

# Status of Paddlefish in the United States

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*Abstract.*—The status of paddlefish *Polyodon spathula* in the United States was first described in two surveys published in 1986 and 1997; in this paper, we report the results of a similar survey of state and federal agency personnel that we conducted in 2006. From the 1970s through the 1990s, the status of paddlefish stocks was on a downward trend throughout much of the species' range. The 2006 survey results suggest that the status of paddlefish stocks has improved since the first survey was conducted; 17 of 26 states in 2006 reported that their paddlefish populations were stable or increasing, compared to only 14 states in 1983 and 1994. The number of states with closed fisheries (i.e., no commercial or sport harvest) increased to 12 in 2006 from 8 in 1983. The number of states reporting declining or stable/declining paddlefish populations dropped from seven states in 1983 to only three states in 2006. The two principal reasons cited for reported declines have remained the same for more than three decades: habitat loss and overfishing. Two states where paddlefish were listed as extirpated (New York and Pennsylvania) have begun restoration efforts that may one day allow the status of paddlefish in those states to be changed. As long as the demand for caviar remains strong, pressure on paddlefish stocks will undoubtedly remain high in the seven states where they are commercially exploited. However, earlier fears of a basin-wide collapse in paddlefish stocks should continue to diminish if resource managers are successful in combating overfishing and continued habitat destruction, which will always threaten the long-term viability of paddlefish stocks throughout the Mississippi River basin.

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## Introduction

Paddlefish *Polyodon spathula* have historically occurred throughout the Mississippi River and Gulf Coast drainages (Burr 1980), and the population status and distribution of North American paddlefish have been dynamic over the past 20 years. Several recent reviews have synthesized published studies pertaining to the ecology, status, and management of paddlefish in North America (Jennings and Zigler 2004; Pikitch et al. 2005). In two previous mail surveys (Gengerke 1986; Graham 1997), the authors contacted all states where paddlefish were known (or thought) to historically occur to gather information on their distribution, abundance, and status. In an effort to update that information and assess possible changes in species' status over the past 20 years, we sought to repeat those earlier assessments by distributing similar surveys to those same states.

## Methods

An email questionnaire (Appendix A) was distributed in 2006 to determine how the status, distribution, and management of paddlefish within the United States has changed since Gengerke (1986) and Graham (1997) surveyed state agencies in 1983 and 1994. In addition to the original questions asked in 1983, representatives from each state were also asked in our 2006 survey to describe current commercial and sportfishing regulations and ongoing research initiatives. A cover letter accompanied each questionnaire and explained the purpose and importance of the study. The cover letter, the questionnaire, and a copy of the most recent paddlefish status paper (Graham 1997) were emailed to resource agencies in all states known to be within the historic range of paddlefish. Agencies were given 4 weeks to complete the survey. One reminder email was sent out 1 week before the deadline, follow-up emails were

sent 3 weeks after the deadline to all nonrespondents, and follow-up phone calls were made 5 weeks after deadline to the remaining nonrespondents. Once questionnaires were received, they were reviewed and additional contact was made if any clarification was needed. The final response rate was 100%.

## Results

### *Distribution and Status*

Populations had been extirpated from four states on the periphery of their historic range: Maryland, New York, North Carolina, and Pennsylvania (Table 1). However, two of those states (New York and Pennsylvania) initiated reintroduction programs using hatchery-reared paddlefish in 1998 and 1991, respectively.

Paddlefish populations were reportedly stable, stable/increasing, or increasing in 16 states, whereas three states (Louisiana, Montana, and Tennessee) reported their stocks to be stable/decreasing or decreasing (Figure 1). Three states reported the status of paddlefish to be unknown (Texas and Virginia) or stable/unknown (Iowa). The reported status of paddlefish stocks changed between 1994 and 2006 for 13 of the 22 states where paddlefish were not extirpated (Table 1). Change in status followed a negative trend in only 3 of those 13 states: Tennessee (unknown to declining), Louisiana (stable to stable/declining), and Wisconsin (increasing to stable). Due to perceived changes in the status of paddlefish populations (both positive and negative), 8 of the 22 states where wild (i.e., self-sustaining) paddlefish stocks still existed in 1994 changed their classifications of paddlefish by 2006 (Table 1). Five states increased protection of paddlefish by either changing their classification from special concern in 1994 to protected in 2006 (Alabama, Louisiana, and West Virginia), protecting paddlefish

Table 1. Classification and paddlefish population status reported by state biologists in 1983, 1994, and 2006 within the historic range of paddlefish. Responses in 1983 and 1994 are from Gengerke (1986) and Graham (1997), respectively.

State	Classification			Status		
	1983	1994	2006	1983	1994	2006
Alabama	Commercial	Special concern	Protected	Decline	Stable/decline	Stable/increase
Arkansas	Commercial	Sport/ commercial	Sport/ commercial	Increase	Stable	Stable
Illinois	Commercial	Sport/ commercial	Sport/ commercial	Decline	Decline	Stable/increase
Indiana	Sport	Sport	Sport/commercial	Stable	Stable	Stable
Iowa	Commercial	Sport	Sport/protected	Stable	Stable	Stable/unknown
Kansas	Sport	Sport	Sport	Decline	Stable/increase	Stable
Kentucky	Commercial	Commercial	Commercial	Stable	Stable	Stable
Louisiana	Commercial	Special concern	Protected	Stable	Stable	Stable/decline
Maryland	Threatened	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Minnesota	Protected	Threatened	Threatened	Stable	Stable	Stable/increase
Mississippi	Commercial	Commercial	Commercial	Stable/increase	Stable	Stable
Missouri	Game	Game	Game	Stable	Stable	Stable
Montana	Sport	Sport/special concern	Game/special concern	Stable	Stable/decline	Stable/decline
Nebraska	Sport	Sport	Sport	Stable	Stable/decline	Stable
New York	Extirpated	Extirpated	Not classified	Extirpated	Extirpated	Extirpated/ increase
North Carolina	Not classified	Endangered	Endangered	Extirpated	Extirpated	Unknown/ extirpated
North Dakota	Commercial	Sport/special concern	Sport	Stable/increase	Decline	Stable/increase
Ohio	Endangered	Threatened	Threatened	Decline	Unknown	Stable
Oklahoma	Commercial	Nongame	Sport	Unknown	Stable	Increase
Pennsylvania	Extirpated	Extirpated	Protected nongame	Extirpated	Extirpated	Extirpated/ increase
South Dakota	Sport	Sport	Game	Decline	Stable	Stable
Tennessee	Commercial	Sport/ commercial	Sport/ commercial	Stable	Unknown	Decline
Texas	Endangered	commercial	commercial	Decline	Increase	Unknown
Virginia	Endangered	Endangered	Threatened	Decline	Stable	Unknown
West Virginia	Nongame	Threatened	Threatened	Stable	Unknown	Unknown
Wisconsin	Sport	Special concern	Protected	Decline	Increase	Increase
	Watch list	Watch list	Threatened	Stable	Increase	Stable

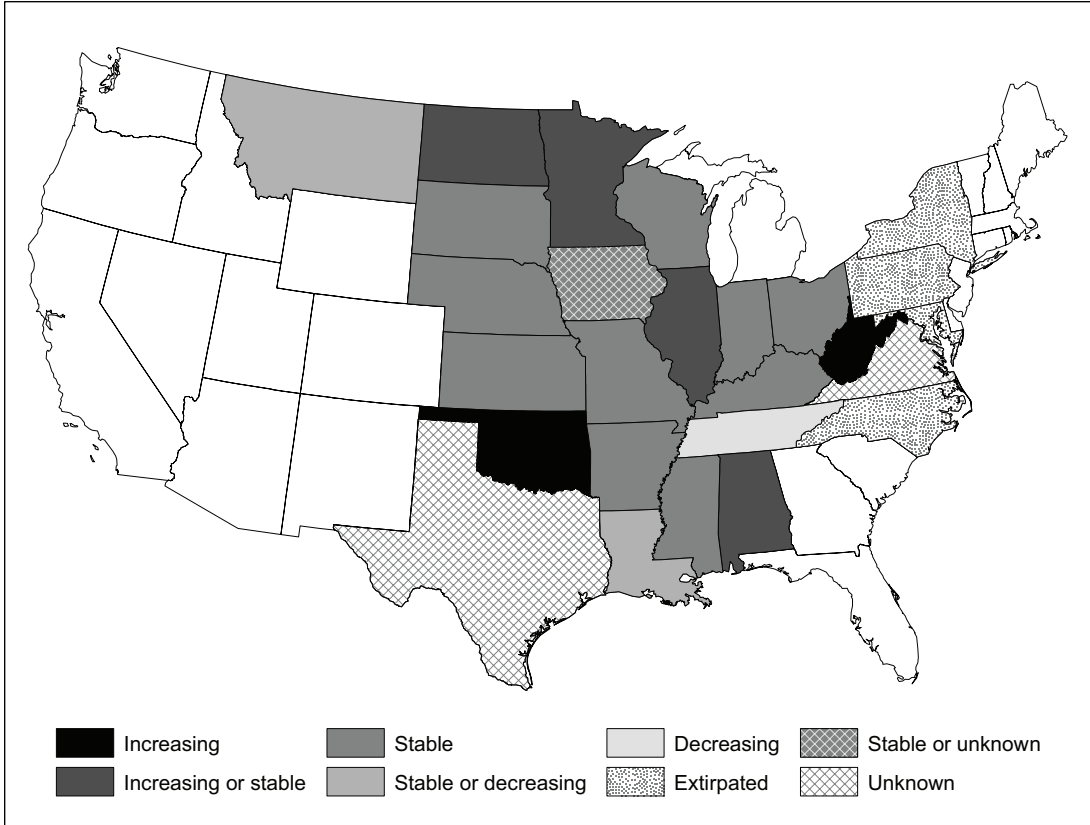


Figure 1. Status of paddlefish stocks in the United States based on a 2006 survey of state and federal agency personnel.

in some waters from sport fishing (Iowa), or moving paddlefish from a watch list to a list of threatened species (Wisconsin). Three states reduced protection between 1994 and 2006 by allowing recreational harvest (Oklahoma), reclassifying the species from endangered to threatened (Texas), or opening up some waters to commercial harvest (Indiana). Since 1994, only one state has changed the type of fishery permitted in their state (Table 2): Indiana permitted commercial fishing and continued their sport fishery. Fourteen states in 2006 allowed sportfishing for paddlefish and seven states (Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee) allowed paddlefish to be fished commercially.

### *Defining Sampling Activities*

A few questions in the survey (4, 5, and 6 of the “General Questions”) were asked about paddlefish sampling and research activities conducted in each state. From the broad answers received to these questions, six general categories were created that defined why data were collected: contaminant analysis, habitat use (during spawning or nonspawning periods), harvest, movements, population dynamics (e.g., abundance, growth, and mortality), and reproduction. If any state indicated that fishery-independent or fishery-dependent data collection efforts targeting paddlefish occurred on a consistent basis, that state was recorded as performing “routine sampling.”

Table 2. Comparison of types of paddlefish fisheries allowed in 1983 (Gengerke 1986), 1994 (Graham 1997), and 2006 (present study) in all states within the historic range of paddlefish.

State	Commercial			Sport		
	1994	2006	1983	1994	2006	1983
Alabama	Yes	No	No	Yes	No	No
Arkansas	Yes	Yes	Yes	Yes	Yes	Yes
Illinois	Yes	Yes	Yes	Yes	Yes	Yes
Indiana	Yes	Yes	Yes	No	No	Yes
Iowa	Yes	Yes	Yes	Yes	No	No
Kansas	Yes	Yes	Yes	No	No	No
Kentucky	Yes	Yes	Yes	Yes	Yes	Yes
Louisiana	No	No	No	Yes	No	No
Maryland	No	No	No	No	No	No
Minnesota	No	No	No	No	No	No
Mississippi	Yes	Yes	Yes	Yes	Yes	Yes
Missouri	Yes	Yes	Yes	Yes	Yes	Yes
Montana	Yes	Yes	Yes	No	No	No
Nebraska	Yes	Yes	Yes	No	No	No
New York	No	No	No	No	No	No
North Carolina	No	No	No	No	No	No
North Dakota	Yes	Yes	Yes	No	No	No
Ohio	No	No	No	No	No	No
Oklahoma	Yes	Yes	Yes	Yes	No	No
Pennsylvania	No	No	No	No	No	No
South Dakota	Yes	Yes	Yes	No	No	No
Tennessee	Yes	Yes	Yes	Yes	Yes	Yes
Texas	No	No	No	No	No	No
Virginia	Yes	No	No	Yes	No	No
West Virginia	Yes	No	No	No	No	No
Wisconsin	No	No	No	No	No	No

### *Status and Sampling Activities by State*

*Alabama.*—(Sport or commercial fishing prohibited; classified as a protected species; status: stable/increasing). Paddlefish stocks in the Alabama River drainage and the Alabama waters of the Tennessee River were the focus of several studies in the 1990s (Hoxmeier and DeVries 1996; Lein and DeVries 1998); paddlefish populations were self-sustaining in the Alabama River drainage but scarce in the Tennessee River. There has been a moratorium on all paddlefish harvest in Alabama since 1989, and paddlefish populations are now believed to be stable or increasing. Ongoing research in the state includes an examina-

tion of fish passage through dams and further assessment of the paddlefish stock in the Alabama River.

*Arkansas.*—(Sport and commercial fisheries permitted; classified as a sport/commercial fish; status: stable). Major changes or trends in Arkansas paddlefish populations were not identified. Arkansas is very active in terms of paddlefish sampling and research activities (Table 3). Paddlefish are sampled as part of routine sampling activities and special evaluations have been performed, or are ongoing, in the Arkansas River, White River, Mississippi River, Red River, and Ouachita River. Biologists periodically observe catches of commercial fishermen and ongoing studies are assessing a broad range of topics, including

Table 3. Types of research conducted for all states within the historic range of paddlefish and whether or not paddlefish were targeted in routine sampling activities in 2006.

State	Routine sampling	Types of research conducted					
		Contaminant	Habitat use	Harvest	Movement	Population	Reproduction
Alabama	Yes				•	•	
Arkansas	Yes		•	•	•	•	•
Illinois	Yes	Flesh/eggs		•	•	•	
Indiana	Yes	Flesh				•	
Iowa	Yes					•	
Kansas	No						
Kentucky	Yes	Flesh/eggs			•	•	•
Louisiana	No						
Maryland	No						
Minnesota	No						
Mississippi	No				•	•	•
Missouri	Yes		•	•	•	•	•
Montana	Yes			•	•	•	•
Nebraska	Yes				•	•	
New York	Yes				•	•	
North Carolina	No						
North Dakota	Yes	Flesh		•	•	•	
Ohio	Yes					•	
Oklahoma	No	Flesh		•	•	•	
Pennsylvania	Yes		•		•	•	
South Dakota	Yes			•	•	•	
Tennessee	Yes	Flesh/eggs		•	•	•	
Texas	No						
Virginia	No						
West Virginia	Yes				•	•	
Wisconsin	No						

commercial season length, habitat use, and population assessments. Special population assessments have been performed for Beaver Lake, an impoundment on the White River, which was last stocked in 2001 and is closed to commercially fishing. Arkansas biologists have participated in the Mississippi River basin-wide paddlefish tagging project sponsored by the Mississippi Interstate Cooperative Resource Association (MICRA) since its inception in 1995 (see Grady and Conover [1998] or [www.aux.cerc.cr.usgs.gov/MICRA/Index.htm](http://www.aux.cerc.cr.usgs.gov/MICRA/Index.htm) for more information on the MICRA paddlefish project).

*Illinois*.—(Sport and commercial fisheries permitted; classified as a sport/commercial fish; status: stable/increasing). The status of paddlefish has improved since 1994, when stocks were judged to be de-

clining. The only paddlefish data collected in 1986 came from commercial harvest records. Biologists have taken a more active role since 1995 in sampling paddlefish stocks by participating in MICRA's paddlefish tagging project. Most sampling is by gill nets and occurs in winter in Pool 26 on the Mississippi River and in the Wabash River and Ohio River. The annual goal is to collect and tag 300 paddlefish per year with coded wire tags. Illinois has sampled paddlefish eggs for contaminants at John T. Myers lock and dam on the Ohio River; a consumption advisory currently does not exist.

*Indiana*.—(Sport and commercial fisheries permitted; classified as sport/commercial fish; status: stable). Paddlefish populations have been stable since 1984 and Indiana biologists have used gill nets and electrofishing gear to participate in MICRA's sam-



pling program since its inception. Indiana is a member of the Ohio River Fisheries Management Team (which includes Illinois, Indiana, Kentucky, and West Virginia) and standardized gill-net samples have been collected from select tailwaters each winter since 2001. Biologists in Indiana have tested paddlefish flesh for polychlorinated biphenyl (PCB) contamination in the Ohio River, and a consumption advisory exists: adults should not consume more than one meal per month. Indiana's sport and commercial fisheries are confined to the Ohio River. Although Indiana always allowed sport fishing for paddlefish, waters were not opened to commercial fishing until 1985 when the United States Supreme Court granted Indiana partial ownership of the Ohio River. The commercial fishery does not have season length, size limits, or license quotas, and gear are not restricted, other than requiring fishers to use gill nets or trammel nets. Instituting stricter commercial fishing regulations is currently being investigated because of the increasing numbers of commercial fishers seeking paddlefish in Indiana waters and truncated size and age structures, which indicated overharvest of larger, older paddlefish.

*Iowa*.—(Sport fishery permitted; classified as a sport fish on the Mississippi River and protected on the Missouri River; status: stable/unknown). Iowa's fisheries for paddlefish occur in the Missouri River and Mississippi River. The current status of the Mississippi River paddlefish population is stable, but the status of the Missouri River paddlefish population is unknown. In the past, Iowa biologists have participated in MICRA's coded-wire tagging stock assessment project and captured paddlefish by using snag lines and trammel nets. Currently, biologists are switching to gill nets and tagging fish with jaw tags. Iowa closed its sport fishery on the Missouri River in 1986 but still maintains a sport fishery on the Mississippi River.

*Kansas*.—(Sport fishery permitted; classified as a sport fish; status: stable). Paddlefish populations within the state were described as declining in 1986, stable and increasing in 1994, and are currently described as stable. Paddlefish fisheries in Kansas rely on fish moving upstream from Missouri and Oklahoma waters. The fishery below Osawatomie Dam on the Marias des Cygnes River (a tributary of the Osage River) is based on fish migrating upriver from Harry S. Truman Reservoir, Missouri. The fishery in the Neosho River (also known as Grand River) below Chetopa Dam is supported by fish migrating upriver from Grand Lake, Oklahoma. Kansas attempted to establish a fishery in Tuttle Creek Reservoir on the Big Blue River (a tributary of the Kansas River), but with little success. Kansas has also stocked paddlefish into John Redmond Reservoir on the Neosho River. All stocked fish are tagged with coded wire tags following MICRA protocols.

*Kentucky*.—(Sport and commercial fisheries permitted; classified as a commercial species; status: stable). The status of paddlefish populations in Kentucky has remained stable since the first survey was distributed in 1983. Kentucky biologists routinely sample paddlefish as part of cooperative sampling programs coordinated by the Ohio River Fisheries Management Team and MICRA. Paddlefish are tagged in the rostrum with MICRA-supplied microtags (hatchery-reared fish only) and also with aluminum jaw tags. Age and growth information has been gathered recently and may be used to establish new harvest regulations on the Ohio River. Kentucky stocks paddlefish only to supplement populations that may have experienced fish kills; in any given year, Kentucky typically stocks less than 2,000 paddlefish. The paddlefish flesh and egg consumption advisory for the Ohio River calls for not more than six meals per year and suggests that

women of childbearing age and children 6 years or younger should not consume paddlefish flesh or eggs. These advisories were issued because of high concentrations of PCBs and mercury. Researchers from Kentucky State University have a long record of studying the feasibility of rearing (or ranching) paddlefish as an aquaculture species (e.g., Onders et al. 2001).

*Louisiana.*—(Sport or commercial fisheries prohibited; classified as a protected species; status: stable/declining). Paddlefish populations are stable in inland waters but are decreasing in Gulf Coast systems. The decrease in populations in coastal rivers is thought to have resulted from fish kills associated with hurricanes. Louisiana does not specifically target paddlefish in any routine sampling, but data are recorded on paddlefish when they are encountered during sampling activities targeting other species. Louisiana regularly stocks 10,000 to 30,000 paddlefish per year.

*Maryland.*—(Sport or commercial fisheries prohibited; classified as extirpated; status: extirpated). Whether paddlefish ever occurred or were ever recorded from Maryland waters is unclear. Gengerke (1986) reported, based on a personal communication, that paddlefish were extirpated from Maryland. Paddlefish may have existed in the western tip of the state, but current resource personnel claim that they have no historical documentation of paddlefish ever being sighted within state waters (B. Lunsford, Maryland Department of Natural Resources, personal communication).

*Minnesota.*—(Sport or commercial fisheries prohibited, classified as a threatened species; status: stable/increasing). Minnesota waters such as the St. Croix River, a tributary of the upper Mississippi River, represent the northern periphery of the species' range (Lee et al. 1980). Paddlefish are encountered incidentally when other fish populations are sampled. Based on limited observations, biologists generally agree that

the paddlefish population in Minnesota is stable or perhaps even increasing slightly. However, the paddlefish population in the upper Mississippi River is small. One possible explanation offered for increased abundance of paddlefish is enhanced water quality in recent decades.

*Mississippi.*—(Sport and commercial fisheries permitted; classified as a commercial species; status: stable). Through 2006, Mississippi was unique in having a commercial fishing season for paddlefish in the summer months (other states have winter/spring commercial seasons). The Mississippi Department of Wildlife, Fisheries, and Parks proposed in 2007 that the commercial season change in 2008 to coincide with the seasons of adjoining states (i.e., Tennessee and Arkansas) where commercial fishing occurs on the Mississippi River. Sport fish regulations were recently changed to prohibit the possession of any paddlefish longer than 762 mm (30 in) eye-to-fork length, and the creel limit is two fish per day. A self-sustaining paddlefish population in the Tennessee–Tombigbee system of the upper Mobile River drainage has been the subject of recent investigations into its status and reproductive requirements (O'Keefe et al. 2007).

*Missouri.*—(Sport and commercial fisheries permitted; classified as a game fish; status: stable). While paddlefish populations in Missouri have remained stable over the past 20 years, the number of commercial fishers in Missouri has declined. Commercial fishing in Missouri is restricted to the Mississippi River. The lower St. Francis River commercial fishery was closed in 1989. Creel surveys on Lake of the Ozarks, Table Rock Lake, and Harry S. Truman Reservoir monitor sport harvest during the spring snagging season. In addition to an ongoing coded wire tag retention study and collaborating with MICRA tagging and stock assessment activities, researchers are studying movement, habitat use,



and reproduction in the lower Osage River. Missouri stocks Table Rock Lake with 3,000 paddlefish fingerlings annually, and an additional stocking of up to 6,000 fish occurs every 3 years. Lake of the Ozarks and Harry S. Truman Reservoir (both on the Osage River) are each stocked with 15,000 paddlefish fingerlings annually (with an additional stocking of up to 30,000 fish every 3 years), and the Black River (a tributary of the White River in Arkansas) is stocked with 750 paddlefish fingerlings annually.

*Montana.*—(Sport fishery permitted; classified as a game fish and species of special concern; status: stable/declining). Among all paddlefish stocks, those in the upper Missouri River and Yellowstone River in Montana and western North Dakota have been perhaps the most intensively studied and over the longest period of time (Scarnecchia et al. 2007). Over the past 20 years, the status of paddlefish in the state has been reported to be stable or declining. The stock upriver of Ft. Peck Reservoir on the Missouri River has been decreasing because of reduced recruitment, whereas the Yellowstone River/Lake Sakakawea stock below Ft. Peck Reservoir has been stable. The latter stock is managed cooperatively with the state of North Dakota. Although paddlefish are classified as a game species, a commercial caviar operation associated with the Yellowstone River sport fishery exists. Through a special arrangement with the Montana Department of Fish, Wildlife, and Parks (MDFWP), anglers who snag a ripe female may donate the roe for processing and sale by the Glendive (Montana) Chamber of Commerce, which sells the roe and shares the proceeds with the MDFWP. In exchange, anglers get their paddlefish carcasses cleaned and packaged for transport. The MDFWP has actively sampled paddlefish for decades. The Yellowstone River population has been sampled regularly since the 1960s, with an emphasis on tagging studies and creel surveys; a re-

cruitment/harvest model is being developed and refined to direct the management of that population. The Ft. Peck Reservoir stock has been sampled annually with gill nets, and fish have been tagged since 1977; creel surveys are conducted every other year to monitor the sport fish harvest of paddlefish. In order to index year class strength, annual young-of-year paddlefish surveys have been conducted in Ft. Peck Reservoir since 1999.

*Nebraska.*—(sport fishery permitted; classified as a sport fish; status: stable). Personnel with the Nebraska Game and Parks Commission (NGPC) stated that the reason for the change in status (stable/declining in 1994 to stable in 2006) was intensive management such as imposing a harvest quota on the Missouri River (i.e., anglers and archery fishers apply for a limited number of paddlefish tags) and establishing a protected slot limit (89–114 cm eye-to-fork length). Nebraska's increasingly popular 30-d archery seasons for paddlefish in July and snagging season in October on the Missouri River below Gavins Point Dam are jointly managed with South Dakota Department of Game, Fish and Parks. The NGPC is currently working to increase the cost of the permits and implement a preference system to insure that anglers and archery fishers draw a permit on a regular basis. Nebraska biologists attempt to net 300 adult paddlefish each year in the reach of the Missouri River from Gavins Point Dam to the mouth of the Big Sioux River. The NGPC is currently working with the University of Nebraska to develop a research project on paddlefish in the Nebraska/South Dakota reach of the Missouri River. This project will examine population status, interjurisdictional movement, and the response of paddlefish to river flow management.

*New York.*—(Sport or commercial fisheries prohibited; officially not classified – considered extirpated; status: extirpated/

increasing). Although paddlefish are officially listed as extirpated in New York, a paddlefish restoration and restocking program began in 1998 during which more than 2,000 fish are stocked annually into Allegheny Reservoir on the Allegheny River, at the upper end of the Ohio River. New York recently broadened the program, and some paddlefish are stocked into Conewango Creek, near to Chautauqua Lake in an adjacent tributary watershed of the Allegheny River. There have been few reports of paddlefish incidentally caught in Allegheny Reservoir, and emigration downstream of the reservoir has been documented. New York biologists believe that paddlefish might become established in Allegheny Reservoir by reproducing upstream in the Allegheny River.

*North Carolina.*—(Sport or commercial fisheries prohibited; classified as an endangered species; status unknown/extirpated). The status of paddlefish in North Carolina is unknown; the species is believed to be extirpated. Historically, North Carolina waters (i.e., tributary rivers in the upper Tennessee River drainage) represented the periphery of the paddlefish's range. Research or sampling activities are not planned.

*North Dakota.*—(Sport fishery permitted; classified as a game fish; status: stable/increasing). The paddlefish population in North Dakota in 1983 was described as stable or increasing, but in 1994, the population was considered to be declining. In 2006, the population appeared to be on the rebound, and the status was upgraded to stable/increasing. Sport fisheries exist in the Missouri River and Yellowstone River above Lake Sakakawea (i.e., the Williston Reach) and in the Yellowstone River; that stock has been the subject of numerous investigations (e.g. Firehammer and Scarnecchia 2006). The Yellowstone–Sakakawea stock trended downwards from the mid-1970s through the mid-1990s, but better

reproduction and recruitment in the mid-1990s slowed the declining population trend and stabilized or at least temporarily increased numbers of juvenile and adult fish. Although little information is available regarding the population within the Garrison Reach (downstream of Garrison Dam to the headwaters of Lake Oahe), it is thought to be stable but small. The prolonged and ongoing drought in the upper Missouri River and Yellowstone River basins has negatively affected spawning success and recruitment. Paddlefish were stocked regularly in North Dakota waters between 1985 and 1992 and in 1995 and 1997, but fish have not been stocked since then. North Dakota maintains an active paddlefish sampling and research program aimed at assessing harvest and population status. The North Dakota State Health Department has tested paddlefish flesh for contaminants, and no consumption advisories have been issued.

*Ohio.*—(Sport or commercial fisheries prohibited; classified as a threatened species; status: stable). The paddlefish population that was considered to be declining 20 years ago has now stabilized. Ohio biologists are active participants in the Ohio River Fisheries Management Team, which meets regularly to formulate and pursue paddlefish research objectives. From such research efforts, population models have been developed to understand how commercial fishing on the lower Ohio River has affected population dynamics throughout the river. Ohio biologists collect standardized gill-net samples at fixed stations below the Greenup locks and dam on the Ohio River in late winter and early spring and in the Great Miami River in fall.

*Oklahoma.*—(Sport fishery permitted; classified as a sport fish; status: increasing). Since the last mail survey in 1994, Oklahoma paddlefish populations are thought to be increasing. Sport fishing for paddlefish has become increasingly popular in

the state (Gordon 2009, this volume), and paddlefish populations in the Grand River and Neosho River systems are regularly monitored using gill nets and creel surveys. The characteristics of a self-sustaining paddlefish population in an Oklahoma reservoir near the southwestern edge of the species' range were described in recent years (Paukert and Fisher 2000; Paukert and Fisher 2001). Together with the U.S. Fish and Wildlife Service, the state has also stocked a small number of paddlefish. Although the state has not tested paddlefish flesh or eggs for contaminants, the Peoria Tribe of Indians of Oklahoma tested the white meat, red fatty meat, and livers of 20 paddlefish for pesticides in 2006. The results of this analysis came back below the threshold for consumption and no advisories have been issued for paddlefish meat or eggs.

*Pennsylvania.*—(Sport or commercial fisheries prohibited; classified as a protected, non-game species; status: extirpated/increasing). The species remains officially extirpated; the last known wild specimen was collected from Pennsylvania waters in 1919. However, paddlefish abundance is increasing in Pennsylvania as a result of a restoration effort started in 1991 in the Ohio River and Allegheny River. The state tries to stock 10,000 fingerlings annually. Mature adults have been collected, but natural reproduction has not been observed. Recent and ongoing research projects have examined movement and habitat use by juvenile paddlefish (Barry 2004), food availability (Counahan 2004), and status of paddlefish in Pennsylvania waters (Argent and Kimmel 2006). Research is being proposed to determine whether paddlefish are reproducing in Pennsylvania waters.

*South Dakota.*—(Sport fishery permitted; classified as a game fish; status: stable). Paddlefish abundance in Lake Francis Case on the Missouri River is thought to have stabilized because of an ongoing

stocking program that releases 2,000–15,000 paddlefish annually into the system. However, there is no indication of natural reproduction or recruitment by this population. Natural reproduction and recruitment have been documented downstream in the Missouri River below Fort Randall Dam, Lewis and Clark Lake, and the Missouri River below Gavins Point Dam, and the paddlefish populations are considered to be stable or increasing. Past research includes telemetry projects in Lake Francis Case in the late 1990s that examined habitat use and movements by juvenile and adult paddlefish (Stancill et al. 2002; Roush et al. 2003). South Dakota has been an active participant in the MICRA coded wire-tagging project since its inception. South Dakota's annual paddlefish sampling program includes collecting broodstock for artificial propagation and estimating angler effort and harvest during the archery and snagging seasons. Sport fish harvest is allowed only in the Missouri River below Gavins Point Dam, and the separate archery and snag fisheries are managed jointly with Nebraska.

*Tennessee.*—(sport and commercial fisheries permitted; classified as a sport/commercial species; status: declining). The most recent study on Kentucky Lake, a Tennessee River impoundment that supports the state's biggest commercial fishery, revealed that the population was being overfished (Scholten and Bettoli 2005). Regulations were enacted in 2006 (e.g., shorter season; higher minimum size limit) to prevent further declines, but it is too early to determine whether those regulations will help rebuild stocks. Other recent research demonstrated high levels of bycatch (i.e., males and immature female paddlefish) in the Kentucky Lake fishery (Bettoli and Scholten 2006). The status of other paddlefish fisheries in Tennessee is unknown. Tennessee does not conduct fishery independent sampling on a regular basis; instead, biologists accom-

pany commercial fishers each season to collect data on at least 300 paddlefish to evaluate current regulations. Stock assessments of paddlefish in the Cumberland River, the upper Tennessee River, and the Mississippi River are planned. Biologists also hope to examine dam passage and the degree that reservoir populations are closed to immigration or emigration. Currently, the plan for stocking paddlefish in Tennessee waters is to stock fingerlings into waters throughout the state as they become available. Since 2000, the number stocked each year has been small, varying between 450 and 4,600 fish.

*Texas.*—(Sport or commercial fisheries prohibited; classified as a threatened species; status: unknown). Paddlefish are protected in Texas, where they historically occurred in several major river systems (e.g., Trinity, San Jacinto, Sabine, and Neches rivers). Several aspects of paddlefish biology and habitat suitability in Texas river systems were examined in the 1990s (e.g., Pittman and Parks 1994; Moore and Cotner 1998). Habitat alteration in the forms of dams has negatively impacted Texas paddlefish populations. The latest research on paddlefish populations in Texas assessed the success of stocking above dams in rivers that had historically supported paddlefish, but no longer did (Betsill 2000). Downstream losses through dams were too high for stocking to be a feasible restoration technique when coupled with the lack of natural recruitment. Impediments to the establishment of self-sustaining populations include inundation of historical spawning sites and lack of suitable substrate for paddlefish egg incubation.

*Virginia.*—(Sport or commercial fisheries prohibited; classified as a threatened species; status: unknown). Paddlefish are considered extremely rare and critically imperiled in the state (Roble 2006). Virginia biologists do not specifically target paddle-

fish for routine sampling. They regularly sample the fish communities in the Clinch River and Powell River (in the headwaters of the Tennessee River) where paddlefish once occurred, but they have never collected a paddlefish.

*West Virginia.*—(Sport or commercial fisheries prohibited; classified as a “non-harvest species” [i.e., all paddlefish encountered must be returned to the water immediately]; status: increasing). Paddlefish populations in West Virginia are thought to have increased in recent years due to annual stockings of 3,000 to 8,000 fingerlings. Annual sampling activities include gill netting tailwaters in the Ohio River during winter and spring following Ohio River Fisheries Management Team protocols. Ongoing research focuses on movements of paddlefish through locks and dams, basic population characteristics, and stocking efficacy.

*Wisconsin.*—(Sport or commercial fisheries prohibited; classified as a threatened species; status: stable). Paddlefish are uncommon in the main stem of the Mississippi River and the lower reaches of its largest tributaries (Lyons et al. 2000), although they are locally common in some reaches of the Wisconsin, Black, and Chippewa rivers. Runstrom et al. (2001) estimated the population size and some other population parameters for the paddlefish stock in the Wisconsin River, a tributary of the Mississippi River; they considered that stock a source population for the upper Mississippi River. Paddlefish movements and habitat use have been extensively studied in those same waters (e.g., Zigler et al. 2004). Currently, paddlefish populations within the state are thought to be stable, although data are limited. The U.S. Fish and Wildlife Service in Wisconsin expressed the need to begin regular sampling of paddlefish and the need to assess fishway designs to pass paddlefish up and downstream through dams.



## Summary

The status of paddlefish and other caviar-producing species around the world continues to receive much attention by the scientific community (Pikitch et al. 2005). Based on our survey, the status of paddlefish stocks has improved since earlier surveys were conducted in 1983 and 1994; 18 of 26 states reported in 2006 that their paddlefish populations were stable or increasing, compared to only 14 states in 1983 and 1994. Compared to the 1980s and 1990s, more state and federal agencies are actively sampling paddlefish in 2006 and collecting fishery-independent data in order to make informed management decisions. The number of states with closed fisheries (i.e., no commercial or sport harvest) increased from 8 in 1983 to 12 in 2006: Alabama, Louisiana, Maryland, Minnesota, New York, North Carolina, Ohio, Pennsylvania, Texas, Virginia, West Virginia, and Wisconsin. The number of states reporting declining or stable/declining paddlefish populations dropped from seven states in 1983 to only three states in 2006. Of those three states, only one does not conduct routine sampling (Louisiana) and two have ongoing stocking programs (Tennessee and Louisiana). The two principal reasons for reported declines have remained the same for more than three decades: habitat loss and overfishing. Two states where paddlefish were listed as extirpated (New York and Pennsylvania) have begun restoration efforts that may one day allow the status of paddlefish in those states to be upgraded.

Of the 18 states where respondents indicated stable or increasing paddlefish stocks, eight states stocked paddlefish and the number stocked each year varied widely. Only two of those eight states (South Dakota and West Virginia) considered their stocking program to be responsible, in part for maintaining or improving the status of paddlefish in their state. States without a routine paddlefish sampling program ( $n = 10$ ) were more

likely to classify their stocks as extirpated or of unknown status (Fisher's Exact test;  $P = 0.0140$ ); the four states with no routine sampling program and where paddlefish were extirpated or of unknown status (Maryland, Virginia, North Carolina, and Texas) were all on the periphery of the range of the species. There was no geographic pattern regarding the states where paddlefish stocks were reported to be declining.

Reversing the downward trend in paddlefish stocks in some locales and directing attention to dwindling or overfished stocks elsewhere were aided by cooperative research and management fostered by MICRA and its members. The creation in the 1990s of the paddlefish/sturgeon subcommittee under the auspices of MICRA came at a crucial time, as it preceded global shifts in the international supply of caviar, ever-climbing prices paid for paddlefish roe, and increased fishing activity where harvest was still allowed. The creation of MICRA coincided closely with renewed interest throughout the Mississippi River basin in assessing paddlefish stocks, changing regulations when called for, and undertaking paddlefish restoration activities.

How far into the future caviar prices and demand for paddlefish roe will remain high is unknown; in Tennessee in 2006–2007, wholesale prices paid to fishers approached \$US45/kg for paddlefish roe or about double the price only 2 years earlier. As long as current market forces remain in place, pressure on paddlefish stocks will undoubtedly remain high. However, if current trends continue and resource managers and researchers are successful in identifying and eliminating overfishing and further habitat destruction, fears of a basin-wide collapse in paddlefish stocks should fade.

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