Paddlefish Recreational Fisheries: State Management of a Migratory Fish with a Complex Identity

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species, including snagging (the most common method) and archery since adults are primarily filter feeders and thus not susceptible to more traditional angling methods used for sport or game fishes. The prevalence of recreational snagging throughout the Mississippi and Missouri basins increased greatly over the period 1950–1975, associated with impoundment of upper Mississippi and Missouri mainstem and tributary reaches. More Paddlefish became accessible to snaggers below dams as spawning and feeding migrations were impeded and fish aggregated in tailwaters. The variability of legal and administrative classifications of Paddlefish and differing perceptions of the species by harvesters, managers, and the public have resulted in a fish with a complex identity. While Paddlefish in the past have been petitioned for federal listing under the Endangered Species Act, to date they have not been listed. Recreational fisheries management strategies, goals, and objectives have varied widely, perhaps understandably, since the species is managed at the state level. To assess the current situation, we administered an electronic survey to state

relatively few ýsh are present, recruitment is poor, and the stock is depleted due to habitat loss or overýshing. Recreational angling and other harvest may be severely limited or prohibited on some stocks (Runstrom et al. 2001). Some of these stocks may also be artiýcially enhanced by hatchery-reared ýsh (Graham 1986; Argent and Kimmel 2006; Grady and Elkington 2009; Hupfeld et al. 2018). With the Paddleýshûs diverse, broadly deýned identity, and variable legal and administrative status as a commercial, recreational, and protected species, management goals, objectives, and actions for the species have been equally diverse among or across jurisdictions.

Origin of Recreational Fisheries

Although the exact origins of snagging for Paddleýsh are not precisely documented, snagging probably occurred in many states before regulations were written that speciýcally managed it. Early photos (1910) at the Intake Diversion Dam on the lower Yellowstone River, Montana, suggest that some opportunistic snagging of ýsh below the dam may have occurred early in the last century. Purkett (1963) reported catch statistics from snagging eﬀorts on the Osage River in Missouri from the late 1950s and early 1960s. The prevalence of recreational snagging throughout the Mississippi and Missouri basins increased greatly over the period 1950ï1975. One factor associated with development of recreational Paddleýsh snagging over this period was the high rate of construction of dams on Upper Mississippi and Missouri mainstem reaches and major tributaries nationwide in the previous decades (Dieffenbach 1948; Hart 1957). More Paddleýsh became accessible to snaggers below dams as spawning and feeding migrations were impeded and ýsh staged in aggregations in tailwaters for long periods (e.g., Missouri River mainstem dams: Park 1962; Friberg 1972; Mestl and Sorensen 2009; upper Mississippi River: Helms 1976; Anderson 1977). Old, long-lived adult ýsh often grew to large sizes of interest to trophy anglers, even if spawning success in impounded sections was poor (e.g., Big Bend Dam tailwaters, South Dakota; Friberg 1972). The eﬀects of dams on Paddleýsh spawning were mostly negative; most stocks decreased and could not sustain initial catch rates (Mestl and Sorensen 2009). Some stocks, however, increased with improved rearing habitat of reservoirs (as a surrogate for eliminated backwaters and side channels of the natural river) provided that spawning habitat above the impoundment was maintained (e.g., Yellowstone River, Montana; Robinson 1966). Stock responses to habitat changes have been mostly negative but have varied widely throughout the species range (Bettoli et al. 2009; Schwemm et al. 2019, Chapter 2 this volume).

As reservoir ýsheries increased in area over the period 1950ï1975 at the expense of often more diﬃcult free-þowing river ýshing, there was also increased societal emphasis on leisure activities associated with water (McFadden 1969). Anglers bought more and larger boats and more ýshing equipment. Reservoir and tailwater ýsheries proliferated (Jenkins 1970). Increased funding of recreational ýshing research, management, information, and education through the Federal Aid to Sportýsh Restoration Act (American Fisheries Society 2000) led to state agencies developing and managing more recreational ýsheries, including scattered local on ^

ýsh by snagging below Gavins Point Dam in the late 1950s (Mestl and Sorensen 2009). Montanaôs snag ýsheries below the Intake Diversion Dam expanded greatly in the early 1960s after a Paddleýsh population boom in the newly constructed Lake Sakakawea, North Dakota resulted in a strong run of mature ýsh of the Yellowstone-Sakakawea stock up the lower Yellowstone River (Robinson 1966; Rehwinkel 1978; Scarnecchia et al. 1996). North Dakota, harvesting the same stock, did not open a snag ýshery until 1976 (Scarnecchia et al. 2008). Kansas sanctioned its ýrst legal snag ýshery below Chetopa Dam on the Neosho River in 1972 (Neely et al. 2015a, 2015b). Illinois legalized snagging in 1973 and Iowa followed in 1974; Paddleýsh were commonly caught below locks and dams built in the previous decades (Ackerman 1975; Helms 1976; Anderson 1977; Beck 1978). Recreational Paddleýsh snagging in Oklahoma has been pursued for decades and has been actively managed since 1979 (Gordon 2009; Scarnecchia et al. 2013; Schooley et al. 2014). Missouriôs recreational Paddleýsh ýsheries have a long history before and after dam construction on the Osage River and have expanded to other reservoirs in the state (Graham 1986; Schwinghamer et al. 2019, Chapter 10 this volume). Other states have recreational ýsheries, including some with coexisting commercial harvest (Quinn 2009).

Other recreational methods besides snagging developed on an ad hoc basis as a result of particular conditions resulting in ýsh availability. For example, archery ýsheries in the Dredge Cuts below Fort Peck Dam, Montana, and below Gavins Point Dam became more

Results

Legal Classification and Social Perceptions of Paddlefish

As of 2017 Paddleýsh continue to be legally classiýed and socio-economically identiýed broadly in various states as commercial, recreational, or protected, or combinations thereof. Paddleýsh are protected in 9 of 24 states (38%) responding to the survey, with the remaining states split evenly between states that only allow recreational ýshing (7; 29%) and states that allow commercial ýshing with or without recreational ýshing (8; 33%, Table 1). Geographic trends in legal classiýcation of Paddleýsh emerged, with commercial states located in the core of the species range and protected status accorded in the northern, eastern, and southern periphery (Figure 1). States with recreational ýsheries were primarily located in the western, as opposed to eastern, portion of the species range. In 8 of the 9 states where Paddleýsh are protected, they are listed as extirpated, endangered, threatened, or of special concern. Paddleýsh are also listed as a species of special concern in more than one third of the states where they are concurrently ýshed and harvested.

The complexity of socioeconomic identiý-cation of the species was manifested by a wide-ranging level of interest in the species among

2). The ýrst group consists of those states from the core of the species range, most with commercial ýshing (Alabama, Arkansas, Indiana, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee). The second group includes those states that do not have commercial ýshing and actively manage Paddleýsh as a sport or trophy species and includes the western states (Iowa, Kansas, Montana, Nebraska, North Dakota, Oklahoma, and South Dakota) and Pennsylvania. The ýnal group are all of the states that protect Paddleýsh, with the exception Pennsylvania, and are located around the periphery of the species range in the north (Minnesota and Wisconsin), northeast (New York, North Carolina, Virginia, and West Virginia) and the southwest (Texas).

Paddlefish Recreational Fishery Management Strategies

As of 2017, the wide range of recreational ýshery management strategies continues to reþect the complex identity of Paddleýsh and the variable level of interest in them. Paddleýsh recreational ýshing is allowed in 14 states (Figure 1), but two states (Louisiana and Mississippi) allow only harvest of incidentally caught ýsh (Table 3). Snagging for Paddleýsh is allowed in the remaining 12 states; archery is legal in six states (Kentucky, Montana, Nebraska, Oklahoma, South Dakota, and Tennessee), while other methods (including, spears, spear guns, and various forms of throw, trot, bank, and set lines) are

the harvest of one Paddleýsh per permit (and only one or two permits per snagger). Daily bag limits and seasons with hook and gear restrictions, but no length limits, are being used in Arkansas, Kentucky, and Tennessee, which also allow commercial ýshing. Daily bag limits and seasons with a minimum length limit or an annual bag limit are being used in Kansas, Missouri, and Oklahoma. Catch-and-release ýshing is allowed in 12 states, with three states requiring catch and release on certain days (Montana, North Dakota, and Oklahoma). High grading or culling (e.g., holding and later releasing a ýsh in favor of a more desirable one) of Paddleýsh is now prohibited by all states. About half (54%) of the states that allow recreational ýsheries have some sort of Master Angler Program to reward anglers for some type of angling success (e.g., catching a ýsh larger than a certain size).

Eleven of the 14 states that allow recreational harvest have established seasons on some or all waters within their state that contain Paddleýsh (Table 3). Of the three that allow harvest year-round, two allow only incidental catch and the other allows an angler to harvest only two ýsh per year (harvested ýsh must be electronically reported within 24 h). In states with sport ýshing seasons, most are one to three months in duration and 75% occur during the spring. Most states (77%) have different Paddleýsh ýshing regulations for different water bodies. Harvest quotas are managed using special permits and seasons in Iowa, Montana, Nebraska, North Dakota, and South Dakota.

More than half (54%) of states have a management plan for Paddleýsh; 60% of the states have a Paddleýsh monitoring program (Table 4). Fifteen states reported natural reproduction of Paddleýsh

Table 3. Continued.

Is catch and release allowed (not high grading)?	No	Yes	Certain days
	2	10	2

Is there a Paddleýsh sport ýshing season?	No	Yes
	3	11

Are there diverent regulations for diverent water bodies?	No	Yes
	3	10

Do you have a Master Angler program for Paddleýsh?	No	Yes
	6	7

Table 4. Summary of Paddlefish life history and state management across the species range states (survey questions 24, 25, 29, 31, 32, and 33, Appendix A).

Does your state have a Paddleýsh management plan?		Does your state have a Paddleýsh monitoring plan?	
		No	Yes
No	11	8	3
Yes	13	1	12

Has natural reproduction been documented in your state?		Are Paddleýsh considered self-sustaining in your state?	
No	6	No	6
Yes	15	Yes	18

Do you feel that current regulations and management strategies are adequately managing Paddleýsh in your state?		Do you feel that Paddleýsh are being managed on a biologically relevant scale?	
		No	Yes
No	5	4	1
Yes	17	2	15

Figure 3. State management strategies for Paddlefish as of 2017 with results of cluster analysis.

their Paddleýsh management programs in part through sales of caviar from roe donation programs.

Since 2006, seven states have changed their Paddleýsh sport ýshing regulations (Table 6). Arkansas opened new snagging seasons on the Black, St. Francis, and White rivers below Beaver Tail Dam. Illinois made changes to standardize border water regulations with neighboring Iowa and Missouri. Iowa changed open season dates and adopted an 84 cm maximum length limit on the upper Mississippi River in addition to opening a new snagging season on the Missouri River with an 89ï114 cm protected slot (also requiring the purchase of a Paddleýsh permit).

Nebraska rescheduled their Paddleýsh ar-

for Paddleýsh. For example, Alabama and Indiana, which group with states where Paddleýsh are perceived less as a sport species than a commercial species, have both eliminated sport ýshing for Paddleýsh and now allow only commercial ýshing. Virginia and West Virginia, which at one time allowed recreational ýshing but where Paddleýsh are not strongly viewed as a sport ýsh, have both given Paddleýsh protected status. Louisiana is unique in that although it groups with states that principally view Paddleýsh as a commercial ýsh; they have removed Paddleýsh from the commercial list and made it a sport ýsh but allow only incidental recreational harvest. These changes reþect the existing diversity of agency perceptions of an unconventional ýsh with an unconventional life history that is not harvested by conventional angling methods.

As of 2018, Paddleýsh remain a state-managed ýsh without a single, uniýed framework plan or philosophy. There exist complex and diverging identiýcation and socio-economic characterizations of the species, and a disparate social status accorded the species by anglers, commercial harvesters, and the public. Its complex identity is reþected in a wide range of management strategies, goals, and objectives applied to it among states across the species range and even within individual rivers (Hansen and Paukert 2009; Scholten 2009). The regional

ing the ýsheries, by oxering free, voluntary cleaning of the Paddleýsh harvested (both sexes) in controlled recreational ýsheries for donation of any roe from the harvested ýsh. Caviar produced from the programs is sold with a portion of the net proceeds (Montana and North Dakota) or all net proceeds (Oklahoma) returned to the public through state management agencies for public conservation exorts (Scarnecchia et al. 2008; 2013). This approach has led to the development of centralized ýsh cleaning stations, resulting in more complete, less expensive data collection for stock monitoring and a stable funding source for managing the ýsheries. However, this stock assessment strategy is not necessarily appropriate or applicable for all states or all Paddleýsh stocks.

The challenges of managing recreational Paddleýsh snagging ýsheries are further complicated by the speciesô highly variable life history (Scarnecchia et al. 2019a, Chapter 1 this volume). Life history characteristics vary by stock across a latitudinal gradient (Scarnecchia et al. 2011). Average lifespan, age at maturity, and maximum size are typically reduced among Southern stocks while irregular patterns of recruitment are observed throughout the range (Scarnecchia et al. 2019a, Chapter 1 this volume). Even with trophy ýsheries, successful management must proceed so that older aged spawning ýsh remain present (Scarnecchia et al. 2019b, Chapter 5 this volume). Historically, little was known about Paddleýsh spawning locations and movement (Russell 1986) and population demographics. However, since the second AFS Paddleýsh Symposium in 2006 (Paukert and Scholten 2009), there have been signiýcant studies conducted to address these needs, including Paddleýsh stock assessments (e.g., Sharov et al. 2013; Scarnecchia et al. 2014), investigations into movement (Budnik 2010; Tripp et al. 2019, Chapter 3 this volume; Hoover et al. 2019, Chapter 4 this volume), investigations into recruitment (Scarnecchia et al. 2009; Scarnecchia et al. 2019b, Chapter 5 this volume), and surveys exploring angler success and angler demographics (Hayden 2009; Jager and Schooley 2016). Recreational ýsheries managers now have more information to apply to their management

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Appendix A.

Appendix A. Continued.

Question	Answer Options
20 - If so, what are the qualifying length/weight requirements?	*
21 - What is the ýne/liquidated or civil damages fee for an illegally harvested Paddleýsh in your state?	*
22 - How popular would you consider Paddleýsh sport ýshing in your state?	No interest, Little interest, Moderate interest, High interest
23 - How do you think Paddleýsh are perceived by these diverent groups (Anglers, Commercial Fishers, Public, State Fish and Game Agency Administrators, State Fisheries Biologists) in your state?	Unaware, Rough Fish, Commercial Fish, Just Another Fish, Game Fish, Big Game/Trophy Fish, Nuisance
24 - Has Paddleýsh reproduction been documented in your state?	Yes/No
25 - Are Paddleýsh considered self-sustaining in your state?	Yes/No
26 - Does your state stock Paddleýsh?	Yes/No
27 - If yes, does your state have a Paddleýsh conservation genetics stocking plan?	Yes/No
28 - If yes, does your state monitor the success or evects of the stocking program?	Yes/No
29 - Does your state currently have a Paddleýsh management plan?	Yes/No
30 - What is/are the goal(s) of your state Paddleýsh management plan? (e.g., maximize harvest, provide a trophy ýshery, maintain a self-sustaining population, etc.)	*
31 - Does your state have a Paddleýsh monitoring program?	Yes/No
32 - Because Paddleýsh are capable of moving long distances and sometimes cross political boundaries, do you feel Paddleýsh in your state are managed on a biologically relevant scale?	Yes/No
33 - Do you feel that current regulations/management strategies are adequately managing Paddleýsh in your state?	Yes/No
34 - If you could recommend changes to existing regulations or management strategies to manage Paddleýsh, what would they be?	*

Question	Answer Options
35 - What information for managing Paddleýsh in your state do you feel is missing?	*
36 - What do you feel are the greatest threats to Paddleýsh populations in your state?	Overharvest, Illegal harvest,

States	Legal status	Stocked, monitored	Perception (anglers)	Reproduction documented	Population sustainable	Reg. Change	Status Change
AL	C	N	R	Y	Y		*
AR	SC	N	U	Y	Y	*	
IA	S	N	S	Y	Y	*	
IL	SC	-	-	-	-	*	-
IN	C	N	J	-	Y		*
KS	S	Y,N	J	Y	Y		
KY	SC	N	C	-	Y		
LA	S	N	R	Y	Y	*	
MN	P	N	U	-	Y		
MO	SC	Y,Y	S	Y	Y		
MS	SC	Y,Y	J	Y	Y		
MT	S	Y,Y	S	Y	Y		
NC	P	N	-	N	N		
ND	S	Y,Y	T	Y	Y		
NE	S	N	T	Y	Y	*	
NY	P	Y,Y	-	N	N		
OH	P	N	J	Y	Y		
OK	S	Y,Y	T	Y	Y	*	
PA	P	N	T	N	N		
SD	S	Y,Y	T	Y	Y		
TN	SC	N	S	Y	Y	*	