10% of sauger and walleye in Lewis and Clark Lake looked like hybrids, suspected that hybridization took place because of limited spawning area and overlap of the spawning seasons. Ward (1992) reported similar hybridization rates in Lake Sakakawea, North Dakota, another Missouri River reservoir. In a study of three Missouri River reservoirs, Graeb (2006) reported natural hybridization rates ranged from 4% in Lakes Sharpe and Francis Case to 21% in Lewis and Clark Lake. In each system, hybrids comprised several year classes, indicating consistent low-level recruitment.

The physical condition of female sauger during winter and early spring can affect the quality of eggs produced, and subsequently larvae survival. Madenjian et al. (1996) showed that the lipid content of female walleye—a congener—in Lake Erie was positively correlated to recruitment success. Adequate lipid reserves accumulated only when gizzard shad, *Dorosoma cepedianum*, were abundant the fall prior to spawning. While this specific relationship has not been examined for sauger in any system, gizzard shad are a primary prey species in lower Missouri River reservoirs, and have been shown to substantially increase growth of sauger in the Ohio River during fall (Wahl and Nielsen 1985). Thus, Graeb (2006) reasoned that the availability of gizzard shad prior to spawning might influence sauger spawning success in Missouri River reservoirs.

After spawning, many variables influence the survival of sauger eggs, larvae, and juveniles (Buckmeier 1995; Graeb 2006); however, sampling constraints limit the knowledge of larval sauger in rivers (Pitlo 1992). Sampling efforts to capture larvae in the water column are difficult because larvae can occur anywhere in a river section. Pitlo et al. (2004) noted that young sauger can occur in most habitats of the Mississippi River. Biologists find them in backwater, side channel, and main channel border and tailwater habitat over substrates of silt, sand, rock, and detritus. Although sauger might seem ubiquitous, sand substrate often seems to be preferred. Interestingly, results from larval sampling might not translate into accurate predictions of age-0 abundance. For example, Steuck (2006) noted that large numbers of sauger larvae collected in drift samples during 1993 did not result in large numbers of fall fingerlings in Pools 11 and 13 of the Upper

Mississippi River. Conversely, drift samples of larval sauger collected during May 1994, 1997, and 2000 did not reflect the large sauger year classes that appeared in fall electrofishing samples. Additionally, Pitlo (2002) detected no correlation between the abundance of larval sauger in the spring drift and abundance of age-0 fish in fall electrofishing samples. Stevens (1997) assessed Lake Pepin in Pool 4 and reported that a multiple gear/multiple age-class approach reduced variability and provided reliable indices of year-class strength.

Sauger egg incubation ranges from 7 to 28 days, depending on water temperature; the higher the water temperature, the sooner the eggs will hatch (Pitlo et al. 2004). Pitlo (1998) reported that incubation lasted about 24 days when water temperatures ranged from 42–62°F. Newly-hatched larval saugers are passively transported downstream (Walburg 1972). If flows are high, larvae might be transported into areas of either higher predation or lower food availability, or in some cases, completely out of a system. For example, flushing rates of larval walleye and sauger through Gavins Point Dam were as high 700,000 fish per day (Walburg 1971). Penkal (1992) reported that virtually all sauger hatched in the Tongue and Powder Rivers, Montana, drifted to downstream areas near the mouth of the Yellowstone—a distance of up to 300 km—putting them near the headwaters of Lake Sakakawea. Fryda (2002) noted that the majority of young-of-year (YOY) sauger were sampled in the upper, more riverine reaches of Lake Sakakawea and suggested these areas were major rearing habitats. Similarly, several studies in Wyoming suggested that saugers might depend on Boysen Reservoir and not the upstream river system as nursery habitat (Amadio et al. 2005; Kuhn 2005; Lionberger 2006). As larvae grow and mature, they become demersal and occupy benthic habitats through adulthood. These juvenile (>30 mm) fish are susceptible to many sampling gears and occupy habitats that are more discrete. Because of this multifaceted early life history, sauger might be particularly at risk during the period from hatching until the late juvenile stage. Lyons and Welke (1996) reported that sauger recruitment in the Mississippi River was established during the first year of life, indicating that age-0 saugers are particularly vulnerable to habitat changes. Nelson (1968b) reported that large fluctuations in Missouri River flows exposed sauger eggs deposited in shallow water to air, resulting in reproductive failure. Pitlo (2002) showed that spring water-warming rates explained 59% of the sauger recruitment in Pool 13 of the upper Mississippi River. Similarly, Steuck (2006) documented that the abundance of age-0 sauger in Pools 11 and 13 was positively correlated to the rate of water warming from April 15 to May 5.

Historically, sauger recruitment in the Mississippi River basin has been highly variable, and the sources affecting recruitment variability are numerous and complex (Churchill 1992; Thomas 1994; Buckmeier 1995; Minnesota Department of Natural Resources 1997; Fischbach 1998; Brecka 2001; Pitlo 2001; Von Ruden 2001; Pitlo et al. 2004). Possible biotic and abiotic causes cited for low sauger recruitment have been loss of suitable spawning or nursery habitat, poor adult condition and abundance, predation on sauger eggs and larvae, tow-boat propeller mortality, water level fluctuation, high or low dam discharges, and low water temperature during spawning and larval development, and poor larval dispersal (Saylor et al 1983; Alexander 1987; Hevel 1988; Woodward et al. 1988; Hickman et al. 1990; Ickes 2000; Pitlo 2002; Pitlo et al. 2004). Ickes (2000) analyzed 36 years of sauger recruitment data from Pool 4 and found spawning stock abundance and discharge fluctuations to be significant recruitment determinants. Buckmeier (1995) reported that spring discharges affected sauger recruitment in the Tennessee River; however, results conflicted between the upper and lower river reservoirs. At Pickwick Dam—the most downstream site sampled—Buckmeier (1995) reported a strong negative correlation between spring discharges and age-1 catch rates one year later. Conversely, the author found a positive correlation in upper reaches of the river. While assessing special spring flow releases, Hickman and Buchanan (1995) found that a minimum discharge of 8,000 cubic feet per second (cfs) from Watts Bar Dam, Tennessee, positively influenced sauger reproduction, whereas a minimum discharge of 4,000 cfs had no affect. Current models suggest that February to April discharges between 8.4 x 10^9 and 15.4 x 10^9 m^3 might enhance recruitment in the Tennessee River, whereas discharges above or below this range are detrimental (Fischbach 1998). Graeb (2006) suggested that higher than average recruitment can be expected during years with warmer spring/early summer water temperatures in Lakes Sharpe and Francis Case, South Dakota, and during years when flows are reduced in Lewis and Clark Lake. Studies in other locations indicated that sauger abundance fluctuated widely and that year-class strength was likely attributable to abiotic factors (Schupp and Macins 1977; Hackney and Holbrook 1978; Thorn 1984; Steuck 2006). As noted by Pitlo et al. (2004), recruitment varies because of relationships between biotic and abiotic determinants. While biologists have minimal control over these variables, it seems that natural fluctuations provide a variable, yet sustainable, quality sauger fishery on the upper Mississippi River.

2.3.2 Feeding and Growth

Saugers are visual and primarily benthic predators. Peak activity occurs during dusk and dawn, with movement from offshore, daytime resting areas to inshore feeding areas (Carlander and Cleary 1949; Ali and Anctil 1968; Collette and Banarescu 1977; McGee et al. 1977; Swenson 1977; Wahl and Nielson 1985, Vallazza et al. 1994; Welker et al. 2002). Retinal adaptations—a highly developed tapetum lucidum—provide sauger with improved vision under reduced light conditions, allowing them to feed intermittently throughout the day in highly turbid water (Ali and Anctil 1968, 1977, 1977). Ryder (1977) stated that light is the principal factor that determines feeding behavior of sauger.

Sauger are not a highly selective piscivore and feed on a wide variety of benthic and pelagic fish in proportion to their abundance and vulnerability (Swenson and Smith 1976; Elser et al. 1977; Swenson 1977; Priegel 1983). In a food habit study, Mero (1992) showed that sauger were opportunistic feeders and keyed more on food availability rather than actively selecting for specific prey. Similarly, Parken (1996) used electivity indexes and determined that sauger were opportunistic feeders, while walleye were selective feeders. Swenson (1977) reported that sauger used demersal prey throughout the day in Lake of the Woods, Minnesota. Wahl and Nielsen (1985) reported that saugers fed on emerald shiners, *Notropis atherinoides*, during summer but switched to gizzard shad during autumn as water temperature declined. They suggested the switch to gizzard shad was attributable to their increased vulnerability to predation with cooler water temperatures. Larval sauger feed heavily on cladocerans, copepods, chironomids, and burrowing mayflies but switch as juveniles to a primarily piscivorous diet (Nelson 1968;

Etnier and Starnes 1993; Scott and Crossman 1998; Ross 2001; Boschung and Mayden 2004; Schell et al. 2004).

Adult saugers are top predators, taking a variety of fishes but also eating leeches, crayfish, and aquatic insects when fish prey is scarce (Vanicek 1964; Priegel 1969; Collette et al. 1977; McGee and Griffith 1977; Nelson and Walburg 1977; McBride and Tarter 1983; Scott and Crossman 1998; Stewart and Watkinson 2004). Fishes documented as sauger prey include: emerald shiner, black crappie (*Pomoxis nigromaculatus*), black bass (*Micropterus* spp.), gizzard shad, and threadfin shad (*Dorosoma petenense*) in Tennessee; emerald shiner, gizzard shad, river carpsucker (*Carpiodes carpio*), white crappie (*Pomoxis annularis*), orangespotted sunfish (*Lepomis humilis*), smallmouth bass (*Micropterus dolomieu*), freshwater drum (*Aplodinotus grunniens*), yellow perch (*Perca flavescens*), and fathead minnow (*Pimephales promelas*) in South Dakota; yellow perch and trout-perch (*Percopsis omiscomaycus*) in Minnesota; sauger, walleye, burbot (*Lota lota*), emerald shiner, white bass (*Morone chrysops*), freshwater drum, trout-perch, and "bait minnows" in Wisconsin; rainbow smelt (*Osmerus mordax*), goldeye (*Hiodon alosoides*), freshwater drum, white bass, common carp (*Cyprinus carpio*), paddlefish (*Polyodon spathula*) in North Dakota; alewife (*Alosa pseudoharengus*), gizzard shad, emerald shiner, freshwater drum, channel catfish (*Ictalurus punctatus*), mimic shiner (*Notropis volucellus*), bluegill (*Lepomis macrochirus*), rock bass (*Ambloplites rupestris*), white bass, least brook lamprey (*Lapetra aepyptera*) in Ohio and West Virginia; silver chub (*Macrhybopsis storeriana*) in Michigan; emerald shiner, stonecat (*Noturus flavus*), mottled sculpin (*Cottus bairdii*), longnose sucker (*Catostomus catostomus*), flathead chub (*Platygobio gracilis*, western silvery minnow (*Hybognathus argyritus*), sturgeon chub (*Macrhybopsis gelida*), and sicklefin chub (*Macrhybopsis meeki*) in Montana (Kinney 1954; Priegel 1963; Vanicek 1964; Nelson 1968; Priegel 1969; Collette et al. 1977; Elser et al. 1977; McGee and Griffith 1977; Nelson and Walburg 1977; Swenson 1977; Fitz and Holbrook 1978; Hackney and Holbrook 1978; Rawson and Scholl 1978; Gardner and Berg 1980; McBride and Tarter 1983; Wahl and Nielsen 1985; Mero 1992; Etnier and Starnes 1993; Mero et al. 1994; Scott and Crossman 1998; Ross 2001; Parken and Scarnecchia 2002;

Boschung and Mayden 2004; Derosier 2004; Schell et al. 2004; Bellgraph 2006; Wuellner et al. 2006). Though predation on centrarchids by sauger is infrequently reported in the literature, saugeyes (female walleye × male sauger) were found to reduce the abundance of small, slow-growing white crappie in an Oklahoma impoundment and black crappie in a South Dakota impoundment (Boxrucker 2002; Galinat et al. 2002).

Young sauger grow rapidly and attain over half the ultimate size in two years (Boschung and Mayden 2004). The largest growth in length occurs during the first year of life, and growth is typically faster in reservoirs than in rivers (Carlander 1950; Priegel 1963; Vanicek 1964; Vasey 1967). First-year growth and growth rate at maturity are positively correlated with temperature, suggesting that, in terms of growth, sauger respond to environmental differences consistently throughout their life cycle (Pierce et al. 2003). Although the annual growth in length decreases as the fish grow older, the annual growth in weight increases through the seventh year (Deason 1933; Carlander 1950). In the seventh year, the average increase in weight was more than the increase during the first three years combined. Southern sauger grow faster than northern sauger; however, northern sauger live longer and are able to attain the same ultimate size as southern sauger (Scott and Crossman 1998; Bratten and Guy 2002; Boschung and Mayden 2004). Pierce et al. (2003) reported sauger to be the only Missouri River benthic species that had an increasing trend in condition for all length categories from upstream to downstream.

Hassler (1957) suggested that slow rate of growth of northern sauger might be associated with increased longevity. Braaten and Guy (2002) concluded that the absence of gizzard shad at northern latitudes and their presence at southern latitudes, combined with an earlier shift to piscivory at southern latitudes, provided a basis for faster growth rates in the south. Females grow faster than males, typically exceeding the length of males after three years (Higgins 1936; Carlander 1950; Carufel 1963; Priegel 1969; Nelson and Walburg 1977; Cooper 1983). In Norris Reservoir, Tennessee, Hassler (1957) found that females grew faster than males after the first year. Similarly, Hoxmeier (2001) reported that female sauger grew slightly faster than male sauger in Pool 4 on the Upper

Mississippi River. At the same age, he found females to be about an inch longer than the males.

Saugers consume from 0.5 to 3.5% of their body weight each day over the course of a year and grow fastest from September to January (Swenson and Smith 1976; Wahl and Nielson 1985). Early literature considered 580 mm in seven years to be good growth for female sauger (Carufel 1963; Vasey 1967). Total length of saugers at sexual maturity is 250-300 mm in most locations, with females maturing at larger sizes than males (Deason 1933; Priegel 1969, Maceina et al. 1996). Sauger average 250-460 mm TL in length; however, Carufel (1963) reported a sauger of 762 mm TL from Garrison Reservoir, North Dakota. The world record sauger—3.97 kg—was caught from Lake Sakakawea, North Dakota, in October 1971 (http://www.schoolofflyfishing.com/resources/worldfreshrecords.htm).

Although some studies reported the average lifespan of sauger to be seven years (Priegel 1969; Gebkin and Wright 1972), state data vary widely. Krueger et al. (1997) captured 13-year-old sauger in Wyoming, but Schell et al. (2004) failed to collect any sauger greater than age-4 in a multi-year study on the Ohio River. It was unclear whether electrofishing surveys did not effectively sample larger fish or no larger fish were present. Pitlo et al. (2004) noted studies documenting sauger 9-10 years old from Pool 4 on the Upper Missouri River. In general, maximum age in the north seems to be about 13 years, whereas it is about 7 years in the south (Etnier and Starnes 1993; Scott and Crossman 1998; Boschung and Mayden 2004). Specific length-at-age data provided by state surveys are presented in Section 3.2.

2.4 HABITAT

Adult saugers in large rivers and lakes use a variety of habitats on a seasonal basis, but habitat preferences often vary among populations (Pitlo 1992). Saugers are typically demersal (McGee et al. 1977) and move regularly from offshore, daytime, resting areas to inshore, feeding areas at night (Wahl and Nielson 1985, Vallazza et al.

1994). Many studies suggested that adult saugers preferred habitats characterized by high turbidity, low channel slope, and deep, low-velocity pools (Crance 1987; Hesse 1994; Vallazza et al. 1994; Maceina et al. 1996; Pegg et al. 1996, 1997; Gangl et al. 2000; Welker et al. 2001, 2002; Berry et al. 2004; Amadio et al. 2005; Galat et al. 2005; Kuhn 2005; Bellgraph 2006). Several researchers reported sauger to be among the numerically dominant species in tributary confluences of the channelized lower Missouri River (Clark 1979; Dieterman et al. 1996; Braaten and Guy 1999). Their occurrence was attributed to lower velocity and turbidity compared to main channel habitats. Similarly, Lenz (2003) reported that low-velocity tributary habitats of the Ohio River contained the highest abundances and diversity of fishes, including sauger, during winter surveys.

In the Little Wind River drainage of Wyoming, Kuhn (2005) found that, throughout the year, saugers selected large, deep pools with low current velocities. Saugers selected the deepest pools available over the entire study reach and within each river segment. Similarly, Amadio et al. (2005) reported maximum depth of a habitat unit was the most important site-specific habitat feature affecting sauger occurrence. Also in Wyoming, Welker et al. (2002) reported sauger in low-velocity areas over mudflats along the Big Horn River margin, and on the downstream side of islands, during spring and summer. By late-autumn and winter, sauger moved to backwater eddies on river bends and behind physical structure (i.e., riprap, car bodies, and brush piles), where velocity was reduced. Across all seasons, Welker et al. (2002) reported sauger used more homogeneous substrates instead of areas with high heterogeneity. Although sauger showed clear selection patterns for substrate type and heterogeneity, the authors noted that substrate variables were likely secondary characteristics of low-velocity sites because low-velocity locations in the Big Horn River were typically had homogenous silt and sand substrates. Others also have reported sauger to prefer low-velocity areas dominated by silt or sand substrates (Crance 1987; Hesse 1994; Vallazza et al. 1994; Maceina et al. 1996; Pegg et al. 1996, 1997; Gangl et al. 2000; Stantec 2000; RL&L Environmental 2002a, 2002b; Amadio et al. 2005).

Bellgraph (2006) reported that sauger primarily selected pools in downstream, outside bends of the middle Missouri River in Montana. These bluff and riprap pools recruited rocky substrate, contained areas of slow water that provided velocity refuge, and had greater depths than other channel unit types. He reasoned that the positive selection of these areas might be related to the microhabitat characteristics: deep water, low velocities, and large rocky substrate as cover. Similarly, sauger in the Alberta, Canada, reach of the Milk River—a Missouri River tributary—occurred in pools containing rocky substrates (Willcock 1969).

Because the sauger is highly light sensitive (Collette et al. 1977), areas of low water clarity seem to be an important component of habitat selection. Crance (1987) speculated that turbidity might be the most important form of cover for sauger, and other studies suggested turbidity was an important delineator of habitat suitability for sauger (Nelson 1978; Nelson and Walburg 1977; Schlick 1978). In a telemetry study, Welker et al. (2002) noted that sauger left previously occupied habitats when turbidity was low and did not return until seasons of high turbidity. Deep pools provide shelter during high light conditions, as well as a velocity refuge. The depth variability in bluff and riprap pool habitats might allow sauger to adjust their depth as light intensity or turbidity changes (Amadio et al. 2005; Bellgraph 2006). Use of structure (i.e., submerged vegetation, woody debris, boulders, car bodies, riprap, and junk piles) by sauger has been observed during several studies (Kitchell et al. 1977; Valazza et al. 1994; Welker et al. 2002; Bellgraph 2006). Because velocity is reduced behind cover, the use of cover is likely related to preference for low-velocity habitat.

From 1 July 1972 to 30 June 1973, Groen and Schmulbach (1978) conducted a catch survey on the Missouri River from Gavins Point Dam, South Dakota, downstream to Rulo, Nebraska. The authors reported that 81% of all sauger harvested came from the unchannelized reaches, where sauger was the most abundant species creeled. They attributed these findings to more backwater aquatic habitat and greater habitat diversity in the unchannelized river. Similarly, Hesse (1994) reported that the highest CPUEs for larval sauger occurred in unchannelized segments.

Sternberg (1971) identified six habitat types in the pooled sections of the Upper Mississippi River: main channel, main channel border, tailwaters, side channels, river lakes and ponds, and sloughs. Pitlo and Rasmussen (2004) provided a thorough description of these habitats. Seigwarth et al. (1993) noted that sauger occurred in every reach of the Upper Mississippi River and in all of these habitats during some period of their life.

In the Upper Mississippi River of Minnesota, Gangl et al. (2000) located sauger—primarily over silt and sand substrates—in the main channel 30% of the time, and near wing dams or channel borders 25% and 23% of the time, respectively. During summer, sauger used backwater areas more frequently than other habitats. Barko et al. (2004) reported that both adult and juvenile sauger primarily used main-channel border habitats without wing dikes in the unimpounded Upper Mississippi River.

2.4.1 Reservoir Use

Saugers in regulated river systems display seasonal shifts in habitat use (Nelson 1968; St. John 1990; Bulow et al. 1991; Pegg et al. 1997; Welker et al. 2001, 2002). Because regulated systems have altered and variable flow regimes that limit the availability of preferred habitats—deep, low-velocity areas—the timing and magnitude of sauger movements might be influenced by unstable riverine habitat. For example, a rapid increase in sauger abundance in Lake Sakakawea, North Dakota, might have been partially due to movement out of the Yellowstone River (Fryda 2002). The mean annual flows of the Yellowstone River decreased substantially beginning in 1987 and might have caused significant sauger movement downstream into the lake.

Throughout their range sauger exhibits seasonal use of river reservoir habitat. In the Upper Mississippi River, sauger congregate in tailwaters to overwinter, stage prior to spawning, and to spawn (Holland 1985; Pitlo 1985; Pitlo 1992). Sauger also use reservoirs for several weeks in post-spawning periods, suggesting a recuperative period in low-velocity habitat (Pitlo 1992). With the exception of spring spawning activities, Ickes et al. (1999) reported that sauger used lake habitats in Lake Pepin, Minnesota, almost to the exclusion of all other habitat types in Pool 4.

Hackney and Holbrook (1978) noted that sauger in the Tennessee and Cumberland River systems congregated in the tailwaters of the next upstream dam beginning in late autumn and remained there through spring. The fish scattered throughout the reservoirs the remainder of the year. Pegg et al. (1997) documented a rapid downstream migration in the spring from a tailwater area to the main basin of Kentucky Lake on the Tennessee River. Some fish moved downstream more than 200 km in less than 10 days in this semiclosed system.

Similarly, Nelson (1968) described upstream movements of adult sauger from Lewis and Clark Lake, South Dakota, into the Missouri River in autumn and winter, returning to the reservoir after spawning in late spring. Nelson and Walburg (1977), in a study of South Dakota reservoirs, noted that sauger mainly used the more river-like, turbid, upper reservoir sections, which closely approximated original river habitat. Likewise, in Big Horn Lake, Yekel and Frazer (1992) reported that 75% of all sauger were caught by anglers in the upper (Wyoming) end of the reservoir, even though the majority of anglers fished the lower (Montana) end. Conversely, nearly 90% of all walleye were caught in the Montana end of the reservoir. The authors suggested that sauger and walleye were somewhat segregated, with sauger occupying the turbid, shallow, more river-like upper end of the reservoir and walleye occupying the less turbid, deep, canyon section of the reservoir. Fryda (2002) noted that, historically, the highest adult sauger catch rates have occurred in the upper half of Lake Sakakawea, North Dakota. Because sauger evolved in rivers, it is not surprising that the more turbid, river-like conditions in the upper end of reservoirs provide important habitat.

In a telemetry study on the Big Horn River, Wyoming, Welker et al. (2001, 2002) noted that individual sauger moved down into Yellowtail Reservoir during the summer; however, more sauger moved down into the reservoir during winter. At full pool, Yellowtail Reservoir flooded a large upstream area, creating low-velocity, turbid habitat used during the summer. High reservoir levels also provided low-velocity, deep-water habitat used during winter. Winter usage is consistent with studies on other river-reservoir systems (Nelson and Walburg 1977; Vallazza et al. 1994; Pegg et al. 1997; Ickes et al. 1999; McMahon and Gardner 2001; Lionberger 2006). Research on the Wind River, Wyoming, showed that larval sauger drifted downstream from riverine spawning areas into Boysen Reservoir, resided in the reservoir as juveniles, moved upstream into the river between age 4 and 5—approximate age of sexual maturity—and resided in riverine habitat afterward (Amadio 2003; Amadio et al. 2005, 2006; Lionberger 2006).

2.5 MOVEMENT

The sauger is widely regarded as the most migratory percid species in North America (Collette et al. 1977). Research documents sauger moving hundreds of kilometers in large river systems where passage is not restricted (Schoumacher 1965; Collette et al. 1977; Maceina et al. 1996; Pegg et al. 1997; Jaeger et al. 2005). For example, in the lower Tennessee River, Pegg et al. (1997) documented downstream movement of up to 276 km, while in Montana, Jaeger et al. (2005) reported the round-trip distance of the annual migration between spawning and home river locations ranged from 10 to 600 km, averaging 89.5 km. Conversely, Kuhn (2005) reported sauger in the Little Wind River drainage, Wyoming, to be relatively sedentary, making only short (10 km average) and infrequent movements compared to sauger in large river systems. Preferred habitats—deep pools with low current velocities—were abundant throughout the Little Wind River drainage, and sauger did not need to move far from summer and autumn locations to over-wintering or spawning areas. During autumn and winter, saugers were sedentary, moving only short distances between pools of close proximity. Longer movements—both upstream and downstream—occurred during spring spawning migrations. In general, long pre-spawn and post-spawn movements (Bulow et al. 1991; Penkal 1992; Ickes et al. 1999; Welker et al. 2001), reduced movement from late summer through winter, and short, secondary movements to winter locations (Penkal 1992; Vallazza et al. 1994; Ickes et al. 1999; Welker et al. 2001) characterize sauger migration patterns.

While Kuhn (2005) reported that sauger in the Little Wind River drainage, Wyoming, moved only short distances, Welker et al. (2001) noted longer movements—maximum of 146 km, mean of 45 km—in the Big Horn River system. Interestingly, Kuhn (2005) reported that, after spawning, most sauger returned to the exact pool of autumn residence. Likewise, two Montana studies documented strong site fidelity after the migratory season (Jaeger et al. 2005; Bellgraph 2006). Jaeger et al. (2005) reported that all telemetered saugers reoccupied individual home-location habitat units, and 73% used the same individual habitat unit used during the previous year. Bellgraph (2006) documented sauger returning to the same Missouri River reach where they were caught and tagged the previous year, with many fish returning to the exact channel unit where they were tagged.

In Montana, middle Missouri River and Yellowstone River sauger both exhibited long downstream migrations (up to 245 km in the Missouri River and 300 km in the Yellowstone River) prior to the presumed spawning period and returned back upstream after spawning (Jaeger et al. 2005; Bellgraph 2006). The similarity of sauger movement in the middle Missouri and Yellowstone Rivers suggests that anthropogenic moderation of middle Missouri River discharge has not greatly affected sauger migratory behavior; however, historical migratory patterns of middle Missouri River sauger are not completely known (Bellgraph 2006). Sauger in both rivers also migrated to river reaches with similar geological features. In the middle Missouri River, sauger used a section of river in the Judith River Geologic Formation, which forms resistant ledges, while sauger in the Yellowstone River selected the Tullock and Lebo Members of the Fort Union Formation, which form bedrock outcrops (Jaeger et al. 2005; Bellgraph 2006).

While seasonal migrations of sauger in the middle Missouri and Yellowstone Rivers were similar in length and direction, they differed from other systems (Siegwarth et al. 1993; Pegg et al. 1997; Gangl et al. 2000). Sauger in Pool 16 of the Mississippi River also migrated downstream to spawning sites (Siegwarth et al.1993), but migrations were shorter (i.e., 5 to 10 km) than sauger movements in Montana. Conversely, sauger in Pool 2 of the Upper Mississippi River migrated upstream and into the Minnesota River during the spawning period (Gangl et al. 2000). Radio telemetry and tagging studies have been widely used in the Upper Mississippi River to track sauger spawning movements (Pitlo et al. 2004). Ickes et al. (2000) reported sauger traveled long distances to staging areas in Pool 4, both from upstream and downstream locations. Also in Pool 4, Thorn (1984) observed sauger making upstream movements during the spring. Spring movements into tributaries—Minnesota, Volga, Turkey, and Wisconsin Rivers—have been documented from various pools (Boland and Ackerman 1982; Gangl et al. 2000). For example, Gangl et al. (2000) reported sauger traveled into the Minnesota River from Pool 2, with the greatest upstream movement 90 km.

While saugers historically migrated upstream to spawning reaches, construction of locks and dams on the Mississippi River and all of its major tributaries impedes much of this movement, resulting in large congregations of sauger in tailwater areas throughout the basin. However, studies of the Upper Mississippi River system have documented sauger presence in, and movement through, navigational lockages (Boland and Ackerman 1982; Bertrand and Sallee 1985; Marecek and Wlosinski 1996; Johnson et al. 2005; Keevin et al. 2005). In a review of 126 studies examining fish movement on the Upper Mississippi River, Marecek and Wlosinski (1996) found 10 studies on sauger movement. Of 7,203 marked sauger, 1,120 were recaptured, with 16% having moved past a dam, the majority moving upriver (91%). Boland and Ackerman (1982) recovered 21% (Pool 11) and 17% (Pool 13) of tagged sauger outside the tagging pool. Most fish moved upstream, and the average distance was 95 km for Pool 11 and 115 km for Pool 13. Bertrand and Sallee (1985) marked 1,323 saugers from 1981 to 1983 in the tailwaters of Dams 16, 17, and 18. They recaptured 142 saugers, with more than half of those fish coming from pools upriver of where they were originally tagged. However, the authors presented information showing that fish passage probably occurred when dam gates were out of the water.

Likewise, several studies on the Tennessee River documented that saugers migrated through navigation locks (Hackney and Holbrook 1978; Ridley 1980; Hevel 1988; Scott and Hevel 1991; Pegg 1994; Pegg et al. 1996). In a tagging study on the

Tennessee River, Maceina et al. (1996) reported that sauger moved as far as 366 km, and movements greater than 100 km were common. In a radio-telemetry study on the Tennessee River, Pegg et al. (1997) reported that sauger moved up to 277 km, with an average linear range of 67 km. Cobb (1960) noted that many sauger apparently migrated into the Tennessee River system from the Ohio River. In Montana, Helfrich et al. (1999) suggested that sauger passage on the middle Yellowstone River was feasible at individual dams during high flows. Similarly, Jaeger et al. (2005) observed sauger movements past all dams on the Yellowstone River except Huntley Diversion. Consecutive relocations immediately below dams were rare, indicating the absence of passage delays. In an Ohio River study, most of the 539 sauger tagged were recovered in the same pool where they were tagged (Schell et al. 2004). Movement was primarily upstream and limited to one or two pools, but some fish were recovered seven pools upstream from where they were tagged.

2.6 REASONS FOR DECLINE – LIMITING FACTORS

2.6.1 Physical Habitat Alterations

A highly migratory nature (Collette et al. 1977; Penkal 1992; Pegg et al. 1997), propensity to spawn in only a few areas (St. John 1990; Penkal 1992), and reliance on a wide variety of habitats with natural temperatures and turbidities throughout their life history (Penkal 1992; Hesse 1994; Amadio et al. 2005) combine to make sauger sensitive to habitat fragmentation and alteration (McMahon 1999). Though specific causative mechanisms contributing to sauger declines are poorly understood, the detrimental effects from operation of impoundments, range-wide habitat degradation and fragmentation, and climatological variation were the general premises of many studies (Rawson and Scholl 1978; Hesse and Mestl 1985; Hesse 1994; Pegg et al. 1997; McMahon and Gardner 2001). Migration barriers, loss of spawning habitat, climate conditions, changes in flow regimes, entrainment in irrigation canals, overexploitation—particularly at times of aggregation—plus interspecific competition and hybridization with walleye are some factors suspected of contributing to declining sauger populations, but speculation has been common due to a general lack of information (Jaeger et al. 2005; Bellgraph 2006; Graeb 2006).

Habitats of the once free-flowing Missouri, Mississippi, Ohio, and Tennessee River systems—historical sauger strongholds—have been fragmented by multiple dams that alter physical habitat characteristics, flow regimes, and water quality. For example, construction of dams along the upper Missouri River has transformed a once turbid river with highly variable flows into a series of large reservoirs, with regulated flows in unimpounded segments (Kuhn 2005). Impoundment and subsequent flow management have isolated sauger from important spawning and rearing habitats, reduced turbidity and temperature, and altered the timing and magnitude of the hydrograph from the natural regime in which saugers evolved (Hesse 1994; McMahon and Gardner 2001). For example, Fryda (2002) noted that flows in the Garrison Reach of the Missouri River—located between Lake Sakakawea and Lake Oahe, North Dakota—were entirely regulated by releases from Garrison Dam. Warm, turbid water that characterized the natural Missouri River was replaced by releases of cold, clear water, resulting in a decline in sauger abundance and an increase in walleye numbers. Nelson and Walburg (1977) attributed declines in sauger abundance in three Missouri River reservoirs in South Dakota to decreasing turbidity levels during the first 10 years of impoundment. By contrast, the high turbidity and more riverine conditions of Lewis and Clark Lake continued to support good populations of sauger (Nelson and Walburg 1977).

McMahon and Gardner (2001) reported a clear association between low river flows and low reservoir water levels and a substantial decline in sauger populations throughout Montana in the late 1980s. The declines in Montana and North Dakota initially were attributed to an extreme drought—and subsequent reduction in tributary flows and reservoir levels—lasting from the late 1980s to early 1990s (Fryda 2002). The failure of populations to rebound when normal flows and water levels returned prompted comprehensive reviews of sauger status throughout Montana (McMahon 1999) and North Dakota (Fryda 2002). The review by Fryda (2002) noted that, along with the drought, other factors, such as a rainbow smelt die-off, a population dominated by large individuals reaching the end of their longevity, and angler exploitation of the aging population, might have contributed to the decline of sauger in Lake Sakakawea.

Similar patterns were observed in other sauger populations where abundance was positively correlated with river flows and reservoir water levels (Nelson 1968; Fischbach 1998). Fluctuating flow can expose sauger eggs, causing desiccation and reproductive failure. Nelson (1968) noted that water level fluctuations caused by the operation of Fort Randall Dam intermittently exposed large areas of spawning habitat. Because sauger spawned when water levels were at a maximum, the harmful effects of fluctuating water levels increased. Walburg (1972) attributed more than 80% of the variation in year-class strength of Lewis and Clark Lake sauger to water level changes over spawning grounds, mean June reservoir water temperature, and reservoir volume exchange rate. Reduced river flows restrict downstream transport of sauger larvae, eliminate side channel rearing habitat, and decrease prey fish availability (Nelson 1968; Nelson and Walburg 1977; Gardner and Berg 1980; Penkal 1992; Hesse 1994; Kuhn 2005).

Likewise, Hesse and Mestl (1987) modeled the timing and volume of discharge from Fort Randall Dam with an index of year-class strength. They demonstrated significant negative relationships between artificial flow fluctuations in the spring and poor year-class development for eight species of fish, including sauger. Hesse (1996) reported that the sauger population declined when Missouri River flows in the spring fluctuated greatly for electrical power peaking or were low because water was being stored in upstream reservoirs. Sudden changes in discharge and flow changed water temperature, depth, velocity, and clarity, causing sauger to cease spawning.

Migration barriers create discontinuity in a system where migratory fish, such as sauger, have evolved to benefit from the river's continuity. Their highly migratory nature and tendency to spawn in only a few areas make sauger particularly vulnerable to habitat fragmentation from migration barriers (McMahon and Gardner 2001; Kuhn 2005). Because upstream movement is often associated with spawning migrations (Vallazza et al. 1994; Ickes et al. 1999; Gangl et al. 2000), barriers might force sauger to spawn in unsuitable downstream habitats (Maceina et al. 1996; Pegg et al. 1997). Six main-stem, low-head irrigation diversion dams on the Yellowstone River, Montana, were suspected to individually or cumulatively restrict sauger movement (Graham et al. 1979; Swedberg 1985; Helfrich et al. 1999), impeding recovery by limiting access to seasonally important habitats (McMahon 1999). Although, Jaeger et al. (2005) reported that diversion dams did not seem to significantly restrict the movements of adult saugers, Welker et al. (2001) related the absence of sauger in a reach of the Big Horn River, Wyoming, to habitat fragmentation by a series of five irrigation diversion dams between Thermopolis and Worland that impeded upstream movement of sauger. Consequently sauger did not occur in this river section, although they were common from the lowermost diversion dam down to Yellowtail Reservoir, a reach where access was unimpeded. Welker et al. (2001) provided anecdotal evidence from Simon (1951) that, prior to construction of a dam below the present-day site of Boysen Dam, thousands of sauger were caught annually by anglers as far as 97 km above the dam site. During the time the dam blocked the river channel to migration of fish, sauger were rarely caught above it. Following removal of the dam, sauger were again caught by anglers. Welker et al. (2001) suggested that sauger once migrated from the Big Horn River upstream to the Wind River above Boysen Reservoir, but historical migration routes have been altered by construction of impoundments and irrigation diversion dams. In the Wind River watershed, Wyoming, Amadio et al. (2005) reported that the upstream boundaries of sauger distribution were affected by constructed barriers to upstream movement. St. John (1990) noted that the decline of sauger in the upper Tennessee River system followed the loss of an important spawning tributary blocked by a dam.

Habitat degradation associated with dewatering and with channel modifications related to irrigation development was identified as the primary factor adversely affecting sauger in Wyoming and Montana (Bergstedt et al. 1993; Bergstedt and Bergerson 1997; Hiebert et al. 2000; Jaeger 2004). Periodic sluicing of sediments deposited upstream of an irrigation diversion resulted in extremely high levels of suspended solids downstream and decreased fish condition on the Little Wind River Reservation (Bergstedt et al. 1993; Bergstedt and Bergerson 1997). Hiebert et al. (2000) noted that 67,000 sauger, most of which were juveniles, were annually entrained in Intake irrigation diversion canal, lower Yellowstone River, Montana. Additionally, in Montana, sufficient flows for sauger to spawn did not occur in the Tongue River—a Yellowstone River tributary—in 19 of the 24 years from 1980 to 2003 because of dewatering for irrigation (Jaeger 2004). Preservation of natural fluvial processes and upstream mobility of fish might be the single greatest habitat management need for maintaining sauger populations in the Wind River watershed and other small river systems (Amadio et al. 2005). Additionally, Amadio et al. (2005) identified mean summer water temperature as the most important drainage-scale habitat feature limiting sauger range in the Wind River system of Wyoming.

Since the onset of channelization and impoundment, Missouri River sauger populations have been reduced by as much as 98% in some areas (Hesse 1994). Channelization reduces off-channel habitats used as feeding, resting, and nursery areas (Gardner and Berg 1980; Hesse 1994; Kuhn 2005). Funk and Robinson (1974) documented a 50% loss in water surface area and decreased numbers of side channels and backwaters—habitats considered critical for sauger populations—due to channelization of the lower Missouri River. Accordingly, Groen and Schmulbach (1978) reported that 81% of all saugers harvested came from the unchannelized river, where sauger was the most abundant species creeled. Similarly, Berry et al. (2004) noted higher catch rates of sauger in the least-altered zone of the Missouri River than in the inter-reservoir or channelized zones. Along with channelization, Seigwarth et al. (1993) noted that pre-spawn habitats were limited in Pool 16 of the Mississippi River by extensive shoreline development in tailwater habitats. The authors recommended avoiding further development or channel maintenance activities and enhancement of these critical habitat areas to help ensure the long-term protection of existing sauger populations. Hesse (1994) stated that recovery of native sauger stocks in the Missouri River will require a complete cessation of harvest, recovery of the natural hydrograph, recovery of sediment transport, recovery of snags and organic-matter dynamics, and reconnection of cut-off side-channel morphology.

2.6.2 Mortality and Exploitation

Though sauger were thought to be a lightly exploited species (≤10% annual rate) in many parts of their range (Carlander 1950; Cobb 1960; Hickman et al. 1990), other studies showed rates of mortality and exploitation ranging from 10% to 88% (Nelson 1969; Nelson and Walburg 1977; Fitz and Holbrook 1978; Hackney and Holbrook 1978; Thorn 1984). Schell et al. (2004) suggested that Ohio River sauger suffered high rates of natural or angling mortality or a combination of both. Mortality estimates were calculated only between ages 1 and 2 because older fish were poorly represented in their surveys. Over a five-year study, total annual mortality ranged from 63% to 98% for five studied tailwaters. Their total annual mortality estimate from 2002 autumn electrofishing data for fish collected during the period of highest angler harvest (November and December) was 79%. Based on these data, Schell et al. (2004) concluded that, though abundant, the Ohio River sauger population had truncated size and age structures and high mortality indicative of overharvest.

Multiple studies noted that excessive exploitation might be responsible for sauger declines. Sauger are most vulnerable to angling when they congregate below dams during late autumn and early spring in low-velocity water associated with current breaks (Hackney and Holbrook 1978; Pitlo et al. 2004; Schell et al. 2004). Range-wide declines in abundances, and the collapse of several sauger fisheries, have been attributed to overexploitation of these congregations (Nelson 1969; Hesse 1994; Pegg et al. 1996; Maceina et al. 1998). In some areas, overexploitation might occur because of the seasonal aggregations of entire stocks in discrete spawning areas (St. John 1990; Penkal 1992) and a migratory behavior that might result in unusually high concentrations of sauger at dams and diversion structures (Nelson 1969; Hesse 1994; Pegg et al. 1996). Some states have implemented a seasonal sauger fishery to reduce overexploitation. For example, Iowa closed the Bellevue tailwater (Pool 13) to fishing from December 1 through March 15 to decrease the total annual mortality of sauger from 80-85% down to near 50% (Steuck 2006). Conversely, Jaeger et al. (2005) reported that exploitation occurred primarily in early spring and late autumn, was low annually (18.6%), and was not related to aggregation.

In the lower Tennessee River, Pegg et al. (1996) documented annual exploitation rates of 50%. Upstream in Alabama, Maceina et al. (1998) reported that sauger was harvested at too high a rate before reaching their full growth potential. Modeling a 356-mm minimum size limit with natural annual mortality rates of 25% and 40% increased yield at exploitation rates ranging from 30% to 80% when compared with no size limit. Maceina et al. (1998) suggested that length limits combined with a reduced creel limit would allow more saugers to realize their full growth potential. Additionally, they noted that saugers mature at about 300 mm TL, and the size limit would protect these fish from harvest. Hackney and Holbrook (1978) noted that excessive exploitation might be responsible for high mortality rates in the Tennessee River system. Buckmeier (1995) reported that age-3 and older sauger were rare—0-3% of the number collected—in the lower Tennessee River, where exploitation was high (32-60%). In the upper Tennessee River, where angling pressure was lower, sauger sometimes comprised up to 25% of the total number collected. Pegg (1994) reported greater than 40% exploitation of sauger in Kentucky Lake in Kentucky and Tennessee. Studying sauger in the tailraces of Guntersville, Wheeler, and Wilson dams along the Tennessee River in Alabama, Maceina et al. (1998) found that total annual mortality between age-1 and age-2 fish was high, ranging from 64% to 83%. They noted that age-1 and age-2 sauger averaged about 270 and 350 mm TL, respectively, and that sauger anglers routinely harvested fish at age-1. The average adjusted—corrected for nonreported tags—exploitation rate ranged from 28% to 89%. The authors concluded that data on both age and size-structure and on total and fishing mortality, indicated that sauger exploitation was high.

Both natural mortality and angler exploitation have been estimated for sauger on the Mississippi River. Thorn (1984) estimated total annual mortality in Pool 4 ranged from 59% to 63%, with angler exploitation accounting for 38%, while natural mortality accounted for 21-25%. Furthermore, Thorn (1984) noted the largest increase in sauger abundance coincided with the initiation of continuous fishing—from previous years having a closed season during spawning—in Pool 4 of the Upper Mississippi River. Over a 15-year period (1967-1981), sauger populations fluctuated widely; however, fluctuations seemed unrelated to fishing pressure and were attributed to abiotic factors.

During a nine-year study, Pitlo (2001) reported total annual mortality averaged 80% for Pool 11 and 65% for Pool 13. His angler exploitation rates averaged about 18%. Steuck (2006) noted that total annual mortality in Pools 11 and 13 of the Upper Mississippi River ranged from 47% to 94% during a 14-year period, 1992-2005. In a study of the same area, Boland and Ackerman (1982) reported a range of 56% to 67% total mortality. Radio-telemetry studies by Pitlo (1984) indicated that some radio-tagged sauger never move into tailwaters; however, it is unknown what proportion of the sauger population moves into tailwaters and if those numbers vary annually. Consequently, Steuck (2006) noted that tailwater population estimates were not a reliable indicator of pool-wide sauger populations and should not be used to estimate exploitation.

Boland (1990) reported 2% initial mortality for two walleye/sauger tournaments on the Mississippi River. For one of the tournaments, estimated delayed mortality was 44% for tournament-caught fish held in nets for five days. On the Lake Winnebago system, Hoffman et al. (1996) estimated high initial mortalities for three walleye/sauger tournaments: 48%, 34%, and 80%. Additionally, they estimated delayed mortalities—within one week of release of tagged fish—at 18%, 9%, and 0%. The authors suggested that tournament mortality might be reduced by holding tournaments when water is cool, by limiting stress on fish (e.g., requiring aeration of live wells and holding tanks, and avoiding large temperature changes) and by limiting catch (e.g., restricting creel limits, fishing time, and angler participation; increasing size limits; and establishing a "catch-measure-release" procedure).

To address concerns with snagging on the Tennessee River system, Bettoli et al. (1999, 2000) assessed hooking mortality of sauger in Kentucky Lake and Watts Bar Reservoir. They concluded that the use of stinger hooks did not increase the rates of foul-hooking and wounding. Also on the Tennessee River system, Timmons et al. (1989) reported that sauger constituted 57% of the incidental catch in small mesh—76 mm and 89 mm—commercial gill nets in Kentucky Lake, Kentucky and Tennessee. Incidental catch of sauger decreased as mesh size increased. Timmons et al. (1989) estimated an overall incidental sportfish catch of 2.1 fish/1,000 m of net, concluding that commercial fishing did not pose a threat to sauger populations.

2.6.3 Biological Interactions

Bellgraph (2006) suggested that similar use and selection of habitats indicated sauger and walleye have the potential to compete in the middle Missouri River, although habitat use was only assessed during the non-migratory season. Competition during the non-migratory season might be high because low discharge limits the amount of available habitat and confines sauger and walleye to a smaller area. Bellgraph (2006) also suggested that increased water temperature might increase the metabolic rate and, thus, increase the demand for food. Combined low discharge and higher water temperatures might lead to competition potential for food resources. Accordingly, diet overlap between sauger and walleye was high during the spring and summer; however, similar relative weight fluctuations suggested that neither species was having negative effects on the other (Bellgraph 2006). Diets of sauger and walleye were also similar in other systems where they were sympatric (Priegel 1963; Swenson and Smith 1976; Fitz and Holbrook 1978; Mero 1992), though diet differences also have been observed (Rawson and Scholl 1978). Staggs and Otis (1996) reported that the more abundant walleye had a strong negative influence on first-year sauger growth in Lake Winnebago, Wisconsin. While both predators grew better in years of high prey abundance, the authors speculated that competition for limited zooplankton or fish food sources occurred in some years. Sauger and walleye were assumed to be competing for food resources during June and July in Lake of the Woods, Minnesota, based on resource overlap and low prey availability (Swenson and Smith 1976). Competition then decreased in August and September as prey abundance increased and sauger and walleye were spatially separated (Swenson and Smith 1976).

Non-native predators other than walleye also might potentially compete with sauger in the middle Missouri River (McMahon and Gardner 2001; Gardner 2005; Bellgraph 2006). Smallmouth bass are non-native to the middle Missouri River and were first recorded in sampling surveys in 1993. Smallmouth bass replaced sauger as the most common top predator in the Tongue and upper Missouri Rivers following impoundment and the resultant decrease in turbidity and alteration of the natural hydrograph (McMahon and Gardner 2001). Relative abundance of smallmouth bass below Morony Dam, Montana, increased to 19.2 fish per hour in 2003 and might have contributed to further competition for resources with sauger (Gardner 2005). Additionally, northern pike (*Esox lucius*), rainbow trout (*Oncorhynchus mykiss*), and brown trout (*Salmo trutta*) were also present in the middle Missouri River at low abundances (Gardner 2005), potentially competing with sauger for resources. At present, the impacts of these non-native predators are unknown. In Lake Erie, Schaefer and Margraf (1987) documented white perch (*Morone americana*) predation on walleye eggs. Though there was no evidence that egg predation affected recruitment, and there is no evidence of predation on sauger eggs, white perch—an Atlantic coast native—have been introduced into and are expanding in the Mississippi River basin. In a study of anti-predator behavior of larval walleye and saugeye, Quist and Guy (2004) reported saugeye five to seven days old to be responsive—rapid swimming—to simulated predator attack, while walleye showed little response. Though no saugers were available for this study, the authors suggested that saugers might have historically contended with multiple predators at all stages of ontogeny and evolved strong anti-predator behaviors relative to walleye.

Kuhn (2005) reported that American white pelicans (*Pelecanus erythrorhynchos*) preyed on sauger during spring. A 1,045-g female sauger was taken from a spawning area during mid-May, suggesting that predation by American white pelicans during times of spawning concentration might be a source of mortality in the Little Wind River, Wyoming.

2.6.4 Hybridization

Sauger hybridize naturally with walleye in many river systems (Stroud 1948; Nelson and Walburg 1977; Trautman 1981; Billington et al. 1988; Flammang and Willis 1993; Van Zee et al. 1996; Leary and Allendorf 1997; Billington and Koigi 2004;

Billington et al. 2004a; Billington et al. 2005; White et al. 2005; Billington et al. 2006; Graeb 2006) and artificially under experimental conditions (Nelson 1968; Hearn 1986). Natural hybrids between walleye and sauger were first reported in 1948 from Norris Reservoir, Tennessee, and hybrids between walleye and sauger, in particular saugeye (female walleye × male sauger) have been crossed by fish culturists since 1968 and used in stocking programs (Stroud 1948; Hearn 1968). Hybridization between naturally sympatric sauger and walleye populations seems to be rare (Clayton et al. 1973; Billington et al. 1988; Ward et al. 1989; Todd 1990). However, human-induced changes to aquatic systems—dams and diversions—and factors related to management practices (e.g., walleye or hybrid stocking, escapes from hatcheries, over fishing) often result in increased hybridization and introgression (Ward 1992; White and Schell 1995; Billington and Palmer 2001). For example, Billington and Palmer (2001) reported hybridization levels <2% in naturally sympatric populations but up to 70% in altered systems. Although factors influencing the extent of walleye introgression with sauger are poorly understood (McMahon and Gardner 2001), reduction of spawning habitat, possibly mediated by reservoir management, is thought to exacerbate hybridization (Nelson and Walburg 1977).

Hybridization is widespread in the Mississippi River basin. Recently, Billington et al. (2006) documented hybridization rates from 0% to 22% in the Montana portion of the Missouri River drainage, 0% to 4% in the Yellowstone River drainage, and 20.4% in Lake Sakakawea, North Dakota. Earlier studies documented hybridization rates of 14% in the Yellowstone River (Leary and Allendorf 1997) and 10% in Lake Sakakawea (Ward 1992). Downriver in South Dakota, Graeb (2006) documented hybridization rates that varied from 4% in Lakes Sharpe and Francis Case to 21% in Lewis and Clark Lake. Hybrids comprised several year classes in each system, indicating that hybridization did not occur in erratic pulses, but rather at a consistent, low-level recruitment rate. A previous study noted 10% hybridization with walleye in Lewis and Clark Lake (Van Zee et al. 1996). Multiple studies confirmed past hybridization events and hybrid reproduction in Ohio River percid populations (White and Schell 1995; Kassler and Phillip 2000, 2001; Schell et al. 2004). Other studies documented natural hybridization in the Illinois River (Billington et al. 1997) and Tennessee River (Stroud 1948; Fiss et al. 1997).

Hearn (1986) reported that their F1 hybrids produced F2 hybrids and also backcrossed to both parental species. Many studies have shown that morphological characters are unreliable to identify among sauger, walleye, and their hybrids (Flammang and Willis 1993; Ward and Berry 1995; White and Schell 1995; Van Zee et al. 1996; Billington et al. 1997; Fiss et al. 1997; Leary and Allendorf 1997; Kassler and Phillip 2000; Billington et al. 2003; Schell et al. 2004; Billington et al. 2006). For example, Billington et al. (2004a) reported that hybrids were grossly underestimated by morphology. In their study of Lewis and Clark Lake, South Dakota, 39% of fish identified as walleye had sauger alleles, while 9% of fish identified as sauger by morphology had walleye alleles. Overall, 23% of the fish were misidentified by morphological examination. While several external morphological characteristics distinguish sauger from walleye, first generation (F1) hybrids tend to be intermediate for these characteristics, often expressing features of both parental species (Van Zee et al. 1996; Billington et al. 2004a). Accordingly, backcrosses of F1 hybrids to either of the parental species are more difficult to detect by morphological criteria, because they tend to resemble one of the parental species. Therefore, it can be difficult to separate hybrids from their parental species by morphological criteria, especially if backcrossing has occurred (Billington et al. 2004a). In Montana, Leary and Allendorf (1997) reported that while 98% of genetically pure walleye and sauger were correctly identified, only 9% of hybrids were correctly identified as saugeye. The authors suggested that introgression of introduced walleye genes into native sauger populations was largely the cause of misidentification of sauger and hybrids as walleye during walleye spawning operations. Kassler and Phillip (2000) reported that only 36% of Ohio River fish field-determined as saugeye, were correctly identified. They noted that visual identification of the three *Sander* spp. can be difficult, with mistakes in all possible directions.

As noted by Billington et al. (2004a), this has important implications for management agencies that use wild fish for brood stock in supplemental stocking programs. They recommend that to maintain the genetic integrity of the fish produced, especially if they are to be stocked into other water bodies, it is essential that potential broodfish of both *Sander* species be screened by protein electrophoresis prior to their being spawned where they co-occur or in drainages where hybrid saugeye have been stocked. Ward and Berry (1995) warned that the potential exists to seriously impact the genetic integrity of recipient natural populations following stocking, because a few hybrids or backcrossed individuals accidentally included as broodfish can result in the production of many hundreds of thousands of fry and fingerlings containing foreign alleles. Bellgraph (2006) noted the potential threat to sauger conservation by diluting genetic purity and masking advantageous traits that allow adaptation to their native environment. Given the highly migratory nature of sauger, stocked hybrids could easily interact with genetically pure populations in other river reaches. To protect sauger populations, several suggestions are offered in the literature: genetic analysis of broodfish in agency culture programs (Ward and Berry 1995; Billington and Palmer 2001), eliminate saugeye stocking in areas where self-sustaining parental populations occur (Schell et al. 2004), and remove pure walleye and hybrids from native sauger waters (Bellgraph 2006; Billington et al. 2006).

2.7 ECOLOGICAL IMPORTANCE

The sauger is an important recreational sportfish species throughout the major river systems of the Mississippi River basin (Bettoli 1998; Berry and Young 2001; Pitlo et al. 2004; Schell et al. 2004). Additionally, sauger plays an important role in the fish community. In a survey of lakes containing percid populations, Clady (1978) found that fish community structure was more diverse in lakes where sauger were well established. As a top, native predator, they can have marked influence on community structure. For example, Mero (1992) reported paddlefish to be seasonally vulnerable to sauger predation. Mero et al. (1994) noted that sauger might prey on a substantial number of paddlefish, potentially influencing the success of Lake Sakakawea paddlefish stocking. Kuhn (2005) noted that Wyoming sauger are genetically pure (Krueger et al. 1997;

Amadio et al. 2005) and have a high conservation value in light of population declines in other areas of the native range of the species.

Moreover, sauger are a known fish host for the following freshwater mussel species: slippershell, *Actinonaias carinata*; mucket, *A. ligamentina*; threeridge, *Amblema plicata*; butterfly, *Ellipsaria lineolata*; plain pocketbook, *Lampsilis cardium*; Higgins eye, *L. higginsii*; pink mucket pearly mussel, *L. orbiculata*; pocketbook, *L. ovata*; fatmucket, *L. siliquoidea*; white heelsplitter, *Lasmigona complanata*; black sandshell, *Ligumia recta*; washboard, *Megalonaias gigantea*; sheepnose, *Plethobasus cyphyus*; monkeyface, *Quadrula metanevra*; fawnsfoot, *Truncilla donaciformis*; and deertoe, *T. truncata* (Fuller 1974; Watters 1994; Kyhm and Layzer 2000; Hove and Kapuscinski 2002). Kyhm and Layzer (2000) documented sauger as the most suitable host for black sandshell of seven fish species tested. They related that the decline and low abundance of black sandshell in many rivers was concurrent with a decline in sauger runs. For example, black sandshell were rare in the Clinch River above Norris Reservoir, and the Licking and Green Rivers where sauger were present in low numbers (Kyhm and Layzer 2000). In contrast, sauger were relatively abundant below Pickwick Dam on the Tennessee River, where black sandshells were common.

3.0 STATE SURVEY RESULTS

The Watershed Institute (TWI) conducted a survey of 28 MICRA states to determine the current status and management actions affecting sauger. TWI contacted state fishery supervisors to identify the biologist(s) having specific sauger management responsibilities and sent electronic survey forms to the appropriate individual(s) within each state. Specifically, TWI solicited the following information:

- Current distribution, noting water body and habitat type.
- Strategies implemented to manage sauger.
- Effectiveness of implemented strategies.
- Equipment and procedures used to monitor sauger populations.
- Life history data.
- Importance to the state's sport fishery.
- Research conducted on sauger populations.

Twenty five of 28 states returned completed surveys. Two of the 25—Georgia and Texas—reported that sauger either did not occur in their state or that they did not occur in the Mississippi River basin tributaries. While Georgia has introduced sauger to the Savannah River basin—Atlantic Ocean drainage—their portion of the Mississippi River basin is composed of moderately high-elevation streams containing trout and other cold/cool water fishes. Texas reported that sauger were historically present in the Red River, along the Texas-Oklahoma border. However, fishery managers in the area (originally employed in 1971) have never encountered the species. A single stocking in 1985 (Lake Belton, central Texas) failed. To gather sauger information on the non-reporting states, TWI used published literature (research reports, field guides, and fish distribution atlases) and websites (state natural resource agency and GAP programs) specific to the state. Appendix B contains all surveys received from MICRA states. The following sections summarize information reported by each state.

3.1 CURRENT DISTRIBUTION

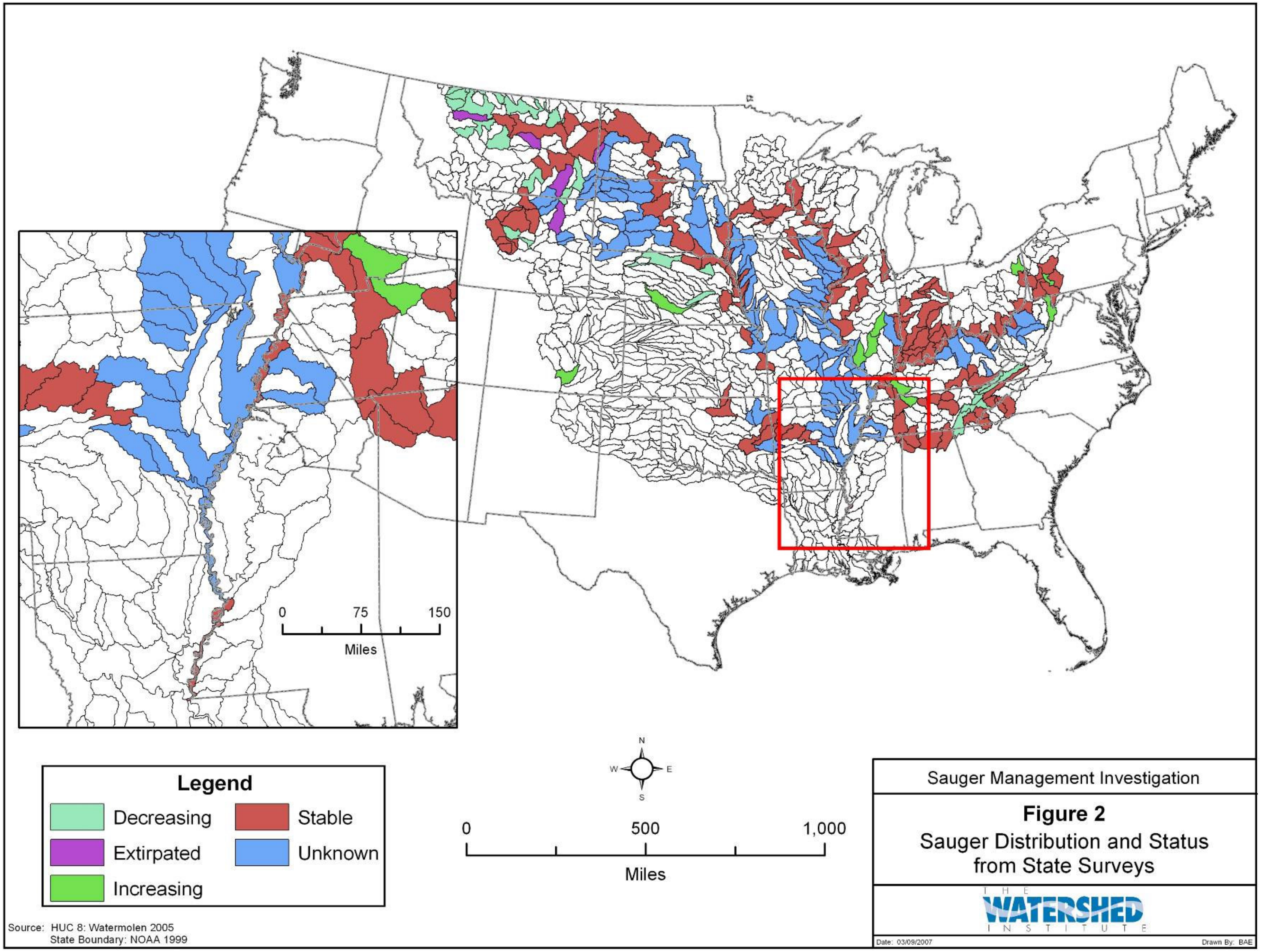
State surveys reported that sauger is present in 237 HUC-8 watersheds (see Table 2 and Figure 2). Of these, 111 (46.8%) HUC-8 watersheds had stable populations. The population status of 21 (8.8%) watersheds was decreasing, 9 (3.8%) had increasing populations, and 96 (40.5%) watersheds had sauger status that was unknown. Montana reported sauger was extirpated from another five watersheds.

Seven of the nine watersheds with increasing sauger populations seemed to benefit from stocking. Three of the seven increasing watersheds occurred in the Kaskaskia River basin in Illinois. The Kaskaskia has been stocked directly with sauger fingerlings. The Beaver River and Bessemer Lake in Pennsylvania have been stocked directly. Increasing populations in the Kiskiminetas River (Pennsylvania) were likely due to stocking of two reservoirs—Conemaugh River Lake and Loyalhanna Lake—in the watershed. Sauger stocking into six impoundments within the same HUC-8 (10200101, Nebraska) has produced stable to increasing populations in all lakes. Sauger introduction into Horseshoe Reservoir (11020006, Colorado) has resulted in an increasing population. Increasing populations in the Cheat River (05020004, Pennsylvania) might be the result of improving watershed conditions (Knapp 2003).

3.2 SAUGER MANAGEMENT

Carlander et al. (1978), in a survey of percid habitat throughout North America, found that no agencies in the United States or Canada were managing waters specifically for sauger. Additionally, Webster et al. (1978) noted that sauger receives much less management consideration than walleye, although successful sauger fisheries have been established through introductions. Their larger overall size and success as a stocked and managed game species seem to elevate walleye management to a higher priority with most agencies. Based on state survey results, this pattern holds today.

While effective management and mitigation of anthropogenic influences requires an understanding of the ecology of a species under natural conditions, almost all river systems where saugers occur have been altered to such an extent that research directed at achieving such an understanding might not be possible (Jaeger et al. 2005). Furthermore, the interjurisdictional nature of major sauger waters and the migratory nature of the species complicate data collection, interpretation, and management. For example, sauger moving upstream from Pickwick Dam in Tennessee enter Mississippi and ultimately Alabama waters, while those moving downstream enter Kentucky waters (Pegg et al. 1997). Likewise, the Mississippi (Minnesota, Wisconsin, Iowa, Illinois, Missouri, Arkansas, Mississippi, and Louisiana), Missouri (Montana, North Dakota, South Dakota, Nebraska, Iowa, Kansas, Missouri), and Ohio Rivers (New York, Pennsylvania, Ohio, West Virginia, Indiana, Kentucky, and Illinois) have shared state jurisdictions. Additionally, combined sauger/walleye/saugeye creel limits in areas of co-occurrence confound management strategies specific to sauger. Moreover, difficulties in angler identification—and even professional identification—of sauger and walleye and their hybrids, limits management of sauger separately. Finally, sauger life history—a highly fecund, pelagic broadcast spawner, exhibiting no parental care—results in populations having high natural variability and susceptibility to abiotic influences. All these factors affect management of the species. Table 3 summarizes the management strategies provided through state surveys.



Sauger Management Investigation

Figure 2
Sauger Distribution and Status
from State Surveys

Source: HUC 8: Watermolen 2005
State Boundary: NOAA 1999

TABLE 3
STATE MANAGEMENT STRATEGIES

STATE	CREEL LIMIT		MINIMUM LENGTH	HARVEST SEASON	ASSESSMENT TECHNIQUES	
	Daily	Possession			Population	Movement
Alabama	10[1]	-	14”	Year round	Gill net	-
Arkansas	6	12	-	Year round	Electrofishing, gill net, creel survey	-
Colorado	5[2]	5[2]	-	Year round	Gill net	-
Iowa	5[2]	10[2]	-	Year round	Electrofishing, creel survey. Gill net and trammel net used rarely.	Radio telemetry, floy tag
Mississippi R	6[2]	12[2]	-	Mar 16-Nov 30[3]		
Missouri R[4]	4[2]	8[2]	-	Year round		
Illinois	6[2]	6[2]	14”	Year round	Unknown	Unknown
Misc waters[5]	6[2]	6[2]	18”	Year round		
	6[2]	6[2]	16”	Year round		
	3[2]	3[2]	18”	Year round		
	3[2]	3[2]	16”	Year round		
	3[2]	3[2]	14”	Year round		
				Year round		
Indiana	6[2]	12[2]	-	Year round	Electrofishing (night-time in Nov-Dec), creel survey	T-bar anchor tag
Ohio R	10[2]	20[2]	-	Year round		
Kansas	5[2]	12	15”	Year round	Electrofishing, gill/trap net, creel survey	Radio telemetry
Kentucky	6[2]	12[2]	-	Year round	Unknown	Unknown
Misc waters	6[2]	12[2]	14”	Year round		
Dale Hollow L	10[2]	20[2]	14”	Year round		
Louisiana	-	-	-	Year round	-	-
Missouri	4[2]	4[2]	15”	Year round	Electrofishing, seine, trawl, gill net	Mark-Recapture
Mississippi R	8[2]	8[2]	-	Year round		
Misc. waters	4[2]	4[2]	18”	Year round		

Minnesota[6]	6[2]	-	Only 1 >20”	Mid-May -Feb 28	Electrofishing, gill/trap net, seine, trawl, creel survey	Radio telemetry
Minnesota R	6[2]	-	Only 1 >20”	March 1 – mid May		
Mississippi R [7]	6[2]	6[2]	-	Year round		
Mississippi R	Catch/Release	-	-	Year round		
St. Croix R	6[2]	-	-	May 1-Feb 28		
Mississippi	15	-	-	Year round	-	-
Montana	5[2]	10[2]	-	Year round	Electrofishing, seine, gill net	Radio telemetry, floy tag
Big Horn L	5[2]	5		Year round		
Big Horn R	1	2	-	Year round		
Marais R	1	2	-	Year round		
Missouri R[8]	1	2	-	Year round		
Fort Peck R	1	2	-	Year round		
Yellowstone R	1	2	-	Year round		
Nebraska	4[2]	8[2]	15”	Year round	Gill net	-
New York[9]	5[2]	-	18”	Early May-Mar 15	-	-
North Carolina	8	-	15”	Year round	-	-
North Dakota	5[2]	10[2]	-	Year-round	Electrofishing, gill net, creel survey	-
Ohio	6[2]	-	-	Year-round	Electrofishing, creel survey, tagging-return	Tagging
Ohio R	10[2]	-	-	Year-round		
Oklahoma	5	10[10]	18”	Year-round	Electrofishing, gill net	-
Arkansas R[11]	5	10[10]	16”	Year-round		
Pennsylvania	6	-	12”	Early May-mid Mar	Electrofishing, creel survey	-
South Dakota	4[2]	8[2]	-[12]	Year-round	Electrofishing, gill net, creel survey	Radio telemetry, Dangler tag
Lake Sharpe	4[2]	8[2]	15” [12, 13]	Year-round		
Lake Francis Case	4[2]	8[2]	15” [12, 13]	Year-round		
Missouri R[14]	4[2]	8[2]	15” [12, 13]	Year-round		
Missouri R[15]	4[2]	8[2]	15”	Year-round		
Tennessee	10	20	15”	Year-round	Gill net	Radio telemetry
Misc reservoirs[16]	10[2]	20[2]	15”	Year-round		
Norris Reservoir	5[2]	10[2]	15”	Year-round		

Normandy Res	15[2]	30[2]	15”	Year-round		
Kentucky L	10[2]	20[2]	14”	Year-round		
Virginia	2	-	-	Year-round	Electrofishing	-
West Virginia[17]	8[2]	16[2]	-	Year-round	Unknown	Unknown
Statewide rivers	10[2]	20[2]	-	Year-round		
Wisconsin	5[2]	-	15”[18]	Year-round	Electrofishing, creel survey	-
Mississippi R	6[2]	6[2]	-	Year-round		
Wyoming	6	6	-	Year-round	Electrofishing, gill net	Radio telemetry, floy tag, PIT tag
Big Horn L[19]	5	5	-	Year-round		

Notes: Unless identified by specific waterbody, management strategies apply statewide.

[1] Up to 3 fish <14-inches allowed in daily creel.

[2] In aggregate with other *Sander* species.

[3] Applies to the tailwaters of Dams 11, 12, and 13.

[4] Includes Big Sioux River.

[5] A few waters have a restricted harvest slot and maximum length: only 2 fish allowed between 14”-18” and 1 fish > 24”.

[6] Minnesota River regulations.

[7] MN-WI boundary reach.

[8] Reach between Morony Dam and Fort Peck Reservoir.

[9] These regulations – 5 daily limit, 18” minimum – begin in 2008. Currently no creel or size limits.

[10] Non-resident possession limit = 5.

[11] Keystone Dam downstream to OK-AR state boundary.

[12] No minimum size limit; however, only 1 sauger >20” allowed in daily limit.

[13] No size restriction during July and August.

[14] From NE border upstream to Fort Randall Dam.

[15] From Gavins Point Dam upstream until river is no longer SD-NE boundary water.

[16] Cherokee, Chilhowee, Douglas, Fort Loudoun, Melton Hill, and Tellico reservoirs.

[17] Statewide impounded waters.

[18] Includes a no-harvest 20-28” slot with 1 fish > 28” allowed in the daily limit.

[19] A 2 fish daily creel and possession limit proposed for 2008.

3.3 IMPORTANCE TO STATE SPORTFISHERY

State surveys show that saugers are of low to moderate importance in the sport fishery of most MICRA states. On a scale of 0 (no importance) to 5 (very important), scores ranged from 0 to 5, with 10 states reporting scores of 0 or 1, 13 states reporting 2 or 3, and 3 states reporting 4 or 5 (see Table 1). Indiana scored inland waters at 3 and the Ohio River at 5. The average of reported state scores is 1.96. Wyoming noted that sauger importance was more related to their role in native fish assemblages than as a sportfish.

3.4 MANAGEMENT STRATEGIES

3.4.1 Harvest Limits

All states, except Louisiana, currently maintain daily creel and possession limits for sauger. Daily limits range from a low of 2 sauger (Virginia) to a high of 15 (Mississippi). Possession limits vary from the daily limits of a state to three times the daily limit. One state—Oklahoma—limits non-resident possession limit to one-half the limit of resident anglers. Twelve states have only statewide limits, while 14 have a statewide limit plus special regulations for specific waterbodies. Creel limits in 19 of the 26 states include a combination of all *Sander* species.

Four states currently have a spring non-harvest season designed to protect spawning aggregations. Most Upper Mississippi River states have no season closures for Mississippi River sauger. For example, Wisconsin initiated a continuous open season on its portion of the Mississippi River in 1967 with Minnesota following suit in1969. However, Iowa recently closed all fishing in the tailwaters at three navigation dams from December 1 of each year through March 15 of the following year. This regulation is designed to reduce exceedingly high mortality rates (75-90%) for sauger in these areas. Evaluation of this regulation is in the third year of a planned five-year study. Closed fishing areas are:

1. From Dam 11 at Dubuque downstream to the railroad bridge near river mile 579.9.

2. From Dam 12 at Bellevue downstream to the mouth of Mill Creek, near river mile 556.0.
3. From Dam 13 at Clinton downstream to the downstream end of Stamp Island near river mile 521.5.

On the other hand, Thorn (1984) reported that saugers were not significantly impacted by a fishing season without a spring closure. Extensive creel and netting surveys in Minnesota indicated that, although sauger populations have substantial natural fluctuations, their abundance 15 years after opening a continuous season was similar to abundance when the fishery had a seasonal closure (Thorn 1984). Similarly, Schell et al. (2004) noted that total annual mortality of sauger generally exceeded 90% throughout the Ohio River. Their results indicated that natural mortality exceeded 50%, and they suggested that there would be no benefit from length or creel limits regardless of management objectives. In their survey, Indiana noted that high natural and low angler mortality rates precluded enactment of length limits or more restrictive creel limits on the Ohio River. Pitlo et al. (2004) stated that the Upper Mississippi River sauger fishery was a fast growing, early maturing population exhibiting relatively high natural mortality. Therefore, the authors considered it appropriate to continue the continuous open season and current regulations.

3.4.2 Length Limits

Length limits currently vary widely among reporting states, with seven states having no length limit and two states having slot limits on selected waters. Typical minimum length limits range from 14 inches to 18 inches; however, limits can vary by waterbody and season within a state. For example, Alabama maintains a 14-inch minimum limit but allows up to three fish less than 14 inches in a daily creel of 10. Illinois allows only two fish from a restricted slot of 14-18 inches and one fish greater than 24 inches in a creel of six. For general statewide regulations, South Dakota has no minimum size limit but allows only one fish greater than 20 inches. On portions of the Missouri River, South Dakota maintains a 15-inch length limit, except during July and

August, when no length limit is effect. Much of the variation in length limits is determined by walleye management efforts rather than specific efforts to manage sauger populations.

3.4.3 Stocking

Only seven states reported stocking sauger (see Table 4). Three states—Colorado, Kansas, and Nebraska—stocked impoundments to provide new and additional angling opportunities. Pennsylvania introduced sauger into three impoundments to establish reproducing populations for the impoundment and streams upriver. Indiana, Oklahoma, and Tennessee stocked rivers, or associated main-stem impoundments, to bolster native populations. Fingerling stocking predominates; however, Kansas stocked both fry and fingerlings into Perry Reservoir. Only three states—Colorado, Indiana, and Nebraska—reported that stocking efforts were evaluated and considered successful. Arkansas noted that increased stocking was necessary to improve sauger populations on the Arkansas River yet provided no specific information.

TABLE 4
STATE REPORTED STOCKING

STATE	STOCKING		STOCKING EFFECTIVE?
	SIZE	RATE	
Colorado	Fingerlings[1]	100/ac	Yes
Indiana	Fingerlings[2]	50/ac	Yes
Kansas	Fingerlings[1]	6 – 111/ac	Unknown
	Fry[1]	8.65/ac	Unknown
Nebraska	1-2 in [1]	50/ac	Yes
Oklahoma	2 in [3]	-	Unknown
	1.5 in [2]	-	Unknown
Pennsylvania	-	50/ha[1]	Unknown
	-	80/ha[2]	Unknown
Tennessee	Fingerlings[1]	5-10/ac	Unknown

[1] Lake/reservoir stocking.
[2] Stream/river stocking.
[3] Stocked into the upper end of RS Kerr to enhance spawning runs up the Illinois River.

While literature concerning stocking saugers into lakes exists (McCarraher et al. 1971; Rawson and Scholl 1978), Heidinger and Brooks (1998) reported only personal communication references to river stockings in peer-reviewed literature (Carlander et al. 1978; Hackney and Holbrook 1978; Conover 1986; Hesse 1994). Most river stockings were perceived to have failed or were ultimately of little consequence to sauger fisheries. Only an introductory sauger stocking in the Appalachicola River, Florida, was considered successful (personal communication in Hackney and Holbrook 1978). Thomas (1994) reported that the annual abundance of age-1 sauger in the upper Tennessee River seemed to depend on the number of fingerling sauger stocked the previous year. Fischbach (1998) reported that recruitment was not related to fingerling stockings in two upper Tennessee River reservoirs; yet age-2 sauger catches in Old Hickory Reservoir—Cumberland River—were related to the number of fingerlings stocked two years earlier.

Heidinger and Brooks (1998) reported that stocking 50-mm saugers was preferable to stocking sauger fry in the Peoria Pool of the Illinois River. Stocking sauger fingerlings in the Peoria Pool contributed substantially to year-classes when natural reproduction was low, and stocking did not follow a strong natural year-class. Total contribution of all stocked saugers after 6 years to all year-classes was 22.8%. Stocked saugers also contributed to the Peoria Pool fishery, with 9% of all age-2 and older saugers collected almost exclusively by anglers and in fishing tournaments being stocked fish. Similarly, the Illinois Department of Natural Resources (IDNR) reported that fingerling stocking in the Des Plaines River had been successful (IDNR 2006). A total of 12,021, 2-inch sauger was stocked in 2001, with another 28,000 released in 2004. Fish from both 2001 and 2004 were present in subsequent electrofishing collections, and they averaged 16 inches and 8 inches in length, respectively. Abundance and condition of sauger were improved in Carlyle Lake on the Kaskaskia River (IDNR 2006). Twelve to 13 million fry were stocked annually in the lake, and movement upstream provided a river sauger fishery between Carlyle Lake and Lake Shelbyville.

3.4.4 Effectiveness of Management Strategies

Length and creel limits were considered the most effective management strategies. Seven states listed length limits as most effective, noting that minimum size restrictions allowed a proportion of the spawning females the opportunity to spawn before they were vulnerable to harvest. Six states identified creel limits as effective because they allowed a more equitable distribution of fish among licensed anglers. Three states noted that stocking in areas with little to no recruitment was most effective. Three states identified habitat protection and restoration as important strategies. For example, Montana considered minimizing the introduction of exotic species (e.g. walleye and smallmouth bass) and restoring habitat (including maintaining instream flows) as critical to sauger populations. Seven states have not evaluated the effect of management strategies on sauger populations.

3.4.5 Assessment Techniques

State surveys reported eight population assessment techniques: creel survey, boat electroshocker, gill net, trap net, trammel net, seine, bottom trawl, and tag returns. Electrofishing, gill netting, and creel surveys were most used, being noted by 14, 12, and 10 states, respectively. Fourteen states documented using a combination of gears to assess sauger populations. Four states reported that no assessment techniques were used to assess sauger populations, while three states did not list using any specific gear. Ten states have assessed sauger movement, with eight using radio telemetry and seven using various tagging methods. Four states have used a combination of radio telemetry and tagging to assess movement.

In the Missouri River benthic fishes study, Berry et al. (2004) caught most sauger by electrofishing, with much lower total catch in other gears. While saugers were caught with all gears, the combination of electrofishing and gillnetting produced 79% of the catch. The catch per effort for several gears was highest in outside bend macrohabitats in the upper river segments compared to other macrohabitats. Saugers were commonly caught in drifting trammel nets in channel crossover, inside bend, and outside bend habitats in all segments upstream from Lake Sakakawea, but rarely caught in these macrohabitats downstream. The authors caught sauger over a wide range of depths and velocities. Silt and sand substrates and high turbidity levels characterized sauger catch sites. They noted that total catch doubled when temperatures reached 20°C.

3.5 LIFE HISTORY

3.5.1 Growth

State reported growth rates are provided in Table 5. Though highly variable, these data follow the general trends noted earlier that young saugers grow rapidly and attain over half their ultimate size in two years and that southern saugers grow faster than northern ones, but northern fish live longer, attaining similar size as southern populations. Braaten and Guy (2002) inferred that the absence of gizzard shad at northern latitudes, combined with an earlier shift to piscivory in southern latitudes, provided a basis for faster growth rates in the south.

In the Ohio River, Schell et al. (2004) reported that all age-0 sauger sampled in December exceeded 200 mm, autumn age-1 sauger ranged in length from 251 to 271 mm, autumn age-2 sauger ranged in length from 212 to 365 mm, autumn age-3 sauger ranged from 326 to 410 mm, and autumn age-4 sauger ranged from 380 to 478 mm. As noted earlier, various biotic and abiotic factors influence growth. Walburg (1976) noted that decreased growth in saugers paralleled the decreased abundance of small forage fish—a direct result of water-level fluctuations—in Lewis and Clark Lake, South Dakota. Otis and Staggs (1996) reported that March, April, July, and August water temperatures and May to August water levels were positively correlated to age-0 sauger growth, while walleye abundance was a negative influence. Pierce et al. (2003) reported that first year growth and growth rate at maturity are positively correlated with temperature, suggesting that, in terms of growth, sauger respond to environmental differences consistently throughout their life cycle.

For comparative purposes, we provide growth data from two publications—Buckmeier (1996) from the Tennessee and Cumberland Rivers and Pitlo et al. (2004) from the Upper Mississippi River—representing southern and northern sauger populations (Table 6).

TABLE 5
STATE REPORTED LENGTH (mm) AT AGE

STATE	AGE (years)									
	1	2	3	4	5	6	7	8	9	10
Alabama										
Guntersville	278	367	448	416						
Arkansas										
Lake Dardanelle	291	385	406	404	455					
Iowa *Miss. R.*										
Pool 11		279	356	429	467	467	490	508		
Pool 13	208	282	356	414	452	472	488	495		
Indiana *Ohio R.*	232	336	377	420						
Minnesota										
Minnesota R.	146	253	320	386	437	459	475			
St. Croix R.		170	277	328	394					
Mississippi R.	253	347	411	440	480	502	504			
Montana	127	229	279	330			457			
Nebraska	176	307	393	464	542					
North Dakota										
L. Sakakawea	149	269	336	411	474	472	487	492		
L. Oahe	139	251	337	406	468	525				
Missouri River	120	215	288	346	402	466	523	650		
Ohio	227	347	380	423	414					
Pennsylvania	219	291	328	369	380					
South Dakota										
Lewis & Clark L[2]	167	327	395	447	488	510	513			
L Francis Case[2]	190	327	354	395						
Lake Sharpe[3]	263	326	367	390	401	411	395	448	452	
Wisconsin										
L. Wisconsin[1]	162	279	340	390	431					

[1] Averaged from 14 years (1984 – 2005).

[2] Mean back-calculated total lengths at annulus.

[3] Mean length-at-age-at-capture as determined by aging otoliths.

TABLE 6
SELECT PUBLISHED GROWTH DATA

WATERBODY	AGE (years)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Upper Mississppi[1]	*Northern Populations*									
Pool 4	144	244	326	377	415	444	478	480		
Pools 8 and 9	186	259	306	354	376	387	422	414		
Pool 11	192	280	352	410	420	444	478	501		
Pool 13	196	291	355	407	448	481	484	452		
	Southern Populations									
Tennessee R. [2]	276	361	430	458	497	510	513	470	530	490
Cumberland R.[2]	277	355	413	428	462					

[1] Average of averages—back-calculated lengths at annulus—from Pitlo et al. (2004), Table 2.

[2] Mean length-at-age-at-capture as determined by aging otoliths, from Buckmeier (1996), Table 4.

3.5.2 Size-at-Maturity

Considerable variation is evident for size and age at maturity from both the state reported data and the literature. State reported size-at-maturity is provided in Table 7. Alabama reported that most male sauger begin to mature by 250 mm and are fully mature by 300 mm. Most females mature from 260 mm to 300 mm. South Dakota noted that lengths averaged 374 mm for immature, age-3 sauger and 398 mm for mature, age-3 sauger. In the Tennessee and Cumberland Rivers, Churchill (1992) found that >50% of males were mature by age-2 and most females by age-3. Approximately 25% of males and females from the Cumberland River were mature by age-1, and 52% of males in the upper Tennessee River were mature at this age. Most Tennessee River males reached maturity from 350 mm to 450 mm, while females matured from 450 mm to 500 mm. Pitlo et al. (2004) reported most Upper Mississippi River male and female sauger matured at age-2 and age-4, respectively. In Pool 13, male sauger begin to mature at 292 mm and females at 330 mm; however, immature fish at 381 mm were still found (Pitlo et al. 2004).

TABLE 7
SIZE AT MATURITY

STATE	TOTAL LENGTH (mm)		AGE (years)	
	Male	*Female*	*Male*	*Female*
Alabama	250	260	—[1]	—[1]
Arkansas	292	393	—[1]	—[1]
Iowa	353[2]		—[1]	
Indiana	377[2]		2	
Minnesota	330	406	—[1]	—[1]
Ohio	—[1]	—[1]	2	3
South Dakota	—[1]	—[1]	4	3

[1] Not provided by state survey.

[2] Sex not provided in state survey.

3.5.3 Fecundity

The number of eggs produced by a single female varies with fish size, age, and condition. Fecundity reported in the literature ranged from a low of 9,000 eggs (Boschung and Mayden (2004) to a high of 210,000 (Rohde et al. 1994). Most research reported an average fecundity range from 40,000 to 60,000 eggs. For example, Churchill (1992) reported that, although 550-mm females can produce up to 175,000 eggs, mean fecundities of sauger <475mm were 54,903 (Tennessee River) and 43,148 (Cumberland River). State surveys reporting fecundities fall within the average range. Arkansas reported Lake Dardanelle females to average 56,002 eggs/gravid female. South Dakota reported that fecundity ranged from 43,840 eggs from a 398 mm, age-3 sauger to 67,028 eggs from a 522 mm, age-6 sauger. Average fecundity for sampled females was 55,621 eggs.

3.5.4 Mortality and Exploitation

The state of Alabama reported that total annual mortality ranged from 50% to 80%. Similar ranges were provided by other states:

- *Arkansas* (Lake Dardanelle Pool, Arkansas River) – Mean = 66%.
- *Iowa* (Pool 11, Mississippi River) – 1994-2005; Mean = 82.9%, Range = 73-92%.

- *Iowa* (Pool 13, Mississippi River) – 1992-2005; Mean = 70.1%, Range = 47-86%.
- *Minnesota* (Lake Pepin) – 1965-2005; (age-2 to age-6), Mean = 50%, Range = 26-82%.
- *Nebraska* – Range = 40-60%.
- *South Dakota* (Lewis and Clark Lake) – 1990-1991; Mean = 50%.
- *South Dakota* (Lewis and Clark Lake) – 2004-2005; Mean = 65% excluding age-0 fish.
- *South Dakota* (Lake Francis Case) – 1990-1991; Mean = 41%.
- *South Dakota* (Lake Francis Case) – 2003-2004; Mean = 50%.
- *Indiana* (Ohio River tailwaters) – 1998-2002; (age-1 and 2) Range = 63-98%; mean of 2002 data = 79%.
- *Ohio* – Range = 71-92%.

In Alabama, annual angler exploitation ranged from 40% to 60%. Minnesota reported a range of 28-58%, with a mean of 38% from Pool 4 of the Upper Mississippi River. These data were calculated from voluntary tag returns in 1978 and 1979. Downstream in Pools 11 and 13, Iowa documented ranges of 14-37% and 13-25%, respectively. Mean anger exploitation was 27% for Pool 11 and 22% for Pool 13. In Pools 24, 22, and 21, Missouri documented 9% exploitation for 2005-2006. Indiana estimated overall angler exploitation at 10%, with a range of 7-17% on sauger tagged in November/December 2005 and harvested through June 2006. They also reported that exploitation was 6% for fish <350 mm and 35% for those >350 mm. In Ohio, exploitation ranged from 9% to 27%. Ohio was investigating hooking mortality or mortality of released fish. South Dakota calculated 3% angler exploitation of tagged sauger in Lewis and Clark Lake, from time of tagging to the end of the first calendar year. From an earlier study on Lewis and Clark Lake (Riis et al. 1993), South Dakota reported angler exploitation of 17-29% for sauger tagged in 1986 and 22-25% for fish tagged in 1987.

3.6 LIMITING FACTORS

Ten states identified limiting factors for sauger (see Table 8). Three states—Montana, South Dakota, and North Dakota—identified biotic limiting factors: competition with non-native species, hybridization with walleye, and forage availability. Montana noted that non-native predators (walleye and smallmouth bass) potentially compete with sauger in the middle Missouri River, citing McMahon and Gardner (2001), Gardner (2005), and Bellgraph (2006). South Dakota stated that high levels of over-winter mortality for age-0 gizzard shad often occurred at the northern extent of gizzard shad range. Because gizzard shad comprised much of the forage base, high seasonal mortality might negatively affect sauger populations. South Dakota also mentioned the presence of Asian carp (silver carp, *Hypophthalmicthys molitrix*, and bighead carp, *H. nobilis*) in the Missouri River below Gavin's Point dam. While interactions between Asian carp and the native fish communities are relatively unknown, efforts to keep silver and bighead carp from entering Lewis and Clark Lake should be beneficial for native fish communities. The findings of Schrank et al. (2003) suggested the potential for bighead carp to negatively affect growth of age-0 paddlefish when food resources are limited. Nine states listed one or more abiotic limiting factors, including habitat degradation and fragmentation, migration barriers, air and water temperature fluctuations, hydrologic manipulation, sedimentation, gravel mining, channel dredging, migration barriers, towboat induced mortality, and overexploitation. Both northern and southern states—Minnesota, Wyoming, Arkansas, Alabama—identified water temperature as a limiting factor, indicative of variability at ends of the species range. Many of these limiting factors are identified and discussed in Section 2.6.

TABLE 8
STATE IDENTIFIED LIMITING FACTORS

STATE	LIMITING FACTORS	
	ABIOTIC	BIOTIC
Alabama	Water temperature	
Arkansas	Sedimentation; fluctuating flow; water temperature during the spawning season; large dams congregating fish during the winter months, leading to excessive angler exploitation.	
Iowa	Spawning habitat on the border rivers; decreased survival of drifting larvae due to towboat induced mortality.	
Minnesota	Water temperature; global climate change.	
Missouri	Angler harvest; sedimentation; gravel mining; channel dredging and spoil placement; migration barriers.	
Montana	Habitat fragmentation and degradation; overexploitation.	Competition with non-natives; hybridization with walleye.
North Carolina	Dams presumed to limit range.	
North Dakota		Competition with walleye.
South Dakota	Spring temperature fluctuations and warming trends; precipitation and snowpack inputs.	Forage availability (gizzard shad).
Virginia	Siltation, sedimentation.	

3.7 CONTAMINATION ISSUES

Three states—Indiana, Minnesota, and Pennsylvania—identified chemical contamination leading to sauger consumption advisories. Water bodies identified included the Ohio (Indiana, Pennsylvania), Mississippi, and St. Croix Rivers (Minnesota). South Dakota noted that mercury in Lake Sharpe and Little Missouri River sauger—while present—was below advisory concentrations. A review of state web sites showed sauger consumption advisories existed for six other states in the Mississippi River basin (see Table 9). Two states—Montana and Wyoming—identified hybridization and introgression between native saugers and introduced walleyes or saugeyes as a contamination issue.

TABLE 9
SAUGER CONSUMPTION ADVISORIES

STATE	WATER BODY	CONTAMINANT(S)
Illinois	All waters	Mercury
	Ohio River	Polychlorinated biphenyls (PCBs)
Indiana	Ohio River	PCBs
	Interior rivers	PCBs
Kentucky	Ohio River	Mercury, PCBs
	All waters	Mercury
Minnesota	Mississippi River	Mercury, PCBs
	St. Croix River	Mercury, PCBs
North Dakota	Lake Sakakawea	Mercury
Ohio	Ohio River	PCBs
	Scioto River	Mercury
Pennsylvania	Ohio River	PCBs
Tennessee	Mississippi River	Chlordane
	Watts Bar Reservoir	PCBs
West Virginia	All waters	Mercury, PCBs
	Hughes River	Mercury
	Kanawha River	Dioxin, Mercury, PCBs

Specific information regarding fish size and meals consumed per month is available on state agency websites.

4.0 SUMMARY

Saugers are widespread and their populations respond to a variety of complex—and not well understood—biotic and abiotic relationships across their range. Additionally, angler interest in sauger, and their importance to the sport fishery, varies by state. Consequently, state management actions range from nonexistent to high priority. Through the available literature and state surveys, we identified several key challenges to sauger management.

Saugers are early maturing, exceptionally mobile, highly fecund, broadcast spawners that provide no parental care. They exhibit high natural mortality and temporal variation in abundance. Such characteristics are not easily controlled through direct management intervention, and biologists have minimal control over these variables. However, research opportunities exist to improve management capabilities. For example, nursery and juvenile habitat requirements are relatively unknown. Range-wide research to describe and quantify nursery and juvenile habitat used by sauger might also identify river processes required to maintain these habitats.

There is little understanding of the extent of competition with walleye for food and spawning habitat. Similar resource use between walleye and sauger suggests that, if resources become limiting, competitive interactions might increase. Furthermore, changes in river habitat—hypolimnetic discharges that result in unnaturally low summer water temperatures and reduced turbidity downstream from reservoirs—often give walleye a competitive advantage over sauger. Additionally, hybridization among sauger, walleye, and saugeye dilutes sauger genetic purity and masks advantageous traits that allow sauger to adapt to their native environment. Research on the basic reproductive ecology of *Sander* species would increase understanding of natural reproductive barriers and how they are breaking down in altered systems. To protect sauger populations, the following recommendations should be implemented: genetic analysis of broodfish in agency culture programs (Ward and Berry 1995; Billington and Palmer 2001), eliminate saugeye stocking in areas where self-sustaining parental populations occur (Schell et al.

2004), and remove pure walleye and hybrids from native sauger waters (Bellgraph 2006; Billington et al. 2006).

While overexploitation might not be problematic range-wide, some areas show truncated population age structure related to fishing mortality. Studies quantifying natural and fishing mortality, combined with population modeling, would provide a better understanding of the potential role of exploitation in structuring sauger populations.

Habitats of the once free-flowing Missouri, Mississippi, Ohio, and Tennessee River systems—historical sauger strongholds—are fragmented by multiple dams that alter physical habitat characteristics, flow regimes, and water quality. Impoundment and subsequent flow management isolate saugers from important spawning and rearing habitats, reduce turbidity and temperature, and alter the timing and magnitude of the hydrograph from the natural regime in which saugers evolved. Nearly all river systems where saugers occur have been altered to the extent that understanding critical habitat requirements might not be fully possible. Additionally, altered conditions likely have changed the carrying capacity of sauger in most major river systems. To ensure sustainable sauger populations, a portion of the historical hydrologic and geomorphic processes that maintained the river-floodplain ecosystem must be restored. While future management actions meant to conserve and enhance sauger populations should focus on restoration of river processes, these decisions are often determined by political realities—another variable over which biologists have limited control—rather than recovery of ecological processes.

State surveys showed that saugers were of low to moderate importance in the sport fishery of many MICRA states. Angler preference for walleye over sauger often elevates walleye management to a higher priority with many agencies. Difficulty in identification among the *Sander* species and hybrids has lead to aggregate creel limits, which obscure sauger-specific management actions. These situations pose substantial challenges to be addressed by sauger managers. Additionally, the interjurisdictional nature of the major sauger waters complicates management and increases the likelihood of political considerations overriding biological concerns. Yet, multi-state, interagency cooperation among biologists, water managers, and regulatory agencies is necessary to manage sauger at the watershed scale. Sauger mobility and reliance on a wide variety of habitats throughout their life history pose difficulties for managers attempting to manipulate their abundance solely by local habitat modification or regulation. Also, the sauger population status of 40.5% of HUC-8 watersheds supporting the species is unknown. Therefore, we suggest that an interagency sauger coordination team—much like MICRA's Paddlefish Committee or the American Fisheries Society, North Central Division Walleye Technical Committee—could effectively identify and address research needs, conservation goals, management objectives, and cooperative monitoring programs, ensuring long-term sustainability of sauger populations. The coordination team would develop a sauger management plan—or provide leadership to develop multiple, basin specific plans—outlining definite research goals having ecologically-based objectives, clear management actions, an implementation schedule with detailed performance measures, and an adaptive management process to address information gained through research. A similar approach was taken in the Ohio River basin where the Ohio River Fisheries Management Team (ORFMT)—comprised of fisheries personnel from Ohio, West Virginia, Indiana, Illinois, and Kentucky—assessed the population composition, abundance, size structure, age structure, growth, body condition, mortality, exploitation, inter-pool movement, and hybridization of sauger and walleye throughout the Ohio River main-stem (Schell et al. 2004). Additionally, the team analyzed the recreational fishery characteristics, including angler effort, catch, and harvest. This research allowed the ORFMT to make river-wide recommendations on sauger population assessment strategies, angling regulations, propagation, and stocking. Comparable projects in other major Mississippi River basins would provide important information for sauger management.

Much research exists in the Upper Mississippi, Missouri, and Tennessee River basins to develop sauger management plans. For example, the Upper Mississippi River Conservation Committee Fisheries Compendium (Pitlo and Rasmussen 2004) compiled and presented many pieces of research and survey information—both published and from agency files—on sauger populations in the basin. This document, combined with other recent work (e.g., Kirby and Ickes 2006; Steuck 2006), provides a basis for a multi-agency team to begin discussion of basin-wide sauger management. A substantial body of recent sauger research exists for the Missouri River basin (Welker et al. 2001, 2002; Fryda 2002; Amadio 2003; Roberts et al. 2003; Jaeger 2004; Galat et al. 2005; Kuhn 2005; Bellgraph 2006; Billington et al. 2006; Graeb 2006; Lionberger 2006). Furthermore, the Missouri River Benthic Fishes Study—a research project to evaluate changes in the fish community on a large spatial scale conducted on the main-stem Missouri River from Montana to Missouri—produced 12 publications, including several with information on sauger (Berry and Young 2001; Pierce et al. 2003; Bergstedt et al. 2004; Berry et al. 2004). In the Tennessee River basin, research throughout the 1990s (Churchill 1992; Pegg 1994; Thomas 1994; Buckmeier 1995; Maceina et al. 1996; Pegg et al. 1996, 1997; Bettoli 1998; Maceina et al. 1998; Bettoli et al. 1999, 2000) focused on sauger. These documents provide a foundation for discussion of a basin-wide sauger management plan.

Successful management of sauger populations will require maintenance of fluvial processes and a diversity of habitats. Additionally, as noted by Pitlo et al. (2004), biologists must lead efforts to monitor trends in sauger abundance, population characteristics, and size structure; conduct creel surveys to document catch, harvest, and pressure; and document and protect spawning and other critical habitat areas. Coordinating these efforts among the agencies charged with sauger management provides a challenging opportunity to MICRA and other aquatic resource organizations.

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APPENDIX A

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APPENDIX B

STATE SURVEYS

ALABAMA

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
Guntersville Res/TN River	06030001	Native	67,900 Acre	Stable
Wheeler Res/TN River	06030002	Native	63,565 Acre	Stable
Wilson Res/TN River	0603002	Native	15,500 Acre	Stable
Pickwick Res/TN River	0603005	Native	43,100 Acre	Stable

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

The sauger in Alabama is restricted to the northern section of the state within the Tennessee river drainage. The fishery is seasonal with the majority of angling pressure occurring during the late fall/winter months. Also, most angling for sauger in tailwater areas. Anglers target sauger for the table and most legal fish caught are harvested.

Current management strategies for sauger fisheries include a 356mm (14”) minimum length limit and a daily creel limit of 10 fish/angler. Three fish less than 356mm may be allowed in the creel.

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

The minimum size restriction, if followed and enforced, is the most effective strategy to improve/protect sauger fisheries in AL. The minimum size restriction helps to prevent growth over-fishing.

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

Sauger populations are monitored using experimental gill nets following the policies outlined in “Alabama Standardized Reservoir Sampling Manual”.

Please list known information—from your state—for the following sauger attributes:

Growth Rate:

Mean length at age for sauger collected from Guntersville tail-water, 2002.

Age	Year Class	Number	Percent	CPE	Mean TL	SE
1	2001	8	7.5	2.7	278.1	7.5
2	2000	93	86.9	31.0	367.4	1.9
3	1999	3	2.8	1.0	448.3	15.0
4	1998	3	2.8	1.0	416.0	29.8
Total		107	100.0	35.7		

Size at Maturity:

Male sauger mature by 250 mm TL and are fully mature by 300 mm.
Females are mature by 260 mm TL and are fully mature by 300 mm TL

Fecundity: Not assessed

Movement: Not assessed

Annual Mortality: Can range from 50-80%.

Angling Mortality: Exploitation can range from 40-60% (Maceina, et al 1998).

Habitat Requirements: Not assessed

Limiting Factors: Water temperature

Contamination Issues: Not assessed

Other Pertinent Information: None

Please rank the overall importance of sauger to your state's sport fishery:

0 1 [✓ 2] 3 4 5
None Very Important

Overall the fishery is only moderately important due to the limited distribution. In the Tennessee Valley sauger are an important sport and food fish.

ARKANSAS

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
Arkansas River	11110104	Native	300 miles/0.3 miles	Stable
Arkansas River	11110201	Native	300 miles/0.3 miles	Stable
Arkansas River	11110203	Native	300 miles/0.3 miles	Stable
Arkansas River	11110207	Native	300 miles/0.3 miles	Unknown
Arkansas River	08020401	Native	300 miles/0.3 miles	Unknown
White River	11010013	Native	180 miles/0.18 miles	Unknown
White River	08020303	Native	180 miles/0.18 miles	Unknown
White River	08020301	Native	180 miles/0.18 miles	Unknown
Little Red River	11010014	Native	25 miles/75 yds	Unknown
Mississippi River	08010100	Native	220 miles/0.5 miles	Unknown
Mississippi River	08020100	Native	220 miles/0.5 miles	Unknown
Mississippi River	08030100	Native	220 miles/0.5 miles	Unknown
Eleven Point River	11010011	Native	40 miles/75 yds.	Unknown
Spring River	11010010	Native	30 miles/75 yds.	Unknown
Current River	11010008	Native	30 miles/75yds.	Unknown
Strawberry River	11010012	Native	30 miles/75yds.	Unknown
St. Francis River	08020203	Native	40 miles/100 yds.	Unknown

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

Currently, there are very few strategies implemented to manage sauger in Arkansas. Saugers are protected by a daily creel limit of 6 fish (possession limit of 12). Saugers have been stocked in the Arkansas River, but the last stocking occurred in 2001.

The effectiveness of the daily creel limit and stocking efforts are unknown.

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

Daily creel limit of 6 fish – Protects fish from exploitation, especially when they are concentrated below dams (Arkansas River) or during spawning runs.

Stocking – AGFC management biologists believe that increased stocking is necessary to improve sauger populations on the Arkansas River.

Minimum length limit – Research recently completed on the Lake Dardanelle Pool of the Arkansas River indicates that a minimum length limit may be necessary to prevent “recruitment overfishing” from occurring.

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

1.) Gill nets and boat electrofishing have been used to evaluate sauger fisheries. A small number of saugers are also captured during cove rotenone fish population samples.
2.) N/A
3.) N/A

Comments: Management biologists believe that creel surveys are needed on selected pools of the Arkansas River to evaluate angler impacts on sauger populations.

Please list known information—from your state—for the following sauger attributes:

Growth Rate: Lake Dardanelle - von Bertalanffy growth equation: TL= 533 (1 – e0.259(t-2.308))
Age 1 = mean length = 291 mm (n=44)
Age 2 = mean length = 385 mm (n=47)
Age 3 = mean length = 406 mm (n=30)
Age 4 = mean length = 408 mm (n =6)
Age 5 = mean length = 455 mm (n = 1)

Size at Maturity: Males: 292 mm; Females: 393 mm

Fecundity: Lake Dardanelle Pool of the Arkansas River: (18 females) mean = 56,002 eggs/gravid female (SE = 4,857)

Movement: N/A

Annual Mortality: Lake Dardanelle Pool of the Arkansas River: Annual Mortality = 66% (based on catch curve – $R^2 = 0.87$)

Angling Mortality: N/A

Habitat Requirements: Sufficient flow, adequate substrate for spawning, little fluctuation in water temperature and flow during spawning period.

Limiting Factors: Sedimentation, fluctuating flow and water temperature during the spawning season. Presence of large dams on Arkansas River act to congregate fish during the winter months, which could lead to excessive angler exploitation.

Contamination Issues: N/A

Other Pertinent Information

Please rank the overall importance of sauger to your state's sport fishery:

0	**1**	**2**	**3**	**4**	**5**
None	1 or greater				**Very Important**

COLORADO

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
Horseshoe Reservoir	11020006	I	180 ac.	I

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

Stocking 100/ac – fingerlings. Resulted in slow population level increases.

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

All we have is stocking. Not much emphasis on sauger.

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

Gillnet surveys to monitor population levels.

Please list known information—from your state—for the following sauger attributes:

None

Other Pertinent Information: None

Please rank the overall importance of sauger to your state's sport fishery:

0 ○ **1** **2** **3** **4** **5**

None **Very Important**

GEORGIA

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
None				

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

Georgia's portion of the Mississippi River drainage is composed of fairly high elevation streams with trout and other cold/cool water fishes. I checked with some coworkers since and no one knows of any sauger existing in our Mississippi drainage streams or reservoirs.

Georgia does have sauger in the Savannah River drainage, which empties into the Atlantic Ocean, but this does not meet the criteria of Mississippi watershed. Other than an eight fish creel limit, there is no special management directed at sauger.

Please rank the overall importance of sauger to your state's sport fishery:

[✓ 0] 1 2 3 4 5

None Very Important

IOWA

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
Mississippi River	07060001	Native	312/1.75	Stable to decreasing
	07060003			
	07060005			
	07080101			
	07080104			
Big Sioux River *(based upon Kirby personal experience, likely exist up to Klondike Dam in Lyon County, upstream barrier and distributional limit for Flathead catfish)*	10170203	Native	79.2/0.03	Stable to decreasing
Missouri River	10230001	Native	268.1/0.20	Stable to decreasing
	10230006			
	10240001			
Turkey *(collected in six different samples by Decorah Management or Manchester Research between 2000 and 2002, Hook and line by D. Kirby near Osterdock, no collection upstream of Elkader)*	07060004	Native	43.1/0.03	Stable to decreasing
Upper Iowa *(5 collections between 1983 and 1999, farthest upstream below the Lower Dam, Winneshiek County)*	07060002	Native	57.0/0.03	Stable to decreasing
Yellow River	07060001	Native	10/0.02	Stable to decreasing
Cedar River *(11 collections since 1964, multiple collections in or near Pallisades-Kepler Park, but none from above)*	7080206	Native	70/0.10	Stable to decreasing
Iowa *(7 collection since 1988, none above Iowa City dam)*	07080209	Native	79.3/0.13	
Maquoketa *(4 collection by Manchester Fish Management from 1996-1997, as far upstream as Maquoketa on South Fork and near Crab-*				

Town on North Fork)				
Wapsipinicon *(Menzel in 1982 in northeast Blackhawk County and Sleeper in 1998 near central City)*	07080102			
(Sleeper in 2002 SE of Anamosa)	07080103			
Boyer *(1 collection by Wilton in 1998 from Otter Creek north of Deloit, Crawford County)*	10230007			
Floyd *(3 collections in total the most recent 1969 by Kline north of Woodbury-Plymouth county line)*	10230002			
Little Sioux River *(a single record from 1963 west of Turin in Monona County)*	10230003			
Des Moines River *(7 collections since 1950, the most recent being 1977, farthest upstream collection from NE of Eddyville, Mahaska, County)*	7100009			
Maple *(2 collections from 1958 with that farthest upstream near the Monona-Woodbury County line)*	10230005			
Monona-Harrison Ditch *(3 collections from 1958-63 not far upstream from Missouri River)*	10230004			
Rock *(1 Sioux County collection by Gelwicks in 2000)*	10170204			
Skunk *(1 collection southwest of Black Hawk bottoms from 1964)*	07080107			
West Nishnabotna *(2 collections in 1998, both from Walnut Creek southwest of Red Oak)*	10240002			

The border rivers (Mississippi, Missouri and Big Sioux), support our best sauger populations. Sauger populations exist in the tributaries (Yellow HUCs have the best tributary pops- you may exclude the white ones if you wish but I included them because they had records of sauger) of the border rivers but only below the lowest impassible dam and most likely exist as an extension of the border river populations. Records of sauger exist in several tributaries above the lowest impassible dam but not in numbers that we would consider a population or fishery. Most if not all of our inland rivers are managed for stocked walleye fisheries, and hence, sauger are managed as walleye in those instances where they exist above the lowest impassible dam.

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

Continuous open season except there is a closed season for all fishing on the Mississippi River in the tailwaters at three navigation dams from Dec. 1st of each year through March 15th of the following year. These closed fishing areas are:

1. From Dam 11 at Dubuque downstream to the railroad bridge near river mile 579.9.
2. From Dam 12 at Bellevue downstream to the mouth of Mill Creek, near river mile 556.0.
3. From Dam 13 at Clinton downstream to the downstream end of Stamp Island near river mile 521.5.

Winter closures below the dams are aimed at reducing exceedingly high mortality rates (75-90%) for sauger in these areas. Evaluation of this regulation is ongoing in its third year of a five year study.

Bag limits: Inland waters: Combined (walleye/sauger) daily bag of 5 fish and combined (walleye/sauger) possession limit of 10; Boundary waters: Mississippi River combined (walleye/sauger) daily bag of 6 fish and combined (walleye/sauger) possession limit of 12. Big Sioux and Missouri Rivers combined (walleye/sauger) daily bag of 4 and combined possession limit of 8.

No length limits for sauger.

The border rivers (Mississippi, Missouri and Big Sioux), support our best sauger populations. Sauger populations exist in the tributaries (Yellow HUCs have the best tributary pops- you may exclude the white ones if you wish but I included them because they had records of sauger) of the border rivers but only below the lowest impassible dam and most likely exist as an extension of the border river populations. Records of sauger exist in several tributaries above the lowest impassible dam but not in numbers that we would consider a population or fishery. Most if not all of our inland rivers are managed for stocked walleye fisheries, and hence, sauger are managed as walleye in those instances where they exist above the lowest impassible dam.

There are no sauger fisheries in our inland lakes (natural or constructed), they are managed for walleye only.

An evaluation of stocking saugeye in our small impoundments concluded that walleye do as well as saugeye, as a result, stocking of saugeye was discontinued and not recommended for any lakes in Iowa (Hill 2000).

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

The three main sauger fisheries in our state are managed by bag and possession limits. A 6 fish daily bag and 12 fish possession limit on the Mississippi River and a 4 fish daily bag and an 8 fish possession limit on the Big Sioux and Missouri Rivers.

These are considered our most effective strategies because the population modeling to date has shown that reduction of the bag or implementing a minimum length limit on sauger has no benefit to the population.

A management strategy we are in the process of evaluating is the closed season at three navigation dams on the Mississippi River.
There is a closed season for all fishing on the Mississippi River in the tailwaters at three navigation dams from Dec. 1st of each year through March 15th of the following year. These closed fishing areas are:

1. From Dam 11 at Dubuque downstream to the railroad bridge near river mile 579.9.
2. From Dam 12 at Bellevue downstream to the mouth of Mill Creek, near river mile 556.0.
3. From Dam 13 at Clinton downstream to the downstream end of Stamp Island near river mile 521.5.

Winter closures (roughly 1 to 1.5 miles of river) below each dam are aimed at reducing exceedingly high mortality rates (75-90%) for sauger in these areas. Evaluation of this regulation is ongoing in its third year of a five year study.

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

1) Equipment and procedures used to monitor sauger fisheries in Iowa is DC electrofishing and creel surveys. Trammel and gill nets are only used sporadically in an effort to reduce fish mortality in those gears.
2) Equipment and procedures used in the past to assess movement patterns of sauger in Iowa has been radio telemetry and floy tagging.
3) Equipment and procedures used to assess the effectiveness of regulations implemented to improve sauger fisheries in Iowa is DC electrofishing and creel surveys.
4)

Please list known information—from your state—for the following sauger attributes:

Growth Rate: Mississippi River Mean Length at Age (inches)
Pool 11: 1994, 1995, 1998, 1999

Age	I	II	III	IV	V	VI	VII	VIII	IX
N=430		11.0	14.0	16.9	18.4	18.4	19.3	20.0	

Pool 13: 1992, 1993, 1996, 1997, 2000, 2001, 2002, 2004, 2005

Age	I	II	III	IV	V	VI	VII	VIII	IX
N=911	8.2	11.1	14.0	16.3	17.8	18.6	19.2	19.5	

Size at Maturity: Upper Mississippi River, Pool 13: 13.9 inches at age III

Fecundity: Upper Mississippi River Pool 13;
Number of Eggs = -184282 + 586.32 * Length in millimeters.

Movement: Radio telemetry of sauger from Upper Mississippi River Pool 13, UMR have shown seasonal movement up to 20 miles, however movements of radio tagged fish did not include movement between pools.

Annual Mortality: Mississippi River Total Annual Mortality
Pool 11, 1994-2005: Mean=82.9%; Range=73-92%
Pool 13, 1992-2005: Mean=70.1%; Range=47-86%

Angling Mortality: Mississippi River angling mortality:
Pool 11: 1995, 1996, 1999, 2000: Mean=27.0%; Range=14.0-36.9%
Pool 13: 1993, 1994, 1997, 2001, 2002, 2003: Mean=21.7%; Range=12.6-25.3%

Habitat Requirements: Deep water for overwintering, suitable spawning habitat.

Limiting Factors: Spawning habitat on the border rivers. Decreased survival of larvae after hatching while drifting due to towboat induced mortality.

Contamination Issues: None

Other Pertinent Information:

IRIS, Iowa Rivers Information System. 2004-2006. http://maps.gis.iastate.edu/iris/. A database of information for rivers and streams in Iowa. Iowa Cooperative Fish and Wildlife Unit, Iowa State University Geographic Information System Facility, Iowa Department of Natural Resources – Fisheries.

Please rank the overall importance of sauger to your state's sport fishery:

0	**1**	**2**	**3**	**4**	**5**
None					**Very Important**

The overall importance of sauger to Iowa's sport fishery is between 3 and 5. Viable sauger populations are only found on the border rivers. These rivers are very important fisheries to the state and sauger are an important sport fishery component of those rivers.

INDIANA

DISTRIBUTION:

Ohio River and all tributaries to first impassable dam upstream.
Native stable population.
Wabash River and all tributaries to first impassable dam upstream.
Native stable population.
White River and all tributaries to first impassable dam upstream.
Native stable population.

MANAGEMENT STRATEGIES:

All state waters except for Ohio River:
- Daily bag limit of six in combination with walleye and hybrids.
- Possession limit of twelve in combination with walleye and hybrids.
- No size limit.

Ohio River:
- Daily bag limit of ten in combination with walleye and hybrids.
- Possession limit of twenty in combination with walleye and hybrids.
- No size limit.

Stocking:
- Are only stocked for reintroduction purposes.
- Fingerlings stocked in the upper portions of the East and West Forks White River at 50/acre.
- Good fingerling survival but no evidence of natural production in the East Fork.

MOST EFFECTIVE MANAGEMENT STRATEGY:

Ohio River: none, high natural and low angler mortality rates preclude enactment of size limits or more restrictive bag limits.

ASSESSMENT EQUIPMENT AND PROCEDURES:

1) Monitor fisheries: Ohio River ORFMT (Ohio River Fish Management Team) Tailwater Protocol: nighttime DC boat electrofishing, November-December, water temperature < 15º C, six fifteen-minute transects in downstream direction, three transects along each shoreline immediately downstream of dam.
2) Access movement patterns: same as above with addition of tagging all percids ≥ 250 mm with T-bar anchor tags.
3) Access regulation effectiveness: combination of #1 and #2 with the additional of tailwater angler creel surveys.

SAUGER ATTRIBUTES:

Ohio River:
Growth Rate:

Age 0: 232 ± 2 mm
Age 1: 336 ± 2 mm
Age 2: 377 ± 3 mm
Age 3: 420 ± 9 mm

Size at Maturity: 377 mm, age 2

Fecundity: ?

Movement:

- 535 miles upstream from Newburgh Dam Tailwater (IN/KY) to Racine Dam Tailwater (OH/WV) from 11/05 to spring 2006.
- 160 miles upstream from Ohio River (Myers Dam) to White River (Wabash River tributary) from November to spring.

Annual Mortality:

- total annual mortality (ages 1 to 2) ranged from 63% to 98% from 1998 to 2002 for five Ohio River study tailwaters.
- total annual mortality estimate based on 2002 fall electrofishing data was 79%.

Angling Mortality:

- overall angler exploitation was estimated at 10% (6.5 to 17.3%) on fish tagged during 11-12/05 and harvested through 6/06.
- angler exploitation was 6% for sauger < 350 mm and 35% for sauger > 350 mm.

Habitat Requirements: Riverine

Limiting Factors:

- none for Ohio River
- unknown for interior Indiana Rivers

Contamination Issues:

- Ohio River PCB consumption advisory:
    - 1 meal/month for sauger 13-23 inches in total length.
    - 1 meal/ 2 months for sauger > 23 inches.
- Interior Indiana Rivers PCB consumption advisory:
    - 1 meal/2 month for sauger 13-19 inches in total length.
    - do not eat > 19 inches??????

SAUGER OVERALL IMPORTANCE TO INDIANA’S SPORT FISHERY:

Ohio River – 5 (very important)
Interior Rivers – 3 (somewhat important)

KANSAS

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	8-Digit HUC[2]	Native or Introduced	Size[3]	Status[4]
Missouri River	10240008	N		Unknown
Missouri River	10240005	N		Unknown
Missouri River	10240011	N		Unknown
Kansas River	10270104	N		Unknown
Perry Reservoir	10270103	I	12,000 ac	S
Melvern Reservoir	10290102	I	7,000 ac	S
Banner Creek Reservoir	10270103	I	535 ac	Unknown

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

There is a statewide 15-inch length limit and a daily creel limit of 5 as a single species or in combination with walleye and saugeye.

Populations at Perry and Melvern Reservoirs and Banner Creek Lake were established by stocking fingerlings with various stocking densities. In 2000, Melvern was stocked with sauger fingerlings (5.0/acre were requested, 5.88/acre were stocked). Perry was stocked with 6.11 fingerlings per acre and 8.65 fry per acre. Banner Creek was stocked with 111 fingerlings per acre.

No evaluations of harvest regulations or stocking have been completed.

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

These have not been evaluated.

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

1. Standard fall netting samples with gill nets and trap nets. Night time electrofishing.
2. Movement was monitored at Melvern Reservoir with radio telemetry to locate spawning areas.
3. General creel surveys have been conducted at the three impoundments, but none of the these targeted sauger. Harvest at Melvern Reservoir ranged from 0.02 to

0.21 fish/acre (mean =0.08/acre) from 2001-2005. At Perry Reservoir, harvest ranged from 0.002/acre in 2004 to 0.006/acrein 2001.

Please list known information—from your state—for the following sauger attributes:

Growth Rate: No qualitative data have been collected to target any of these attributes in Kansas, except a little at Melvern Reservoir.

Size at Maturity: N/A

Fecundity: N/A

Movement: N/A

Annual Mortality: N/A

Angling Mortality: N/A

Habitat Requirements: N/A

Limiting Factors: N/A

Contamination Issues : N/A

Other Pertinent Information: N/A

Please rank the overall importance of sauger to your state's sport fishery:

0 1 2 [✓ 3] 4 5

None Very Important

Sauger are perhaps most important for their use in the production of saugeye. Anglers may target sauger on the Kansas and Missouri Rivers but we do not have adequate information about this.

Please list any databases, peer-review literature, agency reports, university research, or gray literature that provides information on the status of sauger populations—or life history information—in your state.

We have limited length frequency and condition data for sauger at the three impoundments. Limited stream survey data may exist for the Kansas River and streams feeding the Missouri River, but these data are not quantitative.

LOUISIANA

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
Mississippi River		N		Unknown

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

N/A

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

N/A

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

N/A

Please list known information—from your state—for the following sauger attributes:

None

Please rank the overall importance of sauger to your state's sport fishery:

[✓ 0] 1 2 3 4 5

None Very Important

Please list any databases, peer-review literature, agency reports, university research, or gray literature that provides information on the status of sauger populations—or life history information—in your state.

None

MINNESOTA

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
Mississippi River below St. Anthony Falls: details below, acreages include areas in WI.				
Pool 1 - Mississippi River / riverine impoundment	07040000	Introduced	6.0 miles / unknown acres	
Pool 2 - Mississippi River / riverine impoundment	07040000	Native	32.7 miles / unknown acres	Stable
Pool 3 - Mississippi River / riverine impoundment	07040000	Native	18.3 acres / 8,038 acres	Stable
Pool 4 - Mississippi River (including Lake Pepin) / riverine impoundment	07040000	Native	44.1 miles / 39,260 acres	Stable
Pool 5 - Mississippi River / riverine impoundment	07040000	Native	14.7 miles / 12,580 acres	Stable
Pool 5a - Mississippi River / riverine impoundment	07040000	Native	9.6 miles / 7,000 acres	Stable
Pool 6 - Mississippi River / riverine impoundment	07040000	Native	14.4 miles / 5,910 acres	Stable
Pool 7 - Mississippi River / riverine impoundment	07040000	Native	11.6 miles / 13,580 acres	Stable
Pool 8 - Mississippi River / riverine impoundment	07040000	Native	23.3 miles / 21,910 acres	Stable
Pool 9 - Mississippi River (MN portion only) / riverine impoundment	07040000	Native	5.4 miles / 1,635 acres	Stable
St. Croix River below Taylor's Falls, including Lake St. Croix / river & natural lake:	07030000	Native	52 mi/8,170 ac. (Lake St. Croix acre only)	Stable
Minnesota River below Minnesota Falls / river	07020000	Native	255 miles / unknown acres	Stable

NOTE – answers to the sections below are organized according to the three primary Mississippi River drainages in Minnesota where sauger are present. These drainages include the:

1) Mississippi River - below St. Anthony Falls (Lock and Dam 1)
2) St. Croix River - below Taylor's Falls
3) Minnesota River - below Minnesota Falls.

Sauger are an important component of the sport fishery in these rivers, however regulations, population surveys and management efforts are focused primarily on walleye.

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

Mississippi River:

Current regulations on the MN-WI boundary water portion (downstream from the confluence with the St. Croix) of the Mississippi River for walleye and sauger (either or combined) is a daily and possession limit of six. There is a 15" minimum size limit for walleye, but the size limit does not apply to sauger. The absence of a minimum size limit on sauger is appropriate as sauger are fast-growing and relatively short-lived in this reach of the Mississippi River.

The MN-WI portion of the Mississippi River is also unique in that it is the only water in MN that has a year-round season for all gamefish species. The continuous open season was initiated by Wisconsin in 1967 on its portion of the Mississippi River and Minnesota followed suit in1969. Controversy exists among anglers; however, biological data has shown that walleye and sauger populations have not been negatively impacted by the continuous season.

The best indicator of trends in the sauger population of the Mississippi River comes from Lake Pepin/Pool 4 where the MN DNR has monitored the fish populations annually for 40 years. The 1986-2006 average for sauger is 23.3 per gill net lift. The 40-year database has outlined periods of high (>60 sauger per gill net lift) and low (10-20 sauger per gill net lift) sauger abundance, but in general these differences are a result of year class variation in recruitment and are not influenced by biotic constraints or high exploitation. Size and age structure have shown remarkable stability over this time period and total annual mortality is has generally declined over time. The continuous season does provide a unique opportunity for anglers to fish for walleye and sauger during a time of year when angling is prohibited on other waters.

Upstream of the St. Croix River confluence, the Mississippi River is no longer border water and is regulated solely by MN DNR. The portion of Pool 3 that lies between the mouth of the St. Croix and the Pool 2 dam has a 15" minimum size for walleye to facilitate enforcement on the Wisconsin border waters. Pool 2 of the Mississippi River~~,~~ has a catch-and-release only regulation for sauger, walleye, largemouth bass and smallmouth bass.

Poor water quality and associated habitat impacts in the Upper Mississippi River have generally been the largest constraints for many fish species in the past 50-75 years. However, improved sewage treatment facilities near the Twin Cities metro area and improved farming practices (to some degree) have resulted in better water quality in the past 20 or so years and increases of sensitive fish species have been observed. Fisheries managers on the Upper Mississippi River will continue to promote reduced agricultural runoff and more comprehensive sewage treatment facilities.

St. Croix River:

The St. Croix River is also border water shared with the State of Wisconsin. Unlike the Mississippi River, the St. Croix does not have a continuous season for sauger and walleye. Harvest season for these species runs from the Saturday nearest May 1st to the end of February. The daily and possession limit for sauger and walleye (either or combined) is six and there is a minimum size limit of 15” for walleye.

Minnesota River:

The Minnesota River lies entirely within state boundaries and is therefore subject to statewide angling regulations. Per statewide fishing regulations, angling for walleye and sauger is prohibited on the Minnesota River from March 1 to mid-May. Daily and possession limit for walleye and sauger (either or combined) is six, and not more than one over 20 inches can be taken daily.

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

There are no specific examples of management strategies focused only on sauger in the Minnesota portion of the Mississippi River basin. In general, sauger management tends to be secondary to walleye management and sauger may indirectly be affected by regulations and/or management actions directed at walleye. In river systems where sauger are abundant, they often represent a substantial portion of angler catch and harvest. In Pool 4, for example, sauger harvest is generally more than double that of walleye.

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

Mississippi River **:**

1) Twenty-four experimental gillnets (0.75”-2.0” bar mesh) are set in the fall (early October) at fixed locations annually in Lake Pepin (Pool 4). This sampling has been done annually since 1986. In addition, trawling and fall YOY electrofishing is annually conducted to provide additional measure of year-class strength.
2) Occasionally, special projects will be implemented to address specific questions of interest. Biotelemetry was used in Pool 4 in 1997 and 1998 to assess the use of backwater habitats for spawning by sauger and to assess affinity for habitat selection.
3) Creel surveys are conduced in Pool 4 two out of every six years to obtain catch, harvest, and pressure estimates.

4) Currently, biologists are evaluating the effects of catch and release mortality on sauger caught from deep water during the winter below Lock & Dam 3. Results from this study will be available by May 2007.

St. Croix River:

Lake St. Croix (the portion below Stillwater) is monitored using standard Minnesota Lake Survey procedures every 5 years. The portion of the St. Croix from Taylor's Falls to Stillwater is monitored using electro-fishing gear, shoreline seines and river trap nets every 5th year. Both portions were done in 2006 to coincide with investigations conducted in the upper St. Croix.

No attempt has been made to assess movement of sauger or assess the effectiveness of regulations.

Minnesota River:

Sauger have been sampled on the Minnesota River in conjunction with fish community assessments in 2004, 1998, 1992, and 1978-82. Multiple gear were used, but not targeted toward sauger. Sauger were sampled with electrofishing in all four surveys. They were also collected by gill nets in 1992, and trap nets (3/4 and 1 in mesh) in 1998. In the four studies combined, the walleye to sauger ratio is more than 4 to 1.

The summer creel in 1998 reported only 4 sauger caught, two of which were released

Please list known information—from your state—for the following sauger attributes:

Mississippi River (all data are from Pool 4):

Growth Rate: Provided below is the mean total length (in.) at age of sauger from the 1998-year class. von Bertalanffy growth parameters are as such: Linf = 533.855; K = 0.398; to = -0.62

1998 Year Class		
Age	Mean TL	N
1	9.97	35
2	13.67	39
3	16.17	41
4	17.34	35
5	18.89	31
6	19.75	20
7	19.86	11

Size at Maturity: Based on maturity and total length data from 1999-2004, percentages of mature fish at length (in.) are provided below.

Female Sauger						Male Sauger				
Length (in.)	IF	F	Total	% Mature		Length (in.)	IM	M	Total	% Mature
9	18		18	0.00		9	13	3	16	18.75
10	28		28	0.00		10	27	17	44	38.64
11	30		30	0.00		11	10	40	50	80.00
12	24	4	28	14.29		12	5	45	50	90.00
13	22	14	36	38.89		13	0	53	53	100.00
14	18	45	63	71.43		14	1	47	48	97.92
15	18	41	59	69.49		15		44	44	100.00
16	1	44	45	97.78		16		43	43	100.00
17		47	47	100.00		17		38	38	100.00
18		40	40	100.00		18		49	49	100.00
19		43	43	100.00		19		32	32	100.00
20		26	26	100.00		20		14	14	100.00
21		15	15	100.00		21		3	3	100.00
22		5	5	100.00		22			0	.
23		1	1	100.00		23			0	.

Fecundity: Has not been assessed.

Movement

Objective: Determine the use of backwater habitats for spawning by sauger and assess affinity for habitat selection during two spawning seasons (in Pool 4, Mississippi River). Results: during staging, sauger frequented main channel border and deep-water flat habitat associated with the shipping thalweg; during spawning, sauger exclusively used habitat associated with the main channel. See Ickes 2000.

Annual Mortality: Provided below is annual mortality (AM) estimated using catch curve analysis (annual experimental gillnet data) for age 2-6 sauger in Lake Pepin. Annual mortality ranged from 0.26 in 1993 to 0.82 in 1969. The average annual mortality estimate from 1965 to 2005 was about 0.50.

Sauger Annual Mortality	
Period	AM
1965-1969	0.608
1970-1979	0.517
1980-1989	0.459
1990-1999	0.441
2000-2005	0.5275
1965-2005	0.4969

Angling Mortality: Rates of exploitation were calculated from voluntary tag returns in 1978-79 (see Thorn 1984). Sauger exploitation ranged from 27.6 to 58.0% with an average of 37.8%.

Habitat Requirements: No studies completed to address habitat requirements. See movement category for sauger spawning habitat preferences.

Limiting Factors: Water temperatures/global climate change

Contamination Issues: Seventy-three sauger have been tested for PCB since 1975 and ranged from 0.010 to 1.700 PPM. HG samples on 83 sauger indicate a range of contamination between 0.046 to 0.36 PPM. Current consumption guidelines from the Minnesota Department of Health for the Mississippi River below Red Wing recommend no more than one meal per week for the general population.

St. Croix River:

Growth Rate: Length at age for sauger in Lake St. Croix (2002).

				AGE				
	0	1	2	3	4	5	6	7
Mean TL		6.7	10.9	12.9	14.8	15.5		

Size at Maturity: No Data

Fecundity: No Data

Movement: No Data

Annual Mortality: No Data

Angling Mortality: No Data

Habitat Requirements: No Data. Habitat is apparently adequate as populations are stable.

Limiting Factors: Not determined.

Contamination Issues: **t**en sauger have been tested for PCB since 1975 and ranged from 0.010 to 0.11 PPM. Mercury (HG) samples from seven sauger indicate a range of contamination between 0.094 to 0.510 PPM. Current consumption guidelines from the Minnesota Department of Health recommend no more than one meal per week for the general population.

Minnesota River:

Growth Rate: Provided in table below is the mean back-calculated total length (inch) at age of sauger from the Minnesota River in 2004.

AGE

	0	1	2	3	4	5	6	7
Number Aged	0	0	1	20	2	3	2	1
Mean TL		5.76	9.98	12.60	15.19	17.19	18.06	18.69
Std Error		0.27	0.34	0.35	0.55	0.14	0.17	0.00

Size at Maturity: unknown

Fecundity: unknown

Movement: Has not been investigated

Annual Mortality: unknown

Angling Mortality: unknown

Habitat Requirements: Has not been specifically investigated in the Minnesota River

Limiting Factors: ??

Contamination Issues: Twenty-nine sauger have been tested for PCB since 1975 and ranged from 0.020 to 1.70 PPM. Mercury (HG) samples on 23 sauger indicate a range of contamination between 0.110 to 0.850 PPM. Current consumption guidelines from the Minnesota Department of Health recommend no more than one meal per week for the general population.

Please rank the overall importance of sauger to your state's sport fishery:

0 1 [✓ 2] 3 4 5

None Very Important

From a statewide perspective, sauger importance to our fisheries ranks low (2), but in some localities it could rate as high as 4.

Please list any databases, peer-review literature, agency reports, university research, or gray literature that provides information on the status of sauger populations—or life history information—in your state.

Other creel survey report citations for pool 4 can be found in the UMRCC Fisheries Compendium available at http://www.mississippi-river.com/umrcc/

Various MN DNR Fisheries publications and reports can be downloaded at http://www.dnr.state.mn.us/publications/fisheries/index.html

MISSOURI

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
South Fabius River	07110003	N	29 mi.	Unknown
Auxvasse River	07140105	N		Unknown
Mississippi River (Upper)	07110009	N	39 mi	Unknown
Mississippi River (Upper)	07110004	N	86 mi	Unknown
Mississippi River (Upper)	07110001	N	40 mi	Unknown
Black River	11010007	N	83 mi	Unknown
Mississippi River (Middle)	07140105	N	119 mi	Unknown
Mississippi River (Middle)	07140101	N	79 mi	Unknown
Mississippi River (Lower)	08010100	N	128 mi	Unknown
Missouri River (Lower)	10300200	N	105 mi	Unknown
Missouri River (Lower)	10300102	N	121 mi	Unknown
Missouri River (Upper)	10240001	N	23 mi	Unknown
Current River	11010008	N	100 mi	Unknown
Perche Creek	10300102	N		Unknown
Gasconade River	10290203	N	102 mi	Unknown
Osage River	10290111	N	69 mi	Unknown
St John’s Bayou	08020201	N		Unknown
Meramec River	07140102	N	34 mi	Unknown
Big River	07140102	N		Unknown
Missouri River (Lower)	07110009	N		Unknown
Missouri River (Upper)	10240005	N	78 mi	Unknown
Missouri River (Upper)	10240011	N	73 mi	Unknown
Salt River	07110007	N	54 mi	Unknown
Nodaway River	10240010	N		Unknown
Grand River	10280101	N	27 mi	Unknown
St. Francis River	08020202	N		Unknown
Grand River	10280103	N	61 mi	Unknown
Moniteau Creek	10300102	N		Unknown
Moreau River	10300102	N		Unknown
Maple Slough	07110009	N		Unknown
Maries River	10290111	N		Unknown
Mud Ditch	07140105	N		Unknown
Nishnabotna River	10240004	N		Unknown
Fabius River	07110003	N	3 mi	Unknown
Fox River	07110001	N		Unknown
Blackbird Creek	10280201	N		Unknown
South River	07110004	N		Unknown
Shoal Creek	10280201	N		Unknown

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

No specific management efforts for sauger have been conducted or evaluated in Missouri. Current statewide regulations include a four fish daily limit in the aggregate with walleye and a 15-inch minimum length limit except on the Mississippi River where the daily limit is eight in the aggregate, no length limit. Habitat improvement/mitigation projects and instream flow recommendations have been implemented in some large rivers, and these improvements are likely beneficial to sauger and many other species.

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

Missouri has not implemented specific strategies, other than daily and possession limits, for sauger.

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

1. Pulsed DC electrofishing, seines, trawls, gill nets.
2. Mark-recapture.
3. None conducted.

Please list known information—from your state—for the following sauger attributes:

Growth Rate: Unknown

Size at Maturity: Unknown

Fecundity: Unknown

Movement: Unknown

Annual Mortality: Unknown

Angling Mortality: Upper Mississippi River pools 24, 22, 21 during 2005 -2006 = 9%.

Note: Some of this information will be collected as part of a recently initiated assessment of walleye and sauger in tailwaters of Lock and Dams 20, 21, 22, 24, 25, and 26.

Habitat Requirements: Free-flowing waters. Gravel, cobble substrate.

Limiting Factors: Angler harvest, siltation/sedimentation, gravel mining, channel dredging and spoil placement, migration barriers.

Contamination Issues : Unknown

Other Pertinent Information:

Please rank the overall importance of sauger to your state's sport fishery:

0 1 2 [✓ 3] 4 5

None Very Important

Please list any databases, peer-review literature, agency reports, university research, or gray literature that provides information on the status of sauger populations—or life history information—in your state.

Missouri Department of Conservation fish database – Columbia, MO

LTRMP Open River Field Station fish community databases – Cape Girardeau, MO

Upper Mississippi River walleye and sauger database – Hannibal, MO

Several public use surveys and creel surveys for Missouri River and Upper Mississippi River – Columbia, MO

MISSISSIPPI

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
Pickwick Lake - impoundment	06030005 06030006	Native	6,700 acres in MS	Stable
Mississippi River	08020100	Native	?	Stable
Mississippi River	08030100	Native	?	Stable
Mississippi River	08060100	Native	?	Stable
Mississippi River	08060204	Native	?	Stable
Mississippi River	08060100	Native	?	Stable
Data from museum collections				
Sauger probably occur in entire length of Miss. River along western border of state.			418.5 river miles	

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

Creel Limit of 15 per person per day. No length restrictions. No stocking or populations assessment. No information on effectiveness of creel limit.

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

Unknown.

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

None utilized.

Please list known information—from your state—for the following sauger attributes:

None known.

Other Pertinent Information

In Mississippi, sauger are considered a species of "special concern" with regards to conservation status. Ross (2001) stated that sauger are uncommon in Mississippi, but it is not known whether their scarcity is due to the habitat conditions at the extreme southern end of their range or a decline from populations that were once more abundant.

Please rank the overall importance of sauger to your state's sport fishery:

[✓ 0]   1   2   3   4   5

None   Very Important

Please list any databases, peer-review literature, agency reports, university research, or gray literature that provides information on the status of sauger populations—or life history information—in your state.

Mississippi Museum of Natural Science fish database.

MONTANA

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC**[2]	**Native or Introduced**	**Size**[3]	**Status**[4]
Middle Missouri	1003000 1004000	Native	Historic/1999 207/207	Stable lower 2/3, declining upper 1/3
Marias River	10030200	Native	170/60	Declining
Teton River	10030205	Native	50/0	Mostly Extirpated
Judith River	10040103	Native	53/53?	Declining
Musselshell River	10040200	Native	75/0	Probably Extirpated
Lower Missouri	1003000 1004000 1006000 1007000	Native	315/234	Stable to declining
Milk	1005000	Native	425/150	Declining
Middle Yellowstone	10100000	Native	50/4	Stable
Bighorn River	10080000	Native	128/4	Mostly extirpated
Lower Yellowstone	10100000	Native	295/237	Stable
Tongue River	10090000	Native	150/0	Extirpated
Powder River	10090000	Native	?/?	Declining
Little Missouri River	10110200	Native		
Beaver Creek	10110204	Native	50/0	Extirpated
Little Beaver Creek	10110204	Native	20/0	Extirpated
Box Elder Creek	10110202	Native	?/?	

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

Very little sauger stocking has taken place in Montana. Most of the stocking that has occurred has been in the Upper Missouri River Basin from Great Falls, MT to the Marias River. These stocking efforts constituted a conservation effort to bolster their numbers in the upper portion of this reach. The idea was to use 3 small upstream reservoirs as grow-out areas for early fingerling sauger, which would eventually flush downstream. This augmentation effort is currently being evaluated.

General harvest regulations in the Central and Eastern fishing districts in Montana allow the harvest of 5 walleye/sauger per day and 10 in possession. In some areas, more restrictive harvest regulations allow harvest of 5 Sauger/Walleye daily, only 1 may be a sauger, possession limit is 10, and only 2 may be sauger. (see the enclosed MFWP fishing regulations, Bighorn River, Exceptions to Standard Regulations). The effects of reducing sauger creel limits in the middle Missouri River is presently being evaluated.

Montana FWP has initiated an angler education program to help anglers differentiate sauger from walleye.

Montana FWP has focused on habitat improvements to benefit sauger populations. Specifically, MFWP has worked to improve fish passage at irrigation diversions, install fish screens to prevent fish entrainment into irrigation canals, and to improve in-stream flows. Montana FWP has also initiated research to investigate competition and hybridization between walleye and sauger; to better understand the risks of introduced walleye.

sauger were listed as a state of Montana species of concern in 2000.

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

Along with minimizing the introduction of exotic species (e.g. walleye and smallmouth bass), working to improve and restore habitat (including maintaining instream flows) is critical to sauger fisheries in Montana.

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

Montana utilizes standard large-river fish sampling equipment to monitor sauger populations. Equipment includes: electrofishing, seines, and entanglement gear to sample sauger populations. Population evaluations are usually measured using Proportional Size Structure indices, relative weight, catch per unit effort, and population estimates. Movement has been addressed using telemetry and tagging fish with standard tag types (e.g., Floy tags). Each of the above gears and methods are used to assess the effectiveness of fishing regulations. Floy tags are also being used to estimate survival and angler harvest. Telemetry studies are being implemented to improve our understanding of the environmental factors that affect our trend sampling data.

Please list known information—from your state—for the following sauger attributes:

Growth Rate: The following growth information was taken from Fishes of Montana, Dr. C.J.D. Brown 1971

1 year	5 inches
2 years	9 inches
3 years	11 inches
4 years	13 inches
7 years	18 inches

As of 1971, the oldest reported sauger in Montana was 7 years old.

Carlander's 1997 book on icthyopercid and percid fishes of the US and Canada might expand on the known growth rate information for Montana. Other information has been attached to this message.

Size at Maturity: During their third or fourth years when they attain a length of 9 to 12 inches (Fishes of Montana, Dr. C.J.D. Brown 1971).

Fecundity: 10,000 to 100,000 eggs depending on their size (Fishes of Montana, Dr. C.J.D. Brown 1971)

Movement: Varied. Movements have been observed up to 350 km.

Annual Mortality: Unknown

Angling Mortality: Mostly unknown or poorly understood.

Habitat Requirements: **S**augers require large, functioning, un-fragmented rivers with natural flow and sediment regimes.

Limiting Factors: Limiting factors for Montana sauger include: habitat fragmentation and degradation, competition with non-natives, and hybridization with walleye. Overharvest may be a limiting factor in some areas.

Contamination Issues: Hybridization with walleye.

Please rank the overall importance of sauger to your state's sport fishery:

0 1 2 [✓ 3] 4 5

None **Very Important**

For the lower Missouri and Yellowstone River basins, sauger are very important to the local fisheries. On a statewide basis, sauger are less important due to the size of our state and the diversity of available fisheries.

NORTH CAROLINA

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
French Broad River/Lg. river	06010105	Native (or reintroduced)	~ 20 RM	Unknown
Pigeon River/Med. river	06010106	Native (or reintroduced)	0 to ~10 RM, based on flow.	Unknown

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

We have no data on sauger populations in North Carolina. Based on angler reports, they probably exist only in the reaches of the French Broad and Pigeon rivers from the Tennessee state line up to the first dam on each system. I have no records of sauger from the North Carolina portions of the Watauga or Nolichucky systems, and the Little Tennessee and Hiwassee systems are essentially impounded or dewatered throughout the reaches that may have once supported the species. We have never collected sauger in any of our reservoir samples in western North Carolina. Impoundment and pollution extirpated a number of large fish species from the North Carolina portions of all these rivers in the mid-20th century, and the sauger was likely among the species lost. Restoration efforts have focused on a sport fishery for muskellunge in the upper French Broad, and on cyprinid and darter species in the upper Pigeon. No effort has been made to reintroduce sauger into these reaches.

Statewide regulations for sauger are 8 fish per day, with a minimum length of 15 inches; this regulation was likely established to match the regulation for walleye and avoid confusion when anglers caught the occasional sauger. The length limit for walleye has since been removed for most North Carolina waters, but the sauger limit has never been changed.

We have no active management program for sauger because their current range extends only marginally into the state. I have never seen a sauger in North Carolina waters.

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

Not applicable; see response above.

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

None/not applicable.

Please list known information—from your state—for the following sauger attributes:

Growth Rate: None.

Size at Maturity: None.

Fecundity: None.

Movement: None.

Annual Mortality: None.

Angling Mortality: None.

Habitat Requirements: None.

Limiting Factors: Dams presumed to limit range.

Contamination Issues: No data.

Other Pertinent Information: None.

Please rank the overall importance of sauger to your state's sport fishery:

[✓ 0]   1   2   3   4   5

None   Very Important

Please list any databases, peer-review literature, agency reports, university research, or gray literature that provides information on the status of sauger populations—or life history information—in your state.

I know of no literature or databases on North Carolina sauger populations.

NORTH DAKOTA

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
Lake Sakakawea/Impoundment		N	365,000 ac	S
Lake Oahe/Impoundment		N	100,000 ac	S
Missouri River		N	100 mi x ¼ mi	S

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

Daily limit – 5 sauger or walleye or combination
Possession limit – 10 sauger or walleye or combination

The combination limits effectively restrict the harvest of sauger because walleye are more abundant and pursued by anglers. Not many anglers fish specifically for sauger.

Not stocked. No other regulations.

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

Combination limit.

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

1. Standard netting surveys using experimental gill nets (impoundments) and electrofishing (river). Creel surveys.

2. None

3. Creel surveys.
4.

Please list known information—from your state—for the following sauger attributes:

Growth Rate

	1	2	3	4	5	6	7	8
Sakakawea	149	269	336	411	474	472	487	492
Oahe	139	251	337	406	468	525		

Missouri R.	120	215	288	346	402	466	523	650

Size at Maturity: N/A

Fecundity: N/A

Movement: N/A

Annual Mortality: N/A

Angling Mortality: N/A

Habitat Requirements: N/A

Limiting Factors: Competition with walleye.

Contamination Issues : N/A

Other Pertinent Information: None

Please rank the overall importance of sauger to your state's sport fishery:

0 [✓ 1] 2 3 4 5

None Very Important

NEBRASKA

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
Pawnee Reservoir	10200203	I	740 ac	D
Willow Creek Reservoir	10220002	I	700 ac	D
G.I. Eagle Scout Pit	10200103	I	40 ac	D
Plum Creek Canyon Reservoir	10200101	I	250 ac	I
Gallagher Canyon Reservoir	10200101	I	180 ac	I
Midway Canyon Reservoir	10200101	I	600 ac	I
Blue Hole West Pit	10200101	I	25 ac	S
Phillips Canyon Reservoir	10200101	I	140 ac	I
Niobrara River	10150007	N	40 mi	S
Missouri River, Upper	10170101	N	40 mi	S
Johnson Reservoir	10200101	I	2200 ac	I
Cottonwood Lake	10150004	I	35 ac	D
Alkali Lake	10150004	I	375 ac	D
Lewis and Clark Reservoir	10170101	N	30,000 ac	S
Missouri River, Lower	1023	N	320 mi	S
Platte River, Lower	10200203	N	100 mi	S

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

Our management of sauger is for the most part lumped together with the management of sauger. For example, our regulations lump walleye, sauger, and saugeye together. We have a statewide bag limit of 4 and a possession limit of 8. A 15-inch limit applies statewide except for waters that have more restrictive length limits on walleyes and the stretch of the Missouri River below Gavins Point Dam where we have no length limits on our walleye populations, but have done no evaluations for sauger.

The only other management strategy we have used to enhance sauger fisheries has been stocking. Almost all of those stockings have been into reservoirs, natural lakes or pits where no saugers were present. All of our sauger stockings in the state have been 1-2-inch fingerlings which we stock at a 50/ac rate. Stockings have been successful in creating a viable sauger fishery in most of the reservoirs where they have been stocked. Stockings in small waters, pits made by the mining of sand and gravel, have been less successful, but in at least one of those waters sauger can now be found. In natural lakes the success of sauger stocking has been less or not as well evaluated and we have discontinued those stockings.

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

Stocking has probably been our most effective management strategy to improve sauger fisheries in Nebraska. That has been the tool we have used to expand sauger fisheries into some reservoirs where no sauger fisheries previously existed.

Although we have not evaluated the impact of our length limit regulations on sauger populations (they have been lumped together with walleyes for which the regulations were intended), I would expect that those regulations are restricting the harvest of sauger. That may be of most benefit in our systems where sauger are native and continue to maintain their populations by natural reproduction.

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

1. We monitor sauger populations in our standing waters with monofilament, experimental gill nets.
2. We have not assessed the movement patterns of saugers in any standing waters in Nebraska.
3. We have not done any assessment of the impact of any regulations on our sauger fisheries.

Please list known information—from your state—for the following sauger attributes:

Growth Rate
176 mm at age-1
307 mm at age-2
393 mm at age-3
464 mm at age-4
542 mm at age-5

Size at Maturity: Unknown

Fecundity: Unknown

Movement: Unknown

Annual Mortality: From catch curve analysis of our gill net data, I would estimate our annual mortality rate to be at 0.4. It appears higher on our heavily-fished waters, perhaps as high as 0.6.

Angling Mortality: Unknown

Habitat Requirements: Unknown

Limiting Factors: Unknown

Contamination Issues : None that we know of.

Other Pertinent Information:

Please rank the overall importance of sauger to your state's sport fishery:

0 1 [✓ 2] 3 4 5

None Very Important

Please list any databases, peer-review literature, agency reports, university research, or gray literature that provides information on the status of sauger populations—or life history information—in your state.

We do have all of our sampling data in a database. That database is managed by Keith Hurley, keith.hurley@ngpc.ne.gov, 402-471-5589.

There are no publications that I am aware of that summarize or provide information on the status of sauger populations in Nebraska. Currently we have an extensive effort underway to monitor the status of fish populations in the Missouri River along Nebraska's border. The focus of that work to this point has not been on sauger, but those sampling efforts have resulted in the accumulation of some data on sauger in the Missouri River. Gerald Mestl is in charge of that program and may be able to provide additional data on sauger in Nebraska's stretch of the Missouri River (Gerald.mestl@ngpc.ne.gov, 402-471-1512).

Dr. Dave Willis and students from South Dakota State University have recently been doing some sauger research on the Missouri River above Lewis & Clark Reservoir. That stretch of river is shared by South Dakota and Nebraska and the two states are collaborating on that research effort. I am sure Dr. Willis would have some excellent sauger information to share from those efforts.

NEW YORK

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
Lake Champlain/Natural lake	02010006 - north 02010004 - main 02010001 - south	Native	278,400	Decreasing

LAKE CHAMPLAIN IS NOT WITHIN THE MISSISSIPPI DRAINAGE

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

Lake Champlain is the only inland water of New York State where sauger may still exist as a viable population. Sauger were once common in Lake Champlain, but this population seems to be in decline. Sauger may also exist in small numbers in Lake Erie, but are almost never seen during routine fish population surveys.

Through 2008, sauger can be harvested from Lake Champlain by anglers from the first Saturday in May – March 15. There are currently no restrictions on size or number harvested. Because of the apparent population decline, proposed regulations for 2008 – 2010 set a minimum length at 18" and a daily limit of 5. These would match the walleye regulations for the lake.

Sauger are listed as a species of greatest conservation need in the Lake Champlain Basin in the publication "Comprehensive Wildlife Conservation Strategy for New York". This report lists recommended actions for conserving the species (see below).

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

Because sauger reach a maximum adult size of about 18 inches, the proposed regulations for 2008-2010 would eliminate the legal harvest of juvenile and many adult fish. This should minimize any harvest-related stress on the population.

Also important was the listing of sauger in the publication "Comprehensive Wildlife Conservation Strategy for New York" as a species of greatest conservation need in the Lake Champlain Basin. Recommended priority strategies for sauger are:

- Determine the abundance and distribution of this species in the Lake Champlain watershed (including the Poultney River)

- Monitor newly discovered and existing sauger populations to determine population trends
- Research habitat requirements for sauger in this basin

If these recommended strategies are implemented then a detailed examination of the status of the Lake Champlain sauger population could be determined and appropriate management strategies could be developed. There are no currently proposed or developed projects that address these recommendations.

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

There are no current monitoring or assessment actions specific to the Lake Champlain sauger population.

Please list known information—from your state—for the following sauger attributes:

Growth Rate: Unknown.

Size at Maturity: Occasionally reach 18 inches.

Fecundity: Unknown.

Movement: Unknown.

Annual Mortality: Unknown.

Angling Mortality: Unknown.

Habitat Requirements: Unknown.

Limiting Factors: Unknown.

Contamination Issues : Unknown.

Please rank the overall importance of sauger to your state's sport fishery:

0 1 [✓ 2] 3 4 5

None **Very Important**

Please list any databases, peer-review literature, agency reports, university research, or gray literature that provides information on the status of sauger populations—or life history information—in your state.

New York State Department of Environmental Conservation. 2006. Comprehensive Wildlife Conservation Strategy. Albany, NY: New York State Department of Environmental Conservation.
http://www.dec.state.ny.us/website/dfwmr/swg/cwcs2005.html

http://www.dec.state.ny.us/website/dfwmr/fish/fishspecs/perchtxt.html#sauger

OHIO

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
Ohio River / river	?	Native	~400 river miles	stable
Lake Erie & tributaries	?	native	2.5 million acres	unknown

LAKE ERIE AND TRIBUTARIES ARE NOT WITHIN THE MISSISSIPPI RIVER BASIN.

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

Ohio River: We have a daily bag limit of 10 Sander spp. (walleye, sauger, and saugeye) in the aggregate with no minimum length limit on sauger. Catch rates can be extremely high for sauger in Ohio R. tailwaters, the purpose of the daily bag limit is to distribute the harvest over a longer period of time. It is effective at accomplishing that goal.

Lake Erie and tributaries: 15” minimum, daily bag of 3 from 1 march to 30 April and 6 during the rest of the year. Sauger in the Lake Erie drainage of Ohio are typically low-density populations and these regulations are focused primarily towards management of the walleye population.

Remainder of state: No minimum length limit and a daily bag of 6 Sander spp. in the aggregate. Sauger provide limited fisheries in Ohio’s reservoirs and streams/rivers (except the Ohio R.). These regulations are primarily focused on management of reservoir saugeye and walleye populations.

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

Ohio River: Daily bag limit of 10. It is effective at distributing the sauger harvest more equitably among anglers over time.

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

Ohio River: Sauger are assessed annually via night time tailwater electrofishing surveys conducted in November. Periodic on-site angler surveys are conducted at the dam tailwaters (where a majority of sauger catch / harvest takes place). Sauger exploitation has been estimated for a number of pools via tagging / angler tag returns.

Please list known information—from your state—for the following sauger attributes:

Growth Rate: Mean length at age from November surveys:

Age	mean TL (mm)
0	227
1	347
2	380
3	423
4	414

Size at Maturity: Sauger males are typically fully mature at age-2. Sauger females begin to mature at age-2 (depending on growth) but are fully mature at age-3.

Fecundity: unknown

Movement: We have some information on sauger movement but the results (a side-bar from our tagging work) are still preliminary at this point. No movement : 73%; upstream: 26%; downstream: 1%

Annual Mortality: A = 0.71 to 0.92

Angling Mortality: Estimates of exploitation range from 9-27% Hooking mortality or mortality of released fish is currently being investigated.

Habitat Requirements: unknown

Limiting Factors: Under investigation

Contamination Issues : For information on fish contaminant issues please see the Ohio EPA website www.epa.state.oh.us

Please rank the overall importance of sauger to your state's sport fishery:

0 **1** **2** [✓ **3**] **4** **5**

None **Very Important**

OKLAHOMA

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
R. S. Kerr Reservoir	11110104	Native	42,000 Acres	I
Canadian River below Eufaula Dam	11100302	Native	27.5 miles long	S
Illinois River below Tenkiller Dam	11110103	Native	7.5 miles long	S
Verdigris River	11070105	Native		?
Webbers Falls Reservoir		Native	12,000 Acres	S
Arkansas River	110600	Native		S
Poteau River	11110105	Native		?
Neosho River	11070209	Native		?

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

Harvest Regulations
Statewide- Five (5) daily with 18” minimum, except the Arkansas River from Keystone Dam downstream to the Arkansas-Oklahoma state line. Daily limit in this portion is five (5) per day with a 16” minimum length. Includes Webbers Falls, RS Kerr, WD Mayo and James Trimble Reservoirs. Also included is the Illinois River below Tenkiller Dam.

Possession limit
- Residents-one (1) days legal limit
- Non-residents-Two (2) days legal limit

Stocking
- 2001-5,000 2” fingerlings were stocked in the upper end of RS Kerr.
- 2002-10,000 1.5” fingerlings stocked in the Illinois River

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

Oklahoma decreased the minimum legal length from 18” to 16” in 2004. We are currently evaluating the effectiveness of the change and should see results, positive or negative, by spring 2007.

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

1. Sauger populations are monitored by electrofishing during the spawning migration and by gillnetting during the fall surveys.
2. Currently , we don't monitor movement patterns except through fishing reports.
3. The legal size limit was lower from 18" to 16" in 2004. Length frequencies taken from electrofishing and gillnetting are expected to show improvement if the regulation is effective. Other information could come from the relatively few anglers who fish for sauger in Oklahoma.

Please list known information—from your state—for the following sauger attributes:

Growth Rate: Unknown

Size at Maturity: Unknown

Fecundity: Unknown

Movement: Annual spawning migration to tailraces along the Arkansas River, summer movement from RS Kerr to cooler water in Illinois River

Annual Mortality: Unknown

Angling Mortality: Unknown

Habitat Requirements: Unknown

Limiting Factors: Unknown

Contamination Issues: Unknown

Other Pertinent Information: Sauger are slowly gaining popularity as a sport fish but its distribution is limited to the eastern portion of the state. The Fishes of Oklahoma book shows historical distribution in the Poteau, Illinois and Neosho Rivers, which are tributaries to the Arkansas River, and the Red River. Angler surveys show several sport fish are more popular and more easily identified than sauger. Management efforts have been focused towards more popular sport fish and I doubt if that trend will change in the near future.

Please rank the overall importance of sauger to your state's sport fishery:

0 [✓ **1**] **2** **3** **4** **5**

None **Very Important**

Please list any databases, peer-review literature, agency reports, university research, or gray literature that provides information on the status of sauger populations—or life history information—in your state.

Very little work has been done on sauger here in Oklahoma. It is not a very popular fish but does have some devotees. Its priority with the public seems to be as a parent for the more popular and better known saugeye that has been stocked in a variety of locations within the state.

PENNSYLVANIA

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
Allegheny River-Lower/ River	05010009	Native	58.3 km/381.0 m	Stable
Allegheny River- Middle/ River	05010006	Native	53.2 km/287.0 m	Stable
Monongahela River-Lower/River	05020005	Native	147.6 km/ 215.2 m	Stable
Ohio River-Upper/ River	05030101	Native	64.4 km/30.7 m	Stable
Youghiogheny River/ River	05020006	Native	74.4 km/103.8 m	Stable
Kiskiminetas River/ River	05010008	Native	43.0 km/109.0 m	Increasing
Raccoon Creek/ Stream	05030101	Native	63.4 km/30.7 m	Increasing
Beaver River/ Stream	05030103	Native	20.3 km/100.3 m	Increasing
Cheat River	05020004	Native	5.6 km/122.3 m	Increasing
Bessemer Lake/ Impoundment	--	Introduced	11.3 ha	Stable
Conemaugh River Lake/ Impoundment	--	Introduced	259.0 ha	Stable
Loyalhanna Lake/ Impoundment	--	Introduced	194.0 ha	Stable

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

1. Harvest Regulations- Statewide:
    a. Harvest Season- early-May to mid-March,
    b. No Harvest Season- mid-March to early-May.
    c. Minimum Size- 12 inches.
    d. Daily Limit- 6 fish.
2. We have stocked sauger in three impoundments at 50/ha to establish reproducing populations for the impoundment and streams upriver. Success of this strategy has not been determined to date.
3. One river section has been supplementally stocked at 80/ha to augment natural reproduction that is below desired levels. Success of this strategy has not been determined to date.

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

The Minimum Size Limit for reducing total annual mortality and allows us to maintain a higher quality component in our fishery.

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

1) Spring night flat bottom boat electrofishing.
2) None.
3) Spring night flat bottom boat electrofishing and angler use, harvest, opinion, and economic impact surveys.

Please list known information—from your state—for the following sauger attributes:

Growth Rate

Annulus	Mean Length (mm)
1	219
2	291
3	328
4	369
5	380

Size at Maturity: Not Available.

Fecundity: Not Available.

Movement: Not Available.

Annual Mortality: Not Available.

Angling Mortality: Not Available.

Habitat Requirements: Not Available.

Limiting Factors: Not Available.

Contamination Issues: Ohio River- From the Point at Pittsburgh (RM 0.0) to the Montgomery Lock and Dam (RM 31.7)- 1 meal per month- PCB.

Please rank the overall importance of sauger to your state's sport fishery:

0 1 2 [✓ 3] 4 5
None Very Important

Please list any databases, peer-review literature, agency reports, university research, or gray literature that provides information on the status of sauger populations—or life history information—in your state: Agency Resource Data Base of the Pennsylvania Fish and Boat Commission, Bureau of Fisheries, Fisheries Management Division.

SOUTH DAKOTA

CURRENT DISTRIBUTION				
Waterbody/ Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
Lewis & Clark-Reservoir	10170101	Native	≈26,000 ac	Stable
Lake Francis Case-Reservoir	10140101	Native	≈79,073 ac	Stable
Lake Sharpe-Reservoir	10140101	Native	≈61,800 ac	Stable
Lake Oahe-Reservoir	10130105	Native	≈273,500 ac	Stable
Missouri River-Below Gavins Point Dam-Riverine		Native		?
Big Sioux River-Riverine	101702	Native		?
James River-Riverine	101600	Native		?
White River-Riverine	101402	Native		?
Bad River-Riverine	10140102	Native		?
Cheyenne River-Riverine	101201	Native		?
Moreau River-Riverine		Native		?
Grand River-Riverine		Native		?
Belle Fourche River-Riverine				?
Vermillion River-Riverine		Native		?
Little Missouri		Native		?

MANAGEMENT STRATEGIES: Please list all strategies-harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options-that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

2006 Regulations-South Dakota has statewide harvest limits for certain species. Along with these limits, there are also lake specific regulations with some waters having exceptions to the statewide restrictions. Walleye/sauger fishing is open year-round in South Dakota. There are no closed seasons.

Statewide walleye/sauger/saugeye (any combination)-4 daily, 8 possession. Only one walleye in the daily limit may be 20 inches or longer.

Lake specific restrictions

Lake Oahe- WALLEYE/SAUGER OR HYBRID: daily limit 4, possession limit will be 8 beginning January 1, 2007. The former possession limit of 12 arose during a forage crash (rainbow smelt) in 1999/2000. Walleye condition drastically declined during this period. South Dakota Game, Fish and Parks took a proactive approach to dealing with the situation by increasing daily and possession limits in an attempt to decrease the number of adult walleye in the population to allow forage species to recover. Daily limit may include no more than one walleye/sauger 20" or longer year round.

Lake Sharpe- WALLEYE/SAUGER OR HYBRID: Daily limit 4, possession limit 8. Minimum length limit 15" year round, EXCEPT July and August when there is no restriction. Daily limit may include no more than 1 walleye/sauger 20" or longer year round.

Lake Francis Case- WALLEYE/SAUGER OR HYBRID: Daily limit 4, possession limit 8. Minimum length limit 15" year round, EXCEPT July and August when there is no restriction. Daily limit may include no more than 1 walleye/sauger 20" or longer year round.

Additional restrictions to **Lake Francis Case**:

--An additional exception exists during the winter ice fishery on **Lake Francis Case**. From the northern Gregory-Charles Mix county line downstream to Fort Randall Dam, size restrictions do not apply while fishing through the ice, anglers fishing through the ice are required to keep the first 4 walleye/sauger they catch. This regulation is due to concern for initial or delayed mortality due to fish being caught from relatively deep waters of the lower half of **Lake Francis Case**.

--Fishing is closed in the waters between the railroad bridge and I-90 bridge causeway in Brule and Lyman counties referred to as the "dredge hole". Waters are closed to fishing from December through April of the following year, except that shorefishing is allowed from the Brule County side of this area year round.

Missouri River from the Nebraska border upstream to Fort Randall Dam- WALLEYE/SAUGER OR HYBRID: WALLEYE/SAUGER OR HYBRID: Daily limit 4, possession limit 8. Minimum length limit 15" year round, EXCEPT July and August when there is no restriction. Daily limit may include no more than 1 walleye/sauger 20" or longer year round.

Missouri River from Gavins Point Dam upstream to the SD-Nebraska border to the point where the river becomes entirely in SD (Lewis and Clark Reservoir)- WALLEYE/SAUGER OR HYBRID: Daily limit 4, possession limit 8. Minimum length 15" year round.

STOCKING

Sauger stocking contribution has been nearly nonexistent in South Dakota during the previous century. One record was found of 52 adult sauger stocked in the "Missouri River" in 1955. The exact location of this stocking is not listed. The record has the headline "Stocking records for sauger and walleye for Lake Francis Case, Lake Sharp and Lake Oahe from 1939-2002". The second stocking was the following year, 1956, in Hipple Lake, a backwater area of Lake Sharp a few miles below the Lake Oahe dam near Pierre, SD with 10 adults stocked.

EFFECTIVENESS OF MANAGEMENT

With the alteration of the Missouri River to its current reservoir state, as expected, walleye populations have increased dramatically. However, sauger populations in South Dakota have persisted relatively well during the reservoir era. Lewis and Clark Lake, the lowermost reservoir on the Missouri River, has a strong sauger population with 2006 fall gill net catches of sauger outnumbering walleye. Graeb (2006) indicated that while sauger populations throughout the upper Missouri River System (Montana) and the lower Missouri River System (Iowa, Missouri) continue to decline, his research on population ecology shows relative stability in South Dakota sauger populations.

Hybridization of walleye and sauger is an issue in Lewis and Clark Lake. Graeb (2006) examined 1,454 sauger, walleye and naturally produced hybrids from Lakes Sharpe, Francis Case and Lewis and Clark. Hybridization rates tended to be low for Lake Sharpe (4%) and Lake Francis Case (4%), while Lewis and Clark (21%) exhibited rates more than twice that of Van Zee et al. (1996), who found 10% hybridization rates. Combined walleye and sauger limits could confound management of sauger populations. However, angler identification of walleye and sauger, especially with high rates of hybridization such as in Lewis and Clark, limits management of walleye and sauger separately.

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

Physical differences in reservoirs throughout South Dakota, along with reservoir aging could affect sauger populations. Lewis and Clark Reservoir, where populations of sauger appear to be thriving, contains more diverse environments with reservoir, riverine, and delta habitats present. Graeb (2006), showed a transition in sauger spawning habitats from the Ft. Randall dam area, where sauger spawning has historically taken place, to the Niobrara Delta area, which likely functions more similarly to the historic Missouri River channel. These habitat differences throughout the various reservoirs may be more important to sauger population status than management strategies. However, continued monitoring through fall gill netting and creel surveys will allow biologists to detect changes in South Dakota’s sauger populations, and take proactive steps to sustain populations at their current levels. Monitoring of hybridization between sauger and walleye should also continue to insure rates are not increasing.

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

1) Sauger are generally sampled during fall walleye gill netting in September on Missouri River Reservoirs. Standard multifilament gill nets are 91.4 m (300 ft) long x 1.8 m (6 ft) deep, with 15.2 m (50 ft) panels of the following bar mesh sizes: 12.7 mm (1/2 in), 19.1 mm (3/4 in), 25.4 mm (1 in), 31.8 mm (1 ¼ in), 38.1 mm (1 ½ in), and 50.8 mm (2 in). Young of the year sauger are also sampled, along with walleye, during the fall on Lake Sharpe to help estimate reproduction. Incidental sampling of sauger takes place while electrofishing for other species.
2) Graeb (2006) looked at shifts in sauger spawning habitats after 40 years of reservoir aging on Lewis and Clark Lake. Radio transmitters (Holohil Systems model PD-2, 90 d expected battery life) were externally attached to 50 mature sauger adults in 2003 with fish tracked weekly during spawning in April and bi-weekly during postspawn through early June.
   Wickstrom (2006b) looked at seasonal distribution and movement of sauger in Lewis and Clark Lake in the spring of 2002. Dangler tags were affixed to 155 sauger with angler tag return and sampling recapture locations allowing for analysis of movements.
   3) Yearly monitoring of sauger populations through gill net sampling allows biologists to track population trends in Missouri River Reservoirs. Creel surveys assess recreational catch and harvest, with surveys taking place annually on Lakes Oahe, Sharpe and Francis Case. Lewis and Clark creel surveys take place every third year.

Please list known information-from your state-for the following sauger attributes:

Growth Rate: Mean back-calculated total lengths (mm) at annulus for year-classes of sauger collected with gill nets from Lewis and Clark Lake, 2005. N=sample size
Mean annual growth increments (mm) of back-calculated total lengths for each year class of sauger collected with variable-mesh gill nets during September 2004 from Lake Francis Case. N=sample size

Year Class	Age	N	Growth Increment at age			
2003	1	28	189			
2002	2	79	187	95		
2001	3	12	182	110	55	
2000	4	4	201	100	60	34
All classes			190	102	62	41
N		123	123	95	16	4

Mean back-calculated total lengths (mm) for each year class of sauger collected with variable-mesh gill nets during September 2004 from Lake Francis Case. N=sample size

Year Class	Age	N	Back-calculated length at age			
2003	1	28	189			
2002	2	79	187	282		
2001	3	12	182	292	347	
2000	4	4	201	301	361	395
All classes			190	292	354	395
N		123	123	95	16	4

Mean length-at-age-at-capture (mm) values for sauger collected in the standard August coolwater gill net survey, 2002-2005, on Lake Sharpe, South Dakota, as determined by aging otoliths.

Year		**Length at age at capture (mm)**								
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
2002	**Mean**	265	329	364	393	404	407	--	448	445
	N	1	41	17	26	6	1	--	7	5
	SE	--	4.2	7.9	15.6	8.5	--	--	24.5	17.9
2003	**Length**	--	315	356	374	391	--	--	--	458
	N	--	2	21	16	8	--	--	--	2
	SE	--	2.5	24.9	5.7	8.6	--	--	--	56.5
2004	**Length**	260	315	353	379	410	414	--	--	--
	N	9	6	8	31	5	8	--	--	--
	SE	3.1	11.7	17.7	4.2	10.5	15.8	--	--	--
2005	**Length**	--	343	396	415	398	411	395	--	--
	N	--	16	6	1	9	3	6	--	--
	SE	--	4.0	12.4	--	4.9	12.0	7.5	--	--
Mean of means		263	326	367	390	401	411	395	448	452

Size at Maturity: Gonad samples were taken from a limited number of Lewis and Clark Lake sauger (B. Graeb, South Dakota State University, unpublished data). Average length of the four sauger deemed immature was 312 mm with ages of 1, 2, 3 and 3. Age of mature sauger ranged from 3 to 11 with an average length of 480 mm. Average lengths for immature, age 3 sauger was 374 mm and for mature, age 3 sauger was 398 mm. Thus, it appears that female sauger begin maturing at age-3, but the cohort is not fully mature until age-4.

Fecundity: Gonad samples were taken from a limited number of Lewis and Clark Lake sauger (B. Graeb, South Dakota State University, unpublished data). A subsample of eggs was counted from six sauger. Total fecundity ranged from 43,840 eggs from a 398 mm, 3 year old sauger to 67,028 eggs from a 522 mm, 6 year old sauger. Average fecundity for sampled sauger was 55,621 eggs.

Movement: Graeb (2006) externally attached radio tags to 50 adult sauger captured in 2003 from the delta and upstream in the recreational river reach. Sauger began moving into the delta during the second week of April and commenced spawning, which was confirmed through egg collection and hatching from a side channel of the delta where tagged sauger were continually encountered. Tagged sauger were located in the delta habitat throughout the spawning and post-spawn period, while no sauger were located in the recreational reach during the same time period. Thus, spawning habitat has shifted from historical locations near the Ft. Randall Dam, to the emerging habitat of the Niobrara Delta. The reason for this shift suggested by Graeb (2006) stems from changes within the reservoir as a result of the novel habitat that has developed as the system aged.

Wickstrom (2006b) tagged 155 sauger during April through June of 2002 from Lewis and Clark Lake. The greatest number of sauger tagged were captured in the reservoir portion of Lewis and Clark Lake, followed by the upstream river portion and the Ft. Randall tailwater area. Fourteen saugers were recaptured downstream from their original capture site, with only four traveling upstream. The furthest distance from original capture site to recapture site for sauger traveling downstream and upstream was 21 river km and 41 river km, respectively. One sauger passed through Gavins Point Dam and was recaptured in the associated tailwater area.

Riis and Stone (1993) looked at walleye, sauger and smallmouth bass movement in the Missouri River system. In 1986, sauger were tagged primarily in the reservoir portion of Lewis and Clark Lake (N=127) with limited numbers tagged in the river portion (N=58) and the Ft. Randall tailwater area (N=5). In 1987, forty-four additional sauger were tagged in Lewis and Clark Lake, one in the river portion and 14 in the Ft. Randall tailwater area. Over 10% of walleye and sauger recaptures during 1986 occurred below Gavins Point Dam, indicating significant numbers of fish move through Gavins Point Dam and survive. For those walleye and sauger tagged in 1986, over 50% of the fish recaptured were collected upstream from their original release location. For fish tagged in 1987, when a large number were tagged in the Ft. Randall tailwaters, over 60% were recaptured at their original release location. Movements exceeding 25 river miles, both upstream and downstream, were not uncommon.

Annual Mortality: Wickstrom (2006a) listed annual survival for 2004-2005 pooled sauger data at 65% for Lewis and Clark Lake, as estimated from catch curve analysis and excluding age-0 fish. Johnson et al. (1992) listed annual survival (S), annual mortality (A) and instantaneous mortality rates (Z) of 0.59, 0.41 and 0.531, respectively, for 1990-1991 Lake Francis Case data. Johnson et al. (1992) listed annual survival (S), annual mortality (A) and instantaneous mortality rates (Z) of 0.50, 0.50 and 0.686, respectively, for 1990-1991 Lewis and Clark Lake data. Sorensen and Knecht (2006) listed annual survival for 2003-2004 pooled sauger data at 50% for Lake Francis Case, as estimated from catch curve analysis.

Angling Mortality: Wickstrom (2006b) calculated angler exploitation of tagged Lewis and Clark sauger, from time of tagging to the end of the first calendar year, was approximately three percent. Riis and Stone (1993) calculated angler exploitation of sauger tagged at Lewis and Clark Lake in 1986 ranging from 17 to 29% and from 22 to 25% for sauger tagged in 1987.

Habitat Requirements: Graeb (2006) showed sauger spawning habitats have shifted from post-reservoir historic locations near Ft. Randall dam to newly formed delta habitats near the mouth of the Niobrara River. Construction of reservoirs has altered the Missouri River from its original riverine state. With the saugers propensity for higher turbidity, changes in the Missouri River to a more lentic system, have favored walleye over sauger. Habitat in Lakes Oahe, Sharpe and Francis Case (during normal water levels) is primarily reservoir-like, while the downstream most reservoir, Lewis and Clark contains reservoir and riverine habitats along with an expanding delta habitat. In recent years, reservoir aging has added another element for fisheries managers to deal with. Sedimentation has altered water depths and bottom composition throughout much of the Missouri River system. The Niobrara Delta exemplifies the aging process. Graeb (2006) suggests the delta system may function in a manner more similar to the historic Missouri River. For example, riverine processes such as sediment transport and habitat formation occur in the delta, but are much reduced in remnant riverine habitats and reservoirs. With the continued formation of the delta, further changes in habitat utilization by fish and other aquatic organisms may occur.

Limiting Factors: South Dakota year class strength for many fish species is dictated by environmental factors including spring temperature fluctuations and warming trends, precipitation and snowpack inputs from within the basin, etc. Spawning habitat is usually not an issue for walleye and sauger in most Missouri River reservoirs. Forage availability can be an issue for walleye and sauger, with much of the forage base seasonally available in the form of gizzard shad. With South Dakota on the northern edge of the gizzard shad range, high levels of over winter mortality for age-0 gizzard shad are thought to occur. Rainbow smelt numbers have proven to be a limiting factor for walleye in Lake Oahe. Rainbow smelt numbers plummeted due to entrainment in the Oahe Dam from excessively high precipitation and flushing rates causing walleye relative weight values to dramatically decrease.

Contamination Factors: Contamination testing of fish is a collaborative effort between the South Dakota Departments of Game, Fish and Parks, Environment & Natural Resources and Health. Sauger sampled from Lake Sharpe in 1999 and the Little Missouri River in 2002 were tested for a variety of pesticides along with mercury, cadmium and selenium concentrations. Lake Sharpe sauger contained mercury concentrations of 0.09 parts per million, while Little Missouri River sauger contained mercury concentrations of 0.48 parts per million. The state of South Dakota issues a mercury warning when concentrations of mercury reach 1.0 parts per million.

Other Pertinent Information: Asian carp species (silver and bighead) currently inhabit waters of the Missouri River below Gavins Point dam. Interactions between Asian carp and the native fish communities are relatively unknown. Schrank et al. (2003) suggest there is potential for bighead carp to negatively affect growth of age-0 paddlefish when food resources are limited. Efforts to keep silver and bighead carp from entering Lewis and Clark Lake will be beneficial for native fishes.

Schrank, S.J., C.S. Guy and J.F. Fairchild. 2003. Competitive interactions between age-0 bighead carp and paddlefish. Transactions of the American Fisheries Society. 132:1222-1228.

Please rank the overall importance of sauger to your state's sport fishery:

0 1 [✓ 2] 3 4 5

None Very Important

Anglers do not generally target sauger in the state of South Dakota. However, walleye and sauger are often times grouped together and considered the same fish species by some anglers. Sauger importance in South Dakota relates to sauger harvest as by-catch while anglers are targeting walleye.

TENNESSEE

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
Cordell Hull Res.--Impoundment	05130106	Native	11,960 Acres	Stable
Old Hickory Res.--Impoundment	05130201	Native	22,500 Acres	Stable
Cheatham Res.--Impoundment	05130202	Native	7,450 Acres	Stable
Barkley Res.--Impoundment	05130205	Native	15,902 Acres	Increasing
Cherokee Res.--Impoundment	06010104	Native	30,200 Acres	Stable
Upper French Broad--River	06010105	Native	Unknown	Stable
Pigeon--River	06010106	Native	Unknown	Stable
Douglas Res.--Impoundment	06010107	Native	30,600 Acres	Stable
Watts Bar Res.--Impoundment	06010201	Native	38,600 Acres	Decreasing
Tellico Res.--Impoundment	06010204	Native	15,860 Acres	Stable
Norris Res.--Impoundment	06010205/06	Native	34,200 Acres	Decreasing
Melton Hill Res.--Impoundment	06010207	Native	5,750 Acres	Stable
Watts Bar/Emory--River	06010208	Native	Unknown	Decreasing
Chickamauga Res.--Impoundment	06020001	Native	34,500 Acres	Decreasing
Chickamauga Res./Hiwassee--River	06020002	Native	Unknown	Stable
Guntersville Res.--Impoundment	06030001	Native	1,156 Acres	Stable
Pickwick Res.--Impoundment	06030005	Native	6,163 Acres	Stable
Kentucky Res.--Impoundment	06040001/03/05	Native	108,277 Acres	Stable
Mississippi--River	08010100	Native	99,211 Acres	Stable
Wolf--River	08010210	Native	Unknown	Unknown
Hatchie--River	08010208	Native	Unknown	Unknown
Many of our populations are classified as stable but are very cyclic. These fisheries are stocked to keep them more consistent for anglers.				

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

The statewide creel limit for sauger is 10 fish per day. Except: on Cherokee, Chilhowee, Douglas, Fort Loudoun, Melton Hill, and Tellico reservoirs the daily creel limit is 10 sauger or walleye (in combination) per day; on Norris reservoir the daily creel limit is 5 sauger or walleye (in combination) per day; on Normandy reservoir the daily creel limit is 15 sauger, saugeye, or walleye (in combination) per day The statewide minimum length limit is 15” (except on Kentucky Reservoir the minimum length limit is 14”). The possession limit is twice the daily creel limit. Many of the fisheries with recruitment problems receive annual stockings of fingerling sauger at a rate of 5-10 fish per acre.

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

Size limits (to allow a proportion of the spawning females the opportunity to spawn before they are vulnerable to harvest) and stocking (in areas with little or no recruitment).

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

1) monitor sauger fisheries: We monitor our sauger fisheries by sampling annually with experimental gillnets during the month of March.
2) assess movement patterns of saugers: See methods described in: Pegg, M.A., P.W. Bettoli, and J.B. Layzer. 1997. Movements of saugers in the lower Tennessee River determined by radio-telemetry, and implications for management. North American Journal of Fisheries Management 17:763-768.
3) assess the effectiveness of regulations implemented to improve sauger fisheries: When funding becomes available we will assess the effectiveness of our sauger regulations using the methods described in: Maceina, M.J., P.W. Bettoli, S.D. Finley, and V.J. DiCenzo. 1998. Analyses of the sauger fishery with simulated effects of a minimum size limit in the Tennessee River of Alabama. North American Journal of Fisheries Management 18: 66-75.

Please list known information—from your state—for the following sauger attributes:

Growth Rate

See: Maceina, M.J., P.W. Bettoli, S.D. Finley, and V.J. DiCenzo. 1998. Analyses of the sauger fishery with simulated effects of a minimum size limit in the Tennessee River of Alabama. North American Journal of Fisheries Management 18: 66-75.

Churchill, T.N. 1992. Age, growth, and reproductive biology of sauger Stizostedion canadense in the Cumberland River and Tennessee River systems. MS Thesis, Tennessee Technological University, Cookeville. 62 pp.

Thomas, C.D. Sauger recruitment in Tennessee River and Cumberland River impoundments. MS thesis, Tennessee Technological University, Cookeville. 96 pp.

Buckmeier, D.L. 1995. Population structure and recruitment of sauger in the Tennessee and Cumberland River Systems of Tennessee. MS thesis, Tennessee Technological University, Cookeville. 60 pp.

Size at Maturity

See: Maceina, M.J., P.W. Bettoli, S.D. Finley, and V.J. DiCenzo. 1998. Analyses of the sauger fishery with simulated effects of a minimum size limit in the Tennessee River of Alabama. North American Journal of Fisheries Management 18: 66-75.

Churchill, T.N. 1992. Age, growth, and reproductive biology of sauger Stizostedion canadense in the Cumberland River and Tennessee River systems. MS Thesis, Tennessee Technological University, Cookeville. 62 pp.

Thomas, C.D. Sauger recruitment in Tennessee River and Cumberland River impoundments. MS thesis, Tennessee Technological University, Cookeville. 96 pp.

Bettoli, P.W., and M. Fischbach. 1998. Factors associated with recruitment of saugers in the Tennessee and Cumberland river reservoirs. Fisheries Report 98-12, Tennessee Wildlife Resources Agency, Nashville. 41 pages.

Fecundity

See: Churchill, T.N. 1992. Age, growth, and reproductive biology of sauger Stizostedion canadense in the Cumberland River and Tennessee River systems. MS Thesis, Tennessee Technological University, Cookeville. 62 pp.

Thomas, C.D. Sauger recruitment in Tennessee River and Cumberland River impoundments. MS thesis, Tennessee Technological University, Cookeville. 96 pp.

Movement

See: Pegg, M.A., P.W. Bettoli, and J.B. Layzer. 1997. Movements of saugers in the lower Tennessee River determined by radio-telemetry, and implications for management. North American Journal of Fisheries Management 17:763-768.

Annual Mortality

See: Maceina, M.J., P.W. Bettoli, S.D. Finley, and V.J. DiCenzo. 1998. Analyses of the sauger fishery with simulated effects of a minimum size limit in the Tennessee River of Alabama. North American Journal of Fisheries Management 18: 66-75.

Thomas, C.D. Sauger recruitment in Tennessee River and Cumberland River impoundments. MS thesis, Tennessee Technological University, Cookeville. 96 pp.

Angling Mortality

See: Bettoli, P.W., C. Vandergoot, and P. Horner. 2000. Hooking mortality of saugers in the Tennessee River. North American Journal of Fisheries Management 20: 833-837.

Pegg, M.A., J.B. Layzer, and P.W. Bettoli. 1996. Angler exploitation of anchor-tagged saugers in the Lower Tennessee River. North American Journal of Fisheries Management 16:218-222.

Habitat Requirements/ Limiting Factors

See: Buckmeier, D.L. 1995. Population structure and recruitment of sauger in the Tennessee and Cumberland River Systems of Tennessee. MS thesis, Tennessee Technological University, Cookeville. 60 pp.

Bettoli, P.W., and M. Fischbach. 1998. Factors associated with recruitment of saugers in the Tennessee and Cumberland river reservoirs. Fisheries Report 98-12, Tennessee Wildlife Resources Agency, Nashville. 41 pages.

Contamination Issues: Unknown

Please rank the overall importance of sauger to your state's sport fishery:

I would give our sauger fisheries a ranking of 4 in overall importance.

TEXAS

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
None known				

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

While historically present in the Red River, along the Texas border (with Oklahoma), fishery managers in the area (originally employed in 1971) have not encountered any. A single stocking in 1985, in Lake Belton (Central Texas), seems to have failed; but I could not find any documentation on it except for the stocking record.

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

N/A

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

N/A

Please list known information—from your state—for the following sauger attributes: Unknown

Please rank the overall importance of sauger to your state's sport fishery:

[✓ 0] 1 2 3 4 5

None **Very Important**

VIRGINIA

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
Clinch River	06010205	N	125km x 30m	D
Powell River	06010206	N	66km x 20m	D

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

Sauger are listed as a species of special concern. Population densities are very low based on electrofishing samples. A daily creel limit of two sauger per angler was implemented to restrict harvest.

We have requested sauger fingerlings for stocking into the Clinch and Powell Rivers. To date we have not been able to obtain fingerlings for stocking.

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

The reduced creel limit of two fish per day is our best option at this point. Populations are at low density.

We would like to stock sauger to bolster or recover the populations. We have requested fingerlings for stocking but have not been able to obtain any.

Can you assist us by providing potential sources of fingerlings?

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

We monitor sauger populations in the Clinch and Powell Rivers using boat-mounted electrofishing gear. Our collection data is somewhat limited because of limited boat access.

Please list known information—from your state—for the following sauger attributes:

Growth Rate: Unknown – Maximum total length in Clinch River 490mm. Maximum total length in Powell River 525mm.

Size at Maturity: Unknown

Fecundity: Unknown

Movement: Unknown

Annual Mortality: Unknown

Angling Mortality: Unknown

Habitat Requirements: Unknown

Limiting Factors: Siltation, sedimentation

Contamination Issues: Unknown

Other Pertinent Information: Distribution is limited to the Clinch and Powell Rivers and their tributaries.

Please rank the overall importance of sauger to your state's sport fishery:

0 1 2 [✓ 3] 4 5

None Very Important

Could be a valuable sport fishery if populations were recovered.

Please list any databases, peer-review literature, agency reports, university research, or gray literature that provides information on the status of sauger populations—or life history information—in your state.

We have a very limited amount of sauger collection data in our Agency's warmwater streams database and Fish and Wildlife Inform

WISCONSIN

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC**[2]	**Native or Introduced**	**Size**[3]	**Status**[4]
Lake Wisconsin/Impoundment		N	9,000 ac	S
Wisconsin River – Miss. River		N	93 mi	S
to Lake WI Dam				
Wisconsin River – above Lake		N	35 mi	S
WI upstream to next dam				
Mississippi River		N		S

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

For Wisconsin River and Lake Wisconsin:

Regulations since 1991 – 5 bag in aggregate with walleye; 15" minimum size limit (prior to 1991 no size limit). Season open year round.

Beginning in 2001 – in addition to 15" minimum a no-harvest 20-28" slot with 1 fish > 28" included in the 5 total bag. This slot regulation has seen 20-22" sauger appear in angler catches which were rare before. Largest sauger recorded from Lake WI is 5 lbs. 13 oz. and 25". Since the 20-28" slot anglers are reporting 25" sauger.

Annual recruitment monitored on Lake WI since 1994 has been stable at ~30/mile (fall fingerling).

All native, no stocking.

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

For Lake WI and WI River have only dealt with the 15" minimum and the 20-28" no harvest slot.

Prior no size limit – not documented by high harvest of 13-14" fish occurred.

The 20-28" slot appears to be allowing 20"+ sauger to be present, but growth potential is in mid 20's.

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

1. Angler diaries and fall boomshocking.
2. None
3. Same as #1.
4.

Please list known information—from your state—for the following sauger attributes:

Growth Rate: See attached report.

Size at Maturity: None

Fecundity: None

Movement: None

Annual Mortality: Cropped heavily at 15" minimum.

Angling Mortality: Cropped heavily at 15" minimum.

Habitat Requirements: None

Limiting Factors: None

Contamination Issues: None

Other Pertinent Information: None

Please rank the overall importance of sauger to your state's sport fishery:

0 ○ **1** **2** **3** **4** **5**

None **Very Important**

Sauger not present in that many waters – compared to other species. Where they are present, I'd rate a 3.

WYOMING

CURRENT DISTRIBUTION				
Waterbody/Habitat Type[1]	**8-Digit HUC[2]**	**Native or Introduced**	**Size[3]**	**Status[4]**
Wind River	10080001	Native	60 km, 35 m wide	Stable
Little Wind River	10080002	Native	58 km, 24 m wide	Stable
Popo Agie River	10080003	Native	34 km, 21 m wide	Stable
Little Popo Agie River	10080003	Native	26 km, 7.5 m wide	Stable
Boysen Reservoir	10080005	Native	7,916 ha	Decreasing
Upper Bighorn	10080007	Native	58 mi, 300ft wide	Stable
Nowood	10080008	Native	27 mi, 75ft wide	Stable
Greybull	10080009	Native	5 mi, 40ft wide	Stable
Big Horn Lake	10080010	Native	62 mi, 350ft wide	Stable
Tongue River	10090101	Introduced	Unknown	Unknown
Clear Creek	10090206	Native	Unknown	Unknown

MANAGEMENT STRATEGIES: Please list all strategies—harvest regulations, stocking contributions (with stocking rates), bag and possession limits, creel limits, length restrictions, refuges, or other management options—that are implemented to manage sauger in your state. Also, please note the effectiveness, success, or failure of each strategy.

No known stocking from an outside source has occurred in Wyoming. One transplant was made from Boysen Reservoir to the Tongue River in the 1960s.

Current regulations allow for a 6 sauger daily creel and possession limit, with no length restrictions. The only exception to this statewide regulation is in Big Horn Lake were the creel and possession limit is 5. The Wyoming Game & Fish Dept. will be proposing a 2 sauger daily creel and possession limit to begin in 2008.

We currently have no program in place to determine the effectiveness or success of regulations as they pertain to sauger.

Which management strategies do you consider the most effective to improve sauger fisheries in your state? Why?

Sauger management in the upper Wind River Drainage is complicated by the Wind River Reservation, where the Wyoming Game & Fish Dept. has no jurisdiction. The Shoshone and Arapaho tribes have, however, been very interested in sauger research, management, and protection. We are currently working with the USFWS, who work with the tribes in an advisory capacity, to develop a comprehensive management plan for sauger within the Wind River Drainage. Protection of crucial habitat from possible future alteration from land management and water development activities may be the most critical strategy for long-term viability of sauger populations in the drainage.

In the Bighorn River drainage (same drainage as the Wind River but downstream of Boysen Reservoir) angling has a minimal influence on sauger populations. While habitat conditions are currently considered stable, the most probable threats to the long-term survival of sauger in the drainage are the potential for increased water development, upstream passage barriers and entrainment, unintentional introduction of saugeye by the state of Montana and changing habitat conditions due to the regulation of the river by Boysen Reservoir. Given these potential threats we believe the most effective management strategies are to clearly convey opposition to water projects that would alter habitat, try to gain passage over Norwood and Bighorn River diversion dams, continue to encourage the Montana Fish Wildlife and Parks to stock sterile walleye into Big Horn Reservoir and pursue habitat improvement projects that reduce the impacts of river regulation.

What equipment and procedures are used to 1) monitor sauger fisheries, 2) assess movement patterns of saugers, and 3) assess the effectiveness of regulations implemented to improve sauger fisheries?

Annual gill netting programs are utilized at Boysen Reservoir to monitor trends in sauger abundance and size structure. A monitoring program for lotic habitats upstream of Boysen Reservoir will be part of the management plan presently being developed in cooperation with the USFWS and the Wind River Reservation. Electrofishing of established study reaches will likely be the technique used to monitor trends in abundance, size structure, and year-class strength.

To assess movement patterns of sauger, radio-telemetry has been used in both the Wind and Bighorn River drainages (Welker et al 2001, Kuhn Thesis). Floy tags and PIT tags have been used to assess movement and harvest in the Bighorn River drainage (Norwood, Bighorn Lake, Greybull, and Upper Bighorn HUC's). Boat mounted electrofishing has been the primary tool for monitoring sauger fisheries in the Bighorn River drainage.

Please list known information—from your state—for the following sauger attributes:

Growth Rate: For the Wind River Drainage, please refer to Amadio Thesis.

Size at Maturity: For the Wind River Drainage, please refer to Kuhn Thesis. For Bighorn River drainage Roberts et al (2003), WGF administrative report

Fecundity: Unknown for the Wind and Bighorn River Drainage.

Movement: For the Wind River Drainage, please refer to Kuhn Thesis. For Bighorn River drainage Welker et al (2001), WGF administrative report

Annual Mortality: Unknown for the Wind and Bighorn River Drainage.

Angling Mortality: Unknown for the Wind and Bighorn River Drainage.

Habitat Requirements: For the Wind River Drainage, please refer to Amadio, Kuhn, and Lionberger Thesis'. For Bighorn River drainage Welker et al (2002), WGF administrative report

Limiting Factors: Unknown for the Wind River Drainage.

Contamination Issues: (genetic)**-** Billington et al (2006)

Other Pertinent Information: All genetics work has indicated that populations within Boysen reservoir and the Wind River drainage are genetically pure. See Billington et al (2006)

Please rank the overall importance of sauger to your state's sport fishery:

0 1 [✓ 2] 3 4 5

None Very Important

Within Wyoming, the importance of sauger is more related to its role within our native fish assemblages, rather than as a sport fish.

Please list any databases, peer-review literature, agency reports, university research, or gray literature that provides information on the status of sauger populations—or life history information—in your state.

All literature pertinent to the Wind River Drainage, Wyoming can be found within the literature cited sections of the three masters theses provided in the CD.

All literature pertinent to the Bighorn River Drainage, Wyoming can be found within the literature cited sections of the reports provided in the CD.