

Chapter 13

Proactive Harvest Management of Commercial Paddlefish Fisheries

STEVEN J. RIDER*

*Alabama Division of Wildlife and Freshwater Fisheries
River and Stream Fisheries Program
1507 Karley Drive, Opelika, Alabama 36801, USA*

DENNIS K. RIECKE

*Mississippi Department of Wildlife, Fisheries, and Parks, Fisheries Bureau
1505 Eastover Drive, Jackson, Mississippi 39211, USA*

DENNIS L. SCARNECCHIA

*Department of Fish and Wildlife Sciences, University of Idaho
875 Perimeter Drive, Moscow, Idaho 83844, USA*

Abstract.—Overexploitation of wild sturgeon (Acipenseridae) species worldwide for caviar has led to a shift in harvest to Paddlefish (Polyodontidae: *Polyodon spathula*), another Acipenseriform species and a state-managed fish still harvested commercially in eight states within the United States. State game and fish agencies with commercial fisheries are increasingly being pressured to open or extend commercial Paddlefish fisheries under their respective jurisdictions. In addition to the increased needs for a multi-state management framework among states, new demands on the Paddlefish within states and its high vulnerability to overharvest require more proactive, innovative, and restrictive management approaches than the frequently liberal regulations of the past. This paper describes proactive management strategies implemented by state fisheries agencies in Alabama and Mississippi for the long-term conservation of their Paddlefish fisheries. The management actions implemented fall into

*Corresponding author: steve.rider@dcnr.alabama.gov

three broad areas: (1) fishing areas, seasons, and participation; (2) fishing and harvest restrictions; and (3) licensing fees, reporting, and training. Actions taken under (1) included defining Paddlefish management areas, establishing specific harvest seasons and daily harvest times, and limiting the number of harvesters. Actions under (2) included enacting length limits and female-only harvest (Alabama), implementing harvest (carcass) tags to track fish and roe, and establishing gear restrictions to reduce unintended Paddlefish mortality. Actions under (3) included establishing rational permit requirements and fees, establishing specific harvest reporting requirements, and providing informational training to aid in angler compliance. Although there are many similarities in the approaches taken, each state has tailored its regulations to its political and biological situation. Alabama and Mississippi will be evaluating the effectiveness of their approaches and needed adaptations will be made to ensure long-term sustainability of the Paddlefish.

“Commercially the Paddlefish is much esteemed by fishermen. The flesh is good and, though it has not become known under its own name, it is shipped to the larger markets there to be dried, smoked, and masqueraded as “dried sturgeon” or as “boneless cat.” The roe is much more valuable than the meat; ersatz caviar is made from the eggs... The roe [is] so nearly like that of sturgeon that Paddlefish caviar ... is hardly to be designated as an imitation. In 1917, at Keokuk, Iowa, sturgeon roe was bringing \$2.95 per pound and the meat approximately 16 cents per pound. Paddlefish roe probably brought approximately the same price, and ... it is evident that an individual fish in proper condition represents a very valuable catch” (p. 95).

—R. E. Coker (1923)

“[In Lake Washington, Mississippi], the long seine is wound upon a huge reel securely built on the seining-barge, and ... the barge is pulled around in an oval course one mile long, the seine being unwound... as the boat proceeds... The barge is then anchored securely, and a crew of seven men wind the seine back upon the reel, while an eighth man stays in a skiff at the head post, piloting the seine between two poles, thus guarding the only possible outlet ... they wind for about four hours, until a mile of net thirty-three feet wide is again upon the reel and the fish are driven into a “round-up” box... set at the head posts... In this lake as many as one hundred and fifty barrels of [dressed] fish have been taken in a single haul, though now ten barrels is considered a fairly good catch” (p. 459).

—C. R. Stockard (1908)

Introduction

A fundamental need for sustaining fish stocks and their human use is effective management of the harvest. Gezelius (2008) asserted that “the essence of fisheries management is that scarcity of fishery resources calls for political decisions that limit fishermen’s access to these resources” (p. 7). In the harvest management of fishery resources in the inland United States, these decisions are often enacted by state agencies acting under the Public Trust Doctrine. Under this Doctrine (Sax 1970; Meyers 1989), the fish resources are held in trust by the government for the benefit of the entire public; state agency fishery biologists act as trust managers (Smith 2011; Decker et al. 2015) in administering actions to meet this commitment to sustainability for the benefit of present and future generations. Agency mission statements which specify the protection, conservation, and enhancement of natural resources arise from the Public Trust Doctrine.

How restrictive management actions must be in limiting access to fishery resources to ensure sustainability depends on (1) the life history and productivity of the fish species or stock (King and MacFarlane 2003) and (2) how intensively the resource is impacted by human activity such as habitat changes and intensity of harvest (Gross et al. 2002). In general, fish species and stocks that have shorter life cycles, reproduce and recruit reliably, occupy stable habitats, and are abundant and of low value relative to human demands can often be sustained with liberal harvest management regulations. Species and stocks that have more complex and protracted life histories (e.g., late age-at-maturity, long lifespan; Crouse 1999; Stevens 1999), with less reliable, more easily disrupted recruitment, occupy degraded habitats, attract greater human demand, and have high value need more scrupulous, restrictive harvest management. Although

these two contrasting situations may seem to logically require fundamentally different management approaches, in our view, far too little attention has been paid to formally implementing regulations consistent with this reality. In too many cases, the same forms of liberal harvest regulations (open and continual harvest access, anywhere, and anytime) potentially acceptable for more easily replenishable species have been applied to more vulnerable species. King and MacFarlane (2003) outlined several different life history strategies of fish species and discussed how these require different management approaches. Acipenseriform species, including sturgeons and paddlefishes share most characteristics of marine fish species that they classified as periodic strategists, including slow growth, long lifespans, and irregular recruitment. In practice, they also share some characteristics of species they classified as equilibrium strategists in that they typically have a low functional rate of increase and are vulnerable to incidental overharvest as bycatch. Both life history types require low or moderate harvest that also ensures maintenance of older aged spawners in the breeding portion of the stock. The few Acipenseriform fish stocks worldwide with successful management records meet these requirements (e.g., Lake Winnebago Lake Sturgeon *Acipenser fulvescens*, Bruch 1999; Montana-North Dakota Paddlefish *Polyodon spathula*, Scarnecchia et al. 2008; Snake River White Sturgeon *A. transmontanus*, Kozfkay and Dillon 2010). As fish of high value (sometimes thousands of dollars per fish), their management also requires much more accurate and precise harvest management and stock monitoring (e.g., Bruch 1999; Scarnecchia et al. 2008) than is typically necessary for lower-valued species.

The Paddlefish, an ancient species (Grande and Bemis 1991) native to central North America (Gengerke 1986), is a species

requiring more scrupulous harvest management and robust law enforcement than most freshwater fishes. Prior to the late 1800s, Paddlefish were abundant in many rivers and large streams of the Mississippi, Missouri, Ohio, and Mobile river basins; they also inhabited some Gulf Coast drainages and the Great Lakes (Carlson and Bonislawsky 1981; Graham 1997; Jennings and Zigler 2009). However, since the early 1900s, local extirpations have occurred (Gengerke 1986) along with dramatic declines in other Paddlefish stocks (Sparrowe 1986). These declines have been attributed to: (1) increased demands on rivers and large streams to provide commercial navigation, hydropower generation, and flood control resulting in destruction and alteration of riverine habitat; (2) overharvest and unregulated fishing; and (3) industrial and municipal pollution (Carlson and Bonislawsky 1981; Sparrowe 1986; Gerken and Paukert 2009). Widespread habitat degradation and spawning migration blockages have accentuated the need for even more cautious harvest management than would otherwise be necessary.

Paddlefish have been exploited for both flesh and roe (caviar) markets since the late 1800s (Stockard 1908; Hussakof 1910; Pasch and Alexander 1986). Coker (1923) noted that catch in 1894 in the Mississippi River and some tributaries amounted to more than 450,000 kg. In most localities, the fish was considered a rough fish unworthy of much focused management attention. By the early 1900s, however, some fisheries biologists recognized the distinctiveness and evolutionary significance of Paddlefish and were increasingly concerned about the viability of exploited stocks (Stockard 1907; Alexander 1914; Coker 1923). By the 1920s, the value of Paddlefish and its roe had risen (Coker 1923), but regulation changes remained modest. Paddlefish harvest numbers had decreased substantially by 1950 (Carlson and Bonislawsky 1981). Many of the traditional harvest regu-

lations used to manage Paddlefish were oriented towards managing meat or flesh fisheries during eras where Paddlefish were bycatch in catfish *Ictalurus* spp. and buffalo *Ictiobus* spp. fisheries (Bryan and White 1958). These traditional, often liberal regulations typically consisted of long or year-round harvest seasons, open access to commercial harvesters, and few gear restrictions.

Throughout much of the 20th century and into the early twenty-first century, worldwide demand for Paddlefish eggs has continued to increase as wild sturgeon caviar has become less available (Hochleithner and Gessner 2012; Harris and Shiraishi 2018; Fain 2019, Chapter 8 this volume). For instance, prior to 2004, the United States was the world's largest importer of Beluga Sturgeon *Huso huso* caviar, receiving over 80% of the caviar produced (BBC 2002). However, due to the listing of Beluga Sturgeon as threatened in 2004 (USFWS 2004), import of any products from this species was banned in the United States (USFWS 2005a, 2005b). Over the period 2010–2015, Paddlefish had become the largest wild source of caviar traded in import/export markets (Harris and Shiraishi 2018).

With this increase in demand for Paddlefish roe, the price paid to harvesters has steadily increased. Commercial Paddlefish harvesters received up to \$275 per kg (\$125 per lb) for processed roe (caviar) in the mid to late 2000s (E. Ganus, Tennessee Wildlife Resources Agency (TWRA), personal communication) and in 2016 harvesters received \$300 per kg (\$135 per lb) for processed roe in Alabama (S. Rider, unpublished data). Although wholesale caviar prices have fallen with the addition of farmed caviar on the market in recent years (e.g., from \$221/kg in 2015, \$173/kg in 2016, to \$112/kg in 2017 in Illinois; Maher 2017), individual wild fish remain very valuable. Some state fish and wildlife agencies have continued to receive political pressure to open Paddlefish commercial roe fisheries in their states.

The Paddlefish's vulnerability to exploitation (Boreman 1997) is high because: (1) they have a protracted life history characterized by late age-at-maturity and irregular recruitment (Scarnecchia et al. 2007; 2009; 2014; 2019, Chapter 1 this volume); and 2) they congregate in a variety of riverine habitats (Southall and Hubert 1984; Moen et al. 1992; Mettee et al. 2009), including slack water and backwater areas (Donabauer et al. 2009) and in deeper water during winter, all of which make them extremely susceptible to entanglement gears. Once Paddlefish populations are overexploited, population recovery has typically been slow or negligible (Carroll et al. 1963; Carlson and Bonislowsky 1981; Unkenholz 1986; Jennings and Zigler 2000; Runstrom et al. 2001; Bettoli 2005; Pikitch et al. 2005). For example, Scholten and Bettoli (2005) provided evidence that the Kentucky Lake Paddlefish population was commercially overfished and made recommendations to conserve and recover the population. However, this recovery has been negligible in succeeding years (Ganus, personal communication).

A total of 18 states have allowed the commercial harvest of Paddlefish at one time or another (Scholten 2009). By 2006, however, commercial harvest states numbered only seven: Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee (Scholten 2009), with Mississippi not allowing commercial harvest during the spawning season (November–April). In 2013, Alabama became the eighth state to allow the commercial harvest of Paddlefish (Rider et al. 2012). As of 2018, only these eight states permit the commercial harvest of Paddlefish. Quinn (2009) and Scholten (2009) provided range-wide commercial Paddlefish harvest details and summaries prior to 2006. Commercial Paddlefish fisheries region-wide have long been plagued by overexploitation and illegal harvest (Forbes 2012; Newstalk 1280 2012; Kansas City Star 2013; MDC 2013; USA

Today 2012; USFWS 2013; WRDB 2017). There has been a long recognized need for the Paddlefish, as a migratory fish crossing management jurisdictions, to be managed at a broad landscape scale with a framework management approach involving multiple states (e.g., Elser 1986; Scarnecchia et al. 2008; Pracheil et al. 2012; Hupfeld et al. 2016). The Mississippi Interstate Cooperative Resource Association (MICRA) formed in 1991 to manage such interjurisdictional fishes. An eight-state framework plan for cooperative Paddlefish harvest management of the state commercial fisheries, which occur in the core of the Paddlefish's range, has been planned, but has not yet been implemented.

Along with more multi-jurisdictional cooperation and coordination is the vital need, and the focus of this paper, for more proactive management of individual stocks and harvest management units. Historically, most states' management of Paddlefish has been reactive. Agency managers have been charged with managing fisheries of increasing value and interest occurring over large geographical areas and long periods with little to modest funding for fishery sampling, stock assessment, and enforcement of regulations. This historically reactive approach has hampered agencies in fulfilling their management responsibilities. More proactive harvest management approaches are needed to sustain Paddlefish fisheries for not only the long-term benefit of commercial harvesters, but for the long-term benefit of the entire public in this and future generations.

The purpose of this chapter is to provide a description of more proactive approaches to commercial Paddlefish management implemented in Alabama and Mississippi in the 12 years since the "Paddlefish Conservation and Management" symposium was held at the Midwest Fish and Wildlife Conference in Omaha, Nebraska, on December 5, 2006 (Paukert and Scholten 2009). Fisheries man-

agers tasked with Paddlefish management in Alabama and Mississippi confronted many similar problems, such as inadequately controlled and monitored legal harvest, as well as illegal harvest. Compliance with the regulations needed for sustainability has long been a concern in both states. Initially, Alabama and Mississippi managers developed their states' management approaches in part by applying lessons learned from managers' experiences in Arkansas (Quinn et al. 2009), Tennessee, and other states in their commercial Paddlefish fisheries. In this chapter, more recent, proactive approaches from Alabama and Mississippi will be compared for similarities and differences and their wider relevance discussed in the broader context of harvest management needs for Paddlefish stocks range-wide.

Stock Descriptions and Harvest Regulation History

Alabama

In Alabama, Paddlefish are found in the Tennessee River drainage, the Mobile River basin and tributaries (i.e., Tallapoosa, Alabama, Tombigbee, Black Warrior, and Tensaw rivers; Mettee et al. 1996), and Mobile Bay (Rider, unpublished data).

The history of commercial Paddlefish fishing in Alabama has been one of overharvest, limited regulations, and numerous compliance issues. Overfishing of Alabama Paddlefish stocks was evident in early records from the 1940s in the Tennessee River portion of the state; harvest of fish with snag lines from 1941 to 1946 declined 83%, from 323,865 kg to 53,750 kg (Pasch and Alexander 1986). In 1946, the Alabama legislature legalized the use of nets to encourage increased harvest and overexploitation of Paddlefish as demand for meat and roe surged (Pasch and Alexander 1986). Paddlefish harvest increased the following year (1947)

to 68,745 kg, but by 1954 had declined to 53,750 kg. Targeted agency sampling efforts in the Tennessee River from 2015 to 2017 indicated that those stocks had not yet recovered sufficiently to allow harvest at a sustainable level (Rider, unpublished data).

In the early 1980s, increased commercial fishing pressure occurred on other Paddlefish stocks in Alabama as commercial harvesters directed their efforts to the Mobile Basin after depleting the Tennessee River Paddlefish stocks of Kentucky and Tennessee (F. Harders, Alabama Division of Wildlife and Freshwater Fisheries (ADWFF), personal communication). This increased fishing effort resulted in a severe decline in Paddlefish abundance and sizes (N. Nichols, ADWFF, personal communication). Alabama had not actively managed Paddlefish prior to 1988. However, because of widespread overharvest, the ADWFF placed a moratorium on the capture, possession, and harvest of Paddlefish in Alabama waters beginning November 1988 (ADWFF regulation 220-2-.94). Even after the moratorium went into effect, and into the mid-1990s, it was not uncommon to see dead Paddlefish floating down the Alabama River with their bellies split open, as poachers sought roe (A. Roach, ADWFF, personal communication).

In the early 2000s, ADWFF received numerous inquiries about the possibility of opening a commercial Paddlefish fishery. Therefore, ADWFF set forth developing a plan to ensure the long-term viability and conservation of Paddlefish populations subject to commercial fishing pressure with the ever-increasing demand for wild Paddlefish roe. Based on a telemetry study (Mettee et al. 2006, 2009) and additional Paddlefish sampling (Rider 2006), ADWFF found that Paddlefish abundance had increased since the harvest moratorium of 1988. However, the ADWFF did not have adequate data to suggest the stock could be commercially exploited, so they initiated a study to: (1) ob-

tain baseline data and demographic information for the Paddlefish stock in the Alabama River; (2) assess if sustainable harvest was possible; and, if so, (3) develop harvest management recommendations.

By 2012, results from the study indicated the Alabama River Paddlefish stock had recovered into a robust population with many older ages and prime spawners (*sensu* Scarnecchia et al. 2007), a result of being unexploited for nearly 25 years (Rider et al. 2012). The ADWFF concluded that a fishery was justifiable, but that a more proactive, conservative, and targeted approach than the historically liberal fisheries was needed. Accordingly, the ADWFF proposed a “provisional” or temporary fishery, informing all would-be harvesters that this approach would allow the ADWFF to assess the initial fishery and determine if it should be continued temporarily, continued more permanently, or terminated. This new approach had several goals. One goal was to minimize or eliminate nonharvest mortality (Bettoli and Scholten 2006), as well as mortality of nontargeted species, including those listed as state- or federally threatened or endangered. Other goals were to minimize user conflicts, protect a higher percentage of spawning females than had historically been protected (Scarnecchia et al. 1989), avoid harvest of immature and reproductively-inactive females (Scarnecchia et al. 2019, Chapter 1 this volume), and obtain useful and accurate data for management from the fishery (Silvert 1978).

Mississippi

In Mississippi, Paddlefish occur in the Tombigbee, Pearl, and Pascagoula River drainages of the Gulf of Mexico Basin, and in the lower Mississippi South, lower Mississippi North, Big Black, and Yazoo River drainages of the Mississippi River Basin (Ross 2001). During the late 1890s and early 1900s, important commercial

Paddlefish fisheries existed in the large oxbow lakes such as Lake Washington and Moon Lake, which are adjacent to the Mississippi River (Stockard 1907, 1908; Husakof 1910). Mississippi led the nation in Paddlefish harvest during this period (Coker 1930) and total commercial landings were reported to be 1,105,000 kg in 1899. Cook (1959) described the Paddlefish as the third most important commercial species in the state, behind Channel Catfish *Ictalurus punctatus* and buffalo *Ictiobus* spp. Even so, recreational fishing and game fish were more valued in Mississippi. Local residents blamed poor sport fishing in Moon Lake on commercial fishing activity (Anderson 1955) and were successful in getting legislation passed that prohibited commercial fishing in Coahoma County where Moon Lake is located. Abundant, rough fish stocks were blamed for poor sport fishing at Moon Lake; local residents succeeded in getting legislation passed allowing the Mississippi Game and Fish Commission (MGFC) to begin a rough fish removal project. In what was considered appropriate management in 1951, MGFC removed 25,047 kg of Paddlefish as rough fish (Fuller 1951). Thousands of Paddlefish with hundreds weighing from 16 to 45 kg (35–100 lbs.) were caught in 1950–1952 from Moon Lake, which had been closed to all commercial fishing for “a number of years” (Cook 1959). Historical records document the expansion and recovery of Paddlefish stocks not subjected to commercial fishing and the perceived conflicts between commercial and sport fishers which persist to this day. Several decades later, in 2010, commercial harvesters would again be allowed to remove these rough fish from Moon Lake in an effort to improve sport fishing.

As in Alabama, historical harvest regulations in Mississippi were inadequate for conservation. However, some modest regulations such as size limits, season limits, and area

closures were enacted in Mississippi. For example, from at least as early as 1959 (Cook 1959), until 1985, it was unlawful to possess Paddlefish less than 813 mm (32 in) TL. In 1986 the Mississippi Department of Wildlife Conservation (MDWC, formerly MGFC) increased the minimum length of commercial Paddlefish harvested from 813 mm (32 in) TL to 1,321 mm (52 in) TL. In July 1988 all size and season limits on Paddlefish harvest were removed (MDWC 1988), but the following year, in May 1989, the MDWC prohibited the take, sale, or possession of Paddlefish from January 1 to April 30 statewide, and the border waters with Louisiana and the Pascagoula River were closed to Paddlefish harvest from November 1 to April 30 (MDWC 1989). In July 1997, the again renamed Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP) implemented this November 1 to April 30 closed season statewide (MDWFP 1997) so that the statewide open season (including the Mississippi River) was from May 1 through October 31. This open season was designed to allow commercial fisherman to retain Paddlefish for meat. At the time, MDWFP fisheries biologists believed Paddlefish did not have roe suitable for processing into caviar during these months. Later it was learned, however, that this was not the case, because some Paddlefish have small, shiny eggs that could be sold (Kim Campbell, commercial fisher, personal communication) and that commercial fishers, especially those from other states, were harvesting Paddlefish in September and October in Mississippi for their roe when the Paddlefish seasons in other states were closed. Since caviar-grade roe is usually in short supply in these months, there was a strong demand for any Paddlefish roe, even of lesser quality for the lucrative holiday trade and cruise ship market (Lucas 2012).

Despite some time, area, and fish length restrictions, Mississippi's commercial Paddlefish were still being pursued, presumably for their meat, for six months per year

(May–October) over a wide geographical area, with open access, leading to inevitable harvest management and enforcement challenges. Problems with enforcement also arose because of inadequate fines for violations. Violations of agency rules and state laws concerning Paddlefish were Class III offenses (Miss. Code Ann. §49-7-101) with only \$25.00–\$100.00 fines. MDWFP Conservation Officers noted that these small fines were not an effective deterrent to prevent illegal Paddlefish harvest activity.

Initial development of MDWFP's harvest management for Paddlefish commercial fisheries began in earnest in 2000. Important early changes were in penalties for harvest violations. In response to the formerly weak penalties for harvest violations, Mississippi enacted Miss. Code Ann. §49-7-90 in 2001, which made violation of Paddlefish laws a Class I offense (Miss. Code Ann. §49-7-141) punishable by a \$2,000–\$5,000 fine, 5 d in jail and forfeiture of all fishing, hunting, and trapping privileges of not less than 12 months from the date of conviction. Miss. Code Ann. §49-7-90 also stipulated that Paddlefish violators shall pay a \$500 fee to have their fishing privileges restored. In 2008, Miss. Code Ann. §49-7-90 was revised to also make violation of Paddlefish regulations, which are promulgated by the MDWFP, a Class I violation.

The process of adopting more proactive harvest regulations began in April 2007, when all Paddlefish harvest was prohibited (MDWFP 2007) while fisheries biologists composed new harvest regulations. MDWFP biologists and managers consulted with their counterparts in Arkansas and Tennessee state agencies regarding their Paddlefish harvest rules and recommended adopting many similar regulations as in those states. For example, Arkansas residents had for several years been harvesting Paddlefish in the Mississippi River in Arkansas waters adjacent to Mississippi, even though all Mississippi waters were

closed to Paddlefish roe harvest. To allow Mississippi residents the same harvest opportunity as Arkansas residents, the MDWFP decided to compose commercial Paddlefish roe harvest rules. The resulting regulations established an initial commercial Paddlefish roe harvest season on the Mississippi River, only along the Arkansas border from December 1, 2008 to March 3, 2009 with the same 864 mm (34 in) minimum eye-to-fork (EFL) length limit as allowed by Arkansas (MDWFP 2008). Since the 2009–2010 season, interior Mississippi waters in the Yazoo River Basin have been open to commercial Paddlefish harvest. Respecting the Louisiana decision in 1992 to close their waters for commercial Paddlefish harvest due to little information and to prevent overharvest, Mississippi has never allowed commercial Paddlefish harvest on any waters that border Louisiana. Thus, Mississippi has resisted lobbying by Paddlefish harvesters to allow them to fish the Mississippi River where it forms the border with Louisiana.

Out of the MDWFP's planning process came this and other regulations designed to: (1) provide Mississippians an additional commercially sustainable fishing opportunity; (2) maintain healthy Paddlefish populations which are protected from overexploitation; and (3) track and document Paddlefish roe production to satisfy requirements of the Convention on the International Trade of Endangered Species (CITES). Lacking any sampling data, the MDWFP decided to rely upon existing, relevant literature and to proceed cautiously with restrictive fishing regulations and length limits.

Alabama and Mississippi Paddlefish Management Actions

The proactive management actions implemented by the two states fall into three broad areas: (1) fishing areas, seasons, and participation; (2) fishing and harvest restric-

tions; and (3) licensing fees, reporting and training. Actions taken under (1) included defining Paddlefish management areas, establishing specific harvest seasons and daily harvest times, and limiting the number of harvesters. Actions under (2) included enacting length limits and female-only harvest (in Alabama), implementing carcass tags to track fish and roe, and establishing gear restrictions to reduce unintended Paddlefish mortality. Actions under (3) included establishing rational permit requirements and fees, establishing specific harvest reporting requirements, and providing informational training to aid in harvester compliance.

Fishing Areas, Seasons, and Participation

Restrictions on areas open to fishing, length of season, and participation were enacted in both states based on the recognition that long duration, open access fisheries for a vulnerable, high-value fish such as Paddlefish are not consistent with proactive, enforceable, sustainable management at a reasonable cost to the public. The more proactive approach of opening fisheries for specific harvest management units for specific times to specific harvesters allows managers to better manage and monitor the harvest. In contrast, inadequate knowledge of where and when fishing and harvest are occurring, where fish are being landed, and who the participants are, seriously inhibits cost-effective management. States have limited personnel to observe and monitor commercial harvesters.

Alabama Paddlefish Management Areas

Out of both fish stock and fishery enforcement concerns, the ADWFF defined three Paddlefish Management Areas (PMAs) within the Alabama River basin. The PMAs, which are separated by sets of locks and dams,

have well-defined boundaries in the main-stem of the river; fishing in tributaries and backwaters is prohibited. The first PMA, designated as the Upper Alabama River (UAR) PMA, extends from Alabama River kilometer (ARK) 235.5–207.0, and 197.1–166 (59.6 river kilometers). In addition, a 15.9 km section of the river (ARK 207.0–197.1) near Selma (Dallas County) that is extremely popular during winter with recreational and tournament anglers for other species was closed to commercial Paddlefish fishing to minimize user conflicts. The second PMA, the Middle Alabama River (MAR), extends from ARK 131.6–85.6 (46 river kilometers). The third, and most downriver, PMA, the Lower Alabama River (LAR), extends from ARK 71.8–27.4 (44.4 river kilometers). In all, the three PMAs constitute 64% of the Alabama River channel below the Robert F. Henry Lock and Dam at ARK 380.3.

All commercial Paddlefish harvesters could launch and take out only from designated boat ramps in the UAR (4 ramps), MAR (3 ramps), and LAR (3 ramps). This restriction provided some flexibility to harvesters yet greatly facilitated efforts by ADWFF to contact and monitor the harvesters for effective enforcement and collection of fishery-dependent data.

Mississippi Paddlefish Management Areas

Paddlefish Management areas within Mississippi are shown in Figure 1. Since the initial 2008–2009 Paddlefish winter roe harvest season, Mississippi has allowed the harvest of Paddlefish in the Mississippi River and all public waters between the main-line levees of the Mississippi River where it forms the border between Arkansas and Mississippi. Areas open to harvest in the state's interior waters are more specific. Since the 2009–2010 Paddlefish roe harvest season, Mississippi has opened various waters in the

Yazoo River basin to commercial Paddlefish harvest at certain times within the period mid-November to mid-April (MDWFP 2009). Refuge areas closed to harvest were designated each year in the Yazoo River basin harvest zones. The MDWFP has also allowed Paddlefish harvest on an experimental basis for short periods (e.g., one week) in water bodies lacking stock data to determine in a cost-effective way, if, or how many, harvestable-sized Paddlefish are present. Mississippi areas open to Paddlefish roe harvest are listed annually in the MDWFP Public Notices (MDWFP 2008, 2009, 2010, 2011, 2012) and MDWFP Rules (MDWFP 2013a, 2014a, 2015a, 2016a, 2017a).

Alabama Harvest Seasons and Daily Fishing Times

Traditionally, commercial Paddlefish seasons in Alabama have been open in commercial states anywhere from 5 months to year-round, with harvest permitted 24 h a day (Scholten 2009). The long seasons have inevitably led to numerous enforcement issues and violations. Another consideration is the need to minimize nonharvest mortality. Bettoli and Scholten (2006) reported that 92% of Paddlefish caught with gill nets in Kentucky Lake were sublegal-sized fish; a mortality rate of 71% was observed when water temperatures exceeded 17°C. For other species elsewhere in the nation, traditional gill netting with long soak times have also caused problems (35–70% mortality for Coho Salmon *Oncorhynchus kisutch*; Buchanan et al. 2002). A mortality rate of 50% has been observed for Paddlefish collected with gill nets for mark–recapture studies during late spring and summer in the Alabama River (Rider, unpublished data). A shorter, more focused season and warm season closures would address these issues.

After consulting with managers from other state agencies and identifying problems

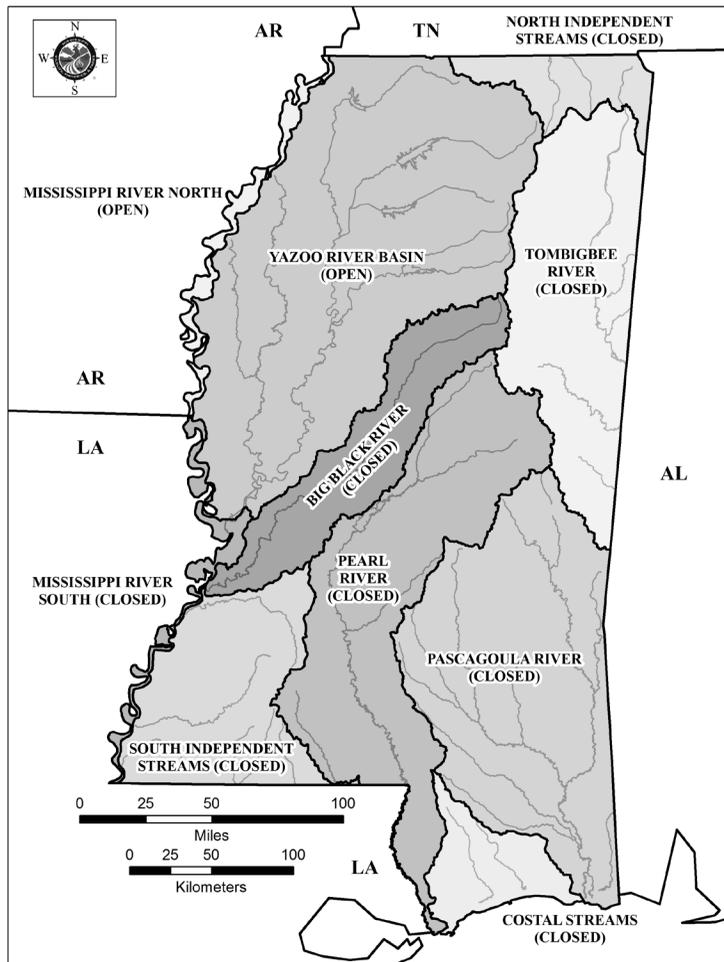


FIGURE 1. Map of Mississippi commercial Paddlefish harvest zones.

associated with statewide open seasons, ADWFF elected to open a 35-d season starting February 1 of each year. This shorter season would limit total effort while still maintaining an opportunity for harvesters to catch gravid females, the highest valued fish. In addition, fishing was permitted only on weekdays during daylight hours from 0600 to 1600 hours; all nets needed to be removed by 1600 hours. Daylight fishing only has been enacted in several other states with recreational harvest, also to improve enforcement and to reduce violations, which occur most commonly at night (Scarnecchia et al. 2008). This also enabled ADWFF fisheries biologists and law

enforcement officers to monitor harvest and harvesters much more effectively with limited personnel.

Mississippi Harvest Seasons and Daily Fishing Times

The MDWFP opens the Paddlefish roe harvest season in mid-November and closes it in mid-April. This period matches the Arkansas harvest season on the Mississippi River and it confines Paddlefish harvest to a period when water temperatures are typically less than 15°C. As in Alabama, in Mississippi the MDWFP seeks to minimize unintended

Paddlefish mortality. Paddlefish caught in overnight sets of gill nets during periods when water is above 15°C have a low rate of survival (Bettoli and Scholten 2006).

Fishing times have also been more precisely defined and limited by area. Until the 2012–2013 season, the Mississippi River was open to harvest November–April with various Yazoo River basin areas also open to harvest within this time frame (MDWFP 2012). From the 2013–2014 season through the 2016–2017 season, only one harvest area was open to Paddlefish at a time (MDWFP 2013a, 2014a, 2015a, 2016a). In the 2017–2018 season both the Mississippi River zone and the Yazoo River basin zone were open to harvest the entire season (MDWFP 2017a) with the same minimum length limit (940 mm (37 in) EFL; MDWFP 2017b).

The MDWFP has also established harvest caps for each harvest zone since the 2014–2015 season. These caps or harvest quotas were established based on the average Paddlefish catch per day from previous seasons in each harvest zone. They were adopted as a cautionary tactic to prevent overharvest. As of 2018, the cap for each zone has not been reached (MDWFP 2014a, 2015a, 2016a, 2017a). To reduce illegal and enforcement problems associated with night fishing, since the 2012–2013 season, Mississippi has prohibited harvesters removing fish from nets from ½ hour after sunset to ½ hour before sunrise (MDWFP 2013b).

Limiting the Number of Harvesters in Alabama

Whereas historical Paddlefish fisheries in most states, including Alabama, were open access, the new approach called for a manageable total of no more than 15 commercial Paddlefish harvester permits or five harvester permits per PMA each season. Residents of Alabama aged eighteen (18) years and older that had purchased a resident

commercial freshwater fishing license from October 1 to September 30 of the previous year were eligible to apply for a resident commercial Paddlefish harvester permit. Nonresidents of states that allow Alabama residents to commercially fish for Paddlefish (as of 2018, Illinois, Kentucky, Missouri, and Tennessee) could also apply. Residents of these four states that were issued valid roe or fish harvest permits/licenses from their state of residence, which were valid for that state's respective license year prior to October 1, were eligible to apply to commercially harvest Paddlefish in Alabama for the following season. However, nonresidents of states that prohibit Alabama residents from commercially harvesting Paddlefish were ineligible. There is no guarantee a commercial harvester will get a permit each season, as commercial Paddlefish harvester permits are randomly selected each year. However, harvesters who held a commercial Paddlefish harvester permit in previous years receive an extra chance in the lottery drawing.

Limiting the Number of Harvesters in Mississippi

As in Alabama, Mississippi has within the past decade limited the participants to a manageable and enforceable number. Since Arkansas does not allow nonresidents to purchase commercial fishing licenses and Arkansas roe taker/seller permits, Mississippi prohibited nonresidents from applying for Paddlefish harvester and Paddlefish helper permits. Due to reciprocal license agreements, persons with Arkansas roe taker/seller permits can only fish in Mississippi border waters (i.e., mainly that portion of the Mississippi River shared between Arkansas and Mississippi). For the 2011–2012 season, the maximum allowable number of Paddlefish harvesters was reduced from 25 to 16 (MDWFP 2011) where it has remained as of 2018. For the 2013–2014 season, the number of

Paddlefish harvesters was limited to 10 per harvest zone (MDWFP 2013a). Annually from 2008 to 2018, 2 to 15 individuals have purchased Paddlefish Harvester permits for Mississippi's Paddlefish roe fishery.

Fishing and Harvest Restrictions

In addition to the area and time restrictions, fishing and harvest restrictions are needed to ensure that the fish harvested meet harvester preferences for mature female fish but also protect immature fish from harvest and maintain some older, prime spawning females in the breeding population (Scarnecchia et al. 2019, Chapter 1 this volume). Mississippi Paddlefish length limits, gear restrictions, tagging requirements, and unlawful and lawful acts are revised annually in MDWFP Public Notices (MDWFP 2008, 2009, 2010, 2011, 2012) and MDWFP Rules (2013b, 2014c, 2015c, 2016c, 2017b).

Length Limits

Alabama Length Limits

To protect immature or non-roebearing fish, a minimum length limit (MLL) of 864 mm (34 in) was placed on all harvested Paddlefish in 2013. The MLL was measured as the curved eye-to-fork length (CEFL; Ruelle and Hudson 1977) from the anterior portion of the eye on the left side of each fish measured along the curvature of the body to the fork of the caudal fin. Commercial Paddlefish harvesters were permitted to harvest all male and female Paddlefish over the MLL. However, the highest price for Paddlefish flesh in 2013 was \$1.50/kg, if the buyers even bought the meat. A number of harvesters were unsuccessful in marketing the meat in 2013, so to prevent males and females with no roe from being wasted, starting in 2014 only roebearing females greater than 864 mm (34 in) could legally be harvested. Gravid females

were identified from males by girth robustness, then confirmed by using a sterile syringe to extract a small sample of eggs. This change in the regulation was fully supported and even requested by some commercial Paddlefish harvesters.

Although this regulation was enacted by ADWFF, the agency is aware that roe fisheries can be difficult to manage as commercial harvesters target the large, older, gravid females (Francis et al. 2007). These larger and older female fish have been referred to as big, old, fat, fecund, female fish or BOFFFFs (Hixon et al. 2014). Recently, a growing body of work related to BOFFFFs has indicated these fish may be more important to stock sustainability and productivity than smaller, younger fecund females (Berkeley et al. 2004a, 2004b; Sharpe and Hendry 2009; Stewart 2011; Hixon et al. 2014). These BOFFFFs have higher fecundity, spawn earlier, and spawn in different and more locations, which may increase survival of larvae. Removal of BOFFFFs can lead to age and size truncation, which could lead to stock collapse (Beamish et al. 2006; Levin et al. 2006). The evaluation of BOFFFFs has been investigated in marine fish populations; however, has been only partially considered in Paddlefish (i.e., prime spawners Scarnecchia et al. 2007). Further investigation is warranted to determine if these larger and older Paddlefish females should receive additional protections to ensure their continued presence in Alabama stocks.

Mississippi Length Limits

Over the most recent decade, (2008–2017) MDWFP has moved to enact more restrictive fishing and harvest regulations to further limit bycatch and mortality of sublegal-sized Paddlefish and in response to concerns from MDWFP Conservation Officers. In the initial Paddlefish roe harvest season, Mississippi had a MLL of 965 mm (38 in)

(MDWFP 2008) and since the 2009–2010 season Mississippi has had a MLL of 940 mm (37 in) (MDWFP 2009) on all interior waters. This length limit is thought to protect 30% of the spawning potential of the Paddlefish stock from harvest. This level of protection has been deemed appropriate in other southern waters (Scholten and Bettoli 2005). Unlike Alabama, Mississippi specifies that Paddlefish are to be laid flat and then measured on a flat board from the front of the eye to the fork in tail (MDWFP 2008). Stretching a tape along the side of the Paddlefish body to obtain a length is not considered a valid measurement in Mississippi. Since the initial Paddlefish egg harvest season in 2008–2009 until the 2012–2013 season, Mississippi has used the Arkansas eye-to-fork (EFL) MLL of 864 mm (34 in) for the Mississippi River border waters. Since the 2013–2014 harvest season, this MLL has been 889 mm (35 in) coinciding with the change in Arkansas regulations (MDWFP 2013b). MDWFP law enforcement personnel were concerned that these two harvest areas (Mississippi River and interior waters) had different MLL (864 mm, then 889 mm in the Mississippi River and 940 mm in the Yazoo River Basin zones); sublegal-size fish were being harvested from the Yazoo River Basin zones but were being reported on the harvest forms as being legally caught in the Mississippi River. To prevent falsification of the information on the location of harvest and the harvest of fish less than 940 mm in the interior of Mississippi, from the 2013–2014 thru the 2016–2017 seasons, MDWFP never had the Mississippi River zone open when any other zone was open to harvest (MDWFP 2013a; 2014a; 2015a; 2016a). Since the 2017–2018 season, the MLL limit has been 940 mm for every harvest zone (MDWFP 2017b). Paddlefish harvesters had requested more fishing opportunities and were willing to have one minimum EFL for all waters to obtain those fishing opportunities.

Carcass (Harvest) Tags

For fish of high value such as Paddlefish (Coker 1923), it is important for management and enforcement to be able to track individual fish and monitor “chain of custody” of individual fish and roe back to the commercial harvester and forward to markets (Scarnecchia et al. 2008). Tracking capability allows legally and illegally harvested roe to be more reliably differentiated. A tag system has been used for some recreational Paddlefish fisheries by agencies in several other states (e.g., Montana, North Dakota, and Oklahoma: Scarnecchia et al. 2007, 2013; Nebraska and South Dakota: Mestl and Sorensen 2009). Historically there has not been an effective way to accomplish this in most states, including Alabama and Mississippi.

Alabama Harvest Tags

In 2013, the use of carcass (harvest) tags was adopted by the ADWFF from the MDWFP rule to allow tracking and monitoring of all harvested Paddlefish and their roe. In 2013, all harvested Paddlefish were required to be checked at ADWFF stations in each PMA by ADWFF biologists. ADWFF biologists attached the carcass tag to each fish after obtaining the biological data from each fish. Thereafter, starting in 2014, the check stations were discontinued, so harvesters were required to tag each harvested fish. Each harvested Paddlefish must be tagged through the dorsal fin with an individually-numbered tag (Figure 2) after removal from the net and retained in the harvester’s boat until landed at one of the designated ramps. The tag must remain with the fish until the carcass is processed and/or packaged for sale. The removal (i.e., stripping) of roe from the harvested fish is not permitted while on the water or riverbank; roe can only be removed once the boat has been trailered from the water at a designated ramp or removed later, at a pro-



FIGURE 2. Carcass tags used by ADWFF and MDWFP and placement in the dorsal fin of a commercially-harvested Paddlefish.

cessing facility. This requirement reduces or eliminates incentives to strip undersized, roe-bearing females on the water, mix roe from several fish, and then claim it was from only one fish. Roe removed from a given fish must be kept in its own container, labeled as roe, and identified with the fish's unique carcass tag number. For the ADWFF, it provides a highly effective identification system for enforcement and for the ADWFF's harvest database used in stock assessment.

Mississippi Harvest Tags

Since the initial Paddlefish roe harvest season (2008–2009) Mississippi has required that all harvested Paddlefish be immediately tagged upon removal from the net by attaching a serially numbered plastic truck seal type tag to the dorsal fin (MDWFP 2008). These tags, analogous to the carcass tags used in Alabama, must remain on the fish until the flesh is packaged for retail sale. Only those with a Paddlefish Harvester Permit can purchase

Paddlefish tags and tags cannot be traded or given to others. The tagging of each fish allows Mississippi to link caviar to individual fish and harvesters and to verify that the roe was legally harvested.

Mississippi Paddlefish roe processing regulations are listed in MDWFP Public Notices (MDWFP 2008, 2009, 2010, 2011, 2012) and MDWFP Rules (2013c, 2014b, 2015b, 2016b, 2017c). Since evisceration for roe removal on the water makes enforcement of minimum length limits difficult, Mississippi Paddlefish harvesters have never been allowed to remove the roe from the body cavity until they reach the shore. Since the initial 2008–2009 season it has been unlawful to mutilate Paddlefish or expose Paddlefish roe while on the water or at any time prior to the exchange of Paddlefish with a Paddlefish processor (MDWFP 2008). Mutilation is defined as cutting, puncturing, tearing, or disfiguring the body portion of a Paddlefish. However, a 12-gauge needle may be used to check for the presence of roe and to aid in

transport, the paddle anterior of the eye and the tail posterior to the fork may be removed (known as blocking) (MDWFP 2008). Since the 2010–2011 season Mississippi has allowed the gill rakers to be cut on harvested fish to bleed them to improve roe processing and quality (MDWFP 2010). Harvesters wishing to process their own catch must also purchase a Paddlefish Processor Permit. Once on shore, Paddlefish harvesters must document their catch on a Paddlefish sales transaction form before transporting the fish to a Paddlefish processor for roe removal and processing.

Since Mississippi seeks to ensure that high-quality, consumer-safe caviar is produced from its Paddlefish, roe processing (i.e., washing, screening, salting, and packaging) has been required to be done in a facility that complied with state and federal health agency regulations. Since the 2013–2014 season, Mississippi required that Paddlefish processing facilities be in the State of Mississippi, be registered with the U.S. Food and Drug Administration, and have an approved Hazard Analysis Critical Control Point (HACCP) plan. Processors must notify the MDWFP of the movement and location of their processing facility during the roe harvest season (MDWFP 2013c; 2014b; 2015b; 2016b; 2017c). Paddlefish waste must be disposed of in an approved sanitary landfill.

Gear Restrictions

Gear restrictions have been enacted as a primary tool to minimize or eliminate both initial discard mortality and delayed nonharvest mortality (Bettoli and Scholten 2006), outcomes considered vital for efficient, sustainable management. Studies have shown that the use of gill nets can have highly negative, unintended consequences for Paddlefish and other species if the fisheries are not properly controlled and gillnets are not tended

with adequate promptness. As water temperatures increase, Paddlefish mortality in Alabama increases in gill nets set overnight (Rider, unpublished data). In addition, the Alabama River is also home to the world's most rare and endangered sturgeon species, the Alabama Sturgeon (*Scaphirhynchus suttkusi*) (Rider and Hartfield 2007; Kuhajda and Rider 2016; Pflieger et al. 2016). The last Alabama Sturgeon was collected on April 3, 2007, while using gill nets targeting Paddlefish. Likewise, the Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) is also found in the Alabama River (Rider et al. 2015; Pflieger et al. 2016). Both species are state protected, with the Alabama Sturgeon listed as federally endangered and the Gulf Sturgeon as federally threatened. Incidental mortality of these species is to be avoided.

Gear Restrictions in Alabama

In Alabama, Paddlefish can only be commercially harvested using gill nets, defined as a single net attached to float and lead lines. ADWFF sought to enact regulations designed for nets to harvest Paddlefish of the intended sizes while minimizing unintended mortality on Paddlefish and sturgeon. These regulations included prohibition of hobbled gillnets, prohibition of monofilament gillnets, a maximum 2-h soak time, a minimum 152 mm bar measure gillnet mesh, a maximum of five nets fished concurrently, an upper limit on gillnet dimensions (61 m in length and 7.3 m in depth), and specifications on highly visible floats to identify Paddlefish set nets to aid in enforcement and monitoring.

To promote increased size selectivity of gillnets, the use of tied-down gill nets is prohibited for commercial Paddlefish harvest statewide. Tied-down or hobbled gill nets are tied to decrease the depth of the net by creating a pocket toward bottom of the net. For example, to hobble a 91-m long \times 7.3-m

deep gill net you would tie the bottom of the net to a depth of 5.5 m. In other states that allow commercial Paddlefish harvest the use of tied-down or hobbled gill nets is permitted and most commercial Paddlefish harvesters use them. However, tied-down gill nets have been shown to be nonsize selective as the range and mean lengths were not significantly different with different sizes of mesh in Kentucky Lake, Kentucky and Tennessee, and the Alabama River, Alabama (Scholten and Bettoli 2007; Rider et al. 2012).

In Alabama, only multifilament netting is allowed to be used by commercial Paddlefish harvesters. The use of monofilament gill nets is popular with many other commercial species, including commercial Paddlefish fisheries elsewhere (Quinn 2009; McMullen and Siech 2017; Ganus, personal communication). Mississippi prohibited the use of monofilament gill nets for Paddlefish in the 2013–2014 season (MDWFP 2013b). The use of monofilament netting increases Paddlefish mortality (Bettoli and Scholten 2006). Bettoli (2005) and Bettoli and Scholten (2006) recommended the use of multifilament netting instead of monofilament netting for the commercial harvest of Paddlefish in Kentucky Lake, Kentucky and Tennessee.

Soak time of nets (i.e., number of hours a gill net is set without being checked or removed from the water) has a major impact on mortality. The longer the soak time, the higher the mortality rate. For Paddlefish gill nets, with their larger mesh, the intent to minimize initial and delayed mortality provides a strong justification for minimizing soak times. In Alabama, commercial fishers using gill nets for species except Paddlefish can set nets overnight; however, they cannot check or work the nets at night. To reduce unintended mortality of nontargeted Paddlefish and prevent incidental sturgeon mortality, the ADWFF limited soak times for Paddlefish gillnets to a maximum of two hours.

Commercial Paddlefish gill nets must have a minimum mesh size of 152-mm bar measure (knot to knot) in Alabama. Rider et al. (2012) showed 152-mm bar measure (6 in) mesh caught more large-sized Paddlefish on average than smaller mesh sizes. The use of larger-sized meshes minimizes bycatch and mortality of smaller Paddlefish and nontargeted species. In the interior rivers of Mississippi and in Tennessee, the minimum mesh size for commercial Paddlefish nets statewide is also 152 mm (Scholten and Bettoli 2006; MDWFP 2017b).

The size and number of gill nets a commercial Paddlefish harvester can use is also limited. Commercial Paddlefish gill nets cannot exceed 61 m in length and 7.3 m in depth and five is the maximum number of gill nets permitted to fish concurrently and in possession while on the water during commercial Paddlefish fishing. The above gear restrictions are being evaluated on a yearly basis for effectiveness in meeting goals to minimize or eliminate discard mortality and delayed nonharvest mortality (Bettoli and Scholten 2006).

All commercial Paddlefish gill nets are required to have an orange-colored float attached to each end of the gill net and each float must be visible from the surface of the water. The float must be similar in size to a bullet-type float measuring 127 mm in diameter and 279 mm in length or the size of a 3.8-l (1 gal) milk container. This designates the gear as a commercial Paddlefish gill net and allows for easy location and visual inspection by ADWFF biologists and enforcement officers.

Gear Restrictions in Mississippi

Since the 2012–2013 season, to reduce sublegal Paddlefish bycatch and mortality, the minimum mesh size for gillnets in the Paddlefish fishery was increased from 102 mm (4 in) to 152 mm (6 in) and Paddlefish

nets were required to be marked with a floating orange buoy (MDWFP 2012). Since the 2015–2016 season, Mississippi has allowed its Paddlefish harvesters to use 89 mm (3.5 in) gill nets (which is the minimum mesh size for gill nets in Arkansas) or larger bar measure gill nets and trammel nets, only in Arkansas waters in the Mississippi River (MDWFP 2015c). Because monofilament netting increases Paddlefish mortality (Bettoli 2005; Bettoli and Scholten 2006), since the 2013–2014 season, Mississippi has required that Paddlefish harvesters only use gill nets and trammel nets of multifilament, multitwist filament, or monotwist filament construction, thereby prohibiting the use of monofilament nets (MDWFP 2013b). Mississippi prohibits (Miss. Code Ann. §49-7-9.1) gill and trammel nets greater than 914 m (3,000 ft) in length but there is no limit on the number of nets that may be used. Unlike Alabama, gill and trammel nets may be tied-down or hobbled. No commercial fishing gear can be set so that it extends more than halfway across the width of any water body (Miss. Code Ann. §49-7-81). All commercial gear is required to be tagged with the license holder's MDWFP number.

Since the 2012–2013 season, Mississippi has required that Paddlefish harvesters run their nets at least once every 24 h and has prohibited removing fish from nets ½ hour after sunset to ½ hour before sunrise (MDWFP 2012).

Licensing Fees, Reporting, and Training

Important components of management of Paddlefish commercial fisheries in both states are harvester licensing, catch reporting, and training. Because of the dearth of ways to fund the needed management of commercial Paddlefish fisheries range-wide, license sales typically constitute a critical source of needed funding for sustainable management.

Harvest records, if collected accurately, are a cost-effective method of obtaining monitoring data. Both states seek to gather as much pertinent fishery-dependent data as possible (Silvert 1978). Increased interaction and communication with harvesters are considered vital parts of a sustainable harvest management program. Intended outcomes are improved communication between the agency and harvesters, the beneficial use of harvest data to aid in management and monitoring, increased understanding by all parties, and more willing compliance by harvesters with needed regulations.

Alabama Permit Requirements and Fees

In Alabama, a commercial Paddlefish dealer's license (\$750 for Alabama residents) is required of every resident person, firm, association, or corporation to buy, sell, process, or ship Paddlefish roe or flesh acquired from a permitted Paddlefish harvester (Required by Section 9–11–153, Code of Ala. 1975, as amended by Act No. 2012–471). For nonresidents, the cost of a commercial Paddlefish dealer's license is the same as what the applicant's State of residency would charge an Alabama resident to buy, sell, process, or ship Paddlefish roe or flesh within that state; in no event, however, will the cost be less than the fee charged to an Alabama resident.

A commercial Paddlefish harvester permit (\$750 for Alabama residents) is required to fish for and take Paddlefish in a designated Paddlefish management area (PMA) for harvesting flesh and roe during designated commercial Paddlefish seasons. This permit also allows one commercial fishing helper per permit holder. As with a dealer's license, the cost for nonresidents is the same as what the applicant's State of residency would charge an Alabama resident to commercially fish for Paddlefish in that state, but in no event is the

cost less than the fee charged to an Alabama resident. An Alabama Commercial Freshwater Fishing License is required in addition to the Commercial Paddlefish Harvester Permit to harvest and possess Paddlefish. The cost of the license is \$100 for residents, with non-residents charged what an Alabama resident would be charged to commercial fish in their resident state.

Mississippi Permit Requirements and Fees

Mississippi established the Paddlefish permit fee structure after considering what other states had done. Permit fees are high relative to other license types and this is intentional to discourage inexperienced fisherman from participating in the Paddlefish fishery. Mississippi Paddlefish permit application types (Table 1), requirements, permit fees, and harvest reporting regulations are specified in MDWFP Public Notices (MDWFP 2008, 2009, 2010, 2011, 2012) and MDWFP Rules (MDWFP 2013c, 2014b, 2015b, 2016b, 2017c). Permit types include Paddlefish harvester, Paddlefish helper, Paddlefish processor, and Paddlefish buyer/exporter. A Paddlefish harvester is defined as a Mississippi resident who possesses a valid Paddlefish harvester permit that allows them

to fish for, attempt to take, possess, and transport a Paddlefish to a Paddlefish processor for documentation of harvest, after which the sale and processing including the removal of roe may take place. A Paddlefish helper is defined as a Mississippi resident who possesses a valid Paddlefish helper permit who assists a person with a Paddlefish harvester permit with fishing for, attempting to take, and taking of Paddlefish. A Paddlefish helper can also transport Paddlefish to a Paddlefish processor.

Paddlefish processors are persons who possess a Paddlefish processor permit which allows them to purchase, attempt to purchase, barter for, process, sell, ship, import, and export Paddlefish, Paddlefish roe, and Paddlefish flesh. Paddlefish processing agents are persons who possess a valid Paddlefish processing agent permit who can assist a Paddlefish processor in processing and can document the harvest of Paddlefish received from Paddlefish harvesters and transport Paddlefish to a processing facility. From the 2008–2009 season through the 2012–2013 season, Mississippi required that those with a Paddlefish processor permit produce 40–60% of their roe made into a retail product ready for consumption, packaged into a container weighing 1 kg or less and with a label stating, “Product of Mississippi, USA.” This re-

TABLE 1. Mississippi Paddlefish Permit types and costs 2008–2018.

Permit Type	2008–2009 Season Cost	2009–2013 Seasons Cost	2013–2018 Seasons Cost
Harvester	\$1,000	\$750	\$1,000
Helper	\$200	\$100	\$200
Processor	\$2,000	\$1,000	\$1,000
Nonresident Processor	Not offered	Not offered	\$2,000*
Processing Agent	Not offered	Not offered	\$200
Buyer /Exporter	\$5,000	\$3,000	Not offered

*Not offered for the 2013–2014 season.

quirement proved difficult to enforce and was discontinued. Those with a Paddlefish buyer/exporter permit were persons defined as having the same privileges as Paddlefish processors but without the requirements to make a product ready for consumption and label it as a “Product of Mississippi, USA.”

In some years Mississippi prohibited individuals from purchasing more than one type of Paddlefish permit, thereby requiring the exchange of Paddlefish between a Paddlefish harvester and a Paddlefish processor. This prohibition prevented Paddlefish harvesters from removing roe from their fish. All persons desiring to apply for Paddlefish permits are required to have a valid Mississippi freshwater commercial fishing license (\$32.29 for residents; \$204.29 for nonresidents). Only Mississippi residents may apply for and purchase Paddlefish harvester permits and Paddlefish helper permits.

To exclude known violators from participating in the Paddlefish roe harvest fishery, each year the MDWFP requests that the U.S. Fish and Wildlife Service (USFWS), the Arkansas Game and Fish Commission (AGFC) and the Tennessee Wildlife Resources Agency (TWRA) check their law enforcement violation databases for the names of all those who apply for Mississippi Paddlefish permits to determine if they have any serious fish and wildlife violations. Since the 2011–2012 season, those who have violations of any state or federal law or regulation within the previous three years involving Paddlefish or have the equivalent of a Mississippi Class 1 violation have been prohibited from purchasing Paddlefish permits (MDWFP 2011).

Harvest Reporting in Alabama

Commercial Paddlefish harvesters and commercial Paddlefish dealers are required to report daily Paddlefish catch, daily harvest, and daily buyers’ reports. The harvesters’ and buyers’ information and data are recorded on

the same form for each fishing day (Figure 3). Falsification of, or failure to submit by the specified time or date, the required Paddlefish reports to the ADWFF is a violation and subjects the harvester to denial of future fishing privileges.

Harvest Reporting in Mississippi

Since the initial 2008–2009 Paddlefish roe harvest season, Mississippi has required (MDWFP 2008) all Paddlefish harvesters and Paddlefish processors to report their fishing and harvest activities on a Paddlefish sales transaction form (MDWFP 2008). The Paddlefish tag number, EFL, fishing locations, number and mesh size of nets used, date and hours fished, date of sale, and name and signature of the harvester are recorded on this form, which accompanies each fish until it is exchanged with a Paddlefish processor. When a Paddlefish processor takes possession of the Paddlefish, the processor signs this form. After processing, the Paddlefish processor records the sex, raw roe weight, and screened roe weight on this form. The Paddlefish harvesters submit this form monthly and the Paddlefish processors submit an electronic version within 24 h of processing and submit a paper copy at the end of each month. This form links the caviar and flesh to a tag number, a harvester, and a processor. Paddlefish processors submit a monthly processor report which lists the weight of roe processed by container size and who purchased the processed roe. Paddlefish harvesters and Paddlefish processors are required to retain copies of the Paddlefish sales transaction form for three years. The MDWFP uses these forms to summarize harvest and in documenting legal harvest of Paddlefish eggs for the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) export permits. Commercial harvest data from the 2008–2018 Mississippi Paddlefish seasons are summarized in Table 2.



ALABAMA DAILY COMMERCIAL PADDLEFISH HARVESTER AND DEALER'S REPORT



Commercial Paddlefish Harvester's Name: _____		Permit No. (last 8 digits) _____		PMA: _____	Start Time: _____	No. Gillnets: _____
Commercial Paddlefish Harvester Helper's Name: _____		Date: _____	End Time: _____	No. Gillnet Sets: _____		
I fished but did not harvest any Paddlefish on: _____ (Date).			NUMBER OF PADDLEFISH RELEASED: _____			
SECTION 1: HARVESTED PADDLEFISH (TO BE COMPLETED BY COMMERCIAL PADDLEFISH HARVESTER)						
ADCNR Tag Number	Eye-to-Fork Length (inches)	Total Fish Weight (lbs.)	Total Egg Weight (lbs.)	Total Screened Egg Weight (lbs.)	Recapture Tag Number	
ADCNR-						
ADCNR-						
ADCNR-						
ADCNR-						
ADCNR-						
ADCNR-						
ADCNR-						
ADCNR-						
<i>I certify this report is a true and accurate record of my catch and harvest information.</i>						
Commercial Paddlefish Harvester's Signature: _____			Date: _____		Commercial Paddlefish Harvester Helper's Signature: _____	
					Date: _____	
SECTION 2: DISPOSITION OF HARVESTED PADDLEFISH FLESH AND ROE (TO BE COMPLETED BY COMMERCIAL PADDLEFISH DEALER)						
Date Product Received	Time Product Received	Pounds of Processed Paddlefish Flesh Received	Pounds of Screened Paddlefish Eggs Received	<i>I certify this is a true and accurate record of my transaction with the Commercial Paddlefish Harvester.</i>		
				Commercial Paddlefish Buyer's Signature: _____		
				Date: _____		
				<i>I certify this is a true and accurate record of my transaction with the Commercial Paddlefish Dealer.</i>		
				Commercial Paddlefish Harvester's Signature: _____		
				Date: _____		
<small>Commercial Paddlefish Harvester's and Dealer's Report: No. 2015-001</small>						

White Copy send to ADCNR; Pink Copy to be retained by Commercial Paddlefish Dealer; Yellow Copy to be retained by Commercial Paddlefish Harvester

FIGURE 3. Alabama daily commercial Paddlefish harvester and dealer report.

Mandatory Training Course in Alabama

All permitted commercial Paddlefish harvesters are required to attend a preseason briefing and instruction meeting with the AD-WFF prior to the Paddlefish fishing season. This meeting is only open to valid commercial Paddlefish harvester permit holders. AD-WFF fisheries biologists and conservation law enforcement officers review the commercial Paddlefish regulations and requirements and answer all questions harvesters have on current regulations for the upcoming season. This training meeting is designed to aid harvesters in understanding the regulations and aid in compliance; it is not intended as a forum to discuss any changes or provide justification for any regulation or requirement.

Mandatory Training Course in Mississippi

Since the initial 2008–2009 harvest season, Mississippi has required all vetted Paddlefish harvest permit applicants to also attend a mandatory harvest rule training meeting immediately prior to the opening of Paddlefish roe harvest season (MDWFP 2008). Those that fail to attend are ineligible to purchase a Paddlefish Harvester Permit and are excluded from the fishery. This meeting affords Paddlefish harvesters the chance to meet with Paddlefish processors and with MDWFP personnel. The Paddlefish harvest rules and harvest reporting requirements are reviewed at this meeting. Beginning with the 2014–2015 season, MDWFP also required that Paddlefish processor applicants attend

TABLE 2. Summary statistics from Mississippi commercial Paddlefish harvest seasons 2008–2018. Totals in parentheses exclude Moon Lake. NA = not available.

	2008- 2009	2009- 2010	2010- 2011	2011- 2012	2012- 2013	2013- 2014	2014- 2015	2015- 2016	2016- 2017	2017- 2018
Paddlefish Caught	55	1,163	11,810	9,878	3,066	3,831	1,316	672	568	254
Number of Harvesters	3	2	8	15	15	11	15	6	4	4
Number of Nets	86	313	2,242	3,770	1,541	1,189	503	273	358	238
Paddlefish per Net	0.64	0.27	5.26	2.62	1.99	3.22	2.61	2.46	1.59	1.07
Paddlefish Harvested	26	175	2,405 (1,328)	1,574	851	823 (490)	88	118 (44)	85	6
Number of Fish Released	29	988	9,405 (7,954)	8,304	2,215	3,008 (2,651)	1,228	554 (74)	483	246
Number of Fish Released w/eggs	4	70	1,087 (1,076)	1,328	301	438 (393)	158	NA	NA	NA
Raw Egg Weight (kg)	33	NA	7,773 (3,251)	2,740	2,104	1,369 (675)	201	435 (220)	206	21
Screened Egg Weight (kg)	29	273	5,074 (2,475)	2,056	1,589	998 (489)	135	277 (151)	132	11

these mandatory meetings (MDWFP 2014b). As in Alabama, the training by MDWFP is designed to aid harvesters in understanding the regulations and aid in compliance.

Commercial Harvest Management of Paddlefish—Past, Present, and Future

For more than a century, the Paddlefish, has been harvested commercially for meat and especially for roe (Stockard 1907, 1908; Coker 1923). Even though *Acipenseriform* caviar is perhaps the world's most expensive consumed fishery product (Harris and Shirai-shi 2018), throughout the first three fourths of the 20th century, Paddlefish caviar was not revered, nor valued nearly as highly, as caviar of the favored Caspian Sea sturgeons. Since then, however, demand for wild Paddlefish caviar has continued to increase worldwide as species and global stocks of sturgeon have been depleted and the availability of wild caviar has decreased.

By the 1980s it was recognized by some managers that more active management of Paddlefish was needed (Pasch and Alexander 1986). As the 1983 and 2006 Paddlefish symposia (Dillard et al. 1986; Paukert and Scholten 2009) attest, in the last quarter of the 20th century, state and federal agencies began developing a more specific interest in Paddlefish as both a commercial and a recreational (snag fishery) species. In the United States, the Paddlefish is not listed as threatened or endangered at the federal level and is a state-managed fish. With the increase in demand for caviar has come a much greater responsibility on states for implementing regulations and measures to prevent overfishing. These demands come at a time when fisheries managers receive continued pressure from the commercial sector and political interests to provide more harvest opportunities. The demands also come at a time when funds

available for managing commercial fisheries remain much scarcer than those available for recreational fisheries under Federal Aid to Fish Restoration Programs (American Fisheries Society 2000).

The more proactive approaches to Paddlefish management by the ADWFF and the MDWFP detailed in this paper, i.e. (1) constraints on fishing areas, seasons, and participation; (2) fishing and harvest restrictions; and (3) licensing fees, reporting, and training result from a recognition that the more common historical approaches of reactive management and chasing after harvesters widely dispersed in time and area for fisheries data are expensive, inefficient, and seldom, if ever, lead to scientifically defensible, sustainable management. Paddlefish conservation is thus compromised. Agency credibility with harvesters and the public also suffers.

We would advise states that are contemplating composing regulations for any new Paddlefish fisheries to consult with states that currently have Paddlefish fisheries. This allows them to benefit from what other states have experienced regarding the successes and failures in their regulations. Secondly, we think it is advisable to initially adopt very restrictive regulations for this valuable species, which can be relaxed later according to stock status and the level of compliance by harvesters. It is much more difficult to try to adopt more restrictive regulations after having less restrictive ones. Because the states of Alabama and Mississippi were opening or re-opening commercial Paddlefish fisheries (Alabama in 2013 and Mississippi in 2008), rather than modifying existing fisheries, they were more easily able to apply lessons learned from fisheries in their states as well as other commercial states in crafting regulations. This freedom would not have been possible if commercial Paddlefish exploitation had existed continuously (Combs 1986; Pasch and Alexander 1986; Scholten 2009)

or was pursued by organized commercial fishing groups.

Effective harvest monitoring, stock data acquisition, and stock assessment are critical. States which lack Paddlefish sampling data are advised to rely upon existing, relevant literature, and to proceed cautiously with restrictive fishing regulations and length limits designed to limit fishing mortality and reduce the chances of overexploitation. States should strive to require that Paddlefish harvesters and processors report as much fishery information as possible to aid in the management of their Paddlefish stocks.

Although the new strategies described in this chapter have at times been termed “excessively restrictive” by the commercial industry, the measures have been deemed necessary by ADWFF and MDWFP for the long-term benefit of the commercial harvesters, for long-term sustainability of Paddlefish, and because of past compliance transgressions by harvesters. Effective implementation and enforcement of the necessary regulations and compliance by harvesters is not intended to stop commercial fishing for Paddlefish. It is instead intended, and considered necessary, to provide a stable fishery and avoid the necessity of closures.

Moving forward, ADWFF and MDWFP will be evaluating their approaches for effectiveness and needed improvements will be made. Multi-state cooperation and communication continues to improve. For these and other Paddlefish commercial fisheries, actions such as limiting harvest times and areas, protecting prime spawners, monitoring recruitment, limiting bycatch, reducing nonharvest mortality, requiring adequate fees and training of harvesters, and improving communication between agencies and harvesters will all help to ensure that the Paddlefish commercial fisheries provide benefits to all, yet are adequately regulated to function as instruments of sound public policy for present and future generations.

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