



Current status and trends in shovelnose sturgeon (*Scaphirhynchus platyrhynchus*) management and conservation

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Summary

The objective of this study was to update information regarding the status of shovelnose sturgeon fisheries. Although a substantial amount of shovelnose sturgeon research has been conducted in the past decade, the study purpose was not to provide a comprehensive review of the literature; the primary interest was in the status, trends, and management of *Scaphirhynchus platyrhynchus* fisheries in North America. Biologists were surveyed in all 24 states within the native distribution of the species; results indicate that commercial harvest is currently permitted in eight states, recreational harvest is allowed in 13 states, and that regulations vary within rivers and jurisdictional boundaries. Although recreational exploitation of shovelnose sturgeon is thought to be low and not a significant threat to populations, commercial harvest is a major concern in states with a commercial fishery. In the last decade harvest has increased in all states with commercial shovelnose sturgeon fisheries, but recent implementation of regulations has decreased harvest in some states. Approximately half of the states with extant shovelnose sturgeon populations conduct routine monitoring of the species, and the understanding of shovelnose sturgeon populations is increasing.

Introduction

Sturgeons (family Acipenseridae) are ancient freshwater and anadromous fishes that inhabit lakes, rivers, and marine habitats in Europe, Asia, and North America. Sturgeons are highly-migratory, late-maturing, long-lived fishes that do not reproduce annually. Because of their unique reproductive ecology, sturgeons are highly susceptible to human activities such as habitat alterations, commercial harvest, and pollution (Boreman, 1997). As such, seven of eight North American sturgeon species and the majority of acipenserids world-wide are classified as endangered, threatened, or vulnerable (Birstein, 1993; Jelks et al., 2008). For example, Birstein (1993) reported several sturgeon species inhabiting the former Soviet Union and China are facing extinction, and that several European acipenserids could have similar fates. Eight sturgeon species representing two genera are extant in North America, three of which are classified as river sturgeons (genus *Scaphirhynchus*). Two of the three *Scaphirhynchus* species are federally endangered: pallid sturgeon *S. albus* and Alabama sturgeon *S. suttkusi*. Although the third member of the genus, shovelnose sturgeon *S. platyrhynchus*, is currently abundant in

the Missouri, Mississippi, and Ohio river drainages, commercial harvest and habitat degradation has decreased their abundance and distribution (Keenlyne, 1997; Pflieger, 1997).

A comprehensive survey regarding the status of shovelnose sturgeon has not been compiled since 1997. Keenlyne (1997) surveyed biologists to examine changes in the distribution of shovelnose sturgeon, trends in their populations, and to assess the conservation classification and major threats to *S. platyrhynchus*. The author reported that most shovelnose sturgeon populations had declined since 1940, but that the status of the populations since 1990 was relatively unknown. Additionally, most survey respondents indicated that habitat alteration was the main concern to the welfare of shovelnose sturgeon populations (Keenlyne, 1997).

The objective of this study was to update information regarding the status of *S. platyrhynchus* fisheries. Although a substantial amount of shovelnose sturgeon research has been conducted in the last decade (e.g. Morrow et al., 1998; Quist et al., 2002; Bajer and Wildhaber, 2007; Colombo et al., 2007; Kennedy and Sutton, 2007; Kennedy et al., 2007; Koch et al., 2009; Tripp et al., 2009), the purpose of the study was not to provide a comprehensive review of the literature on the ecology of shovelnose sturgeon. Rather, we were primarily interested in describing the status and trends in the conservation and management of *S. platyrhynchus* fisheries in North America.

Materials and methods

The current status of shovelnose sturgeon was assessed with an online survey that was sent to biologists in the 24 states within the native distribution of the species. Surveys were sent to biologists identified as shovelnose sturgeon authorities in their respective state agency by their activity in the Mississippi Interstate Cooperative Research Association (MICRA) and the MICRA sturgeon–paddlefish committee. The survey was used to collect information about population trends, conservation status, and the current distribution of shovelnose sturgeon. Additionally, information was obtained regarding the presence and regulation of commercial and recreational shovelnose sturgeon fisheries. Data were also gathered regarding threats to shovelnose sturgeon persistence, as well as information about current monitoring, conservation, and restoration activities. Most questions required respondents to check one, several, or the most applicable answers to survey questions, but some questions required a detailed textual explanation that was useful in interpreting answers and gaining additional insight into shovelnose sturgeon populations. Below, questions are outlined with responses grouped

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into broad focal areas (i.e. distribution, shovelnose sturgeon fisheries, current status, and outlook).

Distribution

If there have been extirpations of shovelnose sturgeon in your state, approximately what percentage of the historic distribution of shovelnose sturgeon has been lost? Shovelnose sturgeon are a highly-mobile species found in large rivers of the Mississippi River drainage (Bailey and Cross, 1954; Keenlyne, 1997). Historic records of shovelnose sturgeon exist from the Rio Grande and Pecos rivers as well as in the Alabama-Mobile River basin; however, survey results indicate the species is now considered extirpated from these drainages as well as from four states (i.e. New Mexico, Alabama, West Virginia, and Pennsylvania). Our survey results indicate that seven additional states have had local extirpations. Although limitations in historic data prevented some states from determining whether extirpations have occurred, Nebraska, Kansas, Kentucky, and Iowa reported that 1–25% of the historic distribution of shovelnose sturgeon has been lost, and Tennessee estimated that 26–50% has been eliminated. Approximately 51–75% of historic shovelnose sturgeon habitat has been lost in Wyoming, while the historic distribution in Oklahoma has been reduced by 76–99%.

Is there a shovelnose sturgeon reintroduction program in your state? Reintroduction efforts have been implemented for several North American sturgeon species including lake sturgeon *Acipenser fulvescens* (Schram et al., 1999), shortnose sturgeon *A. brevirostrum* (Smith and Collins, 1996), Atlantic sturgeon *A. oxyrinchus* (St. Pierre, 1999), white sturgeon *A. transmontanus* (Ireland et al., 2002), and pallid sturgeon (Krentz et al., 2005). To mitigate extirpations or decreases in shovelnose sturgeon abundances, biologists reported that reintroduction programs have been implemented in the Bighorn River in Wyoming (stocking of hatchery-reared juveniles and larvae), the Scioto River in Ohio (relocation of adults, stocking of hatchery-reared juveniles), and the Ohio River in West Virginia (relocation of adults, stocking of hatchery-reared juveniles and larvae). Although most reintroduction efforts have not been extensively evaluated, reintroduced shovelnose sturgeon seem to be thriving in the Bighorn River system in Wyoming (T. Annear, Wyoming Game and Fish, pers. comm.). Similar to shovelnose sturgeon, hatchery-reared juvenile and larval pallid sturgeon have been stocked in the Missouri and Mississippi river systems (Krentz et al., 2005). Recapture information suggests that stocked pallid sturgeon are surviving and growing in the Missouri River (Steffensen and Hamel, 2008). Additional evaluations of reintroduced sturgeons in several systems indicate that hatchery-reared sturgeons survive and contribute to spawning populations (Secor et al., 2000, 2002).

Shovelnose sturgeon fisheries

Is sport fishing for shovelnose sturgeon allowed in your state? Recreational shovelnose sturgeon fisheries have been described as a small but important activity in some locations, especially in the spring when most recreational take occurs (Keenlyne, 1997; Peters and Parham, 2008). Survey respondents reported that 13 states allow sport fishing for shovelnose sturgeon (Table 1). In some states and rivers, surveyed

biologists indicated that only relict populations of shovelnose sturgeon are present and recreational regulations are unnecessary. Keenlyne (1997) reported that 12 states permitted sport fishing for shovelnose sturgeon; however, the author incorrectly reported that Tennessee did not have a sport fishery for shovelnose sturgeon. Recreational fishing for *S. platyrhynchus* has never been prohibited in Tennessee (G. Scholten, Tennessee Wildlife Resource Agency, pers. comm.). Thus, there has been no change in the number of states that allow recreational fishing for shovelnose sturgeon since the 1997 survey by Keenlyne. Survey results indicate that shovelnose sturgeon are targeted by <1% of anglers in 89% of states that provided estimates of shovelnose sturgeon recreational fishing pressure. Although we are unaware of any recent data regarding shovelnose sturgeon recreational exploitation, the vast majority of fisheries biologists indicated that recreational harvest is likely not a significant threat to shovelnose sturgeon populations. Keenlyne (1997) suggested that few anglers fish specifically for shovelnose sturgeon and that most sport harvest results from incidental catch; however, Peters and Parham (2008) reported that in April and May from 2002 to 2004, shovelnose sturgeon was the most commonly sought species during creel surveys near the confluence of the Platte River, Nebraska. Although there appears to be isolated, seasonal shovelnose sturgeon fisheries, our survey results indicate that the sport harvest is relatively low.

Is commercial fishing for shovelnose sturgeon allowed in your state? In the late 1800s, shovelnose sturgeon were considered an undesirable species by commercial fishermen because of their low monetary value and difficulties associated with capturing large quantities in commercial gear (Coker, 1930). However, in the early 1900s, a substantial market developed for shovelnose sturgeon flesh and roe, and soon (i.e. the 1920s) concern was raised by researchers regarding overexploitation of populations (Coker, 1930; Carufel, 1953). More recently, increases in shovelnose sturgeon roe harvest and value have prompted several studies examining the sustainability, potential management, and possible effects of shovelnose sturgeon harvest (e.g. Quist et al., 2002; Colombo et al., 2007; Kennedy and Sutton, 2007; Koch et al., 2009; Tripp et al., 2009). Shovelnose sturgeon roe, marketed under the name 'American Hackleback' currently retails for around US\$770 per kg; whereas smoked flesh sells for about US\$9 per kg.

Survey respondents indicated that commercial shovelnose sturgeon fisheries exist in eight states. Similar to the report by Keenlyne (1997), substantial harvests occur in the upper, middle, and lower Mississippi, lower Missouri, Ohio River, and Wabash rivers. Harvest of *S. platyrhynchus* is also legal in the White River of Indiana and the Arkansas, White, and St. Francis rivers in Arkansas. Historically, commercial fishing was permitted by Kansas, Nebraska, and Iowa in their respective reaches of the Missouri River; however, commercial shovelnose sturgeon fisheries were closed by Nebraska in 1956 (Zuerlein, 1988), Kansas in 1991 (T. Mosher, Kansas Department of Wildlife and Parks, pers. comm.), and Iowa in 2003 (G. Jones, Iowa Department of Natural Resources, pers. comm.). Also, Missouri closed commercial shovelnose sturgeon harvest in the Missouri River upstream of Kansas City, MO and between river km 189–230 near the mouth of the Osage River in 2003 (V. Travnichek, Missouri Department of Conservation, pers. comm.). In addition, commercial shovelnose sturgeon fishery closures in the lower Mississippi River

Table 1
Presence and regulations of current commercial and recreational shovelnose sturgeon (*Scaphirhynchus platyrhynchus*) fisheries within the historical distribution. *States where extirpated. All length restrictions are fork length (FL) unless noted otherwise

State	River	Commercial	Commercial length restrictions	Commercial season	Recreational	Recreational regulations
AL*	All Alabama waters	N			N	
AR	Arkansas, White, St. Francis, Black	Y	533 mm minimum – lower river closed ^{b,c,d}	15 November–1 May	Y	533-mm minimum length limit
IA	Mississippi, Red ^a Mississippi	N Y	685 mm minimum in IA–IL waters; 685–864 mm harvest slot in IA–WI waters	15 October–15 May	Y Y	533-mm minimum length limit No length or possession limits
	Missouri	N			Y	Daily limit – 10; possession limit – 20; no length limit
	Big Sioux	N			N	No harvest or possession
	Interior rivers including: Cedar, Iowa, Des Moines, Maquoketa ^a	N			Y	No length or possession limits
IL	Mississippi	Y	610–813 mm harvest slot limit	1 October–31 May	Y	No length or possession limits
	Ohio	Y	610–813 mm harvest slot limit	1 October–31 May	Y	No length or possession limits
	Wabash	Y	635 mm minimum length limit ^e	1 October–31 May	Y	No length or possession limits
	Illinois, Rock ^a	N			Y	635-mm fork length minimum size limit
IN	Ohio, Wabash, White (including East and West Forks) Other Indiana waters ^a	Y N N	635 mm minimum length limit	1 October–31 May	Y	635-mm fork length minimum size limit
KS	Missouri, Kansas, Republican ^a	N			Y	No length or possession limits
KY	Ohio, Mississippi	Y	610–813 mm harvest slot	15 October–15 May	Y	No length or possession limits
	Tennessee, Cumberland ^a	N			Y	No length or possession limits
LA	Mississippi, Atchafalaya, Red, Ouachita, Black ^a	N N			N	No harvest or possession
MN	Mississippi	N			Y	Possession limit – 10; harvest only allowed downstream of Mississippi River Lock and Dam 3
	Minnesota, St. Croix ^a	N			N	No legal harvest or possession
	Mississippi	Y			Y	No harvest or possession
MO	Missouri	Y	610–813 mm harvest slot	15 October–15 May	Y	Daily limit – 10; possession limit – 20; no length limit
	Grand, Osage ^a	Y	610–762 mm harvest slot ^f	1 November–15 May	Y	Daily limit – 10; possession limit – 20; no length limit
	Mississippi ^a	N			Y	Daily limit – 10; possession limit – 20; no length limit
MS	Mississippi ^a	N			N	No harvest or possession
MT	Missouri, Yellowstone, Milk, Marias, Powder, Tongue, Teton ^a	N N			Y	Daily limit – 5; possession limit – 10; none over 1016 mm
ND	Missouri, Yellowstone ^a	N			N	No harvest or possession
NE	Missouri, Platte ^a	N			Y	Daily limit – 10; possession limit – 20; no harvest upstream of mouth of Big Sioux River
NM*	Rio Grande	N			N	
OK	Red, Arkansas, Verdigris ^a	N			N	
OH	Ohio, Scioto ^a	N			N	No harvest or possession

Table 1 (Continued)

State	River	Commercial	Commercial length restrictions	Commercial season	Recreational	Recreational regulations
PA *	Ohio ^a	N			N	No harvest or possession
SD	Missouri, Big Sioux, James ^a	N			N	No length or possession limits
TN	Mississippi ^a	Y	610–813 mm harvest slot	15 October–15 May	Y	No harvest or possession
TX	Red ^a	N			N	WI–IA waters no bag limit or minimum length
WI	Mississippi	Y	WI–IA waters-harvest slot of 685–864 mm fork length; WI–MN waters-minimum 635 mm total length ^g	Continuous season	Y	WI–IA waters no bag limit or minimum length
						limit; WI–MN waters downstream of Mississippi
						River Lock and Dam 3; 10 bag limit, no minimum length
	Wisconsin	N			Y	Lower WI River from Prairie du Sac to Miss River, 3 bag limit, no size limit
						No harvest or possession
WV	Chippewa ^a	N			N	No harvest or possession
WY	Ohio ^a	N			N	Daily limit – 2; no length limit
	Powder, Wind, Bighorn ^a	N			Y	

^aThe regulation may not be limited to these rivers, and is the regulation for shovelnose sturgeon fisheries in the remaining waters within the respective state.

^bCommercial fishery in Arkansas River closed in lower 26 miles of Arkansas river below Dam 2 and in Pool 13.

^cCommercial fishery closed in White River from Mississippi River to Montgomery Point Dam and upstream of mouth of Black River.

^dCommercial fishery in St. Francis River closed below the Huxtable plant.

^eNo entanglement gear permitted for harvest in Wabash River.

^fCommercial harvest in Missouri River permitted downstream of Kansas City, MO except between river km 189–230. Only Missouri residents may commercially harvest on the Missouri River.

^gCommercial harvest in WI–MN boundary waters of the Mississippi River only permitted by trot line.

occurred in Louisiana in 1990 (B. Reed, Louisiana Department of Wildlife and Fisheries, pers. comm.) and in Mississippi in 1997 (D. Riecke, Mississippi Department of Wildlife, Fisheries, and Parks, pers. comm.).

If your state permits commercial shovelnose sturgeon harvest, to what degree has harvest increased or decreased during the last 10 years? In 1992, over 108 000 kg of shovelnose sturgeon were harvested in Arkansas, Illinois, Iowa, Missouri, and Wisconsin (Keenlyne, 1997). In recent years, concern has been raised regarding North American sturgeon fisheries because of collapsing foreign sturgeon stocks and bans on imported caviar (Quist et al., 2002; Secor et al., 2002). Although the degree to which commercial shovelnose sturgeon roe harvest has increased or decreased in the last decade is currently unknown in Arkansas and Indiana, survey respondents suggested that commercial harvest has increased during the last 10 years in every other state where commercial shovelnose sturgeon fishing is permitted. Although these increases in harvest have raised concern, it was noted by some biologists that harvest has recently decreased in some states (i.e. Iowa and Missouri). Survey respondents suggested that decreases in shovelnose sturgeon roe harvest are possibly attributed to the recent implementation of regulations (e.g. length restrictions, closed seasons, commercial sturgeon harvest permits, or area closures). Additionally, biologists reported that the regulations may have simply redistributed commercial anglers to adjacent states with less-restrictive regulations or seasons.

How many commercial fishermen actively harvest shovelnose sturgeon in your state? Of the eight states with commercial shovelnose sturgeon fisheries, Illinois reported the most licensed commercial shovelnose sturgeon harvesters, exceeding 50 fishermen that actively harvest *S. platyrhynchus* roe and flesh. Arkansas, Indiana, and Wisconsin reported relatively small numbers of roe fisherman (i.e. 1–10 harvesters); whereas, Iowa, Missouri, and Tennessee reported 11–25 commercial roe harvesters. Kentucky currently has 26–50 licensed shovelnose sturgeon roe harvesters. Some respondents indicated that in their state, there is no differentiation between a flesh and roe fisher. Therefore, although commercial fishers are targeting roe, flesh is a byproduct that is sold when a market is available. If a flesh market is unavailable, the flesh is discarded. Indiana, Kentucky, and Tennessee reported there was no harvest of shovelnose sturgeon flesh by commercial fisherman, indicating that shovelnose sturgeon in these states are solely being harvested for roe. All other states with commercial *S. platyrhynchus* fisheries reported similar numbers of flesh and roe harvesters within their respective states.

What are the commercial shovelnose sturgeon regulations in your state? In response to concerns regarding increases in commercial harvest of shovelnose sturgeon, many states have recently implemented or revised commercial and recreational harvest regulations. Table 1 outlines current harvest length limits and seasons for all states within the historic distribution of shovelnose sturgeon. All length limits should be considered as fork length, unless otherwise noted. Due to differences in shovelnose sturgeon populations within jurisdictional boundaries, harvest regulations often vary within rivers and states. Most states on the Mississippi River (i.e. Illinois, Kentucky, Missouri, and Tennessee) regulate commercial shovelnose sturgeon fisheries with a 610–813-mm

length harvest slot and a 15 October through 15 May season. The exception is Illinois, where the season is open from 1 October to 31 May. The regulation for commercial shovelnose sturgeon harvest for Iowa in the Iowa–Illinois portion of the Mississippi River is a 685-mm minimum length limit and a 15 October to 15 May season, but in Iowa–Wisconsin waters, the regulation is a 685–864-mm harvest slot. In Mississippi River border waters between Wisconsin and Minnesota, the minimum length limit is 635-mm total length, and Wisconsin has no closed season for shovelnose sturgeon commercial harvest. The only commercial sturgeon fishery on the Missouri River exists downstream of Kansas City (except for the portion between river km 189 and 230), Missouri and is regulated by a 610–762-mm harvestable slot limit. The season for the Missouri River commercial fishery is the shortest commercial shovelnose sturgeon season, allowing harvest from 1 November to 15 May. The regulations for the Wabash River commercial fishery in Indiana and Illinois is a 635-mm minimum length limit, which is the state-wide regulation for Indiana's other commercial shovelnose sturgeon fisheries (i.e. Ohio and White rivers). The commercial shovelnose sturgeon fisheries in Arkansas (i.e. Arkansas, White, St. Francis, and Black rivers) are regulated by a 533-mm minimum length limit. Although the minimum length limit in Arkansas is considerably shorter than regulations from other states, it should be noted that the demographics of shovelnose sturgeon in these Arkansas rivers are substantially different than those in the Mississippi River. For example, shovelnose sturgeon in the White and Black rivers are smaller and mature at smaller sizes (i.e. approx. 450 mm) than most other shovelnose sturgeon populations (J. Quinn, Arkansas Game and Fish, pers. comm.).

If a commercial shovelnose sturgeon fishery exists in your state, what data are required to be reported by commercial fisherman? Reporting is an integral part of commercial fisheries (Fabrizio and Richards, 1996). In general, commercial reporting requirements for each state are similar. All states permitting commercial harvest require reporting the weight of harvested roe, and most states require that harvest reports include the number of individuals harvested, the gear used to capture shovelnose sturgeon, amount of effort (e.g. number of nets), and weight of flesh harvested. Less common reporting requirements include the length of harvested individuals, whether or not harvested fish possess eggs, and the number of ovaries harvested. All states require that commercial reports be submitted monthly, and some require that reports be completed daily, but submitted monthly (i.e. Tennessee, Illinois, and Missouri).

Current status and outlook

What is the conservation status of shovelnose sturgeon in your state? Keenlyne (1997) reported that shovelnose sturgeon were considered rare, threatened, or of special concern in eight states, although some states classified shovelnose sturgeon differently in various waters. Currently, shovelnose sturgeon are listed as endangered in Ohio, threatened in Texas, and as a species in need of conservation (SINC: or equivalent) in 10 states (Table 2). Additionally, some survey respondents commented that although they are not currently listed as SINC species, proposals have been submitted to add shovelnose sturgeon to SINC lists.

Table 2
Current conservation status of shovelnose sturgeon (*Scaphirhynchus platyrhynchus*) in states within their native distribution

State	Conservation classification
Alabama	Extirpated, Species in need of conservation
Arkansas	Species in need of conservation
Iowa	Species in need of conservation
Illinois	None
Indiana	Species in need of conservation
Kansas	None
Kentucky	None
Louisiana	Species in need of conservation
Minnesota	None
Missouri	Species in need of conservation
Mississippi	Species in need of conservation
Montana	None
North Dakota	None
Nebraska	None
New Mexico	Extirpated
Ohio	Endangered
Oklahoma	Species in need of conservation
Pennsylvania	Extirpated
South Dakota	None
Tennessee	None
Texas	Threatened
Wisconsin	None
West Virginia	Extirpated, Species in need of conservation
Wyoming	Species in need of conservation

Over the last 10 years, have shovelnose sturgeon populations in your state increased, decreased, remained stable, or is the status unknown? Although shovelnose sturgeon are one of the most abundant and widespread freshwater sturgeon, human activities have undoubtedly reduced their abundance and distribution. Keenlyne (1997) reported that from 1940 to 1997, shovelnose sturgeon populations had declined in 12 states and been extirpated from New Mexico. The results of our survey indicate that since 1997, shovelnose sturgeon populations are stable in nine states, increasing in two states, and decreasing in one state (Fig. 1). In the two states where the populations are increasing, one has implemented a stocking

program (i.e. Wyoming) and one had recently closed their commercial fishery (i.e. Louisiana). From 1990 to 1997, the status of shovelnose sturgeon populations was unknown in 15 states (Keenlyne, 1997). According to our survey, the status is currently unknown in eight states, indicating that shovelnose sturgeon populations may be receiving more attention from state agencies.

If your state has a shovelnose sturgeon monitoring program, what is being monitored? Our survey indicates that 48% of the states with extant shovelnose sturgeon populations regularly monitor the species. The most commonly cited foci of monitoring programs include population dynamics (e.g. growth, recruitment, and mortality), sampling design evaluations (e.g. gear assessments or sample size estimation), movement, and trends in adult shovelnose sturgeon abundance (Fig. 2). Half of states with commercial shovelnose sturgeon fisheries currently monitor the species, and 50% of those states attempt to estimate commercial exploitation. In some states where pallid sturgeon and shovelnose sturgeon coexist, shovelnose sturgeon populations are monitored as a surrogate for the endangered pallid sturgeon. Focal areas are broad for studying surrogate species, and include monitoring shovelnose sturgeon abundance, population dynamics, or life history requirements as a substitute for the rare and closely-related pallid sturgeon.

What are the three greatest threats to shovelnose sturgeon populations in your state? According to Jelks et al. (2008), the greatest threats to freshwater ecosystems are: anthropogenic activities that cause habitat degradation, fragmentation, and loss; flow modifications; introduction of non-native species; overexploitation; and pollution. These threats undoubtedly affect shovelnose sturgeon populations. For instance, in 1997, 19 of 24 states suggested that habitat alteration was a concern with regard to the welfare of shovelnose sturgeon populations, while only one state mentioned overharvest as a concern (Keenlyne, 1997). In our study, the most common concern

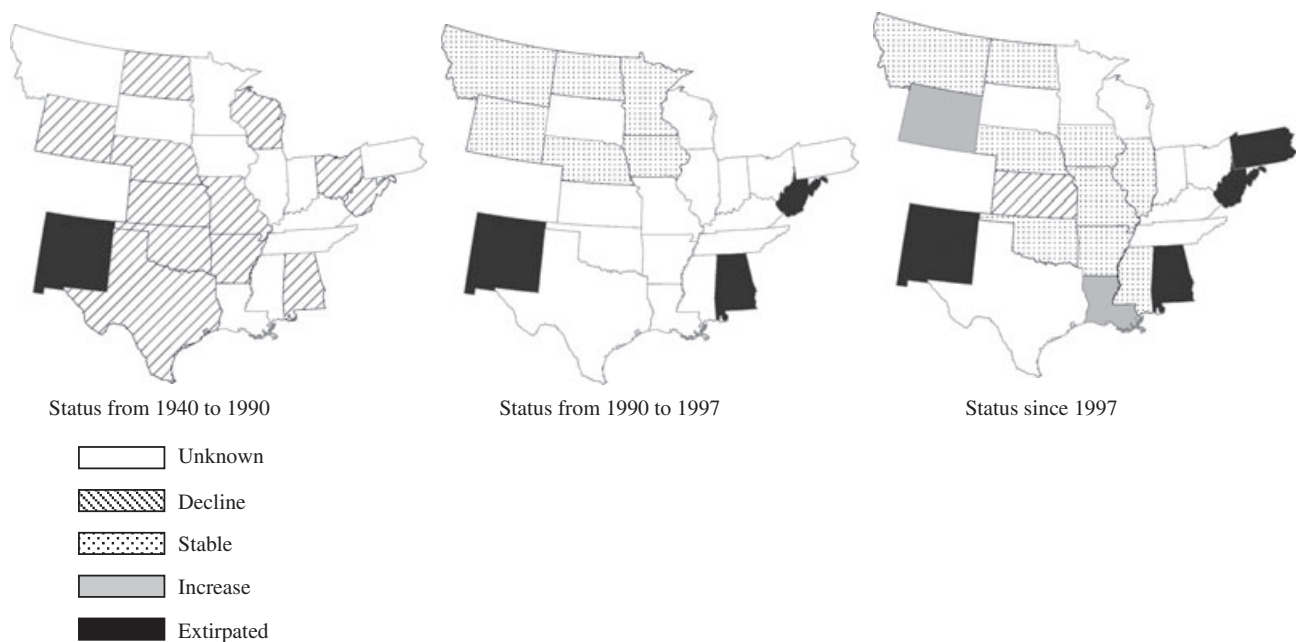


Fig. 1. Status of shovelnose sturgeon populations since 1940, 1990 (adapted from Keenlyne, 1997), and 1997 (current study) in states within the native distribution

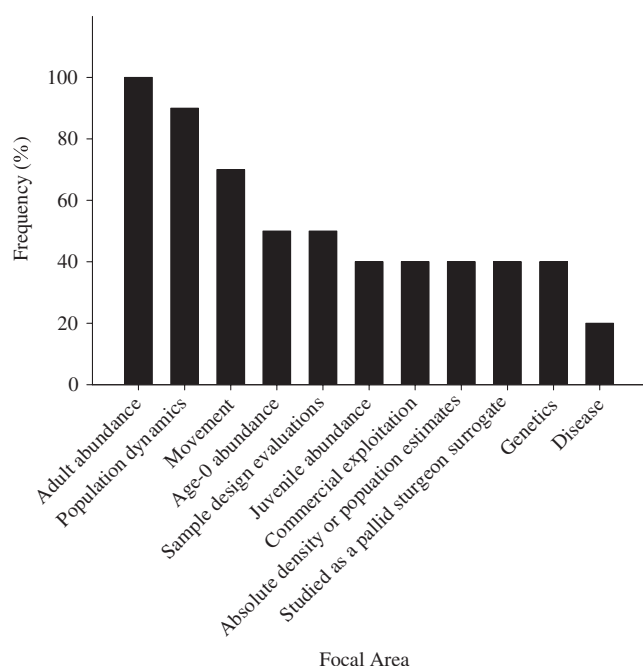


Fig. 2. Frequency of focal areas examined by the 10 states with shovelnose sturgeon monitoring programs

regarding shovelnose sturgeon populations was habitat fragmentation due to water development (i.e. dams; Fig. 3). However, seven out of eight states permitting commercial shovelnose sturgeon harvest reported that roe harvest is a significant threat to their populations. Other commonly reported threats to shovelnose sturgeon populations include loss of spawning habitat, loss of juvenile-rearing habitat, and pollution. Results of the survey indicate that disease in shovelnose sturgeon populations is not a great concern to biologists; however, large shovelnose sturgeon-specific fish kills have raised concern in Indiana and Iowa. Several kills in the Des Moines River, Iowa have been documented since 1990, with some having killed thousands of sturgeon. For instance,

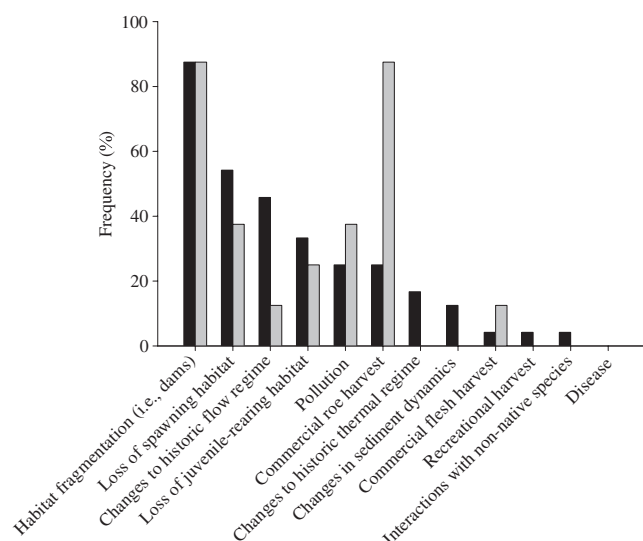


Fig. 3. Frequency of top three threats to shovelnose sturgeon populations reported by biologists in all 24 states within its distribution. All 12 threats were available for survey respondents to select; however, only the most relevant three were selected by each state's respondent. Black bars = threats reported by all states; gray bars = threats reported by states with commercial shovelnose sturgeon fisheries

tens of thousands of shovelnose sturgeon throughout the lower Des Moines River were killed in 2006. Specific causes of the kills are unknown, but an interaction between a naturally-occurring viral pathogen (shovelnose sturgeon iridovirus) and extreme environmental conditions (e.g. high water temperature and low instream flow) are suspected (M. Flammang, Iowa Department of Natural Resources, pers. comm.).

Conclusions

Shovelnose sturgeon are an important species because of the deteriorating world- and nation-wide status of sturgeon populations, their increasing commercial value, and their close relation to endangered *Scaphirhynchus* species (Keenlyne, 1997). Our survey indicates that in the last decade, shovelnose sturgeon populations have received increased attention from state agencies, which has lead to a better understanding of the species. Our survey also suggests that many states are taking a proactive approach to monitoring, recovering, and regulating harvest of the species. Additionally, several states have updated the conservation status of shovelnose sturgeon and have implemented monitoring programs and partnerships with federal agencies, universities, and other organizations to ensure conservation of the species.

While results from our survey suggest that progress has been made regarding the understanding and conservation of shovelnose sturgeon, the multijurisdictional nature of shovelnose sturgeon habitats, fisheries, and their accompanying threats emphasize the importance of cooperation between natural resource agencies. Although difficult, standardization of regulations has proved beneficial in other multijurisdictional fisheries (see Pitlo, 1997). Standardized regulations would not only simplify enforcement, but standard regulations may also prevent commercial harvesters from using 'loopholes' in current regulations that may lead to extremely high levels of harvest in certain areas or times of the year. Regardless, cooperation of regulatory agencies through interstate organizations (e.g. MICRA) will be essential to the sustainability of shovelnose sturgeon fisheries.

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References

- Bailey, R. M.; Cross, F. B., 1954: River sturgeons of the American genus *Scaphirhynchus*: characters, distribution, and synonymy. Pap. Mich. Acad. Sci. Arts Lett. **39**, 169–208.
- Bajer, P. G.; Wildhaber, M. L., 2007: Population viability analysis of lower Missouri River shovelnose sturgeon with initial application to the pallid sturgeon. J. Appl. Ichthyol. **23**, 457–464.
- Birstein, V. J., 1993: Sturgeons and paddlefishes: threatened fishes in need of conservation. Conserv. Biol. **7**, 773–787.
- Boreman, J., 1997: Sensitivity of North American sturgeons and paddlefish to fish mortality. Environ. Biol. Fish. **48**, 399–405.

- Carufel, L., 1953: Sturgeon. North Dakota Outdoors. North Dakota Game and Fish Department, Bismarck, ND, pp. 16–17, 22.
- Coker, R. E., 1930: Studies of common fishes of the Mississippi River at Keokuk. US Bur. Fish. Bull. **45**, 141–225.
- Colombo, R. E.; Garvey, J. E.; Jackson, N. D.; Brooks, R.; Herzog, D. P.; Hrabik, R. A.; Spier, T. W., 2007: Harvest of Mississippi River sturgeon drives abundance and reproductive success: a harbinger of collapse? J. Appl. Ichthyol. **23**, 444–451.
- Fabrizio, M. C.; Richards, R. A., 1996: Commercial fisheries surveys. In: Fisheries techniques, 2nd edn. B. R. Murphy, D. W. Willis (Eds). American Fisheries Society, Bethesda, Maryland, pp. 625–650.
- Ireland, S. C.; Siple, J. T.; Beamesderfer, R. C. P.; Paragamian, V. L.; Wakkinen, V. D., 2002: Success of hatchery-reared juvenile white sturgeon (*Acipenser transmontanus*) following release in the Kootenai River, Idaho. J. Appl. Ichthyol. **18**, 642–650.
- Jelks, H. L.; Walsh, S. J.; Burkhead, N. M.; Contreras-Balderas, S.; Diaz-Pardo, E.; Hendrickson, D. A.; Mandrak, N. E.; McCormick, F.; Nelson, J. S.; Platania, S. P.; Porter, B. A.; Renaud, C. B.; Schmitter-Soto, J. J.; Taylor, E. B.; Warren, M. L., Jr, 2008: Conservation status of imperiled North American freshwater and diadromous fishes. Fisheries **33**, 372–407.
- Keenlyne, K. D., 1997: Life history and status of the shovelnose sturgeon, *Scaphirhynchus platyrhynchus*. Environ. Biol. Fishes **48**, 291–298.
- Kennedy, A. J.; Sutton, T. M., 2007: Effects of harvest and length limits on shovelnose sturgeon in the upper Wabash River, Indiana. J. Appl. Ichthyol. **23**, 465–475.
- Kennedy, A. J.; Daugherty, D. J.; Sutton, T. M., 2007: Population characteristics of shovelnose sturgeon in the upper Wabash River, Indiana. N. Am. J. Fish. Manage. **27**, 52–62.
- Koch, J. D.; Quist, M. C.; Pierce, C. L.; Hansen, K. A.; Steuck, M. J., 2009: Effects of commercial harvest on shovelnose sturgeon populations in the upper Mississippi River. N. Am. J. Fish. Manage. **29**, 84–100.
- Krentz, S.; Holm, R.; Bollig, H.; Dean, J.; Rhodes, M.; Hendrix, D.; Heidrich, G.; Krise, B., 2005: Pallid sturgeon spawning and stocking summary report. US Fish and Wildlife Service, Bismarck, ND, p. 22.
- Morrow, J. V., Jr; Kirk, J. P.; Killgore, K. J.; George, S. G., 1998: Age, Growth, and mortality of shovelnose sturgeon in the lower Mississippi River. N. Am. J. Fish. Manage. **18**, 725–730.
- Peters, E. J.; Parham, J. E., 2008: Ecology and management of sturgeon in the lower Platte River, Nebraska. Nebraska technical series no. 18. Nebraska Game and Parks Commission, Lincoln, p. 232.
- Pflieger, W. L., 1997: The fishes of Missouri, revised edn. Missouri Department of Conservation, Jefferson City, MO, p. 372.
- Pitlo, J., Jr, 1997: Response of the upper Mississippi River channel catfish populations to changes in commercial harvest regulations. N. Am. J. Fish. Manage. **17**, 848–859.
- Quist, M. C.; Guy, C. S.; Pegg, M. A.; Braaten, P. J.; Pierce, C. L.; Travnicheck, V. H., 2002: Potential influence of harvest on shovelnose sturgeon populations in the Missouri River system. N. Am. J. Fish. Manage. **22**, 537–549.
- Schram, S. T.; Lindgren, J.; Evrard, L. M., 1999: Reintroduction of lake sturgeon in the St. Louis River, western Lake Superior. N. Am. J. Fish. Manage. **19**, 815–823.
- Secor, D. H.; Arevyev, V.; Nikolaev, A.; Sharov, A., 2000: Restoration of sturgeons: lessons from the Caspian Sea sturgeon ranching program. Fish Fish. **1**, 215–230.
- Secor, D. H.; Anders, P. J.; Van Winkle, W.; Dixon, D. A., 2002: Can we study sturgeons to extinction? What we do and don't know about the conservation of North American sturgeons. In: Biology, management, and protection of North American sturgeon. W. Van Winkle, P. J. Anders, D. H. Secor, D. A. Dixon (Eds). Am. Fish. Soc. Symp. 28, Bethesda, Maryland, p. 28.
- Smith, T. I. J.; Collins, M. R., 1996: Shortnose sturgeon stocking success in the Savannah River. Proc. Annu. Conf. SEAFWA **50**, 112–121.
- St. Pierre, R. A., 1999: Restoration of Atlantic sturgeon in the northeastern United States with special emphasis on culture and restocking. J. Appl. Ichthyol. **15**, 180–182.
- Steffensen, K. D.; Hamel, M. J., 2008: 2007 Annual report, pallid sturgeon population assessment project and associated fish community monitoring for the Missouri River: Segment 9. Nebraska Game and Parks Commission, Lincoln, p. 138.
- Tripp, S. J.; Colombo, R. E.; Garvey, J. E., 2009: Declining recruitment and growth of shovelnose sturgeon in the middle Mississippi River. Trans. Am. Fish. Soc. **138**, 416–422.
- Zuerlein, G., 1988: Nebraska commercial fishing statistics: the Missouri River. Final Report. Nebraska Game and Parks Commission, Lincoln, p. 100.

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