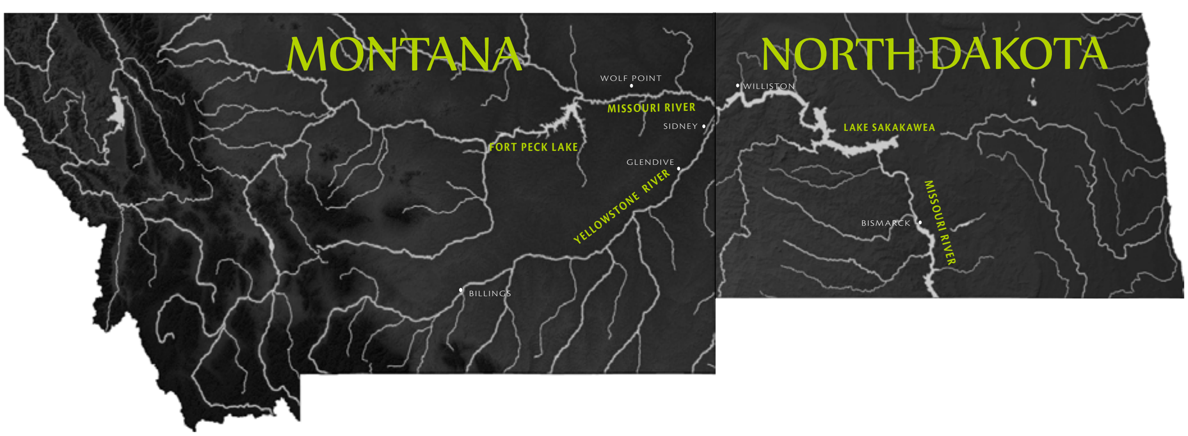
MANAGEMENT PLAN FOR NORTH DAKOTA AND MONTANA PADDLEFISH STOCKS AND FISHERIES



A COOPERATIVE INTERSTATE PLAN

NORTH DAKOTA GAME AND FISH DEPARTMENT
MONTANA DEPARTMENT OF FISH, WILDLIFE & PARKS
UNIVERSITY OF IDAHO

JANUARY 2021

Frontispiece: Shane Shefstad, North Dakota Game and Fish Department, with piebald paddlefish of the Yellowstone-Sakakawea stock, sampled and released in North Dakota.

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Executive Summary

This document outlines a 10-year (2021-2030) Cooperative Management Plan for stocks in Montana and North Dakota by Montana Fish, Wildlife and Parks (MFWP) and the North Dakota Game and Fish Department (NDGF) in consultation with stakeholders and the general public. The Plan covers three stocks and separate management units (Yellowstone-Sakakawea, Fort Peck, and Oahe) within the two state boundaries and proposes, where feasible, uniform data collection, stock assessment, and management approaches. This document is the third ten-year version of the Plan by NDGF and MFWP and updates the previous two versions (Scarnecchia et al. 1995b; 2008). The document is organized into five parts. This introduction (1) is followed by (2) an updated review of life history, fisheries, stock assessment and status for each stock, and (3) a Management Plan providing a philosophical rationale for ongoing and potential management actions, followed by goals, objectives, and tasks for the next decade. Four Appendix sections include (A-1) a management chronology of the three paddlefish stocks, (A-2) habitat status and management, (A-3) an overview of paddlefish from national and international perspectives, and (A-4) a detailed description of the philosophical rationale guiding the goals and objectives. In total, it is intended to be a reference document of past activities, a status review of present conditions, and a guidance document for the future.

The Plan itself consists of a philosophy, expressed as ten fundamental hypotheses, as well as goals and supporting objectives and actions (tasks). The goals of the Plan include providing for management of the stocks, including coordinated management of the Yellowstone-Sakakawea stock, providing an orderly and sustainable recreational harvest, developing a uniform data collection protocol, and maintaining a standardized data base. Other goals include maintaining and enhancing existing habitat in the rivers and reservoirs, facilitating data collection for stock assessments, conducting relevant research, integrating and defining the role of artificial propagation, increasing public awareness through information and education, and obtaining public acceptance and compliance for the Plan. The Plan is woven into actions of caviar programs in Montana and North Dakota for the Yellowstone-Sakakawea stock. Any caviar obtained from the roe donation programs is to be a by-product of sustainably-managed recreational fisheries. Additional studies and fish sampling in the rivers and reservoir will complement data collected at centralized fish cleaning stations. Key components of the Plan include the use of age-specific abundances as early warning indices, a scientifically based harvest cap consistent with population size and five-year recruitment, and stock assessments based on harvest modeling. Early warning of paddlefish reproduction and recruitment success or failure is based on indices of abundance of age-0 and sub-adult fish in reservoir sampling, and the abundance of young males, as early as ages from 7 to 9, recruiting to fisheries. The harvest cap is set based on five-year recruitment of young males (ages 10-14) and females (ages 17-21) and the need to maintain older, prime spawners in the stocks. Data necessary for the stock assessment and harvest management decisions come from an intensive, uniform data collection program in both states at major fishing sites and fish cleaning stations. Additional data are obtained from adult fish jaw tagging, reservoir sampling of age-0 fish, some off-site sampling, as well as on-site and creel censuses by MFWP and NDGF. Data are compiled in a centralized database updated yearly. Management actions to achieve goals and objectives are evaluated for effectiveness at annual management and stock assessment reviews held jointly by the agencies.

Acknowledgements

We thank the professionals of Montana Fish, Wildlife and Parks (MFWP) and the North Dakota Game and Fish Department (NDGF) for their past and current contributions to this plan, including (but not limited to) from MFWP: P. Stewart, A. Elser, V. Riggs, K. Gilge, R. Needham, L. Peterman, H. Johnson, K. McDonald, T. Gallagher, R. Molstad, J. Brost, L. Leslie, W. Wiedenheft, and B. Giddings and from NDGFD: G. Van Eeckhout, J. Hendrickson, J. Lee, L. F. Ryckman J. Vetter and S. Shefstad. We also thank current and past board members and staff of North Star Caviar of Williston, North Dakota and the Chamber of Commerce and Agriculture of Glendive, Montana for their cooperation and assistance. Other assistance from many personnel at the Confluence and Intake fish cleaning stations, including R. Wolter, R. Chelgren and R. Kuehn, is greatly appreciated. We also thank the many paddlefish snaggers who have supported the efforts of MFWP and NDGF in managing these paddlefish stocks while providing for a sustainable paddlefish fishery.

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Report

Appendix

Section 1 - Introduction

And yet there is hope; for man is showing signs of an awakening, or of an atavistic return to which he regarded useful prey as something not to be briefly enjoyed but to be conserved for all time. (p. 102). R. E. Coker (1923) discussing Mississippi River paddlefish and the need for effective management.

The North American paddlefish (Order Acipenseriformes, Family Polyodontidae: *Polyodon spathula)* is an important component of the native fish fauna of the Yellowstone and Missouri rivers of Montana and North Dakota. The Yellowstone-Sakakawea stock, the largest of the three paddlefish stocks found in the region, inhabits the Yellowstone River, the Missouri River below Fort Peck Reservoir, and Lake Sakakawea, a Missouri River mainstem reservoir. In its migratory life history, it moves between the two states and sustains important recreational fisheries in both states (Rehwinkel 1978; Stewart 1990; Owen and Hendrickson 1992; Scarnecchia et al. 1996b: 2008; 2014) and is one of the most important remaining fisheries for the species in its native region (Gengerke 1986; Stewart 1990; Bettoli et al. 2009). A non-profit roe-donation (caviar) program operated by the Chamber of Commerce in Glendive, Montana (http://www.glendivechamber.com) begun in 1990 and a similar program involving two entities in Williston, North Dakota (http://www.northstarcaviar.com/) begun three years later. Both programs derive caviar from the same stock of fish and provide economic and social benefits throughout the region. Development of cooperative, coordinated paddlefish management for this stock by the fisheries agencies of Montana and North Dakota (Montana Fish, Wildlife and Parks (MFWP) and the North Dakota Game and Fish Department (NDGF)) is thus of mutual benefit.

A Cooperative Montana-North Dakota Management Plan also benefits the other two paddlefish stocks in the region immediately upriver and downriver: the Fort Peck stock above Fort Peck Dam in Montana, which also supports a recreational harvest in Montana (Nagel 2017), and the Lake Oahe stock between Garrison Dam and Oahe Dam in North Dakota, which is not harvested as of 2021 (Bailey et al. 2018; Figure 1). The Fort Peck stock acts as a donor of fish (from Fort Peck Reservoir) and the Oahe Stock as a recipient of fish (from both Lake Sakakawea and Fort Peck Reservoir). These two stocks also provide scientific information useful for the management of the Yellowstone-Sakakawea stock.

MFWP and NDGF management of the paddlefish is a vital part of their missions 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 (Rider et al. 2019). Their respective agency mission statements specify the importance of protection, conservation, and enhancement of natural resources for long-term benefits consistent with the Public Trust Doctrine: Montana: https://fwp.mt.gov/aboutfwp/our-vision; North Dakota: https://gf.nd.gov/about/.

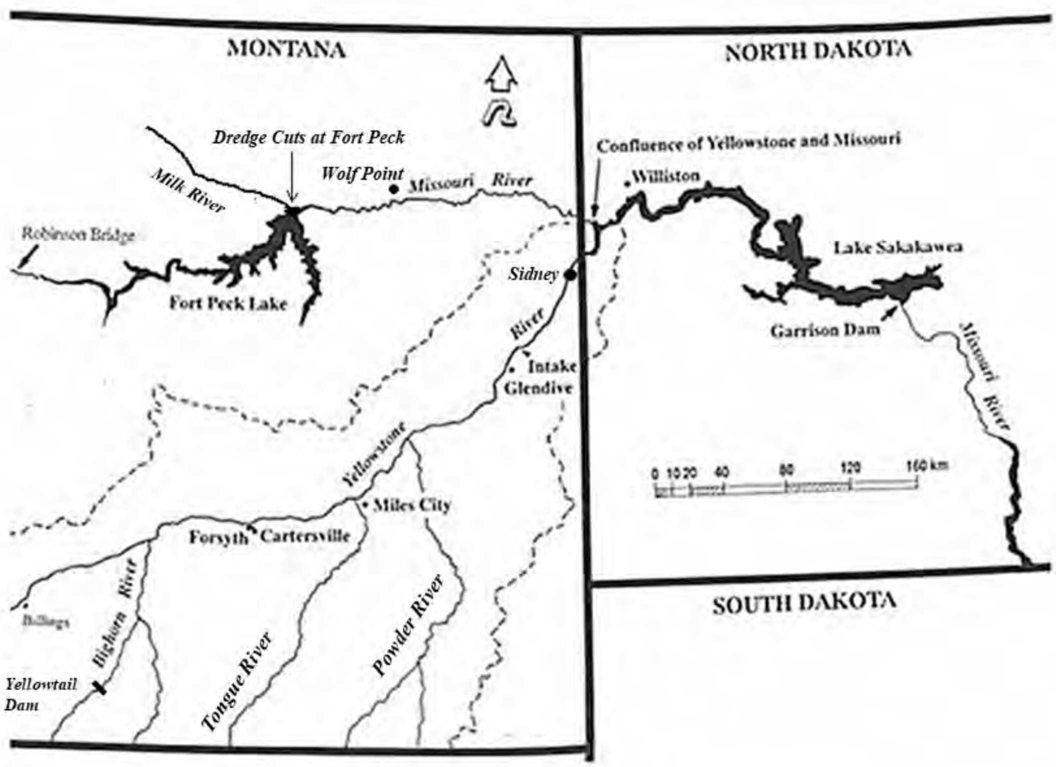


Figure 1. Map of Lower Yellowstone and Missouri Rivers and main stem reservoirs and diversion dams (Intake and Cartersville) in eastern Montana and western North Dakota.

MFWP and NDGF recognize that paddlefish recreational fisheries are more intricate social-ecological systems than they first appear, involving complex interactions between anglers, the paddlefish, managers, stakeholders, and the diverse activities and interests of the general public (e.g., Arlinghaus et al. 2017; Figure 2). An effective Paddlefish Management Plan must have a sufficiently broad conceptual framework and a clear rationale with goals and objectives, so that anglers and the public can fully understand why specific management actions are taken for present and future conservation needs (Knuth et al. 2012; Rider et al. 2019). The Plan must also contain several other important components, including 1) accurate, reliable stock and harvest monitoring and quantitative fish stock assessments, 2) comprehensive habitat monitoring and management of the changing reservoir and riverine habitats, 3) consideration of the effects of invasive species, 4) effective enforcement for legal recreational fisheries, illegal harvest, and the caviar trade, 5) an applied research component, 6) public education, information and outreach on paddlefish and the fisheries, and 7) a process for incorporating new scientific information and ongoing public feedback into management. Ideally, the implementation of the Plan should provide positive feedback in the form of cost-effective management information on the fish, habitat, and fisheries useful in continuously improving the efficacy of the management process.

Cooperative, coordinated harvest monitoring, management, and stock assessment by MFWP and NDGF are important because paddlefish, like their closest relatives the sturgeons, are highly migratory (Russell 1986; Pracheil et al. 2012) and highly susceptible to overharvest (Coker 1923; Waldman 1995) because of their long lifecycle, late maturity, and irregular recruitment (Boreman 1997; Scarnecchia et al. 2014; Scarnecchia et al. 2019a). Accessibility and efficiency of paddlefish snagging have increased in the past two decades due to the technological advances in fish finders and cellphones. Free fish cleaning services provided by the non-profit roe-donation programs in Glendive, Montana and Williston, North Dakota facilitate an enjoyable harvest experience (Scarnecchia et al. 2008). The result has been increased popularity of snagging and increased efficiency of harvest. Meanwhile, paddlefish stocks in Montana and North Dakota are subject to habitat issues such as changes in water quantity (Watson et al. 2017) and water quality (Shrestha et al. 2017), declining natural river function (U.S. Army Corps of Engineers and Yellowstone River Conservation District Council 2015), reservoir sedimentation and aging, and other agriculture- and energy-related habitat effects (McGranahan et al. 2017). Paddlefish occupy a range of riverine and reservoir habitats that are changing continually as the boom-and-bust cycles of energy development in the eastern Montana- western North Dakota (Mondak) region affect natural resources (Putz et al. 2011; McGranahan et al. 2017). Introduced exotic species such as bigheaded carp (e.g., *Hypophthalmichthys nobilis*; Schrank et al. 2003), zebra mussels (*Dreissena polymorpha*; Pegg et al. 2009) and non-native fish predators, have been moving toward the region and have the potential to become highly detrimental to paddlefish and other native fishes. At the same time, the historically high value of caviar and increasing interest in legal paddlefish harvest have led to a need for enforcement to prevent illegal fishing (poaching) of paddlefish for meat and caviar (van Uhm and Siegel 2016). The many new residents in the region resulting from the energy development are often completely unfamiliar with the paddlefish and its complex habitat requirements. An agency response must be increased public informational outreach on

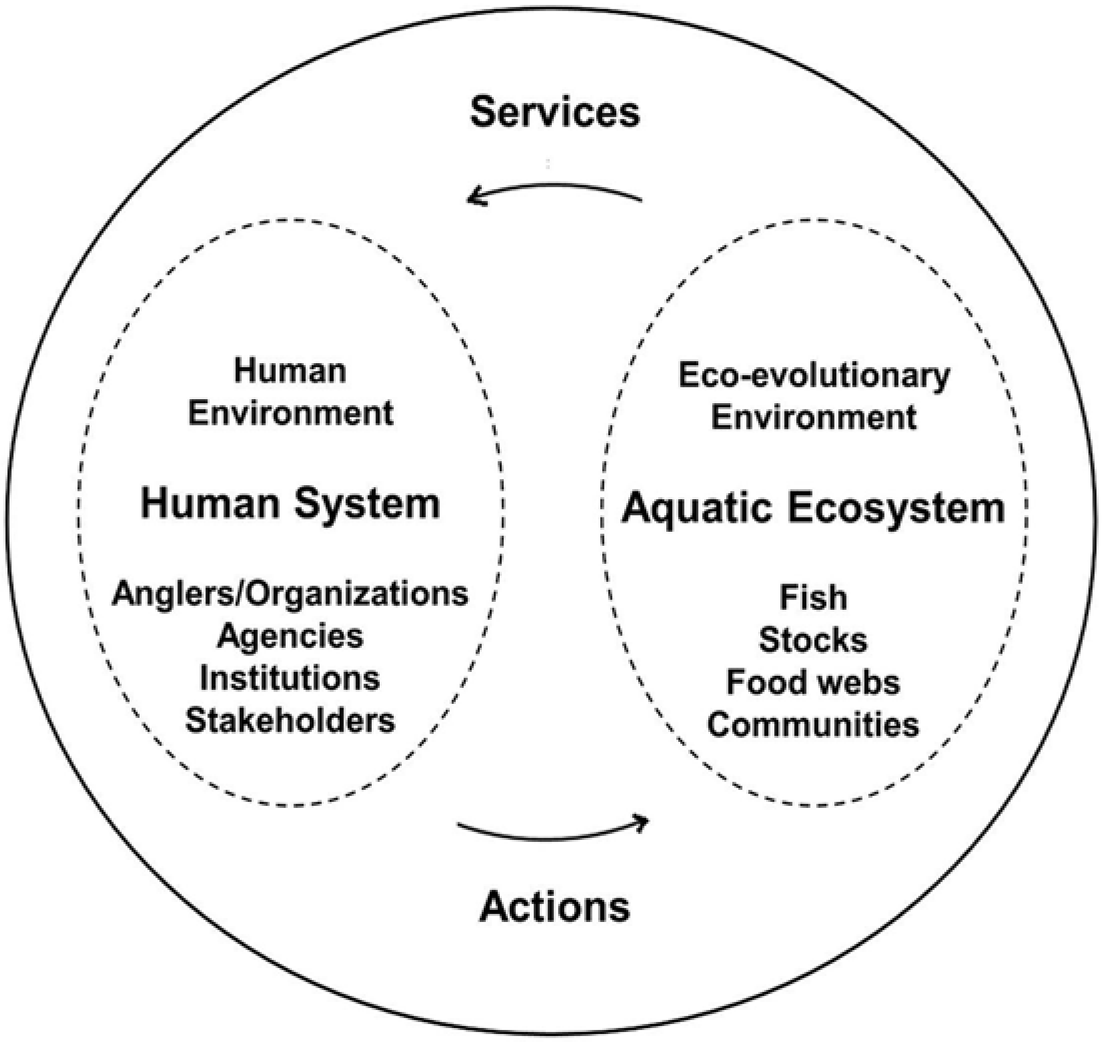


Figure 2. Recreational fisheries as a complex social-ecological system with feedbacks and interactions. From Arlinghaus et al. (2017).

paddlefish. The issues affecting paddlefish are all closely linked between the two states. Effective management of this long-lived species requires a comprehensive, cooperative, consistent, long-term commitment by the agencies.

This document outlines a 10-year (2021-2030) cooperative Paddlefish Management Plan for stocks in Montana and North Dakota by MFWP and the NDGF in consultation with federal agencies, Native American Tribes, stakeholders, and the general public. The Plan covers three management units (Yellowstone-Sakakawea, Fort Peck, and Oahe) within the two state boundaries (Figure 1) and proposes, especially for the interstate Yellowstone-Sakakawea stock, uniform data collection, stock assessment, and management approaches. This document is the third ten-year version of the Plan by NDGF and MFWP and updates the previous two versions (Scarnecchia et al. 1995b; 2008). The document is organized into seven parts. This introduction (1) is followed by (2) an updated review of life history, fisheries, and status of each stock, and (3) the Management Plan providing philosophy, goals, objectives, and tasks for the next decade. As information on other aspects of the paddlefish and its habitat has proliferated, it has become necessary to reorganize this iteration of the Plan with much of the more detailed background information provided into appendices. The four appendices include (A-1) a complete management chronology (retrospective) of the three paddlefish stocks, (A-2) a habitat management section, (A-3) an overview of paddlefish from national and international perspectives, and (A-4) background and details of the philosophical rationale guiding the Plan. In total, the document is intended to be both a working document and a repository: a record of past activities, a status review of present conditions, and a guidance document for the next 10 years (2021-2030) and beyond.

Section 2 - Review of Montana and North Dakota Paddlefish Stocks and Fisheries

Stock identification

Three distinct paddlefish management units or putative stocks (*sensu* Ricker 1972; Epifanio et al. 1989; 1996) have been identified in the Montana-North Dakota region: the Yellowstone-Sakakawea, Fort Peck, and Oahe stocks. Designation of three stocks is based on a combination of genetic differences, geographic separation, and harvest management. Before construction of Missouri River main stem dams (beginning with Fort Peck Dam in the late 1930's), extensive movement of paddlefish occurred throughout the Missouri River mainstem and tributaries, including in Montana and North Dakota. Upriver colonization was possible in the past, before dams, especially in high flow years. With the completion of two mainstem Missouri River dams and reservoirs, Fort Peck Dam and Reservoir, Montana in 1937 (Fort Peck Reunion Committee 1977) and Garrison Dam and Lake Sakakawea, North Dakota, in 1953, paddlefish movements in Montana and North Dakota became impeded as greater physical isolation and habitat fragmentation occurred. Dams blocked upriver fish movements and spawning migrations. Mixing of fish in the region is much more restricted than before the dams were in place. However, tagged fish of the Fort Peck stock continue to be caught in the Yellowstone-Sakakawea fisheries, especially after years of spillway releases (e.g., French 2018), and tagged adult fish of the Yellowstone-Sakakawea stock moved downriver through Garrison Dam in large numbers during the flood of 2011. Bailey et al. (2018) reported that 145 adult paddlefish jaw-tagged above Garrison Dam have been caught or recovered below the Dam over the period 2006-2017. Whereas the Fort Peck stock, as the most upriver stock, is completely isolated by Fort Peck Dam from colonization from downriver, the Lake Oahe fish may consist mostly, or even entirely, of upriver fish from the other two stocks. Otolith and dentary microchemistry (Bock et al. 2017) holds promise for evaluating this interpretation.

The possibility of sub-stocks, especially within the Yellowstone-Sakakawea stock, cannot be ruled out. Migration studies provide some evidence of homing and non-random mixing of adult fish in the Yellowstone and Missouri rivers below Fort Peck Dam (Braaten et al. 2009). More research is needed to clarify this situation.

NDGF and MFWP managers have the option of continuing accepting the unidirectional (i.e., downriver only) movement of fish and genetic resources past the dams or to attempt to mitigate for it, to some extent, by transporting fish upriver (Heist and Mustapha 2008), especially for the Oahe stock which is not known to reproduce (Bailey et al. 2018).

The three stocks

The Yellowstone-Sakakawea stock spawns in the Yellowstone River, as well as the Powder River. Larval paddlefish have been captured in the Powder River in 2014, 2016, 2017, 2018, and 2019 (M. Backes, MFWP, Personal Communication). They also spawn in the Missouri

River and Milk River below Fort Peck Dam (Firehammer et al. 2006; Firehammer and Scarnecchia 2007; Braaten et al. 2009). Young fish most commonly rear in Lake Sakakawea, a large Missouri River main stem reservoir in North Dakota (Figure 1). Some fish in this stock, both mature and immature, also remain in the Dredge Cuts, large, dredged ponds below Fort Peck Reservoir (Frazer 1985; D. Scarnecchia, Unpublished Data). Movement throughout their accessible range is common for individual paddlefish of this stock. Fish tagged and released below Fort Peck Reservoir have been recaptured at Intake on the Yellowstone River, and vice versa (Needham 1968; 1969a; 1969b; 1973a; 1981; Stewart 1990); considerable mixing of fish occurs between these areas. Pre-spawn fish also move from staging areas below the confluence of the Missouri and Yellowstone rivers (hereafter called the Confluence) into one or the other river depending on flow conditions (Firehammer 2004; Firehammer and Scarnecchia 2006; Miller and Scarnecchia 2008).

The Fort Peck stock rears in Fort Peck reservoir and spawns in the Missouri River upriver of the reservoir (Berg 1981; Miller and Scarnecchia 2008; Miller et al. 2008; Figure 1). Its life cycle is completed entirely within Montana. Epifanio et al. (1989) found this stock to be the most genetically distinct when compared to 21 paddlefish samples taken throughout the species' range. This stock was unfortunately not genetically characterized, however, in the more recent studies by Heist and Mustapha (2008) and Zheng et al. (2014). Fish from this stock are isolated from colonization from downriver, but the stock is a donor population to lower river stocks. Fish tagged above Fort Peck Dam have been captured in fisheries targeting the Yellowstone-Sakakawea stock (MFWP, unpublished data).

The Oahe stock inhabits Oahe reservoir and may spawn in the Missouri River and selected tributaries above the reservoir. Unfortunately, no evidence of any successful spawning has been found. Many, perhaps all, of the fish of the Oahe stock are probably Yellowstone-Sakakawea stock and Fort Peck stock fish that have entered Oahe reservoir from above Garrison Dam (Bailey et al. 2018). The total stock size is not known, but the in-river component has been estimated consistently in spring and summer at between 9,000 and 11,000 adult fish, not including recent immigration from the 2011 flood. The stock does not support a fishery as of 2020.

Available genetics studies (Epifanio et al. 1989; 1996) and life history differences indicate that the Yellowstone-Sakakawea and Fort Peck stocks are genetically distinguishable from each other and from downriver stocks. Yet, more recent studies (e.g., Heist and Mustapha 2008) have not clarified the issue and more research is needed in this area. Future studies will hopefully aid in assessing genetic differences and genetic diversity trends, as well as movements of juveniles based on microchemistry (Bock et al. 2017).

More practically, fisheries are distinctly separated geographically by the three reservoirs and their lentic habitats and function as discrete harvest management units. None of the reservoirs support paddlefish fisheries; harvest is confined by agency regulations to the rivers. For those reasons, Montana-North Dakota paddlefish are considered as three separate management units in this report and are treated as three distinct stocks. A complete historical review of each stock is provided below.

Yellowstone-Sakakawea stock and fishery

Realm

The Yellowstone-Sakakawea paddlefish stock inhabits the Lower Yellowstone (YR) and Missouri (MR) rivers of eastern Montana and western North Dakota (Scarnecchia et al. 1996b) and Lake Sakakawea of western North Dakota. The arid to semi-arid region is described as continental in climate, with long severe winters (as low as -45° C), short hot summers (30-35° C), low rainfall (30 cm in the west to 40 cm in the east; Finley 1893; Cunningham 1982), low humidity and a growing season of about 115 days (Torrey and Kohout 1956; Howard 1960). The two rivers dissect the Missouri Plateau area, which consists of exposed bedrock, generally of Late Cretaceous to Tertiary (Oligocene) origin (Leonard 1911; Howard 1960). Treeless uplands, mostly of grasslands, row crops, and scattered badlands, dominate the region, except near rivers, where the forested floodplains contain cottonwoods *Populus* spp. and ravines contain small cedars *Juniperus* spp.

The Yellowstone River, one of North America's last free-flowing large rivers, originates in Yellowstone Park and flows northward to Livingston, Montana, then predominantly northeastward for 1,091 river kilometers (Rkm) to the Confluence, 33 km southwest of Williston, North Dakota (Figure 3). Haddix and Estes (1976) divide the Yellowstone River into three portions, with the lower Yellowstone extending 636 Rkm from the mouth of the Bighorn River to the Confluence. Average gradient in the lower river is 0.53 m/Rkm (Graham et al. 1979). The direct-runoff hydrograph is strongly influenced by snowmelt. Elevated levels of discharge and sediment occur in spring, with the peak discharge typically occurring in June (White and Bramblett 1993). Average June discharge of the lower Yellowstone River at Sidney, Montana (YR km 47) over the period 1965-2019 was 992 m^3/s (35,024 cfs). The minimum mean monthly June discharge over that half century was 378 m^3/sec (13,360 cfs) in 2004, the maximum 1,968 m^3/sec (69,490 cfs), in 2011, and the median 935 m^3/sec (33,030 cfs). Firehammer (2004) described river reaches in the lower portion (YR km 71 to YR km 40) as containing "multiple islands and alluvial channel bars with swift current and substrate consisting of cobble and gravel" (p. 19). Sand replaces gravel as the predominant substrate in the lowermost 40 Rkm (Bramblett 1996). A recent cumulative impacts study (U.S. Army Corps of Engineers and Yellowstone River Conservation District Council 2015) identified numerous human-induced changes in the lower river system. These included a decline in the magnitude of the flood peaks (associated with upriver tributary impoundments), reduced summer flows, increases in bank armoring (e.g., rip rap), increased floodplain and side channel isolation, conversion of forested riparian areas to cropland, reduction in wetland area, increase in invasive species (flora and fauna), and water quality changes associated with agriculture. For more than a century, the lower

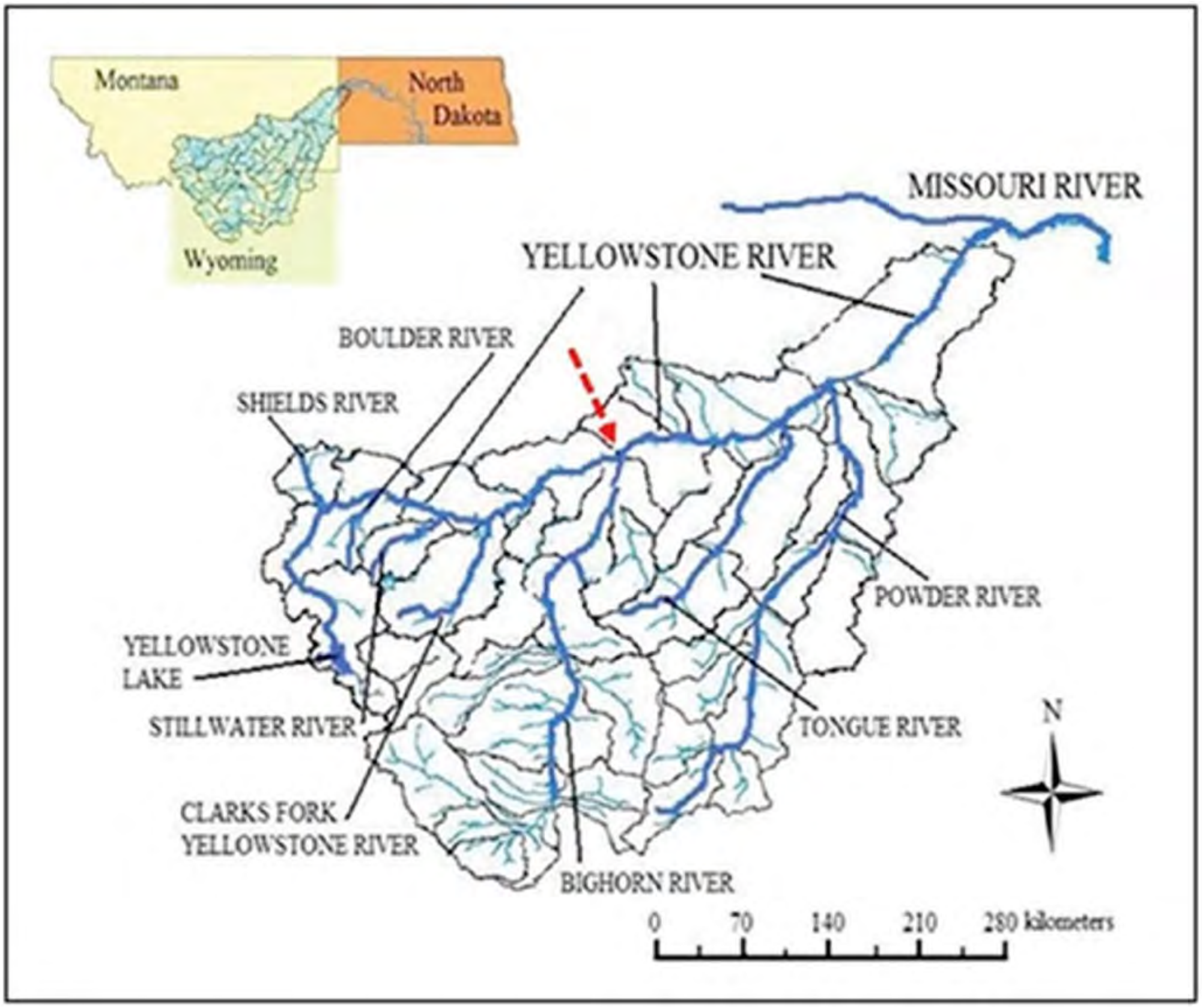


Figure 3. The Yellowstone River Basin. From Watson et al. (2018).

Yellowstone River has provided water for mining, oil, and other energy industries, livestock and row-crop agriculture, municipal use, and fisheries and other recreational uses (Watson 2014). The fish community in the lower river, the portion of the river inhabited by paddlefish, is primarily a warm water fauna (Haddix and Estes 1976) with some additional cool-water species (U.S. Army Corps of Engineers and Yellowstone River Conservation District Council 2015).

The Missouri River originates with the merging of the Gallatin, Jefferson, and Madison rivers in southwestern Montana, flows northward, then eastward to the Confluence near the North Dakota state line (Figure 1). The accessible portion of the Missouri River above the Confluence has been strongly influenced by the Fort Peck Dam and reservoir. Dam completion resulted in a more stable discharge, a reduction in sediment load, and colder summer water temperatures than before impoundment (Welker and Scarnecchia 2004; Braaten et al. 2009; Figure 4). Mean June discharge of the Missouri River at its lowest gauge station above the Confluence (at Culbertson, Montana) over the period 1965-2019 has averaged 344.2 m^3/sec (12,155 cfs), or about 35% of the mean June flow of the Yellowstone River at Sidney during the same month and over the same period. The minimum discharge was 168.5 m^3/sec (5,950 cfs) in 2009, the maximum 2,092.3 m^3/sec (73,890 cfs) in 2011, and the median 271.8 m^3/sec (9,598 cfs).

Lake Sakakawea, the primary rearing habitat for the Yellowstone-Sakakawea stock (Fredericks and Scarnecchia 1997), and the largest Missouri River mainstem reservoir (area, 156,000 Ha), was built under the Pick-Sloan Plan (Hart 1957). Construction of the project “was initiated in 1946, closure of the dam was made in April 1953, and in December 1953 the project was placed in operation for flood control, as an aid to navigation on the Missouri River, and for storage” (p. IV-1) (U. S. Army Corps of Engineers 1978). After the initial filling of the reservoir over a 13-year period (1953-1966; Scarnecchia et al. 1996b), the reservoir has exhibited wide fluctuations in water levels, particularly since 1989. As described by Fryda et al. (2014), “Since 1967… the reservoir has fluctuated from a high of 1854.9 ft msl in July 1975 to a low of 1805.8 ft msl in May 2005… this 50-foot fluctuation amounted to a difference between high and low water marks of 172,884 surface acres and 13,959,592 acre-feet of water. At 1805.8 ft msl Lake Sakakawea contained approximately 40% of full pool volume. The flood of 2011 saw reservoir elevations reach the second highest level ever at 1854.6 ft msl in July. Lake Sakakawea has experienced other high-water events… , most notably August 1995 and July 1997…[reaching] elevations of 1852 and 1854.4 ft msl respectively. However, the 2011 flood was unprecedented in … duration. … [E]levations remained above 1850 msl for more than 4 months and the reservoir was in the exclusive flood control zone (1854 ft. msl) for more than 2 months…. Conversely, during the most recent drought (2004-2008), Lake Sakakawea largely remained below the previous drought low of 1815 ft msl” (p. 32; Figures 5,6,7). Fryda et al. (2014) also noted that reservoir elevations over the first period of the reservoir’s history (e.g., 1953-1989) were much more stable than they have been since then (Figure 5).

Figure 4. Confluence of the more turbid, largely unregulated Yellowstone River (top) and the clearer, regulated Missouri River near Buford, North Dakota.

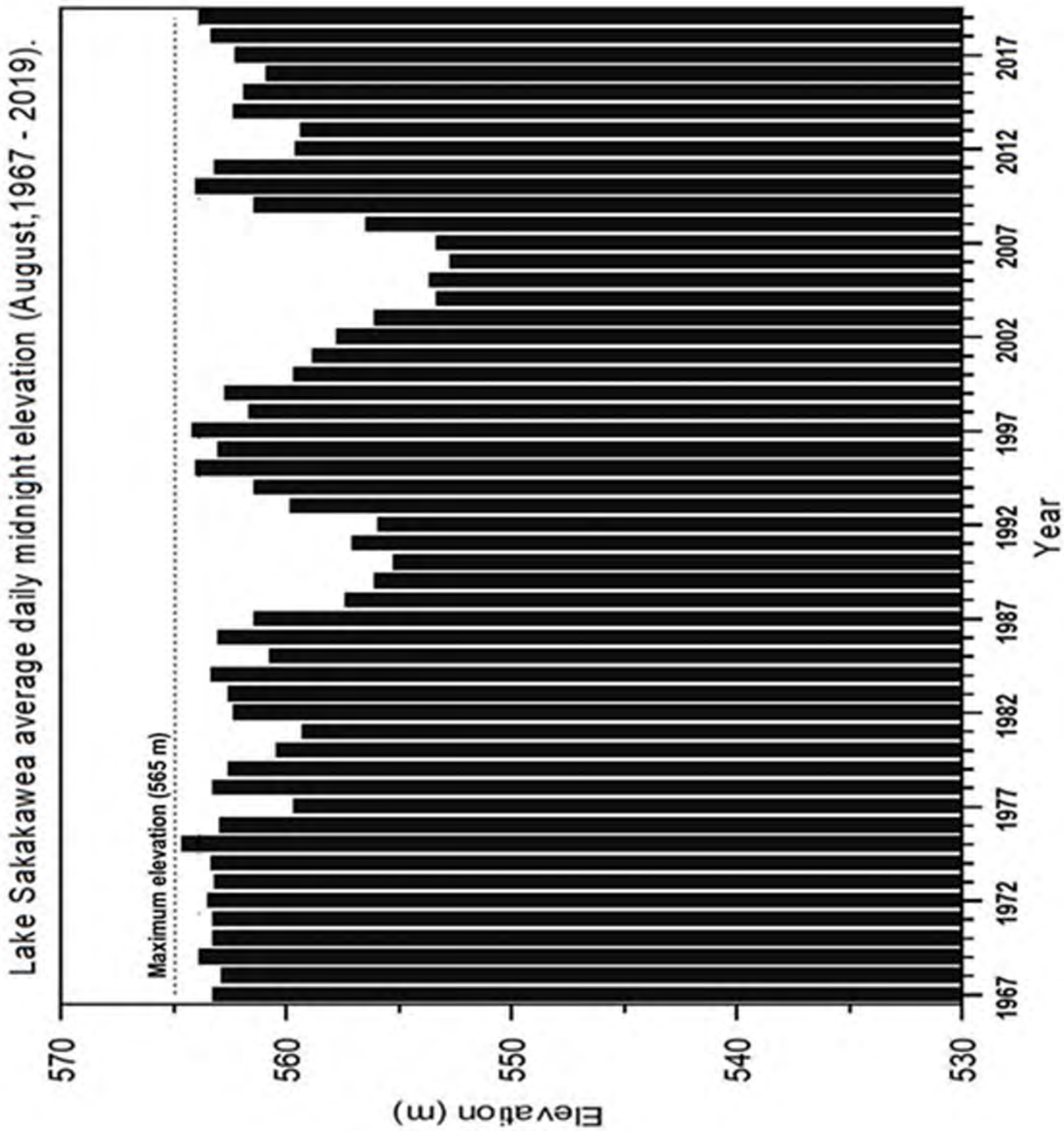


Figure 5. Lake Sakakawea elevations, August, 1967-2019.

Figure 6. a) Ground and b) aerial views of floods in the upper end of Lake Sakakawea, circa 1997.

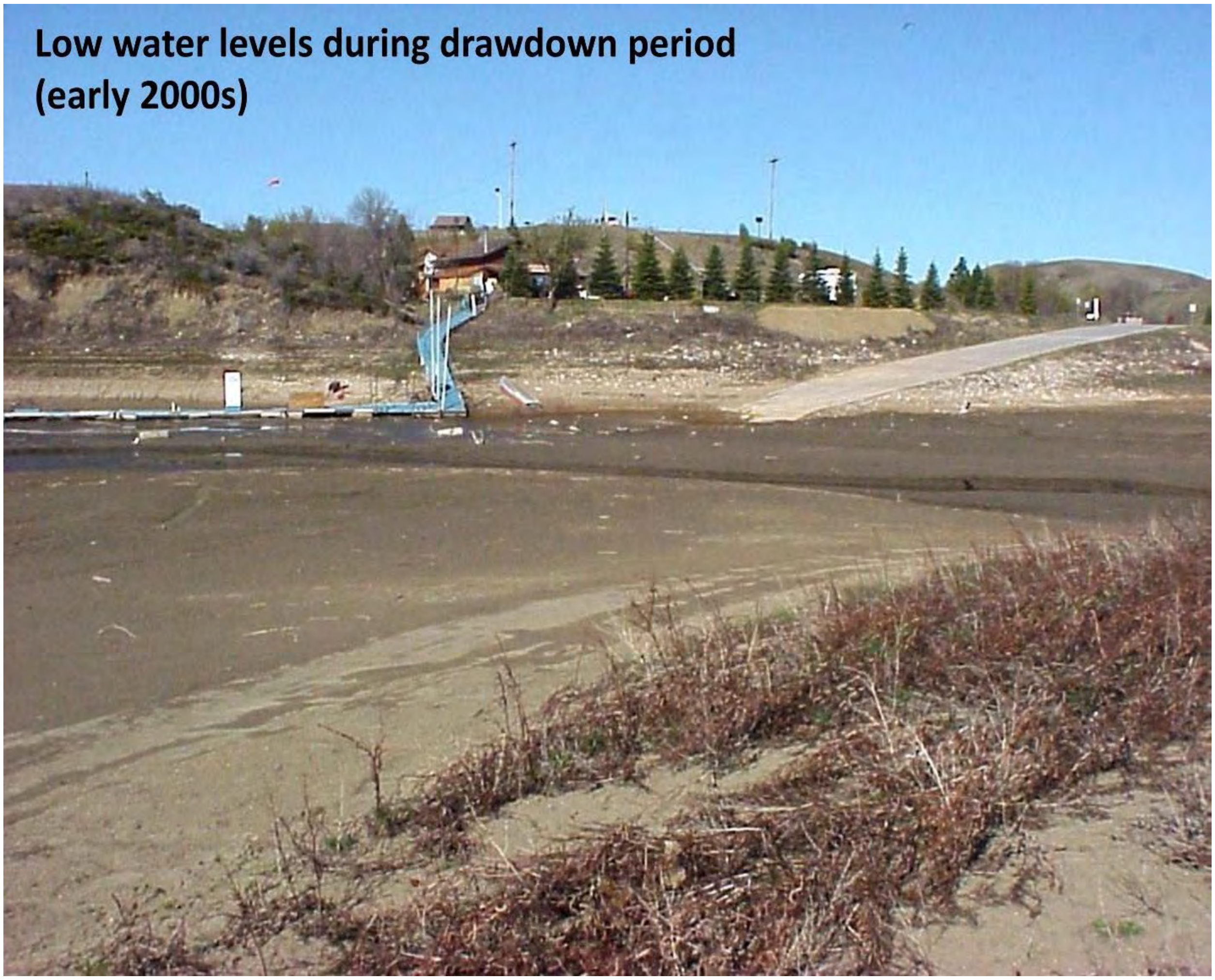


Figure 7. Drawdown during the early 2000s in Lake Sakakawea.

Distribution and migrations

The Yellowstone-Sakakawea paddlefish stock's range extends from Garrison Dam up reservoir through Lake Sakakawea. From the headwaters of the reservoir, the location of which can vary more than 50 Rkm depending on water levels, paddlefish distribution extends upriver to the Confluence, westward up the Missouri River 302 Rkm to the tailrace of Fort Peck Dam, and southwestward up the Yellowstone River 114 Rkm to Intake, the site of a low-head irrigation diversion dam northeast of Glendive (Torrey and Kohout 1956; Figure 1). In years of high spring discharge, some migratory paddlefish historically moved either over or around the dam (via a flooded side-channel around Joe's Island) past Intake as far as the Cartersville Diversion Dam at Forsyth (YR Rkm 382). This side-channel has been completely filled in as of 2020 as part of the Intake Dam fish bypass project. Some fish also enter the Powder River, as indicated by catches of larval paddlefish over the period 2014-2019. In some years of high discharge, fish move past the Cartersville diversion and can reach the Bighorn River (and into it, as in 2017; MFWP, Unpublished Data) and beyond. In a year with average flow conditions, few or no fish make these longer migrations. For example, Bollman (2016) and Rugg et al. (2019) reported that of 40 adult paddlefish radio-tagged and released in May 2015 in the 16 km reach below the Intake Diversion Dam, five were tracked above the Dam, four reaching the mouth of the Powder River (Rkm 230), two passing upstream of the Powder-Yellowstone River confluence, and one fish moving as far as the river reach adjacent to Rosebud, Montana (Rkm 355). Similar upriver movements were found in 2017 and 2018 (Figure 8a). However, in 2016 when discharges at Intake Dam were lower, none of the 53 tagged fish were tracked upriver of the Dam (Figure 8b). Harvest records over more than half a century corroborate that higher spring flows in the Yellowstone River are strongly associated with more extensive movement of pre-spawning paddlefish upriver and greater contributions to the Montana fishery (especially Intake). In years with lower spring discharge, fish typically remain farther down the Yellowstone River and make greater contributions to the North Dakota fishery. In most years, discharges are influenced primarily by snowmelt, although spring rainfall is often an important factor in affecting discharge (e.g., 2011). In low flow years, runoff can be influenced, to an increasing extent, by early season irrigation withdrawals (U.S. Army Corps of Engineers and Yellowstone River Conservation District Council. 2015). Releases from Yellowtail Dam can also affect discharges and paddlefish movements in the lower Yellowstone River.

Life history and ecology

Stock history - The life history of the Yellowstone-Sakakawea paddlefish stock, the most thoroughly studied of the three stocks considered in this Plan, has been reconstructed from past investigations by Robinson (1966), Rehwinkel, (1978), and Scarnecchia et al. (1996b; 2007b; 2009). This stock became more abundant in the mid- to late-twentieth century (Van Eeckhout 1980; Scarnecchia et al. 1996b), in contrast to most other paddlefish stocks nationwide (Carlson and Bonislawsky 1981; Gengerke 1986). During the period 1953-1966, from the closure of Garrison Dam to the complete filling of Lake Sakakawea, the population proliferated due to the increase in rearing habitat and trophic upsurge in the newly-formed, slowly-filling reservoir

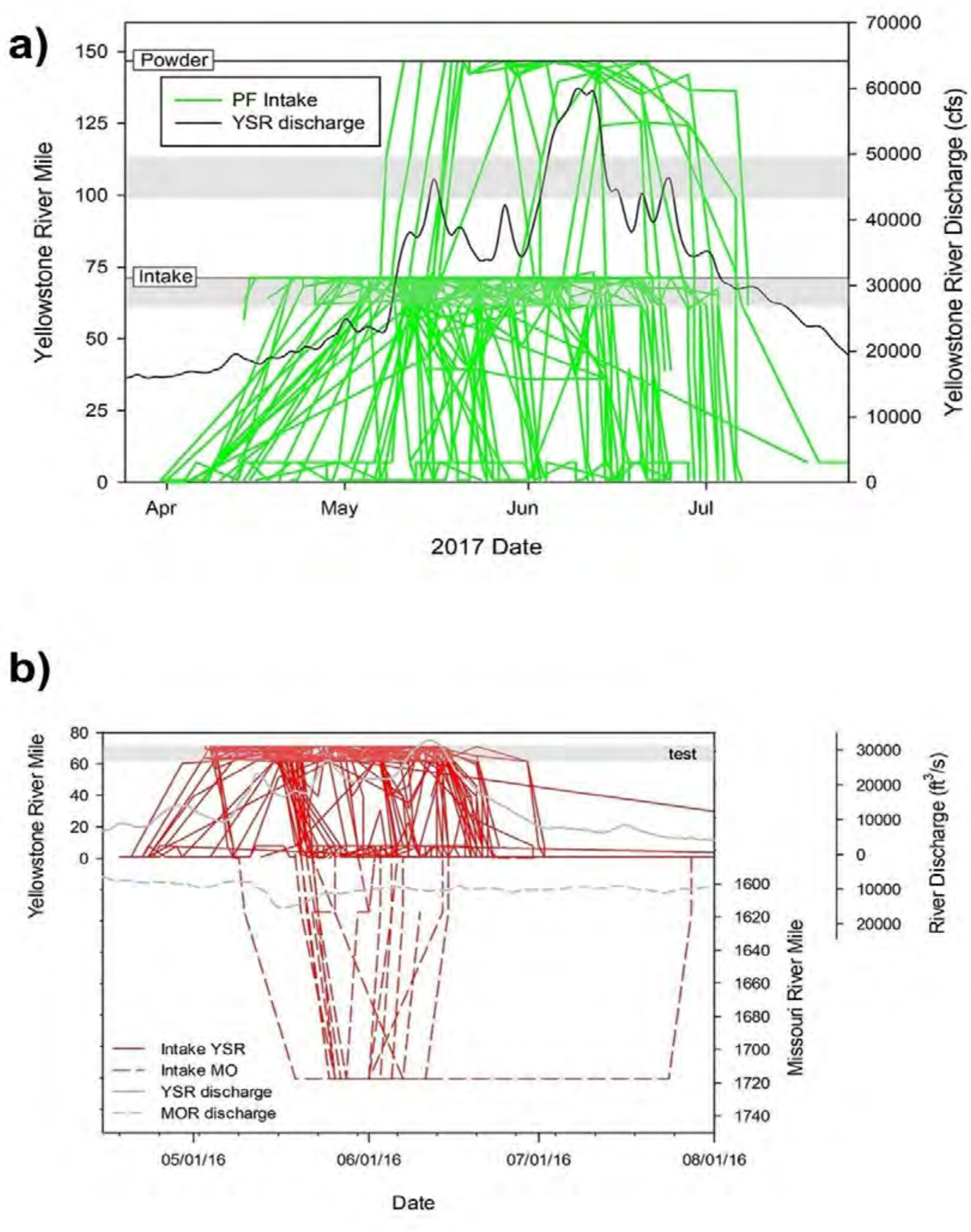


Figure 8. a) Paddlefish movements around the Intake diversion Dam during higher water year, 2017. (C. Bollman, MFWP, Unpublished Data; Rugg et al. 2019); b) Movements blocked by the dam, 2016. (C. Bollman, MFWP, Unpublished Data)

(Scarnecchia et al. 2009). Since dam closure, most Yellowstone-Sakakawea paddlefish have reared in Lake Sakakawea as immature fish and as mature fish between spawning migrations

(Van Eeckhout 1980; Stewart 1990). Some fish also rear in the Dredge Cuts below Fort Peck Dam, sometimes for years (Frazer 1985) and periodically migrate downriver. Young paddlefish survived and grew better in Lake Sakakawea than before the reservoir, when they had relied mainly on riverine habitat and some backwaters such as Trenton Lake (west of Williston).

Evidence of several types supports the idea of increased abundance of paddlefish after Lake Sakakawea came into existence. The first year of significant paddlefish catches at Intake was 1962, nine years after the closure of Garrison Dam. Robinson (1966) reported that during the period 1963-65, 97% of the paddlefish caught at Intake were mature males, which is the expected occurrence if the first males produced after the creation of Lake Sakakawea matured at about 9-11 years of age. Females, which mature at older ages than males (Rehwinkel 1978; Scarnecchia et al 1996b; 2007b), were still immature and remained in the reservoir to feed. Females first appeared in significant numbers at Intake several years later (Elser 1975). By 1973-74, the sex ratio of paddlefish harvested at Intake had reached 1:1, as females approached full recruitment. By 1978, when both sexes were fully recruited, population estimates from tag-recoveries indicated that the population size of harvestable fish peaked at about 120,000 fish. By the mid-1980's the sex ratio of the harvest had shifted to 55-70% females. Weaker year classes ensued as the reservoir aged. It was in the mid-1980s that the large percentage of mature females harvested generated interest in the development of a roe-donation program at Intake.

Since the peak population in the late 1970s, population size of mature fish has steadily decreased. This decrease is attributed to a natural decline in reservoir productivity after the initial trophic upsurge, natural mortality of fish in the strong post-impoundment year classes, and harvest of recruited fish. Since the initial population surge associated with reservoir filling, population size of recruited fish has fluctuated according to recruitment of strong year classes. Harvest gradually decreases stock size in between strong recruitment years (Scarnecchia et al. 2014). In recent years, population size of adult fish migrating up the Yellowstone River in a given year has typically been estimated at between 25,000 and 40,000 fish, depending on the methods used. This number does not include adult (i.e., mature) fish not migrating to spawn that year, nor immature fish in the reservoir.

Pre-spawning and spawning movements - Adult fish destined to spawn in a given year move out of Lake Sakakawea into the Missouri River below the Confluence either that spring or in the autumn before their spawning year (Firehammer et al. 2006; Braaten et al. 2009). In spring (April-June), sexually mature fish ascend from below the Confluence into the Yellowstone River, and to a lesser extent the Missouri River (Miller and Scarnecchia 2008; Braaten et al. 2009) during rising discharge (Penkal 1981; Firehammer 2004; Firehammer and Scarnecchia 2006). Paddlefish have also been confirmed to spawn in the Powder River, as evidenced by collections of larval fish associated with sturgeon studies (Braaten et al. 2017; Braaten 2017). Miller and Scarnecchia (2008) reported that over a two-year period (2003-2004), telemetered paddlefish selected the Yellowstone River over the Missouri River 63% of the time, and that "Fish typically ascended the river with flows that were increasing at a greater rate or decreasing at a lesser rate than the other river" (p. 221). Similar frequency of river selection (i.e., about two-thirds Yellowstone, one-third Missouri) was reported by Braaten et al. (2009) over the period

2002-2005. A high tendency for river fidelity was also found; 93% of the fish implanted in the Missouri River above the Confluence used that river on multiple spawning migrations. Similarly, 96% of the fish tagged below the Confluence selected the same river on multiple spawning events. Some fish that had ascended the Missouri River to near Fort Peck Dam later migrated, at least briefly, into the Milk River, a quasi-natural, turbid, Missouri River tributary entering just below the dam (Terrazas et al. 2016), when cued by rising discharge and high-water events (Braaten et al. 2009; Fuller and Braaten 2012). Paddlefish also spawn in the Milk River, at least in some years (Needham 1980; Gardner and Stewart 1987; Gardner 1992; Bednarski 2004; Braaten et al. 2009). Timing of entry was also typically later into the Milk River than in the Yellowstone River, consistent with the later spawning and later larval emergence on the Missouri and Milk rivers than in the Yellowstone River.

Spawning - Details of actual spawning remain largely unknown in the turbid spring runoff of the Yellowstone River. No clear observations of actual spawning comparable to those of Purkett (1961) in the Osage River, Missouri have been documented, although reports have been made of large fish splashing in several river sections. Well-defined spawning sites have not been identified and may vary from year to year. Eggs have been recovered at several sites in the Yellowstone River in May, June and early July (Firehammer et al. 2006; Miller et al. 2008), most commonly at locations in the lower 40 km. Over the period 2001-2002, Firehammer and Scarnecchia (2006) sampled eggs with mats and tubular collectors (mats silted over and were unsuccessful in 2000) and found 89 identified paddlefish eggs, with the peak of collection in the first week in June, after flow peaks, at Rkm 9.5 and 13.5. Miller et al. (2008) followed up the study of Firehammer and Scarnecchia (2006) in 2003. They found 46 positively-identified paddlefish eggs over the period June 13-July 1, on the descending limb of the hydrograph with a peak on June 26. Highest catch-per-unit-effort (CPUE) was at Rkm 26.5, although 20 of 46 eggs were sampled at Rkm 13.7 or below. In 2004, 246 confirmed paddlefish eggs were sampled, 182 of them in the lowermost 13.7 km of the river. Eggs were collected from June 1 to July 2. CPUE peaked on June 11, and 99% of the eggs were sampled immediately before the sharp peak in the hydrograph. Overall, results were consistent among years, indicating that egg deposition and larval hatching occur most typically in June, with increases in river discharge. Spawning may occur at numerous locations when appropriate conditions exist. Miller et al. (2008) found eggs at all 5 transects they sampled (Rkm 9.7, 13.7, 26.5, 37.0, and 40.2, with the most eggs found at Rkm 26.5). In 2004, eggs were again found at these transects except Rkm 40.2. In addition, observations of mature paddlefish at both cleaning stations (the Confluence and Intake) show that female ovulation is not highly synchronized in time. This lack of synchrony suggests that spawning does not occur at the same time among all pre-spawning fish in a given year. This conclusion is supported by the presence of spawned out females at fish cleaning stations as early as May and the presence of unspawned females into late June or longer. Some pre-spawning migratory fish may not spawn that year; under the present river-only fishing season in spring and the no-kill sampling regime by the agencies at other seasons, their presence would be difficult to detect. More information is needed on the frequency of spawning failure and gonadal atresia.

Larvae and early life history - Early studies on larval paddlefish sampling for the stock are detailed in a series of reports by Gardner (1990; 1991; 1992; 1993; 1995; 1996; 1997). The most effective sampling for larvae was conducted with round and D-ring nets drifted slowly downstream near the river bottom. In all years, however, most larvae were found in June from the area near the Montana-North Dakota state line (Rkm 29.8) downstream to near the Confluence. Highest concentrations were typically centered near the Fairview Bridge (YR Rkm 14.5). Some larvae were also found in the first few kilometers of the Missouri River above the Confluence. Only rarely were larvae sampled upriver near Intake. Estimated timing of spawning of eggs producing the larval fish was generally specifically linked with rising or high discharges events in May and June. For example, in 1996, the last year of Gardner's study, catches of paddlefish larvae were highest during the week of June 12, within 10 days after the river had reached 1,133 m^3/sec (40,000 cfs) and 5 days before the peak discharge of 1,841 m^3/sec (65,000 cfs; Gardner 1997). Gardner (1996) referenced unpublished data collected by J. Liebelt (MFWP), that larvae were found in the Missouri River in mid-July, later than they were typically found in the Yellowstone.

These earlier results were supported by later studies by Fuller and Braaten (2012). They found larval paddlefish in the Yellowstone River every year over a nine-year period (2001-2009), but on average about three weeks earlier in the Yellowstone River than in the Missouri River. Higher larval densities were associated with higher river discharge over the periods May-July and June-July. Larval sampling from the Milk River over the nine-years showed much variation in the number of larval paddlefish collected (Fuller and Braaten 2012). In three of the nine years, no larvae were collected from the Milk River, but all years yielded larvae from the Missouri River sampled downriver at Wolf Point and at Nohly, near the Confluence. Peak densities in the Milk River occurred from early June to early July, depending on the year. Larval production, as indicated by catches, increased with increasing discharges during June. Higher larval densities in the Milk River were typically associated with higher densities downriver at Wolf Point. However, even in years where no larval paddlefish were captured in the Milk River (2003, 2006, 2009), larvae were nevertheless captured elsewhere downriver in the Missouri River, suggesting that the Milk River may not be the sole origin of larvae.

Fuller and Braaten (2009) also found a later occurrence of initial detections of larval paddlefish in the Missouri River than in the Yellowstone River. Initial detections in the Yellowstone River were typically in late May, whereas initial detections in the Milk River were typically in June; both were associated with pulses in discharge. Initial detections downriver in the Missouri River were typically later, extending into July in some years (2003, 2009); these detections were not closely associated with flow pulses. This result is consistent with the idea that the Yellowstone River (including the Powder River, at least in some years; Braaten et al. 2014; Braaten 2017) and Milk River may provide the most utilized spawning habitat. Delayed spawning of adults in the Missouri River system (including the Milk River) is associated with lower water temperatures in the Missouri River mainstem below the Milk River confluence. The delay has the potential to negatively affect their recruitment, as larger age-0 fish have been correlated with increased survival to recruitment (Scarnecchia et al. 2019b).

Fish monitoring efforts primarily associated with pallid sturgeon passage at Intake Diversion Dam included larval sampling in the Powder River in 2014, 2017-2019. Genetic testing of larvae confirmed the presence of paddlefish larvae in the Powder River in 2017 and 2019 (Bollman 2021). Standardized annual larval sampling will be initiated in 2021 for the Tongue, Powder and Yellowstone rivers to monitor paddlefish spawning and larval production upstream of Intake Diversion Dam.

A thorough understanding of egg and larval abundance as it relates to population dynamics is lacking. In all past studies, sampling yielded too few larvae or eggs to draw firm conclusions about factors such as year class strength and peak time of spawning. More effective sampling (higher overall catch and CPUE) is needed to improve the usefulness of egg and larval sampling as a spawning or recruitment success metric or as a sampling tool for a source of fish that could be reared in hatcheries (i.e., as a substitute for hatching eggs from broodstock; https://www.fws.gov/columbiariver/nwfcc2012/presentations/S7_Combs.pdf). This activity deserves attention over the next decade.

Post-spawning - Adult fish typically remain in the Yellowstone River in May and June until spawning is completed or sometimes later into the summer, until river discharge drops sharply, at which time fish descend into the reservoir (Firehammer 2004; Firehammer and Scarnecchia 2006; Miller and Scarnecchia 2008; Rugg et al. 2019). Braaten et al. (2009) reported that adult migratory fish remained longer in the Missouri River than in the Yellowstone River before moving downriver. Some fish linger in the Missouri River above the Confluence into the summer and beyond (Gardner and Stewart 1987), and may remain year-round, a possible response to regulated flows. Less often, fish have also been reported to remain in the Yellowstone River into autumn (Elser 1977). Fish netted below the Confluence in autumn may be early migrants, overwintering and then making a spawning migration the next year (NDGF and MFWP, Unpublished Data).

Biology and ecology in Lake Sakakawea - The life history and ecology of Yellowstone-Sakakawea paddlefish in Lake Sakakawea in their first summer has been investigated by Fredericks (1994), Fredericks and Scarnecchia (1997) and Scarnecchia et al. (2009, 2019b). Newly hatched larvae descend from the Yellowstone River into the turbid headwaters of Lake Sakakawea, where by July and August (as 150-250 mm fork length (FL) fish) they are feeding selectively on invertebrates, chiefly the large, predaceous cladoceran *Leptodora kindtii*. Fredericks (1994) reported that *Leptodora* constituted less than 1% of the ambient zooplankton by number but 85-99% of the stomach contents of age-0 paddlefish. In late July, age-0 fish (150-170 mm FL) appear near the surface of Lake Sakakawea as pink translucent fish with a spear-shaped rostrum. Growth is rapid, so that fish may reach 200-270 mm FL by the second week in August, at which size they appear as grey-black with a fully developed rostrum of nearly one-half their FL. At this size, the fish are not yet filter feeding but are actively pursuing and selecting individual food items. Their electrosensory system is used in food acquisition (Wilkins et al. 2002). Their dentaries have teeth on the upper edge (unlike adult fish), and eye size in relation to fish size is larger than in adult fish. However, Wilkins et al. (1997, 2001) showed that effective prey detection by age-0 fish even occurs under infrared illumination only. The roles of dentary teeth in food acquisition were not described, although it is plausible that they may aid in prey retention. Age-0 fish in Lake Sakakawea frequently occur in loose aggregations with a patchy distribution, which is possibly associated with a patchy distribution of their preferred food. Observations of young fish in captivity suggest that fish evidently feed day and night. When age-0 fish were held in permeable live wells (netting) in Lake Sakakawea, retention led to rapid emaciation within 72 hours, suggesting that growth and survival requires aggressive food acquisition and highly active searching during the summer feeding period, when fish metabolic rate is high. By late fall or the following summer, they are fully filter-feeding on a wide variety of zooplankton and other invertebrates (Michaletz et al. 1982; Fredericks 1994; Scarnecchia et al. 1995a; Fredericks and Scarnecchia 1997) with the aid of long, filamentous gill rakers (Kofoid 1900; Imms 1904; Miller 2004). In Lake Sakakawea, age-0 and sub-adult paddlefish feeding near the surface in late July through September can be seen fleeing from slowly approaching motorboats (Scarnecchia et al. 1997).

Age-1 fish, older sub-adults and adults have been reported in diverse locations of Lake Sakakawea, including, but not limited to, areas previously documented to be occupied by age-0 fish. Historical catches of sub-adults and adults were common with gillnets in the Van Hook Arm and Beaver Bay (G. Power, NDGF, letter to S. Dyke, June 4, 1990). Distribution appears to vary greatly with reservoir level and resulting changes in feeding conditions. Too few paddlefish have been caught, and factors affecting catch rates are too poorly understood, to draw firm conclusions on abundance by area. Available evidence from visual observations and netting, however, indicates that adult fish are widely distributed throughout the reservoir in summer (Jeff Hendrickson, NDGF, Dickinson, Personal Communication). Within the past 30 years, extensive but poorly documented sedimentation in the upper portion of Lake Sakakawea has limited the distribution of all ages of paddlefish.

Biology and ecology in the Dredge Cuts - Life history and biology of the paddlefish in the Dredge Cuts and Missouri River below Fort Peck Dam is detailed most thoroughly by Frazer (1985). Reports by Needham (1968; 1969a; 1969b; 1970; 1971; 1973a; 1973b; 1974a; 1974b; 1976; 1977a; 1977b; 1979; 1980a; 1980b; 1981; 1982; 1985), Needham and Gilge (1986), and Gardner and Stewart (1987) also summarize annual research and management efforts. Many studies were conducted before 1990. Needham (1979) estimated the population size of paddlefish in the upper Dredge Cuts during the summer of 1978 as 3,406 fish. Gardner and Stewart (1987) and Frazer (1985) analyzed recoveries of jaw-tagged fish and concluded that some Dredge Cuts paddlefish are resident, remaining there for several years. Some Dredge Cuts fish also migrate to Intake, and vice versa. Frazer (1985) reported that as of 1985, 45 paddlefish originally tagged in the Dredge Cuts had been harvested in the Yellowstone River, primarily at Intake. Conversely, at least 32 paddlefish tagged at Intake had been recaptured in the Dredge Cuts. Several fish tagged in the Dredge Cuts have been recaptured at Intake more than 35 years after tagging (MFWP, Unpublished Data). Based on age information, Frazer (1985) concluded that the Dredge Cuts supported a distinct, only partly isolated segment of Yellowstone-Sakakawea paddlefish, a segment that had been in the river before Garrison Dam was closed in 1953. The Intake fishery, in contrast, consisted mainly of post-Garrison Dam fish. Frazer (1985) also noted that because of the lack of spawning habitat in the Dredge Cuts, the fishery relied on a continual infusion of fish from downriver areas or, depending on access, from upriver after being flushed out of Fort Peck Reservoir. In his efforts at documenting seasonal movements of Dredge

Cuts paddlefish, fish were typically found in the upper Dredge Cuts (i.e., the ponds) most of the year but moved into the tailpool in the fall. He attributed this movement into the tailpool as a possible response to seasonally warmer water there and seasonally higher concentration of the large zooplankton species such as *Daphnia* and *Diaptomis* (although smaller zooplankton species were more abundant in the upper Dredge Cuts ponds). Growth of Dredge Cuts paddlefish was found to be significantly lower than that of Yellowstone-Sakakawea paddlefish, which was attributed to the lower productivity in the Dredge Cuts than in Lake Sakakawea (Frazer 1985). This slow growth can be seen in lower total weights and closely spaced annuli on dentaries of fish tagged and released in the Dredge Cuts (D. Scarnecchia, University of Idaho, Unpublished Data).

Paddlefish life history framework and validation **-** The life history of the Yellowstone-Sakakawea stock has been explained in detail and interpreted by Scarnecchia et al. (2007b; 2019a) in terms of the costs of reproduction and life history tradeoffs (Sinervo and Svensson 1998). Males and females grow at similar rates to at least age 5. Over the ensuing decade, growth rates of males and females diverge greatly as males begin diverting production away from somatic growth into sexual maturation, indicated by an increasing gonadosomatic index (GSI; Figure 9). Thereafter, males remain shorter in length and weigh much less than females of comparable age (Figures 10,11). Validated ages indicate that males become sexually mature starting at about age-8 and are fully recruited from age-10 to age-12 (Tables 1, 2). Females of the same brood years continue to grow more rapidly than their male counterparts, channeling energy predominantly into somatic growth until about age-13 or age-14, when they begin diverting energy into sexual maturation (Figure 12). By age-15, females weigh on average about 10 kg more than males, and this sexual size dimorphism is maintained throughout the rest of the lifespan (Figures 10,11). Females are mostly recruited by age-17 to age-19, although delayed reproduction of some fish is possible. At the time of the males and females first upstream spawning migration, both sexes have mature gonads, to which are attached gonadal fat bodies (GFBs) consisting mainly of lipids and water that have been amassed during their immature growth period in the reservoir (Figure 13). Some first-time migrants have amassed large GFBs, most have amassed some fat as GFBs, and a few have amassed little or no fat as GFBs (Figures 14,15). Increases in fecundity among young adult males and females, as indicated by GSI (Figures 9, 12) are concurrent with decreases in the weight of GFBs (Figures 14,15). Males typically spawn every one or two years (Figure 16a, 17a) and deplete the lipid reserves gradually over several spawns (Figure 14). Females typically spawn every two or three years (Figures 16b, 17b) and deplete the lipid reserves more rapidly, over two or three spawns, so that it is largely depleted by age-25 (Figure 15). After the females' depletion of the gonadal fat, GSI remains steady and reproductive effort is maximized for another decade, until about age-40, when it may in some fish begin to decrease, an indication of senescence. Younger fish, both male and female, are more likely to migrate upriver to Montana whereas older fish, both male and female, are more likely to remain downriver in North Dakota. Older fish of both sexes also tend to mature and spawn at shorter intervals than younger fish. Fish migrating upriver to Montana that are tagged there are more likely to be recaptured in Montana in subsequent years, whereas fish tagged in North Dakota are more likely to be recaptured in North Dakota in future years. Despite higher fishing mortality rates on females tagged as migratory adults, the number of age-30 and older females exceeds that of males (Tables 1, 2). This difference results from an earlier age at harvest and higher natural mortality on younger mature males (at a time when females are still in the reservoir and not yet vulnerable to harvest) and the more frequent spawning migrations of males. Total mortality rates are comparable for males and females over age-25 (Figure 18). By age-40, mortality (natural or fishing) has removed most fish of both sexes, although both male and females may exceed age-50 (Tables 1, 2).

In summary, Yellowstone-Sakakawea paddlefish life history can be divided into five stages, which occur at different ages for each sex: 1) immature, 2) maturing, 3) somatic growth and reproduction, 4) prime reproduction and 5) senescence to death (Figure 20). Validated ages (i.e., of proven accuracy; Scarnecchia et al. 2006) using dentaries (lower jaw bones) of this stock (Figures 20, 21) have been linked to these life stages (Scarnecchia et al. 2019a), leading to progress in validating their life history (Scarnecchia et al. 2019a). During the first period (immature), fish exhibit rapid somatic growth as well as accumulation of energy reserves in the form of GFBs and other fat deposits. GFBs are near their maximum at the end of this period. During the second period (maturing), somatic growth slows as production and stored energy reserves are diverted into reproduction. Total mortality rates are low during the latter portion of the immature period and the maturing period as the fish are large enough to avoid predation and no fishery acts on them. In the third period (somatic growth and reproduction), fish are allocating energy to both somatic growth and reproduction. Reproductive periodicity is typically close to two years for males and three years for females; gonadal recrudescence is slower than in the fourth period. GSI is increasing and GFBs are depleted over 2-3 spawns in females and reduced more gradually in males. Fish are often migrating longer distances upriver. River fisheries on migratory fish deplete males more rapidly than females. In the fourth period (prime reproduction), somatic growth is slow or negative as energy is strongly routed into reproduction. GSI is at a maximum; GFBs are completely depleted in females and are still being gradually reduced in males. Reproductive periodicity is typically one year for males and two years for females; the rate of gonadal recrudescence is at its maximum, and faster than in the third period. Fish do not tend to migrate as far upriver prior to spawning. In the fifth period, indications of senescence are not strongly detectable, in part because of harvest having eliminated some of the oldest fish. However, GSI of some of the oldest females decreases and the oldest males have reduced energy reserves and are typically long and lean. Additional detail about the life history and its evolutionary significance are discussed by Scarnecchia et al. (2007b; 2011; 2014; 2019a).

Year class strength and recruitment – Evidence indicates that year class strength of Yellowstone-Sakakawea paddlefish is strongly influenced by water levels in Lake Sakakawea. The great increase in numbers of mature male paddlefish at Intake in the early 1960s was associated with the initial filling of Lake Sakakawea over the period 1953-1966 (Robinson 1966; Scarnecchia et al. 1996b; 2009; Figure 5). Similarly, the exceptional strength of the 1995-year class (Figure 22) was associated with the sharp rise in reservoir level beginning in August 1993 and extending through 1995 (Scarnecchia et al. 2009; 2014). This was the longest and greatest

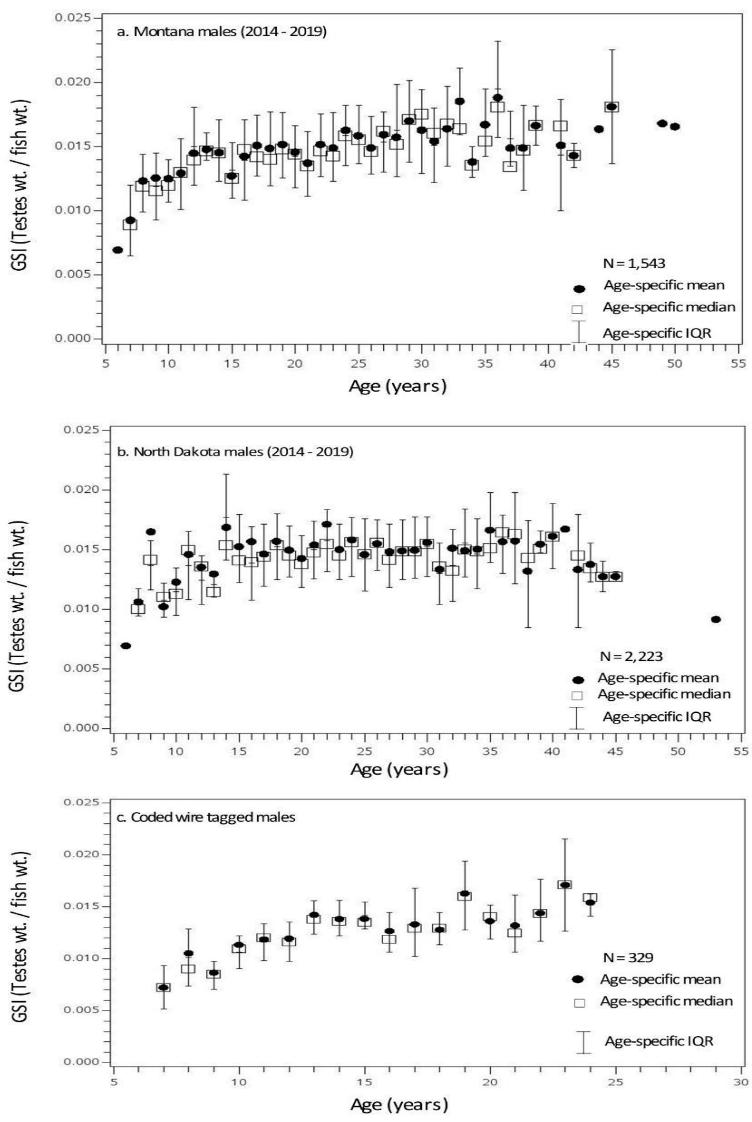


Figure 9. Gonadosomatic index (mean, median and inter-quartile range) for male paddlefish caught in 2014-2019 in a) Montana b) North Dakota, and c) from known age fish of all years 2002-2019.

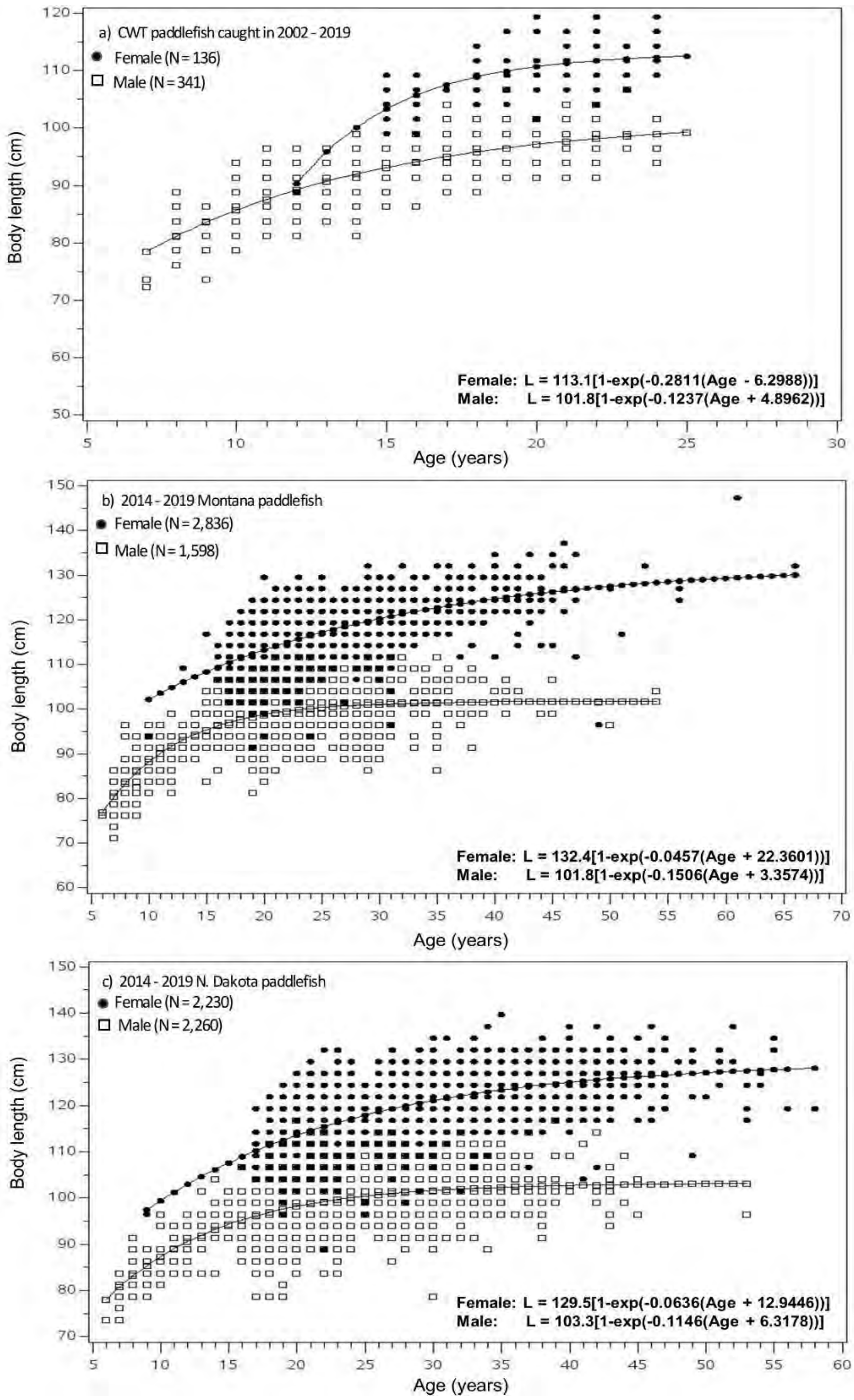


Figure 10. von Bertalanffy growth curves for paddlefish a) of known age, 2002-2019, b) from Montana, 2014-2019 and c) from North Dakota, 2014-2019.

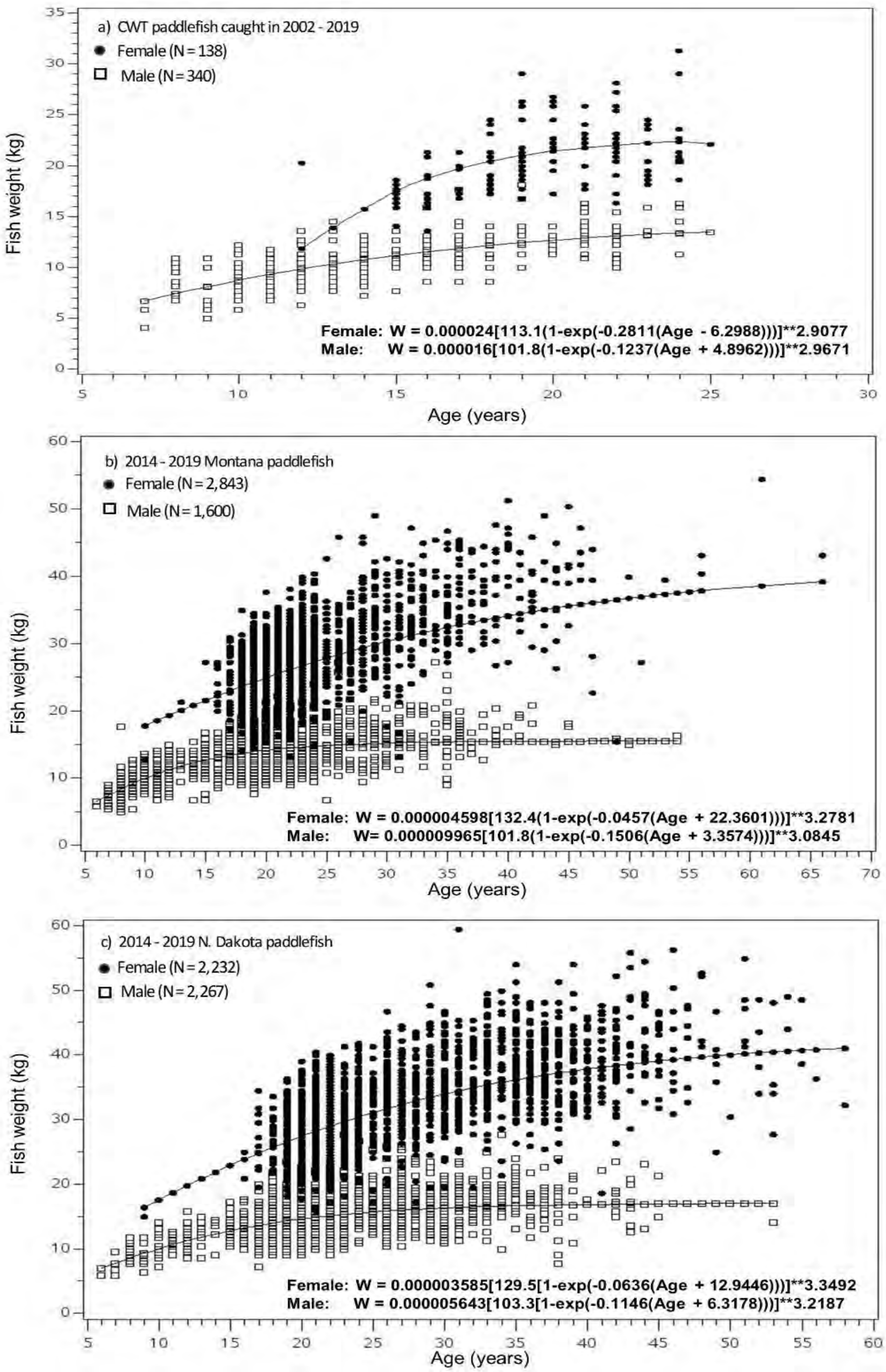


Figure 11. Weight-converted von Bertalanffy growth curves for paddlefish a) of known age 2002-2019, b) from Montana 2014-2017 and c) from North Dakota 2014-2019.

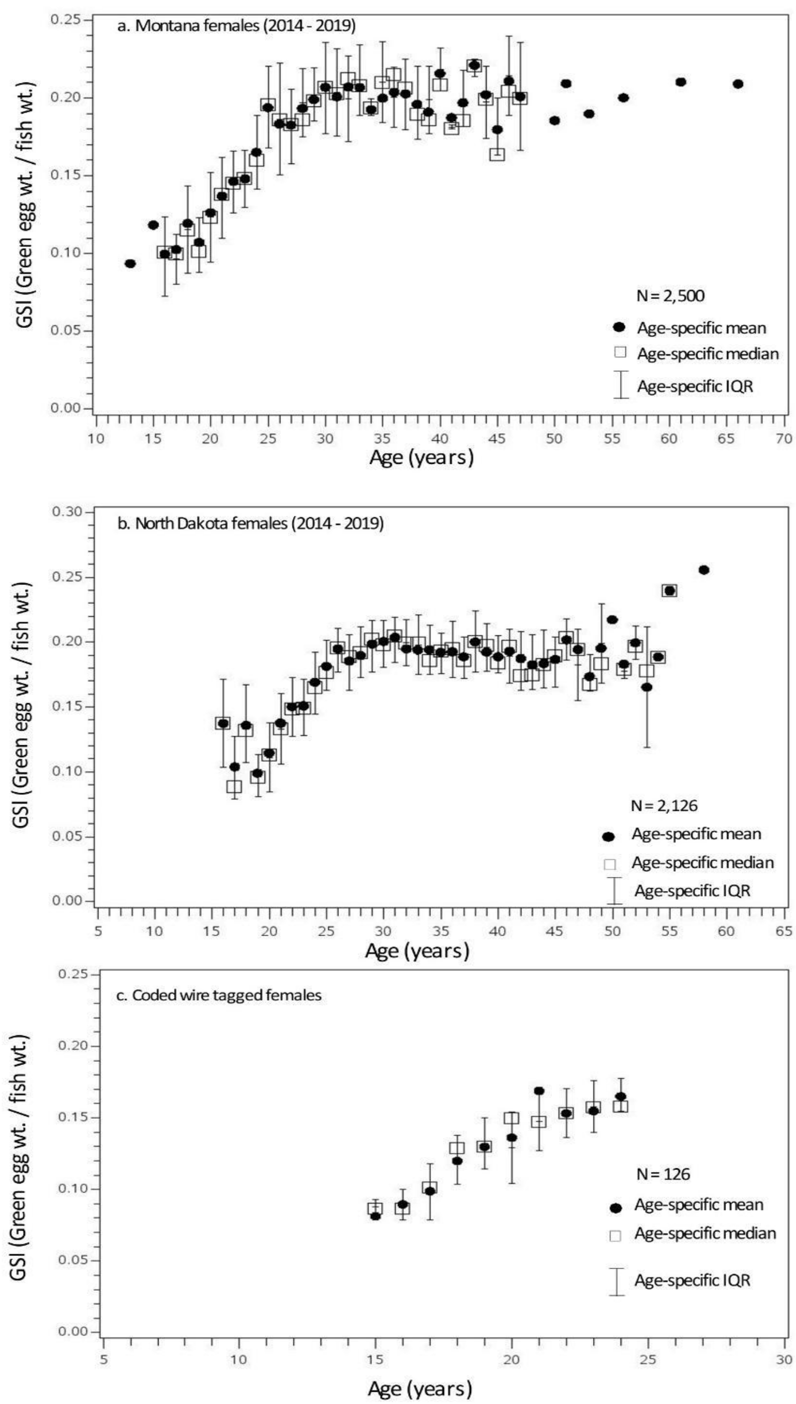


Figure 12. Gonadosomatic index (mean, median, and inter-quartile range) for female paddlefish a) from Montana, 2014-2019, b) from North Dakota, 2014-2019 and c) of known age, 2002-2019.

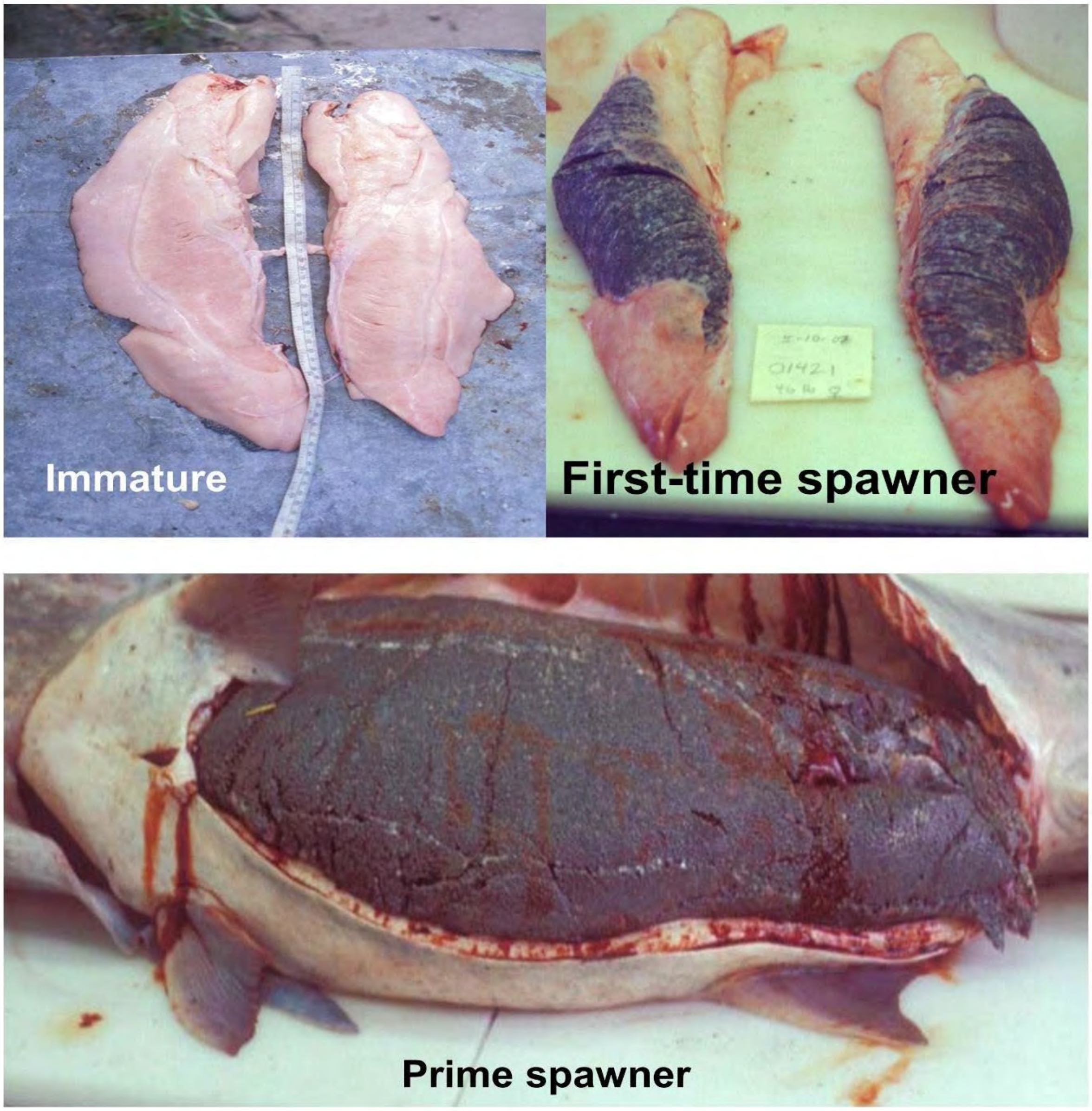


Figure 13. Roe and gonadal fat from paddlefish at three life stages.

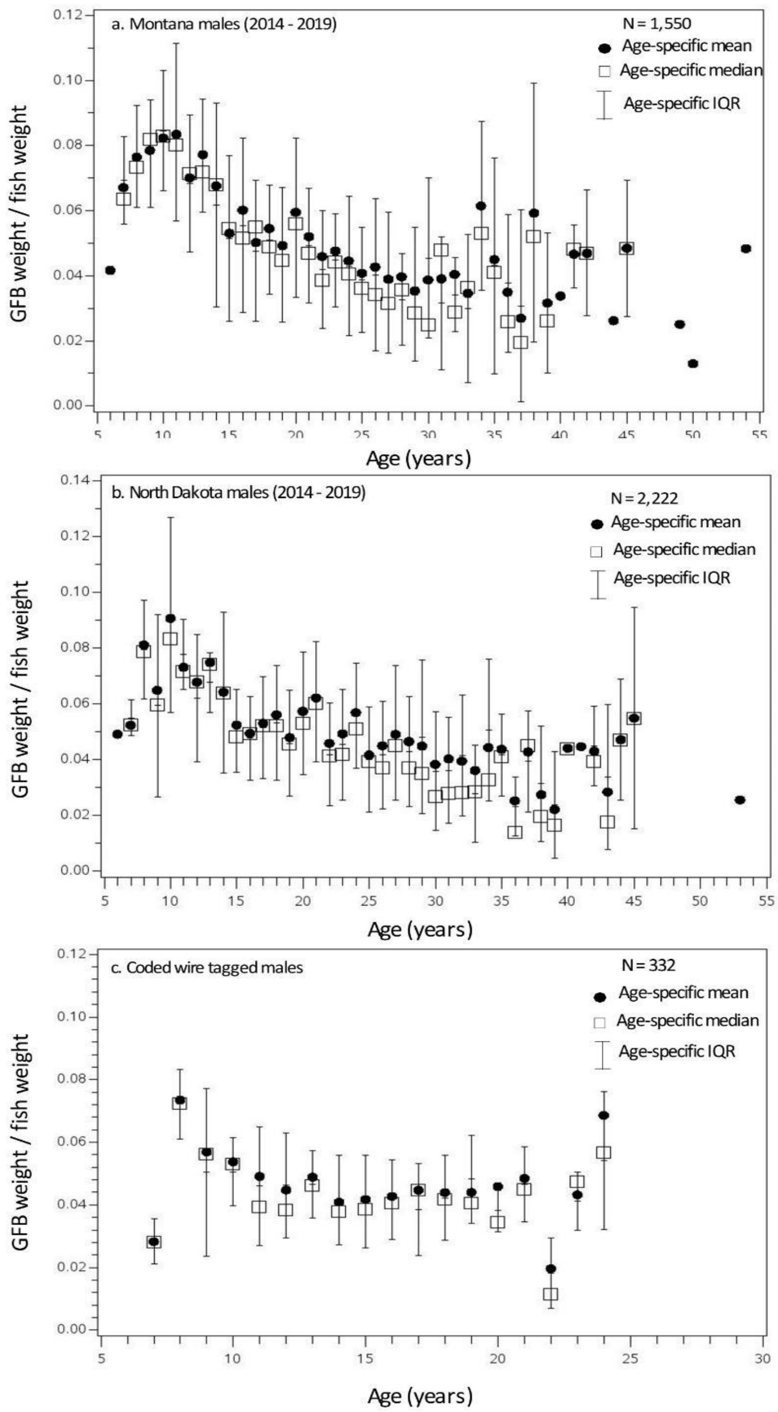


Figure 14. Ratio of total gonadal fat body (GFB) weight to fish weight in relation to the age of male paddlefish, from a) Montana, 2014-2019, b) North Dakota, 2014-2019 and c) known-age fish, 2002-2019

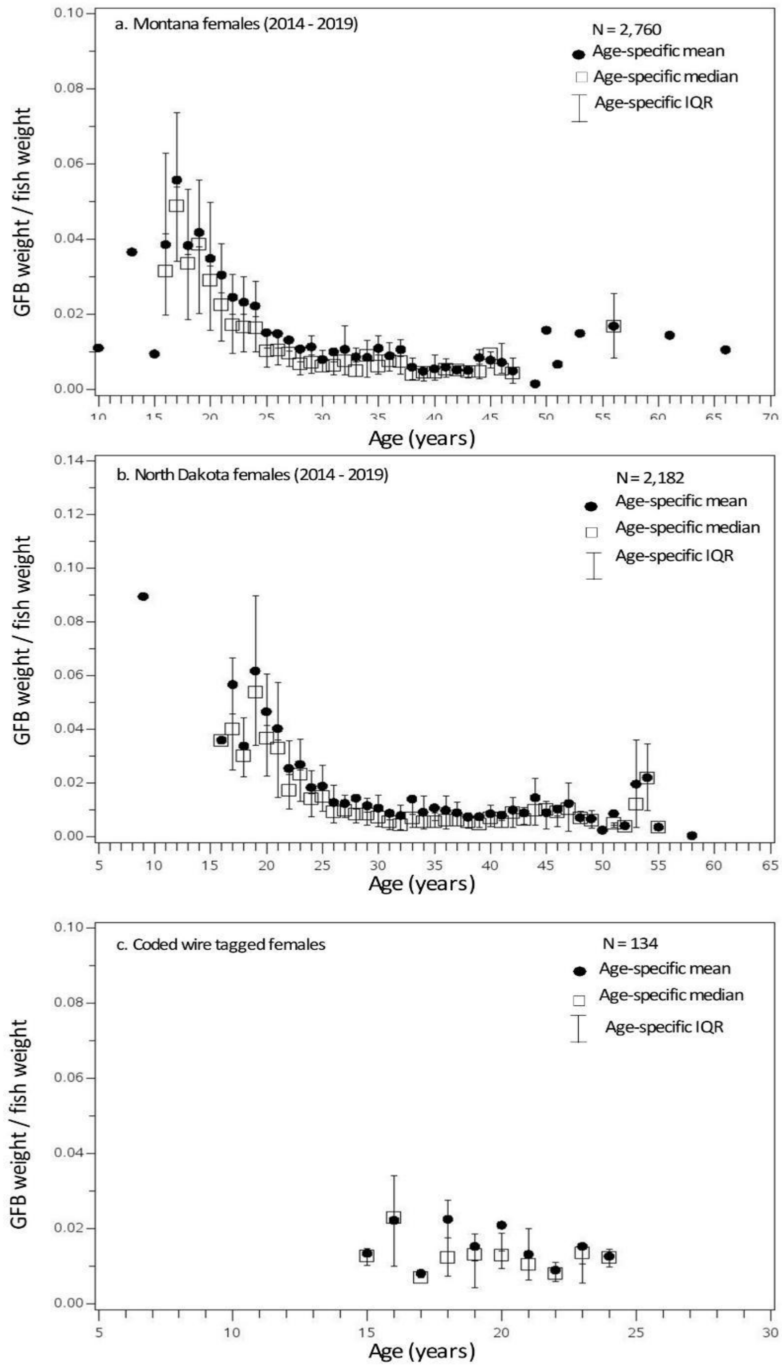


Figure 15. Ratio of gonadal fat body (GFB) weight to total fish weight (mean median, and inter-quartile range) versus age for female paddlefish from a) Montana 2014-2019, b) North Dakota, 2014-2019 and c) known-age fish, 2002-2019.

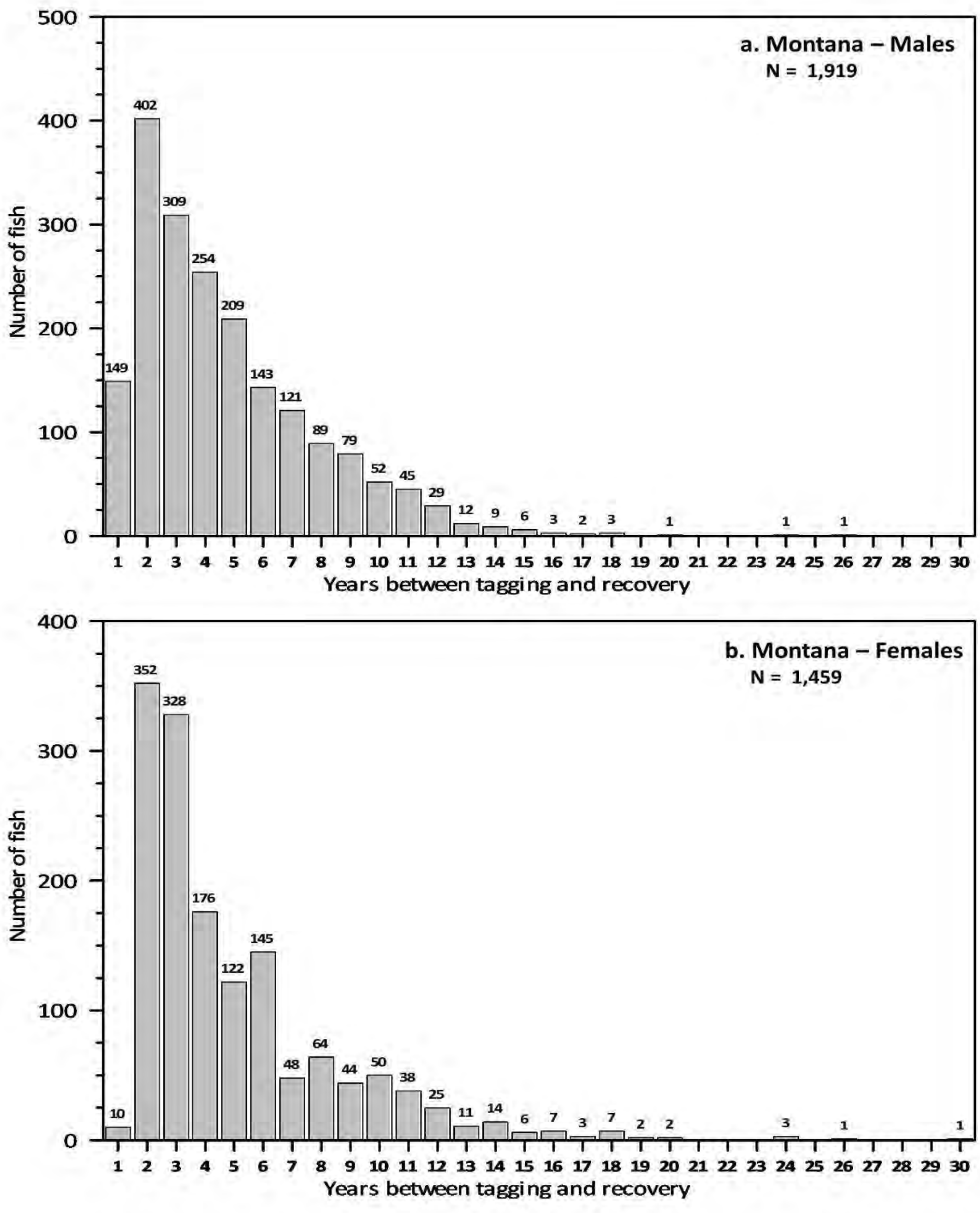
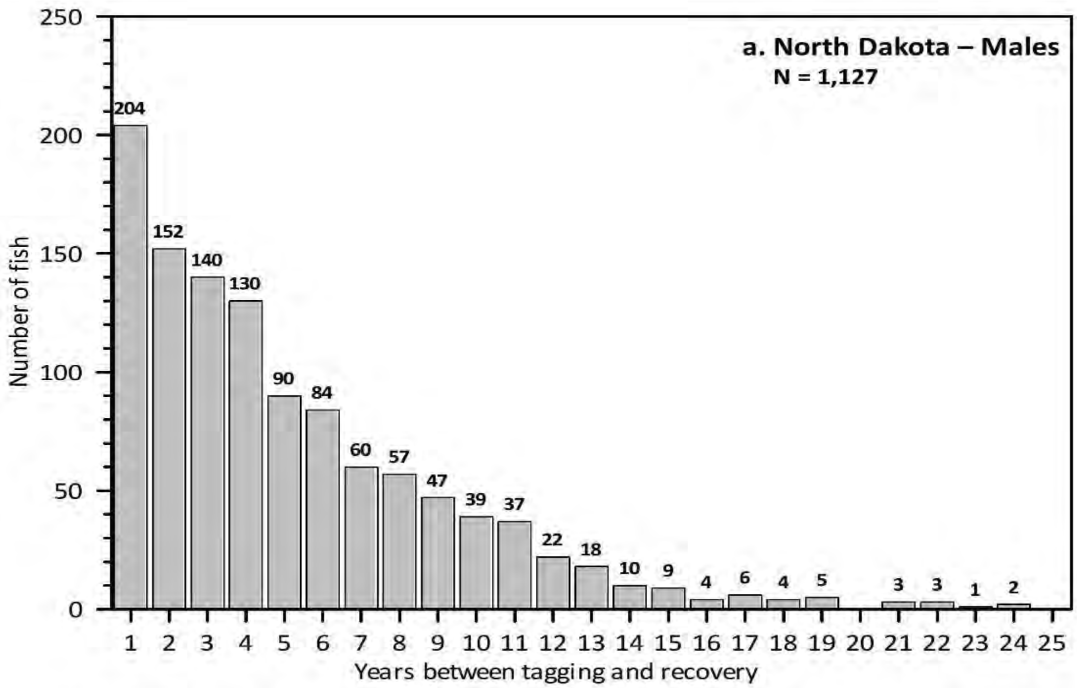


Figure 16. Frequency distribution of the number of years between tagging and recovery for Montana-caught fish, a) males and b) females, 1964-2019. Peak recoveries are reported two years after tagging for males and two, three (and six) years after tagging for females.



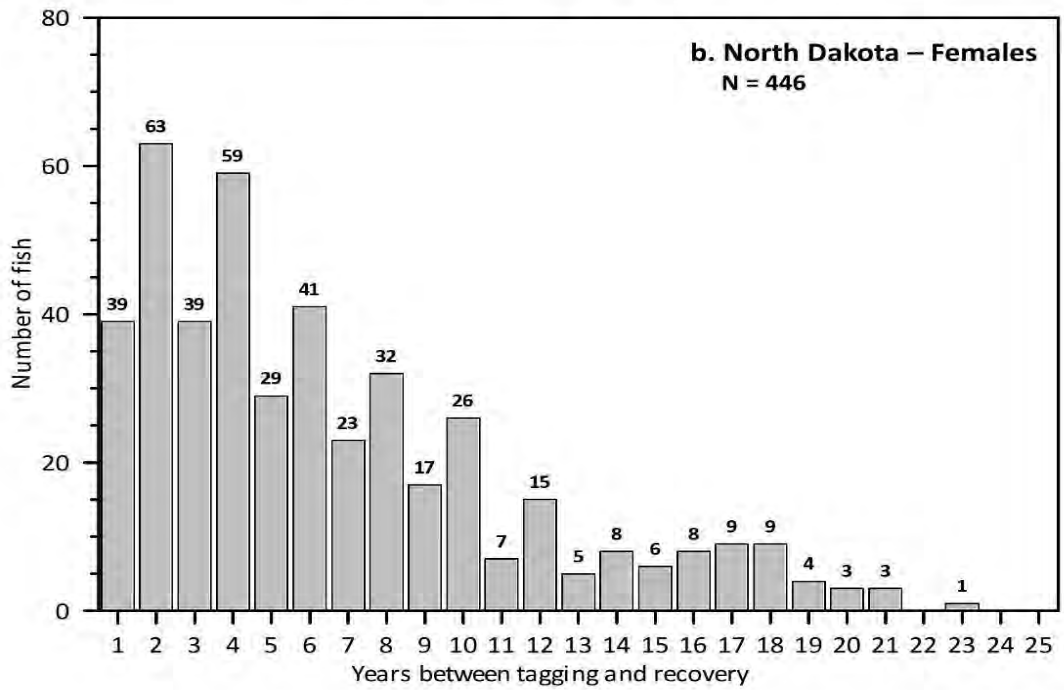


Figure 17. Frequency distribution of the number of years between tagging and recovery for North Dakota-caught fish, a) males and b) females, 1993-2019. Peak recoveries are reported one or two years after tagging for males and two (and four) years after tagging for females.

Age (years) summary for paddlefish caught in North Dakota, 1991-2019

Year	Males: N. of fish	Males: Mean age (yr)	Males: % fish <8 yr	Males: % fish ≤16 yr	Males: % fish ≥30 yr	Males: N. fish ≥30 yr	Males: Max. age (yr)	Females: N. of fish	Females: Mean age (yr)	Females: % fish ≤16 yr	Females: % fish ≥30 yr	Females: N. fish ≥ 30 yr	Females: Max. age (yr)
1991	74	20.7	0	10.8	4.1	3	37	54	24.1	0	7.4	4	33
1992	19	22.1	0	5.2	10.5	2	33	22	24.3	0	4.5	1	34
1993	48	22.1	0	33.3	0	0	29	72	25.2	0	9.8	7	35
1994	368	18.4	<1	35.1	3.0	11	43	471	25.1	<1	13.2	62	39
1995	567	21.5	0	17.1	7.2	41	40	548	28.1	0	35.2	193	44
1996	297	22.9	0	24.9	15.2	45	45	325	29.8	<1	59.1	192	45
1997	315	17.7	0	36.8	<1	1	34	297	24.6	<1	16.5	49	37
1998	667	20.7	0	28.6	11.2	75	42	625	28.1	<1	38.2	239	48
1999	466	20.2	<1	23.4	2.8	13	35	413	26.3	<1	24.2	100	44
2000	454	19.3	<1	30.2	3.7	17	45	400	26.2	1	25.8	103	45
2001	726	22.3	<1	18.4	12.9	94	40	549	26.7	<1	34.4	189	45
2002	841	23.0	<1	17.7	20.2	170	53	454	27.9	1.7	47.8	217	50
2003	434	23.1	<1	20.1	24.9	108	49	356	28.3	<1	49.7	177	47
2004	412	19.5	<1	41.0	19.4	80	46	402	27.8	<1	43.3	174	47
2005	503	19.7	0	43.7	16.7	84	61	365	29.1	0	51.2	187	47
2006	638	15.8	0	68.2	8.5	54	51	259	27.8	0	44.8	116	53
2007	405	18.0	0	58.3	13.3	54	40	212	27.8	0	40.6	86	46
2008	738	19.9	0	51.2	18.7	138	50	238	30.9	0	55.9	133	61
2009	479	18.6	0	59.3	11.5	55	43	231	28.9	1.3	44.6	103	51
2010	620	20.7	0	54.8	17.6	109	47	283	29.4	5.3	47.3	134	52
2011	620	20.7	0	3.2	16.1	100	47	203	29.6	0	46.8	95	51
2012	483	20.5	<1	7.0	10.8	52	47	219	27.4	0	37.9	83	52
2013	569	23.8	0	2.5	25.5	145	49	199	29.2	0	46.7	93	55
2014	352	21.9	0	0.9	11.9	42	44	372	26.3	0	29.6	110	53
2015	345	21.8	0	3.8	10.1	35	53	450	25.5	0	28.4	128	53
2016	479	21.5	0	5.0	5.2	25	38	441	25.4	0	24.5	108	51
2017	415	22.6	<1	3.6	10.4	43	45	411	26.3	0	23.8	98	58
2018	243	23.6	<1	4.5	14.0	34	45	255	30.1	0	45.9	117	51
2019	434	21.1	<1	14.3	7.8	34	44	306	27.1	<1	26.8	82	55
Total	13011					1664		9432				3380	
% age≥30						12.8						35.8	

Table1. Age (years) summary for paddlefish caught in North Dakota, 1991-2019.

Age (years) summary for paddlefish caught in Montana, 1991-2019

Year	Males: N. of fish	Mean age (yr)	% fish <8 yr	% fish <16 yr	% fish ≥30 yr	N. fish ≥30 yr	Max. age (yr)	Females: N. of fish	Mean age (yr)	% fish <16 yr	% fish ≥30 yr	N. fish ≥ 30 yr	Max. age (yr)
1991	721	18.4	1.3	33.7	5.0	36	40	975	25.5	<1	14.8	144	42
1992	219	17.8	<1	39	2.3	5	33	471	26.2	<1	21.0	99	40
1993	1144	15.8	<1	47.2	<1	8	35	605	22.8	3.3	6.0	36	38
1994	116	15.0	1.7	56.9	0	0	29	190	23.0	2.6	5.3	10	35
1995	769	14.7	<1	69.6	2.9	22	40	582	26.7	2.6	35.4	206	49
1996	630	12.4	0	86.0	<1	4	42	466	25.5	<1	23.8	111	41
1997	488	14.1	0	70.0	1.8	9	37	297	25.6	<1	24.9	74	41
1998	295	15.3	<1	68.8	3.1	9	34	276	25.1	1.8	22.8	63	43
1999	587	15.5	<1	62.4	1.7	10	42	703	22.3	5.3	10.2	72	43
2000	216	15.3	4.6	64.8	2.3	5	38	282	24.6	2.5	25.2	71	50
2001	149	18.1	<1	45.6	9.4	14	48	177	23.4	1.1	13.0	23	43
2002	394	18.5	5.84	45.4	17.3	68	45	316	23.5	3.8	26.0	82	56
2003	387	14.9	0	67.4	9.8	38	43	447	21.6	<1	12.3	55	47
2004	100	16.3	0	64.0	12.0	12	41	122	25.0	0	28.0	34	44
2005	775	13.4	0	80.1	7.1	55	47	279	22.7	<1	17.2	48	45
2006	842	13.1	0	84.7	3.0	25	38	348	22.9	0	12.6	44	45
2007	678	12.6	0	93.8	1.0	7	55	177	23.4	2.2	16.4	29	48
2008	669	14.3	0	87.0	2.8	19	41	272	23.6	1.1	18.0	49	46
2009	533	15.6	0	84.6	4.1	22	42	260	25.0	1.5	19.6	51	52
2010	613	17.5	0	79.4	8.6	53	47	202	23.8	12.9	15.3	31	52
2011	462	18.3	0	3.5	7.1	33	44	245	24.1	0	17.1	42	51
2012	301	21.2	0	4.7	15.0	45	47	165	24.8	<1	29.1	48	46
2013	383	21.7	0	5.0	16.7	64	62	364	21.7	0	11.5	42	57
2014	205	19.6	0	13.7	5.4	11	49	490	20.4	0	3.9	19	47
2015	239	19.6	<1	14.2	6.3	15	41	524	22.4	0	11.6	61	53
2016	310	21.3	0	9.4	8.1	25	45	440	22.6	<1	10.2	45	46
2017	208	20.1	1.9	21.6	6.3	13	39	595	23.2	<1	7.6	45	56
2018	244	18.9	14.8	30.3	6.2	15	44	470	24.8	0	12.6	59	46
2019	394	17.3	<1	45.4	9.4	37	54	323	24.9	0	12.7	41	66
Total	13071					679		11063				1734	
% age≥30						5.2						15.7	

Table 2. Age (years) summary for paddlefish caught in Montana, 1991-2019.

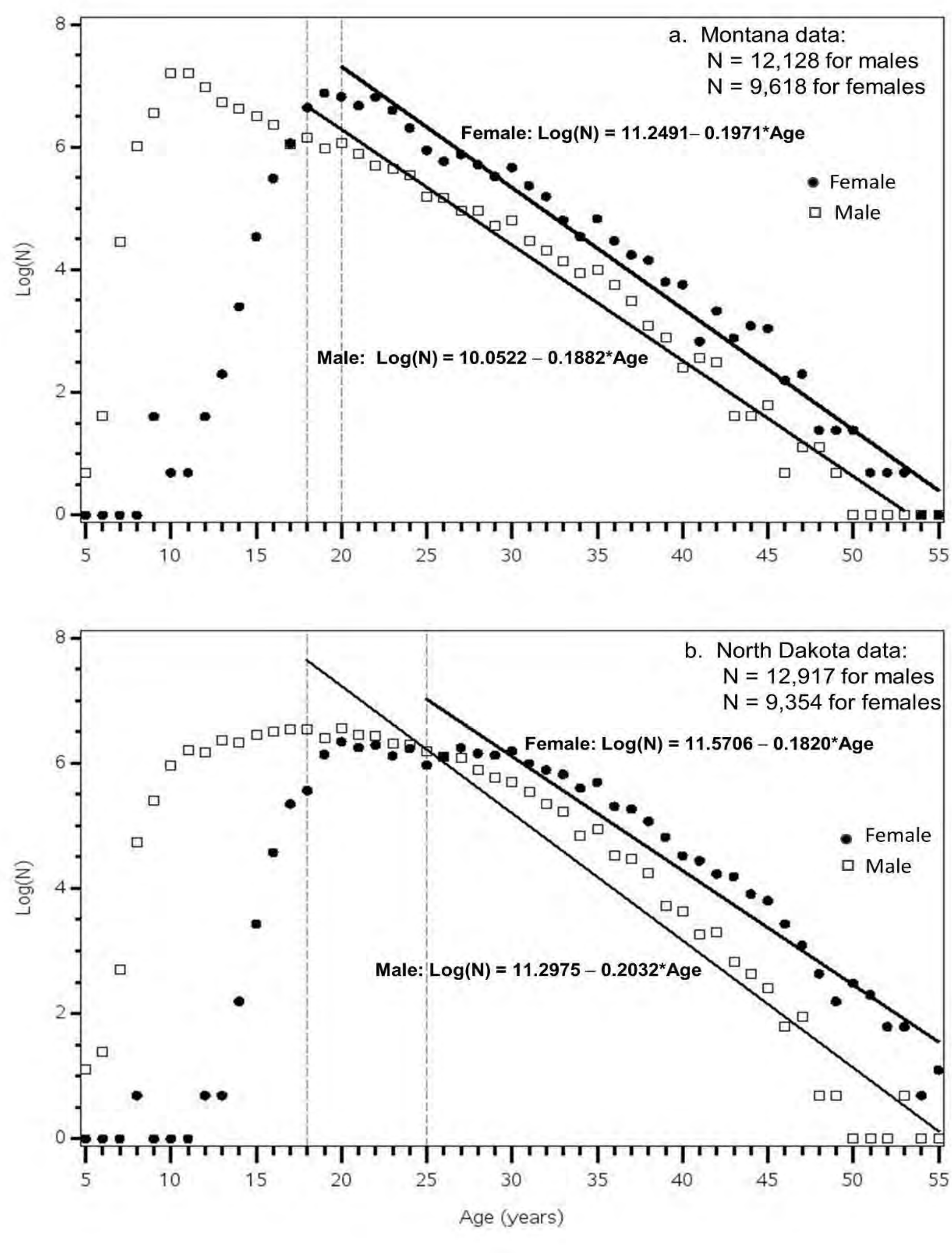


Figure 18. Catch curves and instantaneous rates of total mortality for male and female paddlefish, a) Montana-caught fish, and b) North Dakota-caught fish, 1991-2019.

Paddlefish juvenile and adult life stages

	Somatic growth	GSI	GFB	Spawning interval	Movements
1. Immature	highest	low	Increasing	---	reservoir
2. Maturing	moderate	increasing	near maximum	---	reservoir
3. Somatic growth and reproduction	moderate to low	increasing	decreasing	longer	longer upriver migration
4. Prime Reproduction	low to negative	high/stable	decreasing(♂) depleted(♀)	shorter and minimized	shorter upriver migration
5. Senescence to death	negative	decreasing	decreasing(♂) depleted(♀)	unknown or dysfunctional	shorter upriver migration

Figure 19. Five paddlefish juvenile and adult life stages and their characteristics (Scarnecchia et al. 2007).

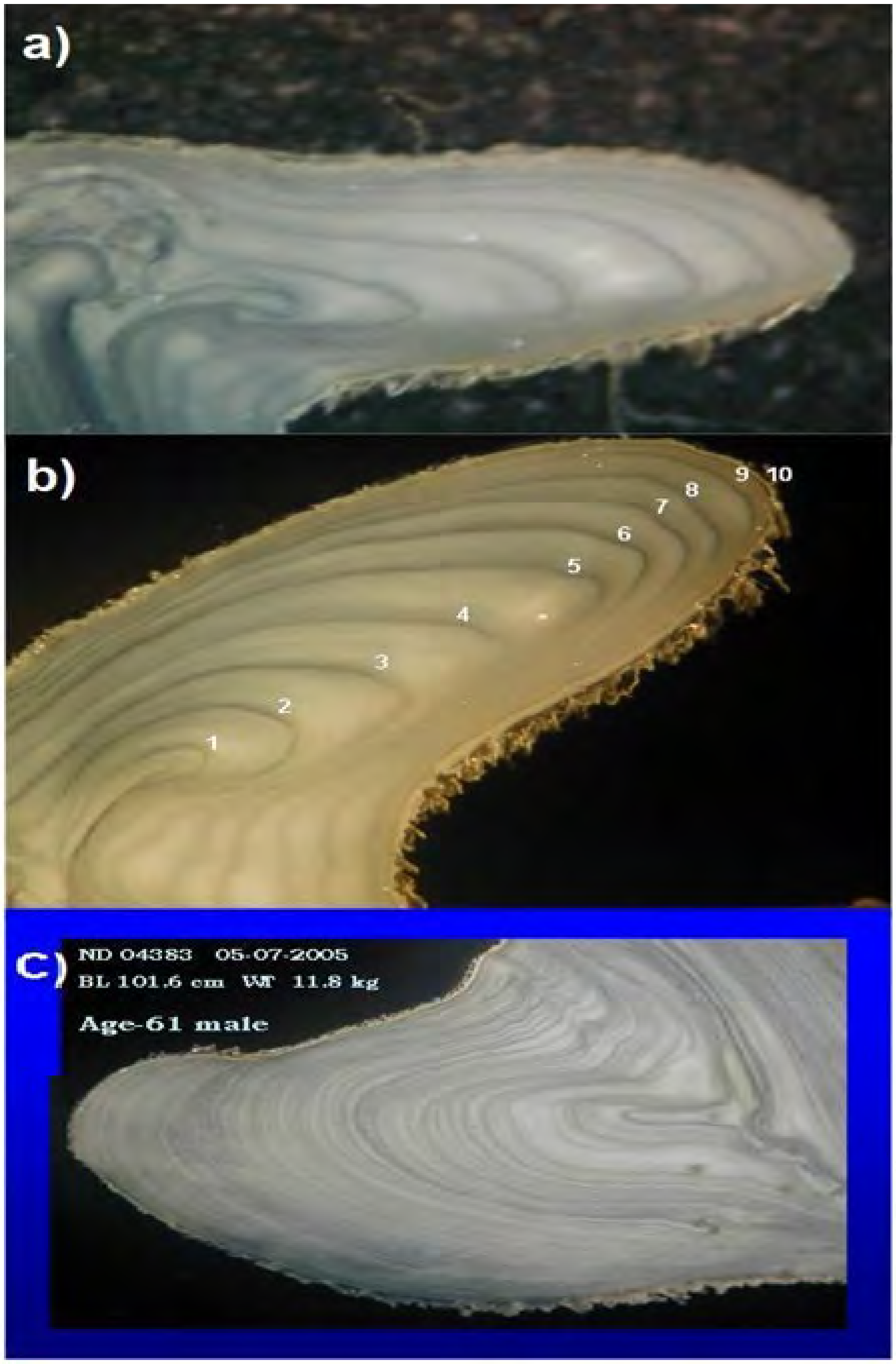


Figure 20. a) Dentary from known age-7 paddlefish reared at Garrison National Fish hatchery in 1995, released in 1995, and harvested in 2002. b) Dentary from known age-10 paddlefish (Scarnecchia et al. 2006) and c) old male fish estimated to be age-61. Validation of fish this old may eventually be possible.

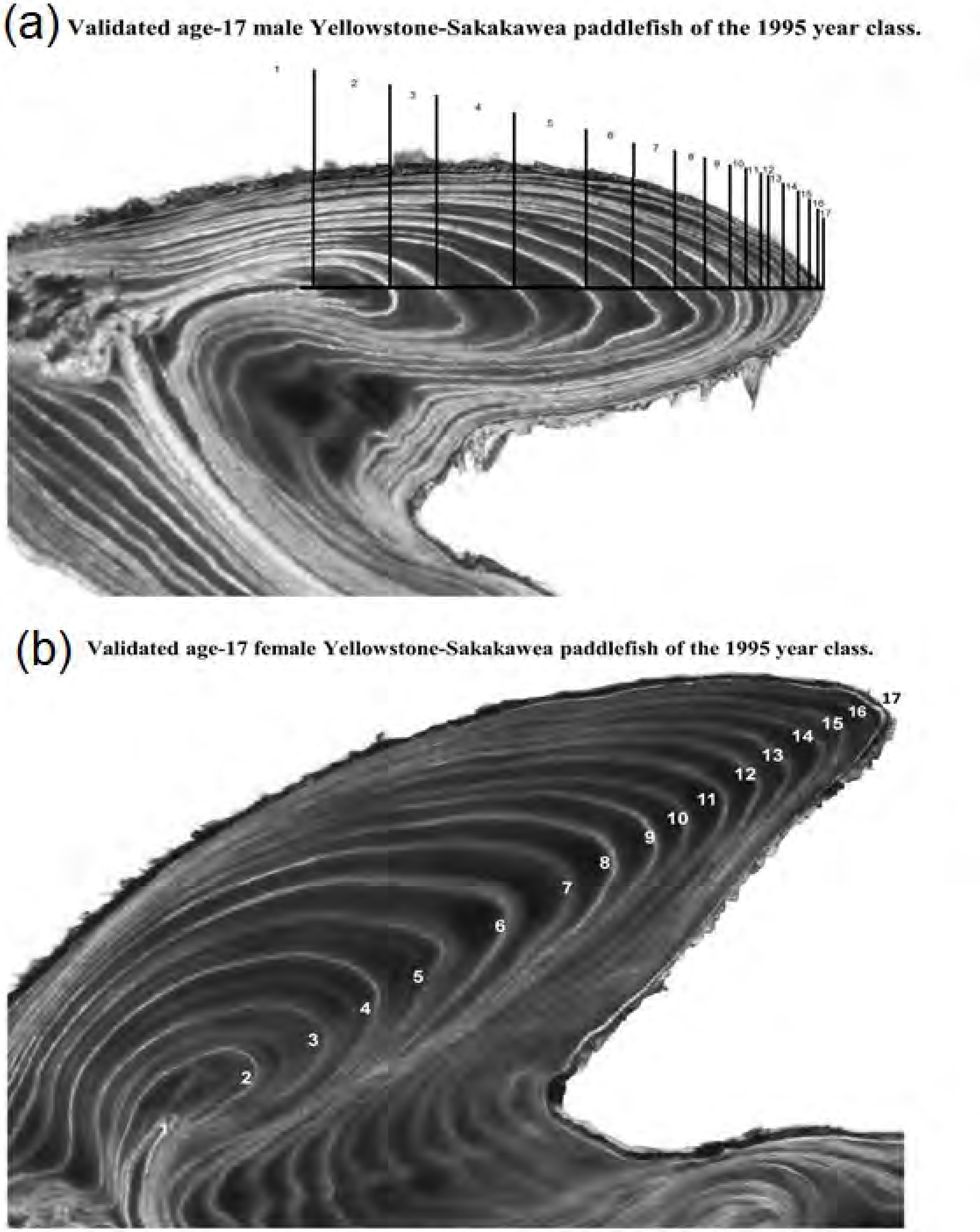


Figure 21. Paddlefish dentary sections from validated known-age 17 a) male, and b) female fish, Yellowstone Sakakawea stock. Note more even spacing of the later maturing, female fish.

period of a rising reservoir since the initial filling and, up to that time, the only period since the reservoir filled when reservoir levels rose substantially in three consecutive years (Figure 5). Recruitment from the 1996 and 1997 cohorts, when the reservoir was near its maximum, was not nearly as strong as in 1995.

The development of the fishery at Intake in the early 1960s and the strength of the 1995 cohort are best viewed as responses to trophic upsurge (Baranov 1966, Benson 1982; Kimmel and Groeger 1986) in Lake Sakakawea. The largest upsurge and the largest population increase occurred upon initial filling (1953-1966); a smaller upsurge and a smaller population increase occurred upon re-filling (1993-1995). In the late 1990's, when reservoir levels were high (Figure 5), age-0 fish were abundant and distributed from Rkm 2433 below Lewis and Clark State Park through Rkm 2476 (American Legion Park), and above (Skunk Hollow). By 2004, the reservoir level had dropped; age-0 fish had been forced down-reservoir to feed below Rkm 2428 in White Earth Bay and beyond. Natural recruitment was poor until 2011, when an increase in reservoir water levels and record floods led to protracted high reservoir elevations (Fryda et al. 2014; Figure 5). These high reservoir levels resulted in another strong year class of paddlefish, along with benefits to other species as well. Fish of this year class began recruiting to the fishery at Intake in measurable numbers in 2018 as age-7 fish. The size of this cohort is not yet completely known, although thirty-eight fish were captured in 2018 and 169 fish in 2019 (Table 3). No harvest fishery occurred in 2020.

Age-0 paddlefish are subject to high mortality from predation until they reach a size large enough to avoid being eaten (Scarnecchia et al. 2019b). Mero (1992) reported that young paddlefish were important in the diets of walleye *Sander vitreus* and sauger *Sander canadensis* in Lake Sakakawea's White Earth Bay in October 1991. Parken and Scarnecchia (2002) reported that both walleyes and saugers preyed on age-0 fish throughout much of the upper reservoir, with larger predators more likely to take young paddlefish than the smaller predators (Figure A2-21). Fish-eating birds have also been observed to eat age-0 paddlefish, although the magnitude of this predation is unknown. Observations of dead young paddlefish indicate that overwinter mortality may be significant in some years. Age-1 paddlefish may also be eaten. Available evidence suggests that those years benefiting from rising reservoir levels and higher river discharge into headwaters throughout summer may contribute to trophic upsurge and greater turbidity in the upper reservoir. These conditions might allow a small, but larger than normal percentage of age-0 fish to grow faster, avoid predation, store more energy reserves (Hemingway and Scarnecchia 2017a) survive the winter, and recruit successfully in the next year or two (Figure 23). The grow-fast-or-be-eaten hypothesis for paddlefish recruitment is detailed in Scarnecchia et al. (2019b).

Fisheries

Locations and timing - During the May-June pre-spawning migration, recreational fisheries based on snagging adult fish occur in both Montana and North Dakota at several sites along the Yellowstone River, and to a lesser extent, the Missouri River. Anglers typically use

2011-year-class caught in 2018 and 2019.

			State	
Year	Age	Sex	Montana	N. Dakota
2018	7	M	36 (14.8%)*	2 (0.8%)*
2019	8	M	135 (34.3%)*	34 (7.8%)*

Note:

* = Proportion of 2011-year-class in male paddlefish caught each year

Table 3. Number of 2011-year-class Montana and North Dakota paddlefish caught in 2018 and 2019.

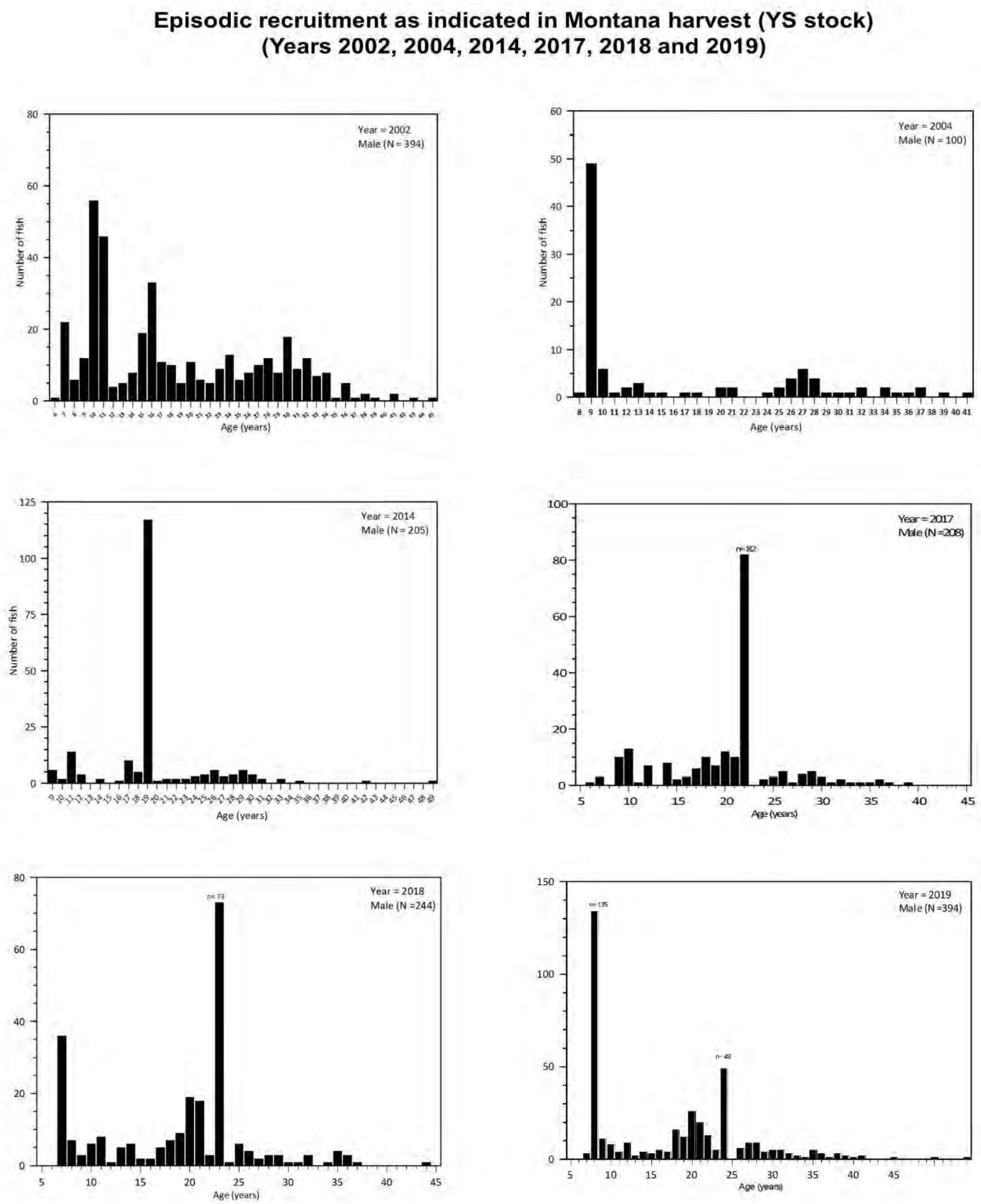


Figure 22. The strong 1995-year class of Yellowstone-Sakakawea paddlefish contributing to fisheries, 2002-2019.

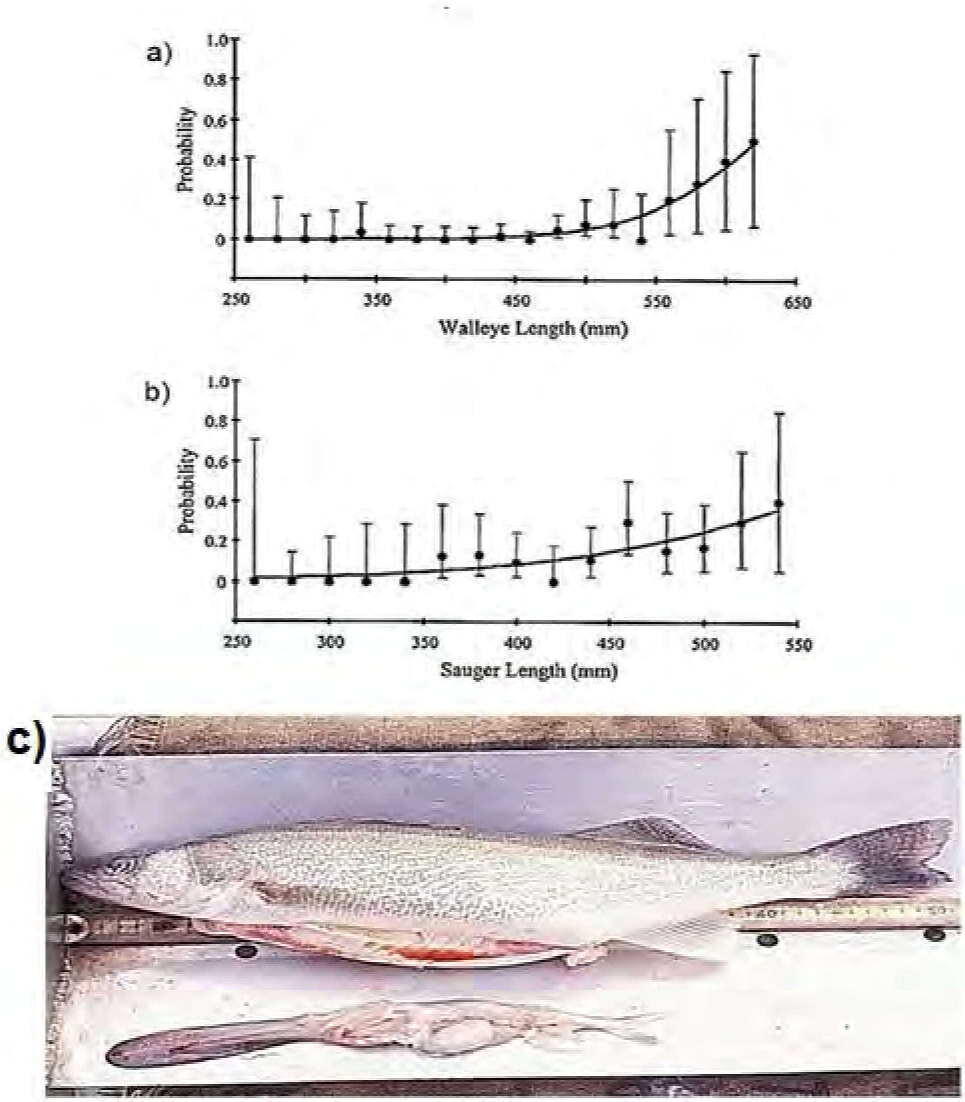


Figure 23. a) Probability of a) walleye and b) sauger containing an age-0 paddlefish increases with size of the predator (Parken and Scarnecchia 2002); c) netted Lake Sakakawea walleye containing age-0 paddlefish.

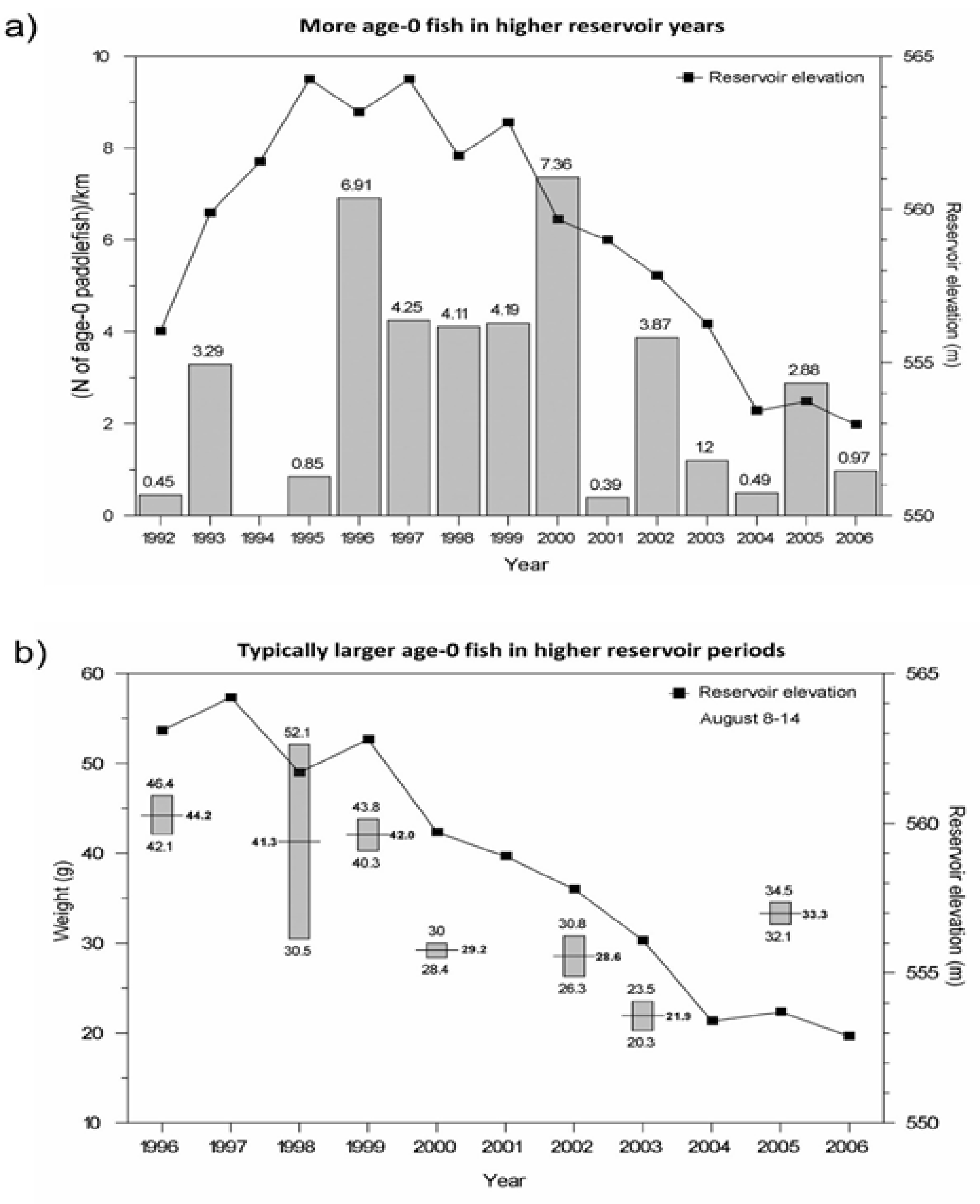


Figure 24. Years of higher reservoir elevation were typically associated with a) higher counts and b) faster growth of age-0 paddlefish, Lake Sakakawea.

long, heavy spinning rods with 6/0 to 8/0 treble hooks and heavy test line to snag the fish as they congregate at known holding sites. Important fishing sites in North Dakota include (in order, progressively upriver) the Pumphouse (MR Rkm 2503; Figure 25a) near Williston, Ryder Point (MR Rkm 2537), the Confluence (MR Rkm 2542, YR Rkm 0), Sundheim Park (YR Rkm 14.5), and the North Dakota Stateline (YR Rkm 24). The most important fishing site in Montana is at Intake, on the Yellowstone River (YR Rkm 114; Figure 25b). Other fishing sites on the Yellowstone River below Intake include the Montana Stateline (YR Rkm 25.7), Richland Park (YR Rkm 35.5), Sidney Bridge (YR Rkm 46.6), Seven Sisters (YR Rkm 63.8), and Elk Island (YR Rkm 82). In North Dakota, fish typically become available first at the lowermost sites (e.g., The Pumphouse, Ryder Point, and the Confluence). As Yellowstone River discharges increase, fish move into that river and fishing success improves at Sundheim Park and the North Dakota Stateline. Similarly, in Montana, fish harvest availability is typically greatest early in the season at the Montana Stateline, Richland Park, and the Sidney Bridge. Later in the season, as discharge increases, fishing typically improves greatly at Intake, and fishing success is relatively poorer downriver (Bollman 2014, 2016; NDGF, Unpublished data). In years of particularly high discharge, some fish formerly (until 2020) traveled around the Intake Diversion Dam via a side channel, or ascend the dam, and could be caught above Intake, most notably at the mouth of the Powder River. (YR Rkm 230). There are also two main fishing sites on Fort Peck Tribal lands on the Missouri River (Wolf Point, MR Rkm 2744; Frazer Rapids, MR Rkm 2813.3). A modest archery fishery also exists in the Dredge Cuts (MR Rkm 2846; Needhan and Gilge 1986; Scarnecchia and Schooley 2020).

Snagger characteristics - Additional details about historical aspects of the snag fishery as well as its socio-economic characteristics of the anglers are available (Scarnecchia et al. 1995b; Scarnecchia et al. 1996a; Scarnecchia and Stewart 1997b). Contrary to some expectations that snaggers were strictly harvest-driven, the values, attitudes, and preferences of paddlefish snaggers have been found to be broader than just harvest and similar to those of Montana anglers in general (Scarnecchia et al. 1996a). Their primary motivations were to be outdoors, to experience the thrill of catching a paddlefish, to enjoy natural surroundings, and to be with friends. Over the past two decades, as angler knowledge of paddlefish ecology has increased, cell phones have become ubiquitous, and internet access to river discharge records has improved, snaggers have become much more knowledgeable about paddlefish and much more efficient in timing their visits to coincide with higher numbers of available fish.

Fisheries statistics - Catch and effort statistics for both fisheries are compiled annually. Estimated harvest in Montana over the period 1972-2019 has ranged from 278 fish in 1994 to 5,318 fish in 1981. Catches since 2006 have fluctuated much less, from 599 fish to 1,102 fish, more closely around the 1,000-fish harvest cap (Figure 26). Angler effort (harvest and catch-and-release days combined) has fluctuated between 3,000 and 8,000 angler days (Figure 27), except for 2015 when catch and excellent catch-and-release fishing drove effort higher (Figure 28). The number of licensed snaggers that participated in harvest were always higher than those participating in catch-and-release (Figure 29). Harvest per active snagger has ranged from 0.26

a)
b)


Figure 25. Recreational snag fisheries at a) the Pumphouse (MR Rkm 2504) and b) Intake (YR Rkm 14.5).

fish in 2006 to just under one fish per snagger (0.97; annual bag limit one) during the good fishing season of 2010 (Figure 30).

For the North Dakota fishery, harvest over the period 1992-2017 has typically tracked the harvest cap, with higher catches during the earlier years under a higher harvest cap (1,500 fish) and lower catches, nearly always about 1,000 fish, associated with the 1,000-fish harvest cap (Figure 31). Mean harvest over the period 2003-2019 under the harvest cap has been 970 fish (Figure 31). The number of snag and harvest angler days has shown no strong trends, ranging from 4,376 in 2016 to 9,899 in 2009 (Figure 32). In contrast, the number of snag-and-release days, typically about a quarter or less of the effort of harvest snagger days, has trended upward in the past decade (Figure 33). The number of snaggers fishing during catch-and-release is also much lower than the number of harvest snaggers, but the snag-and-release numbers are steadier (Figure 34). Harvest per snagger has typically ranged from 0.25 to 0.40 fish (Figure 35), reflecting the greater difficulty of harvesting a fish in North Dakota than during a typical year at the Intake where, below the diversions dam, fish become highly concentrated and especially vulnerable to harvest.

Hatchery production

Hatchery-reared fish have been released periodically into Lake Sakakawea in the past few decades. Over the period 1985 to 1992, 1,619,100 unmarked fry and 123,267 fingerling age-0 paddlefish raised at the Garrison National Fish Hatchery (Figure 36; Table 4) were stocked into Lake Sakakawea, the Missouri River above the reservoir, and in the Yellowstone River in North Dakota by NDGF (Table 4). The survival of those fish is unknown. These stockings were initiated for production reasons.

Although the Plan emphasized natural spawning for production of wild fish, MFWP and NDGF recognize that experimental stocking can provide managers with important stock information otherwise difficult to obtain. Subsequent stockings under the previous two Plans have been for experimental and scientific reasons rather than as directed efforts to produce more fish for harvest. Stocking has provided fish for age validation and for assessing factors affecting recruitment success (Scarnecchia et al. 2019 a, b). In August 1995 and 1997, both high reservoir years, 9,093 large (4/lb.) age-0 fingerlings and 9,994 smaller age-0 fingerlings fish (10/lb.), batch-tagged with coded wire tags, were stocked into Lake Sakakawea (Table 4). In 2007, during a low reservoir period, 23,956 fingerlings large age-0 fish were batch-marked stocked, and in 2011, during a high reservoir period, 32,242 large age-0 fingerlings were batch-marked and stocked. It was anticipated that the stocking would provide information on size-specific survival (1995 vs. 1997) and in relation to reservoir levels (2007 vs. 2011).

As of 2020, 415 male fish of the 1995-year class have recruited to the fishery, beginning in 2002 (Scarnecchia et al. 2006). In addition, 15 hatchery-reared fish from 2007 have recruited, as have three wild fish tagged in Lake Sakakawea in the 1990s (Scarnecchia et al. 2019a).

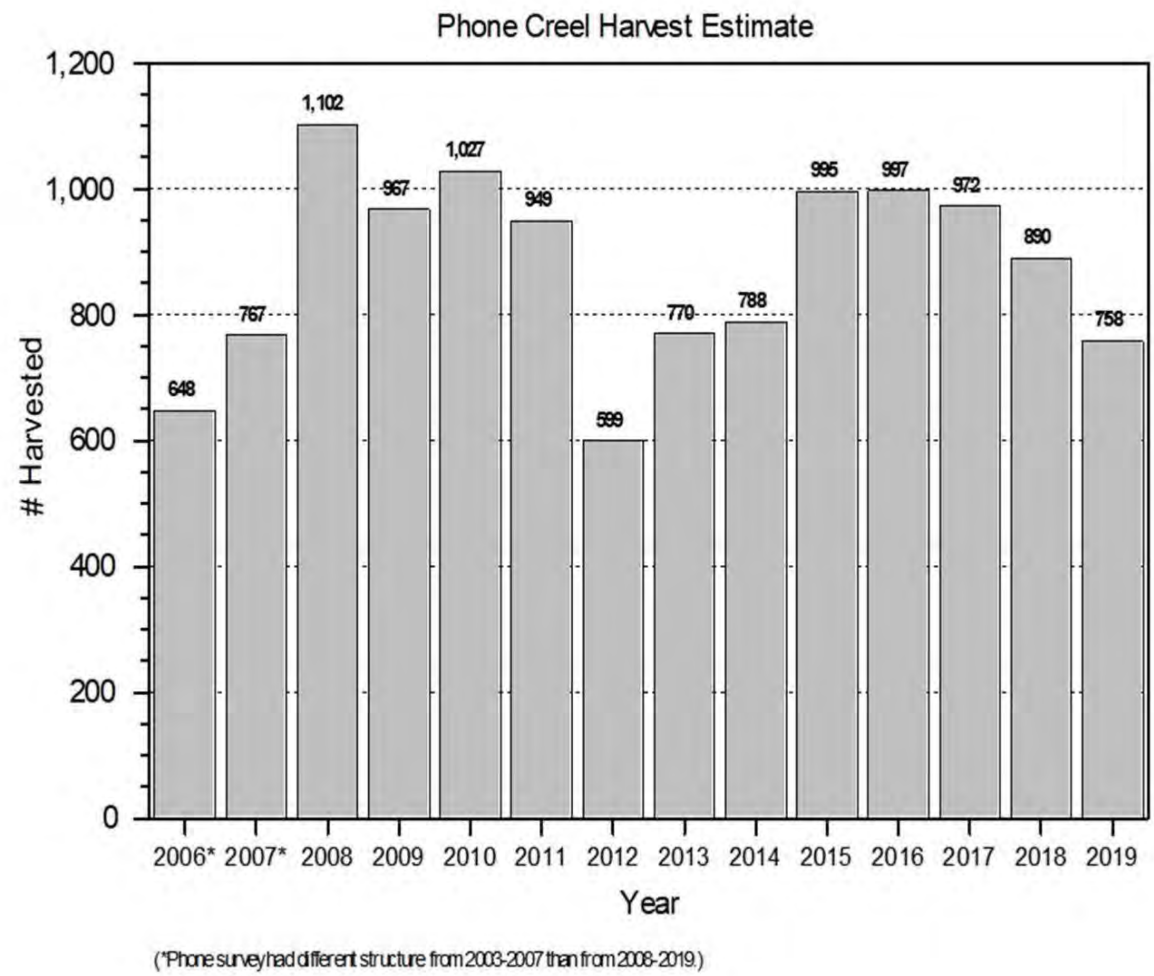


Figure 26. Paddlefish harvest estimate in Montana, Yellowstone-Sakakawea stock, 2006-2019.

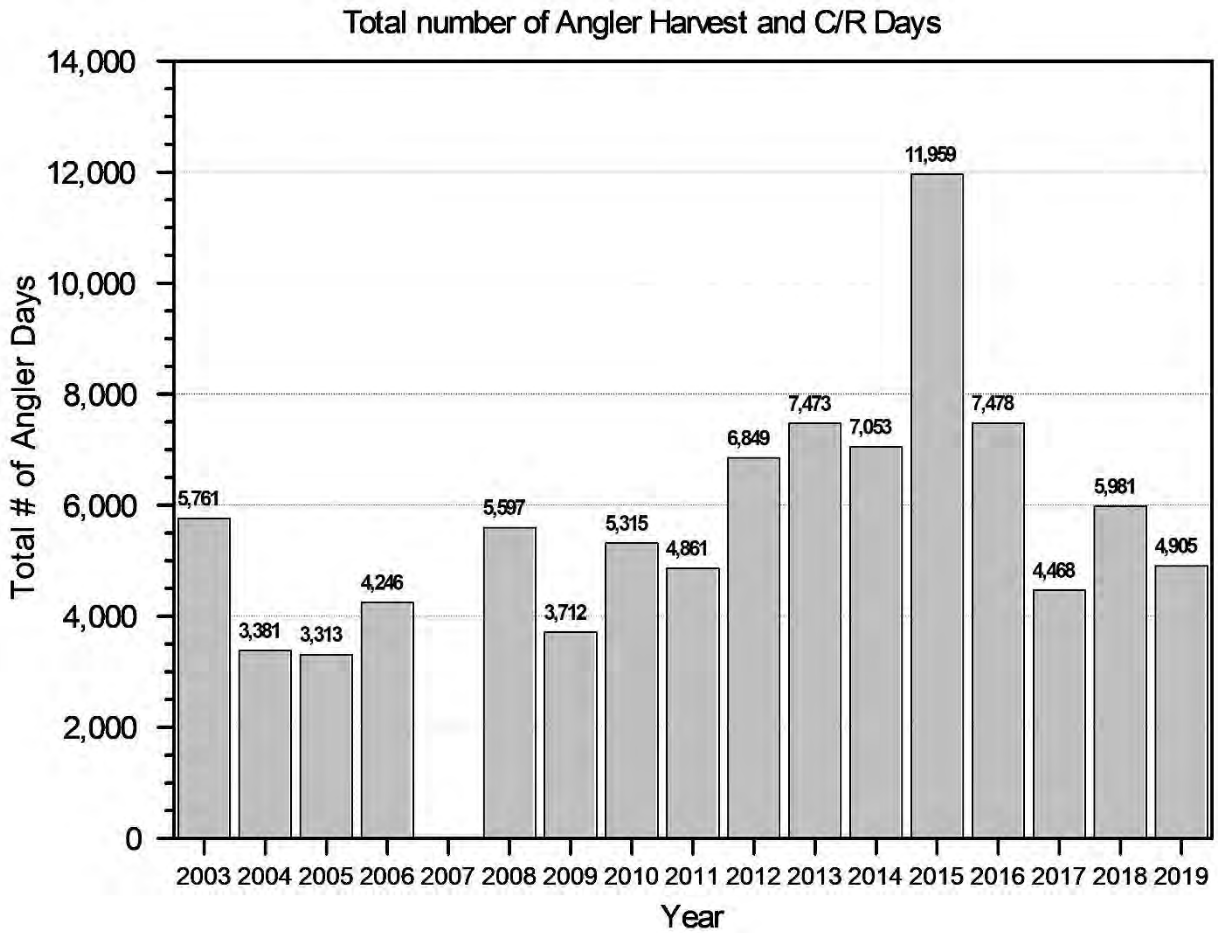


Figure 27. Number of snag and harvest total days in Montana, Yellowstone-Sakakawea stock, 2003-2019.

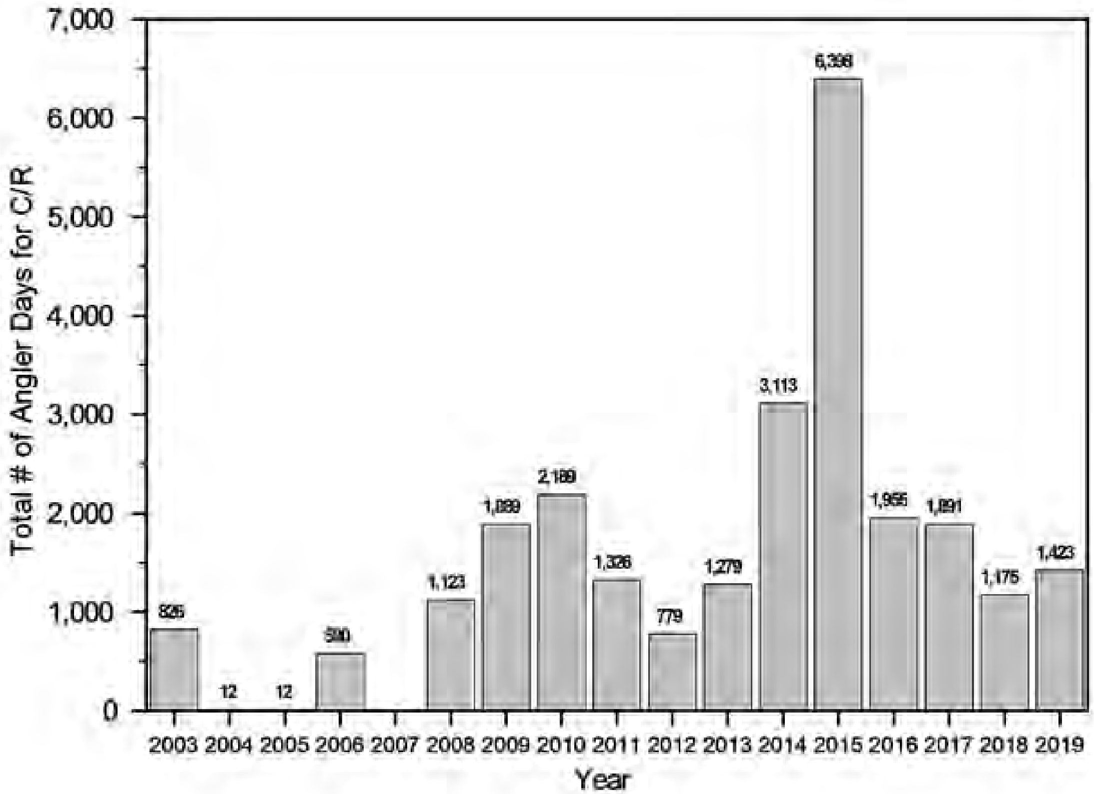


Figure 28. Number of snag-and-release total days in Montana, Yellowstone-Sakakawea stock, 2003-2019.

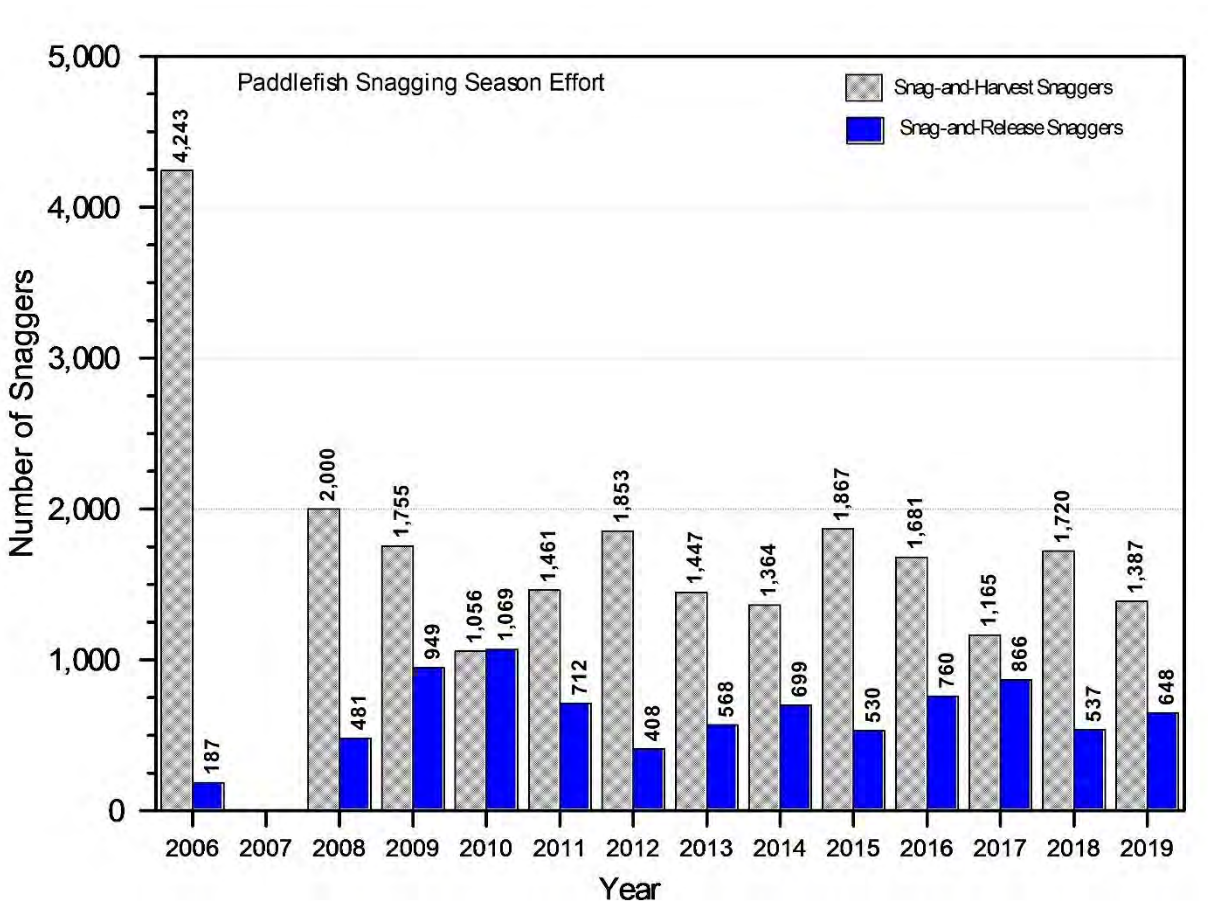


Figure 29. Paddlefish snagging effort in Montana, Yellowstone-Sakakawea stock, 2006-2019.

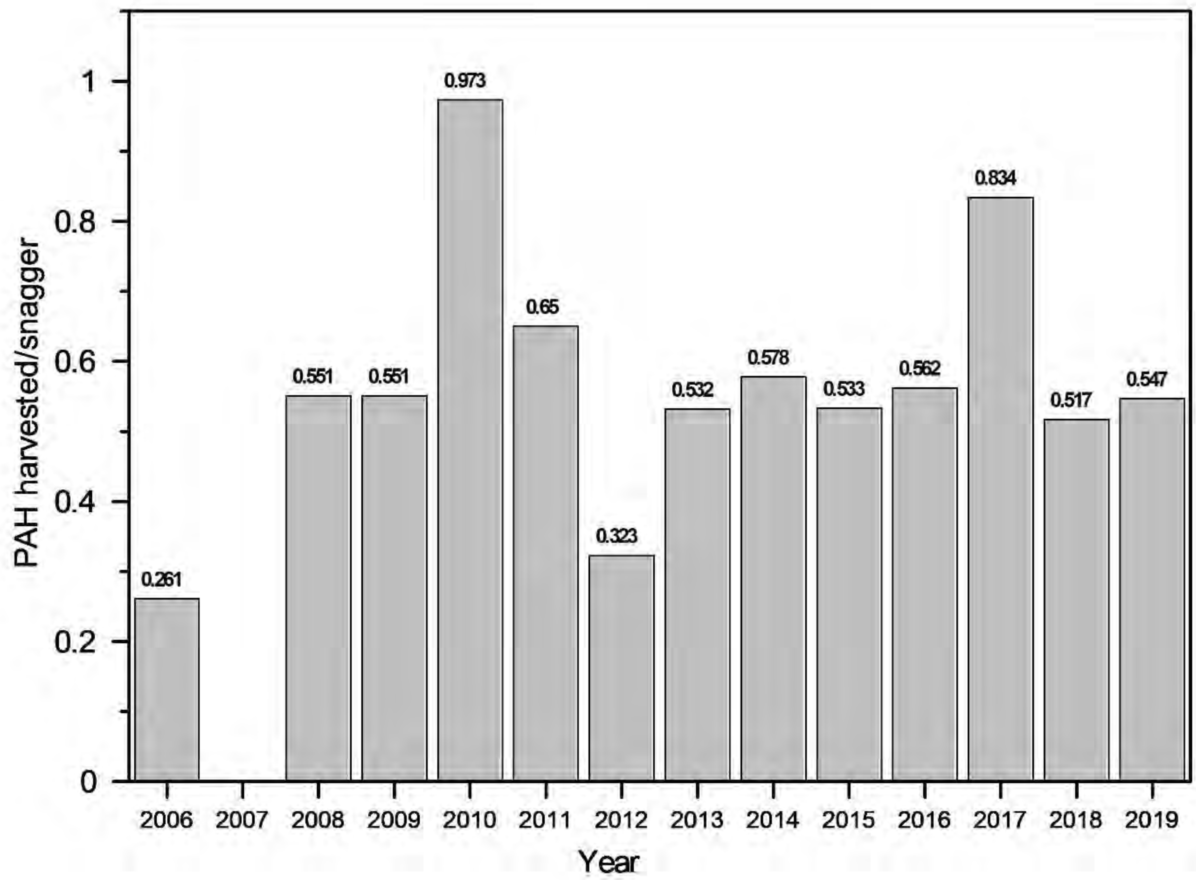


Figure 30. Harvest per snagger in Montana, Yellowstone-Sakakawea stock, 2006-2019.

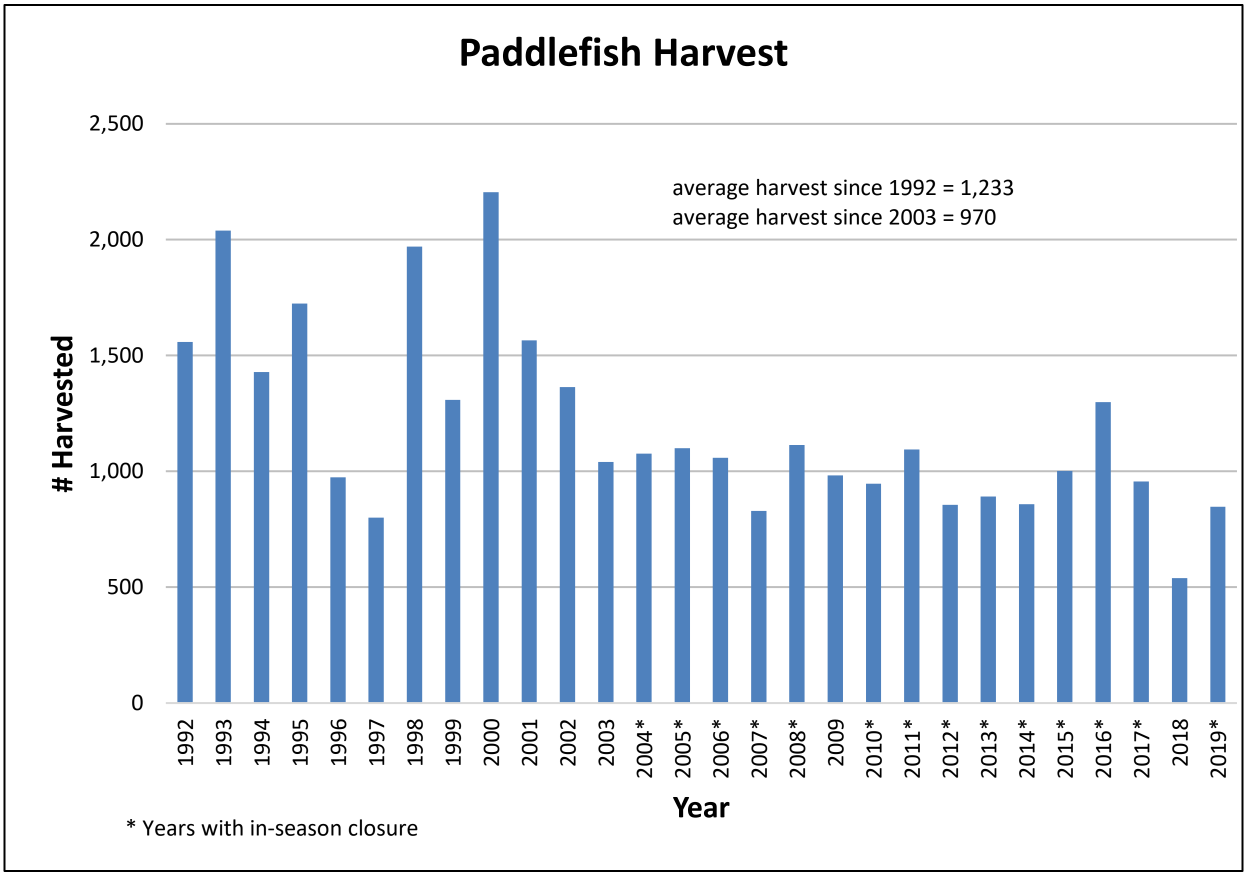


Figure 31. Paddlefish fishery/harvest in North Dakota, 1992-2019.

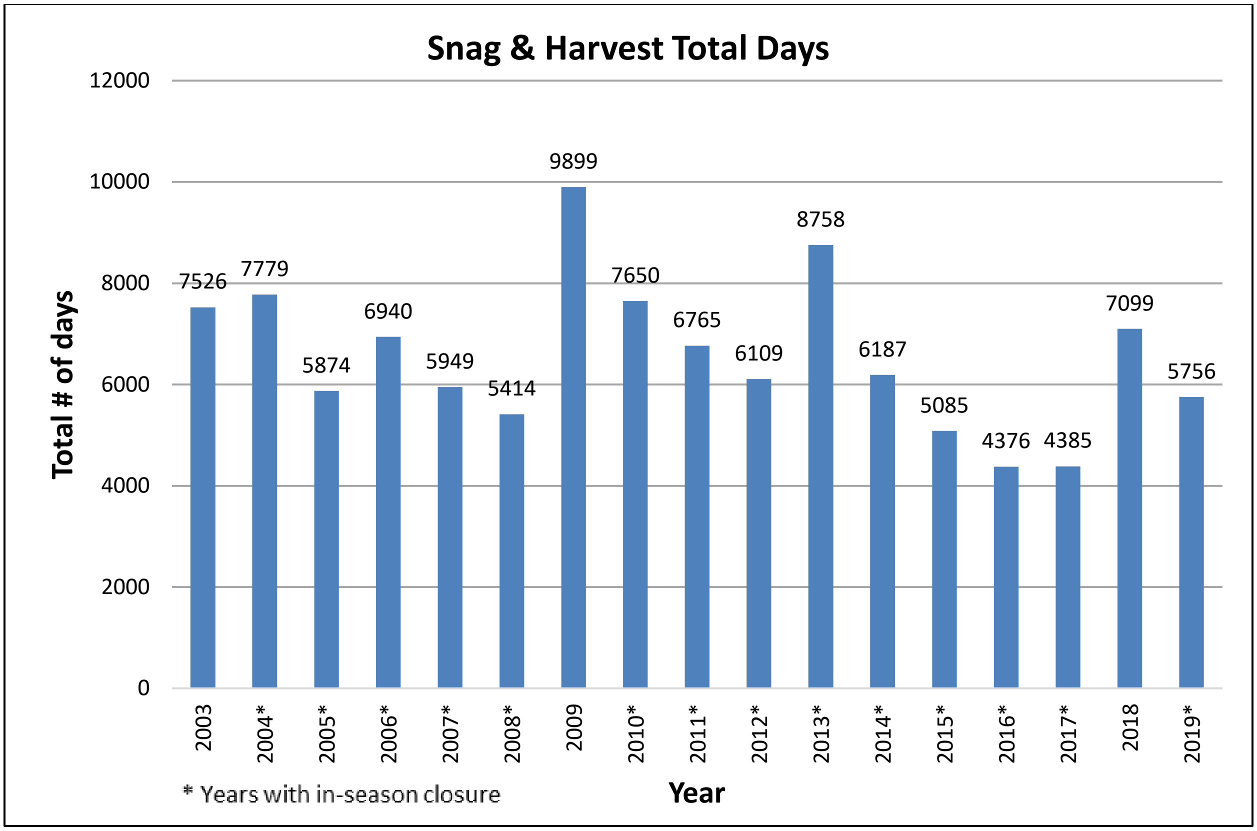


Figure 32. Number of snag and harvest total days, North Dakota, 2003-2019.

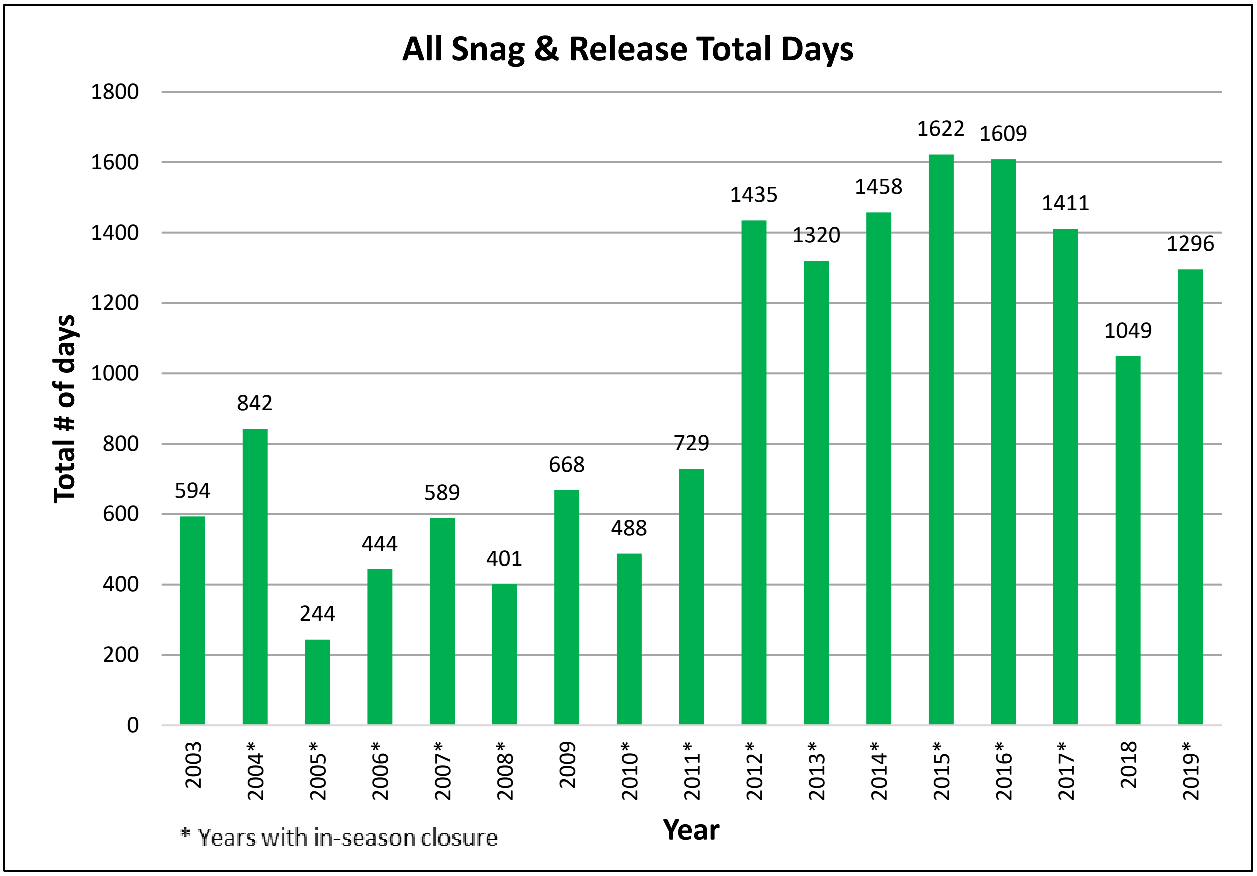


Figure 33. Number of snag-and-release total days, North Dakota, 2003-2019.

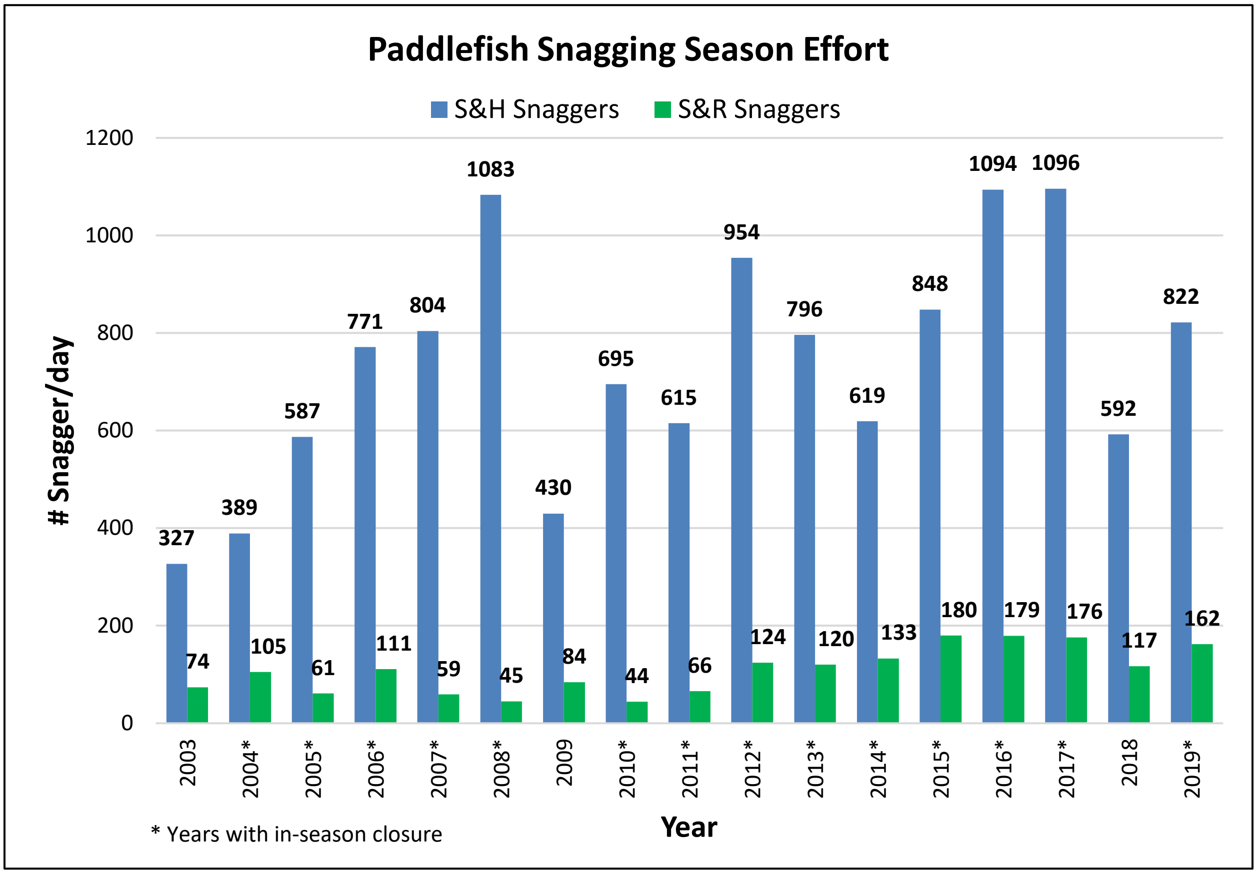


Figure 34. Paddlefish snagging effort, 2003-2019.

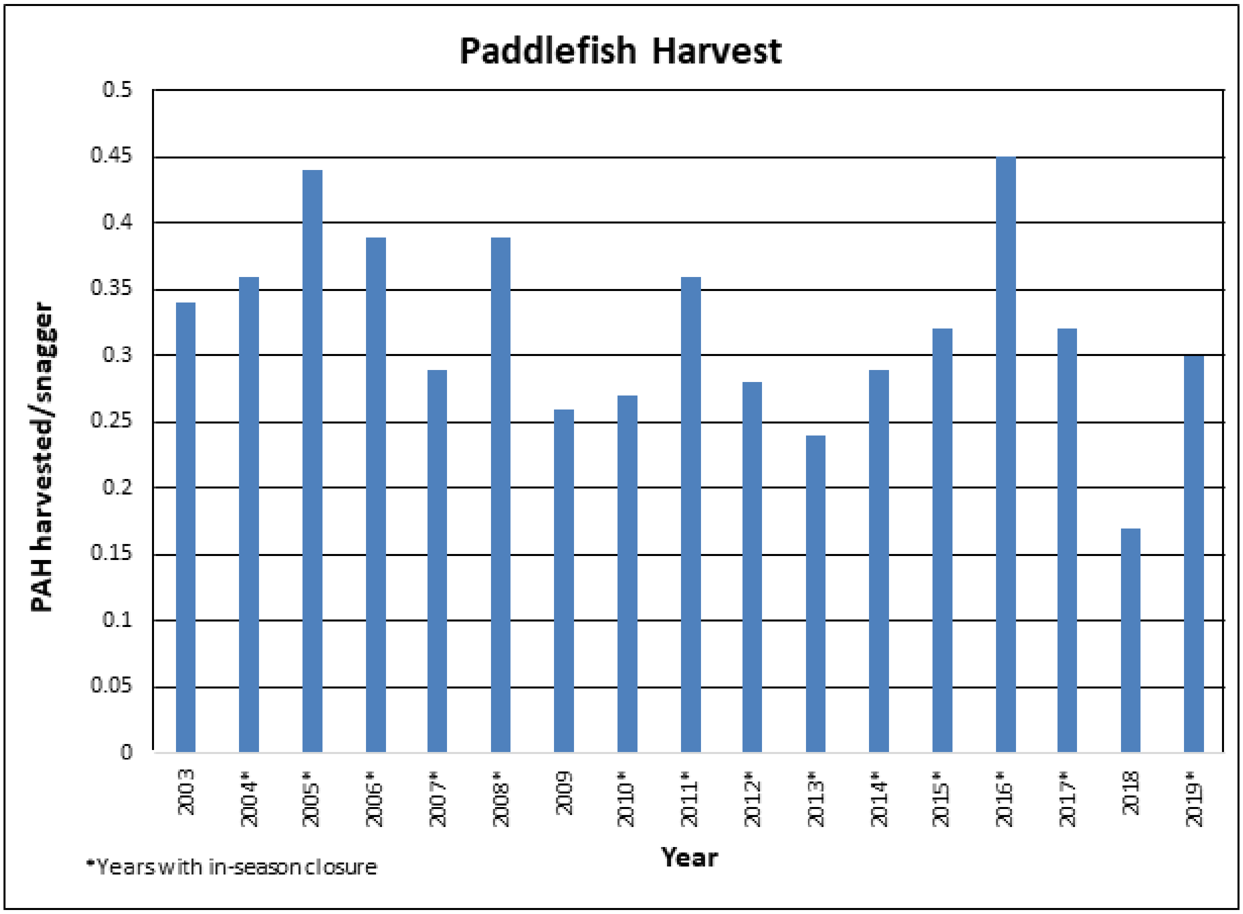


Figure 35. Harvest of paddlefish (PAH) per snagger, North Dakota, 2003-2019.

Figure 36. Paddlefish eggs incubating in hatchery jars at Garrison National Fish Hatchery, 2007.

Historical Stocking Summary For Paddlefish

2018	Lake Sakakawea	Not Specified	297	ADT	0.0 #/Acre		
2018	Lake Sakakawea	Not Specified	2,626	AFG	0.0 #/Acre	480 Lbs.	5 #/lb
2011	Lake Sakakawea	Not Specified	32,242	AFG	0.1 #/Acre	4,548 Lbs.	7 #/lb
2007	Lake Sakakawea	Not Specified	23,956	AFG	0.1 #/Acre	3,871 Lbs.	6 #/lb
1997	Lake Sakakawea	Not Specified	9,944	AFG	0.0 #/Acre	1,040 Lbs.	10 #/lb
1995	Lake Sakakawea	Not Specified	9,093	AFG	0.0 #/Acre	2,082 Lbs.	4 #/lb
1992	Missouri River	Not Specified	400	FGL	0.0 #/Acre	14 Lbs.	28 #/lb
1991	Lake Sakakawea	Not Specified	3,840	AFG	0.0 #/Acre	209 Lbs.	18 #/lb
1991	Lake Sakakawea	Not Specified	3,413	FGL	0.0 #/Acre	137 Lbs.	25 #/lb
1991	Lake Sakakawea	Not Specified	315,000	FRY	0.9 #/Acre		
1990	Lake Sakakawea	Not Specified	7,762	FGL	0.0 #/Acre	210 Lbs.	37 #/lb
1990	Upper Missouri River	Not Specified	3,914	FGL	1.0 #/Acre	154 Lbs.	25 #/lb
1989	Upper Missouri River	Not Specified	33,649	FGL	8.7 #/Acre	517 Lbs.	65 #/lb
1988	Upper Missouri River	Not Specified	22,202	FGL	5.8 #/Acre	431 Lbs.	52 #/lb
1988	Upper Missouri River	Not Specified	372,500	FRY	96.6 #/Acre		
1988	Yellowstone River	Not Specified	200,000	FRY	85.3 #/Acre		
1987	Missouri River	Not Specified	1,000	FGL	0.0 #/Acre	30 Lbs.	33 #/lb
1987	Upper Missouri River	Not Specified	8,748	FGL	2.3 #/Acre	243 Lbs.	36 #/lb
1986	Lake Oahe	Not Specified	1,620	AFG	0.0 #/Acre	253 Lbs.	6 #/lb
1986	Lake Oahe	Not Specified	7,800	FGL	0.1 #/Acre	200 Lbs.	39 #/lb
1986	Upper Missouri River	Not Specified	3,180	AFG	0.8 #/Acre	497 Lbs.	6 #/lb
1986	Upper Missouri River	Not Specified	8,600	FGL	2.2 #/Acre	183 Lbs.	47 #/lb
1986	Yellowstone River	Not Specified	732,400	FRY	312.3 #/Acre		
1985	Lake Sakakawea	Not Specified	26,559	FGL	0.1 #/Acre	624 Lbs.	43 #/lb

Table 4. Historical paddlefish stocking summary.

Dentaries from these known-age fish have been instrumental for age-validation (Scarnecchia et al. 2006, 2019a; Figure 21).

Effects of the coded-wire tagging on feeding and survival of the age-0 fish have not been evaluated. In a laboratory study conducted elsewhere, Hildreth (2003) reported that coded wire tagged, age-0 paddlefish suffered somewhat diminished prey-detection capability at close range and long-range (less-so at intermediate range) than untagged fish.

Stock Assessment and Status

The sampling programs at the Confluence and Intake fishing sites and by agency personnel off-season are designed to collect information used to determine stock size, age structure, growth and mortality rates, reproductive and recruitment success, distribution, migrations and movements, reproductive periodicity, harvest, non-harvest injuries and mortality to paddlefish, and several other stock attributes (Figure 37, 38). The database includes catch and harvest, adult fish jaw tagging and recapture sampling, reservoir fish and habitat sampling data in Lake Sakakawea, and in-season (in person) and post-season (telephone) creel censuses. Angler demographic information is also available. Since 1991, the data collected have been analyzed as part of an annual stock status assessment based on four indices: an Age-0 Index, a Sub-Adult Index, a Young Male Recruit Index, and a Five-Year Recruitment Estimate. The last estimate has proven useful in setting the harvest cap for the stock, which has then been allocated equitably between the two states.

Managers, other scientists and their technicians maintain active on-site presence in managing the fisheries, including directing and overseeing comprehensive data collection from the harvest fisheries. The catch consists almost entirely of sexually mature, pre-spawning migratory fish (Scarnecchia et al. 1996b; 2007a) and is generally more indicative of the actual run with mandatory retention (i.e., the Yellowstone-Sakakawea stock) than without mandatory retention (i.e., the Fort Peck stock). During specified catch-and-release periods (Scarnecchia and Stewart 1997a), when release of fish is mandatory for the Yellowstone-Sakakawea stock, the catch at Intake is also used as a source of fish for jaw tagging.

Data are collected under a protocol designed by NDGF and MFWP in conjunction with the University of Idaho to provide information for comprehensive stock assessment (Scarnecchia et al. 1996c; 2007a; 2009; 2014). Both states use the angler tag system as the cornerstone of the database. When a fish is harvested, the tag must be immediately attached to the fleshy tissue at the front portion of the base of the paddlefish’s dorsal fin (Figure 39a). This unique tag number, linked to the angler at the time of purchase of the tag, remains thereafter associated with the fish, with the roe and caviar, and with all scientific data on the fish in databases.

Figure 37. a) Weighing and measuring paddlefish at the Intake Fishing Access site, Montana and b) at the Confluence, near Buford, North Dakota.

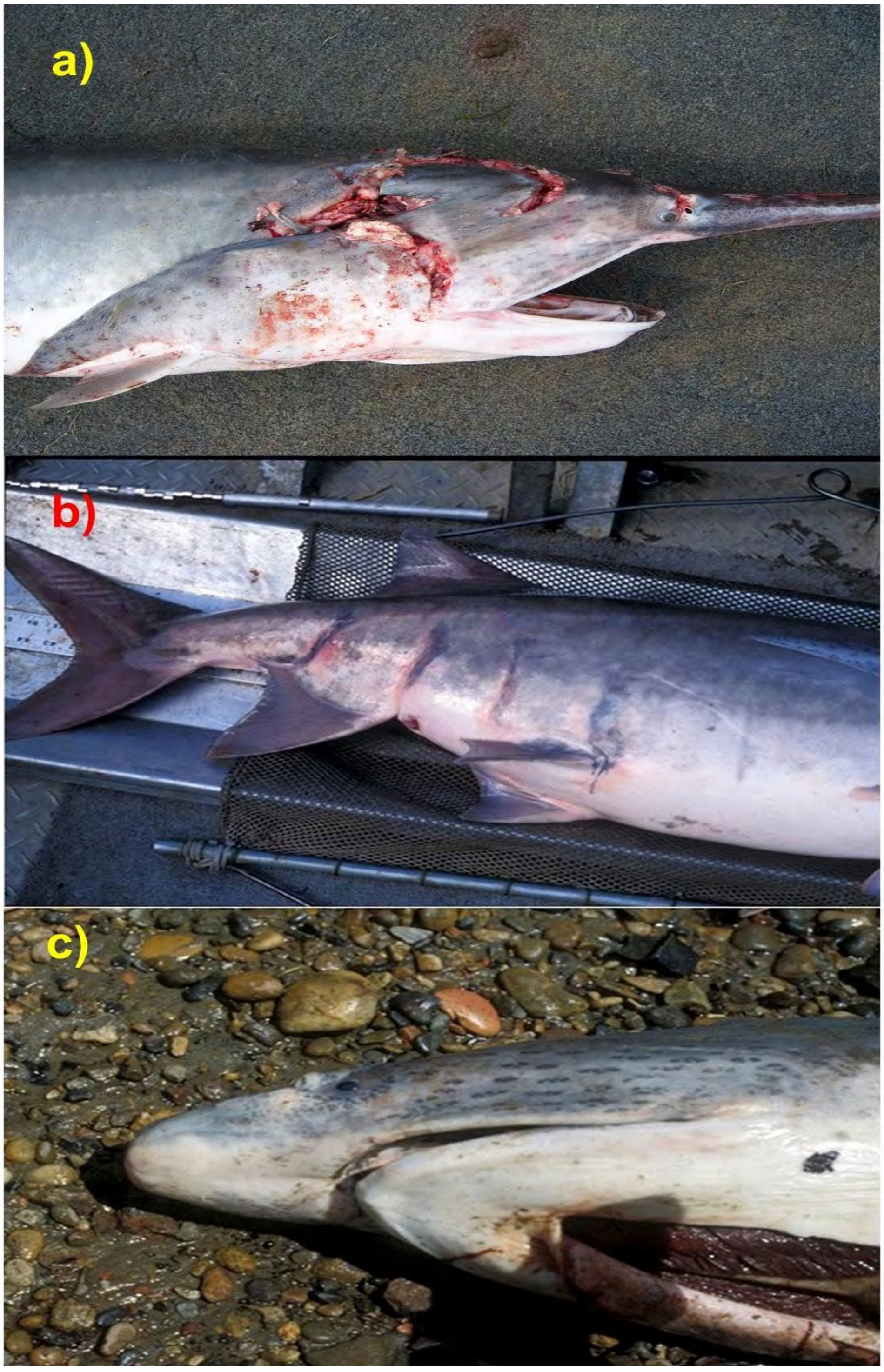


Figure 38. a) Fresh propeller cuts, b) propeller scars, and c) a chopped-off rostrum from Yellowstone-Sakakawea paddlefish.

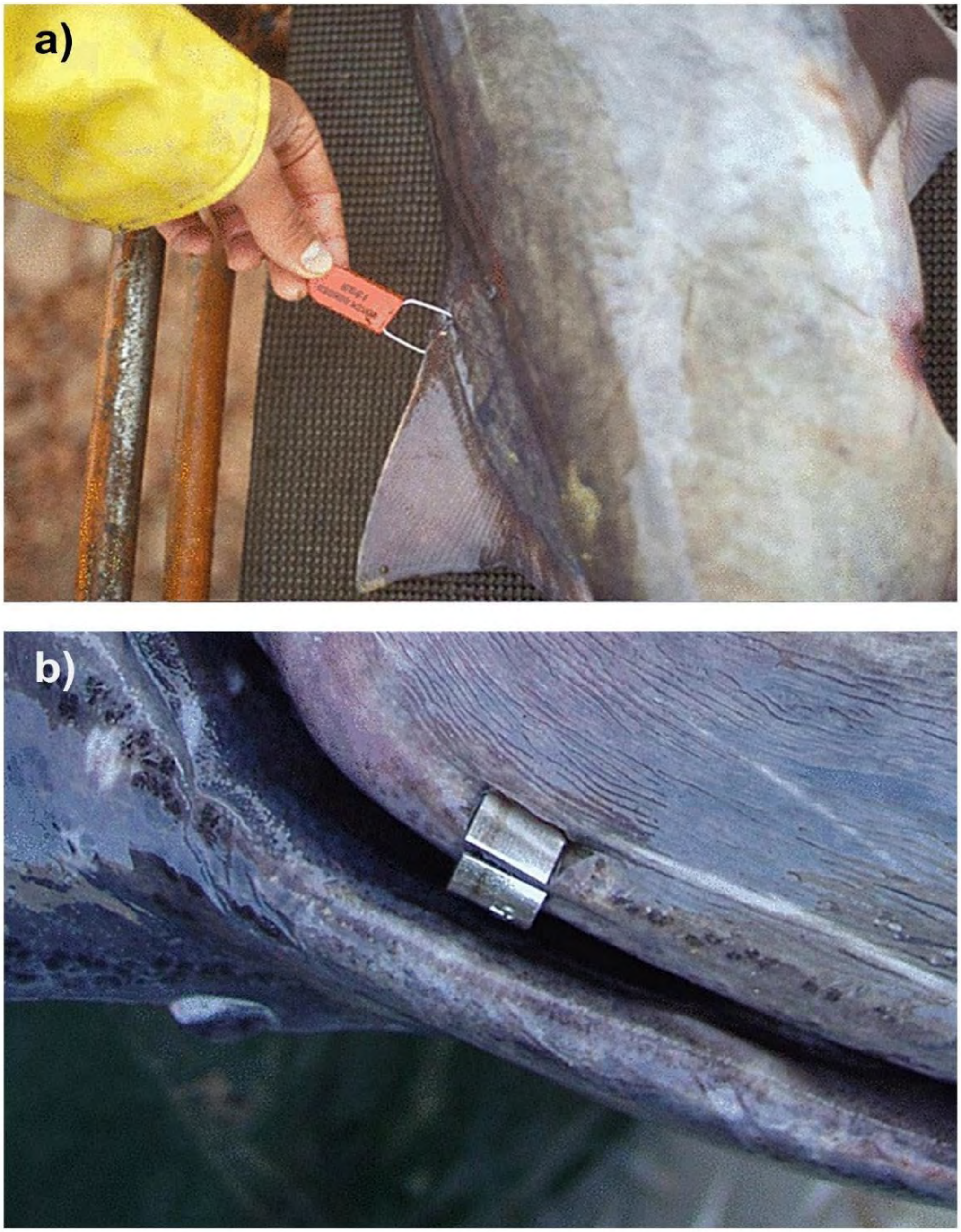


Figure 39. a) individually numbered angler tag and b) individually-numbered paddlefish monel (metal) jaw tag.

Biological and fisheries data from cleaning stations - The Confluence and Intake cleaning stations are primary sources of biological and fisheries data, processing a high percentage of harvested fish in both states (e.g., North Dakota: 74 to 90% of the annual harvest over the period 2001-2016; mean 84.4%; Gangl 2017; a comparable or higher percentage in Montana depending on flows). From each fish, data collected included the date of harvest, harvest location (Rkm), body length (BL; anterior of eye to fork of caudal fin; Ruelle and Hudson 1977) to the nearest 2.5 cm increment, weight to the nearest 0.5 kg, sex, maturation stage (Scarnecchia et al. 1996c; Bruch et al. 2001), gonad weight, gonadal fat body (GFB) weight, caviar weight, presence of injury or scarring to the fish, and dentaries (lower jaw bones) for age determination (Adams 1942; Scarnecchia et al. 2006; 2007a). All fish brought to cleaning stations are also screened for the presence of coded-wire tags and jaw tags. Additional samples for investigations related to genetics, physiology, or other topics are also collected as requested by other investigators.

Over the period 1991-2019, age was determined for a total of 46,577 fish; 24,134 fish (13,071 males, 11,063 females) from the Montana harvest and 22,443 fish (13,011 males, 9,432 females) from the North Dakota harvest. Age determination has been used in assessing recruitment and allowable harvest based on a model which has used the 5-year recruitment of known-age fish.

Several other types of information are collected from anglers besides that collected at the fish cleaning stations. MFWP and NDGF use license and tag application and information from phone surveys to obtain data on snagger state/city of residency, success rate, fishing effort, and other information. Overall, the collection of data from anglers at the cleaning stations and by anglers through the licensing and angler tag program serves as a cost-effective approach to obtaining stock assessment and management data that is the cornerstone of the program.

Adult fish jaw tagging - NDGF and MFWP also supervise and collect adult fish for jaw-tagging. In North Dakota, adult fish are sampled with drifted gillnets by NDGF in the Missouri and Yellowstone rivers. Netting historically occurred in both fall (September) and spring (April) but since 2006 has been conducted strictly in spring, immediately prior to the harvest season, typically from the Confluence to the Highway 85 bridge near Williston. In Montana, fish were historically captured with gillnets by MFWP in the Yellowstone River, typically during the harvest season, and during some controlled special catch-and-release “snag and tag” in-season sessions monitored by MFWP. In the years since 2007, when catch-and-release was expanded to three days per week, nearly all tagging has occurred from fish caught and released by anglers at Intake. Capture during these periods in a monitored fishery has resulted in an effective tagging program with no observed immediate mortality. Records show that many snagged fish that are properly handled can be caught repeatedly, although in nearly all cases some scarring, mostly very minor, remains as evidence of the capture.

Fish captured for tagging are measured, weighed, tagged with jaw tags (if not previously tagged) and released. Putative sex, with high reliability, is recorded although absolute determination of sex is not possible externally in some cases. Over the period 1964-2018, 31,575 adult migratory fish were captured with angling, gillnets or seines and tagged with individually-numbered metal (monel) or plastic poultry band tags around their dentaries (Figure 39b). In 2018, aluminum tags were first used on a trial basis to reduce problems with readability caused by tag corrosion.

Tags are recovered from fish subsequently gillnetted by MFWP or NDGF, harvested by recreational anglers and brought to the Confluence or Intake for cleaning, or captured during catch-and-release snagging. Data collected from mark-recapture tagging efforts include tag and recovery dates and locations, BL and weight, and sex (for harvested fish).

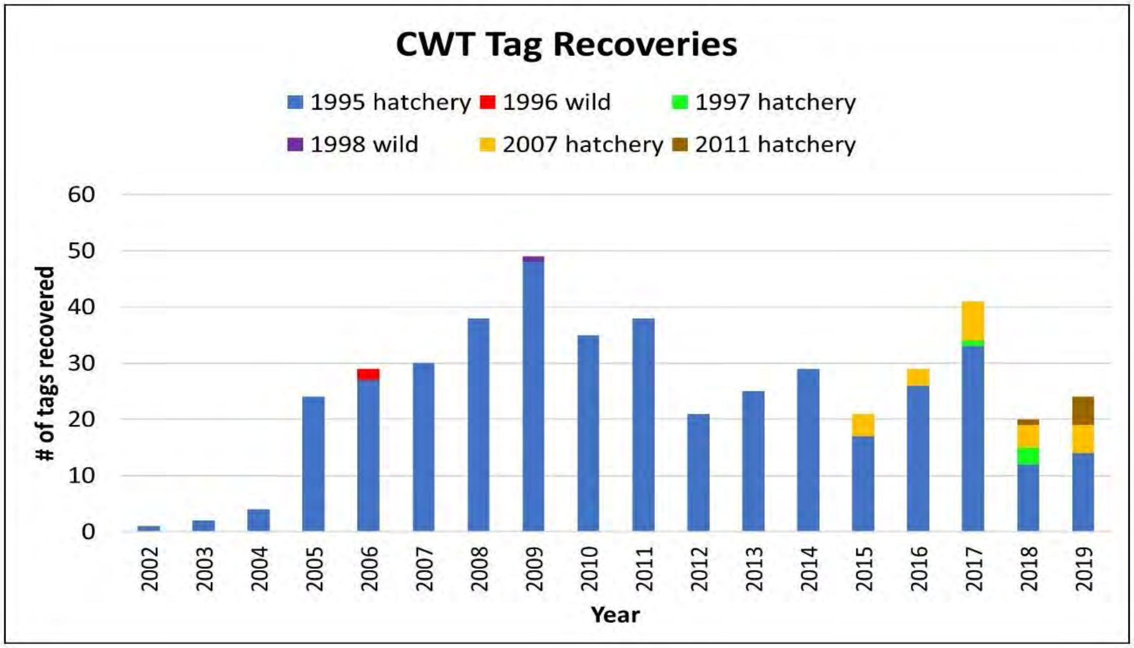
Recoveries of tagged fish provide information on harvest rates, population size, movements, and reproductive periodicity. Over the period 1995-2019, comprehensive historical database was completed and verified for all fish previously tagged. No fish were tagged in 2020. The database is updated and error-checked annually with records from newly-tagged fish and recoveries of previously tagged fish.

Reservoir sampling of age-0 and sub-adult fish, zooplankton, and reservoir habitat - Another source of stock assessment data, used mainly for assessing reproduction and recruitment, is obtained from reservoir sampling from mid-July through early September. Standard transect counts of age-0 and sub-adult fish are conducted. Several limnological characteristics are measured at each transect: transect length, water depth, water temperature, water clarity (Secchi depth) and zooplankton densities (surface tows). Limnological data are analyzed in relation to transect counts of age-0 fish and reservoir water levels.

Age-0 paddlefish feeding in the reservoir are not elusive compared to other fishes and are easily caught in dipnets from the bow or sides of a slow-moving boat (Scarnecchia et al. 1997; Figure 40). This method allows for the capture and tagging of large numbers of age-0 fish in years when they are abundant. It also allows sampling for food habits (Fredericks 1994). Over the period 1996-2020, 22,883 wild age-0 fish have been caught and tagged with batch coded wire tags, the last in 2011 (Figure 40). Recoveries of these fish have thus far been too few (n = 3) to be useful in age validation of wild fish. However, their survival has been lower than the larger hatchery-reared fish tagged and released in 1995, 2007 and 2011 (Figure 41). This difference in survival has provided information on fish size potentially affecting recruitment and year class strength.

Early warning system for reproduction and recruitment success or failure - The stock assessment approach has an early warning system designed to alert managers of low levels or failure of paddlefish reproduction and recruitment. The fish most avidly protected from over-harvest are adult females, which typically need at least 16-18 years to recruit and up to 25 years to reach their prime spawning period (Scarnecchia et al. 2007; 2019a). Indices of abundance of

Figure 40. a) dip netting age-0 paddlefish in Lake Sakakawea, b) weighing and measuring the fish, c) inserting coded-wire tag in rostrum with hand-held tagger, and d) *Leptodora kindtii*, predaceous cladoceran and preferred food of age-0 paddlefish.



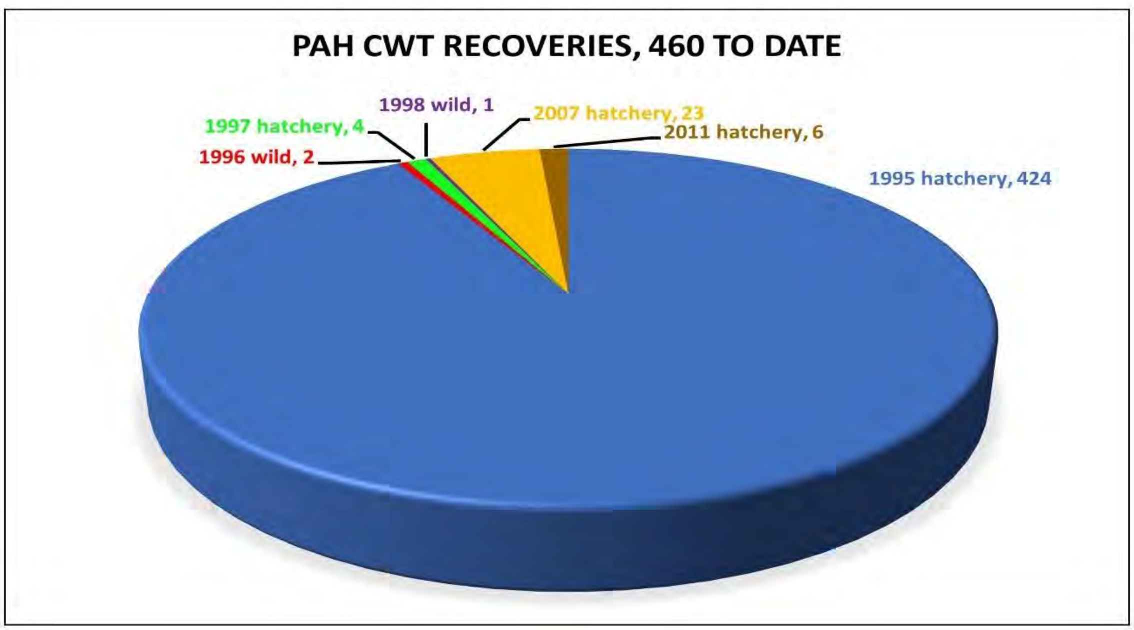


Figure 41. Recoveries of known-age, known sex coded wire tagged paddlefish, Yellowstone-Sakakawea stock, 2002-2019.

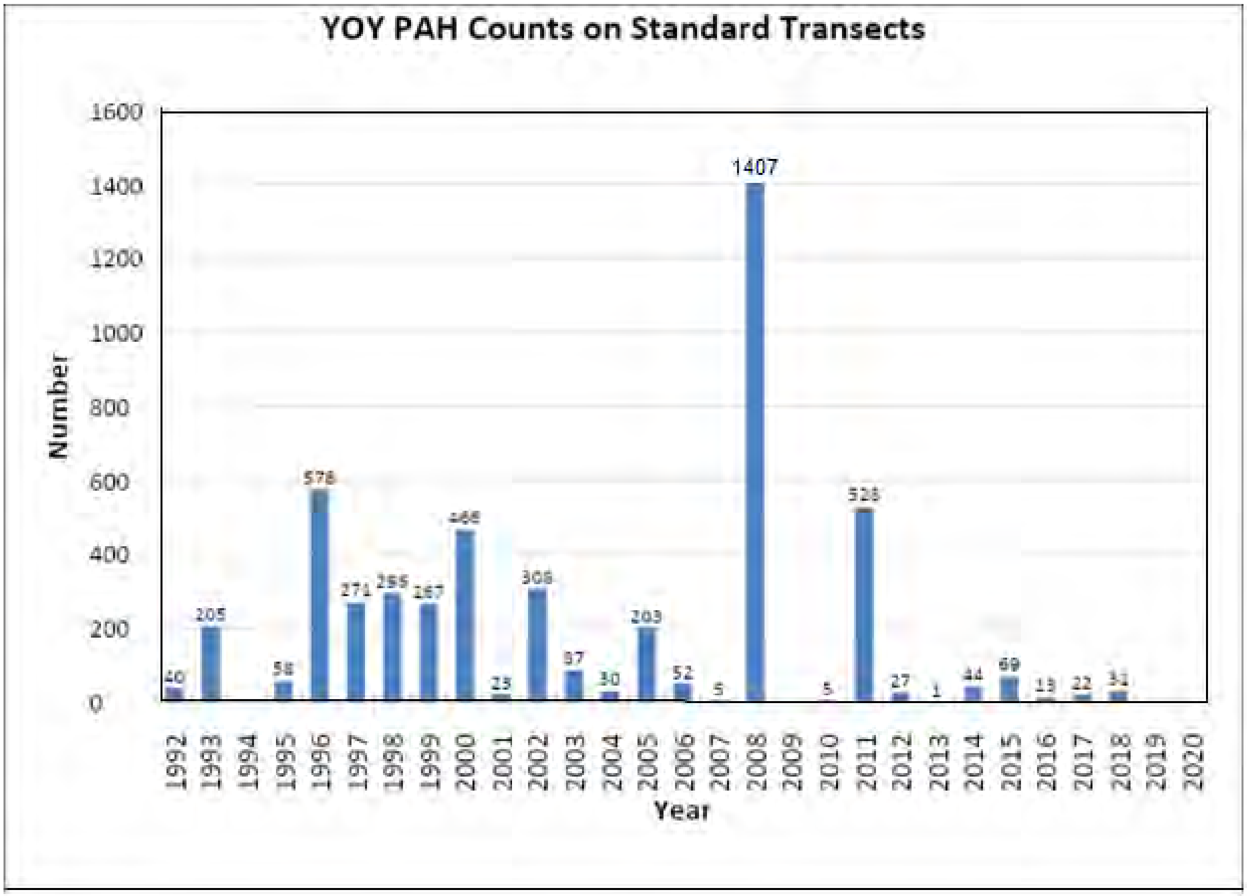


Figure 42. Counts of age-0 paddlefish along standard transects by year, 1992-2020.

year classes are developed using 4 methods: 1) The Age-0 Index, or advanced age-0 fish after larval and early juvenile mortality have acted, 2) The Sub-adult Index, typically only age-1 and age-2 fish, which are mostly past a length at which they are vulnerable to predation, 3) the Young Male Recruit Index of young sexually mature male migrants (ages 6-9-) contributing to fisheries several years before females of their year class, and 4) the Five-Year Recruitment Estimate (ages 10-14 males, 17-21 females), from which the harvest cap can be set and adjusted.

The Age-0 Index - This index of reproductive success is based on relative abundance of age-0 fish counted along standard transects of Lake Sakakawea for several weeks in late July through mid-September. Sampling at that time, after initial larval and fry mortality has acted, provides the best opportunity to sample immature fish. The method consists of surface visual counts along transects at 4.8-km (3-mi.) intervals in the reservoir headwaters. As a two-person crew boats travel at speed of 8 km/hour along the transects, age-0 paddlefish feeding in the water column are startled by the boat, and their attempts to flee drive them to the surface, where they are enumerated within 10-m of each side of the boat (Fredericks and Scarnecchia 1997).

Transect counts have been conducted each year for several weeks since 1992, except for 1996, when counts were conducted for only one week (Figure 42). The wide fluctuations in water levels in Lake Sakakawea over the period 1992-2006 have unfortunately made it impossible to use the same transects every year; transects have moved upriver and downriver with water levels. For example, in 2004, a low water-level year, six transects from MR Rkm 2403 (RM 1494) to MR Rkm 2428 (RM 1509) were sampled. In contrast, in 1996 and 1997, high water level years, transects extended from MR Rkm 2433 (RM 1512) to MR Rkm 2476 (RM1539). Consequently, the most common index has been to use the counts from the highest 4 transects.

The transect method has been shown to be generally effective and quantitatively indicative of relative abundance of age-0 fish in Lake Sakakawea. The method also allows a large surface area of the reservoir to be sampled. Bowersox (2004) also reported that the age-0 paddlefish's preferred food item, *Leptodora kindtii* did not exhibit significant diel vertical migrations (DVM) on Fort Peck Reservoir. The age-0 paddlefish in Lake Sakakawea might thus be expected to be distributed throughout the water column. Fredericks (1994) reported that visual counts in Lake Sakakawea were correlated with experimental trawl catches. Counts of age-0 fish in 1995 were also associated with high catches of ages-9-11 fish in 2004-2006. suggesting that this method can be useful to predict the strength of the future year classes. Visual counts are less expensive and less laborious than trawls, resulting in almost no incidental mortality.

The Sub-adult Index - Sub-adult paddlefish, mostly age-1 and age-2, are also counted along transects. Unfortunately, only few years have yielded enough sightings of these fish that any index of abundance could be obtained. However, this index has proven useful for identifying large year classes. High counts and catches of age-1 fish (such as in 1996) and age-2 fish (such as in 1997) accurately forecasted the strong 1995-year class contributing to the fisheries in 2005-2007. The strong year class in 2011 was detected in age-1 counts in 2012 (Figure 43;

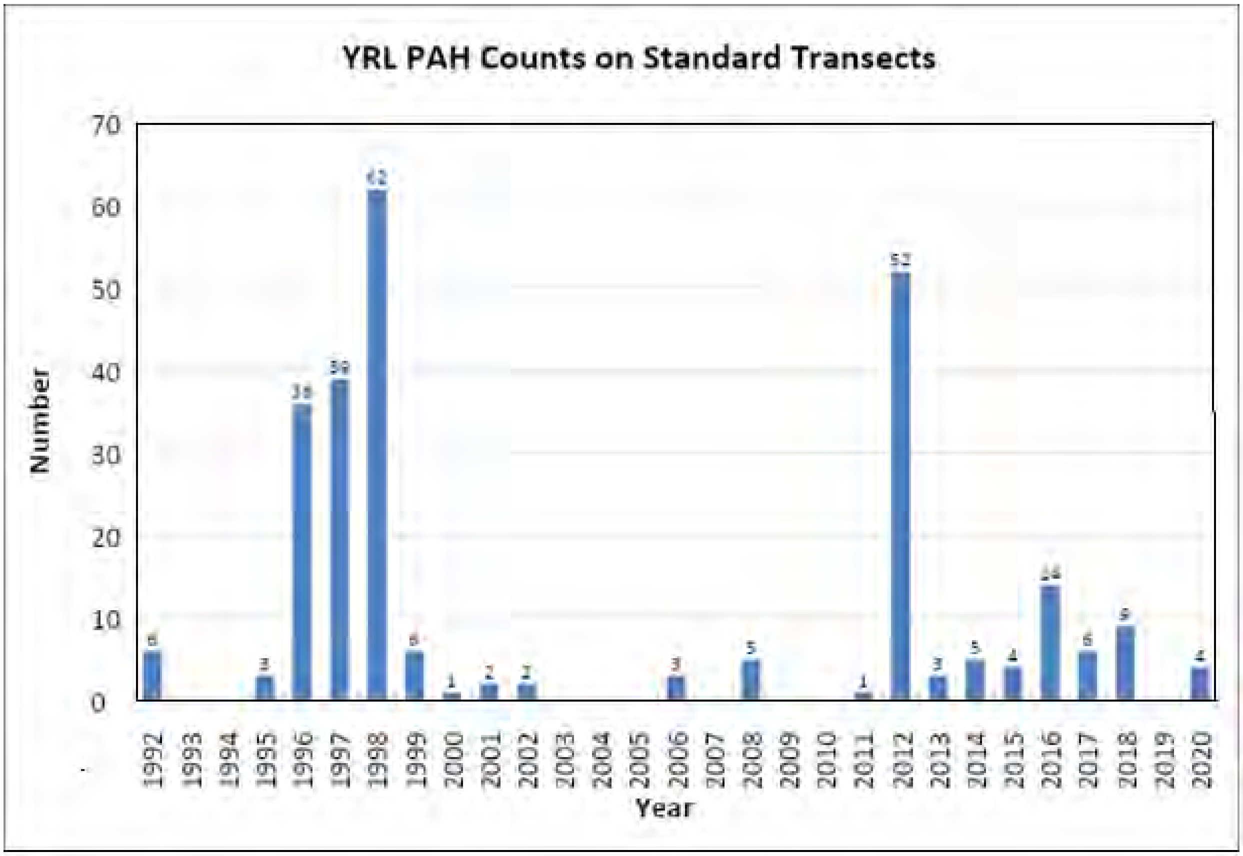


Figure 43. Counts of sub-adult (mostly age-1 and age-2) paddlefish along standard transects by year, 1992-2020.

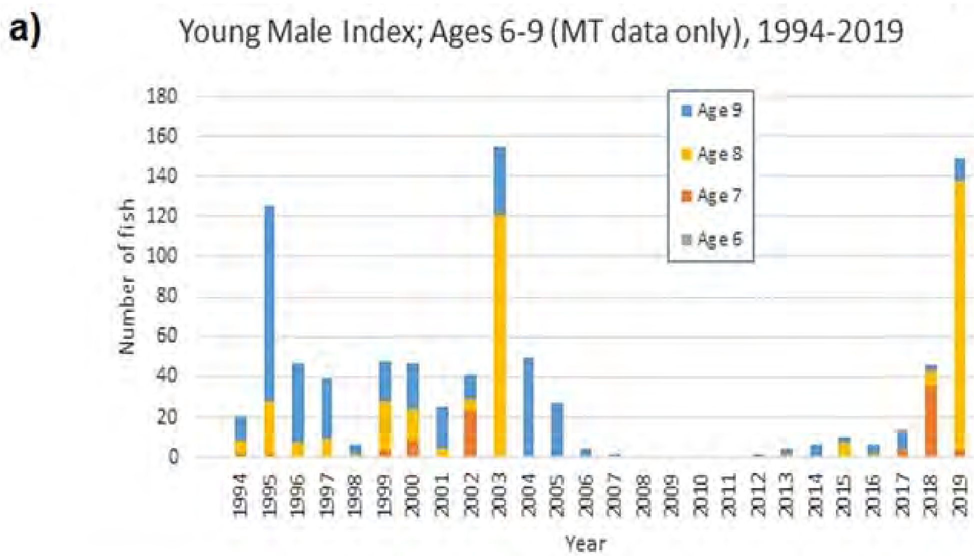
Figure 44. Examples of age-0 and putatively recruited, sub-adult paddlefish, Lake Sakakawea.

Scarnecchia et al. 2007; 2019). After age-2, juvenile paddlefish become much less vulnerable to sampling, and are not quantifiable until they are recruited to the fishery. Numbers of these age-1 and age-2 fish are typically much lower than age-0 fish, but their presence appears to be a more reliable index of recruitment because these fish are past the period of highest juvenile mortality (Figure 44).

Although counts of older sub-adult fish (typically ages 3-5) along transects are kept incidentally to the other indices, to date these data from the reservoir counts have not proven useful for stock assessment. However, a few of these fish have been caught by North Dakota snaggers in the river as small migrants. These fish, although few in number, have proven harbingers of the two strong year class from 1995 and 2011.

The Young Male Recruit Index -- The next good sampling opportunity for a year class of paddlefish does not occur until 6-9 years after hatch, as young male paddlefish migrating up the Yellowstone and Missouri Rivers to spawn are caught in snag fisheries. The Young Male Recruit Index is obtained from fish brought into cleaning stations. Because males mature at a younger age than females, a strong year class of males in the harvest for a few years indicates that in the absence of some external mortality factor, the same strong year class of females will enter the fishery 8-10 years later (Scarnecchia et al. 2007; Figure 45a). The method of using younger recruits to forecast older recruits of the same year class has a long history for other species in management (Jacobsson and Johanssen 1921; Gunsolus 1978; Peterson 1982; United States General Accounting Index 1983; Scarnecchia 1984 and Scarnecchia et al. 1989b). For example, the strong 1995-year class of paddlefish moving through the fishery in 2001 (age 6), 2002 (age 7), 2003 (age 8) and 2004 (age 9) portended high recruitment of females several years later (Figure 45a).

Five-Year Recruitment Estimate and harvest cap - A harvest cap can be set and adjusted based on how well the stock is recruiting over the most recent 5-year period. The attempt is to match the number of fish removed from harvest with fish replaced through recruitment. Information on population sizes (from adult fish tagging and recovery) and age structure of the catch (from dentary samples) is used to estimate the number of young male fish (ages 10-14) and number of young female fish (ages 17-21) recruiting to the fishery over the most recent five-year period (Figure 45b). Harvest is then adjusted accordingly to approximately match the recruitment, such that allowable harvest does not exceed recruitment. Those cohorts are not the youngest recruits but are more fully recruited and therefore more indicative of year class strength. With mandatory retention, age structure of the catch is assumed to be indicative of the population age structure. For example, over the 5-year period 1997-2001, estimated combined recruitment of male fish aged 10-14 and female fish aged 17-21 was 2,000 fish. Maximum total allowable harvest in both 2003 and 2004 was therefore set at 2,000 fish and allocated equally between the two states (i.e., 1,000 fish per state). The harvest cap is not a harvest target, but an annual cap designed to prevent excessive harvest in years when fish are especially vulnerable. It is expected that the cap may not be reached in some years.



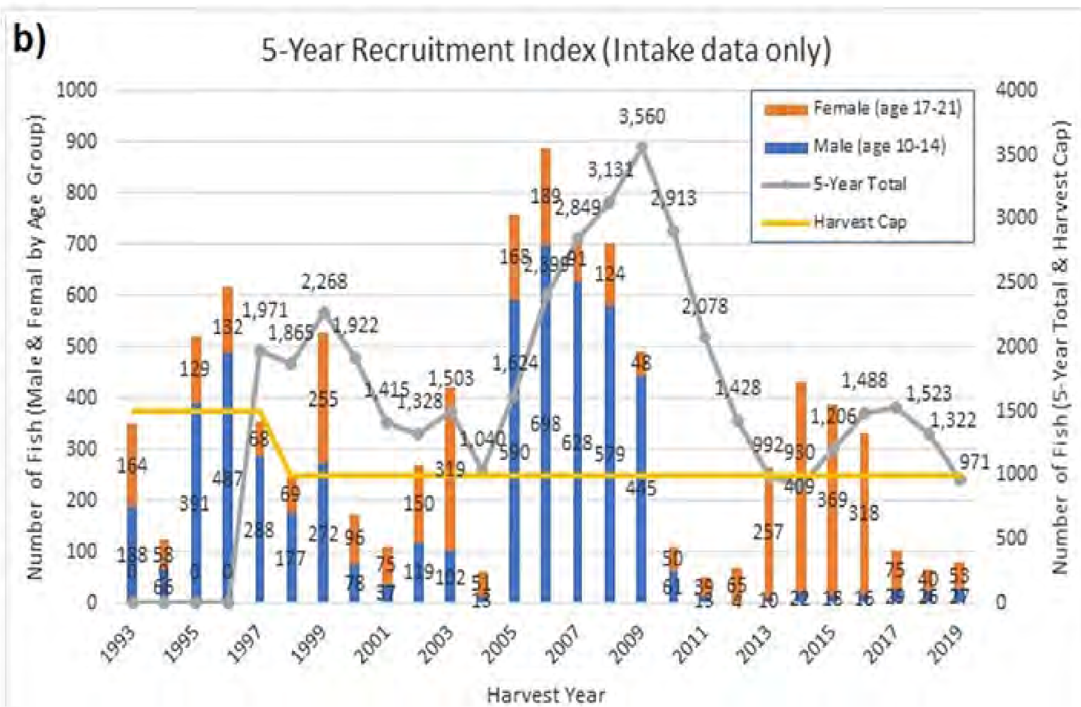


Figure 45. a) Example of ages-6-9 young male recruits from Montana harvest at Intake; b) Example of data used in a 5-year recruitment index, here using only data from Montana. The large 1995 cohort shows up as males (blue) in the index about 8 years before the females (dark Yellow). In estimating the recruitment to set a harvest cap, data from both states are used together. Note above that recruits from 2005-2009 were mostly males, whereas recruits from 2013-2016 were mostly females. Calculations can also be done and harvest caps set using only female fish if desired.

A combination of methods - Present stock status is assessed using a combination of the three indices and the Five-Year Recruitment Estimate, along with monitoring for the presence of old fish in the harvest. Although to date the harvest cap has been set based on the Five-Year Recruitment Estimate, the cap can be adjusted based on information obtained from the Age-0 Index, the Sub-adult Index, and the Young Male Recruit Index. For example, if drought produces low spring discharges and low reservoir levels over a period of years X to X+3, low Age-0 Indices in years X to X+3, Low Sub-adult Indices in Years X+1 to X+4, and low Young Male Recruit Indices in years X+10 to X+13, it would be predicted that recruitment of females would be low in years X+17 to X+20. In years since the last paddlefish Plan, the more uneven recruitment of the stock has created the potential for greater variation in sex ratios, as pulses of young males, then young females, are harvested (Scarnecchia et al. 2014). Virtual population analysis of the stock has shown the strong pulse of the population associated with the entry of the 1995-year class males (Scarnecchia et al. 2014). Under such conditions, the harvest cap can be adjusted accordingly in later years to protect females until more recruitment (and more young males) enter the harvest and, with mandatory retention, buffer harvest of females.

MFWP and NDGF also recognize that retaining a wide range of ages in the recruited stock, from age 9 to age 40 or higher, is critical for the health of the stock (Francis et al. 2007; Scarnecchia et al. 2019a). In particular, female prime spawners (ages 25 and older; Scarnecchia et al. 2007) are not just a source of caviar, but more importantly, are vital to retain in the population for long term stock health (Scarnecchia et al. 2019a). The stock must not only have reproductive success and recruitment, but an age structure with long-lived fish characteristic of the original unfished stock (Scarnecchia et al. 2007; Scarnecchia et al. 2019a; Figure 46). The number of older fish (>30 years; Tables 1, 2) is monitored and their strong decline considered a warning sign for over-harvest. Results to date have indicated the maintenance of older fish in the harvest.

Fort Peck stock and fishery

Realm

The Fort Peck stock is the most northwesterly of paddlefish stocks in the species' native range. The stock inhabits the Missouri River system from Fort Peck Dam westward as far as Morony Dam, 24 km downstream of Great Falls, Montana (Figure 47). As described by Berg (1981), the landscape [in the 240-km Wild and Scenic portion of the river from Fort Benton to the Fred Robinson Bridge] "consists primarily of rolling plains, interrupted by isolated areas of mountain uplift… The gorge- like river valley, which lies 150 to 300 meters (m) below the average elevation of the adjacent upland plains, is comprised largely of spectacular, varied, and highly scenic badlands and breaks…" (p. 2). The landscape in the upper reaches of Fort Peck Reservoir is often forested with ponderosa pine *Pinus ponderosa,* whereas nearer the dam, the landscape is primarily treeless rolling plains with steep scarps carved by rivers and tributaries. Exposed bedrock is typically Cretaceous in age. Surface material in much of the area near the

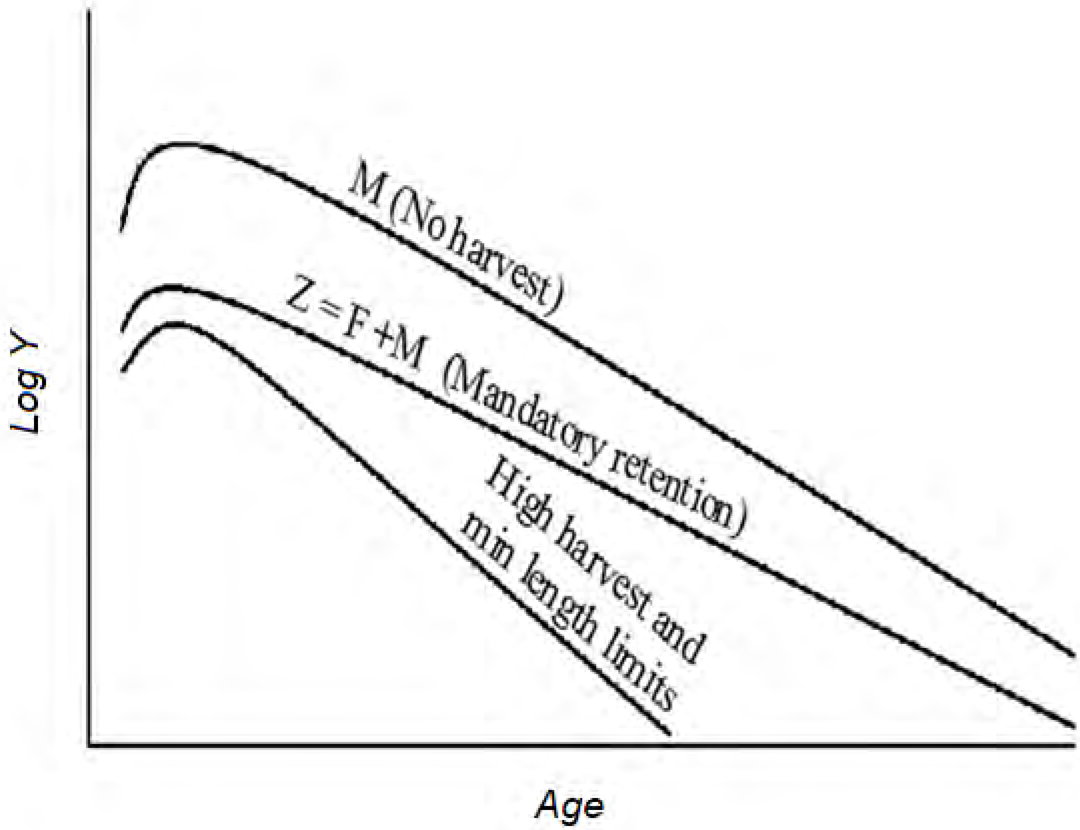


Figure 46. Hypothetical catch curves under conditions of no harvest, high, selective harvest of larger, older fish, and under a plan to avoid age truncation, as under mandatory retention. (from Scarnecchia et al. 2014).

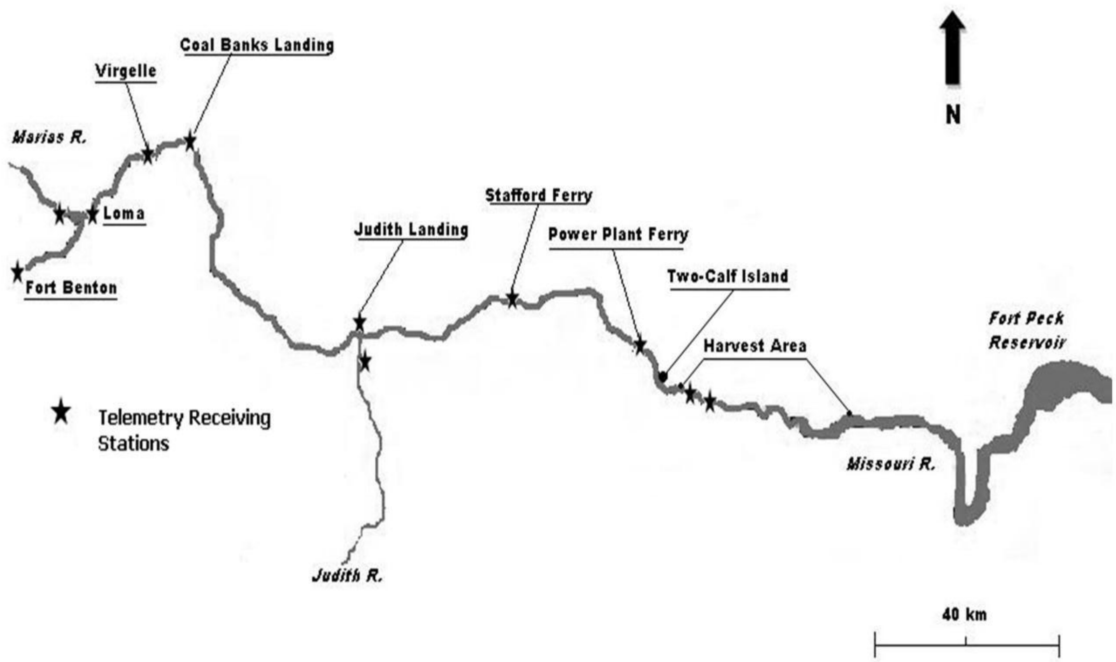


Figure 47. Close-up of the harvest area of the Fort Peck paddlefish stock immediately above Fort Peck Reservoir.

Dam is surface moraine of Wisconsin (Pleistocene) origin (Jensen and Varnes 1964). The semi-arid climate is highly variable annually and prone to periodic drought (Bowman 1931).

The riverine portion from Morony Dam to the reservoir headwaters is 336 km in length. Two major tributaries enter the river in this reach, the Marias River from the North and the Judith River from the south (Figure 47). Berg (1981) reported that 49 species of fish in 14 families were present in the combined river and reservoir areas. The river reach was described as consisting of two fishery zones by Gardner and Berg (1980). The upper reach from Morony Dam to the mouth of the Marias River is a cold water/warm-water transitional zone, with sauger as the predominant game fish. The warm-water zone extends from the mouth of the Marias River downstream to the headwaters of Fort Peck Reservoir. Paddlefish are more common in the lower zone. In the lower portions of the warm-water zone (Cow Island, Fred Robinson Bridge, and Turkey Joe), the river is characterized as having "a wide meandering channel which contains numerous shifting sandbars and large developed islands" (p.2; Gardner and Berg 1980) as well as many side channels and backwaters. Substrate in the Fred Robinson Bridge (FRB) area consists of more gravel and less sand than is commonly found in the lower Yellowstone River below Sidney.

As in the Yellowstone River, runoff of the Missouri River above Fort Peck Dam typically peaks in June, associated with snowmelt. Mean monthly discharge in the Missouri River at the Virgelle gauging station (USGS 10040101) over the period 1935 to 2019 has been highest in June (mean, 470.1 m^3/sec, 16,600 cfs), followed by May (mean, 362.5 m^3/sec, 12,800 cfs) and July (mean, 279.2 m^3/sec, 9,860 cfs). Discharge in June above Fort Peck reservoir averages 1.42 times that at Culbertson as a result of regulation from the dam. This amount is only about 50% of that in the Lower Yellowstone River at Sidney. Since 1990, June flows have been highest in the periods 1995-1997, 2008-2011 and 2018, similar to high flow years in the Yellowstone River.

Fort Peck Reservoir is the fifth largest reservoir in the United States at 202 km long, 980 km^2 in area, and about 2,400 km of shoreline at maximum normal operating pool. It drains an area of 26,418 km^2 (10,200 mi^2). Although the reservoir stores more than 23 billion m^3 (18.7 million acre feet) of water at a maximum operating pool of 684.7 m (2250 ft) above sea level (a.s.l.), elevations in the reservoir have typically resulted in lower water levels, i.e., within the Annual Flood Control and Multiple use zone, and (during drought), the Carryover Multiple Use zone.

Historical details about the development and construction of Fort Peck Dam are reported by the U. S. Army Corps of Engineers (1987) and the first issue of Life Magazine (Anonymous 1936). Upon closure of the dam in 1937 (Fort Peck Reunion Committee 1977), the reservoir took 10 years to reach maximum normal operating pool (683.5 m; 2246 ft a.s.l), only to experience a rapid decline in level in the late 1950s (Figure 48). In the 1970s through the mid-1980s, the reservoir levels fluctuated moderately, remaining between 680 and 686 m a.s.l. Sharp declines in water levels to below 677.5 m a.s.l. occurred in the periods 1990-1993 and 2002-2003 associated with drought conditions and water releases based on multiple use decisions (Figure 48). In

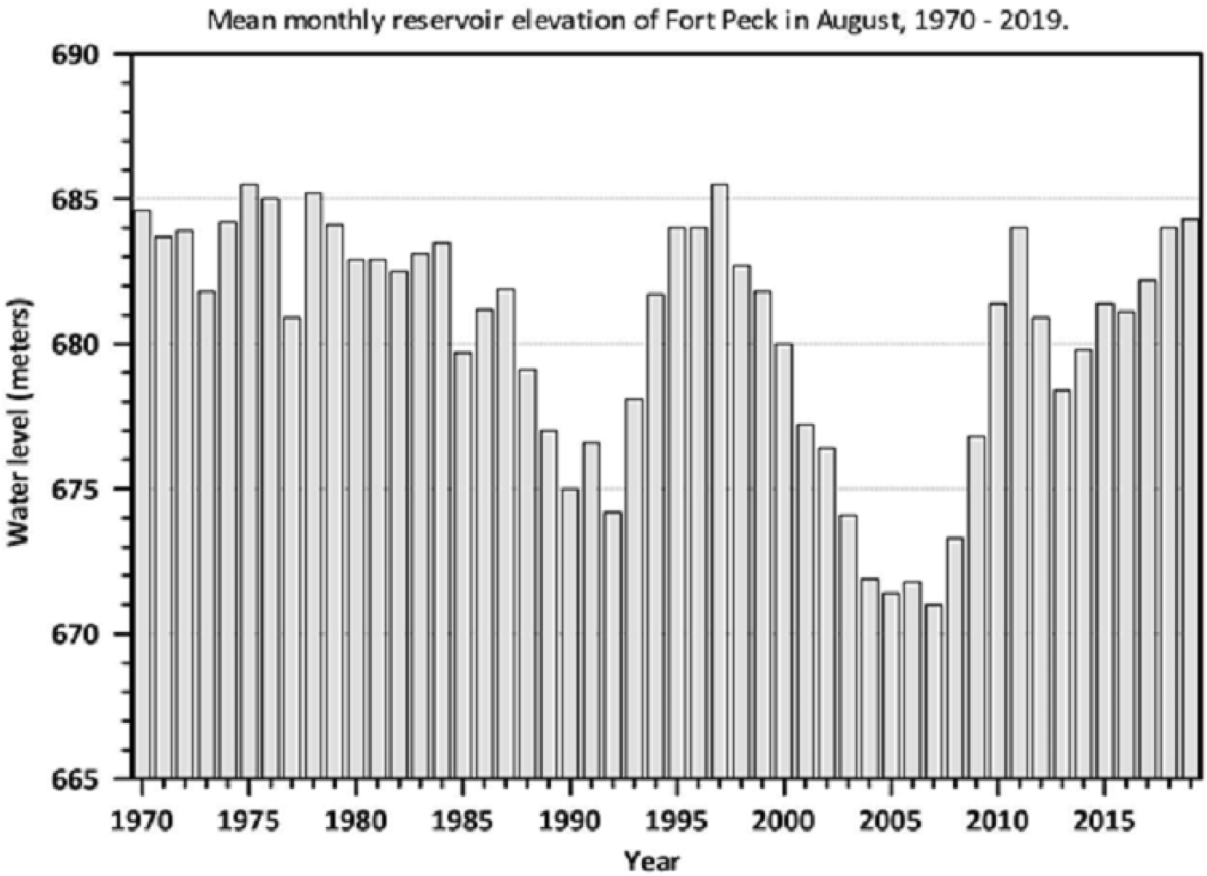


Figure 48. Mean monthly elevation in August, Fort Peck Reservoir, 1970-2019.

August 1, 2007, water level remained low at 670.1 m (2202 ft) a.s.l. From 2008 through 2011, water levels increased to 684 m a.s.l and have remained within about 2 meters of 680 m. Fort Peck Reservoir, much like Lake Sakakawea, has had approximately the same two periods of years of low elevation associated with major droughts since 1985, with the second drought period 2003-2008 also being more intense (Figure 48).

Life History and Ecology

Stock history - Little is directly known about the early history of Fort Peck paddlefish. Neither the ecology of Fort Peck Reservoir nor its paddlefish inhabitants were studied to any extent during the first three decades of reservoir impoundment (Montana Fish, Wildlife and Parks 2011). The stock was first surveyed by tagging and creel census in 1973 by Needham (1973a, b) and was studied intensively for three years (1977-79) by Berg (1981) through a creel census and population sampling with electrofishing (a sampling method now strictly avoided for these stocks over concerns about ruptured notochords; Needham 1977b; Scarnecchia et al. 1999).

Pre-spawning and spawning - Paddlefish migrate upriver from Fort Peck Reservoir in March, April, and May to spawn mainly in June. Most fish do not migrate far up from the reservoir, remaining east of Judith Landing, with highest concentrations typically near the Fred Robinson Bridge. Although, some fish were observed traveling much further up the river. Needham (1981) reported that one fish tagged a few kilometers above the reservoir in 1977 was recaptured in 1981 at Coal Bank Landing, 204 Rkm (127 mi.) above the reservoir.

Time and extent of upstream migration are strongly influenced by river discharge (Berg 1981; Miller et. al. 2006; Miller and Scarnecchia 2011). Berg (1981) noted that significant movements of paddlefish to the spawning sites did not occur until discharge at the Virgelle gauging station, east of Fort Benton, exceeded 396 m^3/sec. In two years with typical river discharges (1978 and 1979), he reported that fish migrated as far upriver as the Three Islands area, 240 km above the reservoir. In 1977, when discharges were much lower (a maximum of about 221 m^3/sec), and no large flood pulse developed, fish migrated only as far upriver as the Slippery Ann-Fred Robinson Bridge Area, about 40 km upriver from the reservoir. Spawning success was thought to be poor that year. Adult paddlefish were observed in numerous areas in 1978 and 1979, including one supposed staging area (the Slippery Ann-Fred Robinson Bridge Area) and nine spawning sites (Upper and Lower Two Calf Islands area, Cow Island-Powerplant Ferry area, Bullwhacker Creek Area, Dauphine Rapids area, Holmes Rapids area, Deadman Rapids area, Little Sandy Creek area, Virgelle Ferry-Boggs Island area, and Three Islands area). Highest concentrations of fish found from electrofishing surveys in 1977, 1978, and 1979 were in three areas: the Slippery Ann- Fred Robinson bridge area, the Upper and Lower Two Calf Islands area, and the Cow Island-Powerplant Ferry area. An egg (positively identified) and two larvae were found in their sampling. Splashing by adult paddlefish over several sites with spawning gravel provided circumstantial evidence of paddlefish spawning.

Since the late 1970s, efforts have been made to characterize migrations, spawning sites, and reproductive periodicity of Fort Peck paddlefish with radio telemetry studies (Gardner and Berg 1980; Wiedenheft 1992; Miller et al. 2006; 2011; Miller and Scarnecchia 2011). Miller and Scarnecchia (2011) tracked a total of 109 radio-tagged paddlefish over a four-year period, 80 for more than one year, and found that at least 46 fish (34 males and 12 females) were repeat migrants, i.e., migrated more than once sometime during the four-year period. Males had a shorter migration periodicity (mean, 1.5 years) than females (mean, 2.3 years); "Among males, 17 had a migration periodicity of one year, 16 had a periodicity of two years, and one had a periodicity of three years. Among females, none exhibited a migration periodicity of one year, nine had a periodicity of two years, and three had a periodicity of three years" (p. 185; Miller and Scarnecchia 2011). Females also typically moved at a faster rate than males (13.4 km/day versus 10.1 km per day) and remained in the river for a shorter time than males (40 versus 45 days). Results from the study were consistent with hypotheses of higher energetic demands for female fish associated with higher fecundity as outlined in Scarnecchia et al. (2007a). Females made more rapid, directed movements prior to spawning, whereas males were more likely to make more numerous short-range movements. The differences in reproductive periodicity between males and females reported in Miller and Scarnecchia (2011) was strongly similar to the periodicity inferred in Scarnecchia et al. (2007) from jaw tag recoveries of the Yellowstone-Sakakawea stock.

As in the Yellowstone Sakakawea stock, directional movements of telemetered Fort Peck paddlefish were associated with changes in discharge. For example, in 2006, when tracking and analysis of fish movements was conducted most intensively, 62% (62 of 100) of upriver movements greater than 10 Rkm occurred during periods of increasing discharge. Conversely, 68 of 107 (64%) downriver movements greater than 10 Rkm occurred during decreasing discharges. Forty-one of 58 (70%) of upriver movements greater than 20 km occurred during periods of increasing discharge and 39 of 57 (68%) of downriver movements greater than 20 km occurred during periods of decreasing discharge. Twenty-two of 27 (82%) of upriver movements greater than 40 km occurred during increasing flows while 22 of 32 (69%) of downriver movements greater than 40 km occurred during decreasing flows. Mean rate of movement for males and females combined over the entire 2006 tracking period was 9.9 km/day (Miller et al. 2006).

Three main migratory patterns were observed. Early upriver-migrants were relocated in staging areas below the Fred Robinson Bridge during stable flows, moved above the bridge with two early rises in discharge (May 19 - 25, mean discharge = 326 m^3/s; May 27-June 2, mean discharge = 315 m^3/s), then moved downriver before peak discharge occurred. Five of 15 males (33%) and six of 15 females (40%) exhibited this pattern. Peak flow upriver-migrants staged below the bridge during stable flows, moved upriver with early rises in discharge, remained at least 10 Rkm above the bridge until about peak discharge, and did not move downriver until the hydrograph began to descend. Two of 15 males (13%) and seven of 15 females (47%) exhibited this pattern. Static migrants either made no upriver movements after tagging or if upriver movement did occur, it did not extend past the bridge. Seven of 15 males (47%) and one female (7%) exhibited this pattern (Miller et al. 2006).

Congregations of fish were observed in specific areas above Fort Peck Reservoir during the 2006 migration indicating that these areas may be important paddlefish habitats for staging, spawning, or both. Two areas were probable staging habitats: downriver of Lower Peggy's Bottom (Rkm 3052 and downriver) and Slippery Ann (Rkm 3076-3080). Two areas were probable spawning habitats: the Powerplant Ferry area (Rkm 3112 - Rkm 3118) and Dauphine Rapids (Rkm 3169). In all, nineteen potential spawning sites were identified between the mouth of the Marias River and the Judith Landing boat launch. Several rapids were observed between Judith Landing and the Stafford Ferry during manual radio-tracking that are potential spawning habitats (Miller et al. 2006). The likely use of the Powerplant Ferry area and Dauphine Rapids as spawning habitats indicated in this study is consistent with the findings of Berg (1981) who identified these areas, in addition to five sites upriver of the Powerplant Ferry and two sites downriver, as likely spawning grounds.

Information was also obtained on macrohabitat use. Most re-locations were made either in channel crossover (45%) or outside bend (29%) habitat types. Approximate depths at site of relocation ranged from 1.5 m to 6 m (mean, 3 m; Miller et al. 2006).

Spawning and early life history - Studies in 2008 and 2009 emphasized sampling of eggs and larvae to identify spawning sites (Miller et al. 2011). Overall success was low. In the two years, 65 and 71 eggs, respectively, sampled with rectangular egg collectors were positively identified through genetic analyses as paddlefish. Larvae were sampled with conical nets. In 2008, eggs were collected between June 10 and June 25. As reported in Miller et al. (2011), "Temperatures during the capture period ranged from 12.0 to 20.7°C (mean, 16.6°C…)… Discharge at the time of peak egg CPUE [2.95 eggs per collector day] was approximately 875 m^3/sec, water temperature was 17.5°C and turbidity 134.3 NTU. The sample site at Rkm 3119.0 yielded the highest egg CPUE…. No fish larvae were collected in 2008" (p. 1294). In 2009, eggs were collected between May 29 and June 12; temperature during the egg capture period ranged from 13.5 to 18.7°C. Egg CPUE, for all sites combined, peaked at 2.5 eggs per-collector-day on June 2 one day before spring discharge peaked at 612 m^3/sec. Discharge at the time of peak egg CPUE was approximately 579 m^3/sec, water temperature 16.8°C, and turbidity 74.5 NTU). Highest catches were made at Rkm 3084 and Rkm 3099.5. Six paddlefish larvae were collected in 2009 over the period June 17-23. In several cases, congregations of radio-tagged adult paddlefish at particular locations were associated with capture of eggs at those same locations (Miller et al. 2011).

Biology and Ecology in Fort Peck Reservoir - Distribution of age-0 paddlefish in the upper portion of Fort Peck Reservoir was studied by Kozfkay and Scarnecchia (2002). At the higher reservoir levels of 1998, age-0 fish were found near the surface from early August to mid-September along standard transects (lengthwise along the reservoir) from Rkm 3024 to 3006, with occasional fish outside of this area. Numerous fish had also been seen during the high reservoir year of 1995. As the river flows and reservoir levels dropped in 1999, numbers of age-0 fish in transects decreased greatly from 1998, the period of highest reservoir levels (Table 5).

Year	Transect Dates	# Stations	Station Locations (RM)	# Transects	# YOY	# Sub-Adults	Reservoir Elevation (August)	Collector
1997				69	113	3	2248'	
1998	7/27 to 9/23	8	1888 to 1866	216	97	54	2239'	Kozfkay
1999	8/25 to 9/20	8	1888 to 1866	174	3	10	2236'	Kozfkay
2000				90	0	11	2230'	
2001				90	1	0	2221'	
2002			1862 to 1856 ?				2219'	Bowersox
2003			1862 to 1856 ?	54	2	4	2211'	Bowersox
2004			1853 to 1838	54	0	3	2201'	
2005	8/8 & 8/16	6	1853 to 1838	36	1	0	2202'	Miller
2006	7/24 & 7/30	6	1853 to 1838	36	2	1	2204'	Miller
2007	7/31 & 8/6	6	1854 to 1838	6	0	2	2201'	Miller
2008	8/6 & 8/12	6	1844 to 1858	36	4	3	2209'	Miller
2009	8/11 & 8/17	6	1843 to 1858	36	0	0	2220'	Miller
2010	7/27 & 8/3	6	1863.5 to 1878.5	36	0	0	2236'	Miller
2011	7/28 to 9/1	6	1866.5 to 1881.5	90	61	3	2242'	Hemingway
2012	7/30 & 8/9	6	1863.5 to 1878.5	36	1	3	2234'	Hemingway
2013	8/5 & 8/14	6	1855.5 to 1870.5	36	0	14	2226'	Hemingway
2014	7/28, 8/4, & 8/17	6	1859.5 to 1874.5	54	0	0	2230'	Hemingway
2015	8/3, 8/10, & 8/18	6	1866.5 to 1881.5	54	0	0	2236'	Hemingway
2016	8/2 & 8/15	5	1863.5 to 1878.5	36	0	1	2235'	Breen
2017	8/4 & 8/16	6	1867.5 to 1882.5	36	1	0	2239'	Breen
2018	7/29 & 8/14	6	1866.5 to 1881.5	36	1	0	2245'	Breen
2019	8/8 & 8/21	6	1866.5 to 1881.5	36	4	6	2246'	Breen
2020	8/5 & 8/18	6	1863.5 to 1878.5	36	0	3	2240'	Facer

Table 5. Counts of age-0 and age 1+ paddlefish in upper Fort Peck Reservoir, 1997-2020.

Numbers of age-0 fish observed in transects have remained low, or been zero, since that time, except for 2011, another year of high flows and reservoir levels (Table 5). Numbers of age-0 fish counted, although very low or zero in most years, have been substantially higher in years associated with high river flows and reservoir levels, consistent with results from Lake Sakakawea (Scarnecchia et al. 2009; 2014; 2019b).

In studies of food habits, age-0 fish selected strongly for *Leptodora kindtii* and chironomids, the largest prey available, and selected against large cladocerans and smaller prey such as cyclopoid and calanoid copepods. In addition, the largest *Leptodora* were preferentially eaten (Kozfkay and Scarnecchia 2002; Kozfkay et al. 2002). Of 12 young paddlefish older than age-0 analyzed for food habits, all but one still showed size-selective food habits characteristic of selective feeding for larger prey (Michaletz et al. 1982). One larger fish (probably age-2) contained stomach contents with a wide range of prey species and sizes characteristic of filter feeding (Kozfkay et al. 2002).

Several species may interact with paddlefish in Fort Peck Reservoir. It is known that "during the 1950s and 1960s, rising water levels inundated vegetation and produced an outstanding fishery for northern pike, crappie and yellow perch" (p. 12; Montana Fish, Wildlife and Parks 2011). Walleye were first stocked into Fort Peck Reservoir in 1951, but a sport fishery for them did not develop until the 1970s (Liebelt 1993). In 2006, completion of the Fort Peck hatchery led to increases in stocking of walleyes. The management program for the species has set targets of stocking at least three million fingerlings annually, leading to specific objectives for harvest by anglers (0.4 walleye per hour) and the MFWP monitoring program with gillnets (3.6 walleye per net; Montana Fish, Wildlife and Parks 2011). Northern Pike *Esox lucius* were not found until after 1951, which suggested to Cooper (1971) that the population now present resulted from the stockings in 1949 and 1951. Cisco were introduced into the reservoir in 1984-1986 to improve forage opportunities for walleye, pike, and lake trout *Salvelinus namaycush* (Mullins 1991; Montana Fish, Wildlife and Parks 2002). Cisco abundance has fluctuated widely since their introduction. Although the cisco has been credited with improving the forage base and condition for walleye, and perhaps other species (Montana Fish, Wildlife and Parks 2002), it is a zooplanktivore (Mullins 1991) with similar dietary preferences as the paddlefish (Russell 1986). The relation between cisco abundance and paddlefish growth has not been evaluated.

It was not specifically documented how Fort Peck paddlefish responded to trophic upsurge associated with reservoir filling. Brown (1951) reported that paddlefish were "rather abundant in the upper end of Fort Peck Reservoir …" (p. 252). The timing of this report is consistent with fish produced during the early years of impoundment. Bowersox (2004) examined changes in paddlefish weight-frequencies and length-frequencies as well as weight-at-age and length-at-age of harvested fish from three different time periods (1977-1978, 1992-1993, and 2000, 2002) to determine if the percentages of large fish and growth rates of young and middle-aged recruits (ages 16-20 and ages 21-25 for females; ages <15, and ages 16-20 for males) have changed over time. Frequencies of heavy fish (>42 kg females, >21 kg males,) and long fish (>126 cm females, >108 cm males) in the population were found to significantly

($P<0.05$) decrease over time. Mean weight-at-age of fish of both sexes has also decreased significantly ($P<0.05$) over time. The cause of the decline in growth rates is not specifically known but was not attributable to selective harvest. One possible factor is faster growth associated with trophic upsurge after filling and subsequent slower growth with trophic depression. A second possible factor is competition with other zooplanktivorous forage fish such as cisco. Smaller trophic upsurges associated with reservoir filling after droughts have been associated with higher transect counts of age-0 paddlefish, supporting the hypothesis that higher river discharges and reservoir levels produce trophic upsurge benefits, resulting in better growth and survival of age-0 fish to recruitment size (Scarnecchia et al. 2019b).

Wiedenheft (1992) had observed concentrations of sub-adult and adult paddlefish in the headwaters of the reservoir in several years. In 1992, he gill-netted 29 paddlefish (most or all sexually mature) in the headwaters and implanted eight fish with radio tags. Three of the tagged fish were tagged May 6 and 7, whereas the other five fish were tagged June 25-July 2. Of the eight fish, none migrated into the river on a spawning migration and only one moved more than a few river kilometers during the period May-September. These fish were probably adult fish foraging in the upper reservoir in a year when they were not undertaking a spawning migration.

An unknown number of paddlefish of the Fort Peck stock (nearly all untagged) move downriver to repopulate the Yellowstone-Sakakawea stock as well as populations further downriver. Recoveries of jaw tagged Fort Peck paddlefish below Fort Peck Dam have numbered 10 through 2017, one in 2001 and 9 since 2013, all caught in the Yellowstone River in Montana. Movement between the two stocks is unidirectional; fish can move down from Fort Peck Reservoir but not up into the reservoir from below Fort Peck Dam.

Paddlefish life history framework - More is known about the mature stages of the life history of the Fort Peck paddlefish than the juveniles. Berg (1981) and Needham and Gilge (1986) presented early evidence of the same sexual size dimorphism characteristic of the Yellowstone-Sakakawea stock. Although there was some overlap in weights between the sexes, males were generally much smaller than females. Males grow more slowly than females of their year class in the years following male sexual maturation (the females are still immature), mature earlier, and tend to die younger than females. The pattern is very similar to that of the Yellowstone-Sakakawea stock. The reproductive periodicity of harvested fish is 1-2 years for males and 2-3 years for females (Miller and Scarnecchia 2011), very similar to the periodicity of the North Dakota catch component of Yellowstone-Sakakawea paddlefish (Scarnecchia et al. 2007).

Age structure of adult migratory paddlefish has been collected in 1977-78 by Berg (1981), and since 1993 during all years when a creel census was conducted. Berg (1981) estimated the age of 132 paddlefish caught by anglers in 1977 and 1978. Sixty-nine males averaged 14 years old and ranged from 6 to 25; 63 females averaged 19 years old and ranged from 11 to 29. Forty-four percent of the females were 20 years or older, whereas only 7% of the males were this old. Some of those fish for which dentary samples remained were subsequently re-aged by Scarnecchia in 1995 (Unpublished) with more technologically advanced sectioning and projecting equipment. Mean ages of the subset of re-aged fish averaged about 6 years older for males and 4 years older for females than for the larger set of fish aged by Berg (1981). The oldest fish aged by Scarnecchia were age 31 for males and age 33 for females, whereas Berg's maximum ages for both sexes were age 25.

More recent dentary samples collected since 1995 have greatly clarified the age structure and life stages of the stock (Scarnecchia et al. 2007). First age at maturity of males is typically 9 to 12; age at maturity of females is typically 15-18. Although most fish are mature by these ages, as in the Yellowstone-Sakakawea stock, it is not known if some fish delay maturation for few years (Scarnecchia et al. 2007). In 2006, for example, ages of 127 male fish ranged from 9 to 38, with one fish at 52. Ages of 110 female fish ranged in age from 14 to 56. In 2017, Males ranged in age from 8 to 36 and females from 15 to 60 (Figure 49a, b). In all years, a large majority of the oldest fish aged are females. Details of these studies are in a report in preparation (D. Scarnecchia, Unpublished Data). Although no data are available for GSI and GFBs for the Fort Peck stock as they are for the Yellowstone-Sakakawea stock, evidence thus far indicates that the overall life history, life history stages and lifespan of this stock are very similar, and in some cases nearly identical, to the life history framework of the Yellowstone-Sakakawea stock described by Scarnecchia et al. (2007). The similarity probably reflects the many similarities in overall habitat and climatic conditions experienced by the two stocks.

Fisheries

Location and timing - Fish are caught at several popular sites on the Missouri River above the reservoir. Although the most accessible and popular site is the Fred Robinson Bridge, other sites both upriver (e.g., Cow Island) and downriver (e.g., Slippery Ann; Rock Creek) of the bridge are utilized. Concentrations of fish at a particular site vary yearly and seasonally and are strongly dependent on discharge amounts and timing.

Although the Fort Peck paddlefish fishery was historically open all year, most harvest has occurred in spring (May and June), with some fall harvest. As of 2017, the snag fishery was open only from May 1 to June 15, with all harvest days. Immediate catch-and-release was permitted. Harvest tags are drawn by a lottery system enacted in 2016 with a 500 fish harvest cap. In 2020, 98% of the 1,000 tag holders and 95% of the anglers harvesting a fish were Montana residents (Nagel 2017; Unpublished Data). The harvest consists of nearly all mature, spawning fish.

Snagger characteristics - The values, attitudes, and preferences of paddlefish snaggers on the Fort Peck stock (Scarnecchia et al. 2000) were very similar to those reported for the Yellowstone-Sakakawea stock (Scarnecchia et al. 1996a) and to Montana anglers in general. Their primary motivations were to be outdoors, to experience the thrill of catching a paddlefish, to experience the natural surroundings, and to be with friends. Although harvest and consumption of meat were secondary considerations, and snaggers were in favor of catch-and-a)

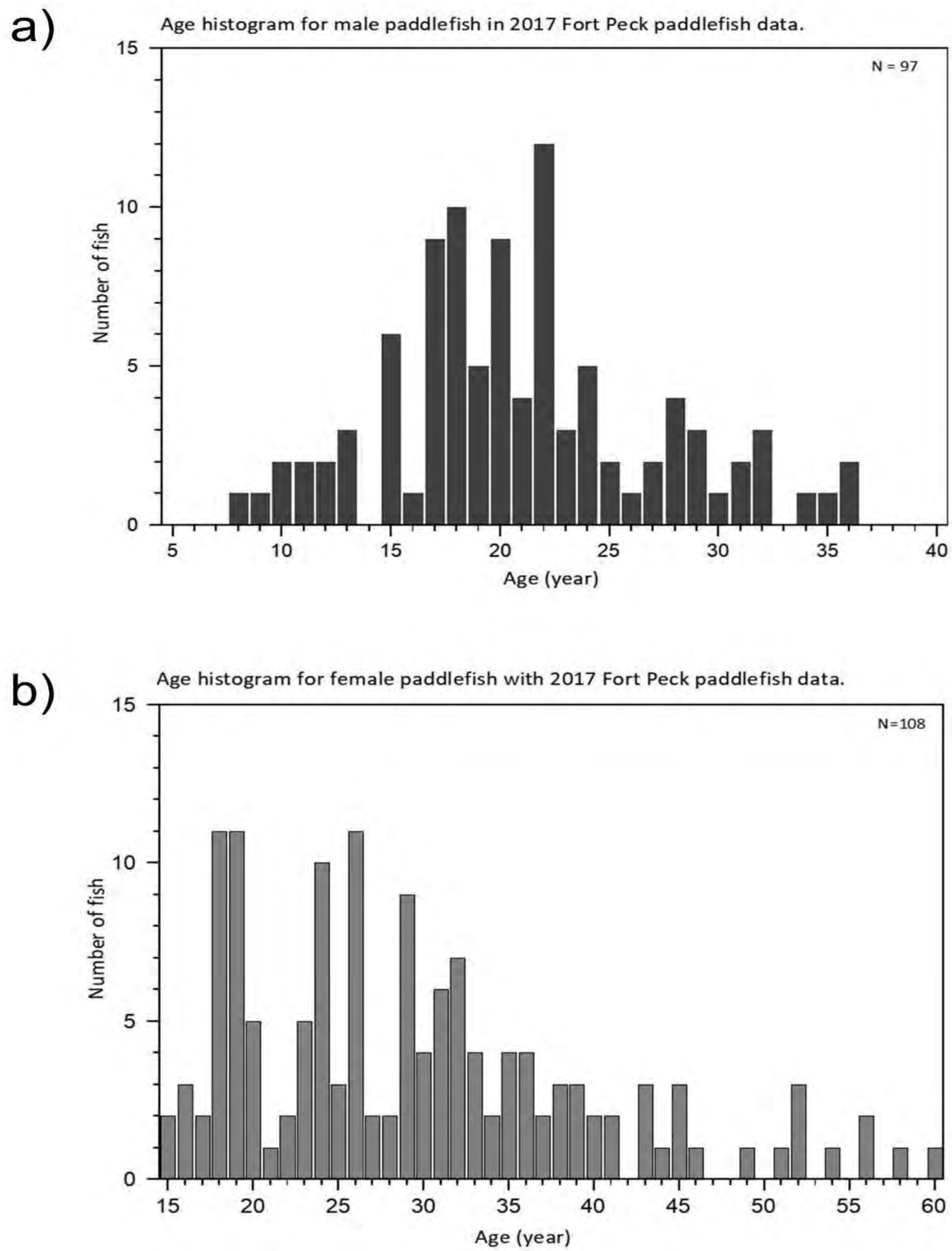


Figure 49. Age distribution of catches a) for males, b) for females of the Fort Peck paddlefish stock, 2017, indicating modest recruitment.

release opportunities, snaggers did not favor mandatory catch-and-release without a harvest opportunity (Scarnecchia et al. 2000).

Fisheries statistics - The absence of a centralized cleaning station makes a creel census less efficient and the data base less comprehensive than for the Yellowstone-Sakakawea stock, even though what information that can be obtained is collected from nearly all anglers (Table 6).

Harvest of Fort Peck paddlefish has been estimated intermittently since 1973. Estimated harvest from 1973 to 2000, based on on-site creel censuses, was always less than 750 fish. Estimated harvest from 2003 through 2006, based on post-season phone creel surveys ranged from 787 fish in 2004 to 1,067 fish in 2006 (Leslie 2007; Figure 50). The number of tags issued remained fairly constant from 2003 to 2015 but increased over the period 2016-2019 (Figure 51; Table 6). The number of angler days has ranged from 1,326 in 1998 to 9,172 in 2004 (Figure 50). With the option to release snagged fish for this stock, snaggers released 29% to 53% of fish caught over the period 2003-2006 (mean, 40%; Leslie 2007). Over the period 2014-2019, percent released has exceeded 80% (Table 6). In 2007, mandatory retention was applied as a regulation, with 634 fish harvested under mandatory retention and no harvest cap. Under harvest caps (500 fish) enacted in 2008, and with the reinstating of optional immediate release of fish, harvest has never exceeded 600 fish, and since 2012 has been less than 400 fish (Figure 50; Table 6).

Hatchery production

There are no known records of hatchery-reared paddlefish being released above Fort Peck Dam. The lack of stocking combined with lack of incoming hatchery fish from other stocking elsewhere renders this stock one of the only, if not the only, purely wild paddlefish stock.

Stock assessment and status

The approach to assessing stock status of the Fort Peck paddlefish is in most ways like that for Yellowstone-Sakakawea paddlefish. Instead of cleaning stations, however, data on length, weight, sex of fish, and jaw-tag recovery have been collected with a roving creel census at the various fishing sites, and most recently, with the two check stations (Kipp Park and Rock Creek) opened for mandatory reporting (Figure 52). In 2020, creel check stations were voluntary using a reward system (free MFWP paddlefish logo hat) for accurate angler responses and their providing of jawbones at the check stations.

Population size - In spring, jaw tagging of adult migratory fish by MFWP provides information for estimating population size of mature fish and reproductive (migratory) periodicity. Netting typically occurs downriver of the Fred Robinson Bridge in spring (April and

Year	Season Dates	Licenses Sold (Harvest Tags Issued)	Harvest Days to Closure	# of Catch and Release Days after Harvest Closure	# Reported as Caught and released to Creel Clerks/Phone Creel Estimate	# Reported as Harvested to Creel Clerks	Reported Males Harvested	Reported Females Harvested	Phone Creel Est. Harvest	On-site Creel Est. Harvest	3-Year Avg. Est. Harvest (On-Site Creel)
2003	4/1-6/14[-]	2,545	None	--	715	--	--	--	868	--	--
2004	4/1-6/14[-]	2,473	None	--	315	--	--	--	787	--	--
2005	4/1-6/14[-]	2,329	None	--	995	787	152 (64%)	85 (36%)	1,028	576	--
2006	4/1-6/19[+]	2,605	None	--	989	382	160 (61%)	101 (39%)	1,067	1,289	-
2007	4/1-6/19[+]	2,481	None	--	400	249	120 (50%)	121 (50%)	634	477	781
2008	5/1-6/15*	2,284	46	0	421	322	172 (58%)	127 (42%)	300	355	707
2009	5/1-6/15*	2,118	22	24	881	249	124 (53%)	112 (47%)	564	594	475
2010	5/1-6/15*	2,366	16	30	974	301	140 (55%)	116 (45%)	575	607	519
2011	5/1-6/15*	2,460	14	32	854	484	191 (45%)	230 (55%)	598	608	603
2012	5/1-6/15*	2,439	10	36	662	403	164 (58%)	119 (42%)	381	475	563
2013	5/1-6/15*	2,356	11	35	855	354	100 (41%)	147 (59%)	292	642	575
2014	5/1-6/15*	2,087	4	42	1,837	402	170 (65%)	93 (35%)	307	561	559
2015	5/1-6/15*	2,410	19	27	1,643	430	92 (44%)	116 (56%)	334	516	573
2016	5/1-6/15[#]	2,717 (750)	46	--	2,136	320	149 (47%)	171 (53%)	350	--	384
2017	5/1-6/15[#]	3,238 (1,000)	46	--	1,483	298	143 (48%)	154 (52%)	346	--	349
2018	5/1-6/15[#]	3,500 (1,000)	46	--	1,795	198	98 (49%)	100 (51%)	199	--	272
2019	5/1-6/15[#]	4,087 (1,000)	46	--	2,238	244	85 (35%)	159 (65%)	305	--	247
2020	5/1-6/15[#]	~1,000	46	--		336	173 (52%)	162 (48%)		--	259

+ Season open year-round with mandatory harvest on Friday, Saturday, Tuesday, and Wednesday and mandatory catch and release on Sunday, Monday, and Thursday. Creel ran from 4/1-6/19

- Season open year-round with anglers allowed to harvest two paddlefish.

* Season open from May 1-June 15 with a 500 fish harvest cap.

Season open from May 1-June 15 (lottery Draw for Harvest)

Table 6. Fort Peck Creel Census, 2003-2019.

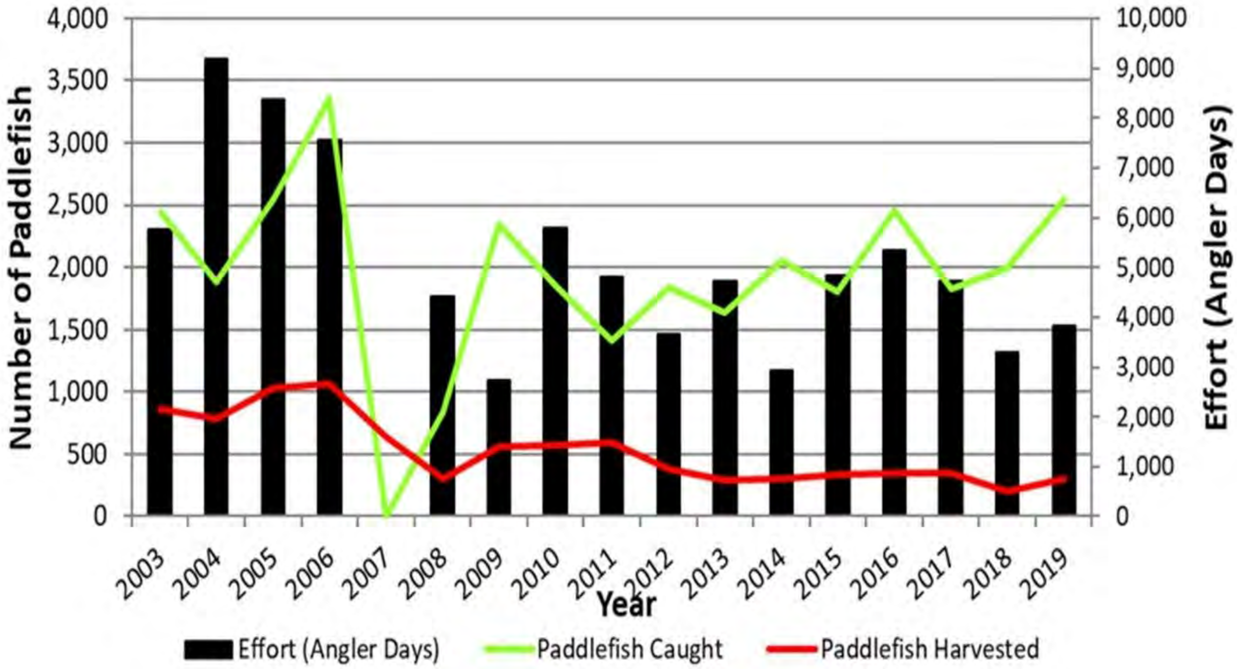


Figure 50. Catch, harvest, and effort for the Fort Peck paddlefish fishery, 2003-2019.

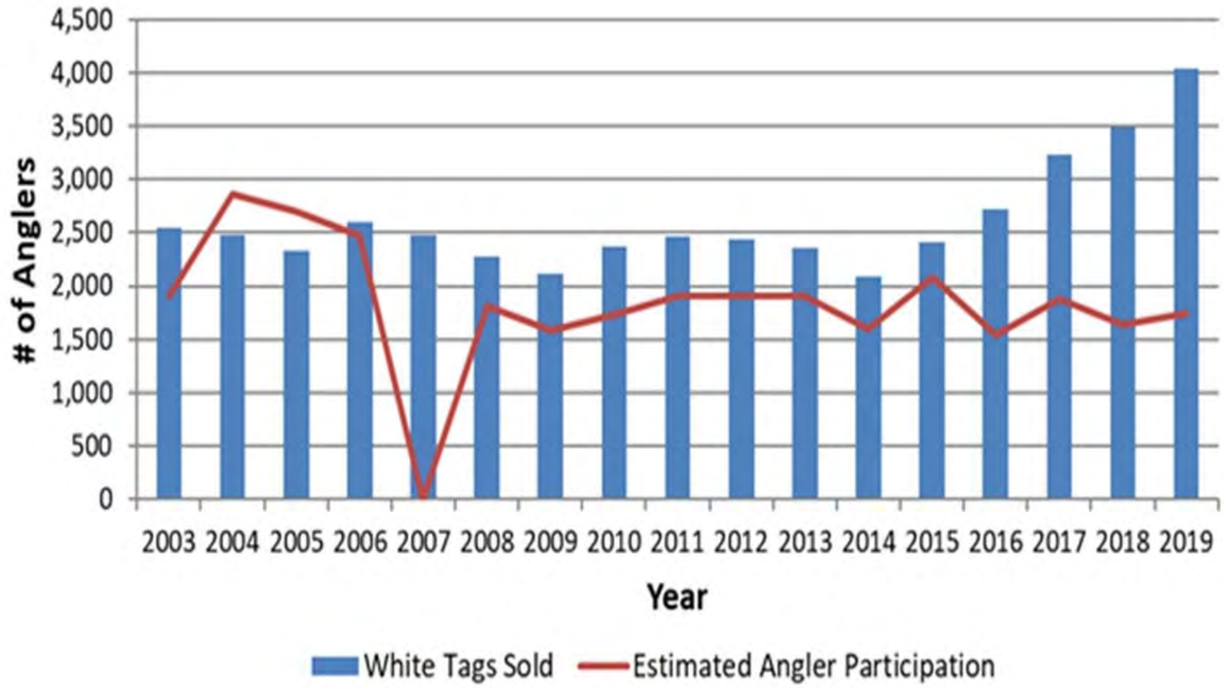


Figure 51. Tags sales for the Fort Peck paddlefish fishery, 2003-2019.

Figure 52. Collecting creel information on paddlefish at the Fred Robinson Bridge.

May; Figure 53). Point estimates of population size and confidence intervals were originally developed using two mark-recapture approaches: a modified Peterson estimate, and a modified Schnabel Modifications have been necessary because only a fraction of the recruited stock matures and thus migrates upstream in a given year. Estimates in 2017 indicated that the population size of recruited adult fish is about 20,000 fish, less than the size of the recruited Yellowstone-Sakakawea stock. Unlike the Yellowstone-Sakakawea estimate, this estimate was based in a multiple mark recapture estimate over three years. The estimate therefore approximated the migratory portion of the population rather than a specific year's population size.

Glassic et al. (2019) used the 25-year mark-recapture data set (1993-2017) and modified Jolly-Seber (POPAN) models to estimate survival, recapture, probability of entry, and abundance of adult paddlefish. Despite low recapture rates for females and males, estimates were obtained for survival and abundance. The best supported model for adult females estimated survival at 0.93 (CI 0.89 – 0.94) and for adult males 0.82 (CI 0.53 – 0.94). Estimated abundance of adult female fish was between 4488 (CI 1698 – 11860) and 10254 (CI 7287– 14431; Figure 54) and for adult males between 4337 (CI 2889 –6512) and 22757 (CI 18525 – 27956; Figure 55).

Glassic et al. (2019) also used phone creel data to examine exploitation rates from 2005-2017. Maximum exploitation rate was 5.0% (CI 3.9 – 6.6%) for females in 2006 and 6.7% (CI 5.2 – 8.7%) for adult males in 2006 (Figure 56). Adult female paddlefish interval fishing mortality (μ) was 0.018 (0.012 – 0.025) and instantaneous fishing mortality (F) was estimated at 0.018 (0.012 – 0.027) in 2017. Total annual mortality (*A*) for adult female paddlefish in 2017 was 0.08 (0.06 – 0.11). Spawning stock biomass per recruit was estimated at 75% of the maximum spawning stock biomass for the estimated instantaneous fishing mortality and adult female paddlefish population size in 2017 (Figure 57).

Multiple lines of evidence suggest the paddlefish fishery is not overfished. First, there was no evidence to suggest that paddlefish length or age declined from 1993 through 2017, survival estimates from the mark-recapture data and von Bertalanffy growth parameters were high for both sexes, and a sustainable fishery at the current fishing effort was also corroborated by the high percent of spawner stock biomass per recruit. As of 2021, population estimates of Glassic et al. (2019) are being refined using a Cormack-Jolly-Seber model.

Recruitment - Analysis of dentaries indicates that some recruitment occurs in most years, but that the high recruitment exhibited in the Yellowstone-Sakakawea stock in the 1995 year class has not been matched by equally high recruitment in the Fort Peck stock. For comparison using 2005 data, catches of young male recruits (ages 10-14) in the Fort Peck stock constituted only 15% of the total catch of males and only 9.5% of the total catch of both sexes (n=200). In contrast, catches of young male recruits (ages 10-14) in the Yellowstone-Sakakawea stock constituted 76% of the male harvest at Intake and 37% of the male harvest in North Dakota. Catches of young male recruits ages (10-14) constituted 40% of the total harvest of both sexes (n=1922; both sexes). The age structure of Fort Peck fish is not directly comparable to the

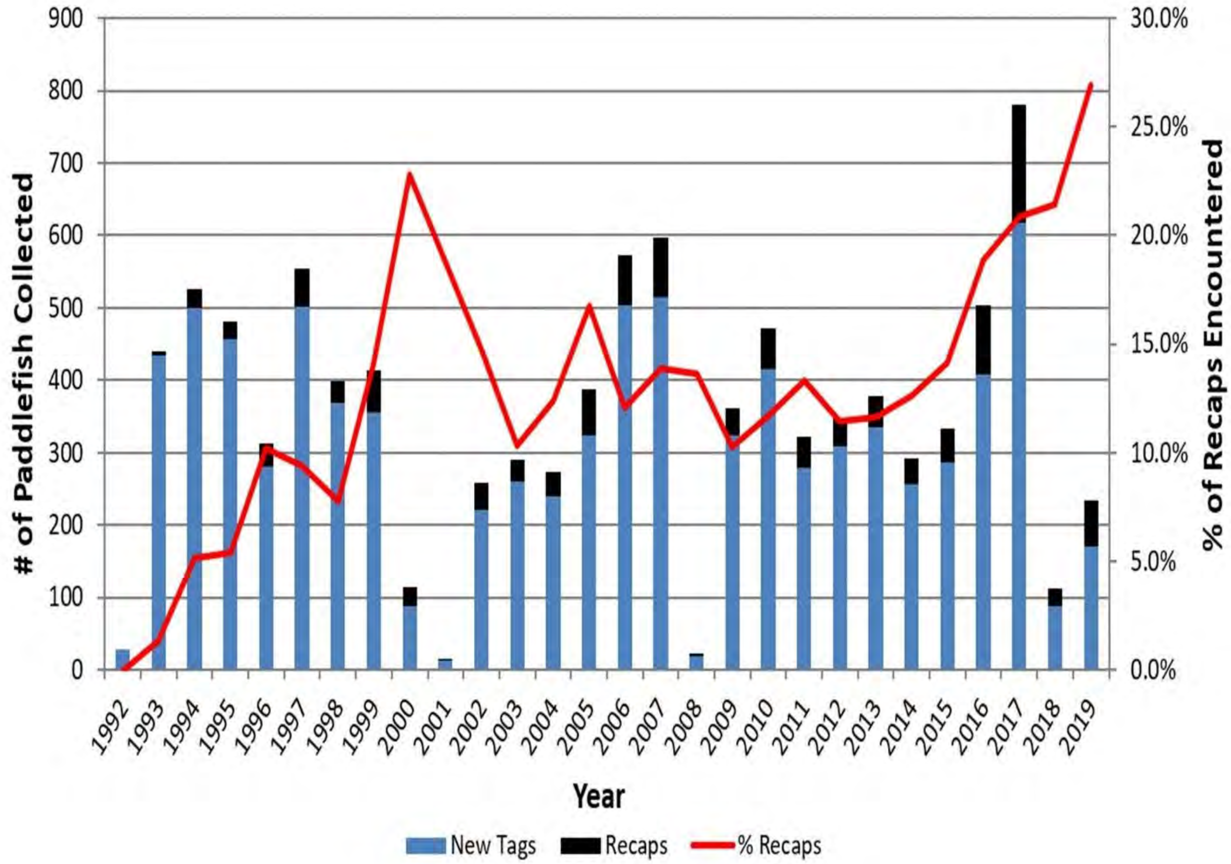


Figure 53. Jaw tagging for the Fort Peck paddlefish stock, 1992-2019.

samples from Lake Sakakawea because of the immediate high grading allowed in the Fort Peck stock. However, large numbers of young male recruits, if they had been present, would have been creeled with some frequency by most snaggers, i.e., all but those people able to demonstrate the skill and have the time to catch large numbers of fish. Results from 2007, with mandatory retention, confirmed those of 2005 and 2006, that recruitment of the Fort Peck stock was modest, less episodic than that of the Yellowstone-Sakakawea stock, a pattern that has persisted (Scarnecchia et al. 2014). These comparisons indicate that the Fort Peck stock has not experienced nearly as strong of a surge in recruitment as the Yellowstone-Sakakawea stock associated with high reservoir levels in the last half of the decade of the 1990s. This limitation and the smaller stock size account for the lower harvest cap for this stock.

Retention of older fish in the spawning stock - Age data also indicate that management actions have had the intended result of maintaining older fish in the population. In 2017, mean age of 97 harvested males was 21 years; mean age of 108 females was nearly 30 years. Twenty-seven of the 108 females (25%) were age-35 and older, the oldest fish estimated at age-60. Over the period 2015 to 2017, females were much more likely to have reached age-30 than males, although in 2015 two males with estimated ages 45 and 46 were harvested. Some of this difference may result from the retention of the largest (and oldest) females under conditions where fish can be sorted.

Indices of reproductive success and year class strength - Reproductive success before recruitment is based on an Age-0 Index, i.e., transect counts of age-0 paddlefish in the upper reservoir in late summer (Miller 2005; Table 5). Season-long counts of age-0 paddlefish in transects were measurable in 1997 (113) and 1998 (97) but declined steadily to near zero by 2007 associated with drought and declining water levels in Fort Peck Reservoir. This indicated that reproductive success of year classes spawned during the drought years was very low. The only measurable numbers of fish seen since 2007 were in 2008 and 2011, the two years of highest June flows and also years of increasing (2008) and high (2011) reservoir levels (Table 5). High sub-adult numbers in 2013, probably from the 2011 cohort suggest that it was a good recruitment year, as it was in the Yellowstone-Sakakawea stock.

Young Male Recruit Index - Recruitment of year classes can be discerned, at least approximately, from the frequency of young males in the harvest, much as is done for the Yellowstone-Sakakawea stock. The lack of a mandatory retention regulation in the fishery until 2007 enabled snaggers to select against small males in the harvest, perhaps resulting in underestimates of young males. However, data from the mandatory harvest year and the fairly balanced sex ratios of the subsequent harvest do not suggest that extensive high-grading is occurring. The amount of high-grading will depend on how abundant the fish are at fishing sites; fewer fish will result in less high-grading.

Five-year Recruitment-based harvest cap – The same approach used for the Yellowstone-Sakakawea stock (balancing 5-year recruitment of age 10-14 males and ages 17-21 females) against harvest is used to set a harvest cap for the Fort Peck stock. For example, based on the

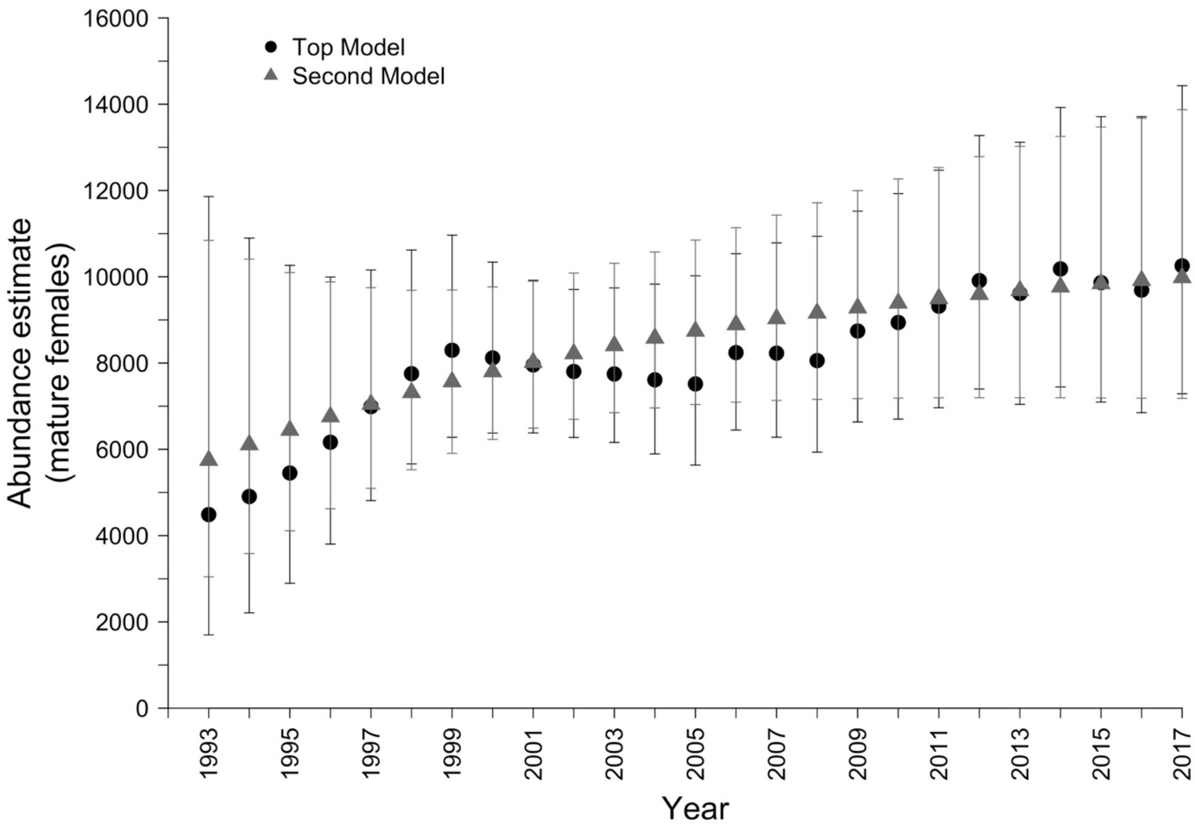


Figure 54. Abundance estimates for the Fort Peck Reservoir population of adult female paddlefish. Bars delineate 95% confidence intervals.

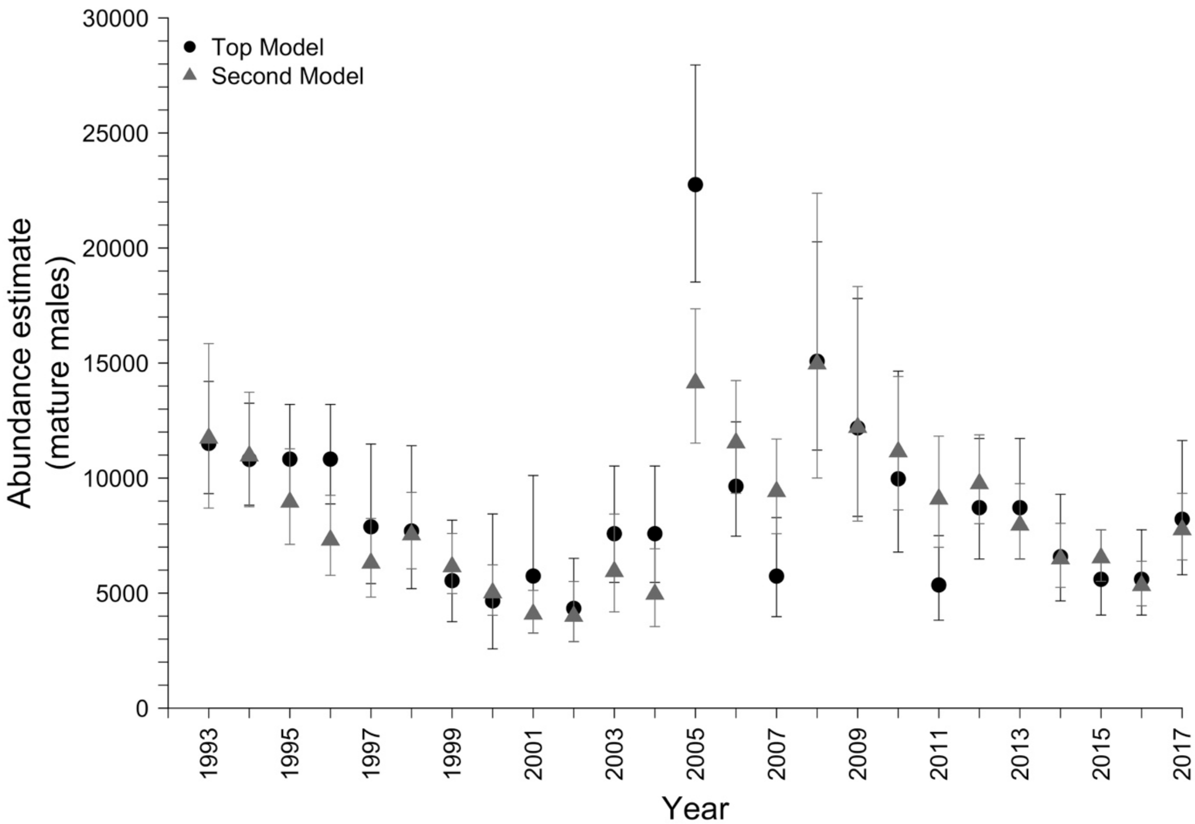


Figure 55. Abundance estimates for the Fort Peck Reservoir population of adult male paddlefish. Bars delineate 95% confidence intervals.

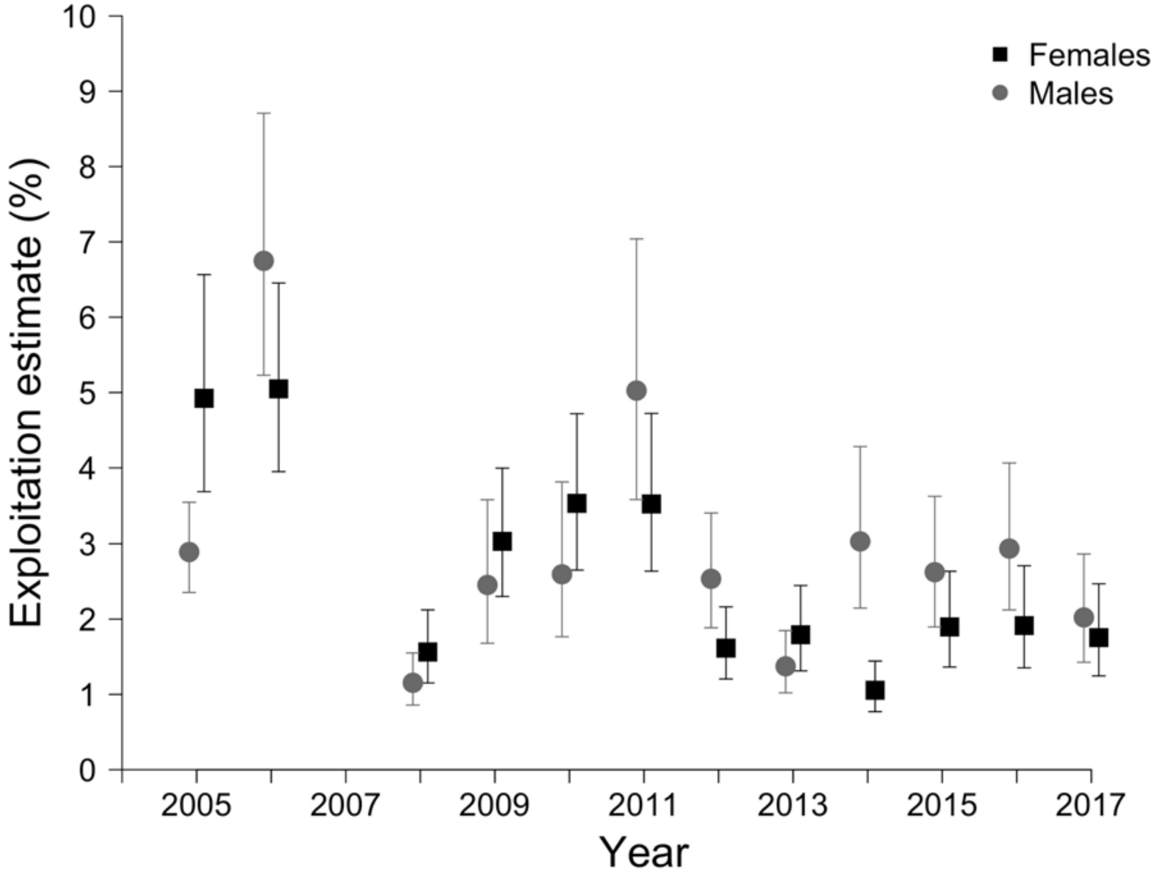


Figure 56. Exploitation estimates for the Fort Peck Reservoir population of adult male and female paddlefish. Bars delineate 95% confidence intervals.

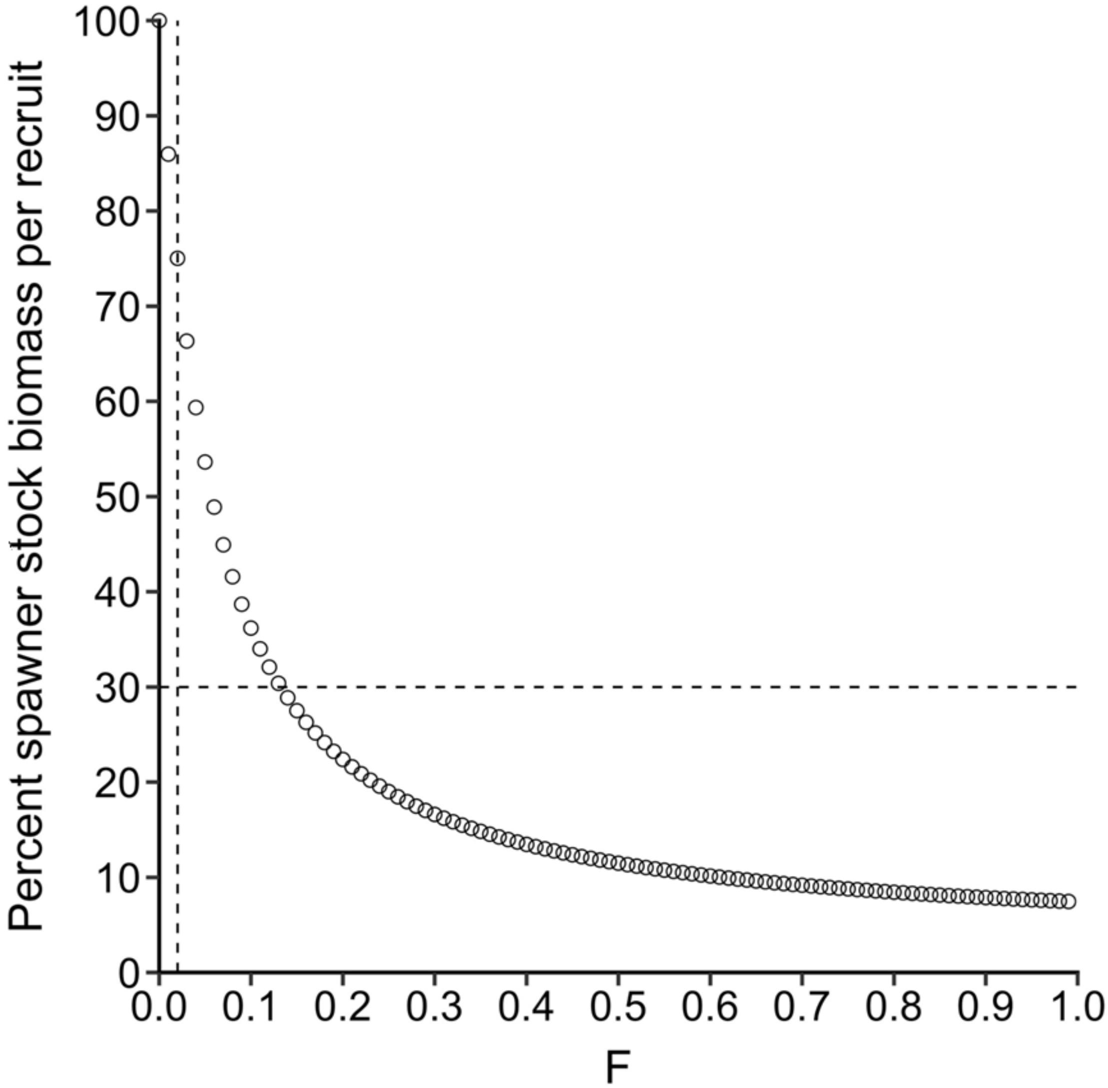


Figure 57. Relationship between percent spawner stock biomass per recruit and instantaneous fishing mortality (F). The dashed vertical line delineates the estimated F for the adult female paddlefish population in 2017. The horizontal line delineates the minimum percent spawner stock biomass per recruit to replace the spawning stock and rebuild and overfished population.

estimated recruitment over the period 2012-2016, it was estimated that the 500 fish harvest cap was consistent with and justified by the recruitment over that period, and that a harvest of 750 fish would not be justified with estimated recruitment (MFWP, unpublished). Efforts are planned to continue obtaining information from anglers to maximize the benefits of the limited number of fish available for capture and harvest.

Oahe stock

Realm

The Oahe stock is found in the Missouri River downriver of Garrison Dam into Oahe Reservoir (Figure 1). Geological and climatic aspects of this region are described in detail in the Lake Oahe Master Plan (U. S. Army Corps of Engineers 2010). Flows in the river are strongly regulated by Garrison Dam. The result is a colder, clearer river with more stabilized banks than in the Williston Reach of the Missouri River above Lake Sakakawea.

Life history and ecology

The Oahe paddlefsh stock rears in Oahe reservoir and migrates, and perhaps spawns, in the Missouri River and tributaries below Garrison Dam. This stock, the smallest of the three, supports no legal fishery, although fish are occasionally netted incidentally or seen when hit by boat propellers.

Little effort was expended in investigations of this stock prior to 2007. Results of tagging since 2007 indicate that Oahe paddlefish make a similar spring pre-spawning migration upriver as those of the Yellowstone-Sakakawea and Fort Peck stocks. In 2007, gillnetting in a 211 km (132 mile) reach during spring (March 22 – May 7), early summer (June 13-25), late summer (August 13-24) and Fall (September 25-October 11) found no fish in the summer period and few in the fall.

Hatchery production

In 1985, 9,420 unmarked fingerling paddlefish raised at Garrison National Fish Hatchery were stocked into Oahe Reservoir (Table 4). The fate of these fish is unknown. Future health of this stock and potential for a viable fishery would depend on additional hatchery production or infusions of fish from upriver during spill events.

Stock assessment and status

Oahe stock paddlefish are known to reach ages similar to those of the Yellowstone-Sakakawea and Fort Peck stocks. An analysis of the age structure of selected fish from 1994 indicated that ages ranged from 3 to 34. Four small fish aged 3-7 were found that were suspected to be hatchery-reared fish. Nearly all fish ranged from age 20 to age 33, and there was no indication of substantial numbers of young recruits (D. L. Scarnecchia, letter to G. J. Power September 27, 1994). Ages of 54 fish sampled in 2007 ranged 4 to 50 years. With no harvest of these fish, there is less likelihood for selective removal of larger fish.

Investigations on the stock since the last Paddlefish Management Plan are summarized by Bailey et al. 2018). Two main components of this stock were identified. Sampling and tagging efforts since 2007 have resulted in 8,469 paddlefish tagged, almost exclusively in two locations: 6,228 (74%) in the Norwegian Bend area (Rkm 1.609- 2227) and 2,107 fish (25%) in the tailrace and spillway area. The Norwegian Bend component of the population has been estimated at about 10,000 adult fish in that section in a given year (Figure 58), leading to an overall estimate of 20,000-25,000 population size of adult paddlefish in the Oahe stock. The tailrace component of the stock, first distinguished in 2012, has shown little movement in and out of the tailrace. The high frequency of injuries (dermal abrasions, torn opercula, rostrum damage, snag scars, skull fractures, and propeller scars, and emaciation (a low relative weight) suggested that they had come from above Garrison Dam. In a sampling effort for these tailrace fish, 44 of 684 fish were found to have been jaw tagged above Garrison Dam. Bailey et al. (2018) concluded that these fish consisted of Yellowstone-Sakakawea stock entrained and spilled into the Lake Oahe river segment during the 2011 flood (Figure 59). They had evidently remained in the tailrace in an effort to ascend the dam. The stranded fish also evidently are not seeking, or are unaware of, the better feeding conditions available downriver. Bailey et al. (2018) concluded that with the documented downriver movement and the lack of observed recruitment, the most likely origin of Oahe fish is from upriver. Downriver movements of fish are most often juvenile fish, although adults may be entrained also in flood years such as 2011. There was also considerable entrainment in 2018 and 2019 with the operation of the emergency spillway, most notably in 2019 when spillway releases went well into late fall. Efforts to assess the origin of captured Oahe fish with otolith microchemistry have not proven successful thus far. As of 2020 there is insufficient resolution to detect origin across the small spatial scale involved (Bock et al. 2017).

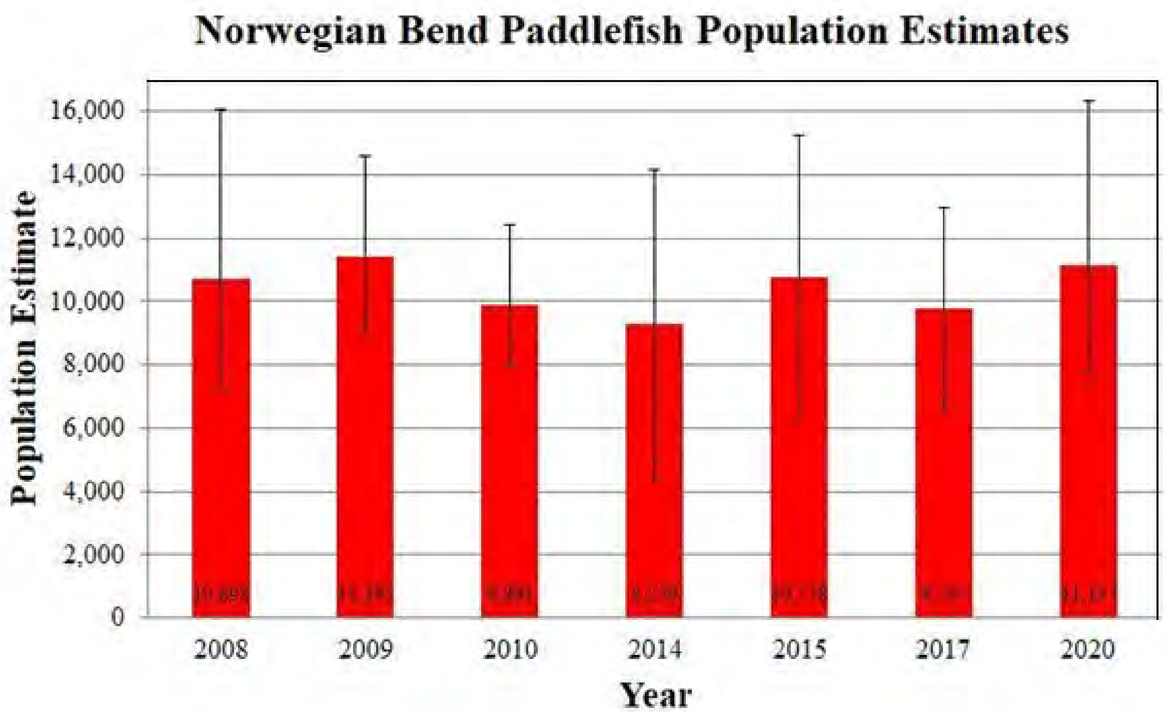


Figure 58. Norwegian Bend paddlefish population estimates.

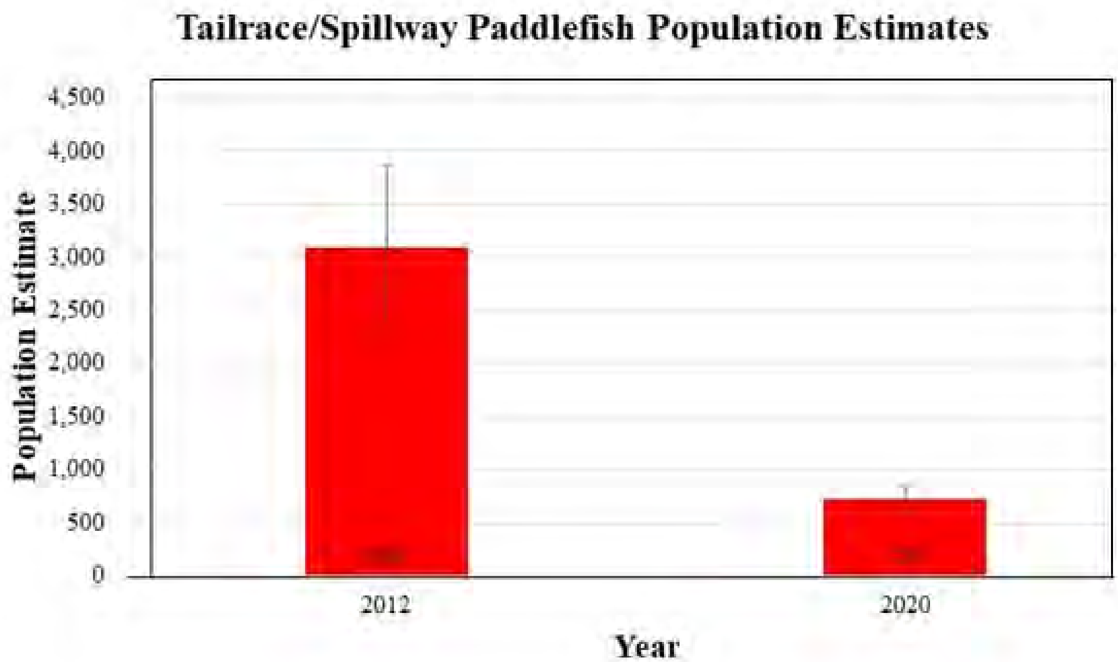


Figure 59. Tailrace/Spillway paddlefish population estimates

Section 3 - The Management Plan

This Plan provides direction and a course of action for management of the paddlefish stocks and fisheries. It builds on the previous two Plans (Scarnecchia et al. 1995b, 2008) while responding to new challenges and incorporating new technological advances useful in research and management. As in the past, the Plan embodies a philosophy, expressed as 10 fundamental hypotheses, followed by eight goals. Specific objectives are listed under each of the eight goals, and actions, or tasks are detailed under each objective. The Plan also indicates how goals and objectives will be achieved through actions involving habitat management, fish sampling and monitoring, fish stock assessments, harvest modeling, public outreach and education, and implementation.

The Plan for all three stocks is based on a unified fundamental approach, although some differences in management will continue to exist for the three stocks. The approach used has been developed most fully for the Yellowstone-Sakakawea stock, because this stock has been investigated and monitored most intensively over the past three decades. Although the other two stocks do not have roe donation programs, substantial advances in information on the Fort Peck stock (Nagel 2015, 2016; 2017, 2018) and the Oahe stock (Bailey et al. 2018) have enabled more specific goals and objectives to be developed for those stocks in this third version of the Plan.

The roe donation programs in both states have proven to be highly beneficial to the regional economies, have provided useful and popular services to anglers, and have also provided (through fish cleaning stations) important sources of stock assessment data. However, caviar *per se* is not the focus of this Plan. Conservation of the paddlefish, their habitat, their successful recruitment, and, where sustainable, their fisheries remain the focus of the Plan, with the caviar as an added beneficial by-product of well-managed stocks and recreational fisheries.

Philosophy

Ten fundamental hypotheses guide the development and direction of this Plan. These fundamental hypotheses are philosophical statements and rationales motivated by human values and supported by the best available scientific evidence from studies on paddlefish and other species, both within the basin and elsewhere, as well as from studies in social sciences. The fundamental hypotheses are useful in setting specific goals, objectives, and actions. The hypotheses are listed here; rationale for each hypothesis is provided in Appendix 4.

1. ***The paddlefish is an irreplaceable species of evolutionary, historical, recreational, commercial, and aesthetic significance in the Mississippi and Missouri river drainages.***

2. ***Maintaining natural habitat conditions and numbers of wild fish adequate to sustain natural recruitment (reproduction, early growth and survival) are critical to the long-term survival of the species.***

3. ***The paddlefish should be managed for the long-term benefit of the entire public, rather than to the short-term benefit of a few individuals or groups.***

4. ***Sustainable recreational harvest and non-harvest fishing opportunities are desirable outcomes to be provided by paddlefish for the benefits of the public.***

5. ***Management should be conducted cautiously, in a risk-averse manner.***

6. ***The management plan for harvest and habitat should ensure sustainability of the resource and be matched to the evolved long life history of the species and the productive capacity of the stocks.***

7. ***High-quality stock and fisheries data are critical to accurate and precise stock assessment and sustainable management; fish harvest should be a key source of necessary data.***

8. ***Goals, objectives, and actions, including management regulations and monitoring, should be as uniform as practicable among the stocks but remain sensitive to stock-specific fisheries constraints and conditions.***

9. ***The Plan for Montana and North Dakota stocks need not be consistent with, but should not be detrimental to, broader (regional or national) paddlefish conservation and management goals and activities. The Plan should be consistent with other Montana and North Dakota fisheries management plans.***

10. ***Regulation, enforcement, evaluation information, and education are keys to the success of the Plan and should be assessed periodically for effectiveness.***

Goals, Objectives and Actions (tasks)

The eight (8) goals (GOAL) of the Paddlefish Management Plan are statements of desirable directions or progress for the program consistent with the 10 fundamental hypotheses. The outcome of a goal is not necessarily a specific endpoint by a specific date or time. It may be improved knowledge, improved management capabilities, or improved public satisfaction with a fishery or the overall conservation effort for paddlefish. Setting specific endpoints for long-term goals for continually changing ecological and social systems such as the paddlefish fisheries may result in too rigid of a management structure.

The objectives (OBJ) of the Plan, in contrast, are statements of intended results to be achieved by a specified date, in this case to be implemented and accomplished over the 10-year period from 2021 to 2030. These objectives are more precise than goals, have endpoints, and thus are more specifically measurable for success or failure than goals. The objectives are associated with specific actions (tasks) to be implemented. Under each goal are one or more specific objectives and actions designed to result in progress toward sustainability of the paddlefish stocks and fisheries.

GOAL 1. Provide a basis for cooperative, coordinated management and allocation of paddlefish of the Yellowstone-Sakakawea stock between the states of Montana and North Dakota in consultation with the appropriate federal agencies and Native American Tribes.

OBJ 1.1 Communicate and coordinate management among relevant state and other entities on a year-long basis.

OBJ 1.2 Provide information on in-season fishing patterns, trends, and harvest estimates for use by managers.

OBJ 1.3 Formulate and implement uniform regulations between states wherever possible; justify the regulations and differences among stocks.

OBJ 1.4 Consult with tribal biologists, especially the Fort Peck Tribal Fisheries Office, for information exchange and data acquisition.

OBJ 1.5 Periodically attend MICRA, CITES, IUCN--SSG, MRNRC, NASPS, and Missouri River fisheries and paddlefish and sturgeon workgroups for management and enforcement information exchange.

OBJ 1.1 Communicate and coordinate management among relevant state and other entities on a year-long basis.

Two e-mail lists will be established and maintained for working group members on paddlefish and caviar-related matters. One will be specific to the working group and the other to a wider audience of agency personnel.

Technical coordination meetings (in-person) will typically be held in spring (February-March), before the fishing season, and, if needed, in fall, after the fishing season, but at least once per year, to review management and monitoring issues and present stock assessment and research results. The meeting site will alternate between Montana and North Dakota sites. An agenda will be prepared and distributed by the host agency before the meeting.

The meeting will include discussions of past fishing season, stock information collected and analyzed in the previous year, stock status, and stock forecasts for the upcoming season. Succinct summaries of (1) stock age structure, (2) stock status, (3) Five-year recruitment Index, and 4) harvest cap will be prepared and distributed prior to the spring meeting for both the Yellowstone-Sakakawea and Fort Peck stocks. An “Index Summary Table” that includes data for all four stock indexes will be provided to the states in annual reports. The data summary for the Yellowstone-Sakakawea stock should include harvest and age data from both states collectively. These reports will be completed and distributed after completion of dentary and other data analysis from the previous year and will include results of those activities. Adequate time will be provided at the meeting specifically for discussion of management and progress toward accomplishing goals of the Plan.

Other *ad hoc* meetings and impromptu sessions will occur as needed, and as opportunities arise at various other meetings within the region.

OBJ 1.2 Provide information on in-season fishing patterns, trends, and harvest estimates for use by managers.

During fishing seasons, managers in Montana and North Dakota will receive updated daily information from the fish cleaning stations on total number of fish processed, trends in effort, flow projections, harvest projections and any other information needed for assessing when closure may be necessary. Updates will be forwarded to regional offices in Miles City and Williston, as well as central offices in Helena and Bismarck. These estimates will allow managers to assess progress of the fisheries and, if necessary, prepare for timely closures.

OBJ 1.3 Formulate and implement uniform regulations between states wherever possible; justify the regulations and differences among stocks.

Unless overriding factors dictate otherwise, uniform regulations for the stocks will be sought. Efforts will be made to develop uniform regulations that will not only facilitate compliance from snaggers (a significant number of whom fish in both states) but will also make it possible to use the data collected as one large, consistent database. However, in some cases site specific socio-economic factors can lead to distinctly different regulations among stocks (e.g., the Fort Peck stock).

Regulations and regulation changes will be fully vetted for their ecological and socio-economic rationale at the annual coordination meetings. This process will be a high priority at annual meetings. Efforts at uniformity will be balanced against distinct, state-specific aspects of each fishery. A data uniformity document, in a draft stage as of 2021, will be finalized by 2023.

OBJ 1.4 Consult with tribal biologists, especially the Fort Peck Tribal Fisheries Office, for information exchange and data acquisition.

Contacts with tribal biologists based at Poplar, Montana will be established, and information will be exchanged on the fisheries. Contacts will be continued through May and June during the fishing season. Harvest data from the tribal fishery will be collected if possible

(Objective 3.4 below).

OBJ 1.5 Periodically attend MICRA, CITES, IUCN--SSG, MRNRC, NASPS, and Missouri River fisheries and paddlefish and sturgeon workgroups for management and enforcement information exchange.

Periodic attendance at selected meetings by workgroup personnel will be useful for information exchange and cooperation both within the group and between the group and other management entities. Cooperative presentations will be made involving working group members. Relevant information will be disseminated to these groups through the broader mailing list (Objective 1.1).

GOAL 2. Conduct orderly, equitable, and sustainable recreational fisheries for paddlefish and harvest consistent with the productive capacity of the stocks.

OBJ 2.1 Coordinate, actively manage, and monitor season- and area-controlled harvest fisheries for paddlefish.

OBJ 2.2 Provide and monitor controlled snag-and-release opportunities for paddlefish.

OBJ 2.3 Improve methods of forecasting reproductive and recruitment success.

OBJ 2.4 Improve and refine estimates of survival and population size.

OBJ 2.5 Improve and refine estimates of harvest and harvest rates in all areas.

OBJ 2.6 Improve the existing age-structured harvest model for estimating stock status and allowable annual harvest.

OBJ 2.1 Coordinate, actively manage, and monitor season- and area-controlled harvest fisheries for paddlefish.

Intensive onsite monitoring of the fisheries during the entire fishing season will continue to be the cornerstone of the program. Information collection and exchange will be important aspect of the monitoring. Daily summaries of the fishery, biological data collected, including egg and caviar weights, and other relevant information will be provided to managers. Daily harvest information will be available to the public, Glendive Chamber of Commerce and Agriculture, and Williston Convention and Visitors Bureau/Friends of Fort Union.

OBJ 2.2 Provide and monitor controlled snag-and-release opportunities for paddlefish.

The snag-and release fishery for paddlefish was instituted based on evidence that a monitored fishery would result in more fishing opportunity with minimal additional mortality (Scarnecchia and Stewart 1997a). Since its implementation in Montana in 1994 and North Dakota in 2003, the fishery has provided additional benefits to anglers and resulted in an important cost-effective source of fish for jaw tagging and population estimation.

MFWP and NDGF will continue to provide controlled and monitored snag-and-release fisheries at sites where they can effectively be managed. Emphasis will be on providing a moderate level of opportunity in places and times where fish can be landed, handled and released with minimal physical damage and mortality to the fish. Whenever feasible, fish will be jaw tagged for improved estimates of survival and population size. Catch-and-release literature from other fisheries for various species will be reviewed, and new findings incorporated into the catch-and-release programs. Criteria will be established for conditions where it may be too warm for catch-and release fishing.

OBJ 2.3   Improve methods of forecasting reproductive and recruitment success.

Forecasting and characterizing success or failure of reproduction and recruitment are critically important. Data will continue to be analyzed to assess the role of river discharge and reservoir water levels on reproductive success and recruitment. Transect sampling will be continued in the upper portions of Lake Sakakawea and Fort Peck Reservoir according to established methods (Fredericks and Scarnecchia 1997; Kozfkay and Scarnecchia 2002). Yearlings and sub-adults will be counted along the same transects as age-0- fish. The particular transects sampled will depend on reservoir levels but will be designed to the type of habitat historically used by age-0 fish. In addition to transect counts, data collected will include transect length, water depth, Secchi depth, turbidity, and surface zooplankton abundance and taxonomic composition consistent with past sampling (Scarnecchia et al. 1996c; 2009).

Sampling of age-0 and sub-adult (age-1 and age-2) fish will occur when numbers are sufficient to warrant the effort. All age-0 fish will be measured and a sub-sample weighed. All age-0 fish (wild or hatchery-reared) will be tagged with coded-wire tags before being released. If numbers and sizes of available fish warrant sorting into lots by size, size at tagging experiments will be conducted. Such experiments would assess the importance of growth and size in subsequent recruitment. Stomach samples will be taken as needed to evaluate food habits. A comprehensive data base for all juvenile fish catches will be maintained and updated yearly.

In Fort Peck reservoir, paddlefish counts have proven less useful for assessing year-class strength because of consistently low counts. Kozfkay and Scarnecchia (2002) found them to be indicative of probable spawning success, but with the declining reservoir levels in Fort Peck Reservoir from 1998 to 2004, counts were near zero. A better method is needed to observe and estimate abundance of age-0 fish in Fort Peck Reservoir, at least in years of low water and low reproduction. Cost-effective possibilities will be investigated.

The fishes caught at fishing sites will provide a Young Male Recruit Index, i.e., the age-specific catch of young males at various sites as an early indicator of a strong year class. Catches of young male (ages 10-14) and young females (ages 17-21) will be used for both harvested stocks to assess recruitment success and determine optimal harvest caps. In addition to the development of the early warning indices, other possible signs of over-harvest, including loss of old-age fish, will be monitored and evaluated.

OBJ 2.4   Improve and refine estimates of survival and population size.

Accurate survival and population estimates are an important part of our stock assessment methodology. We will develop improved estimates and population estimation sampling and analytical methods, emphasizing the use of Cormack-Jolly-Seber models. These approaches will be explored in more detail for both the Yellowstone-Sakakawea and Fort Peck stocks. To reduce uncertainty in the parameter estimates we recommend increasing recapture rates (> 0.05) through increased effort, measure tag loss, and conduct simulations using existing data to better understand the effects of low recapture rates on the assumptions associated with the Jolly-Seber (POPAN) models. For the Oahe stock, for which sampling appears to be more representative of the stock, ongoing estimates will continue (Bailey et al. 2018).

Based on survival and population estimates, recommendations will be developed for how to improve sampling for tagging and recovery, as well as preferred analytical methods and the rationale for them. In addition to more traditional mark-recapture population estimates, if funds are available, the use of side scan sonar and acoustic methods (Hale et al. 2003) will be reviewed and evaluated for assessing the number of paddlefish in the river and reservoir, respectively. Estimation of natural mortality rates (here defined to include all non-harvest mortality) is important for the harvest model.

Two basic approaches will be used to estimate this mortality. The first approach will involve use of the existing database on age structure and adult tag recoveries to estimate non-harvest losses. Survival estimates will be developed and compared with harvest estimates from tag recoveries to separate out harvest from non-harvest mortality. The second approach involves monitoring of losses of paddlefish from information on mortality provided by snaggers. Information will continue to be collected from fishing sites on scars and other damage to paddlefish attributed to human activities (Rosen and Hales 1980).

OBJ 2.5   Improve and refine estimates of harvest and harvest rates in all areas.

Jaw- tagging of adult fish will be continued. A target of 400 fish per season per state (800 total fish per year) has been set for the Yellow-stone-Sakakawea stock. The current target for the Fort Peck Stock is 500 fish. No specific goal is set for the Oahe stock. In addition, tagging of 50 fish per year in the Dredge Cuts is set as a target to obtain information on the status of those fish. Population sizes and harvest rates estimated from recoveries will be used in conjunction with the harvest estimates and age structure to estimate recruitment.

On-going phone creel activities for the Yellowstone-Sakakawea and Fort Peck stocks will continue. Additional creel effort will be expended at off-site areas as needed and as fishing patterns change. A limited creel will also be established for the Dredge Cuts fishery to obtain life history information on that stock component.

Coded-wire tagging of all hatchery-reared young-of-the-year fish and all wild young-of-the-year fish caught will in time result in a significant number of tagged fish being recovered at cleaning stations. By having tag detectors at main fishing sites, a high percentage of tagged fish will be recovered, which will provide increasingly accurate estimates of survival rates as well as relative survival of hatchery-reared and wild fish. Covariates will also be incorporated into the models to account for biases in tagging and recovery sampling.

OBJ 2.6 Improve the existing age-structured harvest model for estimating stock status and allowable annual harvest.

The long-term age data developed for the Yellowstone-Sakakawea stock now permits the development of a more comprehensive, age structured model of the population grounded in actual data. The proposed work involves the use of two primary approaches: Virtual population analysis (VPA; Sparre 1992, Lassen and Medley 2000) and an age-structured population analysis (Beamesderfer 1991; Colvin et al. 2013).

Virtual population analysis (VPA) is an age-based method of stock assessment that is a powerful tool for reconstructing historical recruitment of fish stocks, estimating fishing mortalities, and projecting probable future stock status. VPA looks at a population from the historical perspective by reconstructing the cohorts based on historical catches and based on estimates and assumptions of natural and fishing mortality. Data generated from this assessment allow a complete reconstruction of the historical population and also make it easier to project future stock size and future catches. Age data from 1985 and length data back to 1974 will permit reconstruction far back in time. Population estimates will be used to calibrate the VPA model. Age-structured population analysis will be used in conjunction with population estimates (OBJ 2.4) and survival rates (OBJ 2.5) to project cohort strength into the future.

In addition, the Five-Year Recruitment Index based on the estimated recruitment of young males (ages 10-14) and females (ages 17-21) will continue to be calculated and refined (e.g., on females only), under the assumption that females are limiting to the population and to spawning success. In that approach, the harvest cap would limit the number of fish of both sexes, or females, to a specified number of fish consistent with 5-year recruitment.

GOAL 3. Maintain a standardized data base for stock assessment and yield forecasting.

OBJ 3.1 Manage and improve the uniform MT-ND data collection system using the existing *paddlefish fisheries and tagging systems in Montana and North Dakota.*

OBJ 3.2   Maintain the centralized, error-checked database system with back-up files.

OBJ. 3.3   If needed, develop an effective mandatory reporting program for paddlefish harvest.

OBJ 3.4   Obtain harvest data from Tribal fisheries.

OBJ 3.1   Manage and improve the uniform MT-ND data collection system using the existing paddlefish fisheries and tagging systems in Montana and North Dakota.

All sampling of catches will be coordinated between North Dakota and Montana to insure uniformity and compatibility of data collection. Fish cleaning sites will be sampled heavily and cost-effectively during the fishing seasons. Data from less popular areas will be obtained through on-line reporting and annual phone and creel censuses. Off-site creel census or mandatory reporting may be developed as necessary in case future fish passage improvements at Intake Diversion Dam results in a more dispersed fishery (Yellowstone-Sakakawea stock). In addition to data from the fishery, agency data collection (e.g., adult jaw tagging) will be coordinated for uniformity.

A uniform data collection document (e-version manual of protocols), which is in draft form, will be completed for the fisheries by 2023 and updated periodically. It will be distributed to managers in each region. Data collection issues and needed refinements will be discussed and coordinated at the annual meetings.

OBJ 3.2   Maintain the centralized, error-checked database system with back-up files.

A centralized database that has been developed at the University of Idaho for all three stocks, incorporating nearly all of the past data, will be continued. Data include length-weight-sex information, the adult tagging databases, and juvenile sampling and tagging databases. The database will be updated annually, error-checked and updates delivered in hard copy and electronic form to both MFWP and NDGF. Back-up files will be maintained at three separate locations.

OBJ 3.3   If needed, develop an effective mandatory reporting program for paddlefish harvest.

As needed in both states, mandatory reporting efforts may/will be developed to obtain better information on off-site harvest of paddlefish (i.e., fish creeled at sites that are not sampled). Currently, Montana has such a program but it is not fully effective. North Dakota has not yet developed a program.

OBJ 3.4   Obtain harvest data from Tribal fisheries.

Efforts will be made to estimate both tribal and non-tribal harvest on reservation lands, as well as biological information from harvested fish. This effort will involve either on-site creel (if permitted) at Wolf Point and Frazer Rapids fishing sites or soliciting the assistance of tribal biologists/wardens. In the latter case, one or more packages of sampling gear for paddlefish (for obtaining lengths, weights, sex, dentaries, and tag recoveries) will be delivered to biologists/enforcement personnel before the season.

GOAL 4. Maintain and enhance existing paddlefish habitat and obtain additional information to better define and provide for paddlefish habitat requirements.

OBJ 4.1 Review the existing federal and state laws, rules and investigations for relevance to maintaining or enhancing paddlefish habitat for all life stages, including river flows, water quality, physical habitat, and reservoir levels.

OBJ. 4.2 Use existing data to better identify and define critical habitat needs and requirements for paddlefish at all life stages.

OBJ 4.3 Monitor the potential effects of oil spills and other energy development activities on paddlefish ecology, as needed.

OBJ 4.4 Monitor contaminant concentrations in paddlefish flesh and roe in relation to oil spills other energy development activities, and other habitat conditions.

OBJ 4.1 Review the existing federal and state laws and rules for relevance to maintaining or enhancing paddlefish habitat for all life stages, including river flows, water quality, physical habitat, and reservoir levels.

Plan participants and managers will provide input to other agencies and the public on habitat needs for paddlefish, through working groups, draft comments, and public meetings. Important aspects of paddlefish habitat in need of protection include instream flows and turbidity, free river passage for migratory fish, spawning gravel, water quality, river function, and appropriately varying reservoir levels. Background provided in Appendix 2 will be used as evidence and rationale.

OBJ 4.2 Use existing data to identify and define critical habitat needs and requirements for paddlefish at all life stages.

Existing indices of stock reproductive success and year class strength will be compared with river discharge, river turbidity, and reservoir levels to assess the relations among these variables.

OBJ 4.3   Monitor the potential effects of oil spills and other energy development activities on paddlefish ecology, as needed.

State agencies will coordinate with other agencies to monitor acute and short-term impacts to paddlefish after spills. For example, if an oil spill occurs in Montana, MFWP will participate in incident command processes to coordinate field sampling and communication efforts with the public. This includes coordination with the state's Natural Resource Defense staff.

OBJ 4.4   Monitor contaminant concentrations in paddlefish flesh and roe in relation to oil spills, other energy development activities, and other habitat conditions.

In Montana, MFWP will coordinate with other agencies involved with the incident command process and the States Natural Resource Defense staff to assess potential contaminant levels in fish that affect the short and possibly the long-term health of the fish and the risk to human consumption of contaminated fish. Similar activities will be conducted in North Dakota, including periodic state assessment of contaminants in flesh and roe.

GOAL 5. Conduct and incorporate new research for successful long-term management.

OBJ 5.1   Assess the impacts of adult passage and juvenile screening at the Intake Dam and Canal and upriver projects on the paddlefish migration, spawning, reproduction, and fishery location.

OBJ 5.2   Continue investigations on physical-chemical factors affecting paddlefish reproduction and recruitment success, including reservoir level changes, reservoir aging, and headwater sedimentation.

OBJ. 5.3   Investigate food web effects on paddlefish reproduction and recruitment success.

OBJ 5.4   Evaluate reservoir distribution and movements of age-0, sub-adult and adult telemetered paddlefish in relation to habitat variations and trends.

OBJ 5.5   Assess the ability to capture larval paddlefish as rearing stock for any future hatchery enhancement.

OBJ 5.6   Evaluate the importance of genetic information and microchemistry in terms of stock discreteness and the desirability of fish transfers among stocks.

OBJ. 5.7   Assess and monitor contaminant concentrations in paddlefish flesh and roe.

OBJ 5.8 Develop a plan for paddlefish conservation in an oil spill or energy development-related event.

OBJ 5.9 Periodically review, discuss and where useful implement new research methods and findings on paddlefish and sturgeon for relevance to management.

OBJ 5.10 Utilize bomb radiocarbon dating to assess the maximum age of paddlefish in the stocks.

OBJ 5.1 Assess the impacts of adult passage and juvenile screening at the Intake Dam and Canal and upriver projects on the paddlefish migration, spawning, reproduction, and fishery location.

Fish passage actions at the Intake Diversion Dam, including upstream passage, the loss of the side channel around Joe's Island, and juvenile screening, will have substantial effects on paddlefish movements, spawning, reproduction, and the location and timing of the fishery. Effects on paddlefish should be evaluated as passage improvements are implemented. Paddlefish should also be considered to the extent possible in project design and implementation. Coincident with the creation of the upstream passage facility, a need exists to assess the influence of the structure on paddlefish passage, migrations and spawning at sites upstream of the dam. This research can expand on ongoing activities by MFWP.

It remains important to identify and characterize spawning areas, and to determine if such areas are used for spawning year-to-year or if spawning sites change yearly. Paddlefish tend to spawn during periods of high river turbidity as well as high flows. The importance of turbidity is unknown, but it may facilitate spawning or decrease predation on larval paddlefish drifting in the rivers before reaching the reservoirs. If so, turbidity may be an important component of paddlefish habitat for spawning and early life history. Maintenance of adequate flows in sediment-laden tributaries (e. g., the Powder River) would then become important for maintenance of paddlefish spawning and early rearing habitat. Paddlefish require a minimum temperature of 12.7-15.5 °C (55-60 °F) for spawning (Russell 1986), but actual spawning temperatures in the Yellowstone and Missouri Rivers are not thoroughly evaluated. Telemetered adult pre-spawning paddlefish may provide answers to these and related questions.

OBJ 5.2 Continue investigations on physical-chemical factors affecting paddlefish reproduction and recruitment success, including reservoir level changes, reservoir aging, and headwater sedimentation.

It is important to continue monitoring the ecology of age-0 and sub-adult fishes in the reservoir so that factors influencing survival, growth, and recruitment (year class strength) are clarified. Paddlefish recruitment is the outcome of a complex ecological processes in an ever-changing habitat. Recruitment in the Yellowstone-Sakakawea stock has been characterized as dominated by occasional strong year classes (Scarnecchia et al. 2014, 2019b) whereas recruitment in the Fort Peck stock is more modest but less variable.

A favorable combination of a suite of factors is necessary for a strong recruitment year. Recruitment depends on favorable conditions for growth (mainly favorable bottom-up processes such as trophic factors) and survival (mainly favorable top-down processes such as lack of predation). Suitable upriver spawning conditions, combined with trophic upsurge during reservoir filling and refilling, have created especially favorable trophic and turbidity conditions for age-0 growth, survival and recruitment of paddlefish in the two reservoirs (Scarnecchia et al. 1996b, 2009, 2019b). Higher spring discharge from the rivers (especially the more turbid Yellowstone) results in a stronger plume into the reservoir, increasing nutrients while high suspended sediment load may protect age-0 fish from predation.

Juvenile paddlefish habitat quality in reservoir headwater areas has deteriorated since reservoir filling through sedimentation associated with reservoir aging. Effects of sedimentation have been especially important in reservoir headwater areas, which have been particularly altered as sediment inputs have settled out. There is no certainty that under existing habitat conditions, paddlefish recruitment will ever be as strong as during trophic upsurge associated with initial reservoir filling. Paddlefish early life history (up to age-1) is especially dependent on conditions in the river above the reservoir and the upper third of Lake Sakakawea, areas heavily impacted by physical changes such as sedimentation. More information is needed on the relations among river discharge, sediment plume, reservoir levels, and the changing habitat conditions for paddlefish.

OBJ 5.3 Investigate food web effects on paddlefish reproduction and recruitment success.

Understanding recruitment will require a greater understanding of the food web in Lake Sakakawea and Fort Peck Reservoir. In Lake Sakakawea, pelagic productivity in the reservoir had declined since the trophic upsurge period of the 1950s and 1960s. Juvenile paddlefish food supply has decreased as the food web has shifted to a more benthic form in headwater areas. Anoxic conditions in the transition zone may also be preventing successful recruitment in fishes drifting down into mainstem reservoirs from rivers (e.g., Fort Peck Reservoir; Guy et al. 2015). Juvenile (age-0) paddlefish growth and survival are affected by food quality (i.e., food quality varies depending on abundance of available forage taxa and their energy value). Taxa may have shifted since reservoir filling in both reservoirs. Real time juvenile growth may be correlated with potential food abundance and stomach contents. Higher numbers of larger predator species, partly a result of increased stocking of piscivores such as walleye, may result in more predation pressure in both reservoirs on age-0 paddlefish (Parken and Scarnecchia 2002). Other forage invertebrates and forage fishes may mediate predation by providing alternative prey for potential paddlefish predators. Density dependent growth may also influence year class strength. Mosquito spraying in Lake Sakakawea headwaters may have altered the food web by reducing alternative invertebrate prey species for potential predators on age-0 paddlefish. For example, neonicotineoids (a class of insecticides) shown to be harmful to bees and many other non-pest insects, may affect paddlefish food webs indirectly. For a more complete understanding of recruitment, greater knowledge is needed of the relations among reservoir habitat changes, the food web, and growth and survival of age-0 and age-1 paddlefish in both reservoirs.

OBJ 5.4   Evaluate reservoir distribution and movements of age-0, sub-adult, and adult telemetered paddlefish in relation to habitat variations and trends.

Very little is known about the movements and habitat use of paddlefish in reservoirs in relation to changing habitat conditions, both interannually and by season. Very little is also known about specific preferences for depths and temperatures of paddlefish in relation to feeding and food availability. Movements of age-0 and sub-adults in the upper ends of reservoirs could be tracked with acoustic tags and a few stations.

For sub-adult and adult fish, the use of archival data storage tags will be investigated to provide insight into preferred habitat conditions in the reservoirs. With archival tags, information on depth and temperature by date would be complemented by information on the temperature by depth in different locations in the reservoir, providing an indication of the spatial distribution of fish in the reservoir. Information gained would be related to turbidity, zooplankton abundance, distribution and abundance of predators, habitat variability, and reservoir aging. Archival tags would be useful for sub-adults (netted in reservoir) or adults (netted or snagged in the river). Recovery would occur at harvest or possibly from snag-and-release fisheries, where the tag could be removed from a fish determined from its jaw tag to also be carrying an internal tag. The tags could be recovered slowly but steadily over a period of years.

OBJ 5.5   Assess the ability to capture larval paddlefish as rearing stock for any future hatchery enhancement.

More information on larval fishes would serve several purposes. First, habitat requirements for larval paddlefish are also poorly understood. The instream flow reservations requested for the Missouri and Yellowstone Rivers (See Habitat Requirements and Protection Section) provide good river conditions for spawning, but spawning success at lower river flows is questionable. Also, poorly understood are the relative contributions to paddlefish year class strength from fish spawning in the Milk River and Yellowstone River upstream of Intake in years when paddlefish are able to reach these areas. Spawning areas upstream of Fort Peck reservoir have been suggested by Berg (1981), and efforts are ongoing to further delineate them. Although two studies have documented egg deposition in the Lower Yellowstone River, (Firehammer et al. 2006; Miller 2007), and Missouri River above Fort Peck, much remains to be learned about the main spawning and egg deposition sites in the rivers and how they vary by discharge and year. A recent study by Schooley et al. (2020) documenting positive phototaxis of larval paddlefish in a hatchery setting may eventually lead to improved sampling of larval fish in the wild.

Additional sampling of spawners on the Yellowstone and Milk rivers as well as sampling of eggs and larval fish at key locations are needed to improve understanding of paddlefish spawning and early life history. Improvement of indices of age-0 and sub-adult abundance in reservoirs will also help indicate the success of spawning at various river flows.

Secondly, the ability to sample large numbers of age-0 paddlefish would enable hatchery managers to rear wild spawned fish for stocking instead of hatchery-spawned fish for any production or experimental releases. Sampling efforts for age-0 fish may be improved as with efforts are undertaken to assess the effects of improved fish passage past the Intake Diversion Dam.

OBJ 5.6 Evaluate the importance of genetic information and microchemistry in terms of stock discreteness and the desirability of fish transfers among stocks.

Advances in genetics and microchemistry need to be applied to the stocks in this Plan for deciding how to manage the flow of genetic diversity among stocks. For example, because the Fort Peck stock is a donor stock but not a receiving stock, it may be desirable to move some fish upriver, as would have happened naturally before dams. Adequate information on stock structure is needed to inform such decisions.

OBJ. 5.7 Assess contaminant concentrations in paddlefish flesh and roe.

Contaminants not only have the potential to compromise the safe consumption of paddlefish meat; they may also have the potential to affect reproductive success and the development of intersex fish (Neosho River, Oklahoma: Schooley et al. 2020). No negative effects have been documented in paddlefish in Montana and North Dakota (Montana Sport Fish Consumption Guidelines 2014). As a monitoring tool, we will conduct a follow-up analysis of the concentrations of a wide range of contaminants in paddlefish flesh and roe and compare with acceptable levels. This work will be coordinated with the North Dakota and Montana Departments of Health. We will collect samples for analysis during creel activities at fishing sites and cleaning stations.

OBJ 5.8 Develop a plan for paddlefish conservation in an oil spill or energy development-related event.

A contingency plan is needed for stocks in the event of energy development-related fish kills. For Montana, the Incident Command Structure (ICS) process will be utilized following a disaster such as an oil spill, train derailment, etc. A few MFWP staff in the Miles City office have participated in the introductory 100 and 200 level training for the ICS process. This basic level of training and understanding of the ICS is needed to understand the role states can and cannot play during a natural disaster. A second responsibility for state employees is being aware and responsive to Montana’s Natural Resource Defense process during a natural disaster.

OBJ 5.9 Periodically review, discuss and, where useful, implement new research methods and findings on paddlefish and sturgeon for relevance to management.

Selective relevant papers will be routed among members of the group for incorporation into the management and stock assessment framework. Research progress at other localities should be monitored for application to the stocks in Montana and North Dakota. This work will be monitored through MICRA, IUCN-SSG, and other key meetings.

OBJ 5.10 Utilize bomb radiocarbon dating to assess the maximum age of paddlefish in the stocks.

Jaws and otoliths from old paddlefish sampled in 1985 and the early 1990s can be used with methods outlined by Lackmann et al. (2019) to assess the maximum age of paddlefish.

GOAL 6. Integrate and define the role of artificial propagation and stocking in the successful long-term management.

OBJ 6.1 Articulate specific rationales for stocking in response to reservoir depletion, persistent low water levels, invasive species, recruitment failure, or other potential ecological threats to the species.

OBJ 6.2 More fully evaluate the success of experimental hatchery releases into Lake Sakakawea in relation to interannual environmental differences.

OBJ 6.3 Define the role of the Oahe stock in inter-state management.

OBJ 6.4 Monitor progress on Acipenseriform aquaculture and wild larval fish rearing from sturgeon for application in paddlefish.

OBJ 6.5 When stocking hatchery fish, conform where possible to broader MICRA and USFWS hatchery and release protocols.

OBJ 6.1 Articulate specific rationales for stocking in response to reservoir depletion, persistent low water levels, invasive species, recruitment failure, or other potential ecological threats to the species.

More detailed planning between MFWP and NDGF will be conducted regarding hatchery production so that the intent and desired outcomes of any hatchery releases are clearly defined and delimited. A short document will be developed clarifying when, and under what conditions, to stock fish, e.g., in the event that reservoir depletion, persistent low water levels, invasive species, or other potential ecological threats lead to persistent low recruitment. Genetic planning based on MICRA paddlefish criteria will be used. Additional experimental releases will be conducted in the next decade to test specific hypotheses regarding juvenile survival and recruitment of both hatchery and wild fish.

The relation between any paddlefish stocking program and other stocking programs for other (non-paddlefish) species will be evaluated. Because young paddlefish are highly vulnerable to predation from walleye, sauger and other species (Parken and Scarnecchia 2002), the effects of expanding stocking programs for other species in both states needs to be considered with regard to potential effects on young hatchery-reared and wild paddlefish.

OBJ 6.2   More fully evaluate the success of experimental hatchery releases into Lake Sakakawea in relation to interannual environmental differences.

The status and progress of past experimental hatchery releases in Lake Sakakawea, will continue to be monitored. Results from stockings in 1995, 1997, 2007, 2011, and 2018 as well as wild fish tagged over the past two decades, will be evaluated over the next decade as coded-wire tagged fish return upriver and are caught in the fisheries. Harvested fish will be screened for the presence of coded-wire tags, and all tags will be extracted and interpreted for brood year information. Growth and survival rates of hatchery-reared fish will be compared with those of wild fish. In addition, tagging of all young paddlefish sampled in Lake Sakakawea as well as all young paddlefish released from hatcheries will provide fish of known age for age validation. Dentaries, fin sections, and otoliths will be removed from tagged fish that are recovered and the age of the fish determined for age validation.

Future releases will incorporate size and time at release treatments to provide information on optimal size and time of release. As in the past, all fish will be coded wire tagged (Pitman and Isaac 1995; Fries 2001). Fish will be stocked in both high reservoir and low-reservoir periods so that survival rates of fish tagged during different reservoir levels can be compared. It is not known how well hatchery-reared recruits will spawn. The reproductive state of hatchery-reared fish will be documented, especially the presence of sexually mature and spawned-out females, which might be present during the end of the planning period.

An important need for hatchery-reared fish is maintenance of adequate genetic diversity. It may be desirable for the genetics of hatchery-reared recruits to be compared with that of wild fish as an indicator of comparative genetic diversity. For hatchery releases, the use of parental based tagging, now beginning to be applied to other species such as salmons (Hargrove et al. 2020) and sturgeons (Roques et al. 2019), should be investigated for paddlefish in the three stocks.

OBJ 6.3   Define the role of the Oahe stock in inter-state management.

As understanding of the Oahe stock has increased, the stock appears to be a pool of non-spawning fish perhaps originating mostly from downstream movement of Yellowstone-Sakakawea and Fort Peck fish. Their genetic characteristics should be evaluated, and a document identifying what, if anything, should be done with these fish. It might be desirable to leave them where they are as a repository. Alternatively, fish can be moved upriver to repopulate upriver stocks, as had undoubtedly occurred historically (i.e., in high flow years before dams).

OBJ 6.4 Monitor progress on Acipenseriform aquaculture and wild larval fish rearing from sturgeon for application in paddlefish

Considerable research is being conducted globally on Acipenseriform (sturgeon and paddlefish) aquaculture, some of it focused on conservation. Results have been described in several documents (e.g., Chebanov 2011; Mims and Shelton 2015), where guidelines for sturgeon hatchery practices and management for release are detailed. Relevant finding should be incorporated into paddlefish hatchery and stocking practices. In the longer term, a preferable approach for hatchery production would be to use wild-caught larvae and rear them in hatcheries, as is being implemented experimentally for white sturgeon in the Columbia River. This program should be monitored for success. Research efforts to capture larval paddlefish will be explored as part of the Intake Dam passage evaluation project.

OBJ 6.5 When stocking hatchery fish, conform where possible to broader MICRA and USFWS hatchery and release protocols.

MICRA (the Mississippi Interstate Cooperative Resource Association) established paddlefish stocking protocols designed "to maintain a reproductively viable and genetically diverse paddlefish population…, to allow for differentiation of artificially propagated paddlefish from wild fish, … [and] to minimize spread of fish pathogens and Aquatic Invasive Species (AIS) associated with propagation and stocking of paddlefish" (p. 2-5, MICRA 2012). More recently, the U. S. Fish and Wildlife Service, who spawns and rears paddlefish periodically for stocking in Lake Sakakawea, has reviewed its national stocking program and developed guidelines consistent with MICRA and with the latest scientific information on the species (USFWS 2018). These practices should be implemented in stocking programs for paddlefish.

GOAL 7. Increase public awareness of the paddlefish and its habitat requirements.

OBJ 7.1 Continue public information activities on paddlefish through an organized program and information displays, brochures, popular articles, presentations, blogs, and television segments.

OBJ 7.2. Utilize agency websites and social media as access points for paddlefish information exchange.

OBJ 7.3 Publish working-group, peer-reviewed scientific publications of research and management efforts for the scientific community.

Figure 60. People of all ages are interested in paddlefish. Groups commonly take field trips to Intake and the Confluence.

OBJ 7.1 Continue public information activities on paddlefish through an organized program and information displays, brochures, popular articles, presentations, blogs, and television segments.

Information and education activities will continue at the fish cleaning stations and involve one-on-one interaction as well as short question and answer sessions with interested individuals and groups. (Figure 60). These activities will be supplemented by dissemination of information through several other sources, including information displays, brochures, media presentations and scientific presentations.

Information displays will be prepared and updated as needed for the MFWP for display at Intake during the fishing season, at the Region 7 office at Miles City, and at county fairs and similar functions. NDGF may develop similar displays (e.g. at the Confluence) as needed. Other displays at the State Historical Society of North Dakota sites in Bismarck and the Confluence will be contributed to as requested.

Paddlefish information brochures, free to the public, will be updated at least every other year describing not only basic ecological information on paddlefish, but also new research findings and rationales for current harvest regulations. A combination of paddlefish cookbook/information brochure, free to the public and popular with anglers, will be revised for accuracy and updated by this group in conjunction with the Richland County, Montana Cooperative Extension office.

Articles on paddlefish management and research will be prepared as in the past by the working group and published in *Montana Outdoors* and *North Dakota Outdoors*, the official agency magazines for MFWP and NDGF. Other popular outlets will also be considered.

Oral presentations on paddlefish management and research findings will be presented by working group personnel at popular outlet sites such as Makoshika State Park (Montana), the State Historical Society of North Dakota site at the Confluence, and regional hunting and fishing clubs.

Online blogs (e.g., the Fisheries Blog) and short television information segments will be periodically presented by working group personnel in response to requests.

OBJ 7.2. Utilize agency websites and social media as access points for paddlefish information exchange.

As an increasing proportion of the public obtains their information from the internet and websites such as Facebook, YouTube, Twitter, and blog sites. More effort is needed to reach viewers and provide them with accurate information on paddlefish through these media. A review of such sites shows material of widely varying content and quality. MFWP, NDGF and the University of Idaho will collaborate to create some informational content for YouTube, Facebook, other sites, and for access from agency websites.

OBJ 7.3 Publish working-group, peer-reviewed scientific publications of research and management efforts for the scientific community.

Scientific peer review of published research results and management efforts is an important part of the Plan. Scientific findings will be presented at professional meetings and, of equal importance, published in refereed scientific journals. Results may be synthesized into one or more peer-reviewed books. These actions provide independent professional review, and thereby some quality control and quality assurance for the approaches and methods used, and actions taken.

GOAL 8. Incorporate public acceptance and compliance with the regulatory framework established for long-term management.

OBJ. 8.1 Re-assess values, attitudes, and preferences of paddlefish snaggers through on-site angler attitude surveys.

OBJ. 8.2 Use creel censuses, phone surveys, mail surveys and online reporting to obtain input on catch, effort, and specific management actions.

OBJ 8.3 Obtain input and review on current and potential regulation recommendations from enforcement personnel.

OBJ 8.4 Maintain open dialogue and cordial, professional cooperation with the roe donation programs in both states within the broader goal of sustainable paddlefish management.

OBJ. 8.1 Re-assess values, attitudes, and preferences of paddlefish snaggers through on-site angler attitude surveys.

Updated information is needed on the values, attitudes, and preferences of snaggers and the public at large toward paddlefish. This need will be addressed during the season through on-site surveys at the Pumphouse, Confluence and Intake fishing sites. The survey will be modeled to be comparable with surveys conducted in 1993 and 1994 at Intake. Surveys will be developed with input from agency human dimensions specialists inside and outside the agencies.

OBJ 8.2 Use creel censuses, phone surveys, mail surveys, and online reporting to obtain input on catch, effort, and specific management actions.

In the off-season, information on angler activities and preferences will be obtained through phone creel surveys conducted by MFWP and NDGF. Phone creel surveys, also used to assess angler catch, effort, and fishing site usage, will also continue to be implemented. Surveys will be as uniform and consistent as possible between states and among years, which will permit comparisons to be made and trends identified. Mail creel surveys may also be implemented as needed. Addresses and phone numbers will be obtained through the paddlefish tagging program. Results will aid in formulating policies and in modifying this Plan.

OBJ 8.3 Obtain reviews of regulation recommendations from enforcement and enforceability standpoints.

Current regulations as well as proposed regulation changes will be evaluated by enforcement personnel for feasibility and enforceability. Enforcement issues and concerns will be incorporated into the management framework.

OBJ 8.4 Maintain open dialogue and cooperation with the roe donation programs in both states within the broader goal of sustainable paddlefish management.

MFWP and NDGF agree that the economic desires of the roe donation programs have not been and should not be driving factors impeding the implementation of sustainable paddlefish harvest management programs in either state. However, both agencies will endeavor to have open dialogue, effective communication, and positive working relations throughout the year with their respective Chambers of Commerce involved with the non-profit roe donation programs. Although some of the long-term and short-term goals and objectives of MFWP and NDGF for paddlefish sustainability may not mesh with short-term economic preferences of the caviar programs, most of the goals and objectives are compatible. Input from the caviar programs will be considered in areas where the health of the paddlefish stock, the quality of the recreational fishery, and other agency missions of MFWP and NDGF are not compromised.

APPENDIX SECTIONS

Appendix A-1 Management Chronologies for the Three Stocks

Historical management chronologies for the stocks are designed to provide an institutional memory of prior actions and the rationale for those actions at the time. Their importance increases for long-lived fishes such as the paddlefish in which individual fish can typically outlive the career length of a given manager.

Yellowstone-Sakakawea stock

The management history of the Yellowstone-Sakakawea stock is divided into four periods based on stock trends and differences in regulations. The regulation chronologies are summarized in Table A1-1 (Montana) and Table A1-2 (North Dakota).

Period 1 (1963-1977) - Period 1 was characterized by an increase in the numbers of recruited paddlefish and the beginning of recreational snag fisheries, which were conducted with liberal regulations.

Montana - Although fishing for paddlefish and other river species in the Lower Yellowstone River has a century-long history with European settlers (Figures A1-1, A1-2) and even a longer history with tribal inhabitants, MFWP first began regulating paddlefish snagging in 1963, a year after significant numbers of paddlefish were first caught at Intake. In 1965, the Montana legislature changed the status of paddlefish to a game fish (Robinson 1966). Numbers of paddlefish in relation to fishing effort were high, the size of the recruited stock was increasing (Scarnecchia et al. 1996b), and liberal harvest regulations prevailed. The initial regulations were set broadly for both the Yellowstone-Sakakawea and Fort Peck stocks. Yellowstone-Sakakawea paddlefish could be harvested downstream of Custer (near the mouth of the Bighorn River) to the state line. There was no closed season. The daily limit was 2 fish per day, with 4 in possession. Regulation changes through the remainder of the 1960s and the 1970s were mostly minor. Throughout most of the 1970s, Elser (1975; 1977) provided evidence that the stock status was strong, and that more restrictive regulations were unnecessary. Beginning in 1975, boat fishing was prohibited for the area from the Intake dam 0.40 km (1/4 mile) downstream during May, June and July in an attempt to reduce conflicts between boat-based anglers (snaggers and walleye/sauger anglers) and those snagging paddlefish from the bank.

Annual harvest rates on Dredge Cuts paddlefish were estimated by Needham over the period 1968 to 1979 to range from 0.6% to 2.7% (Needham 1980b). These rates were not considered sufficiently high to warrant additional regulations.

Table A1-1. Summary of Montana paddlefish regulations, 1980-2019. (Only years with major changes are listed)

YEAR	DAILY AND POSSESSION	WATERBODY	REGULATION CHANGE
1980-1981	1 daily and 2 in possession, no tags	Upper & Lower Missouri R.	Open entire year. All waters open to angling are open to bow and arrow and snagging of paddlefish.
		Yellowstone R.	Open entire year. All waters open to angling are open to bow and arrow and snagging of paddlefish (high grading fish allowed). Quarter mile downstream from Intake Diversion Dam closed to snagging from boats from May 1-July 31.
1981-1982	1 per year, tag required	Yellowstone R.	Downstream from the mouth of the Bighorn River: Any paddlefish caught must be **tagged** immediately and counted in limit (mandatory retention).
1982-1983	2 per year, tags required	Yellowstone R.	From May 1- July11 snagging of paddlefish shall be allowed. Quarter mile downstream from Intake Diversion Dam closed to fishing or snagging from boats during paddlefish season.
1983-1984	1 daily and 2 in possession, no tags	Missouri R.	Open entire year.
	2 per year, tags required	Yellowstone R.	From May 1- July 10 snagging of paddlefish shall be allowed.
1984-1985	2 per year, tags required	Yellowstone R.	From May 1-July 8 snagging of paddlefish allowed downstream from the mouth of the Bighorn River.
1985-1986	2 per year, tags required	Yellowstone R.	From May 1 - July14 snagging of paddlefish allowed downstream from the mouth of the Bighorn River.
1986-1988	2 per year, tags required	Yellowstone R.	Open to the snagging of paddlefish May 15- July 10 from the mouth of the Bighorn R. to Cottonwood Cr. Open May 1- July 10 downstream from the mouth of Cottonwood Cr.
1988-1990			(no changes, regulations consistent over this period)

YEAR	DAILY AND POSSESSION	WATERBODY	REGULATION CHANGE
1990-1992	2 per year, tags required	Yellowstone R.	Open to the snagging of paddlefish May 15- June 30 from the mouth of the Bighorn R. to Cottonwood Cr. Open May 1-June 30 downstream from the mouth of Cottonwood Creek.
1992-1993	2 total, tags required: either 2 on the Missouri R. above Ft Peck or 1 above Ft Peck and 1 on the lower Missouri and Yellowstone rivers	Missouri R. Yellowstone R.	Open entire year. Paddlefish must be **tagged or released** immediately. Any paddlefish caught must be **tagged** immediately; unlawful to release a paddlefish.
1994-1995	2 total, tags required	Missouri R. upstream of Fort Peck Dam	Open entire year. Paddlefish must be **tagged or released** immediately.
	1 total, tag required	Missouri R. below Fort Peck Dam Yellowstone R.	Missouri River downstream of Fort Peck open entire year. Yellowstone River open to snagging of paddlefish May 15- June 30 from the mouth of the Bighorn R. to Cottonwood Cr. Open May 1-June 30 downstream from the mouth of Cottonwood Cr. Any paddlefish caught must be **tagged** immediately.
1996-1997	1 total, tag required	Missouri R. below Fort Peck Dam and Yellowstone R.	Yellowstone River from the mouth of the Bighorn R. to Cottonwood Creek open to the snagging of paddlefish May 15- June 30. Missouri River and Yellowstone River downstream from the mouth of Cottonwood Creek open May 1-June 30. In-season closure with 48-hour notice to keep annual harvest below 1,500 fish. Any paddlefish caught must be **tagged** immediately unless accomplished in accordance with the specific catch-and-release regulations on Wed. and Sun. between 3pm and 9pm at the Intake FAS only. Catch and release not allowed in other locations.

YEAR	DAILY AND POSSESSION	WATERBODY	REGULATION CHANGE
1998-1999			(no changes, regulations consistent over this period)
2000-2001	2 total, tags required	Missouri R. upstream of Fort Peck Dam	All paddlefish anglers must **tag or release** a paddlefish immediately upstream of Fort Peck Dam. Once both tags are validated, anglers may not snag for paddlefish. Open entire year.
	1 total, tag required	Missouri R. below Fort Peck Dam and Yellowstone R.	On the Yellowstone River downstream of Cottonwood Creek and Missouri River downstream of Fort Peck Dam once a harvest tag is validated, anglers may not snag for paddlefish.
2002-2003	1 total, tag required	Missouri R. below Fort Peck Dam and Yellowstone R.	In-season closure with 48-hour notice to keep annual harvest below 1,000 fish.
2004-2006	2 total, white tags required	Missouri R. upstream of Fort Peck Dam	White tag(s) required for Missouri River above Fort Peck Dam. All paddlefish anglers must **tag or release** a paddlefish immediately upstream of Fort Peck Dam. Once the tag is validated, anglers may not snag for paddlefish. Open entire year.
	1 total, yellow tag required	Missouri R. below Fort Peck Dam and Yellowstone R.	Downstream of Fort Peck Dam open entire year or until closed by FWP. Yellow tag required for the Yellowstone River or Missouri River downstream from Fort Peck Dam. Standardize season dates - for the Yellowstone R. only open to the snagging of paddlefish May 15- June 30 from Bighorn River to North Dakota line.
2007	1 per year, anglers may purchase only one tag (white, blue or yellow).	Missouri R. upstream of Fort Peck Dam	Open entire year. White tag required upstream from Fort Peck Dam to Fort Benton. Catch-and Release Days on Sundays, Mondays and Thursdays; Harvest Days on Tuesdays, Wednesdays, Fridays, and Saturdays; angling allowed from 6am to 9pm daily

YEAR	DAILY AND POSSESSION	WATERBODY	REGULATION CHANGE
			(elimination of night fishing). Any paddlefish caught must be landed and **tagged** immediately on Harvest Days.
		Fort Peck Dredge Cuts	Open July 15 – August 31. Blue tag required for Fort Peck Dredge Cuts (west of Park Grove Bridge and Nelson Dredge) on the lower Missouri River.
		Missouri R. below Fort Peck Dam and Yellowstone R.	Yellow tag required for the Yellowstone R. and Missouri R. downstream of Fort Peck Dam. For the Yellowstone R. downstream from the mouth of the Bighorn R. including Intake FAS and downstream from Fort Peck Dam open to the snagging of paddlefish May 15- June 30 from 6am to 9pm daily. From Intake Diversion Dam to ¼ mile downstream closed May 15-June 30 to fishing or snagging from boats. Catch-and Release Days on Sundays, Mondays and Thursdays. Harvest Days on Tuesdays, Wednesdays, Fridays, and Saturdays. Any paddlefish caught must be landed and **tagged** immediately on Harvest Days. In season closure with 24-hour notice if the annual harvest reaches 800 fish processed at Intake in order to keep harvest under the 1,000 fish target. Catch- and Release can continue the remaining designated Catch-and-Release days in all areas until June 30. All snag areas: Gaffs, no longer than 1 ½ yard (4.5 ft) in length may be used to land Paddlefish while harvest fishing.
2008	1 per year, anglers may purchase only one tag (white, blue or yellow).	Missouri R. upstream of Fort Peck Dam	Open May 1 – June 15. All paddlefish anglers must **tag or release** a paddlefish immediately. Harvest allowed daily provided an open tag is possessed and catch-and-release

YEAR	DAILY AND POSSESSION	WATERBODY	REGULATION CHANGE
			allowed daily provided proof of tag purchase. Harvest target of 500 fish with 24-hour public notice.
		Fort Peck Dredge Cuts	Open July 1 – August 31.
		Missouri R. below Fort Peck Dam and Yellowstone R.	Open May 15 -June 30. Catch-and Release Days on Sundays, Mondays and Thursdays only at Intake FAS; closed these days in other yellow tag areas. After in season harvest closure catch- and release can continue for 10 consecutive days or through June 30th whichever comes first. All snag areas: Hook size limited to 8/0 or smaller for paddlefish snagging. Any paddlefish **tagged** for harvest must be removed from the water by end of day (9pm, MST).
2009	1 per year, anglers may purchase only one tag (white, blue or yellow).	Missouri R. below Fort Peck Dam and Yellowstone R.	In season closure with 24-hour notice to keep annual harvest under 1,000 fish.
2010-2015			(no changes, regulations consistent over this period)
2016	1 per year, anglers may purchase only one tag (white, blue or yellow).	Missouri R. upstream of Fort Peck Dam	Paddlefish harvest only tags available via lottery draw, application deadline April 1. Harvest target of 500 fish. All snag areas: Mandatory 48-hour reporting initiated for all areas. Reporting options include on-site by angler creel or fish cleaning station, phone hotline (877-397-9453 or 406-444-0356), or online (http://fwp.mt.gov).
2017	1 per year, anglers may purchase only one tag (white, blue or yellow).	Missouri R. below Fort Peck Dam & Yellowstone R.	From the Intake Diversion Dam to ¼ mile downstream closed to fishing, snagging, or **landing** paddlefish from boats/vessels during the open

YEAR	DAILY AND POSSESSION	WATERBODY	REGULATION CHANGE
			paddlefish season (May 15-June 30, may end earlier as posted on site). All snag areas: Mandatory 48-hour reporting call numbers changed to (844-668-5932) or (406-444-5604).
2018	1 per year, anglers may purchase only one tag (white, blue or yellow).	Missouri R. below Fort Peck Dam & Yellowstone R.	In season closure language changed to: *FWP will announce closure of the harvest season with a 24-hour notice to prevent exceeding the harvest target and immediately at the Intake FAS and downstream of Cottonwood Creek, when it is estimated that the target will be reached.* All snag areas: Additional option to fulfill mandatory 48-hour reporting requirement through MyFWP on the state's webpage.
2019			(no changes, regulations consistent over this period)

Table A1-2. Summary of North Dakota paddlefish snagging season regulations for Yellowstone-Sakakawea stock, 1976-2019.

YEAR	SEASON DATES	LIMIT			Snagging Hours/Day
		DAILY	POSSESSION	SEASON	
1976 – 1977	May – mid November	2	2		24
1978	May – mid September	2	2		24
1979	May – mid September		2	2	24
1980	May – mid November		2	2	24
1981 – 1984	May – July		1	2	24
1985 – 1991	May – July 1		1	1	24
1992 – 1993	May – June 30, July 1			2	24
1994 – 1995	May 1 – June 15			2	24
1996 – 1997	May 1 – June 15			1	24
1998 – 2000	May 1 – June 15			2	24
2001	May 1 – June 15			1	24
2002 – 2003	May 1 – May 31			1	16.5
2004 – 2013	May 1 – May 31			1	14
2014 - 2017	May 1 – May 31			1	13
2018 – 2020	May 1 – May 21			1	12

Figure A1-1. Fishing at Intake a) ca. 1910 and b) nearly a century later (ca. 2000).

Figure A1-2. Paddlefish and sturgeon catch near Glendive, Montana, ca. 1910.

North Dakota - Occasional early references to paddlefish exist in North Dakota, including early photographs of 16 fish caught at Buford in 1916 (Scarnecchia et al. 1995a), a short article and photograph about a fish caught at Cannonball in 1939 (North Dakota Game and Fish 1939), and a summary of the biology by Carufel (1954). As of the closing of Lake Sakakawea, the lack of much evidence of the presence of this species indicates that it was not especially abundant. Most fish at that time were caught with nets, traps, seines, setlines, and unbaited hooks. Snagging was illegal (Carufel 1954). Commercial fishing records for paddlefish exist from 1953 to 1981, the last year of commercial harvest. Catch was nominal until 1961, when 779 fish weighing 2,733 kg were harvested. This catch is consistent with the timing of the beginning of the Intake fishery. Total harvest over the period 1953-1981 was 47,355 kg (104,399 lb.). The three highest catch years were 1974 (11,586 kg; 25,543 lb.), 1972 (6,925 kg; 15,267 lb.), and 1966 (4,888 kg; 10,775 lb.). Prices obtained for the fish over the period 1975-1978 ranged from 40-48 cents/kg (18 to 22 cents/lb.; NDGF, Unpublished data).

North Dakota's first paddlefish snagging season was in 1976 and was of minor significance for the next decade. In 1976, bag limits were two paddlefish per day and two in possession, with no annual limit (Van Eeckhout 1978). Annual limits were set at 2 fish in 1978 (Table 4), but there was evidently no mechanism for its enforcement. High-grading snagged paddlefish has always been illegal in North Dakota (Van Eeckhout 1980; Table 4). Open areas included the Missouri River west of Highway 85 to the Montana border, and that portion of the Yellowstone River within North Dakota (Van Eeckhout 1978). Catches were not clearly documented, but Van Eeckhout (1978) reported that catches in 1977, a low flow year, greatly exceeded catches in the higher flow year of 1976.

Paddlefish investigations began on Lake Sakakawea in 1976 (Van Eeckhout 1980). Information was obtained on harvest, non-harvest fishing mortality, and population structure.

Period 2 (1978-1989) - This period was characterized by an increasing size of the recruited stock in the early years, a stable stock in the later years, and a progressively higher fraction of female fish among the recruits and the harvest (Scarnecchia et al. 1996b).

Montana - In 1978, the daily limit was reduced to one fish and a possession limit of two. This change was enacted mainly for social reasons, to relieve increasing crowding along the Intake shoreline (Elser 1979). Following the 1979 season, Elser (1980) summarized statistics from 1964 to 1979, noted a 14.7% rate of harvest on jaw tagged fish, and concluded that further increases in fishing pressure and harvest should not continue. To gain tighter control on harvest, a proposal was made to the Montana Legislature in 1979 (HB 173) to require a paddlefish tag "similar to a deer tag" (Elser 1980; Paddlefish Workshop 1979, p.1). The proposal did not win approval.

In the 1980 paddlefish season, increased interest in caviar by out-of-state processors made it clear that more controlled harvest regulations for paddlefish were necessary. As summarized by Elser (1981), a representative of American Caviar, Inc. of Chattanooga, Tennessee contacted MFWP in the fall of 1979 offering various services at Intake in 1980, including free fish cleaning and wrapping of fish for the angler, fish offal removal and a contracted snack and tackle concession. The program was ostensibly designed to use paddlefish "oils" on the offal for beneficial use, but in mid-season it became apparent that the target product was caviar. The Iranian hostage crisis had reduced international supply and driven up domestic prices. Information collected that year indicated that females made up more than 80% of documented fish cleaned, as the concessionaire selectively cleaned females. Based on an interpretation of the state statutes regarding sale and transport of game fish or parts thereof, the agreement with American Caviar was terminated.

A second problem that became acute in 1980 was high grading (releasing small fish creeled but later discarded after a larger fish was caught). In their enthusiasm to creel a large fish, anglers would tie up a small fish and continue to fish for a larger one. The interest in caviar promoted by the fish cleaners exacerbated the problem. Many anglers were practicing delayed high-grading, resulting in many paddlefish being released in poor condition and washing up on the riverbank soon afterward. Enforcement efforts were inadequate, and considerable illegal fishing occurred (Elser 1983). In response to concerns about over-harvest associated with the sale of paddlefish eggs for caviar, the state of Montana was closed to paddlefish snagging from June 16 to July 19, 1980 (Needham 1980b). Elser (1981) reiterated that more rigorous regulation of the fishery was needed, and in the off season, contacted several states for additional information. He suggested that retention of all snagged fish be required and counted toward the daily limit. He also noted that a second request to the Montana Legislature would be made for a paddlefish tag system.

A major change in paddlefish regulations for the Yellowstone River came in 1981 with the institution of a two-fish annual limit, an angler tag system, and the prohibition of catch-and-release. Anglers were required to have locking, numbered paddlefish tags (issued free-of-charge), with the tag number recorded on their fishing licenses. These regulation changes were enacted not for biological reasons but in response to what were perceived by the public and MFWP as social issues (Elser 1981). In addition to better control over the harvest, the changes resulted in reduced crowding in the most popular fishing area, immediately downstream of the Intake Diversion Dam. No longer could an individual or fishing party occupy prime snagging spots day after day to the exclusion of other snaggers. High grading of any kind was strictly illegal (Table A1.1).

In 1982 the Yellowstone River season was changed from previously being open all year to a season from May 1 through the second Sunday in July. This season corresponded with the seasonal availability of paddlefish and did not significantly impact the fishery. Angler tags, which had been issued free in 1981, cost $3.00 (for two tags) in 1982. The new regulations, including the tagging system and mandatory retention, gained in angler acceptance (Elser 1983).

By the 1983 season, the sex ratio of the harvest at Intake was 83% female, even with mandatory retention requirements (Stewart 1984). The high percentage of females was a natural result of the female fish from the reservoir filling period (1954-1966), and consequent trophic upsurge, finally recruiting to the fishery, and a decrease in recruitment of young males resulting from the later period of trophic depression (Scarnecchia et al. 2007; 2009; 2014). This pattern of mostly females in the catch would persist into the early 1990s. Following the 1984 season, Stewart (1985) expressed concern that the harvest at Intake had increased substantially after the initiation of mandatory retention. Harvest over the period 1972-1979, before mandatory retention, had ranged from 1,410 to 2,887 fish, whereas harvest from 1981 to 1984, after mandatory retention, had ranged from 3,193 to 5,318 fish. He recommended a review of the harvest regulations. In the next five years, however, lower Yellowstone River flows during the spawning season (and a somewhat lower stock size; Scarnecchia et al. 1996b) resulted in lower catches at Intake; harvest from 1985 to 1989 never reached 3,000 fish, ranging from 550 to 2,923 fish (Stewart 1990). As a result, major changes in regulations were not pursued (Stewart, 1986; 1987; 1988; 1989; 1990); only minor regulation changes were enacted. In 1986, the Yellowstone season was changed to May 1 to July 10 downstream of Cottonwood Creek and May 15 to July 10 upstream of the mouth of Cottonwood Creek (i.e., from 8 km downstream of Intake upriver to the Dam and beyond). The later opening date upstream accommodated early season sauger and walleye anglers fishing in boats near the Intake Diversion Dam. The impact on the paddlefish fishery was modest; paddlefish are not typically plentiful immediately below the Intake Dam before May 15 or after June 30 (Table A1.1).

North Dakota - Harvest regulations in North Dakota were one paddlefish per day and two in possession, with no high-grading permitted. Although annual limits were set at 2 fish (1977-1984) and 1 fish (1985-1989), there was evidently no specific mechanism (such as a tagging system) for enforcing this annual limit. Little information on harvest or the effects of the regulation were collected in the 1980s (Ryckman 1995; Table A1-2).

Period 3 (1990-1995) - This period was characterized by the beginning of the non-profit caviar programs in both states, the initiation of highly intensive stock monitoring in both states, a declining stock size (from natural and fishing mortality, trophic depression and reduced spawning success), a further tightening of harvest regulations, and the beginning of a monitored catch-and-release fishery in Montana.

Montana - In 1989, the Montana Legislature passed House Bill 289, which permitted one non-profit corporation to collect, process and market paddlefish roe. The legislation was promoted and shaped by the Glendive Chamber of Commerce and Agriculture, with the intent of utilizing the roe theretofore largely discarded as offal. The Chamber has been (as of 2020) the sole non-profit corporation involved in the program. Under the program, the Chamber provides free cleaning of all male and female paddlefish at the Intake Fishing Access Site for a donation of the roe of the fish, if present. The roe is processed into caviar on-site. Net proceeds go to the Chamber (who provides regional community improvement grants of diverse kinds), and a lesser portion to MFWP (initially 50% of net income, then 40% (1994-2002); most recently 30 % (2003-2019)) for paddlefish research, monitoring, and management activities.

The development of the roe donation program allowed biologists to sample a high fraction of the total paddlefish harvest from Intake and off-site areas annually, resulting in a comprehensive database on the Yellowstone-Sakakawea stock. From the start of the roe donation program, research, monitoring, and management became more intensive. As the fishery and caviar program were inevitably advertised and promoted, intensive management also became a more critical need.

In 1990, low flows (and resulting declines in license sales) during the May 15-June 30 paddlefish season led to the Legislature extending the season (on a one-time basis) until July 10. The impact of this change was minimal; no paddlefish were caught at Intake after July 5 (Stewart 1991b).

From 1991 through 1993, regulations remained unchanged, with a 2 fish per person annual limit and a May 15-June 30 season (Stewart 1992; 1993; 1994). High spring discharges in 1991 resulted in an estimated total harvest of 4,203 fish, low discharges in 1992 resulted in 762 fish harvested and intermediate discharges in 1993 resulted in 1,635 fish harvested. By the end of the 1993 season, however, several factors indicated paddlefish harvest regulations should be tightened. The high catches in 1991 (4,203 fish) indicated that in high flow years, the two fish limit was not adequate to control harvest. Analyses of age structure (based on dentaries; Scarnecchia et al. 1996b) indicated that the ages of the harvested fish were greater than expected and greater than other paddlefish stocks nationwide (Russell 1986). Mean age of the stock had increased steadily since the mid-1970s, and a high percentage of fish harvested was large, older females. Success rate at Intake had dropped from the previous decade, and harvest rates of tagged fish had increased. Recruitment of young fish into the harvestable population was low. The harvestable portion of the stock was declining in numbers and aging. In 1994, these concerns resulted in the lowering of the annual bag limit from two fish to one fish per angler (Table A1-1).

In 1995, a year after the reduction in the bag limit, mandatory catch-and-release fishing was permitted at the Intake site only, for two periods per week (Wednesday and Sunday, 3-9 PM) during the May 15-June 30 paddlefish season (Stewart 1996). The catch-and-release fishery was designed to provide more fishing opportunity for all, while enabling those anglers not wishing to harvest a fish to participate in snagging. An evaluation of catch-and-release (Scarnecchia and Stewart 1997) indicated that both short-term and long-term survival of snagged fish would be high if fish were handled carefully and released immediately. The fishery was to be closely monitored on-site by MFWP personnel. All fish were to be immediately jaw-tagged before release. Paddlefish were present at Intake through most of the season and the catch-and release fishery was well-received (Stewart 1996). During this period, detailed surveys assessing angler values, attitudes and preferences were conducted at Intake (Scarnecchia et al. 1996a; Scarnecchia et al. 1997b) in an attempt to provide fishing regulations consistent with angler interests.

Evidence of a declining stock and an increase in the fishery in North Dakota, however, led to discussions of the need for an annual harvest cap.

North Dakota - In 1992, NDGF instituted a series of new harvest management measures similar to those in Montana. The bag limit was reduced from one fish per day and two in possession to an annual limit of two fish per angler. A tagging system was established requiring harvested fish to be tagged immediately. Tags were free in 1992 and 1993 but cost $3.00 per tag in 1994 (Table A1-2).

North Dakota's tightened management regulations preceded the development in 1993 of a caviar program similar to that initiated three years earlier in Montana. In North Dakota's program, a joint venture called Goldstar Caviar (later renamed Northstar Caviar) was developed between the Williston Chamber of Commerce and the Friends of Fort Union, two non-profit groups. Goldstar offered free cleaning of the fish for a roe donation, with the net proceeds split between the two non-profit groups and utilized for grants, with 25% of net proceeds returning to NDGF. The fish cleaning and roe donation station, located at the Confluence, became the most important source of stock assessment information in North Dakota. The expanding fishery in North Dakota and the initiation and inevitable promotion of a caviar program in 1993 also raised concerns about over-harvest and the need for an annual harvest cap.

Period 4 (1996- 2020) - The fishery for Yellowstone-Sakakawea fish during this most recent period is described in annual reports of MFWP (Stewart 1996, 1997, Riggs 2000, 2001, 2002, 2003 2004, 2005, 2006, 2007, 2008; Riggs and Bollman 2009; Abrahamse 2010a, 2010b; Bollman 2011, 2012, 2013, 2014, 2015, 2016, 2017) and in the annual statewide regulation booklets (e.g., Montana Fish, Wildlife and Parks 2018). Overall, changes in regulations Period 4 (1996 to 2020) since the implementation of the first MT-ND Paddlefish Management Plan have been minor. Compared to the previous three periods, only few refinements were made reflecting successful implementation of cooperative bi-state stock assessment and more biologically sustainable management regulations by MFWP and NDGF. The period has been characterized by the implementation of an equitable annual harvest cap in each state and a response by snaggers of shifting their fishing effort earlier in the season (to insure a successful harvest of a fish). As counter-measures, managers have enacted several regulations designed to attenuate harvest and thereby avoid extremely short harvest seasons. Regulation changes have included prohibition of night snagging and increased opportunities for catch-and-release snagging (Table A1-1). Through the two-decade period, managers in both states have also become more attuned to the importance of successful recruitment and the need to monitor it in order to set sustainable harvest regulations.

Harvest cap - Prior to 1996, there was no harvest cap for the Yellowstone-Sakakawea stock. In 1996, the cap was set at 1,500 fish per state under the previous Plan (Scarnecchia et al. 1995b). The rationale for the cap of 1,500 fish per state was not identified explicitly in the Plan, nor based on a harvest model, which was unavailable at that time. It was based on general historical harvest rates and concerns about the stock's age structure, which was older than previously thought (Scarnecchia et al. 1996a). The limit on harvest has been referred to as a harvest cap rather than quota because it was conceived as not necessarily a target to be met, but a maximum acceptable annual harvest. The cap of 1,500 fish per state remained in place through the 2002 season (with several resulting in-season closures). Over the period 1999-2002, NDGF interpreted the harvest cap of 1,500 for North Dakota as a three-year average cap. Beginning in 2003, the harvest cap was set at 1,000 fish per state and considered by both MFWP and NDGF as strictly an annual cap. As of 2020, the harvest cap for the Yellowstone-Sakakawea stock has remained at 1,000 per fish per state. The rationale for a harvest cap was developed through a straightforward analysis of population estimates, catches, and age structure. The harvest cap was set so that harvest and natural mortality of recruited fish will not exceed, in a given 5-year period, the estimated 5-year average recruitment of fish entering the harvestable stock (Riggs and Bollman 2009).

Although both states have the same harvest cap, they do not necessarily have similar harvests or harvest patterns in a given year. Years of high flow in May tend to favor higher success rates and catches in Montana whereas low flows in May tend to favor higher success rates and catches in North Dakota. Considerable harvest typically occurs immediately from the Confluence downriver on opening day in North Dakota, whereas years of low May discharge in the Yellowstone River, few fish may be harvested at Intake until late May or early June.

Overall, the harvest cap has been effectively adhered to in both states, with occasional exceptions during the early implementation period. Under the 1,000 fish cap in each state, harvest in North Dakota and Montana from 2003 to 2019 has remained close to the cap (Plan, Figures 26; 31). As described below for each state, improved ability to close fisheries in a timely manner has made adherence to the cap more effective. With discharge-driven fisheries, along with mandatory retention, stock assessment data collected has also remained largely compatible with that from years without in-season closure, as far as is known.

Two foreseen outcomes of harvest caps have been early (i.e., in-season) harvest closures and a “race to harvest” by anglers, i.e., to harvest their fish before closure. Since its implementation, the 1,000 fish harvest cap in each state has resulted in anglers fishing earlier and more intensively during the season, and progressively shorter, more intense seasons have resulted in both states. The prospect of in-season closure and the race to fish has frequently created crowding problems at the best fishing sites in both states (Figure A1-3 a, b). In 2007, the North Dakota season had only 7.5 harvest days and the Montana fishery only 3.5 harvest days. In 2017, both state seasons were 4 days or less (Figures A1-4; A1-5). In 2018 and 2019, the numbers of harvest days were 15 and 11 in Montana and 12 and 7 in North Dakota. During this period, both states have attempted to deal with the outcomes of the harvest cap approach in a similar manner.

Montana

In-season harvest closures - In this period (1996-2020) MFWP implemented provisions for early in-season closures. No limit was set on the number of tags sold, but catches were

a) b)

Figure A1-3. Crowding associated with the race to fish a) at the Confluence and b) at the Intake site.

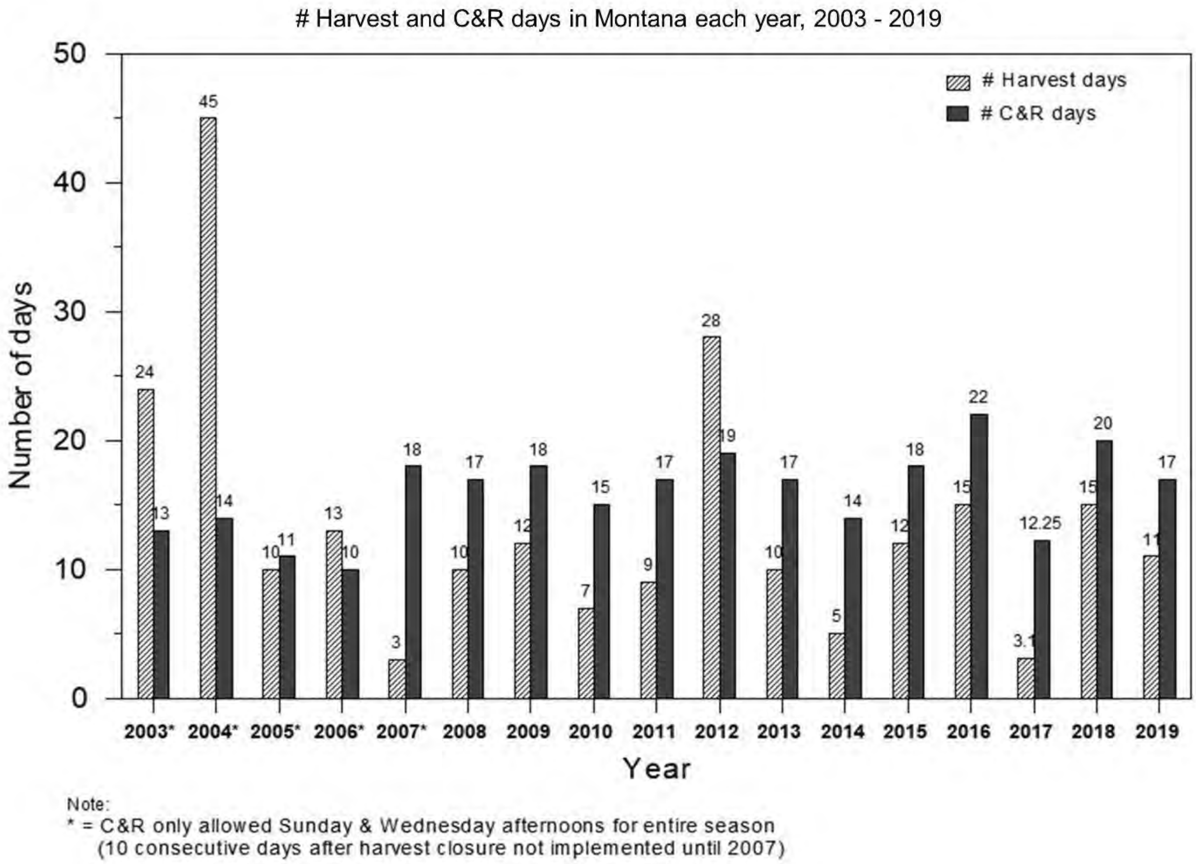


Figure A1-4. Total number of days open to harvest and catch-and-release in Montana, 2003-2019.

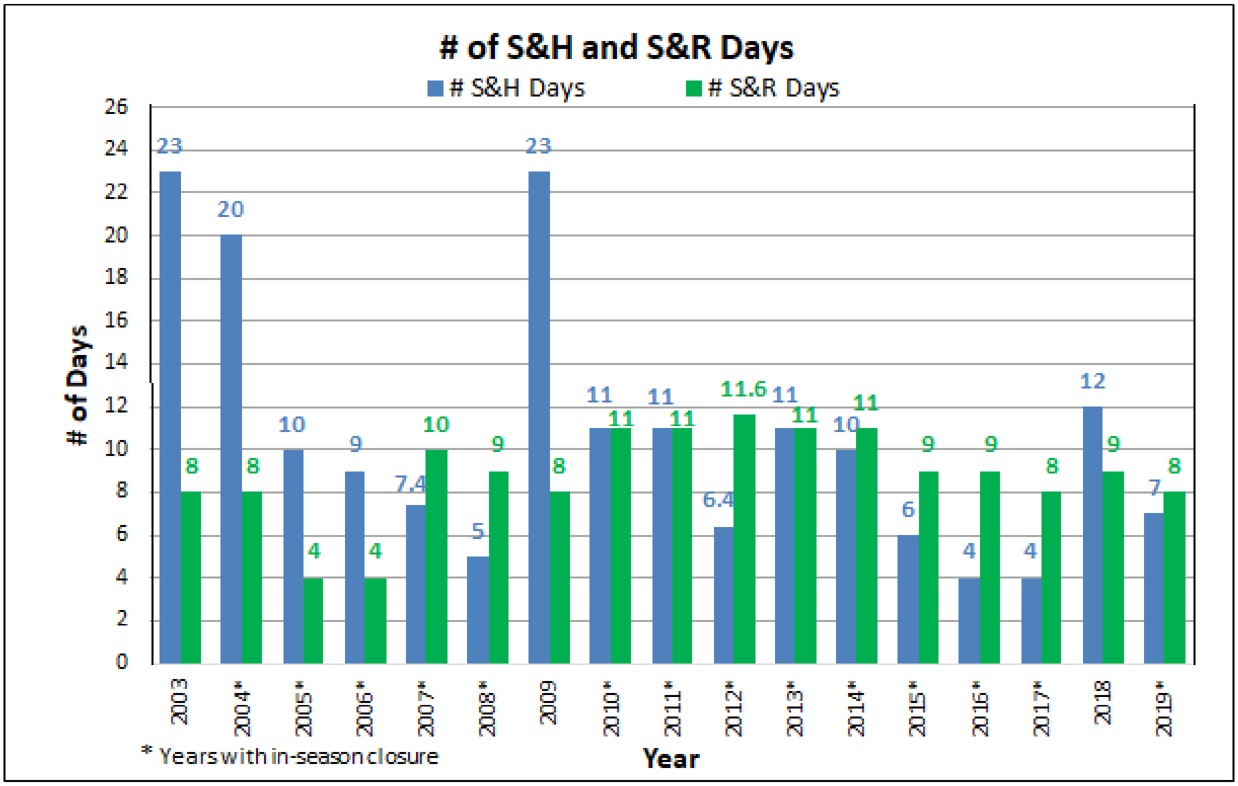


Figure A1-5. Total number of days open to snag and harvest (S&H) and snag-and-release (S&R) in North Dakota, 2003-2019.

monitored in-season, and closures implemented to coincide with the projected attainment of the harvest cap. Effective use required an accurate in-season harvest estimate, which was obtained primarily by tallying catches brought into the fish cleaning/caviar stations. Total harvest, including off-site harvest not brought into cleaning station has been estimated from a phone creel survey since 2003 (Bollman 2016). Since 2016, Montana has required that anglers report their paddlefish harvest to the agency within 48 hours. Off-site harvest in Montana has typically been higher because of the more dispersed fishery, although off-site harvest may also be low in years of high concentrations of fish at Intake. Harvest by Fort Peck tribal fisheries has not been well documented, but is typically low (<100 fish), except in years such as 2005 and 2018 when higher spring discharges in the Missouri River than Yellowstone River increase migration up the Missouri.

The 48-hour mandatory reporting system instituted in 2016 was designed to obtain more reliable harvest and life history information on the off-site harvest, i.e., fish not voluntarily brought into the fish cleaning station at Intake. Fish brought to the Intake site are automatically checked in. As of 2020, anglers reporting a harvested paddlefish are required to provide the following information: angler tag number, jaw tag number (if present), body length (front of eye to fork of caudal fin; Ruelle and Hudson 1977), sex, date of harvest, and harvest location. Instructions are provided to assist anglers in forwarding accurate information. This reporting system was improved in 2017 and 2018, but the strict requirement of reporting before a future tag is issued has yet to be enforced.

In the initial years of the 1,000 fish cap, the inability to close the fishery rapidly enough in Montana resulted in some harvest above the cap. For example, in 2005 and 2006, large numbers of young male paddlefish at Intake lead to high catch days and 1,051 and 1,194 fish were observed to be harvested from the stock (Riggs 2006, 2007); actual harvest was higher. Starting in 2008, closure became possible within 24 hours when the harvest cap was anticipated to be met, and immediate closure was possible at the Intake Fishing Access Site (FAS), from the Dam downriver to the mouth of Cottonwood Creek. This greater responsiveness has allowed managers to adhere to the harvest cap.

Over the period 1996-2020 MFWP instituted several regulations designed to lengthen the harvest season (i.e., counter the race to harvest) and spread the available fish out among more anglers, including elimination of night fishing, a strict statewide limit on one fish per person per year, and increases in catch-and release fishing.

Elimination of night fishing - Through the 2006 season, fishing for paddlefish in Montana had previously always been permitted 24 hours per day during the legal fishing season. In 2007, fishing was restricted to daylight hours of 6 AM to 9 PM (Table A1-1). Prohibition of night fishing was also implemented to reduce night-time snagging violations (e.g., illegal snagging, high-grading, tag switching) and improve the accuracy of harvest estimates.

Statewide harvest limit - Montana’s bag limit for the Yellowstone-Sakakawea stock fishery has remained at one fish per person per year since 1994. An additional adjustment in

2007 was the limitation of harvest to only one fish per person per year statewide. Anglers could then choose to purchase a white tag (Yellowstone-Sakakawea stock excluding Dredge Cuts), a yellow tag (Fort Peck stock) or a blue tag (Dredge Cuts archery fishery), but only one of the three. This regulation was designed to spread out potential harvest among more anglers.

Catch-and-release - Catch-and-release opportunities (Wednesday and Sunday 3-9 PM during the harvest season) remained the same over the period 1995-2006. After closure of the harvest fishery, catch-and-release was allowed until June 30 at the Intake Site. In 2007, in response to rapid attainment of the harvest cap in 2006, and to lengthen the harvest season, three full days (6AM to 9 PM) of mandatory catch-and-release were implemented (Sunday, Monday and Thursday). Following harvest closure, catch-and-release was permitted for three days per week through June 30, not restricted to the Intake Fishing Access Site (FAS). In 2009, this catch-and-release fishery was restricted to the Intake FAS. Starting in 2008, catch-and-release was allowed for 10 consecutive days after closure of harvest, or until June 30, whichever came first. These catch-and release fisheries have been closely monitored at the Intake Site, and captured fish were jaw tagged for recovery in future fisheries.

Catch-and-release snagging at Intake has maintained popularity among a loyal minority of snaggers. Anglers have responded positively to increased catch-and-release opportunities since 2007 (Figure 28). An estimated 27% of total paddlefish anglers participated in angling in 2016 and landed 4,317 paddlefish (2.2 fish per angler) in 1,955 catch-and-release angler days (Bollman 2016). Observations indicate that the amount of catch-and-release angling and number of anglers are both strongly positively related to the numbers of fish available at Intake, which is in turn a function of the water levels. Catch-and-release snagging effort and catch were higher in 2013, 2014, and 2015, years of higher water and more availability of fish, than in 2012, a lower water year with fewer fish available at Intake (Figure 29; Bollman 2016).

MFWP has not yet succeeded in lengthening the paddlefish season (Figure A1-4; Bollman 2016). Evidently, efforts to slow fishing with regulation changes have been compensated for by improved capability of anglers to anticipate the locations of fish. Anglers have become more sophisticated at meeting the challenge of a race to fishing, of interpreting the effects of flows on fish availability, in finding fish with improved fish-finding technology, and in communicating their finding to other anglers.

Other regulation changes and management actions - In 2008, MFWP took some additional steps to fine-tune aspects of the fishery. Snag hook size was limited to 8/0 and smaller, a restriction designed to minimize the potential impact of catch-and-release snagging, particularly on the many smaller males that were being caught from the 1995-year class at that time. MFWP also required, as a wastage-prevention measure, that tagged fish must be removed from the river by the end of the fishing day (9 PM MST). In 2017, anglers were no longer permitted to "land" shore-caught paddlefish at the Intake site with the aid of a boat. These regulations have remained in place; other regulations from 2009 to 2016 remained nearly uniform (Table A1-1). Since 2003, the phone creel census designed to estimate total harvest has also been used to obtain a wide variety of angler information. The 2016 creel census, for example, included 11 questions about angler harvest, angler effort, use of gaffs, use of free cleaning services at Intake, and participation in catch-and-release fishing (Bollman 2016).

North Dakota

North Dakota's paddlefish fisheries in this period are described in NDGF Missouri River reports (Fryda et al. 2010, 2014) and in the biennial fishing proclamations (e.g., North Dakota Game and Fish Department 2016; Table A1-2). North Dakota harvest regulations are promulgated at 2-year (even-year) intervals. As in Montana, North Dakota's regulations have become somewhat more restrictive over the period 1996-2020 to ensure that the harvest cap was not being exceeded and to attenuate the fishing season to counteract the "race to fish" response of anglers (Table A1-2). As in Montana, NDGF has had success with avoiding exceeding the cap, but less success in lengthening the harvest season (Figure A1-5).

Under the 1,500 fish harvest cap, the annual bag limit per snagger was reduced to one fish in 1996 and 1997 but was raised to two fish in 1998 through 2000. Since 2001, the annual bag limit has been one fish (Table A1-2). Beginning in 2002, the fishery was reduced from 6 weeks (May 1-June 15) to one month (May 1 through May 31; Table 4). Catches in June in North Dakota are typically low, as most pre-spawning fish typically exit the state upriver by June and angler interest wanes, so the impact of this change was minimal. In 2018, the season length was further shortened to 21 days. Although the harvest cap was not met in 2018 under this shorter season, past records indicate that in nearly all years, the harvest cap is likely to be met by May 21.

Under a 1,000-fish harvest cap and a one fish per angler per year bag limit, harvest in North Dakota is typically strong on the first day of the season, as fish are already staging at various location between the Pumphouse and Confluence (and sometimes into the Yellowstone during high-flow years). The predictable race to harvest ensued and the number of anglers fishing per harvest day more than doubled from 2003 to 2006, which resulted in increased crowding and placed additional pressure on facilities at fishing sites (L.F. Ryckman, Memo to G. J. Power, October 11, 2006). In subsequent years, harvest effort has continued to become more concentrated during the first week of May, and the number of harvest days has decreased from 23 days in 2003 to 20 days in 2004 to 10 days in 2005 to 9 days in 2006 to 8 eight days in 2007. In 2017, the harvest season was only four days (Figure 32). Regulation changes during this period have consequently been designed to attenuate fishing effort (Table A1-2).

Throughout the period 2006-2019, season and harvest regulations have, consistent with the intent of the Plan, paralleled those of Montana. As of 2020, paddlefishing remains legal from the Highway 85 Bridge near Williston west to the State line, except for the portion of the river between the Pipeline Crossing (Rkm 2537) to the upper end of the Lewis and Clark Wildlife Management Area (Rkm 2518). It is also legal throughout the Yellowstone River in North Dakota. Season duration was the month of May through 2017; in 2018, the season was shortened to May1-May 21. The length of the harvest day has also been nearly constant.

Elimination of night fishing - In 2002, night fishing was eliminated. The change reduced daily harvest and reduced the opportunity for unobserved violations such as high-grading and tag switching, which enforcement reported were more prevalent at night. In 2002 and 2003, harvest was allowed from 5:30 AM to 10 PM Central Time. Over the period 2004-2013, fishing hours were reduced to 8 AM-10 PM CDT and again from 2014 through 2017, to 8 AM-9 PM CDT. In 2018, the fishery hours were shifted to 7 AM-8 PM in the interest of public safety, to avoid crowding and traffic congestion at the Confluence fish cleaning site during darkness.

In-season harvest closures - As the harvest cap is approached, NDGF may institute early season closure of the harvest. The advance period required for notice of harvest closure has decreased as managers have needed greater ability to accurately close harvest for conservation needs. For the 1996-2007 period, 60-hour notice of closure was required, for 2008-2013, 36-hour notice, and for 2014-2018, 24-hour notice. The greater responsiveness has been needed as harvest seasons have often been intense, typically lasting 5-10 days. The responsiveness has been successful in matching harvest to the allowable cap.

Catch-and-release - Concurrently with the need to institute in-season closures, NDGF has attempted to provide some controlled catch-and-release fishing opportunities. During the harvest seasons of 2006 through 2012, Mondays and Tuesdays were designated as strictly catch-and-release days (at all legal snagging sites). For 2012 through 2018, the number of catch-and-release days was increased to three (Sunday, Monday, Thursday), consistent with regulations in Montana. Post-harvest season catch-and-release has developed but has become more restricted in area and time. For 2006-2008, seven days of catch-and-release fishing were allowed following closure at all sites. For 2008 through 2013, catch-and-release seven days after harvest closure (not to exceed May 31) was limited to an area immediately adjacent to the Confluence. For 2014-2018, the post-harvest catch-and-release was limited to the same limited area, but for only four days. In 2020, with no harvest season, seven days of catch-and-release fishing were provided. Unlike catch-and-release in Montana, North Dakota anglers previously harvesting a fish that year may not participate in catch-and-release snagging. This limitation combined with the generally lower availability of fish has made catch-and-release in North Dakota less popular overall than catch-and-release angling at Intake. It is still considered, however, an important aspect of NDGF’s mission of providing fishing opportunity for snaggers not intending to harvest a paddlefish.

Other components of the fishery for the Yellowstone-Sakakawea stock that are not sampled at the cleaning stations include tribal and non-tribal snag fisheries and the archery fishery in the Dredge Cuts.

Non-tribal snag fisheries in Missouri River (Montana) - The snag and archery fisheries in the Missouri River below Fort Peck were historically open year-round until 2006. Through the 1980s, there was a daily limit of one fish, a possession limit of two, and no annual limit for individual anglers or archers. Beginning in 1992, several important regulations for paddlefish below Fort Peck Dam were implemented that were consistent with Yellowstone River regulations, including the annual bag limit and the tagging system. From 1996 to 2006, however, the non-tribal snag and archery fisheries below Fort Peck Dam remained open all year unless closed in response to the harvest cap being met. More recently (2007-2020), this stretch of the Missouri River has been managed consistently for snagging under the same season closures and harvest cap applied to the Yellowstone River for the Yellowstone-Sakakawea stock.

Dredge Cuts Archery Fishery - The archery fishery in the Dredge Cuts has always been a small fishery occurring primarily in summer, after the snag fisheries in other areas of the river. Clear, calmer water during this period favors success. Over the period 2007-2011, the archery fishery was open from July 1 to August 31. Over the period 2012-2020, the season was set from July 1 to August 31. The annual limit is one fish per person. Archers must purchase a special blue tag and cannot have bought a tag for fishing below Fort Peck or in the Yellowstone River (yellow tag) or above Fort Peck (white tag) to be eligible for the archery fishery (Table A1-1).

Tribal fishery - The Tribal fishery harvest has historically been of minor significance. The fishery at Frazer Rapids was known to Needham and Gilge (1989) as perhaps worth monitoring for catches in some years. The fishery is more significant in years of low Yellowstone River flows relative to those in the Missouri River, when more fish are lured up the Missouri River (Firehammer 2004). In those years, Yellowstone River catches at Intake and below may remain low and catches at Wolf Point and Frazer Rapids may be higher. Such was the case in 2004, when the harvest on tribal lands was roughly estimated to be at least 100 fish (D. Scarnecchia, Letter to B. Wiedenheft, June 7, 2004).

As of 2020, tribal harvest is open year-round to tribal members and no limits are established. Non-Tribal harvest on tribal lands is open from May 15 to June 15 with an annual limit of one fish per person. A paddlefish stamp must be purchased along with a Tribal General Fishing Stamp. Anglers must also possess a valid state of Montana paddlefish tag, which must be attached to creeled fish at the base of the front of the dorsal fin as in the non-Tribal fisheries. All persons must cast for and hook his/her own fish. Immediate high grading is allowed (http://www.fortpecktribes.org/fgd/fishing.htm). The fishery is largely self-limiting according to the availability of fish.

Fort Peck stock

Management actions and stock assessment investigations of the Fort Peck paddlefish have been reported annually from 1970 to the present (Needham 1970, 1971, 1973a, 1973b, 1974a, 1974b, 1976, 1977a, 1977b, 1979, 1980a, 1980b, 1981, 1982, 1983, 1984, 1985; Berg 1981; Needham and Gilge 1986, 1988, 1989, 1990, 1991, 1992; Gilge 1993, 2002, Gilge and Brunsing 1994, 1995; Gilge and Liebelt 1996, 1997, 1998, 1999, 2000, 2001, Gilge and Kapuscinski 2004; Leslie 2005, 2006, 2007). Investigations conducted under the most recent Paddlefish Management Plan (since 2007) were reported by Nagel (2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017).

Period 1 (1963-2007) - The management of the Fort Peck stock began in 1963, when the rise of the Intake fishery on the Yellowstone-Sakakawea stock led to the first regulations on paddlefish snagging. The initial regulations were set statewide for both stocks. Numbers of paddlefish in relation to fishing effort were high and liberal harvest regulations were enacted. Paddlefish could be snagged in the Missouri River below Morony Dam. There was no closed season. The daily limit was 2 fish per day, with 4 in possession. Regulation changes through the remainder of the 1960s and the 1970s were mostly minor. By 1980, harvest regulations had been reduced to one fish daily and two in possession.

Creel censuses were conducted in 5 years in the 1970s, one year in the 1980s, 7 years in the 1990s, and six of seven years over the period 2000-2007. In the earliest of the stock assessment reports, Needham (1970) noted that "snagging activity at the upper end of Fort Peck Reservoir has reportedly increased greatly in recent years. The large size (frequently exceeding 100 pounds) of paddlefish in the fishery… attracts many snaggers … [I]nformation is needed to properly manage this fishery…to maintain the abundance of large fish. (p. 4). In the following year, he reported sex-specific average lengths and weights from samples taken in 1971 and in three previous years (1965, 1966, and 1970; Needham 1971). Most samples were of fish of unknown sex. Mean weight of 10 known females was high: 38.6 kg (85 lbs).

In 1972, a creel census was designed (Needham 1973a) and implemented the following year (1973) during the spring snagging season (Needham 1973b). The census was a stratified design with more intensive weekend sampling and less intensive weekday sampling, resulting in data from 53.6% of fisherman trips. The estimated number of fishermen was 1,416 and the estimated catch was 427, with a success rate of 0.30 fish per angler-day. The most common snagger residences were in Billings and Lewistown. That same year, jaw tagging of adult fish was begun to obtain information on movements and harvest rates (Needham 1973b). Through the rest of the 1970s, the stock was surveyed by tagging and creel census in 1973, 1974, 1975, 1977, and 1978 and studied intensively for three years (1977-79) by Berg (1981) with additional creel information and population sampling with electrofishing and gillnetting.

Overall, the conclusion in this period was that the stock was not being heavily harvested. This conclusion was based mainly on low harvest rates, but partly on the remoteness of the fishery and on a subjective comparison with the more developed fishery for Yellowstone-Sakakawea paddlefish. Needham (1981) did not recommend the same restrictive regulations for Fort Peck paddlefish as were enacted for Yellowstone-Sakakawea paddlefish in 1981 because creel censuses and tagging results indicated low fishing pressure and low harvest rates. Summarized results of tagging studies a few years later indicated an annual harvest rate over the period 1973-1986 of only 1.5 to 3.5%, which Needham and Gilge (1986) concluded was sustainable. However, at that time, knowledge of paddlefish life history and reproductive periodicity was less than today, and the very low harvest rates were in part a result of individual tagged fish not migrating upriver every year to spawn. Although annual harvest rates were low, harvest rates over several years were cumulatively not insignificant. Needham (1985) later reported that the highest overall rates of harvest for any group of fish were 21.3 and 21.1 % for 40 fish tagged in 1977 and 48 fish tagged in 1978. Nevertheless, the overall conclusion of low rates of estimated harvest of tagged fish throughout the 1980s resulted in consistent recommendations that no additional harvest restrictions were necessary (Needham and Gilge 1986). In 1992, however, the catch limit for Fort Peck paddlefish was changed from 1 fish per day to 2 fish per year. The limit remained at two fish per year in 1994 even when the limit on the Yellowstone had been reduced to one fish.

In the first decade of the 21st century, indications of low reproduction and recruitment along with increasing effort and catch resulted in concerns about the sustainability of the fishery (Leslie 2007). Nagel (2017) described a five-year native species creel survey that was conducted from 2005-2009 to better understand catch and harvest rates, age structure of harvested fish, angler pressure, and angler demographics from the Fred Robinson Bridge to Peggy's Bottom. In 2007, the fishery remained open all year but was limited to four harvest days per week (Tuesday, Wednesday, Friday and Saturday) with mandatory retention; the other three days were mandatory catch-and-release. Snaggers also had to choose from which paddlefish stock in Montana (Fort Peck or Yellowstone-Sakakawea) they wanted to harvest a fish. Night fishing was eliminated for paddlefish statewide and the fishery was open from 6 AM to 9 PM mountain time. More restrictive regulations were proposed for the 2008 season, including a change from allowing the season to be open all year to a six-week season (May 1-June15), a limit on hook size to 8/0 or smaller, and a 500-fish harvest cap (with 24-hour notice of closure). However, the option to release fish upon capture was reinstated.

Period 2 (2008-2020) - In this most recent period, harvest has been moderated by the 500-fish harvest cap and the option to release fish (2008-2015) and, more recently, a lottery draw system for harvest tags (2016-2020). Catch-and-release fishing has been allowed for the remainder of the season following closure of harvest. Although harvest was less than 600 fish in all years, total fish caught numbered as high as 2,342 in 2009 and 2,048 in 2014. Crowding issues at campsites and fishing areas through 2011, along with the need to close the fishery in-season as the harvest cap was met (and slightly exceeded) in each year, led to some concerns about the race for harvest leading to an overall lower-quality fishing experience. The past more liberal regulations for this stock had previously resulted in a leisurely, camping-oriented experience in this scenic area; the harvest cap, as could be anticipated, had led to conditions more like those experienced for the Yellowstone-Sakakawea stock. These concerns prompted MFWP to seek angler opinions during the phone creel in 2012 on the option to release paddlefish, the possibility of a lottery system and a mandatory harvest reporting system. Anglers strongly favored the option to release (85%), expressed a willingness to accept mandatory reporting (82%), but were much less enthusiastic about a lottery-type draw (34%; Nagel 2017). Nearly two-thirds (64%) of anglers indicated, however, that they would still purchase a license to catch-and-release paddlefish if they did not draw a harvest tag. Additional surveys and angler input led to MFWP's decision for the 2016 season to institute and evaluate a lottery draw for 750 tags along with mandatory reporting of harvest (Nagel 2017). The number of tags allocated was increased to 1,000 in 2017 to allow more harvest participation and align total harvest with the previous cap set at 500. From 2016-2020, reported and estimated harvest has not exceeded 350 paddlefish. The intent was to retain a harvest cap needed for conservation purposes, but to spread out the fishing pressure over the 6-week season as those anglers participating in catch-and-release only would have less incentive to rush to fish early in the season. The result would be a more leisurely fishery that many anglers were accustomed to and favored. As of 2020, the changes enacted have been favorably received, although further evaluation is possible and may be useful.

As described by Nagel (2017), "From 2010-2015 the creel was conducted annually by vehicle and boat from May 1st to June 15th …., focusing solely on paddlefish and paddlefish anglers…. New regulations adopted on the upper Missouri paddlefish fishery were implemented in 2016,… Anglers now have to mandatorily report a harvested paddlefish…In 2016, creel clerks were stationed at two checkpoints located at the Kipp and Rock Creek campgrounds to provide a location for anglers to check in their harvested paddlefish [and to allow MFWP] to collect additional harvest data". As of 2018, anglers were required to provide information in their reporting on their paddlefish harvest tag number, angler name, angler ALS number (a lifetime number given to each Montana angler), harvest date, paddlefish body length, sex, jaw tag information (color and number), and, optionally, a piece of the dentary for aging. Due to the Covid-19 pandemic, no onsite creel clerks were stationed at the two checkpoints in 2020. To accommodate anglers, four self-creel boxes were constructed to provide a location to report harvested paddlefish and collect additional harvest data. The boxes were located at the Kipp, Jones Island, Slippery Ann and Rock Creek campgrounds. Boxes were checked and sanitized twice a week for the duration of the paddlefish season. Anglers who provided harvest information along with a jaw sample of their harvested paddlefish received a MFWP-designed paddlefish hat.

Oahe stock

No fishery exists for this stock. Natural spawning opportunities for this stock are evidently poor. Experimental translocation of 285 adult Oahe Tailrace/Spillway Channel paddlefish (plus four additional fish that were collected above Lake Sakakawea and spawned at Garrison Dam National Fish Hatchery) to above Garrison Dam was undertaken in June, 2018. The objective was to assess the utility of such translocations should a future management need arise. It is currently unknown whether or not paddlefish actively translocated from below (Tailrace/Spillway) to above Garrison Dam (Government Bay, Lake Sakakawea) would contribute to reproductive efforts of the Sakakawea population. Evaluation of these translocated paddlefish is ongoing.

Appendix A-2 Paddlefish Habitat Requirements and Protection

Changes in habitat and the effects on paddlefish have been frequently described in general terms (Sparrowe 1986; Gerken and Paukert 2009); few studies within the region have directly investigated and reported how habitat changes have affected specific aspects of paddlefish life history. The most comprehensive review of habitat changes within the Yellowstone Basin is the Yellowstone River Cumulative Impacts Analysis (U. S. Army Corps of Engineers and Yellowstone River Conservation District Council 2015), which was concerned with the effects of human land and river use activities on river function. Most of the direct investigations on Montana-North Dakota paddlefish habitat have involved conditions for rearing in the Lake Sakakawea (Scarnecchia et al. 2009; 2019b) and to a lesser extent, Fort Peck Reservoir. In general, many of the same riverine factors and habitat requirements for paddlefish are similar to those of other native species adapted to free-flowing rivers. Additional habitat considerations have developed as paddlefish have occupied large reservoir habitats throughout much of their range, including Montana and North Dakota. Habitat requirements and protection for the three paddlefish stocks is accordingly categorized in terms of eight interrelated components: river water quantity, river water quality, riverine habitat features, river function, fish passage, reservoir water quantity, reservoir water quality, and emerging issues.

River water quantity

Importance - Adequate river flows are a primary habitat requirement for successful paddlefish reproduction and long-term sustainability (Russell 1986; Jennings and Zigler 2000). The natural, gradual rise and fall of the hydrograph is one important component of good spawning habitat. Rising river flows in early spring cue upstream spawning migrations in the Yellowstone-Sakakawea stock (Firehammer and Scarnecchia 2006; Miller 2007) and the Fort Peck stock (Miller et al. 2007), and also have an impact on how far upriver the fish migrate (Berg 1981; Rugg et al. 2019). Spawning farther upstream has the potential to improve larval and juvenile survival, as has been hypothesized for pallid sturgeon (Braaten et al. 2012; Marotz and Lorang 2018). However, it is not yet specifically known if more upstream spawning (e.g., in or upriver of the Powder River) will improve recruitment success over fish produced from spawning at Sidney; studies following improvement in passage at Intake Dam will permit an assessment of this hypothesis. Future monitoring is warranted.

Actual spawning in paddlefish is associated with the flood pulse (Russell 1986), and may occur with rising flows, peak flows, or declining flows. Studies on sturgeon by Fuller and Braaten (2012) provide evidence of benefits to Acipenseriform larval fish from higher, more turbid flows. Once eggs have hatched, higher flows provide more rapid conveyance of larval fish to their riverine or reservoir habitats. High turbidity associated with higher flows may also protect young paddlefish from predation by sight-feeding predators within the rivers (Scarnecchia et al. 2019b). Higher river inflows throughout summer also provide the source of water and nutrients to keep reservoir water levels high and productive for paddlefish. Detailed studies of such mechanisms are expensive and difficult to conduct. However, higher water levels in Lake Sakakawea during the mid-1990s associated with years of high spring and summer runoff have been shown to be associated with stronger year classes and faster growth rates of young paddlefish (Scarnecchia et al. 2007; 2019b). Additional evidence (the Age-0 Index) indicates that abundance and year class strength of Fort Peck paddlefish was also higher in those years than in drought years since 2000, when low river discharges and low reservoir levels have prevailed. Maintenance of habitat quality for Yellowstone-Sakakawea and Fort Peck paddlefish thus is critically dependent on adequate water quantity during spring and early summer.

The amount of water available during the spring and early summer in turn depends mainly on how much water is supplied through rain and snowmelt, various natural losses, and as the season progresses, how much is withdrawn by humans for other purposes. Watson et al. (2018) assessed Yellowstone River water quantity through a hydrologic analysis of 18 stations over the period 1898-2007. They found declines in volume and magnitude of seasonal discharges in the river, especially where no water storage reservoirs were located. Timing of flow events throughout the basin (e.g., peak spring runoff) was also increasingly occurring earlier in the year, a trend that was predicted to continue. For example, peak discharge near Sidney has shown a declining trend over the period 1911-2019 with occasional high discharge years such as 2011 (Figure A2-1). Mean monthly discharge in June at Sidney has shown a greater frequency of low flow years, for example, in the drought period of the early 2000s (Figure A2-2). Mean June Missouri River discharges at Culbertson have also trended lower except for anomalous years such as 2011 (Figure A2-3). These discharge trends may be relevant to the Yellowstone-Sakakawea stock, but are difficult to directly investigate. Similarly, for flows relevant to the Fort Peck stock, peak discharge of the Missouri River at the Virgelle gauging station, east of Fort Benton, has trended downward over the period 1935 to 2019 (Figure A2-4). Such declines may be relevant, as Berg (1981) noted that significant movements of paddlefish to the spawning sites did not occur until discharge at the Virgelle station exceeded 396 m^3/sec. Years with high discharges have also been associated with stronger year classes of paddlefish based on age-0 and sub-adult counts along transects in both reservoirs (D. Scarnecchia, unpublished; Scarnecchia et al. 2019b).

Water withdrawals from the Yellowstone River and its tributaries have also been increasing steadily in recent decades, and future projections are that water withdrawals will continue to increase, even as individual irrigation operations become more efficient (Watson 2014; Watson et al. 2017). Excessive water depletions constitute a serious threat to the paddlefish stock and other native fishes, including the endangered pallid sturgeon in the Missouri and Yellowstone River Basins. Maintenance of river flows and monitoring of withdrawals are therefore important aspects of protecting habitat quality for paddlefish.

The early development of water legislation in Montana and the Yellowstone Basin are discussed with regard to irrigation by the Montana Water Resources Board (1979) and Watson (2014) and with regard to tribal water rights by Veeder (1976). Several aspects of water quantity management are discussed below.

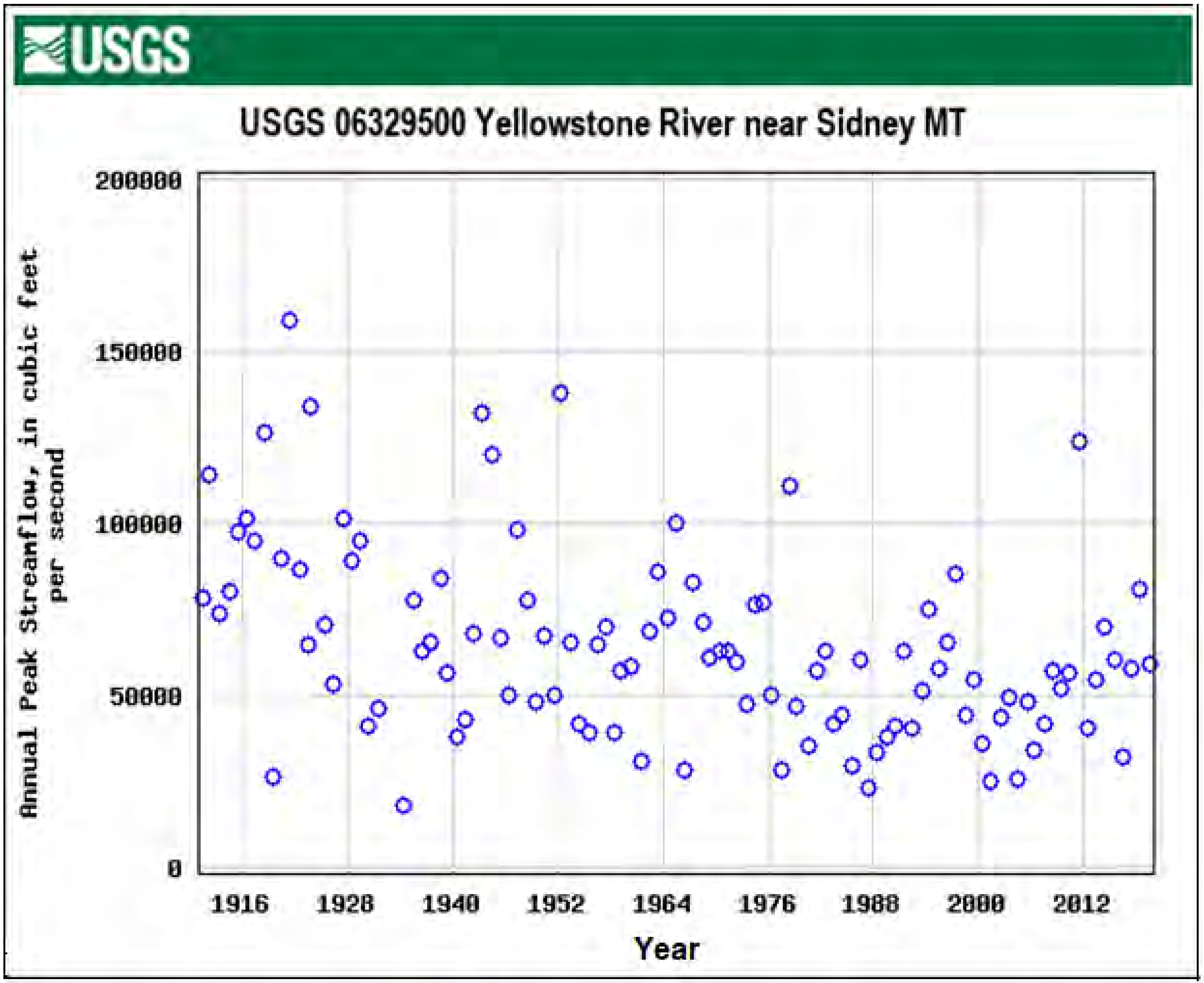


Figure A2-1. Peak discharge (cfs) of the Yellowstone River at Sidney, Montana, 1911-2019.

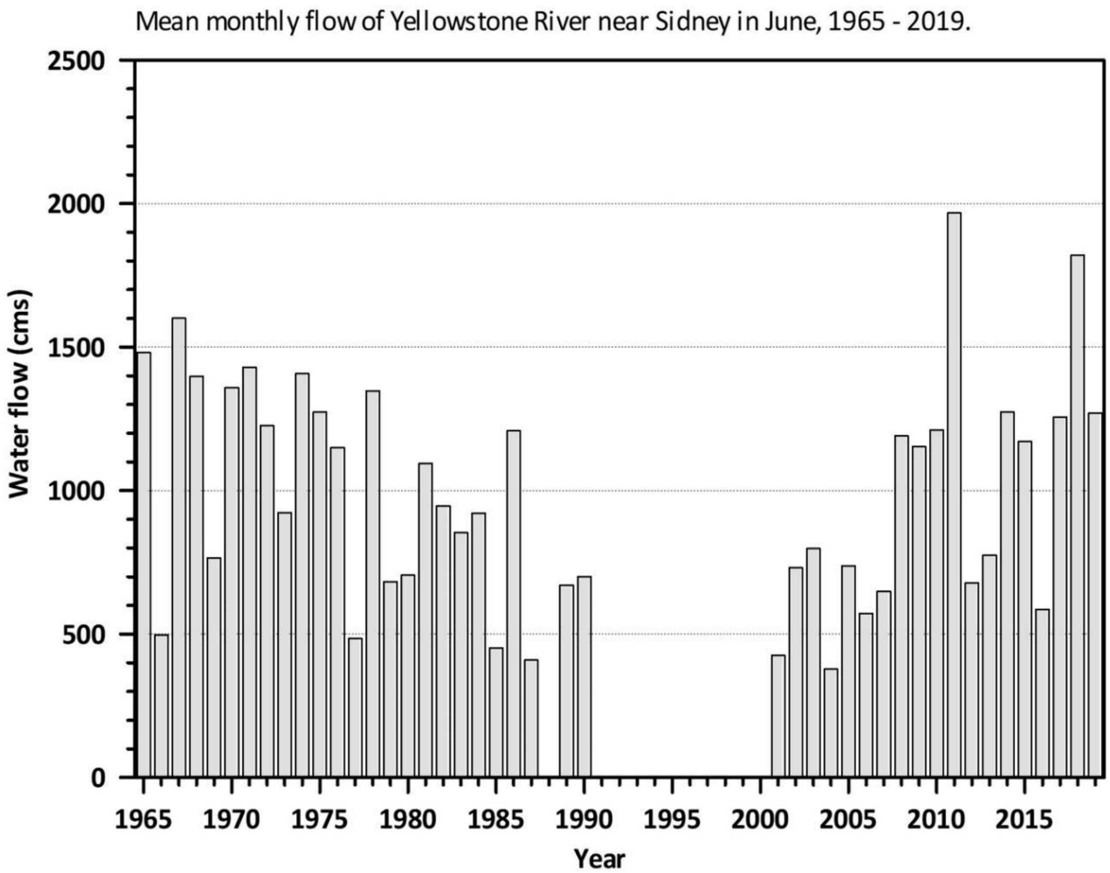


Figure A2-2. Mean monthly discharge in June of the Yellowstone River near Sidney, 1965-2019.

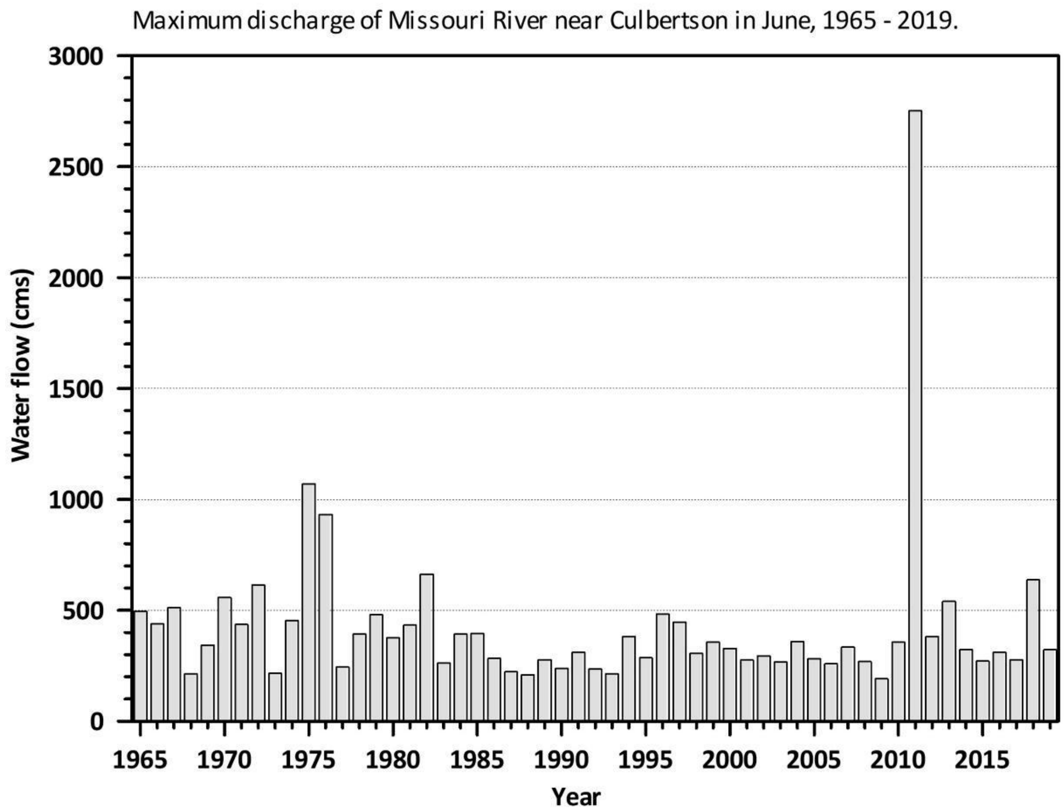


Figure A2-3. Maximum June discharge in the Missouri River near Culbertson, 1965-2019.

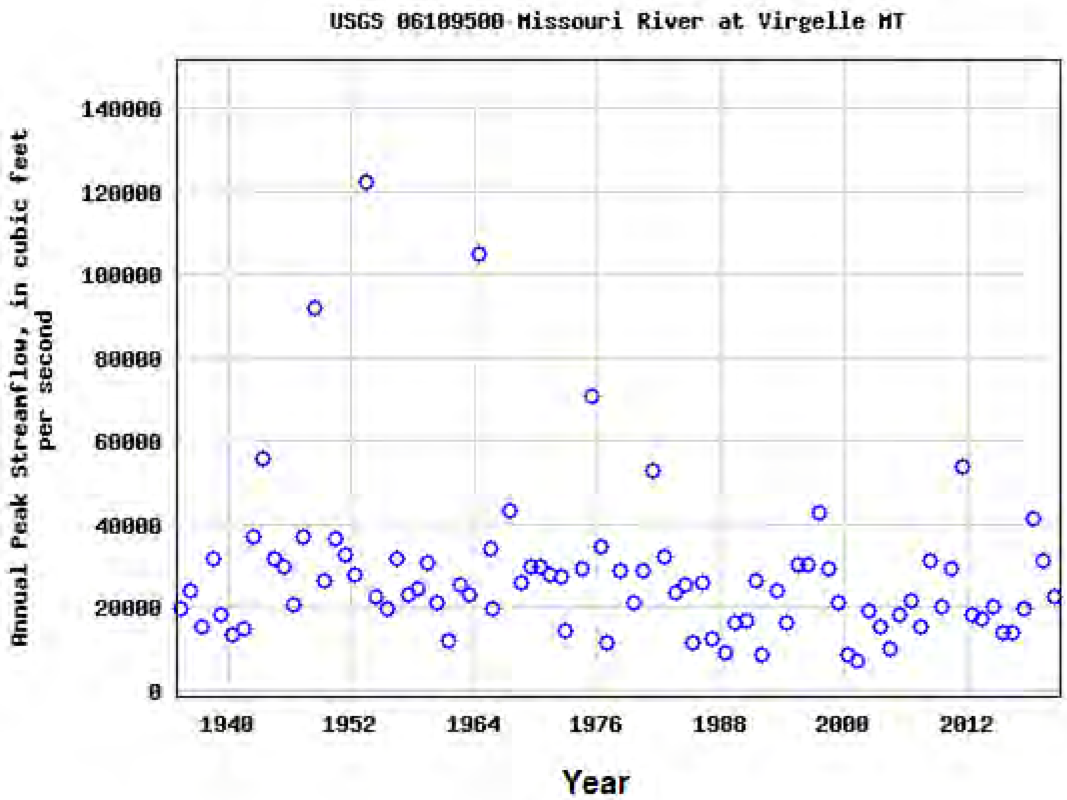


Figure A2-4. Peak discharge (cfs) of the Missouri River at Virgelle, Montana, 1935-2019.

Yellowstone River Compact - Water in the Yellowstone River is apportioned to states under terms of the Yellowstone River Compact, ratified in 1951 by the states of Wyoming, Montana and North Dakota. The three-member Yellowstone River Compact Commission functions to "1) provide for an equitable division and apportionment of the waters of the Yellowstone River and its tributaries, 2) encourage the beneficial development and use of the Basin's waters, recognizing the great importance of water for irrigation that would arise from future projects or programs for the regulation, control, and use of water in the Yellowstone River Basin, and 3) further inter-government cooperation and remove causes of controversy over distribution and use of water" (Http://cr.water.usgs.gov/YRCC/). The rivers controlled include the Yellowstone River (exclusive of the National Park) and its tributaries, the Clarks Fork of the Yellowstone, Big Horn, Tongue, and Powder Rivers. Under the terms of the Compact, rights to beneficial uses of water existing in each state prior to January 1, 1950, would "continue… in accordance with laws governing the acquisition and use of water under the doctrine of appropriation" (https://www.usgs.gov/mission-areas/water-resources/science/yellowstone-river-compact-commission?qt-science_center_objects=0#qt-science_center_objects). The remaining unallocated waters were allocated to states as follows: Clarks Fork: WY 60%, MT 40%; Bighorn (exclusive of Little Bighorn River): WY 80%, MT 20%; Tongue River: WY 40%, MT 60%; Powder River: WY 42%, MT 58%. Special dispensation is provided to the Lower Yellowstone Irrigation Project Under Article V, Section D, which states that "All existing rights to the beneficial use …below Intake, Montana, valid…as of January 1, 1950 are hereby recognized and shall be and remain unimpaired by this Compact. During the period May 1 to September 30, inclusive, of each year, lands within Montana and North Dakota shall be entitled to the beneficial use of the flow of waters of the Yellowstone River below Intake, Montana on a proportionate basis of acreage irrigated. Waters of tributary streams, having their origin in either Montana or North Dakota, situated entirely in said respective states and flowing into the Yellowstone River below Intake, Montana, are allotted to the respective states in which situated". North Dakota was thus not specifically allocated any water from the Yellowstone River or any major tributaries, even though most of the lower 24 km of the Yellowstone River flows through North Dakota, and that section of river contains the most important documented paddlefish spawning and egg depositional habitat (Firehammer et al., 2006; Miller 2007).

Recent litigation under the Compact (Supreme Court of the United States 2018) found a judgment against Wyoming for its reduction in flow volume of the Tongue River, other claims of Montana Against Wyoming were dismissed with prejudice (i.e., permanently). One contentious issue is Montana's claim that groundwater development (not included under the Compact) for coalbed methane and other uses has decreased the amount of surface water Montana is receiving (Irwinsky 2016). It is anticipated that climate change and overestimates of the available water will create challenges for the Compact in the ensuing decades (King 2019).

Irrigation withdrawals - Numerous irrigation activities are undertaken in the Yellowstone Basin, ranging from large irrigation projects involving major infrastructure such as low head dams and canals to individual users pumping water directly from the river. A review of these activities as they relate to paddlefish and other native fishes was conducted by Watson et al.

(2017). Their study reported 687 water withdrawal sites in the basin and tributaries, of which 113 were confirmed to have screening devices present, 120 had no screens, and 454 sites could not be assessed for screening. They made several recommendations for improving the scientific accuracy and credibility of water withdrawals, as well as for improving conditions for native fish such as the paddlefish. Key recommendations included the need to screen all diversions, the need for an identification system to enable a withdrawal site to be specifically linked to a water right, and the need for an accurate and precise system for measuring and reporting water withdrawals. Other identified needs were to complete the adjudication process (not expected for several years in the state of Montana), to review the scientific evidence in support of the differential water use hierarchy in the Yellowstone Basin, and to eliminate ambiguous and imprecise terms used in water usage (Watson et al. 2017).

Projects and individual irrigators exist along the entire river, but only two large projects on the lower river are discussed here. The Lower Yellowstone Irrigation Project (LYIP) exerts a major influence on the habitat of Yellowstone –Sakakawea paddlefish. As described in the Bureau of Reclamation's website of Dams, Projects, and Powerplants: "The Lower Yellowstone Project in east-central Montana and western North Dakota includes the Lower Yellowstone Diversion Dam, Thomas Point Pumping Plant, the Main Canal, 225 miles of laterals, and 118 miles of drains. The purpose of the project is to furnish a dependable supply of irrigation water for approximately 54,000 acres of fertile land along the west bank of the Yellowstone River. About one-third of the project lands are in North Dakota [ca. 17,000 acres] and two-thirds in Montana [ca. 34,000 acres]. … The Lower Yellowstone Diversion Dam, on the Yellowstone River about 18 miles below Glendive, Montana, is a rock-filled timber crib weir about 12 feet high. The dam contains 23,000 cubic yards of material. The Reclamation Service began investigating the project in 1903. A report by a board of consulting engineers, dated April 23, 1904, served as a basis for authorization of the project. …The project was authorized by the Secretary of the Interior on May 10, 1904, under the Reclamation Act of June 17, 1902. Construction began on July 22, 1905. Water was available for irrigation during the season of 1909. The principal crops grown include small grains, alfalfa and other hay crops, pasture, silage, beans, and sugar beets. The town of Savage is supplied with Lower Yellowstone Project water." (https://www.usbr.gov/gp/mtao/loweryellowstone/)

In North Dakota, the neighboring Buford-Trenton Irrigation District, centered between Buford and Trenton, pumps water directly from the Missouri River below the Confluence (Williams County). This project began in the 1940s, was completed in 1943, and irrigates more than 7,000 acres (Esser 2007).

Protecting flows for paddlefish - From the mid-1970s through the early 1990s, two applications for water reservations by MFWP were made to the Montana Board of Natural Resources and Conservation (MBNRC) to protect spawning flows for migrating paddlefish, for the Yellowstone River (reservation approved 1978) and the other for the Missouri River above and below Fort Peck Reservoir (reservations approved 1992 and 1994 respectively). In 1976, instream flows during the time of migration, spawning, and hatching of paddlefish were requested on the Yellowstone River. The requested June 8-30 flow was based on investigations of Peterman (1979), in which it was determined that 45,000 cfs was required for paddlefish to move upstream of the Intake Diversion Dam, where large amounts of suitable spawning gravel are available. Only 25,140 cfs was granted for June by MBNRC representing the 80th percentile exceedance flow. However, MBNRC granted a 24-hour dominant discharge flow of 34,507 cfs upstream at Billings which would increase flow for a short period at points downstream.

In 1991, a flow of 15,302 cfs was requested by MFWP of the MBNRC for the period May 19-July 5 for the reach from Fort Peck Reservoir to the Judith River. Gardner and Berg (1980) found this flow was needed for paddlefish migration to spawning areas upstream of Fort Peck Reservoir. In 1992, in response to this application, the MBNRC granted a flow of only 4,652 cfs, which is 50% of the mean annual discharge as limited by statute (§85-2-316(6)(b), MCA 2019).

The instream flows granted thus provide only partial protection for paddlefish spawning on the Yellowstone River and very little protection on the Missouri River. Furthermore, even the granted flows are not fully guaranteed, but are subject to senior (earlier) water rights (Watson 2014). Other future water users senior in priority to the water reservations in addition to the Conservation District reservations include the reserved rights of the Crow and Northern Cheyenne Tribes (impacting the Yellowstone) and the Tribes of the Fort Peck Reservation (affecting the Missouri river below Fort Peck Dam). Unused allocations to Wyoming under the Yellowstone River Compact are also significant (https://waterplan.state.wy.us/plan/plan.html). The main value of the instream reservations as they exist lies in preventing flow depletions by those possessing junior (later) water rights, i.e., those users with a priority date later than the December 15, 1978 date for the Yellowstone River reservation and the July 1, 1985 date for the Missouri River flow reservations. The situation for instream flows is worsened because the Conservation Districts in the Yellowstone Basin holds a water reservation that can be used by individuals within the basin. This water was granted to the Districts (and selected other public entities) over their concern that water needs of developing energy industries would prevent the future development of additional irrigation. Irrigators can obtain authorization to use some of the reserved water and thereby take advantage of the districts' December 15, 1978 priority date (Montana Department of Natural Resources 1995). The reserved rights issued downstream of the Bighorn-Yellowstone river confluence have precedent over the States instream flows. The potential impacts of these reserved water rights can be substantial. For example, based on a 2015 evaluation, only 13.9% of the Conservation Districts (CD) Water Reservations set aside in 1978 for the entire Yellowstone River has been issued; the remainder (86.1%) remains available for new irrigation. Two projections of river flows at Sidney when 70% and 100% of the CD reservation are issued (potentially taking another 70-100 years to occur based on rate of issue since 1978) show the river going dry for a number of days in August for both projections. Although the effects of low flows in August may not affect use of the river by paddlefish in May and June, it does indicate in a general way the potential magnitude of the future problem for habitat and river function.

This water reserve guaranteed that irrigation would remain the major water user in the basin. The original amount of water reserved was thought to be more than would actually be economically and logistically feasible to develop (Boris and Krutilla 1980). Many of these reserved senior water rights have thus not yet been actually utilized. However, technological advances and any increases in profitability of irrigation often make a development that was infeasible in one decade a reality in the next decade. Their use is continually increasing. It would be unwise to assume that requests for additional irrigation water will not continue to increase substantially in the next decade. In addition to the long-standing irrigation ditches of LYIP and other projects, more interest has been expressed in developing additional (not replacement) sprinkler irrigation on adjacent upland areas.

As a result of existing water development projects, flows in the Yellowstone River have declined from historical levels. Declines in peak flows have been observed in both the Yellowstone River and the Missouri River. In tributaries, over-allocation problems have become immediately apparent when natural hydrologic conditions result in river flows near or less than those used by holders of water rights. Such over-allocation constitutes a highly significant threat to future in-stream flows for paddlefish and other native species.

It is critical for the fishery resources of the rivers that water depletions be accurately monitored (which is feasible but not done at present) and their effects on native fishes assessed (Watson 2014; Watson et al. 2017). In-stream flow strategies for Montana and North Dakota should be re-evaluated for potential effectiveness (Nelson et al. 1978).

Yellowtail Dam flow releases (Bighorn Basin) - Yellowtail Dam releases have the potential to affect paddlefish spawning through their effects on the Yellowstone River hydrograph and on water clarity. Increasing water releases will typically draw paddlefish upriver. The effects of the releases have not been investigated, but in 2017, which was a substantial water flow year in the Bighorn River, numerous paddlefish were documented in the Bighorn River near Fort Smith in August by anglers (Figure A2-5). This location is approximately 603 Rkm upstream from Lake Sakakawea, the starting point for paddlefish spawning migrations. Greater upstream movement is anticipated as passage at the Intake Dam is improved.

Fort Peck Dam flow releases - In the early 2000's, in response to concerns for spawning of pallid sturgeon, recommendations were made to increase flows (and water temperatures) out of Fort Peck Dam in spring. According to the Five-year Pallid Sturgeon Plan: "Recommendations … are based on snowpack, and identify flows ranging from 20,000 to 30,000 cfs between mid-May and the end of June. Higher flows would be recommended during higher snowpack years. To date, utilizing warm water releases [from the spillway] to simulate natural conditions to improve spawning cues for the species have been precluded due to extended drought conditions" (U. S. Fish and Wildlife Service 2007). As of 2018, flow releases remain in

Figure A2-5. Bighorn River anglers Trent Stiefvater (left) holds up a paddlefish he and outfitter Beau McFadyean (right) rescued by hand from a gravel bar, August 8, 2017.

the planning stages. The U.S. Army Corps of Engineers (USACE) Omaha District is preparing an Environmental Impact Statement (EIS) to evaluate impacts of potential test flows from Fort Peck Dam related to pallid sturgeon spawning, larval drift and potential recruitment (https://www.nwo.usace.army.mil/Media/News-Releases/Article/1748682/notice-of-open-house-for-fort-peck-flows-study/; Erwin et al. 2018).

The potential effects of the envisioned Fort Peck flow releases on paddlefish are difficult to predict. The effectiveness may depend on how significant the changes in discharge, temperatures, and turbidity are in affecting suitable spawning and rearing habitat for paddlefish. Recent studies have clearly shown that pre-spawning paddlefish may preferentially migrate up the Missouri River in those years when spring flows in the Missouri River exceed those in the Yellowstone River (Firehammer and Scarnecchia 2006; Miller 2007). Such flows may lure the paddlefish up the colder, clearer Missouri River, which is not the preferred overall habitat for the species, rather than the more natural Yellowstone River, which is the preferred habitat based on historical catch records and telemetry studies (Firehammer and Scarnecchia 2006; Miller 2007). More rapid larval drift into Lake Sakakawea under higher flows may present fewer problems for paddlefish than for sturgeon because available evidence indicates that paddlefish can rear more effectively than sturgeon in reservoir habitat (Scarnecchia et al. 2019b).

Flow releases above Fort Peck Dam - Reservoir operations on the Missouri River and tributaries, especially from Fort Benton to the headwaters Fort Peck Reservoir, also have potential to affect paddlefish movements and spawning. Studies focused on the endangered pallid sturgeon have provided information relevant to paddlefish. The BOR and MFWP conducted a 5-year study to evaluate how operations of three dams (one mainstem, two tributary) had potential to affect pallid sturgeon ecology and movements. These dams (Canyon Ferry on the mainstem Missouri River, Tiber Dam at Rkm 128.7 of the Marias River, and Gibson Dam at Rkm 162.5 of the Sun River) are not run-of the river dams (unlike several others) and their storage (both onsite and off-site) and release operations had potential to affect pallid sturgeon recovery. (U. S. Fish and Wildlife Service 2007; MFWP and BOR 2011). Factors assessed in the study included changes and annual variations in spring discharges (releases), water temperature, and habitat use by shovelnose sturgeon (*Scaphirhynchus platorynchus*) surrogate for pallid sturgeon.

According to their Five-Year Plan, “Operations of Tiber Dam, located on the Marias River, a tributary to the Missouri River, have been recently modified to occasionally accommodate a high flow discharge period in June. During 1995, 1997, and 2002, the BOR [Bureau of Reclamation] provided a June peak release of 4,080, 4,500, and 5,300 cfs, respectively for downstream fisheries benefits. These releases were 1.8 to 2.3 times the average June peak discharge that has occurred since construction of Tiber Dam (1957-1994). A direct response by pallid sturgeon was not observed. However, present numbers of pallid sturgeon could now be too low to detect or elicit a response”.

River water quality

Status - Overall, both the Yellowstone and Missouri Rivers presently have relatively good water quality (White and Bramblett 1993), mainly due to the high-elevation sources of much of the runoff. Under the Montana Water Quality Act, standards for each river have been established for fecal coliform bacteria, dissolved oxygen, pH, turbidity increases, temperature, and toxic substances. Key sources of nutrient input include the atmosphere, agriculture, residential development, and urban development.

In the Yellowstone Basin, water qualities in many of the tributaries such as the Powder River that are affected by mining and energy development, are often not as good as in the main-stem (Farag et al. 2007). Several human uses have in the past lead to decreased water quality, currently affect water quality, and can be expected to do so in the future.

Agricultural and residential land use - In 2016, concentrations of phosphorus and nitrogen were described in a report to the Yellowstone River Conservation District Council (YRCDC) by Kellogg (2016) as "relatively low compared to other major rivers in the United States, [but] some nutrient enrichment does occur along the Yellowstone River and tributaries; primarily the Clarks Fork, Bighorn, and Powder rivers. The main indicator of nutrient enrichment is the excessive growth of algae" (p. 47). Kellogg (2016) also reported that farm fertilizer contributes up to 40% of the nitrogen and 10% of the phosphorus in the basin., whereas "Livestock holding facilities, feedlots, and calving areas contribute only 3% of the nitrogen, but are responsible for 22% of the phosphorus pollution". (p. 47) Sources of these statistics are not identified. He recommends several management guidelines be followed, including soil health management: reduced tillage, increased ground cover, crop rotation, cover crops after annual crop harvest, and conversion of flood irrigation to sprinklers. Feeding and calving pastures should be established off of floodplains and riparian areas wherever possible and rotated frequently if on the floodplains and in riparian areas. Livestock holding facilities should be off of the 100-yr floodplain and manures transported off site frequently to reduce inputs into the river.

The upper Yellowstone Basin was characterized by Kellogg (2016) as having an increasing number of small tracts being developed along the waterways, often associated with bank stabilization and "rock rip-rap, jetties retaining walls, dikes…, storm water runoff, septic systems, riparian clearing, and noxious weed infestations" (p. 49). Although the effects of individual tracts may be difficult to measure, cumulative effects of them in combination are an increasing threat to water quality. He recommends better design and more conscientious management of septic systems. New systems require a county-approved permit before construction can begin according to Montana Department of Environmental Quality (MTDEQ) Circular 4. New systems should be located out of the 100-year floodplain, above the ground water table, and at least 100 feet from domestic wells. Regular maintenance is also needed.

In his prioritization of sub-watersheds for nitrogen and phosphorus inputs, priority is given by Kellogg (2016) to upper basin areas. He notes that a "healthy riparian buffer" is the best treatment for phosphorus inputs. Solid waste removal (metals, lumber, concrete, garbage, pesticide containers, hazardous wastes, bailing twine, and contaminated soils) is specifically identified as habitat improvement. As in paddlefish harvest management, education and outreach are considered important aspects of the program.

Coal, coal bed methane and salinity issues - It has been known for decades that the Northern Great Plains region, including much of western North Dakota, eastern Montana, and northeastern Wyoming, has large coal deposits (Stinson et al. 1982). The Fort Union coal formation, covering all or part of 60 counties in the three states, is one of the world's largest coal fields. The coals, mainly lignite in western North Dakota and eastern Montana, and the higher-energy, lower moisture subbituminous in the Powder River Drainage of Wyoming and Montana, have relatively low sulfur content and low extraction costs (to offset overall low heating value and high moisture content compared to many coal deposits elsewhere). The most valuable and accessible deposits are in the Powder River basin. The extraction of methane from coal seams involves removing often large quantities of water from the coal seam (as much as 17,000 gallons per well per day), resulting in potential runoff of large quantities of water. Such water that is too high in salts results in reduced water quality, reduced soil productivity, and impacts on native fish fauna (Confluence Consulting 2004). In this case, water quality becomes a major issue (Farag et al. 2007; Irwinsky 2016). Davis et al. (2006) reviewed the literature on coalbed methane and its effects on fish and found very little to specifically clarify what its effects would be on Powder River basin fish fauna. Further field and laboratory studies are needed.

Oil and gas wells and spills - Paddlefish habitat in the Mondak region is in the midst of one of the country's largest oil producing areas. An estimated 7.4 billion barrels of recoverable oil are estimated to be in the Bakken formation and Three Forks formation of the Williston Basin (Gadhamshetty et al. 2015; Shrestha et al. 2017). In North Dakota's portion of the Lower Yellowstone River and Missouri River from the Confluence to Lake Sakakawea (known as the Williston Reach), a considerable amount of oil and gas development has occurred, and oil wells, pipelines and oilfield traffic are commonplace. Energy development has also occurred into Montana beyond Sidney, and up the Missouri beyond Culbertson. The earlier development in the 1980s was followed by a downturn in the 1990s and a rapid expansion in the industry starting about 2007, led by advances in drilling technology, hydraulic fracturing (fracking), horizontal drilling, and major increases in production (Lauer et al. 2016). The fracking process can have major impacts on surface and groundwater resources. Contaminants associated with the drilling muds include boric acid, borate salts, rubber-based and synthetic oils, petroleum hydrocarbons, barium, strontium, bromine, heavy metals, salts, and naturally occurring radioactive materials. The entire process of oil development is especially threatening to water in more arid regions, as in the lower Yellowstone Basin where high amounts of water are needed. Each of the Bakken's wells use 3-8 million gallons of water throughout its life, and more than 12,000 wells in the Bakken result in major quantities of two types of wastewater (flowback and produced water; (Gadhamshetty et al. 2015).

Concurrent with development have been increases in spills at production and disposal sites; more than 8,000 spills were recorded in North Dakota alone over the period 2008-2015 (Cozzarelli et al. 2017). Gadhamshetty et al. (2015) list some of the major spills in Williams and McKenzie counties, North Dakota, the two counties that lead the state in water consumption for drilling, and that include the primary Yellowstone-Sakakawea paddlefish rearing and migratory areas. Numerous wells and pipelines are within the active floodplain, and on occasion are completely submerged during periods of high river flows or high lake levels (Figure A2-6). Although most of the spills of oil or brine have been minor, some have had substantial impacts (e.g., the Blacktail spill of 2015; Cozzarelli et al. (2017), as well as a spill in the Yellowstone river upriver of Glendive in the same year (https://news.mt.gov/legal-order-finalized-for-2015-oil-spill-in-yellowstone-river-near-glendive)); Kellogg 2016). Very few have been scientifically investigated for their effects. Furthermore, a study by McEvoy et al. (2017) documented the general tendency for the public within the region to view oil spills as "no big deal" (p.858) because of the general public perception that nature is resilient. The ability of widely distributed, short lived organisms such as insects and other invertebrates to recover may be much more rapid, however, than the rebound capability for 40-year old paddlefish. Following a 2011 pipeline rupture and oil spill near Laurel, the YRCDC commissioned a study that found "39 pipelines intersecting the Yellowstone River Channel Migration Zone (CMZ) at 21 crossings. Thirty of the pipelines cross the channel while nine pipelines are located within the CMZ" (p. 71; Kellogg 2016). Despite a general tendency to ignore their potential effects, the spill at Glendive in 2015 heightened awareness of the potential for damage to aquatic habitat (Kellogg 2016) and also served notice that a major spill within the lower Yellowstone or Williston Reach of the Missouri has the potential to cause severe negative impacts to the Yellowstone-Sakakawea paddlefish at any time. More effective scientific evaluation of effects of spills is needed, as are more realistic risk assessments of development activities in areas near watercourses that are sensitive to major disturbance from spills.

To reduce the likelihood of spills, the YRCDC encouraged the Pipeline and Hazardous Materials Administration (PHMSA), the Federal energy Regulatory commission (FERC) and all pipeline companies working in the Yellowstone River Basin adopt several guidelines as a minimum standard. These include the use of horizontal directional drilling (HDD): 1) all new pipelines at least 30 feet below the river channel bottom; 2) crossings located at a straight channel reach where possible; 3) avoid river bends and braided sections, 4) HDD entry and exit points outside of the channel migration zone (CMZ) boundary; 5) reclamation of drilling pads, staging areas and disturbed areas following HDD pipeline installation; 6) replacement of existing at-risk pipeline crossings with HDD technology; 7) eventual relocation and, in the meantime, regular inspection of all pipelines in the CMZ, even if not crossing the river; 8) removal of abandoned pipelines in the CMZ; 9) spill detection and remote shutoff valve technology; and 10) state and federal oversight and inspections, especially during major floods and ice jams. Other prudent actions, including risk assessment, are described in Kellogg (2016).

Pesticides and other industrial contaminants - Nationally, the greatest concern for contaminants in paddlefish has been expressed in the highly industrialized Ohio river basin with contaminants such as polychlorinated biphenyls (PCBs), DDT, chlorinated hydrocarbons, and

Figure A2-6. Oil well on floodplain during high water period of Lake Sakakawea, 1997.

mercury (Gunderson 2015). Compared to other piscivorous species paddlefish are less susceptible to bioaccumulation of contaminants, however their long lifespan, especially in Montana and North Dakota, affords them more years to bioaccumulate (Gunderson 2015). Irrigation project return flow ditches serve as conduits for the delivery of agricultural fertilizers and pesticides. Montana mining activities are sources of heavy metals and other contaminants.

Available information suggests that Yellowstone-Sakakawea paddlefish are not yet that heavily impacted by pesticides and other toxic substances, at least as indicated by analyses of fish flesh contamination. In 1990, paddlefish roe from 10 females weighing 19.5 to 31.8 kg (43 to 70 pounds) collected at Intake in June, were tested for concentrations of 20 different chlorinated hydrocarbon pesticides and their metabolites and two PCB compounds. Most compounds tested for were either absent or present in amounts below detection limits. DDE and dieldrin were present in some samples, but only in trace amounts. In North Dakota, fish tissue sampling is generally restricted to analysis for methyl-mercury (North Dakota Department of Health 2005). In Montana, the Department of Health and Human Services (DPHHS) and MFWP have worked with the Environmental Protection Agency (EPA) to sample sport-caught fish and develop and publish fish consumption guidelines for use by Montana anglers. Methyl-mercury is also the primary concern. An additional study should be conducted on the fish flesh and roe of Yellowstone-Sakakawea and Fort Peck paddlefish within the next 3-5 years using samples from harvested fish.

Effects of contaminants can also be manifested through biological responses such as the production of intersex fish. Although links between contaminants and paddlefish are not established, gonadal development in paddlefish should continue to be monitored for any presence of intersex fish (Schooley et al. 2020).

Neonicotinoid insecticides have been shown to cause mortality in a wide-range of freshwater organisms that constitute the food sources of young paddlefish (Beketov and Liess 2008; Sanchez-Bayo et al. 2016). Their use has been increasing, and, like most pesticides, their effects on aquatic life in rivers (and reservoirs: See reservoir water quality section below) are not adequately studied.

Legislation and regulations - In North Dakota, water quality issues for the Yellowstone River, Missouri River, tributaries, and Lake Sakakawea are under the purview of the North Dakota Department of Health, located in Bismarck. In Montana, the Department of Environmental Quality is the primary contact. Both states work closely with EPA on water quality issues (Montana Department of Environmental Quality and Environmental Protection Agency 2003).

River function and paddlefish habitat features

Paddlefish riverine habitat - In the past century, paddlefish riverine habitat has deteriorated in most localities as large rivers have been subjected to impoundment, dredging, channelization, bank stabilization, water withdrawals, and flow manipulations associated with water resource development projects (Russell 1986, Sparrowe 1986; Gerken and Paukert 2009). Paddlefish migrations in most large river systems have been hindered or blocked. In a few local or regional cases, paddlefish habitat has benefited, in terms of zooplankton production, from reservoir construction (e.g., Houser and Bross 1959; Scarnecchia 1996b; Scarnecchia et al. 2009). In most cases, however, such benefits have been greatly overshadowed by compensatory losses in river spawning habitat.

As a migratory species of large rivers, habitat use by paddlefish is more complex than for most other freshwater fishes. In the few localities where reservoirs have not completely altered large river habitats, a range of in-river habitat types are used directly and by paddlefish, including the main channel, side channels (connected and unconnected), sloughs, backwaters and tributary mouths. Paddlefish also often ascend larger tributaries, especially in high flow years. In most areas, reservoirs are also an important, and sometimes critical, aspect of paddlefish habitat.

The different aquatic habitat types in large river basins may be important for paddlefish at different life stages or seasons. For example, main channel areas may provide spawning habitat, reservoirs, sloughs and backwaters may provide rearing habitat, tailwaters and confluences with tributary streams may provide staging and spawning habitat, as well as important fishing sites, and small streams and tributaries may contribute water and suspended sediment important for successful spawning and first-year survival. Protection and maintenance of all of these habitat types may be important for paddlefish survival.

Although the typical habitat requirements for nearly all healthy wild paddlefish populations are well understood (natural or quasi-natural river hydrograph, temperature, sediment regimes, and adequate lentic rearing habitat), efforts at accurately and precisely characterizing paddlefish habitat with quantitative measurements and indices (Hubert et al. 1984, Crance 1987) have not been entirely satisfactory. Several reasons exist for this inadequacy. First, precise paddlefish habitat use is often difficult to characterize in their large river habitats. Habitat is easiest to characterize when the fish are more sedentary, as when staging in pools or tailwaters before spawning or over winter. During their feeding period, the fish may be highly mobile and their locations difficult to pinpoint. Secondly, most of the original paddlefish habitat had been highly altered a few decades before efforts at quantitative assessments were begun. Current habitat use for paddlefish, especially large, old adults, may bear little resemblance to the former high-quality habitat, but may merely be the best available remnant. Third, detailed habitat assessments of large rivers must be conducted over several years, at different years, to accurately assess habitat use and preferences. Fourth, the Habitat Suitability Index (HSI) methodologies that have proven more useful for trout and other species in small streams and mid-sized rivers may not be as easily applied for large river situations. Hubert et al. (1984) used the scant information available to develop HSI curves for paddlefish. Crance (1987) used the Delphi Technique, a technique seeking consensus of expert opinion, to assist in the development of HIS curves. Neither study was followed up by field testing. Most descriptions of paddlefish involve largely qualitative descriptions (e.g., Gerken and Paukert 2009).

Until recently, the most commonly used method of characterizing habitat use of sub-adult and adult fish in rivers has been by major river macrohabitat type (e.g. tailwater, side channel, backwater, etc.; Southall 1982; Southall and Hubert 1984; Moen et al. 1992). This approach has worked well in river segments having diverse and well-defined habitat types, as in the Upper Mississippi River, but is less useful in locations where off-channel habitats are scarce.

Recently, efforts have been made to use consumer-grade sonar to assess availability of spawning habitat, based on assumed preferences for specific substrate types (cobble; Schooley and Neely 2018). This and similar methods hold promise for other areas (Whitledge et al. 2019).

With the present limitations of paddlefish quantitative habitat models, one of the most useful approaches has been to use the paddlefish itself as an indicator species. The presence of adequate reproductive success, adequate recruitment, and a range of fishes of different ages is often a useful indicator of good large river habitat and adequate river function. High-quality river segments typically have quasi-natural patterns of discharge, temperature, and turbidity. Yellowstone-Sakakawea paddlefish preferentially select the more natural Yellowstone River for spawning rather than the more highly altered Missouri River above the Confluence (Firehammer 2004, Miller 2007). Whereas both the Yellowstone River and Missouri River above Fort Peck Reservoir are sites with successful reproduction and ongoing fisheries, habitats below main-stem dams (Fort Peck and Garrison) have not been utilized nearly as successfully by the species. This general pattern can be seen at numerous localities throughout the species' range.

Habitat of the Yellowstone-Sakakawea stock - The Yellowstone River is largely unregulated, with no main stem impoundments, and thus exhibits natural, seasonally high flows of turbid water. However, a few tributary impoundments do have an influence on the Yellowstone's flow. For example, Yellowtail Reservoir on the Bighorn River (a significant tributary to the Yellowstone River in Montana), impounds nearly a million acre-feet of water and limits the natural, high discharges of the Bighorn into the Yellowstone during snowmelt periods. In contrast, the flows of the Missouri River upstream of the Confluence are highly regulated (mostly by Ft. Peck Dam, approximately 322 Rkm , 200 river mi.) above the confluence, with summer flows relatively clear and cool.

The Missouri River from the Confluence to Lake Sakakawea (often called the Williston Reach) is unique because it exhibits characteristics of the two very dissimilar rivers which merge to create it. It not only retains many of the physical components of a natural river, it provides important staging, and spawning habitat for one of the most viable populations of paddlefish anywhere within the species range. Like the Lower Yellowstone River, it is a refuge for native Missouri River fish species that are declining in other locations, such as the pallid sturgeon, sicklefin chub *Machrybopsis meeki*, sturgeon chub *Machrybopsis gelida* (the last two species considered endangered on the American Fisheries Society Dakota Chapter list) blue sucker *Cycleptus elongatus*, and flathead chub *Platygobio gracilis*.

When the U. S. Army Corps of Engineers (USACE) purchased the entire lakebed and shoreline of Lake Sakakawea (prior to its impoundment), the acquisition included a substantial portion of the Williston Reach, approximately 40 Rkm (25 river miles). Under USACE water level management of Lake Sakakawea, the Williston Reach is occasionally impacted by very high lake levels. The shoreline and much of the floodplain within this reach, which generally extends from the area near the mouth of the Little Muddy River Rkm 2489 (RM 1547) upstream to the Erickson Island area (Rkm 2533, RM 1574), is almost entirely publicly owned and managed for fish and wildlife by NDGF. Public ownership and management have resulted in a substantial riparian corridor of willows and cottonwoods. A multitude of islands and sandbars of varying elevation throughout the Williston Reach also provide habitat complexity for paddlefish and other fish species. High land values coupled with valuable subsurface minerals complicate potential alternatives for protecting the Williston Reach from further habitat degradation.

Much of the land use on privately-owned property along the Lower Yellowstone River and Missouri Rivers near the Confluence and throughout much of the active floodplain consists of high-intensity agricultural use, mostly irrigated sugar beets, alfalfa, and increasingly, corn. Adoption of best agricultural management practices on the floodplain is an important goal. Paddlefish and other species would benefit from better livestock grazing practices, buffer strip development and management, better timber management practices, and proper fertilizer and pesticide application and management.

Protected areas - The Erickson Island area contains some of the most important paddlefish habitat for the Yellowstone-Sakakawea stock. The stretch of the Missouri River along the south side of the island has been documented to support some of the highest concentrations of adult paddlefish (and pallid sturgeon) found anywhere in the river system. The NDGF has funded an ongoing study to quantify the riverine habitats in this area, in an effort to identify unique habitat requirements. Paddlefishing has been closed in this area, and additional efforts must be made to protect this highly important reach from being degraded. Any development or agricultural project proposed within or in proximity to this area should be carefully scrutinized before it is allowed to proceed.

Importance of river function - A key aspect of the habitat quality for paddlefish is maintenance of river function. Although a deterioration of river function is commonly perceived to be a result of the control and modifications of large rivers, accurately and precisely defining large river function is not straightforward. Generalized conceptual characterizations based on the River Continuum Concept (Vannote et al. 1980) or Flood Pulse Concept (Junk et al. 1989) provide a broad framework for assessing river function, although they are not equally applicable for all rivers (e.g., Sedell et al. 1989). On a more practical level, it is helpful within those broad frameworks to develop a series of metrics by which river function may be assessed (e.g., as in assessing river restoration; Woolsey 2007).

As described in the Yellowstone River Cumulative Impacts analysis, numerous aspects of river function have been affected by development. These include altered hydrology from dams and water withdrawals, bank armoring to reduce local erosion, floodplain and side channel isolation, human development in the channel migration zone, conversion of riparian forests to farmland, wetland losses, invasive plant species, and water quality issues (U.S. Army Corps of

Engineers and Yellowstone River Conservation District Council 2015).

In order to best meet the needs of the various river users, while still protecting the paddlefish and other valued fishes, an objective assessment of management possibilities needs to be conducted. This includes the development and implementation of a resource conservation plan. Public expectations need to be appropriately framed within the context of physical reality. Well-intentioned but unrealistic desires to manage the river for a set of conditions which cannot be economically or ecologically justified must be identified and avoided. Any plan should be driven by unbiased hydrological and biological data complemented with sound public education. In the end, the goal for the USACE, the states of North Dakota and Montana, and the public, should be to maintain a healthy and functioning river.

Some specific characteristics of the Lower Yellowstone and Missouri rivers necessary to maintain and improve the river function, including the current fishery and aesthetic components, include 1) a braided channel in at least 25% percent of the river; 2) a dynamic channel that is allowed to move laterally, through erosion and accretion, rather than vertically; 3) maintenance of the current magnitude, seasonality and other components of the hydrology of the Yellowstone River, including discharge, temperature, and suspended sediment both in the main river and from tributaries; 4) exchange of nutrients between the river's riparian zone and different large river habitats; 5) restoration of a more natural, pre-impoundment hydrology (including temperature regime and sediment load) for the Missouri River below Fort Peck Dam only if sufficient to improve paddlefish spawning, rearing and recruitment success; 6) protection and restoration of flood plain woodlands (Bovee and Scott 2002), backwaters and associated wetlands; 7) unimpeded fish passage; and 8) land management activities which minimize inputs of pesticides and other contaminants.

Bank stabilization and shoreline management - As part of river function, most of the aquatic habitat in the Yellowstone River is being continually rearranged by an active river channel that scours riverbanks and creates a maze of sandbars. River meandering, including both erosion and accretion, is a natural process that is vital to healthy river function. These processes have been curtailed greatly below Fort Peck and Garrison dams as a result of flow regulation and bank stabilization. The purpose of bank stabilization is usually to reduce lateral erosion and loss of agricultural lands (Figure A2-7). The vast majority of the perceived need to complete additional bank stabilization projects on the Missouri and Lower Yellowstone Rivers stems from the highly intensive agricultural use of the floodplain. This is especially true at many locations where crops are planted right up to the edge of the river. However, if the river cannot maintain its sediment load via bank erosion, it will pick sediment from unstabilized areas and the river bottom. The result is the development of new erosion problems, riverbed degradation, and the escalating need for more bank stabilization. Erosion, channel degradation, and island and sandbar losses associated with the 2011 flood have been a particular problem in the highly stabilized and regulated section below Garrison Dam (Schenk et al. 2014).

Approximately 9% of the Williston Reach has been directly affected by revetments, jetties, riprap, car bodies, tires, sheet/wood pilings, or channelization. This estimate includes the impacts to nearly 6.5 km (4 mi.) of meandering river around what is now Erickson Island, where the river was straightened by the USACE. For comparative purposes, approximately 30% of the Garrison Reach of the Missouri below Garrison Dam has been directly stabilized.

There is a great need to protect the natural riparian corridor (and thereby protect natural river function) along much of the private portions of the rivers from additional bank stabilization efforts. Programs to obtain conservation easements and riparian areas in fee title should be encouraged, funded and implemented to help alleviate the demand for additional bank stabilization (Montana Aquatic Resources Services 2017). In the event that significant impacts caused by erosion to private lands are documented, sloughing or conservation easements (as identified by the USACE as the most prudent alternative) should be obtained from the affected landowners, in lieu of bank stabilization. In addition to being far more environmentally friendly, sloughing easements, conservation easements, and fee title acquisition tend to be more economically feasible alternatives than riprap. The USACE estimated that the cost to complete traditional bank stabilization was approximately $600,000 to $1 million dollars per mile. As an example, in 1996 the Corps stabilized approximately 4,000 feet of the Williston Reach using so-called “environmentally-friendly” bank stabilization techniques. The cost of this effort was about $450,000, or $113 per lineal foot (not including an estimated $8,000 annual maintenance cost). By comparison, the cost of purchasing the bank in fee title or acquiring a sloughing easement on the adjacent land was evaluated at $69,000, or only $17 per lineal foot.

Even though approximately 40% of the shoreline and adjoining lands of the Williston Reach of the Missouri and Yellowstone rivers are in public ownership, bank stabilization efforts continue to be recommended in order to protect select infrastructure, regardless of land ownership. The purpose and need for any additional bank stabilization should be critically evaluated. At the very least, no additional public funds should be spent if the sole intent of the project is to protect adjoining private property interests.

Downriver and upriver impacts - Another aspect of river function is the linkage between upriver and downriver reaches. Although the Missouri River Basin has become a highly segmented ecosystem, each reach from Montana to St. Louis (and the Yellowstone River) may have direct or indirect impacts on the others. In the Williston Reach, for example, the Yellowstone and Missouri rivers above the Confluence are very dissimilar, yet the Missouri River below the confluence still maintains many of the same functions as it did before the system was greatly modified. Since approximately one-half of the annual flows of the Missouri River below the Confluence are controlled by Fort Peck Dam, balancing the riverine habitat needs and demands requires a holistic approach toward management and protection. Management actions need to consider both upstream and downstream ramifications, as well as needs for each reach.

Figure A2-7. Riprap and bank stabilization restrict river function.

Legislation and regulations - In Montana, two state laws give MFWP some, but limited, authority and effectiveness in altering or denying river projects that could negatively affect river function and fish habitat, including paddlefish habitat. The first, the Stream Protection Act (commonly known as the 124 Law) applies to "any agency or subdivision of federal, state, county, or city government proposing a project that may affect the bed or banks of any stream in Montana". Activities requiring a permit are "any project including the construction of new facilities or the modification, operation, and maintenance of an existing facility that may affect the natural existing shape and form of any stream or its banks and tributaries" (p. 79; Montana Association of Conservation Districts et al. 2005). The second, the Natural Streambed and Land Preservation Act (commonly known as the 310 Law) applies to "any private, nongovernmental individual or entity that proposes to work in or near a stream on public or private land". Activities requiring a permit are "any activity that physically alters or modifies the bed or banks of a stream." (p. 82; Montana Association of Conservation Districts et al. 2005). In practice, the Stream Protection Act provides MFWP the opportunity to request modifications of a proposed project. Input on the 310 law is primarily advisory. In addition to these two which result in review of applications by MFWP, there are several other laws affecting stream function or fish habitat that require project review by the Montana Department of Environmental Quality and U.S. Army Corps of Engineers (Montana Association of Conservation Districts et al. 2005).

In North Dakota, NDGF has input on projects associated with islands and beds of navigable streams and waters under Article 89-10 of the North Dakota Administrative Code. "Each project which lies either partially or wholly below the ordinary high watermark of navigable streams or waters [i.e. including the entire Missouri and Yellowstone rivers] requires an authorization from the state engineer prior to construction or operation, except as specified in sections 89-10-01-10 and 89-10-01-19" (p. 3; http://www.legis.nd.gov/information/rules/admincode.html).

Fish passage

Although fish passage is less of a problem for paddlefish in Montana and North Dakota than in other areas, problems exist. The Diversion Dam at Intake, part of the LYIP, has historically provided a major, but not total, impediment to upstream migration of pre-spawning paddlefish, and results in the concentrated fishery at Intake; (Figures A2-8a). Water diverted into the main canal for irrigation historically also resulted in entrainment of a wide variety of species, including paddlefish (Hiebert et al. 2000). As part of recovery efforts for pallid sturgeon, fish passage and screening designs for the Dam and canal have been developed (U. S. Army Corps of Engineers 2006) and augmented (U. S. Army Corps of Engineers 2007; Figure A2-9). The primary goal of this effort is to develop suitable fish passage on the Yellowstone River at the Intake Diversion Dam and screening to prevent entrainment of juvenile and adult fish into the canal. Although

Figure A2-8. Historical low head irrigation diversion dams at a) Intake and b) Cartersville (Forsyth), Montana.

Figure A2-9. Fish passage project improvements at the Intake site - pictures a, b, c: new Intake Canal head gate and screens completed in 2014; d) design elements of project; e) downstream portion of the constructed bypass channel March 2020; f) construction causeway removal after completion of the south half of the new concrete weir December 2020, and g) completed south half of new weir January 2021.

designed for the pallid sturgeon, both canal screening and adult passage have the potential to benefit paddlefish migrations, spawning, and juvenile survival.

As of 2019, the canal screening is completed and the bypass channel is under construction. Evaluations of movements of paddlefish over the dam and via the side channel at Joe's Islands by Rugg et al. (2019) indicated that paddlefish movements past Intake were predominately via the side channel . The side channel provided substantial ecological benefits to paddlefish when the Yellowstone river flows were sufficiently high to fill the channel. Despite its documented ecological value, the side channel has been filled in as part of the new bypass channel constructed next to the dam. At this time, it is unclear exactly how the new structure will affect paddlefish movements and the fishery at the Intake site, or paddlefish reproduction and recruitment. Future studies are funded and will begin in 2022 to answer these questions.

Reservoir water quantity

Results of Scarnecchia et al. (2007b) strongly suggest that for the Yellowstone-Sakakawea paddlefish stock, year class strength, recruitment, growth, and energy storage accumulation (GFBs) are greater in years of high reservoir levels than low levels, and greater in years of rising water levels than falling ones (Scarnecchia et al. 2009). Similarly, higher numbers of age-0 fish in Fort Peck Reservoir were also found in years of high reservoir levels. Trophic upsurge (Kimmel and Groeger 1986) associated with rising water levels favors growth and survival of paddlefish. In just over a half century of existence, Lake Sakakawea's water level changes have ranged from high-volume, long-term changes such as the initial filling, to mid-term, mid-volume changes such as in the period 1993-1995, to short-term (seasonal or shorter), low volume changes that commonly occur. The rapid rise in the reservoir in 1993 (Figure 5) following the drought and resulting low water period of 1988-1993 provided much needed recruitment to the fish stock and fishery. Although Lake Sakakawea often has had difficulty in keeping shoreline vegetation established amid rapid fluctuations in levels, the long period of low water levels from 2002 through 2007 resulted in extensive re-vegetation around the shoreline. When climatic factors such as in 1992-1993 and 2011 reoccur, or river management objectives change, and Missouri River discharges are once again held back and Lake Sakakawea rises to full pool, inundation of these shorelines and the vegetation will result in another upsurge period, and an increase in paddlefish year class strength and growth can be expected (Scarnecchia et al. 2014). Between low reservoir levels and the rise, some years are also needed for revegetation to provide a stronger upsurge. It is not yet clear if it would be preferable for paddlefish recruitment to have one rapid rise in the reservoir to full pool (in a year or two) or a step-like annual series of 4-5 increases to full pool. Any such periodic increases in water levels will be favorable for the paddlefish as well as many other fish stocks (Hendrickson 2003; Hendrickson et al. 2007; Scarnecchia et al. 2019b).

Higher water in Lake Sakakawea and Fort Peck must be considered a high priority for paddlefish, even if benefits for other species differ. Gerrity (2005) noted that low water levels in Fort Peck Reservoir created an additional 34 mi (56 km) of riverine habitat upstream of the reservoir and this suggests that maintaining lower reservoir pools may be beneficial in creating additional riverine habitat for pallid sturgeon. Although the beneficial effects of low water levels to pallid sturgeon have not been conclusively proven, the beneficial effects of higher water levels for paddlefish, particularly after a period of low water levels, are well documented (Scarnecchia et al. 2007).

Reservoir water quality

Basic water quality measurements are made in Lake Sakakawea by the North Dakota Department of Health in conjunction with the NDGF (Elstad 2001; North Dakota Department of Health 2005). Overall, water quality has not been considered a major issue. However, persistent low water levels and high rates of accumulated sedimentation in the upper end of Lake Sakakawea may pose problems for feeding by recently hatched paddlefish. Sedimentation in the upper portions of both mainstem reservoirs is inadequately monitored, especially in Lake Sakakawea, where the reduction in available paddlefish rearing habitat has been very great but unquantified. Another issue is the presence of dead zones in the increasingly prevalent sediments of the upper end of reservoirs. The dead zones have the potential to negatively affect recently emerged paddlefish, as has been reported for pallid sturgeon (Guy et al. 2015). Mosquito control efforts between Williston and the Confluence also have the potential to affect food webs important to young paddlefish, especially during their first year of life. Neonicotinoid insecticides have been shown to cause mortality in a wide-range of freshwater organisms that constitute the food sources of young paddlefish (Beketov and Liess 2008; Sanchez-Bayo et al. 2016). Perhaps because of the limited recreational potential and use of the upper portion of Lake Sakakawea, the potential damage to food webs has been largely ignored. It deserves to be investigated.

Emerging issues

Mortality of adult paddlefish from boat traffic - Paddlefish are highly susceptible to being struck by propellers from fast-moving motorboats (Rosen and Hales 1980). Fortunately, as of 2019 neither the Yellowstone-Sakakawea stock nor the Fort Peck stock inhabit areas with a very high volume of boat traffic. Boat traffic in the upper portions of Lake Sakakawea has generally been low even during high water levels. The same low-use patterns generally prevail in the upper end of Fort Peck Reservoir and in the Missouri River below the Fred Robinson Bridge. The Wild and Scenic designation above the Bridge prevents motorized traffic after Memorial Day. In the past decade, however, increased boat traffic around the Confluence associated with spring and fall walleye fishing has posed an escalating hazard to adult paddlefish. Similarly, the Oahe paddlefish often stage in an area near Bismarck with a higher volume of boat traffic. Monitoring of scarred paddlefish from propeller damage is ongoing at the fish cleaning stations for the Yellowstone-Sakakawea stock and will be continued.

Aquatic nuisance species - Aquatic nuisance species are not considered an immediate threat to paddlefish in North Dakota and Montana. However, these species may rapidly pose threats if they find their way into Lake Sakakawea and the Yellowstone and Missouri rivers. Invasive bigheaded carps *Hypophthalmichthys* spp. are filter-feeding zooplantivorous fish that may compete for food with paddlefish in situations where food is limited (Schrank et al. 2003). Zebra mussels can filter large volumes of water, resulting in reduced phytoplankton, diversion of energy from the pelagic to the benthic zone (Ram and McMahon 1996), and negative effects on pelagic zooplanktivores such as the paddlefish. A combination of zebra mussels and bigheaded carps could result in greatly reduced productivity of the pelagic zone along with increased competition for that production. Programs are in place to prevent the introduction and spreading of such aquatic nuisance species into North Dakota and Montana (Missouri Basin "River Watch" Newsletter 2007). Their long-term success is uncertain.

MFWP's Aquatic Invasive Species (AIS) program involves 1) boat inspection stations during the open water months, 2) random sampling of rivers and waterbodies for invasive species, and 3) an educational program to increase the public's awareness of AIS and prevention measures to reduce the spread of invasive species. In 2018, Montana's AIS program included more than 10,000 boat inspections from 35 watercraft inspection stations. The program intercepted 16 out-of-state boats contaminated with mussels. It collaborated with partners statewide to operate watercraft inspection stations at Bighorn Canyon National Recreation Areas, Blackfeet Tribe, Confederated Salish & Kootenai Tribes, Garfield & McCone County Conservation Districts, Glacier National Park, Missoula County Weed district, and Whitefish Lake Institute. Its monitoring crews surveyed 1,450 sites on 250 different waters for invasive plants and animals. More than 2,000 plankton samples were collected for early-detection of mussels (no veligers or adult mussels were detected). Environmental DNA (eDNA) testing was conducted at Tiber Reservoir in July (no mussel DNA was found). Divers and mussel-sniffing dogs were used at Tiber and Canyon Ferry reservoirs (no mussels were detected). Law enforcement issued more than 50 citations and more than 170 warning related to invasive species violations. MFWP and partners conducted a mussel rapid response exercise on Flathead Lake to practice a coordinated response should mussels ever be detected. Through June 2019, the AIS program has conducted more than 26,000 boat inspections, intercepted 11 vessels with zebra or quagga mussels (*Dreissena rostriformis*), and expanded cooperation efforts with County Conservation Districts to operate boat inspection stations at Broadus (Powder River Conservation District) and St Xavier (Big Horn Conservation District). MFWP has collected more than 270 plankton tows for zebra/quagga mussel early detection (220 samples processed so far with no mussels detected). Asian clam shells were found in Lake Elmo in Billings. No live specimens were found but monitoring is ongoing.

Lead sinkers - There is currently no specific evidence of any significant impacts of the loss of lead sinkers on the habitat in the Yellowstone and Missouri Rivers. However, the issue has not been investigated. The scientific literature is replete, however, with studies from other localities showing the negative effects of lead from sporting ammunition and fishing weights (sinkers) on birds (Grade 2018). Some studies are a century old. Despite the evidence, relatively few jurisdictions have limited lead usage in substantial ways (Thomas et al. 2019).

The Intake site presents the greatest potential problem because of the high concentration of snaggers at that site for more than 40 years. Woody debris and tree snags in the channel below the dam collect snagging gear. Although the negative impacts on waterfowl that consume lead shot (i.e., small pieces of lead) are well known, the large size of the lead sinkers (typically 4 to 6 ounce) used in paddlefish snagging are too large to pose a direct threat. A few states have enacted regulations banning small lead sinkers (e.g. ½ ounce or less, in New York; one ounce or less, New Hampshire; Grade et al. 2018; Thomas et al. 2019).

Climate change - If climate change scenarios are accurate, the many potential impacts on Yellowstone-Sakakawea paddlefish are difficult to accurately predict. Modeling studies on sturgeons have most commonly shown concern for the effects of warming waters, leading to the exceeding of thermal maxima (Lassalle et al. 2010, Hupfeld et al. 2015). This problem would seem to pose little immediate concern for paddlefish in this region, which is nearer the northern extremity of their range. It can be anticipated, however, that even with slight warming, snowmelt will be less in high elevation areas, resulting in earlier runoff and a smaller peak discharge in spring (Watson et al. 2018). These effects will be exacerbated by increased water use in the basin as higher temperatures increase demand for water. If sustainable fisheries could be maintained, the seasons would probably start earlier and end earlier. In addition, the paddlefish's protracted life history would also be expected to be shortened as metabolic rates increase in a warmer climate in Montana and North Dakota (Scarnecchia et al. 2011). Other indirect effects might involve increases in other competitive or predatory species or effects difficult to accurately predict.

Appendix A-3 Global Review of Paddlefish

The North American paddlefish is a large, ancient, migratory fish native to the Mississippi and Missouri river basins and a few Gulf Coast Drainages (Russell 1986; Gengerke 1986; Jennings and Zigler 2000; Figure A3-1). The species was once thought to be a close relative of sharks but is now known to be a remnant of an ancient basal-lineage of more modern ray-finned fishes (Grande and Bemis 1991; Crow et al. 2012). A highly specialized polyodontid descended from bottom-dwelling Acipenseriform fishes (sturgeons; Grande and Bemis 1991), *Polyodon spathula* has fossil ancestors known from North America (Grande and Bemis 1991) and China (Lu 1994; Grande et al. 2002). Fossil paddlefish have been found in eastern Montana near Fort Peck from the Upper Cretaceous period (*Paleopsephurus wilsoni*: MacAlpin 1947; Figure A3-2a) and Lower Tertiary period (early Paleocene: *Polyodon tuberculata*: Grande and Bemis 1991; Murray et al. 2020) and from the Eocene in Wyoming (Grande 1984; Grande and Bemis 1991; Figure A3-2b). The species is one of North America's oldest vertebrate animals. The only other recently living paddlefish species, *Psephurus gladius*, formerly found in the Yangtze River of China, appears to have become extinct within the past decade because of habitat loss from dam construction and overharvest (Wei et al. 1997; Zhang et al. 2016, 2020; Figure A3-3). The closest living relatives are the sturgeons (Acipenseriformes: Family Acipenseridae).

Polyodon spathula is unique among its close relatives in its filter feeding with long gill rakers (Imms 1904; Figure A3-4), “more numerous and densely packed stellate bones supporting the lateral parts of the rostrum resulting in a stiff, flattened rostrum rather than just an elongated snout] and lacking the well-developed enameloid tubercles on the skull roof possessed by other species [i.e., less armoring on the head]” (p. 12; Grande and Bemis 1991). Its filter-feeding habits and habitat use also differs markedly from other Acipenseriform species. The distinctiveness of *Polyodon spathula* and its use as a food fish was recognized by several early North American explorers and travelers (Rostlund 1951; Tenney and Power 1992), including Fernando de Soto (Bond 1937), Jacques Marquette, Pierre Esprit Radisson (Adams 1961), Father Louis Hennepin, Zebulon Pike (Coues 1895), James Atkinson (Atkinson 1864), as well as by early fisheries scientists (Alexander 1914; McKinley 1984).

Broad, range-wide reviews of aspects of paddlefish biology, ecology, habitat use, and management have been conducted previously (Vasetskiy 1971; Russell 1986; Hesse and Carreiro 1997; Graham 1997; Jennings and Zigler 2000; Jennings and Zigler 2009; Shelton 2015). The paddlefish inhabits large rivers (Pracheil et al. 2012), floodplain lakes (Clark-Kolaks et al. 2009), and reservoirs (Scarnecchia et al. 2009), using and traversing a variety of interconnected large river habitats to complete its life cycle (Russell 1986; Jennings and Zigler 2009). The species has evolved a highly specialized life history where, beyond their first few months (Michaletz et al. 1982), they filter feed (Imms 1904; Miller 2004) up in the water column, mainly on zooplankton (Eddy and Simer 1929; Rosen and Hales 1981; Russell 1986; Fredericks 1994). An elongated, flattened rostrum (Thompson 1934) and ram ventilation have evolved along with the movement up in the water column (Burggren and Bemis 1992; Sanderson et al. 1994). They detect food

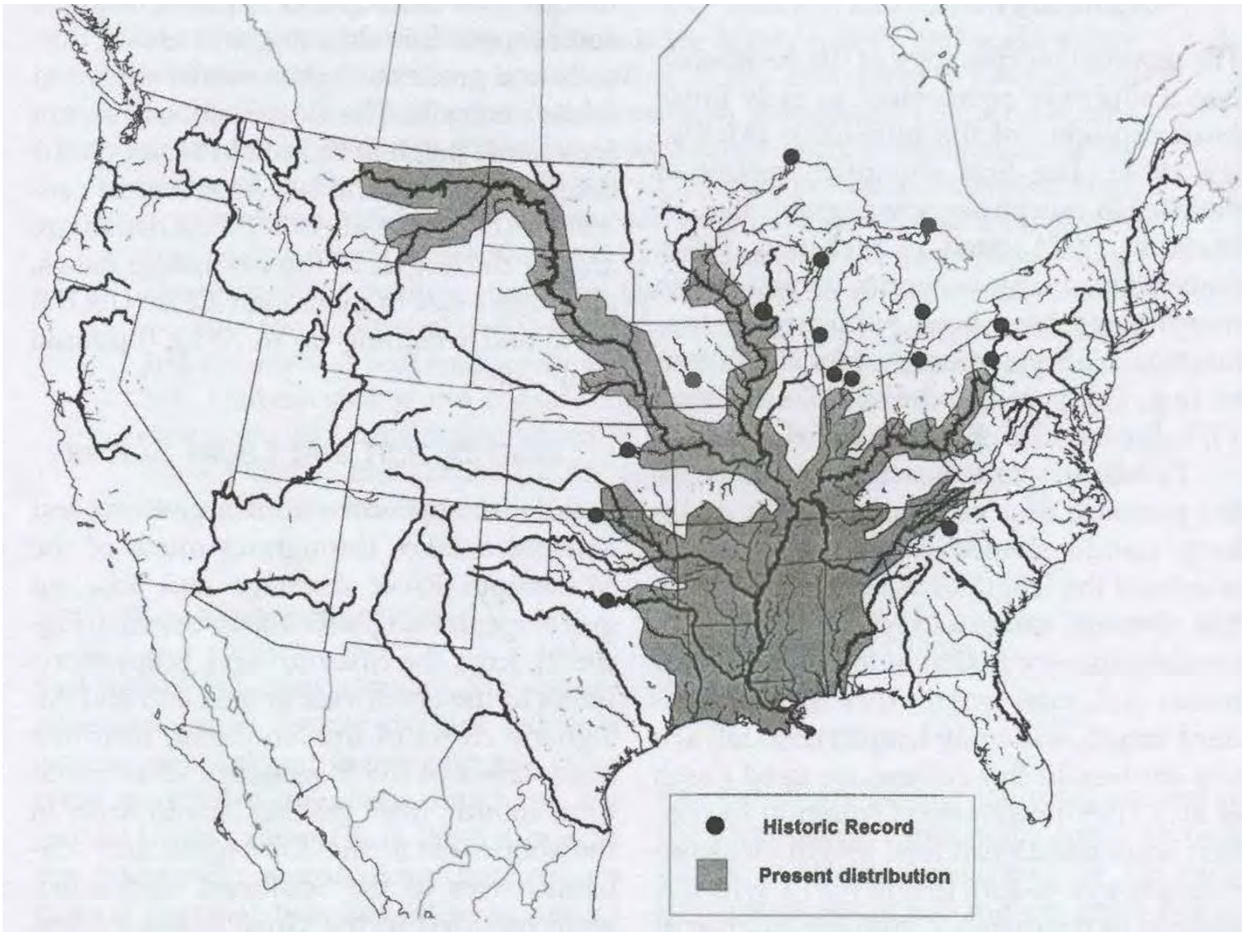


Figure A3-1. Distribution of paddlefish in North America. From Jennings and Zigler (2009) adapted from Carlson and Bonislawsky (1981). The shaded portion shows the current distribution. Dots indicate locations of early historic records of capture without recent confirmation. Note that Montana and North Dakota have the most northern and western stocks of the species.

a) b)

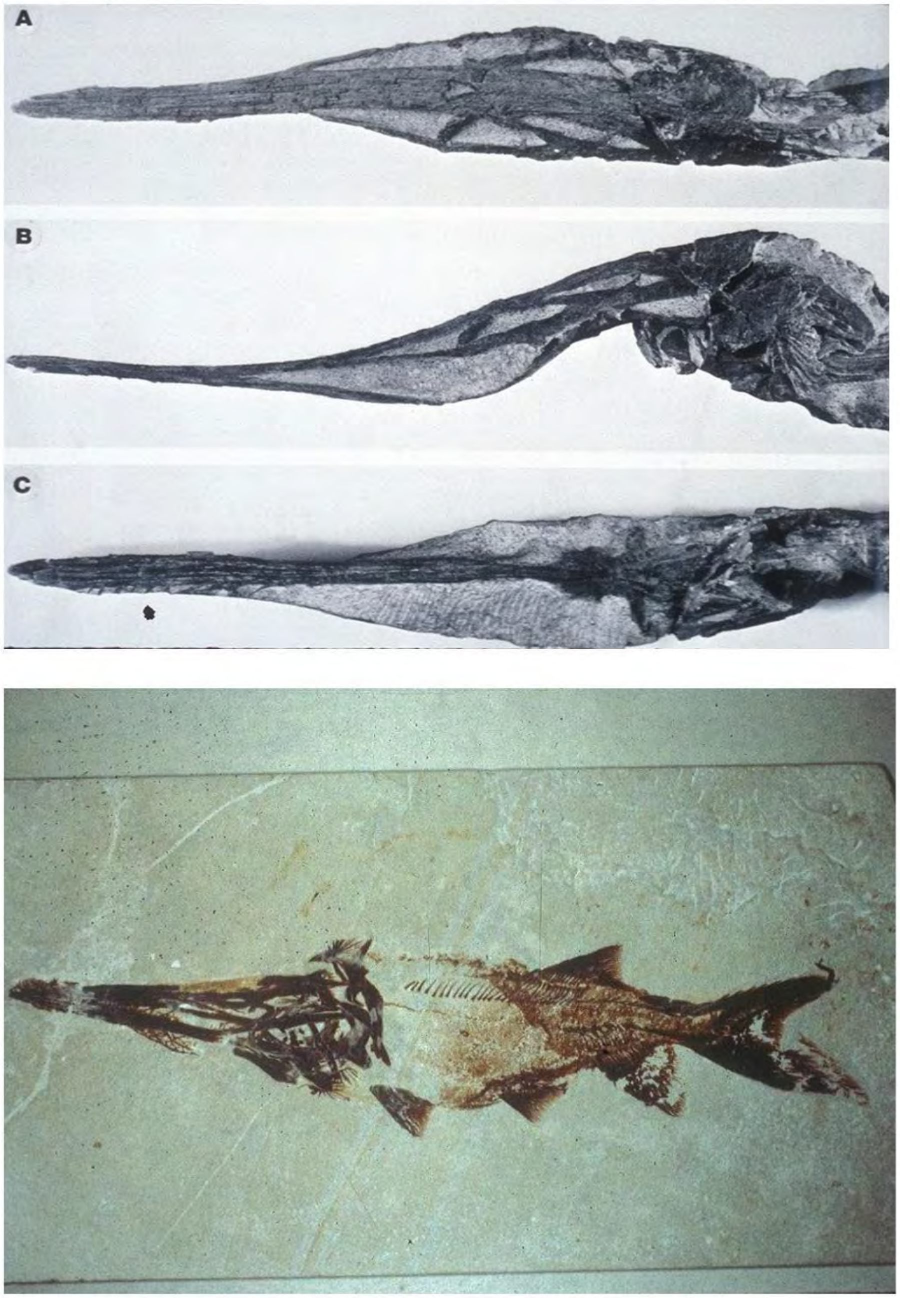
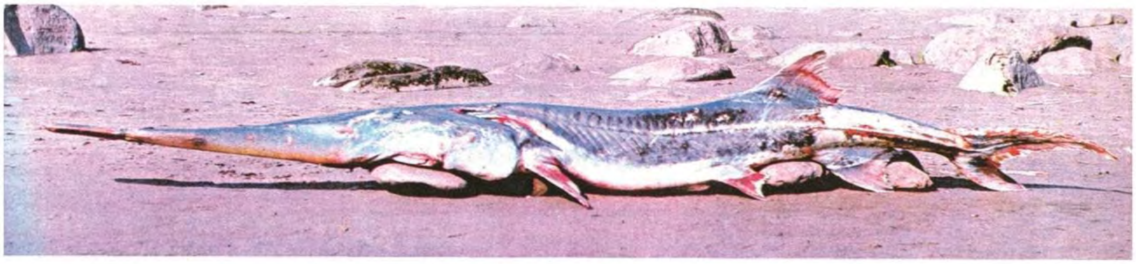
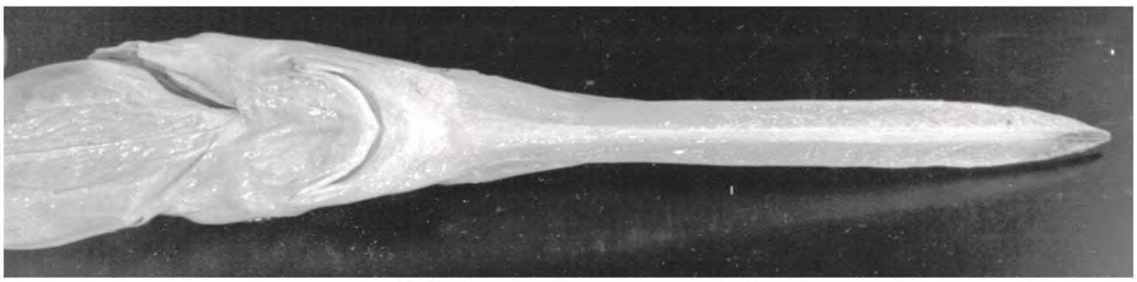


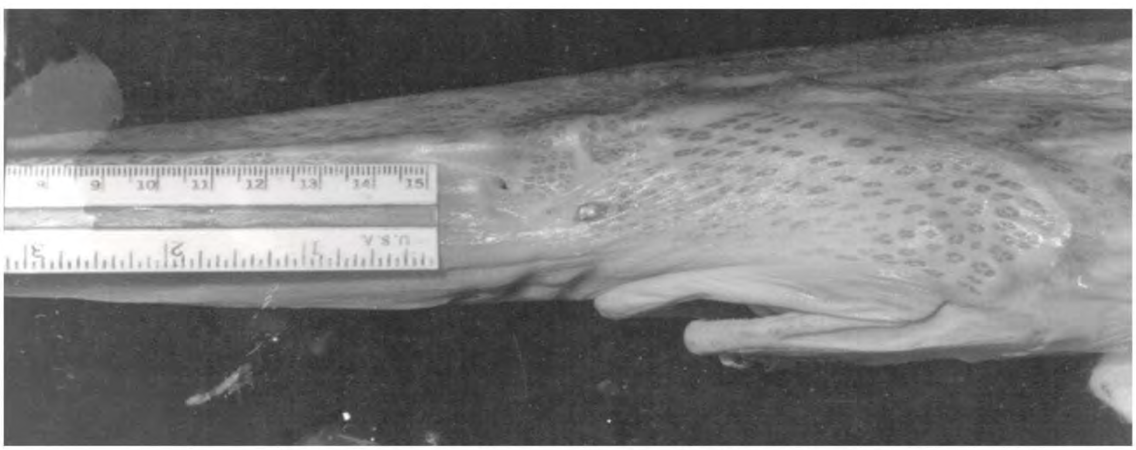
Figure A3-2. Fossil paddlefish: a) *Paleopsephurus wilsoni* from the Upper Cretaceous, Montana (MacAlpin 1947) and b) *Crossopholis magnicaudatus* from the Eocene, Green River Formation, southwestern Wyoming (Grande 1984; Grande and Bemis 1991).

Psephurus gladius



Estimated length: 4.5 – 5 m
Photographer: S. D. Mims





Preserved specimen: 75 cm
Photographer: T. A. Georgi

Figure A3-3. The Chinese paddlefish, *Psephurus gladius*, a bottom-dwelling, large river species with spear-like rostrum. The species has been declared extinct as of 2020 (Zhang et al. 2020).

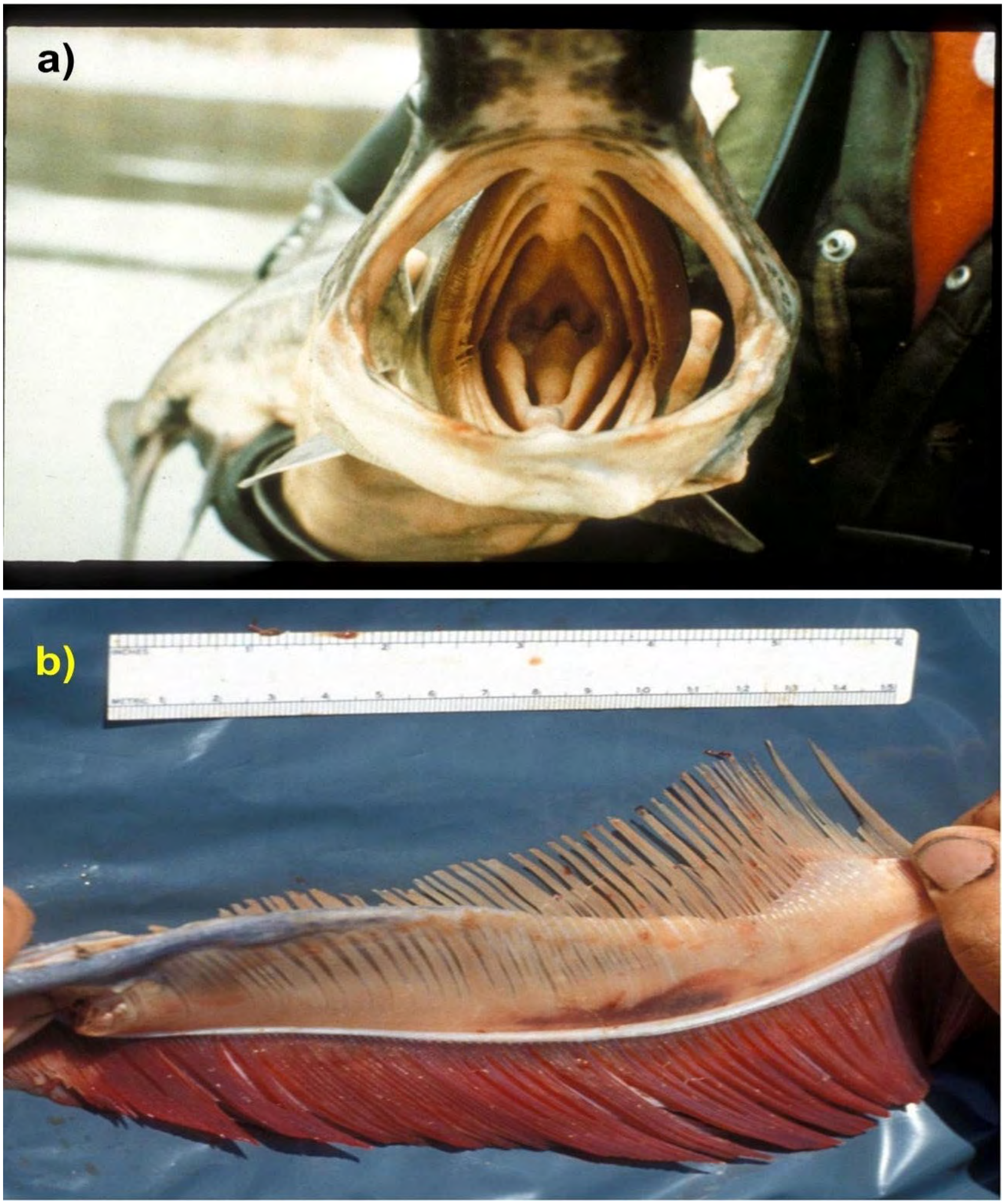


Figure A3-4. a) Open mouth of paddlefish showing gill rakers used by *Polyodon spathula* in filter feeding; b) closeup or rakers on one gill arch. Photos by D. Scarnecchia.

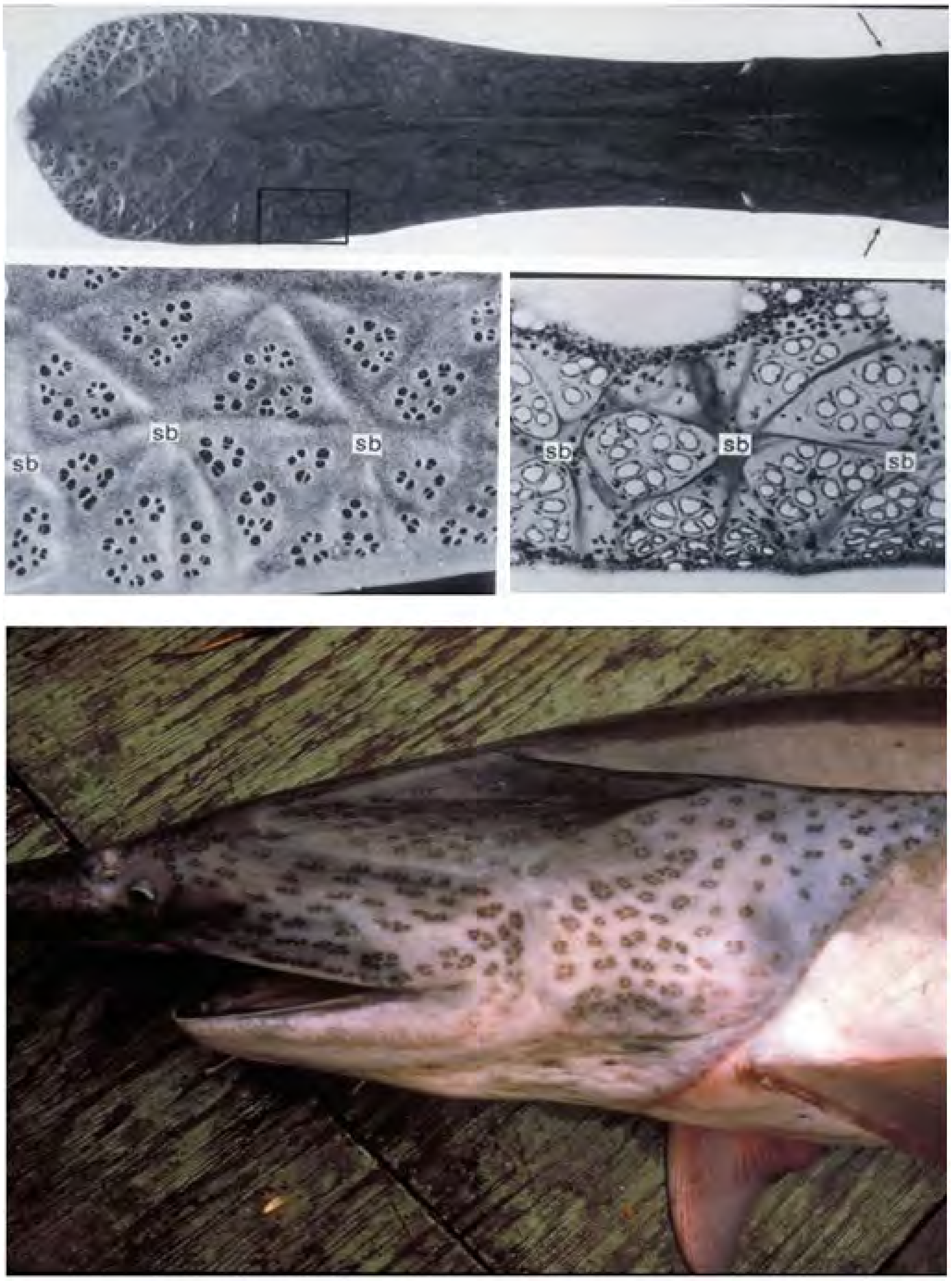


Figure A3-5. Electrosensory system on rostrum, head, and operculum of the paddlefish. (Grande and Bemis 1991)

with an electrosensory system associated with the rostrum, head, and opercula (Kistler 1906;

Nachtrieb 1910; Wilkens et al. 1997; Wilkins 2001; Wilkins et al. 2002; Figure A3-5). The rostrum also provides hydrodynamic lift to stabilize the fish in the water column during feeding (Allen and Riveros 2013; Patel and Riveros 2013). This unique life history and morphological adaptations of *Polyodon spathula* contrast with fossil paddlefish, which were typically bottom feeders much like the present-day sturgeons and *Psephurus gladius* (Miller 2004; Figure A3-3).

Paddlefish occupy, or within the last century occupied, portions of 26 states (Gengerke 1986; Bettoli et al. 2009; Figure A3-1). Although recent conservation efforts (Bettoli et al. 2009; Jennings and Zigler 2009) and reintroductions (e.g., New York-Pennsylvania: Budnik et al. 2014) have stabilized and re-established some populations, some of the largest naturally-spawning populations in historical times have declined greatly in abundance, such as in the Osage River in Missouri (Graham 1992) and the Missouri River in South Dakota (Unkenholz 1986). Their peripheral range contracted in the 20th century (Gengerke 1986; Graham 1997) and mere remnant populations remain in several states where they were once abundant.

Several factors have contributed to declines in paddlefish throughout their native range. Inadequate natural reproduction and poor or erratic recruitment remain major concerns in many localities (Scarnecchia et al. 2009, 2014). Loss of suitable spawning habitat in regulated rivers has been a major cause of the declines (Sparrowe 1986). Before the twentieth century, paddlefish had free access throughout the entire Mississippi and Missouri River basins; migrations of hundreds of kilometers have been documented in the lower basin (Russell 1986). Under historical conditions of greater migratory opportunity and access, sporadic recruitment in a given location may have been compensated for by immigration from other areas (Scarnecchia et al. 2014). High river discharges in spring facilitated long-range migrations (Russell 1986; Pracheil et al. 2012; 2015). Twentieth-century impoundments and channel alterations throughout the paddlefish's range have controlled flood waters, blocked fish migrations (Sparrowe 1986), permanently inundated gravel bars suitable for spawning, and resulted in severe reduction or extirpation of populations (Unkenholz 1986; Jennings and Zigler 2000). Despite habitat alterations, the species continues to live and migrate, among a wide variety of large river habitats, lakes, and recently constructed reservoirs throughout the central United States (Forbes and Richardson 1920; Jennings and Zigler 2009; Pracheil et al. 2012; 2015; Tripp et al. 2019). Although paddlefish feed and grow well in many newly-created reservoir habitats (Houser and Bross 1959; Houser 1965; Graham 1992; Boone and Timmons 1995; Scarnecchia et al. 2009), their requirement of natural or quasi-natural hydrographs for spawning restricts their natural production mainly to areas with free-flowing or quasi-free-flowing rivers. Young paddlefish in their first year are also highly susceptible to predation (Mero et al. 1995; Parken and Scarnecchia 2002) from both native and increasing numbers of non-native piscivorous fishes (Scarnecchia et al. 2019b). Competition with non-native Asian carps also potentially threatens native paddlefish stocks (Schrank et al. 2003; Zhu et al. 2014; Kinlock 2020). Overfishing has also contributed to the decline of paddlefish in many localities (Hoxmeier and DeVries 1996; Jennings and Ziegler 2000; Scholten and Bettoli 2005). In the late nineteenth century, paddlefish were perceived as low-valued and of questionable merit as a food fish (Jordan and Evermann 1896; Mestl et al. 2019). Interest in the fish and their valuable caviar increased greatly, however, in the early twentieth century (Hussakof 1910; Alexander 1914; Coker 1930). Commercial harvest of paddlefish has occurred for over a century (Stockard 1907, 1908; Coker 1923; Quinn et al. 2009; Scholten 2009; Rider et al. 2019).

Paddlefish generate considerable economic activity throughout much of their range. They support commercial harvest in eight states (e.g., McDougall 2005; Scholten 2009; Quinn 2009, Quinn et al. 2009; Leone et al. 2012; Association of Fish and Wildlife Agencies 2014; Hupfeld and Phelps 2014). They are also an important source of high-quality recreation (Oklahoma: Gordon 2009, Schooley et al. 2014; Montana and North Dakota: Scarnecchia et al. 1996a; Kansas: Neely et al. 2015; Mestl et al. 2019; Stockebrand and Neely 2020). Recreational fisheries based on snagging the fish below migration barriers or hindrances have become popular since about 1950 and exist in 14 states (Graham 1997; Hansen and Paukert 2009; Mestl et al. 2019). The species is also a source of high-quality meat (Decker et al 1991; Lou et al. 2000; Onders and Mims 2015) and expensive caviar (Dillard et al. 1986; Waldman and Secor 1998; Jennings and Zigler 2009), the latter contributing widely to global markets (Harris and Shiraishi 2018; Figure A1-6). Domestically, caviar is produced from commercial harvest (Quinn 2009), and recreational fisheries in the states of Montana, North Dakota and Oklahoma are combined with voluntary, non-profit roe donation programs developed to utilize formerly discarded roe. All net proceeds from the three programs either aid directly in resource conservation (all three states) or go to community-based grant programs for public benefit (Montana and North Dakota; Scarnecchia et al. 1996a; 2008; 2011; 2014; Schooley et al. 2014).

Several factors make effective management of paddlefish a greater challenge than for many other species. First, fundamental information on the biology and ecology of the species has been either scarce or lacking in many localities. Much of this information shortage is attributable to the difficulty of sampling adequately in the species' large, turbid riverine habitats (O'Keefe et al. 2007). It was not until the early twentieth century that young paddlefish were even located and identified (Allen 1911; Danforth 1911; Thompson 1933). Age estimation was not effective until Adams' (1931; 1942) research using sectioned dentaries (lower jaw bones). Validation of this method has only occurred fairly recently (Scarnecchia et al. 2006), and the ease of interpretation of dentaries for age determination varies among localities (Scarnecchia et al. 2019a. Other advances such as locating spawning sites (Purkett 1961), sampling eggs and larval fishes (Wallus 1986; Firehammer et al. 2006; O'Keefe et al. 2007; Miller et al. 2008; 2011), quantifying age-0 abundance of fish in reservoirs (Scarnecchia et al. 1997), understanding feeding habits of wild juvenile fish (Fredericks 1994; Hintz et al. 2017), understanding energy storage and utilization (Scarnecchia et al. 2007; Hemingway and Scarnecchia 2017 a,b) and understanding the electrosensory system (Wilkens et al. 1997; Russell et al. 1999; Wilkins 2001; Hofman et al. 2002; Wilkins et al. 2002) have not yet been widely and specifically applied in paddlefish conservation. Inadequate knowledge remains a common factor limiting effective management of Acipenseriform species (sturgeon and paddlefish; Jarić et al. 2017).

Similarly, advances in dentary and otolith microchemistry (Bock et al. 2017) and genetics (Crow et al. 2012; Kaczmarczyk et al. 2012; Schwemm et al. 2014; 2019) are just beginning to see management application in issues such as stock identification. Although the population genetics of paddlefish at a fine-scale within and among watersheds is not thoroughly understood

(Sloss et al. 2009), intraspecific genetic variation among paddlefish is evidently low (Carlson et al. 1982) to moderate (Zheng et al. 2014; Schwemm et al. 2019). Some long-isolated populations have demonstrated greater genetic distinctiveness (e.g., Alabama/ Tombigbee River fish; Heist and Mustapha 2008; Zheng et al. 2014), and Zheng et al. (2014) reported that Yellowstone-Sakakawea fish showed high private allele frequency at one locus. Low to moderate inter-population variation combined with extensive and highly variable inter-annual spawning migrations (Russell 1986; Firehammer and Scarnecchia 2006; Tripp et al. 2019) suggests that in the absence of geographical barriers, paddlefish are unlikely to segregate into numerous discrete stocks, as is seen, for example, with salmon (Ricker 1972). Based on such reasoning, Henley et al. (2001) concluded that Ohio River paddlefish, for example, were unlikely to consist of more than one genetic stock. This conclusion was also reached after analyses of DNA microsatellite loci by Heist and Mustapha (2008), who suggested that recent genetic barriers emanating from dam construction may be a concern in impeding gene flow. Pracheil et al. (2015) also noted that under new conditions of habitat fragmentation of large rivers from dams, high flows may lead to downstream enhancement (repopulation) and upstream depletion, as fish are more likely prevented from moving upstream. Even with the recognition that paddlefish may not naturally segregate into numerous stocks, agencies remain justifiably cautious in efforts to make the most appropriate broodstock selection for hatchery programs (Sloss et al. 2009).

Another challenge for paddlefish management has been the slow development of useful stock assessment methods because of the paddlefish's long and complex life history, which includes a long lifespan, late age-at-maturity, distinct sexual dimorphism in many traits (Scarnecchia et al. 2007), non-annual spawning, and highly migratory behavior. Paddlefish live for 50-60 years or more in some locations (Scarnecchia et al. 2007), mature late in life (Montana: 9-11 for males, 17-20 for females; Rehwinkel 1975, 1978; Scarnecchia et al. 1996b), do not spawn annually (Meyer 1960; Scarnecchia et al. 2007, 2019a), and are particularly subject to overharvest (Boreman 1997), especially as the most sought-after fish are large, mature females rather than the smaller, male fish (Scarnecchia et al. 1989). The highly migratory behavior of the species (Pitman and Parks 1994; Firehammer and Scarnecchia 2007; Pracheil et al. 2012; 2015) makes it difficult to delineate and apply appropriate sampling protocols. Data necessary for meaningful stock assessment and management have seldom been collected systematically or for sufficiently long periods to determine stock status. The partial, short-term studies on paddlefish which dominate the literature on the species have not proven adequate for successful management (Sharov et al. 2013).

Another issue has been the lower priority that paddlefish have had compared to other more common and widely popular game species. Unlike several other Acipenseriform species and their distinct population segments (DPS) listed as federally threatened or endangered under the Endangered Species Act, the paddlefish remains actively harvested throughout much of its native range, as a state-managed fish (Bettoli et al. 2009) with a complex identity—commercial, recreational, trophy, protected, depending on the location (Mestl et al. 2019). Although recreational paddlefish harvest has become very popular with smaller segments of the angling public (e.g., Scarnecchia et al. 1996c; Hayden 2009), paddlefish snagging has been a specialized, niche activity as opposed to more widely available angling for other game fishes. As a result, paddlefish have historically had a lower priority than some other more commonly available species.

The paddlefish's movements across jurisdictional management boundaries (Henley et al. 2001 Hupfeld et al. 2016; Tripp et al. 2019; Devine et al. 2020), and the historical independence of state management have frequently resulted in too little management within states as well as too little coordination in management among states (Hupfeld et al. 2016). Too few efforts have been made to formulate sustainable harvest management strategies based on scientifically defensible stock assessments (Sharov et al. 2013).

Illegal fishing (poaching) of paddlefish for caviar has been a documented problem in several states. Although market demand for paddlefish roe has existed for more than a century (Williamson 2003), demand increased greatly over the period 1990-2010 as supplies of sturgeon caviar from the Caspian Sea dwindled (DeMeulenaer and Raymakers 1996; Speer et al. 2000) and political issues impeded international trade in caviar (Waldman and Secor 1998; Williamson 2003). In the first decade of the twenty-first century, retail prices of paddlefish caviar sometimes reached several hundred dollars per kilogram. Since then, prices have declined as farmed Acipenseriform fish (Chinese and domestic) have increased the supply of caviar, though not from wild stocks. As of 2018, global caviar markets are changing rapidly, with a trend toward increased production of farmed caviar, especially from China (Fain 2019; Ji and Li 2019), and a push toward marketing and promoting the quality of farmed-raised caviar and caviar substitutes (Sicuro 2019). Even with increased quantities of farm-raised caviar and lower prices, it is difficult to forecast impacts on wild caviar, as the market for the wild product as an "exclusive and evocative luxury product (p. 12)" is driven by complex social attitudes and behaviors (Sicuro 2019). As the wild product requires no aquacultural effort, poaching will remain a concern (van Uhm and Siegel 2016). The sex of a paddlefish cannot be absolutely determined by external inspection (Russell 1986); both males and females may in many cases be penetrated or killed by poachers seeking roe.

Management regulations for both commercial and recreational harvests have trended toward becoming more intensive and more restrictive (Graham 1997; Mestl et al. 2019). Reviews of regulations have been conducted by Combs (1986), Elser (1986), Graham (1997), Hansen and Paukert (2009), Quinn (2009), Scholten 2009 and Mestl et al. 2019). Contemporary commercial and recreational regulations vary widely by state, but may involve limited seasons, area closures (Schooley et al. 2015), quotas or harvest caps (Scarnecchia et al. 2008), both individual bag and possession limits (Neely et al. 2015), size limits (especially minimum length limits; Scholten and Bettoli 2005; Hupfeld and Phelps 2014; Hupfeld et al. 2016), mandatory release or retention (Cha and Melstrom 2018), and prohibitions against high-grading (Hansen and Paukert 2009; Mestl et al. 2019). The *2014 State Agency Paddlefish Regulations Summary* published by AFWA provides information on recreational and commercial paddlefish regulations, by state, throughout the basin. Historically, the main rationales for the regulations were to regulate harvest, prevent over-harvest and excessive mortality, and to protect brood stock (Combs 1986), sometimes expressed as spawning potential ratio (SPR: fecundity of exploited stock as a percentage of that of the unexploited stock: Scholten and Bettoli 2005; Kramer et al. 2019). Recreational snagging regulations have been developed to avoid overharvesting or high-grading large females (Scarnecchia et al. 2008) important for caviar (Williamson 2003), and to prevent the harvest of younger fish that have not yet had a chance to spawn. In recent years, harvest caps have been applied to limit recreational harvest (Stone and Sorensen 2002; Scarnecchia et al. 2008). Controlled catch-and-release fishing has also been successfully implemented (Scarnecchia and Stewart 1997a). Efforts have also been made to match recreational fishing regulations to values and attitudes of snaggers (Scarnecchia et al. 1996a; Scarnecchia and Stewart 1997b; Stone and Sorensen 2002; Hayden 2009). A few new, modest fisheries have also been established in the past decade (e.g. Recreational: the Missouri River in Iowa, commercial: Moon Lake in Mississippi; Mestl et al. 2019).

It has long been recognized that there is a need for "(1) consistent regulations based on regional characteristics of paddlefish populations, rather than political boundaries, and (2) an increase in cooperation among states in protecting paddlefish habitat" (p. 62, Elser 1986) and in other aspects of management (Pracheil et al. 2012, 2015; Neely et al. 2015; Hupfeld et al. 2016). Graham (1997) summarized activities regarding international and national planning through the twentieth century. Internationally, paddlefish were listed in 1992 on Appendix II of the Convention on International Trade in Endangered Species (CITES). Appendix II includes species that, although not necessarily threatened with extinction, may become so unless trade is strictly regulated to avoid uses incompatible with species survival. The listing was based mainly on concerns about illegal poaching and the caviar trade (De Meulenaer and Raymakers 1996; Williamson 2003). As part of the Appendix II listing, states must be able to demonstrate non-detrimental effects of fisheries on stocks to obtain permits from the U.S. Fish and Wildlife, Division of Scientific Authority (DSA) for export of caviar. Domestically-sold caviar is not subject to this requirement, however, and the United States is the largest consumer of caviar.

In recent decades, increased emphasis on national or regional inter-jurisdictional coordinated management and stock assessment has expanded through the activities of inter-jurisdictional working groups (National Paddlefish and Sturgeon Steering Committee 1993) and especially the Mississippi Interstate Cooperative Resource Association (MICRA; Grady et al. 2005; Mestl et al. 2005). According to MICRA's strategic plan, "the Paddlefish management mission of the … Paddlefish/sturgeon sub-committee is to provide MICRA with information and recommendations to conserve and manage Paddlefish populations through inter-jurisdictional coordination, communication and assessment." (http://micrarivers.org/). As of 2018, MICRA, as a consortium of state fish chiefs, provides the most useful forum for developing harvest and habitat management guidelines as well as some research and stock assessment collaboration among states (Grady et al. 2005). Its role is primarily advisory, however (McDougall 2005), and its activities have not, as of 2018, resulted in a strongly unified management structure or approach. Efforts at more active coordination of management among state managers through MICRA are underway.

Although fully coordinated management at the national level does not yet exist, considerable management planning and regulation occurs at multi-state and individual state levels. Montana and North Dakota have implemented a long-term cooperative management effort for stocks inhabiting those states (Scarnecchia et al. 1995b; 2008). South Dakota and Nebraska cooperate closely on paddlefish management below Gavins Point Dam on the Missouri River (Stone and Sorensen 2002; Mestl and Sorensen 2009). Six states in the Ohio River basin (Illinois, Indiana, Ohio, Kentucky, West Virginia, and Pennsylvania) have made efforts at cooperative management (Henley et al. 2001). Several individual states have developed plans for Paddlefish restoration and management in the past few decades (e.g., Missouri: Graham 1988, 1992; Yasger et al. 2003; Texas: Pitman 1991, 1992; Oklahoma: Scarnecchia et al. 2013; South Dakota: Unkenholz 1977). Over the most recent two decades, 19 states found it necessary to make changes in the classification, stock status, or regulatory status of the species (U. S. Fish and Wildlife Service, Unpublished data).

Interest in artificial propagation of paddlefish has increased coincident with declines in wild populations (Graham et al. 1986; Semmens and Shelton 1986; Grady and Elkington 2009; Mims et al. 2009; Shelton and Mims 2012; Mims and Shelton 2015). Paddlefish are cultured to enhance depleted populations or restore extirpated ones (Graham et al. 1986; Pitman 1992; Graham 1997; Jennings and Zigler 2000; Grady and Elkington 2009; Argent et al. 2009). In the United States, paddlefish are also increasingly being farmed for flesh and caviar production in isolation and in polyculture (Wynne 2012), as well as ranched in lakes, ponds and reservoirs (Tidwell and Mims 1990; Mims et al. 1999; Mims 2001; Onders et al. 2001; Cuevas-Uribe and Mims 2014; Onders and Mims 2015; Vasilyeva and Elnakeeb 2019.). The species is also being reared in hatchery ponds in several European countries for meat and caviar (Billiard and LeCointre 2001; Lobchenko et al. 2002; Simonović et al. 2006; Hubenova et al. 2007; Kaczmarczyk et al. 2012; Onders and Mims 2015; Simeanu et al. 2015) and has been reported to have escaped into the Danube River (Simonović et al. 2006; Jelkić and Opačak 2013). They are now found widely throughout much of central and eastern Europe (Jarić et al. 2019), and in Russian waters (Kharin and Cheblukov 2009), where aquaculture prospects are being explored (Elnakeeb et al. 2021). Chinese aquaculture efforts on *Polyodon* have increased since its introduction there in 1988 (He 1999; Tian and Wang 2001; Ji and Wang 2009; Mims 2015; Ji and Li 2019; Figure A3-6) and their aquaculture yield is influencing world caviar markets.

Even with greatly improved capability of rearing paddlefish (Mims and Shelton 2015), the long-term prognosis for naturally reproducing populations and their habitats is much less certain. Long-term survival of the species remains dependent on adequate natural reproduction, recruitment, and sustainably managed harvest of wild fish (Scarnecchia et al. 2014).

Figure A3-6. Paddlefish are an important source of a) globally valuable caviar and b) as food, including in China.

Appendix A-4 Background and details of the philosophical rationale guiding the Paddlefish Management Plan.

Ten fundamental hypotheses guide the development and direction of this Plan. These fundamental hypotheses are philosophical statements and rationales motivated by human values and supported by the best available scientific evidence from studies on paddlefish and other species, both within the basin and elsewhere, as well as from studies in social sciences.

1. The paddlefish is an irreplaceable species of evolutionary, historical, recreational, commercial, and aesthetic significance in the Mississippi and Missouri river drainages.

Paddlefish provide important recreational and commercial benefits (Graham 1997; Scholten 2009; Hansen and Paukert 2009; Quinn 2009; Mestl et al. 2019), both within and beyond the upper Great Plains region. The Yellowstone-Sakakawea and Fort Peck stocks constitute some of the last self-sustaining wild stocks capable of providing a significant annual harvest.

Although the value and quality of paddlefish roe as caviar has long been known (Hussakof 1910), the development of community-based roe donation programs in Glendive, Montana and Williston, North Dakota have resulted in programs where the proceeds of the caviar directly benefit the public. Funds from the programs to MFWP and NDGF have also been important in paddlefish stock assessment and fisheries management.

Paddlefish stocks have declined in many locations throughout their range (Bettoli et al. 2009), and reproduction of paddlefish is poor in most locations. Habitat in nearly all other portions of the paddlefish's range is in poorer condition than in the Yellowstone and Upper Missouri rivers. Maintenance of the health of these stocks may be critical to the long-term survival of the species. Primary emphasis should thus be on sustaining these fish as among the highest priority species in both states.

2. Maintaining natural habitat conditions and numbers of wild fish adequate to sustain natural recruitment (reproduction, early growth and survival) are critical to the long-term survival of the species.

Adequate river and reservoir habitat conditions are vital to successful reproduction and recruitment (Gerken and Paukert 2009). Inadequate spawning and inadequate recruitment are serious problems for paddlefish populations throughout their range. Successful recruitment is the limiting factor in maintaining the abundance of spawning fish for the future (Scarnecchia et al. 2019b). Emphasis should be on maintaining and improving habitat conditions for sustaining wild reproduction through the life stages to recruitment and spawning. Studies on the Yellowstone-Sakakawea stock have shown that although reproduction has been observed in most years, recruitment of fish to a size where they can escape predators and eventually contribute to fisheries is much more sporadic (Scarnecchia et al. 2014; 2019b). In the past two decades, only the years of episodically high recruitment (1995, 2011) have allowed the fisheries to continue at present harvest rates. Available data suggest only modest recruitment in other years without distinctively high recruitment years. Recruitment for the Fort Peck Stock appears modest in all years. Reproduction of the Oahe stock has not been documented; the stock may be maintained by immigration from the Yellowstone-Sakakawea and Fort Peck stocks. The free-flowing, relatively unmodified Yellowstone River (U.S. Army Corps of Engineers and Yellowstone River Conservation District Council. 2015) and the Missouri River above Fort Peck are especially important for reproduction and recruitment. Adequate water levels in Lake Sakakawea and Fort Peck Reservoir, as well as occasional rising water levels to create production pulses (Scarnecchia et al. 2007, 2009; 2019b) appear to also be necessary for successful paddlefish recruitment.

The primary role of hatchery fish in the Plan should be to maintain the capability of producing high-quality hatchery fish if habitat destruction necessitates it. Experimental stocking of hatchery-reared paddlefish, if well-designed and well-implemented, may provide some valuable information on survival rates, age validation (Scarnecchia et al. 2006), and perhaps may supplement wild fish production in extended periods of poor reproduction, such as during the chronically low reservoir levels in Lake Sakakawea from 2000 to 2007. However, any such stockings should be coordinated among the agencies, adequately justified, and thoroughly evaluated through the entire life cycle and into succeeding generations.

3. The paddlefish should be managed for the long-term benefit of the entire public, rather than to the short-term benefit of a few individuals or groups.

This philosophy is rooted in the Public Trust Doctrine, i.e., the paddlefish to be sustainably managed for present and future generations (Sax 1970; Blumm 1989; Meyers 1989; Nielsen 1999; Rider et al. 2019). The more people that benefit directly and indirectly from the public resource, the more broad-based will be the support for sustainable management. Consistent with this philosophy, management of the Yellowstone-Sakakawea and Fort Peck fisheries has in recent years emphasized affordable license and tag costs, and low individual bag limits distributed over many interested anglers, rather than concentrating the benefits for a few users. Similarly, commercial benefits from the two roe-donation (caviar) programs, for which public participation is strictly voluntary, have accrued to a broad spectrum of the public, through grant programs, rather than to a few individuals. This approach also avoids a problem commonly arising when a few people, such as commercial fishers, become critically dependent economically on a species or a fishery.

4. Sustainable recreational harvest and non-harvest fishing opportunities are desirable outcomes to be provided by paddlefish for the benefits of the public.

Paddlefish snagging and recreational harvest is a popular spring activity in both Montana and North Dakota, as well as other states (Combs 1986; Graham 1997; Hansen and Paukert 2009; Neely et al. 2015; Mestl et al. 2019). A sustainable paddlefish recreational fishery can be useful in sustaining or increasing interest in and support for conservation of the species by sportspersons and the public-at-large (Brownscombe et al. 2019). Studies of paddlefish snaggers indicate that although the harvesting of paddlefish fish is not their most important motivation for participating in the fishery, the ability to harvest at least one fish is an important part of the experience for most snaggers (Scarnecchia et al.1996a; 2000).

As a partial compensation for limiting harvest, opportunities for catch-and-release fishing should be provided in situations where its implementation is shown to not be detrimental to the stock (Scarnecchia and Stewart 1997a). Catch-and-release fishing provides additional opportunities for public to interact with the paddlefish, can be useful for conservation in situations of poor recruitment, and also provide an outlet for changing values among some anglers regarding the desirability of harvest of the species. Catch-and release has been shown to be a viable option for managers, with low mortality to snagged fish (Scarnecchia and Stewart 1997a), especially if conducted in periods of lower water temperatures and properly supervised handling and release methods. For these reasons, catch-and-release will continue to be pursued and evaluated as a viable management approach.

5. Management should be conducted cautiously, in a risk-averse manner.

Studies from the Yellowstone-Sakakawea stock indicate that stock size of adult fish has dropped from about 120,000 adult fish in the late 1970's to about 50,000 fish as of 2007, and to less than 50,000 in 2017. Although periodic increases on the stock are seen as fish recruit (e.g., Scarnecchia et al. 2014), the long-term multi-decade trend has been downward. This continual decrease has been the result of natural and harvest mortality, poor or modest recruitment in most years (Scarnecchia et al. 2009; 2014; Scarnecchia et al. 2019b) as well as declines in reservoir productivity associated with the natural process of reservoir sedimentation and aging (Scarnecchia et al. 2009). The ultimate causes are predominantly ecological rather than harvest-related. Although paddlefish ecology in the rapidly-changing habitat of Lake Sakakawea and Fort Peck Lake is much better understood than a decade ago (Fredericks 1994, Kozfkay and Scarnecchia 2002; Scarnecchia et al. 2007; 2009), some critical information, such as the stock recruitment relationship and factors influencing it, is lacking. Potential ecological and human effects of climate change are difficult to forecast. Until knowledge improves, it is unwise to implement a harvest strategy that will further decrease the stock size.

6. The management plan for harvest and habitat should ensure sustainability of the resource and be matched to the evolved long life history of the species and the productive capacity of the stocks.

The cornerstone of the Paddlefish Management Plan is long-term sustainability. The fish has evolved a life history strategy characterized by a long-lifespan, late age-at-maturity, and non-annual spawning (Scarnecchia et al. 2007). Management should be designed in a manner consistent with maintaining their life history (Scarnecchia et al. 2019a). In the absence of serious habitat problems, post-juvenile natural mortality of the species is low, and there is no need to risk over-harvest in the short-term at the expense of the long-term. The harvest strategy should be designed to allow the persistence of multiple spawning, older aged fish, known as prime spawners (Scarnecchia et al 2007b; 2019a) as opposed to removing all of the older fish and reducing the number of possible spawning events for all individual fish (Francis et al. 2007;

Scarnecchia et al. 2014). This approach also serves to increase the spawning potential ratio (SPA; Colvin et al. 2013) over management approaches (such as minimum size limits) that allow harvesters to focus on removing only the largest female spawners. Harvest rates will be set with adequate consideration given to recruitment patterns for each stock.

7. High-quality stock and fisheries data are critical to accurate and precise stock assessment and sustainable management; fish harvest should be a key source of necessary data.

Paddlefish inhabit large rivers and reservoirs where agency sampling of the fish is typically expensive and time-consuming. It is preferable for cost-effective and reliable management that the fisheries themselves be configured to provide most of the data necessary for management.

In both states, central fish cleaning and roe processing stations serve as the primary source of fisheries data. License and tag information should be used in conjunction with angler reporting to survey anglers for additional information, including harvest not brought to the stations. Management and reporting requirements should be designed to provide useful and scientifically valid information for MFWP and NDGF managers. As fish passage at the Intake Dam is improved and the distribution of pre-spawning fish in the Yellowstone becomes more dispersed, it remains important that harvest management regulations and reporting requirements be configured appropriately to continue to obtain data from a high fraction of the harvested population.

8. *Goals, objectives, and actions, including management regulations and monitoring, should be as uniform as practicable among the stocks but remain sensitive to stock-specific fisheries constraints and conditions*.

Under the Plan, uniformity of actions among entities is generally beneficial to all parties. Harvest regulations for the Yellowstone-Sakakawea stock that are similar and equitable between states will result in less social conflict and, if rationally justified, will improve agency credibility. Even within states, regulations among stocks that are consistent will generally result in less angler dissatisfaction and confusion. Although how harvestable fish are allocated among anglers is not consistent between the Yellowstone-Sakakawea stock (unlimited tag sales) and the Fort Peck stock (lottery draw), harvest data collected should be as uniform and consistent within and among stocks as possible. Comparative analyses within and between data sets may provide valuable information for management. Although most monitoring activities should thus be uniform and apply to all stocks, distinct social or logistical differences among fishing areas may make it preferable to set special regulations or obtain specialized information for optimal management of a particular stock.

9. The Plan for Montana and North Dakota stocks need not be consistent with, but should not be detrimental to, broader (regional or national) paddlefish conservation and management goals and activities. The Plan should be consistent with other Montana and North Dakota fisheries management plans.

Although paddlefish management is not yet adequately coordinated among all states, actions of MICRA have considerably improved coordination and communication among agencies (Mestl et al. 2019). The Montana-North Dakota Management Plan considers plans in states lower in the Missouri River basin, as well as in the Ohio, and Mississippi rivers, such that upriver management efforts do not negatively impact downriver efforts. However, not all actions upriver need be consistent with actions downriver. For example, the extensive stocking programs in some states (e.g., Texas, Oklahoma) involved with paddlefish restoration need not be implemented upriver. Data collection activities upriver should, however, be as compatible as possible with those downriver, thereby facilitating comparative evaluations (Pracheil et al. 2015).

The Montana-North Dakota Paddlefish Management Plan should be consistent with, and if necessary reconciled with, other state management plans such as MFWP's statewide Fisheries Management Plan (Montana Fish, Wildlife and Parks 2019) and the Fort Peck Reservoir Fisheries Management Plan (Montana Fish, Wildlife and Parks 2012).

10. Regulation, enforcement, evaluation information, and education are keys to the success of the Plan and should be assessed periodically for effectiveness.

Central to the success of fisheries management plans are adequate translation of values and goals into regulations, adequate enforcement of regulations, and evaluation of implemented actions. The success of all such regulations should be evaluated. Continual input from enforcement personnel is vital in all phases of this Plan.

Public education and information exchange are also central to the success of this Plan. For example, public acceptance and compliance with regulations are a result of effective communication of the managers to the public of the bases and rationales for those regulations. Fish cleaning stations, fishing access sites, regional offices, and internet websites are primary locations for information and education. Public receptiveness to conservation efforts will be more positive if they are presented with accurate information on the value and significance of the paddlefish and the management efforts undertaken on its behalf.

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