Review of Paddlefish Management in Kansas from 1972 to 2013 and Implications for Future Conservation

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Abstract: Paddlefish (*Polyodon spathula*) contribute to recreational fisheries in 14 U.S. states, including Kansas. They are found in six major river basins in southern and eastern Kansas (Arkansas, Kansas, Marais des Cygnes, Missouri, Neosho, and Verdigris) during spring spawning migrations and are thought to persist in four of those (Kansas, Marais des Cygnes, Missouri, and Neosho) throughout the year. However, most data pertaining to paddlefish in Kansas exist in internal documents or institutional knowledge. Desire to best manage Kansas fisheries has resulted in a need to consolidate this information and develop a statewide paddlefish management plan. Recreational paddlefish snagging was first designated as a fishing season in Kansas in 1972 on a short stretch of the Neosho River below Chetopa Dam. Snagging seasons were initially unregulated but have since evolved to address various management considerations. Notable changes included development of new snagging opportunities, stocking programs, and harvest regulations. Beginning in 1992, Kansas Department of Wildlife, Parks and Tourism implemented mandatory check stations for harvested fish. These stations ultimately resulted in collection of important fishery data including number and size of harvested fish. Logistic concerns eliminated check stations beginning in 2007 and a permit system was thereafter implemented that allowed anglers to harvest up to six fish annually. The permit system has remained through the 2013 season and provides angler contact information for mail-out surveys following each snagging season. Historical management activities presented herein coupled with continued monitoring through mail surveys will be used to direct future management actions to promote conservation and enhancement of paddlefish fisheries in Kansas.

Key words: Snag fishery, case study, regulation, *Polyodon spathula*, regulation

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Paddlefish (*Polyodon spathula*) are large-bodied, pelagic planktivores endemic to the Mississippi River drainage and areas of the Gulf Slope including all or parts of 26 states (Jennings and Zigler 2009). However, only 22 states reported having paddlefish stocks in 2006 (Bettoli et al. 2009). Numerous factors have been implicated in declining range and density of paddlefish stocks including anthropogenic modifications of river systems (Jelks et al. 2008), increased abundance of invasive species (e.g., bighead carp [*Hypophthalmichthys nobilis*], silver carp [*H. molitrix*], and zebra mussels [*Dreissena polymorpha*]; Pegg et al. 2009), and changes in water quality (Jennings and Zigler 2009). In response to long-term declines throughout the species' distribution, an influx of interest in research and conservation of these populations led to development of management regimes in the mid to late 1900s designed to conserve and enhance extant stocks (Russell 1986). Management programs were largely successful and by 2006, paddlefish populations were considered stable or increasing throughout most of their distribution (Bettoli et al. 2009).

One aspect of paddlefish biology that makes the species attractive to both anglers and managers is their ability to attain large sizes (Jennings and Zigler 2009, Bettoli 2011, Morgan et al. 2012). Paddlefish are relatively fast growing and can reach lengths of up to 500-mm eye-fork length (EFL) by the end of their first year of growth in the southern portion of their range (Houser and Bross 1959, Reed et al. 1992). By age-5, paddlefish in Grand Lake O' the Cherokees, Oklahoma, typically reach 760 to 780-mm EFL (Scarnecchia et al. 2011). Although paddlefish exhibit rapid somatic growth, they are relatively slow maturing (Jennings and Zigler 2009, Scarnecchia et al. 2011). In the southern portions of their range, male paddlefish can reach maturity as early as age 4 and females as early as age 6 (Jennings and Zigler 2009). Nearly all males are mature by age 9 and females by age 12 range wide (Jennings and Zigler 2009), although average age of maturity was age 14 in the northern portion of the species' distribution (Carlson and Bonislawsky 1981). Spawning periodicity of two to three years has been suggested for paddlefish (Russell 1986) although evidence suggests that annual spawning might occur during peak reproductive years in some populations (Scarnecchia et al. 2011).

Of 22 states with paddlefish populations in 2006, seven allowed commercial fishing and 14 allowed sportfishing for paddlefish (Bettoli et al. 2009). Commercial fishers typically target mature female fish as a source of roe for the caviar market (Quinn 2009, Scholten 2009). This contrasts recreational fisheries where anglers usually identify the angling experience as a primary motivator (Scarnecchia et al. 1996, Bettoli 2011, Morgan et al. 2012, Scarnecchia et al. 2013). Recreational fisheries usually rely on congregations of paddlefish at barriers that block further upstream migrations (Quinn 2009). Blind snagging is the most common technique in these areas although archery is an allowable method of take in some populations (Hansen and Paukert 2009). Recreational fisheries can be economically important in regions where they provide a unique angling opportunity (Hunt and Grado 2010). As such, these fisheries remain important to both anglers and managers.

Paddlefish angling opportunities in Kansas have been limited to recreational snagging at specific locations since the inaugural season in 1972 (Bonislawsky 1977, Neely et al. 2015), but commercial fishing has never been allowed in the state (Scholten 2009). Despite localized popularity of paddlefish fisheries, there has been little documentation of paddlefish biology or management actions in the state. Most information collected from Kansas paddlefish populations is presently contained in annual reports, intra-agency memos or as institutional knowledge. The objective of this manuscript was to consolidate information pertaining to paddlefish management in Kansas from the first snagging season in 1972 through 2013. Information obtained from this review will allow assessment of the current status of paddlefish management in Kansas and provide guidance for future management.

Distribution In Kansas

Paddlefish are native to the Arkansas, Kansas, Marais des Cygnes, Missouri, Neosho, and Verdigris river basins in Kansas (Bonislawsky 1977, Dillard et al. 1986; Table 1, Figure 1). However, they are only believed to inhabit the Kansas, Marais des Cygnes, Missouri, and Neosho river basins year-round. Paddlefish are typically found in these mainstem rivers, but have also been found in their tributaries and occasionally in adjacent impoundments within floodplains. In the 1970s, records indicated that paddlefish were present in lower reaches of the Wakarusa River below Clinton Reservoir (tributary of Kansas River) and occasionally in the Ninnescah River (tributary of Arkansas River) (Bonislawsky 1977). In the 1990s through 2010s, paddlefish were observed by game wardens or biologists in several tailwaters including Tuttle Creek Reservoir (Kansas River Basin), Elk City Reservoir (Verdigris River Basin), and Hillsdale Reservoir (Marais des Cygnes River Basin). Since the 1970s, paddlefish have been confirmed (positive identification by game warden or fisheries biologist) in 19 streams and rivers in Kansas throughout the eastern and southern part of the state (Table 1).

Table 1. Locations of paddlefish observations confirmed by game wardens or biologists in Kansas. Basin indicates major river basin and impoundment indicates the immediate upstream reservoir if a fish was located in a tailwater.

River	Basin	Impoundment
Arkansas River	Arkansas	None
Kansas River	Kansas	None
Walnut River	Arkansas	Tunnel Mill Dam
Big Blue River	Kansas	Tuttle Creek Reservoir
Delaware River	Kansas	Perry Reservoir
Republican River	Kansas	Milford Reservoir
Smoky Hill River	Kansas	Salina City Dam
Wakarusa River	Kansas	Clinton Reservoir
Bull Creek	Marais des Cygnes	Hillsdale Reservoir
Iantha Creek	Marais des Cygnes	None
Marais des Cygnes River	Marais des Cygnes	None
North Sugar Creek	Marais des Cygnes	La Cygne Reservoir
Pottawatomie Creek	Marais des Cygnes	None
Missouri River	Missouri	None
Neosho River	Neosho	None
Spring River	Neosho	None
Big Hill Creek	Verdigris	Big Hill Reservoir
Elk River	Verdigris	Elk City Reservoir
Verdigris River	Verdigris	None

Movement In Kansas

Many fish implanted with coded wire tags and stocked in Kansas have been located in other states, most notably Nebraska and South Dakota (Pracheil et al. 2012). Similarly, many paddlefish found in Kansas in spring are suspected to have been stocked in other states. These movements are presumed spawning migrations and corroborate findings by several researchers that suggest paddlefish often exhibit long-distance spawning migrations in spring (reviewed by Jennings and Zigler 2009). This phenomenon has been observed at Chetopa Dam where several fish have been harvested with jaw tags from Oklahoma (R. Friggeri, Kansas Department of Wildlife, Parks, and Tourism [KDWPT], personal communication). Similarly, several fish are reported caught each year at the Lincoln Street Dam on the Arkansas River in Wichita, Kansas (J. Mounts, KDWPT, personal communication). Fish reported at the Lincoln Street Dam are generally small males (typically <610 mm EFL) and are presumed to have migrated from Kaw Reservoir approximately 129 river km downstream. Paddlefish observed in the Marais des Cygnes river basin are likely fish that were stocked by the Missouri Department of Conservation in Harry S. Truman Reservoir, Missouri.

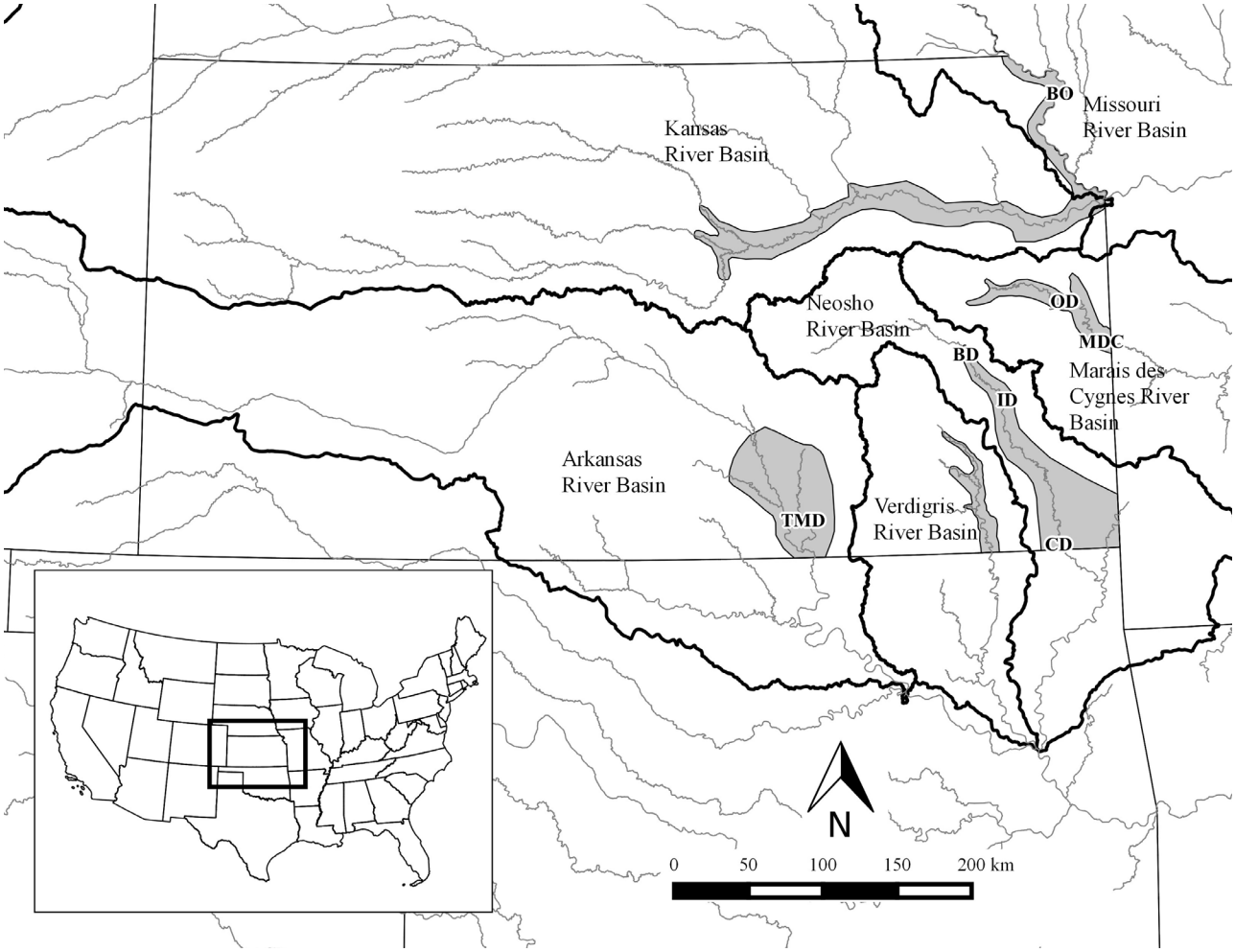

Figure 1. Map of Kansas showing current distribution of paddlefish in the state (shaded area), river basins, and location of fisheries at Browning Oxbow (BO), Burlington Dam (BD), Chetopa Dam (CD), Marais des Cygnes River (MDC), Iola Dam (ID), Osawatomie Dam (OD), and Tunnel Mill Dam (TMD).

Life History In Kansas

Paddlefish populations in some states, including Kansas, can be difficult to study because they are only found in these states during spawning migrations. Paddlefish in the Yellowstone and Missouri rivers, Montana and North Dakota, typically migrated upstream to spawning areas and remained for approximately three months before traveling back downstream (Braaten et al. 2009). Similarly, paddlefish in the Keystone Reservoir system, Oklahoma, occupied presumed spawning areas in the upstream portion of the system for one to two months before returning downstream (Paukert and Fisher 2001). Presumably, paddlefish that migrate into Kansas are within the state for a similar amount of time. Although populations are believed to persist in four river basins in the state throughout the year, densities remain unknown and might limit effectiveness of intensive sampling required to evaluate life history characteristics.

Bonislawsky (1977) investigated paddlefish age and growth and attempted to estimate age at maturity and document spawning in Kansas in 1974 through 1976. Dentary bones were collected from 195 fish harvested from the Chetopa Dam fishery. Male fish entered the fishery at age 5 and female fish at age 13. Age structure of the population indicated that this fishery was supported by few strong year classes rather than consistent reproduction and/or recruitment (Bonislawsky 1977). The 1969 year class constituted 72% of harvested fish in 1974, 78% of harvested fish in 1975, and 27% of harvested fish in 1976. Likewise, the 1970 year class constituted 67% of harvested fish in 1976, suggesting high recruitment in consecutive years (Bonislawsky 1977). This phenomenon of inconsistent recruitment and sporadic, large cohorts dominating the age structure of recreational harvest has also been suggested downstream in Grand Lake O' the Cherokees (Hereafter Grand Lake), Oklahoma (Scarnecchia et al. 2013, Schooley et al. 2014).

Growth was rapid among paddlefish harvested from Chetopa Dam in the 1970s, with fish reaching 772 mm EFL (converted from TL using equation provided in Ruelle and Hudson [1977]) at age 5 and 930 mm EFL by age 8. Bonislawsky (1977) attributed rapid growth of this population to habitat and nutrient availability in Grand Lake where these fish likely reside during the rest of the year. Paddlefish in Kansas are capable of reaching large sizes. The current state record paddlefish (1378 mm EFL, 65 kg) was captured in 2004 in a small Atchison, Kansas, impoundment adjacent to the Missouri River. It eclipsed the previous state record set in 1998 by 24 kg and is currently recognized by the Freshwater Fishing Hall of Fame as the world record (National Freshwater Fishing Hall of Fame 2009).

Paddlefish Stocking In Kansas

A total of 101,829 paddlefish were stocked by KDWPT and the U.S. Fish and Wildlife Service-operated Tishomingo National Fish Hatchery from 1982 to 2013 at Tuttle Creek Reservoir (Kansas River Basin) and John Redmond Reservoir (Neosho River Basin) in Kansas and Kaw Reservoir (Arkansas River Basin) in Oklahoma (Figure 2). Of these stocked fish, 88% were intermediate-size (≈250 mm TL) with the remainder being unknown size. Beginning in 1995, all paddlefish stocked in Kansas waters were implanted with coded-wire tags in their rostrum. John Redmond Reservoir was the most heavily stocked location in Kansas and received over 45,000 fish from 1982–2013. At least two of the stockings in John Redmond Reservoir occurred upstream of the reservoir in the Neosho River. The purpose of these stockings was to create a fishery at Burlington Dam immediately downstream of John Redmond Reservoir. Variation in number stocked and temporal pattern was attributed to fish availability. Tuttle Creek Reservoir was stocked with over 16,000 intermediate-size fish from 1992–1995. Similar to stockings in John Redmond Reservoir, fish were stocked in Tuttle Creek Reservoir in an effort to develop a recreational fishery in the Big Blue River downstream of the reservoir. Paddlefish hatched and raised at Milford Fish Hatchery in Kansas were stocked in the upstream end of Kaw Reservoir, Oklahoma, on the Arkansas River with hopes that these fish would mature and conduct spawning migrations into Kansas. Nearly 40,000 intermediate-size fish were stocked at this location from 1991–1994.

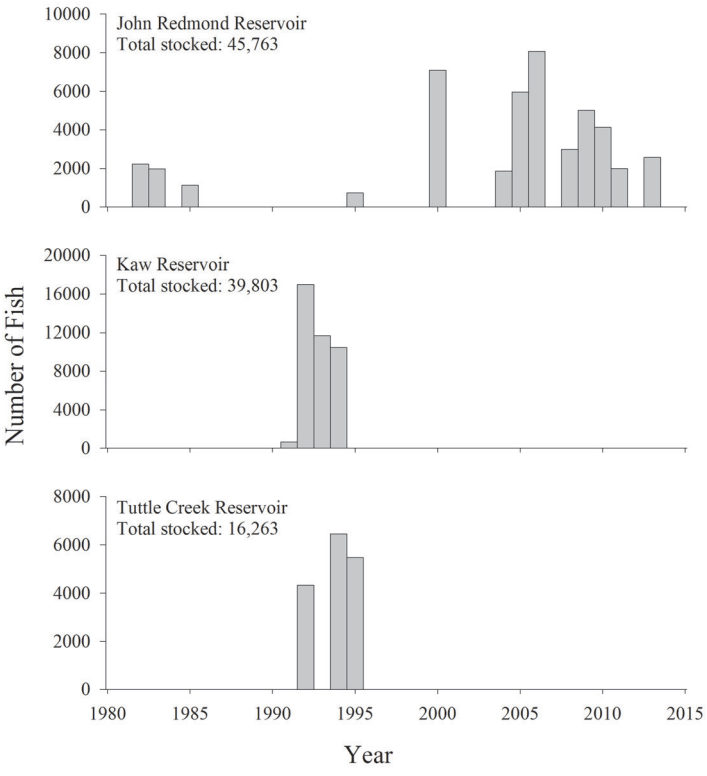

Figure 2. Distribution of 101,829 paddlefish stocked by Kansas Department of Wildlife, Parks and Tourism and U.S. Fish and Wildlife Service, Tishomingo National Fish Hatchery, in Kansas by year and reservoir.

Paddlefish Fisheries In Kansas

Paddlefish snag fisheries have occurred in Kansas at eight locations and in four of the six major river basins that harbor paddlefish (Figure 1; Table 2). The goal of these fisheries has been to maximize opportunity and harvest. From 1972 to 1998, harvest data were only available from Chetopa Dam (KDWPT 2000). Data were available from both Chetopa Dam and Osawatomie Dam from 1999 to 2006 (T. Mosher, KDWPT, personal communication). From 2007 to 2013, harvest and effort data were collected via mail-out surveys and were available for all fisheries (J. Goeckler, KDWPT, personal communication). Mean estimated annual harvest from 1972 to 2006 at Chetopa Dam was 451 fish (SE = 76) and was largely dependent on river discharge (Neely et al. 2014). From 1999 to 2006, mean harvest at Osawatomie Dam was 64 fish (SE = 56). A comprehensive evaluation of the Chetopa Dam fishery from 1992 to 2006 was presented by Neely et al. (2015). Angler effort and harvest varied considerably between seasons and

Table 2. Location, years active, river and river basin for each of the eight paddlefish snag fisheries that have been open in Kansas from 1972–2013.

Fishery	Years active	River	Basin
Tunnel Mill Dam	2002–2005	Walnut River	Arkansas
Osawatomie Dam	1979–2013	Marais des Cygnes River	Marais des Cygnes
Marais des Cygnes Wildlife Area	2010–2013	Marais des Cygnes River	Marais des Cygnes
Browning Oxbow	1997–2010	Missouri River	Missouri
Missouri River	2008–2013	Missouri River	Missouri
Chetopa Dam	1972–2013	Neosho River	Neosho
Iola Dam	2010–2013	Neosho River	Neosho
Burlington Dam	1997–2005, 2007–2013	Neosho River	Neosho

Table 3. Estimated anglers participating (Ang) and estimated harvest (Har) from each paddlefish fishery in Kansas from 2007–2012. Data were collected from mail-out surveys to paddlefish permit holders.

	Burlington		Browning		Chetopa		Iola		M. des Cygnes		Missouri		Osawatomie	
Year	Ang	Har	Ang	Har	Ang	Har	Ang	Har	Ang	Har	Ang	Har	Ang	Har
2007	13	2	0	0	805	1038	0	0	0	0	0	0	111	84
2008	76	187	0	0	874	967	0	0	0	0	0	0	87	11
2009	130	157	5	0	927	780	0	0	0	0	0	0	136	68
2010	49	48	0	0	420	274	33	9	20	3	0	0	62	27
2011	47	20	0	0	232	25	20	0	24	7	0	0	47	12
2012	151	52	0	0	817	176	21	0	21	0	0	0	65	2

sites from 2007–2012 (Table 3). There have been no legal fisheries established in the Kansas River Basin or Verdigris River Basin to date. The following timeline highlights important components of paddlefish fisheries in Kansas.

1972–1976: The first paddlefish season in Kansas was opened in 1972 at Chetopa Dam on the Neosho River. There were no harvest restrictions or season dates. Paddlefish snagging was illegal elsewhere in the state.

1977–1978: Paddlefish were designated by Kansas Fish and Game Commission (now KDWPT) as a sportfish in 1977 and a daily creel limit of two fish was instituted in an effort to regulate harvest.

1979: Popularity of snagging at Chetopa Dam prompted biologists to refine management actions and explore other snagging opportunities. The first designated snagging season was set and established by posted notice. Season guidelines were 15 March to 15 May, but delays in opening and extensions were possible. The daily creel limit was increased to four fish and anglers were limited to either two single-shank hooks or one treble hook. Hooks could not be larger than size 1 or smaller than size 12. Additionally, a new fishery at Osawatomie Dam on the Marais des Cygnes River was opened.

1980: Anecdotal observations by agency biologists created concerns of overharvest and resulted in reducing the daily creel limit to two fish and establishing a four-fish possession limit.

1981–1991: In 1981, the definition of possession limit was changed statewide for all fisheries to three times the daily creel limit. As such, possession limit for paddlefish was increased to six fish. Size restrictions for hooks were also removed. Beginning in 1982, anglers were allowed to use two hooks on a single line. Both single-shank and treble hooks were allowed.

1992: Fish-check stations were initiated at each fishery to monitor harvest in response to paddlefish being petitioned for listing under the endangered species act in 1990 (Federal Register 1990). All harvested paddlefish were required to be checked at an official check station located near snagging areas. Clerks at check stations collected length, weight, and angler information for each checked fish. A mandatory harvest regulation requiring anglers to cease snagging for the day when two fish were caught was instituted to prevent anglers from monopolizing the most productive snagging areas.

1996: Anglers were required to tag their stringer to address concerns about anglers continuing to snag once they reached their daily creel limit. An extension was granted statewide that allowed the 1996 season to extend to 22 May. This season was extended to encompass an active migration that occurred on 15 May (the typical closing date) and maximize harvest.

1997: Two new paddlefish snag fisheries were added: Browning Oxbow on the Missouri River and Burlington Dam on the Neosho River. Browning Oxbow was opened because of its proximity to the Missouri River and in accordance with Kansas/Missouri border water regulations. Burlington Dam was opened because intensive stocking efforts occurred immediately upstream in John Redmond Reservoir in the early 1990s.

2001: An 864-mm EFL minimum-length limit (MLL) was implemented at Osawatomie Dam to mirror regulations in place on the Marais des Cygnes River in Missouri.

2002: A new fishery at Tunnel Mill Dam on the Walnut River was opened. This fishery was opened to target fish that migrated from Kaw Reservoir, Oklahoma, up the Arkansas River and into the Walnut River. Tunnel Mill Dam was a barrier on this route that was presumed to congregate fish during spawning season. An extension was granted statewide that allowed the 2002 season to extend to 30 May to encompass an active migration and maximize harvest.

2005: Barbless hooks were required for fisheries on the Neosho River (i.e., Chetopa Dam and Burlington Dam) to reduce tissue damage of captured fish. This regulation was established with foresight of potentially allowing catch and release in future years.

2006: Fisheries at Tunnel Mill Dam and Burlington Dam were closed. Tunnel Mill was closed because no fish were ever checked from this location. Burlington Dam was closed to reduce harvest. The decision to close Burlington Dam was based on the premise of no harvest in 2006 resulting in greater harvest in 2007. Three ma-

jor harvest regulation changes were implemented for the Chetopa Dam fishery; daily creel limit was reduced to one fish and an 864-mm EFL MLL and no-cull rule were instituted (Neely et al. 2015). The one fish daily creel limit was instituted to match the daily creel limit in Oklahoma. More restrictive length regulations were instituted because of numerous complaints pertaining to paddlefish carcasses littering highways around Chetopa Dam. These carcasses were primarily smaller fish (D. Knuth, Kansas Department of Wildlife, Parks, and Tourism, personal communication) and suggested that some anglers enjoyed the snagging experience, but did not wish to consume smaller harvested fish. The purpose of the length limit was to allow anglers to release smaller fish that they didn't wish to harvest. However, harvest of landed fish >864 mm EFL was still required.

2007: Snagging season was set to 15 March to 15 May and was no longer dictated by posted notice. Also, paddlefish were no longer required to be reported at check stations. This change was attributed to logistic issues with commercial businesses serving as check stations (e.g., store closures, health concerns about handling paddlefish carcasses at establishments that served food). However, harvest information was still necessary to monitor these important fisheries. Thus, a system was devised where a paddlefish permit and carcass tag were required to pursue and harvest fish. Paddlefish anglers were required to possess a permit that contained six carcass tags at a total cost of US$12.50. Immediately upon harvest, anglers were required to attach a carcass tag to the harvested fish, which bounded season harvest at six fish per angler. Anglers who purchased a permit were mailed a survey at the conclusion of snagging season to estimate participation, catch, and harvest. Survey return was mandatory under a state regulation. Two statewide harvest regulations were implemented: two fish daily creel limit and an 864-mm EFL MLL matching the one instituted at Chetopa Dam a year earlier. One exception to these was Browning Oxbow which was managed with a 610-mm EFL MLL to adhere to Missouri River boundary-water regulations. Regulations were standardized statewide to ease concerns about confusion among anglers and to allow harvest of two paddlefish per day. Also in 2007, Burlington Dam was reopened as a snag fishery. This reopening occurred after closure in 2006 with hopes that no harvest for one year would increase harvest the following year.

2008–2009: The permitting program was refined in 2008 by inclusion of a half-price youth permit for anglers under age 16. The statewide 864-mm MLL was rescinded in 2008, and the 610-mm MLL in Missouri River boundary waters remained. Barb restrictions were lifted because catch and release was no longer allowed except for in Missouri River boundary waters.

2010–2013: Fisheries at Iola Dam on the Neosho River and the Marais des Cygnes River within Marais des Cygnes Wildlife Area were opened in 2010. Barbless hooks once again became required in the Chetopa Dam fishery because catch and release was allowed on all Neosho River fisheries if the caught fish was not attached to a stringer (i.e., no culling). Fisheries on the Marais des Cygnes River were once again managed with an 864-mm EFL MLL to mirror harvest regulations set by Missouri Department of Conservation.

Future Management Of Paddlefish In Kansas

As with any fisheries management scenario, there are numerous scales to consider for paddlefish management in Kansas. Analysis of large-scale paddlefish movements prompted Pracheil et al. (2012) to suggest a "swimway" approach for management of paddlefish. They proposed four swimway management units: Missouri-Middle Mississippi-Ohio, Upper Mississippi, Lower Mississippi, and Gulf. Using these management units in Kansas, the Kansas, Marais des Cygnes, and Missouri river basins are in the Missouri-Middle Mississippi-Ohio management unit, and the Arkansas, Neosho, and Verdigris river basins are in the Lower Mississippi management unit. This approach would require KDWPT to manage two distinct paddlefish populations in Kansas: one that inhabits the Kansas, Marais des Cygnes, and Missouri River basins and another that inhabits the Arkansas, Neosho, and Verdigris River basins. One method for management using this approach would be to advocate for interjurisdictional management with adjacent fish management agencies (i.e., Missouri Department of Conservation and Oklahoma Department of Wildlife Conservation). Interjurisdictional management has been implemented successfully for several migratory fish species including striped bass (*Morone saxatilis)* (Richards and Rago 1999), gulf menhaden (*Brevoortia patronus)* (Vaughan et al. 2007) and paddlefish (Mestl and Sorensen 1999, Scholten 1999). An interjurisdictional approach would result in an individual paddlefish being subject to the same harvest regulations throughout the year. This could result in more consistent management and facilitate conservation of these fisheries at a larger geographical scale.

Another option for management would be to consider the spawning population (i.e., paddlefish found in Kansas) separately from the non-spawning population (i.e., paddlefish that don't migrate into Kansas). This could result in KDWPT establishing more stringent regulations than neighboring states in an effort to protect spawning fish and promote natural reproduction. Increased protection for spawning fish has occurred with many gregarious spawning fish populations to reduce reproductive stressors (Isermann and Paukert 2010). An example of this type of management would be establishment of a seasonal MLL based on length at maturity. This type of regulation would limit harvest of fish that mi-

grated into Kansas to those that have already reached sexual maturity and had an opportunity to spawn. An evaluation of over 10,000 paddlefish collected from the Grand Lake population from 2004 to 2010 suggested males and females reached sexual maturity at 6 to 7 and 8 to 9 yrs, respectively (Scarnecchia et al. 2011), similar to earlier findings that paddlefish typically reached maturity by age 7 or age 8 (Adams 1942, Houser and Bross 1959). Similarly, data collected by Missouri Department of Conservation from the Truman Reservoir paddlefish population indicated males reached the lengths at maturity reported by Scarnecchia et al. (2011) by age 7 and females by age 9 (T. Yasger, Missouri Department of Conservation, personal communication). Thus, a 1016-mm EFL (estimated length at age 10 to 11; Scarnecchia et al. 2011) MLL might be used to afford female paddlefish protection during, at minimum, their first potential spawning event. A survey of Montana paddlefish anglers suggested primary motivators for paddlefish angling "were to be outdoors, for the experience and thrill of hooking a paddlefish, to be with friends, to get away from the regular routine, and for the challenge or the sport" (Scarnecchia et al. 1996). As such, obtaining meat is typically not a motivator for paddlefish anglers (Scarnecchia et al. 1996, Bettoli 2011, Morgan et al. 2012, Scarnecchia et al. 2013). Forty-nine percent of harvested paddlefish from Chetopa Dam from 1992 to 2006 were 1016-mm EFL or greater (Neely et al. 2015). If Kansas anglers exhibited similar motivations to paddlefish anglers elsewhere, a 1016-mm EFL MLL might be suitable. An additional consideration for protection of spawning fish is relative harvest in Kansas versus connected downstream fisheries. For example, estimated annual average harvest in the Oklahoma portion of the Neosho River/Grand Lake system from 2008 to 2012 was 8693 fish (Schooley et al. 2014) while estimated annual average harvest in the Kansas portion during the same time period was 444 fish (Table 3). Because only 5% of harvest from this system occurred in Kansas, more protective regulations in the state might not result in increased reproduction. Contribution of fish harvested in Kansas to total harvest in respective systems (i.e., Grand Lake/Neosho River, Harry S. Truman Reservoir/Marais des Cygnes, Missouri River) must be considered to facilitate effective interjurisdictional management.

Future considerations for paddlefish management in Kansas should begin by addressing several questions. The first issue KDWPT faces is whether to alter existing regulations. If so, a reasonable geographic scale for harvest regulations must be determined. Geographic scale options include management statewide under one regulation, treating management units as presented by Pracheil et al. (2012) separately, managing by river basin within the state, or managing each fishery separately. Finally, it must be determined what type of harvest regulation should be implemented for each unit, be it one statewide unit, individual fishery units, or any intermediate scale. Regardless of how KDWPT pursues future management of paddlefish, it should be supported by sound science, be understandable to anglers, and have some level of acceptance from anglers (Hunt and Grado 2010, Isermann and Paukert 2010).

Conclusions

Paddlefish contribute to unique fisheries throughout their range including several locations in Kansas. These fisheries provide opportunities for anglers to catch large fish, explore alternative angling methods, and observe a type of fish many have never seen. As such, development and retention of paddlefish fisheries remains a prevalent issue for conservation agencies (Bettoli et al. 2009). Despite historical decreases in paddlefish abundance attributed to habitat alteration and overfishing (Jelks et al. 2008), 18 of 26 states indicated that their paddlefish populations were stable or increasing in a 2006 survey (Bettoli et al. 2009). The historical sensitivity of paddlefish populations, coupled with demonstrated ability to conserve and enhance populations, highlights the importance of informed management to protect and restore populations both in Kansas and throughout the species' distribution. We encourage agencies that manage paddlefish to review strategies implemented by other agencies when prescribing management plans. This approach will allow agencies to build on previous failures and successes and will ultimately result in improved management of paddlefish throughout their distribution.

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Literature Cited

Adams, L. A. 1942. Age determination and rate of growth in *Polyodon spathula* by means of growth rings of the otoliths and dentary bone. American Midland Naturalist 28:617–630.

Bettoli, P. W. 2011. The recreational snag fishery for paddlefish in Cherokee Lake, Tennessee. Proceedings of the Annual Conference of the Southeastern Association of Fisheries and Wildlife Agencies 65:125–130.

_____, J. A. Kerns, and G. D. Scholten. 2009. Status of paddlefish in the United States. Pages 23–38 *in* C. P. Paukert and G. D. Scholten, editors. Paddlefish management, propagation, and conservation in the 21st century:

building from 20 years of research and management. American Fisheries Society, Symposium 66, Bethesda, Maryland.

Bonislawsky, P. 1977. Paddlefish investigation. Kansas Forestry, Fish, and Game Commission, Federal Aid in Sportfish Restoration Project F-15-R-30 Final Report, Topeka, Kansas.

Braaten, P. J., D. B. Fuller, and R. D. Lott. 2009. Spawning migrations and reproductive dynamics of paddlefish in the Upper Missouri River Basin, Montana and North Dakota. Pages 103–122 *in* C. P. Paukert and G. D. Scholten, editors. Paddlefish management, propagation, and conservation in the 21st century: building from 20 years of research and management. American Fisheries Society, Symposium 66, Bethesda, Maryland.

Carlson, D. M. and P. S. Bonislawsky. 1981. The paddlefish (*Polyodon spathula*) fisheries of the Midwestern United States. Fisheries 6:17–22, 26–27.

Dillard, J. G., L. K. Graham, and T. R. Russell, editors. 1986. The paddlefish: status, management, and propagation. American Fisheries Society, North Central Division, Special Publication No. 7, Bethesda, Maryland.

Federal Register. 1990. Endangered and threatened wildlife and plants; finding on petition to list the paddlefish. Federal Register 55:17473–17475.

Hansen, K. A. and C. P. Paukert. 2009. Current management of paddlefish sport fisheries. Pages 277–290 *in* C. P. Paukert and G. D. Scholten, editors. Paddlefish management, propagation, and conservation in the 21st century: building from 20 years of research and management. American Fisheries Society, Symposium 66, Bethesda, Maryland.

Houser, A. and M. G. Bross. 1959. Observations on the growth and reproduction of the paddlefish. Transactions of the American Fisheries Society 88:50–52.

Hunt, K. M. and S. C. Grado. 2010. Use of social and economic information in fisheries assessments. Pages 425–447 *in* W. A. Hubert and M. C. Quist, editors. Inland fisheries management in North America, third edition. American Fisheries Society, Bethesda, Maryland.

Isermann, D. A. and C. P. Paukert. 2010. Regulating harvest. Pages 185–212 *in* W. A. Hubert and M. C. Quist, editors. Inland fisheries management in North America, third edition. American Fisheries Society, Bethesda, Maryland.

Jennings, C. A. and S. J. Zigler. 2009. Biology and life history of paddlefish in North America: an update. Pages 1–22 *in* C. P. Paukert and G. D. Scholten, editors. Paddlefish management, propagation, and conservation in the 21st century: building from 20 years of research and management. American Fisheries Society, Symposium 66, Bethesda, Maryland.

Jelks, H. L., S. J. Walsh, N. M. Burkhead, S. Contreras-Balderas, E. Díaz-Pardo, D. A. Hendrickson, J. Lyons, N. E. Mandrak, F. McCormick, J. S. Nelson, S. P. Platania, B. A. Porter, C. B. Renaud, J. J. Schmitter-Soto, E. B. Taylor, M. L. and Warren, Jr. 2008. Conservation status of imperiled North American freshwater and diadromous fishes. Fisheries 33:372–407.

Kansas Department of Wildlife, Parks and Tourism. 2000 (KDWPT). Fisheries progress reports 1999, management plan 2000: Region 5. Kansas Department of Wildlife, Parks and Tourism, Pratt, Kansas.

Mestl, G. and J. Sorensen. 2009. Joint management of an interjurisdictional paddlefish snag fishery in the Missouri River below Gavins Point Dam, South Dakota and Nebraska. Pages 235–259 *in* C. P. Paukert and G. D. Scholten, editors. Paddlefish management, propagation, and conservation in the 21st century: building from 20 years of research and management. American Fisheries Society, Symposium 66, Bethesda, Maryland.

Morgan, M. R. Hayden, and R. Pierce II. 2012. Social and cultural aspects of paddlefish anglers at Lake of the Ozarks, Missouri. Proceedings of the Annual Conference of the Southeastern Association of Fisheries and Wildlife Agencies 66:42–48.

National Freshwater Fishing Hall of Fame. 2009. Official world and USA state fresh water angling records: 2008 edition. National Freshwater Fishing Hall of Fame, Hayward, Wisconsin.

Neely, B. C., S. T. Lynott, and B. M. Pracheil. 2014. Influence of river discharge on recreational harvest of paddlefish. Fisheries Management and Ecology 21:259–263.

_____, S. F. Steffen, S. T. Lynott, and J. D. Koch. 2015. Characteristics of the paddlefish fishery at Chetopa Dam, Kansas, 1992–2006. Journal of the Southeastern Association of Fish and Wildlife Agencies 2:15–19.

Paukert, C. P. and W. L. Fisher. 2001. Spring movements of paddlefish in a prairie reservoir system. Journal of Freshwater Ecology 16:113–124.

Pegg, M. A., J. H. Chick, and B. M. Pracheil. 2009. Potential effects of invasive species on paddlefish. Pages 185–201 *in* C. P. Paukert and G. D. Scholten, editors. Paddlefish management, propagation, and conservation in the 21st century: building from 20 years of research and management. American Fisheries Society, Symposium 66, Bethesda, Maryland.

Pracheil, B. M., M. A. Pegg, L. A. Powell, and G. E. Mestl. 2012. Swimways: protecting paddlefish through movement-centered management. Fisheries 37:449–457.

Quinn, J. W. 2009. Harvest of paddlefish in North America. Pages 203–221 *in* C. P. Paukert and G. D. Scholten, editors. Paddlefish management, propagation, and conservation in the 21st century: building from 20 years of research and management. American Fisheries Society, Symposium 66, Bethesda, Maryland.

Reed, B. C., W. W. Kelso, and D. A. Rutherford. 1992. Growth, fecundity, and mortality of paddlefish in Louisiana. Transactions of the American Fisheries Society 121:374–384.

Richards, R. A. and P. J. Rago. 1999. A case history of effective fishery management: Chesapeake Bay striped bass. North American Journal of Fisheries Management 19:356–375.

Ruelle, R. and P. L. Hudson. 1977. Paddlefish (*Polyodon spathula*): growth and food of young of the year and a suggested technique for measuring length. North American Journal of Fisheries Management 106:609–613.

Russell, T. R. 1986. Biology and life history of the paddlefish—a review. Pages 2–20 *in* J. G. Dillard, L. K. Graham, and T. R. Russell, editors. The paddlefish: status, management, and propagation. American Fisheries Society, North Central Division, Special Publication No. 7, Bethesda, Maryland.

Scarnecchia, D. L., P. A. Stewart, and Y. Lim. 1996. Profile of recreational paddlefish snaggers on the Lower Yellowstone River, Montana. North American Journal of Fisheries Management 16:872–879.

_____, B. D. Gordon, J. D. Schooley, L. F. Ryckman, B. J. Schmitz, S. E. Miller, and Y. Lim. 2011. Southern and northern Great Plains (United States) paddlefish stocks within frameworks of Acipenseriform life history and the metabolic theory of ecology. Reviews in Fisheries Science 19:279–298.

_____, _____, _____, and A. A. Nealis. 2013. A Comprehensive Plan for the Management of Paddlefish in Oklahoma. Oklahoma Department of Wildlife Conservation, Oklahoma City.

Scholten, G. D. 2009. Management of commercial paddlefish fisheries in the United States. Pages 291–306 *in* C. P. Paukert and G. D. Scholten, editors. Paddlefish management, propagation, and conservation in the 21st century: building from 20 years of research and management. American Fisheries Society, Symposium 66, Bethesda, Maryland.

Schooley, J. D., D. L. Scarnecchia, and A. Crews. 2014. Harvest management regulation options for Oklahoma's Grand Lake stock of paddlefish. Journal of the Southeastern Association of Fish and Wildlife Agencies 1:89–97.

Vaughan, D. S., K. W. Shertzer, and J. W. Smith. 2007. Gulf menhaden (*Brevoortia patronus*) in the U.S. Gulf of Mexico: fishery characteristics and biological reference points for management. Fisheries Research 83:263–275.