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
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Management Plan
for
North Dakota and Montana
Paddlefish
Stocks and Fisheries

A
Cooperative Interstate Plan

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Executive Summary

This document outlines a 10-year (2008-2117) plan for the cooperative management of paddlefish stocks in Montana and North Dakota by the Montana Department of Fish, Wildlife and Parks (MTFWP) and the North Dakota Game and Fish Department (NDGFD) in consultation with federal, tribal and other agencies. The plan covers the one paddlefish stock that crosses state boundaries (the Yellowstone-Sakakawea stock) and proposes a uniform management approach for the Fort Peck stock (in Montana) and the Oahe stock (in North Dakota). A comprehensive literature review is provided of paddlefish and of the three stocks and fisheries covered under the Plan. The plan itself consists of a philosophy, expressed as ten fundamental hypotheses, as well as eight goals and supporting objectives and actions (tasks). The goals of the plan include providing for coordinated management of paddlefish of the Yellowstone-Sakakawea stock, providing an orderly and sustainable recreational harvest, developing and maintaining a standardized data base, 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. Key components of the plan include the use of age-specific abundances as early warning indices, resulting in a scientifically based harvest cap harvest consistent with recent recruitment. Early warning of paddlefish reproduction and recruitment success or failure is based on indices of abundance of age-0 and sub-adult in reservoir sampling, and the abundance of young male recruits to fisheries. The harvest cap is set based on most recent 5-year recruitment. Overall age structure is also monitored to insure the persistence of older, prime spawners in the stocks. Data necessary for the stock assessment and harvest management decisions come from intensive, uniform data collection programs in both states at major snagging 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 MTFWP and NDGFD. Data are compiled in a centralized data base updated yearly. Major habitat issues include flow reductions from increased water withdrawals, potential loss of river function from bank stabilization, and environmental issues associated with oil and gas development. Management actions to achieve goals and objectives are evaluated for effectiveness at periodic management and stock assessment reviews held jointly by the agencies.

Overview of Paddlefish

The North American paddlefish *Polyodon spathula*, is an ancient, cartilaginous fish (Acipenserformes: Family Polyodontidae; Grande and Bemis 1991) native to the Mississippi and Missouri river basins, as well as several Gulf Coast drainages (Carlson and Bonislawsky 1981; Gengerke 1986). As one of only two remaining living paddlefish species (Grande and Bemis 1991), it is one of North America's most distinctive freshwater fishes (Forbes and Richardson 1920). This large, long-lived, highly migratory fish (Scarnecchia et al. 2007b) of large rivers and reservoirs is a source of commercial and trophy recreational fishing, high-quality food, and expensive caviar (Dillard et al. 1986; Waldman and Secor 1998; Jennings and Zigler 2000).

Although paddlefish populations persist in portions of 22 states, mere remnant populations remain in several states where they were once abundant, and their peripheral range shrunk in the 20th century (Gengerke 1986; Graham 1997). 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). Lack 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). Impoundments and channel alterations throughout the paddlefish's range have controlled flood waters, blocked fish migrations, permanently inundated gravel bars suitable for spawning, and resulted in severe reduction or extirpation of populations (Unkenholz 1986; Jennings and Zigler 2000). Although paddlefish feed and grow well in many new reservoir habitats (Houser and Bross 1959; Graham 1992), their requirement of free-flowing rivers for spawning limits their natural production in many areas.

Overfishing has also contributed to the decline of paddlefish in many localities (Hoxmeier and DeVries 1996; Jennings and Ziegler 2000). In the late nineteenth century, fishers perceived paddlefish as low-valued and of questionable merit as a food fish (Jordan and Evermann 1896). Interest in the fish and their valuable caviar increased greatly, however, in the early 20th century (Hussakof 1910; Alexander 1914; Coker 1930). Commercial harvest of paddlefish has occurred for about a century, and, as of 2007, paddlefish remains a commercial species in seven states (McDougall 2005). Recreational fisheries based on snagging the fish below migration barriers or hindrances have become popular since the 1950s, and exist in 14 states, although in most places with progressively more restrictive regulations (Graham 1997).

Paddlefish fisheries do not have a history of successful management. Several factors make effective paddlefish management 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. Much of this information shortage is attributable to the difficulty of sampling adequately in the species' large, turbid riverine habitats. It was not until the early twentieth century that young paddlefish were identified (Allen 1911; Danforth 1911). Age determination using conventional structures was infeasible and it was not until Adams' (1931; 1942) research on dentaries that reliable aging methods were developed. Validation of this method has only occurred recently (Scarnecchia et al. 2006), and the ease of interpretation of dentaries for age determination varies among localities. Other advances such as locating spawning sites (Purkett 1961), sampling eggs and larval fishes (Wallus 1986), quantifying age-0 abundance of fish in reservoirs (Scarnecchia et al. 1997), understanding feeding habits of wild juvenile fish (Fredericks 1994), understanding energy storage and utilization (Scarnecchia et al. 2007) and understanding the electrosensory system (Wilkins 2001; Wilkins et al. 2002) have not yet been widely applied in paddlefish conservation.

Second, development of useful stock assessment methods has been slow because of the paddlefish's long and complex life history, which includes a long life span, late age-at-maturity, distinct sexual dimorphism in many traits (Scarnecchia et al. 2007b), non-annual spawning, and highly migratory behavior. Paddlefish can live to 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 1978; Scarnecchia et al. 1996b), do not spawn annually (Meyer 1960; Scarnecchia et al. 2007), 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 (Russell 1986; Pitman and Parks 1994; Firehammer and Scarnecchia 2006) makes it difficult to delineate an appropriate scope for sampling plans. 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 fairly modest literature on the species have not proven adequate for successful management.

Third, paddlefish have also had a lower priority for many managers than other more common and popular game species. The lack of popularity, the paddlefish's movements across jurisdictional boundaries (Henley 2001), and the historical independence of state management have resulted in too little management within states, and too little coordination in management regulations among states. As a result, too few efforts have been made to formulate sustainable harvest management strategies based on scientifically defensible stock assessments.

Management regulations for both commercial and recreational harvests are relatively recent. Combs (1986) reviewed paddlefish regulations, which included size limits, seasons, area closures, and, in one case, an incidental quota. Current recreational regulations also vary by state, but typically involve creel limits, season closures, and prohibitions against high-grading (Graham 1997). Combs (1986) reported that the main rationales for the regulations were to regulate harvest, prevent over-harvest and excessive mortality, and to protect brood stock. In recent years, harvest caps have been applied to limit recreational harvest (Stone and Sorensen 2002). Controlled catch-and-release snagging has also been 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).

Illegal fishing (poaching) of paddlefish for caviar has also become a serious problem in several states. Market demand for paddlefish roe has existed for over a century (reviewed in Williamson 2003). Demand has increased greatly in the past two decades as supplies of sturgeon caviar from the Caspian Sea have dwindled (De Meulenaer and Raymakers 1996; Speer et al. 2000) and political issues have impeded international trade in caviar (Waldman and Secor 1998; Williamson 2003). Retail prices of paddlefish caviar can reach several hundred dollars per kilogram. The sex of a paddlefish cannot be absolutely determined by external inspection (Russell 1986); both males and females may thus be killed by poachers in their search for eggs.

Management of paddlefish has been planned and conducted at international, national, regional, inter-state, and state levels. Graham (1997) summarized activities regarding international and national planning. 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 Meulemaens and Raymaker 1996; Williamson 2003).

Nationally, the U. S. Fish and Wildlife Service was petitioned in 1989 to include the paddlefish on the list of threatened and endangered species under the Endangered Species Act of 1973. The petition was not granted but it was concluded that insufficient empirical data existed for the species throughout much of its range. Considerable interest developed in coordinating paddlefish management either nationally (Paddlefish Workshop, Atlanta, GA, 1992, Unpublished; National Paddlefish and Sturgeon Steering Committee 1993) or regionally (Dillard et al. 1986; Henley 2001) for discrete management units that cross jurisdictional boundaries. The increased emphasis on national or regional inter-jurisdictional management and stock assessment has expanded even further in the early 21st century through the activities of 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 committee is to provide MICRA with information and recommendations to conserve and manage paddlefish populations through inter-jurisdictional coordination, communication and assessment." The paddlefish's highly migratory life history in large river systems makes inter-jurisdictional management necessary for most stocks. MICRA has provided a useful forum for broad cooperation, management guidelines as well as limited research and stock assessment collaboration among states (Grady et al. 2005). Its role is primarily advisory, however (McDougall 2005), and its activities have not yet resulted in a strongly unified management structure or approach.

Interstate plans for management of stocks of common interest have been successfully implemented. Montana and North Dakota have developed and implemented a Cooperative Management Plan for stocks inhabiting those states (Scarnecchia et al. 1995b). South Dakota and Nebraska cooperate closely on paddlefish management below Gavins Point Dam (Stone and Sorensen 2002). 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).

In addition, several individual states have developed plans for paddlefish restoration and management in the past 20 years (e.g., Missouri: Graham 1988, 1992; Texas: Pitman 1992). During the period 1983-1991 in response to dwindling stocks and deteriorating habitat, 19 of 22 states where paddlefish remained found it necessary to make changes in the classification, stock status, or regulatory status of the species (U. S. Fish and Wildlife Service, Unpublished). State management of paddlefish has since trended toward becoming more intensive and more restrictive of both commercial and recreational harvest (Graham 1997).

Interest in artificial propagation of paddlefish has increased coincident with declines in wild populations (Graham 1986; Semmens and Shelton 1986). A major use of paddlefish culture at present is supplementation of or mitigation for wild populations depleted or extirpated by loss of spawning habitat (Graham 1992). At least 10 states are actively stocking paddlefish to enhance depleted populations or restore extirpated ones (Graham 1997; Jennings and Zigler 2000). Paddlefish are also being farmed and ranched more frequently in lakes, ponds and reservoirs for flesh and caviar production (Mims et al. 1999; Mims 2001; Onders et al. 2001). The species is being reared in hatchery ponds in several European countries for meat and caviar (Lobchenko et al. 2002; Simonović et al. 2006; Hubenova et al. 2007) and has been reported to have escaped into the lower Danube River (Simonović et al. 2006).

Rationale for a Cooperative Management Plan

Development of a cooperative, coordinated paddlefish management plan between the states of Montana and North Dakota through their respective fisheries agencies, MTFWP and the NDGFD, is of mutual benefit. The paddlefish inhabiting the Missouri and Yellowstone Rivers, Fort Peck Reservoir, and Lake Sakakawea (eastern Montana and western North Dakota; Figure 1) provide some of the most important remaining fisheries for the species (Gengerke 1986; Stewart 1990). The largest of the three paddlefish stocks inhabiting the region, the Yellowstone-Sakakawea stock, crosses state boundaries and sustains important recreational fisheries in both states (Rehwinkel 1978; Stewart 1990; Owen and Hendrickson 1992; Scarnecchia et al. 1996b; Scarnecchia et al. 2007b). Habitat issues for this stock such as water quantity, water quality, and natural river function important to the stock's health are closely linked between the two states. Non-profit caviar programs operated by Chambers of Commerce in Glendive, Montana (http://www.glendivechamber.com) and Williston, North Dakota (http://www.northstarcaviar.com/) derive caviar from the same stock of fish and provide economic and social benefits to public organizations and the public-at-large throughout the region. The other two paddlefish stocks in the region, one in each state, can provide information useful to their individual management as well as to the cooperative management of the inter-state stock.

This document outlines the management plan for paddlefish inhabiting the states of Montana and North Dakota. It reviews and summarizes life history, ecology, stock status, and past and current management. It then provides a 10-year plan for cooperative interstate management by NDGFD and MTFWP of the inter-state stock, including the recreational fisheries, as well compatible management for the other stocks.

Review of Montana and North Dakota Paddlefish Stocks and Fisheries

Broad, range-wide reviews 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). Emphasis here is on biology, ecology, habitat use, and management of the three stocks covered under this plan.

Three distinct and easily identifiable paddlefish management units or putative stocks (*sensu* Ricker 1972; Epifanio et al. 1989; 1996) inhabit the region (Figure 1): the Yellowstone-Sakakawea, Fort Peck, and Oahe stocks. Although the population genetics of these fish are not thoroughly understood, intraspecific genetic variation has thus far with existing technologies been found to be low (Carlson et al. 1982). Low intraspecific variation combined with extensive and highly variable inter-annual spawning migrations (Russell 1986; Firehammer and Scarnecchia 2006) suggests that in the absence of geographical barriers, paddlefish are unlikely to segregate into numerous discrete stocks. 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.

The identification of three stocks for our plan is based on a combination of genetic differences, geographic separation, and harvest management considerations. Before construction of Missouri River main stem dams (beginning with Fort Peck Dam in the late 1930's), extensive movement of fish throughout the entire upper basin, including Montana and North Dakota, undoubtedly occurred. 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, and putative stocks became isolated physically from each other. Greater isolation and habitat fragmentation occurred as dams blocked fish movements and spawning migrations. Although tagged fish of the Fort Peck stock have occasionally been caught in the Yellowstone-Sakakawea fisheries, and fish of the Oahe stock may also consist of some upriver fish, mixing of fish in the region is much more restricted than before the dams. Genetics studies (Epifanio et al. 1989; 1996) and life history differences tentatively indicate that the Yellowstone-Sakakawea and Fort Peck stocks are genetically distinguishable. More practically, fisheries are also distinctly separated geographically and function as separate harvest management units.

The Yellowstone-Sakakawea stock spawns in the Yellowstone and Missouri rivers, as well as the Milk River, and rears in Lake Sakakawea, a large Missouri River main stem reservoir in North Dakota (Figure 1). Some fish in this stock also evidently remain, perhaps for years, in the Dredge Cuts, large dredged ponds below Fort Peck Reservoir (Frazer 1985; Scarnecchia et al 2007d). Movement throughout their 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 2007).

The Fort Peck stock rears in Fort Peck Reservoir and spawns in the Missouri River upriver of the reservoir (Berg 1981; Figure 1). Its life cycle is completed entirely within Montana. Epifanio et al. (1989) found this stock to be the most distinct genetically of 21 paddlefish samples taken throughout the species' range.

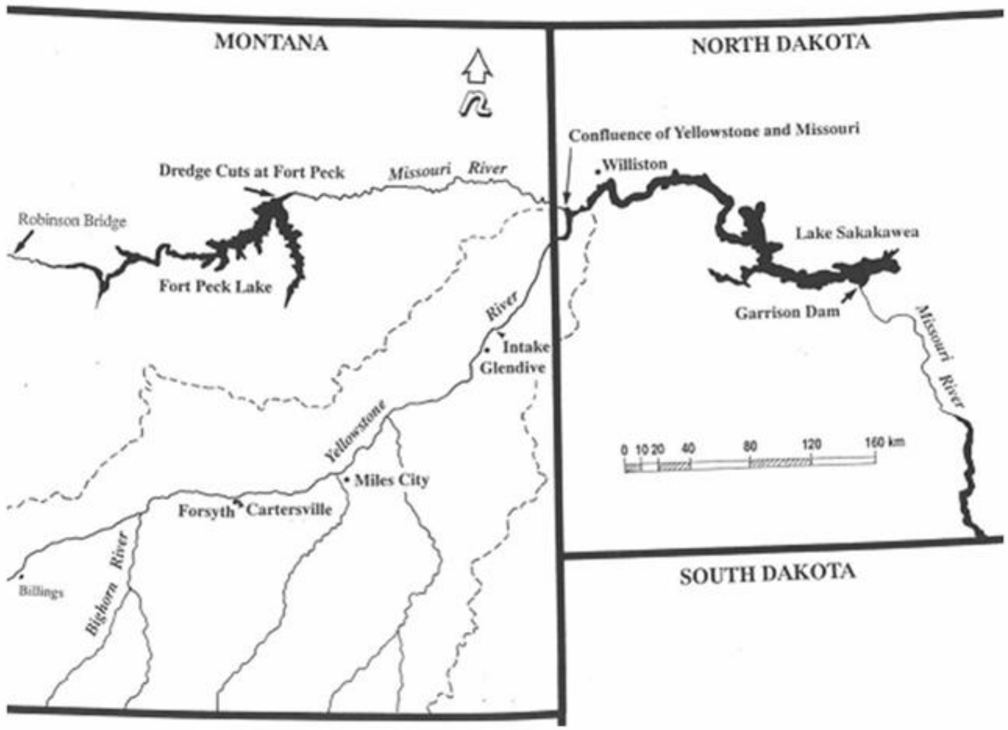
The Oahe stock inhabits Oahe Reservoir and may spawn in the Missouri River and selected tributaries above the reservoir (Figure 1). Many fish of the Oahe stock are probably Yellowstone-Sakakawea stock fish that have entered Oahe reservoir from above Garrison Dam. This stock is the smallest and does not currently support a fishery. A complete historical review of each stock is provided below.

Yellowstone-Sakakawea Stock and Fishery

Habitat

The Yellowstone-Sakakawea paddlefish stock inhabits the Lower Yellowstone (YR) and Missouri (MR) rivers of eastern Montana and western North Dakota (Scarnecchia et al. 1995b; Figure 1), an arid to semi-arid region described as continental in climate, with long severe winters (as low as -30° C), short hot summers (30-35° C), low rainfall (30 cm in the west to 40 cm in the east), 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, which consist mostly of grasslands and scattered badlands dominate the region, except near rivers, where the forested floodplains contain cottonwoods *Populus* spp. and ravines contain small cedars *Juniperus* spp.

Figure 1. Map of Lower Yellowstone and Missouri rivers and Missouri River main stem reservoirs in eastern Montana and western North Dakota.



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. Haddix and Estes (1976) divide the Yellowstone River into three portions, with the lower Yellowstone extending from the mouth of the Bighorn River to the Confluence, a distance of 636 Rkm. Average gradient in the lower Yellowstone 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; Figure 2). The average discharge of the lower Yellowstone River at Sidney, Montana (YR km 47) during June over the period 1967-2006 was 940 m^3/s (33,200 cfs; U.S. Geological Survey 2003). Annual peak flows have ranged from as low as 600 m^3/sec (21,000 cfs) in low flow years to more than 4,200 m^3/s (150,000 cfs) in high flow years (Figure 2). 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). The fish community in the lower river is primarily a warm water fauna (Haddix and Estes 1976).

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. The portion of the river between the Confluence and Fort Peck Dam has been strongly influenced by the dam. The result has been in a more stable discharge, a reduction in sediment load, and colder summer water temperatures than before impoundment (Welker and Scarnecchia 2004; Figure 2). Since closure of the dam, annual flows of the Missouri River at its lowest gauge station above the Confluence (at Culbertson, Montana) have averaged 272 m^3/sec (9,620 cfs), or less than one third of the mean June flow of the Yellowstone River.

The Yellowstone-Sakakawea paddlefish stock's range extends from Garrison Dam up reservoir through Lake Sakakawea (reservoir area, 156,000 Ha). From the headwaters of the reservoir, the location of which can vary more than 50 Rkm depending on reservoir elevation, 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 move either over or around the dam (via a flooded side-channel) past Intake as far as the Cartersville Diversion Dam at Forsyth (YR Rkm 382).

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), whereas in lower flow years, fish typically remain farther down the

Figure 2. Confluence of the more turbid, largely unregulated Yellowstone River (top) and the clearer, regulated Missouri River near Buford, North Dakota.

Yellowstone River and make greater contributions to the North Dakota fishery. Discharges are influenced primarily be snowmelt, and in low flow years, to an increasing extent by early season irrigation withdrawals.

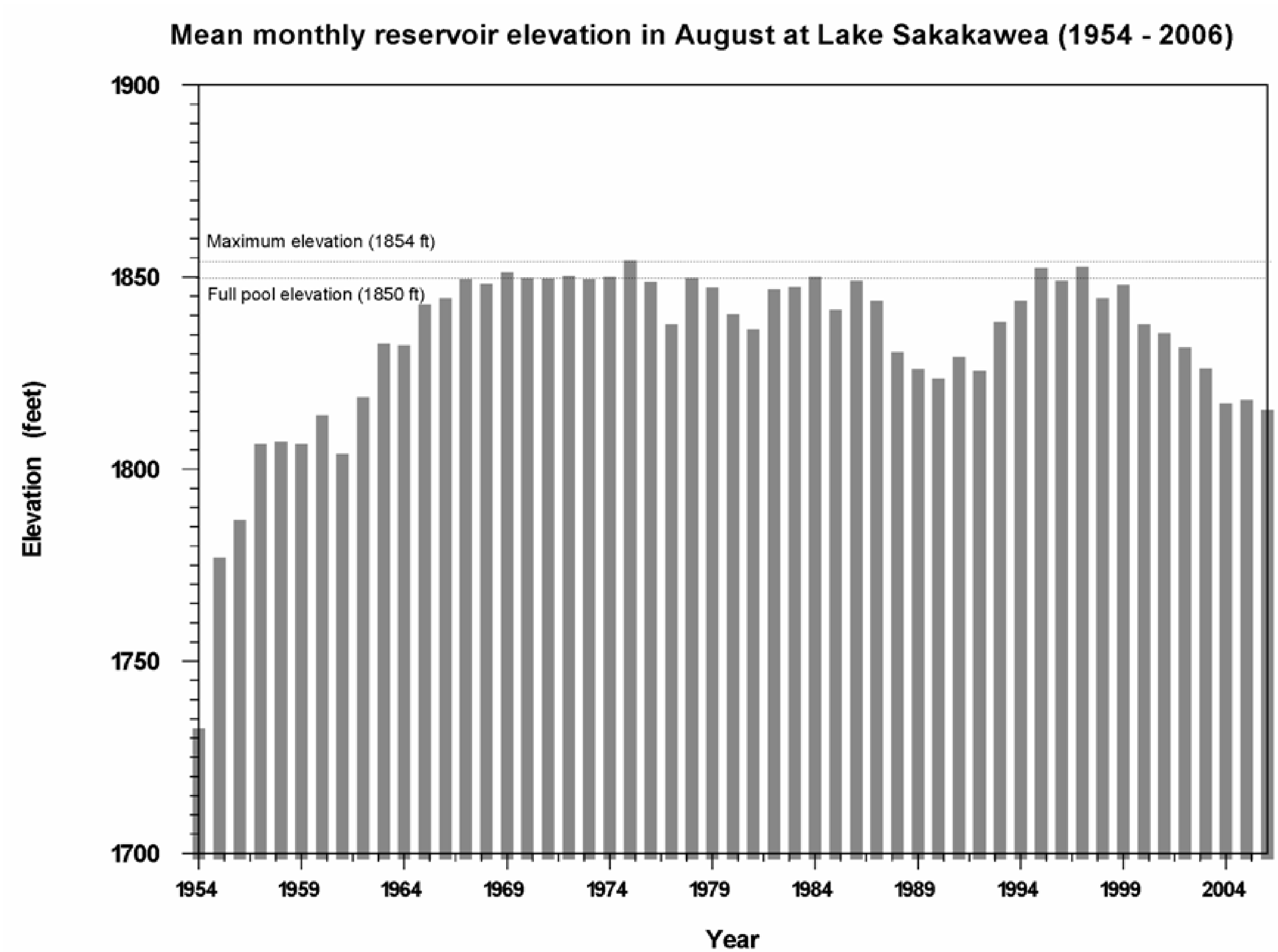
Lake Sakakawea, the primary rearing habitat for this stock (Fredericks and Scarnecchia 1997), has exhibited wide fluctuations in water levels the closure of Garrison Dam in December 1953. After the initial filling of the reservoir (over a 13-year period, 1953-1966; Scarnecchia et al. 1996b), the reservoir water level reached its normal maximum elevation of 564.25 m in the summer (July) of 1969, dropped to 555.71 m in August, 1990, rose to 564.58 m by August, 1997, and dropped steadily over the period 1998-2004 to 553.72 in August 2004 (U.S. Army Corps of Engineers, 2005; Figure 3). As of mid-2007, the water level was at 554.5 m (1818 ft).

Stock History

The 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). In contrast to most other paddlefish stocks (Carlson and Bonislawsky 1981; Gengerke 1986), this stock became more abundant in the twentieth century (Van Eeckhout 1980; Scarnecchia et al. 1996b). During the period 1953-1966, from the closure of Garrison Dam to the complete filling of Lake Sakakawea, the population size burgeoned as a result of increased rearing habitat and trophic upsurge in the newly-formed, slowly-filling reservoir. Since the time of dam closure, nearly all 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 remaining there for years (Frazer 1985) and periodically migrate downriver. Conditions for survival and growth of young paddlefish are better in Lake Sakakawea than pre-reservoir, when mostly riverine habitat and a few backwaters such as the Trenton Lake (west of Williston) and the Dredge Cuts provided less productive habitat for growth.

Evidence from several sources supports the idea of increased paddlefish abundance after Lake Sakakawea was impounded. 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 pattern 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. They 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. In the late 1970's, 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 (1978). By the mid-1980s the sex ratio of the harvest had shifted to 55-70% females. Weaker year classes ensued as the reservoir aged. By the mid-1980's, the large percentage of mature females harvested generated interest in the development of a caviar program at Intake. Since the peak population in

Figure 3. Mean monthly (August) reservoir elevation of Lake Sakakawea.



the late 1970s, population size of mature fish has steadily decreased to about 50,000 fish in 2007. This decrease is a natural result of declining reservoir productivity, reduced year-class strengths, natural mortality of fish of the strong post-impoundment year classes, and harvest of recruited fish.

Life History

In spring (April-June), sexually mature fish ascend the Yellowstone River (and to a lesser extent the Missouri River; Braaten and Fuller 2006; Braaten et al. 2007) during rising discharge (Penkal 1981; Firehammer 2004; Firehammer and Scarnecchia 2006). Some fish also move from Lake Sakakawea into the Missouri River below the Confluence in the autumn before their spawning year. Although exact 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 and June (Firehammer et al. 2006). Larval fish have also been found in both river (Gardner 1995) as well as the Milk River (Braaten and Fuller 2006).

Adult fish typically remain in the Yellowstone River in May and June until spawning is completed or until river discharge drops sharply, at which time fish descend into the reservoir (Firehammer 2004; Firehammer and Scarnecchia 2006). In the Missouri River above the Confluence, paddlefish also spawn in the Milk River, a Missouri River tributary entering below Fort Peck Dam, in some years of higher flows (Needham 1980; Gardner and Stewart 1987; Gardner 1992; Bednarski 2004). Some fish linger into the summer and beyond (Gardner and Stewart 1987), and may remain year-round, a possible response to regulated flows. Occasionally, fish have also been reported to remain in the Yellowstone River into the fall (Elser 1977); these fish (Rehwinkel 1975) as well as fish much more commonly netted below the Confluence in fall overwinter and make a spawning migration the next year (NDGFD and MTFWP, Unpublished Data).

Studies on larval paddlefish sampling for the stock are detailed in a series of reports by Gardner (1990; 1991; 1992; 1993; 1995; 1996; 1997), Braaten and Fuller (2006) and Braaten et al. (2007). In Gardner's investigations, the most effective sampling was conducted with round and D-ring nets drifted slowly downstream near the river bottom. In all years, most larvae were found in June in the area near the Montana-North Dakota state line (YR Rkm 29.8) downstream to the area 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 linked with rising or high discharges 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 collect by J. Liebelt (MTFWP) that larvae were found in the Missouri River in mid-July, later than they were typically found in the Yellowstone. In 2005, Braaten and Fuller (2006) reported capturing paddlefish larvae in the Yellowstone River near the Confluence (YR Rkm 0.2-3.2; n =32), in the Missouri River at Wolf Point (MR Rkm 2737-2748; n =4) and the Nohly Bridge (MR Rkm 2549-2,562; n =6), and in the Milk River within 6.4 km of its mouth (n =17). Larvae were caught in the Yellowstone River over the period June 3-21; catches in the Milk River were on June 20 and 22. Catches on the Missouri River were later, over the period June 21-July 8 (Braaten and Fuller 2005). The absence of paddlefish larvae from the Milk River in 2006 was consistent with the absence of radio-tagged adult fish detected up the Milk River that year (Braaten et al. 2007). Based on the few captures, later larval catches on the Missouri River than the Yellowstone River may have been associated with colder water temperatures and later spawning. In 2006, they caught 54 larval paddlefish in the Yellowstone River, one in the Missouri River at Wolf Point, and none at the Nohly Bridge or in the Milk River. Larvae were caught on the Yellowstone River as early as May 31, peaked on June 6, and continued as late as June 27.

The life history of paddlefish in the reservoir in their first summer has been investigated by Fredericks (1994) and Fredericks and Scarnecchia (1997). 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. By late fall or the following summer, they are 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), for the rest of their life, with the aid of long, filamentous gill rakers (Kofoid 1900; Imms 1904).

In Lake Sakakawea, age-0 and age-1 paddlefish feeding near the surface in late July through September can be seen startled by and fleeing from slowly-approaching motorboats. In late July, age-0 fish 150-170 FL appear as gray-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 on nearly one-half their FL. At this size, the fish are not yet filter feeding but are selecting individual food items. Age-0 fish frequently occur in loose aggregations with a patchy distribution, possibly associated with uneven distribution of their preferred food.

The quantitative distribution of age-1 fish, older sub-adults and adults is less well known, but they have been reported in diverse locations of Lake Sakakawea, including reaches occupied by age-0 fish (Table 1). Greatest catches of sub-adults and adults have been with gillnets in the Van Hook Arm and Beaver Bay (G. Power, NDGFD, letter to S. Dyke, June 4, 1990). Available evidence from visual observations and netting, however, indicates that adult fish are widely distributed throughout the reservoir in summer (Jeff Hendrickson, NDGFD, Dickinson, Personal Communication). Specific sampling to assess their distribution has not been conducted. Too few paddlefish have been caught, and factors affecting catch rates are too poorly understood, for firm conclusions on abundance by area to be drawn.

Table 1. Age-0 and Sub adult paddlefish counted and number of age-0 paddlefish tagged, Lake Sakakawea, 1992-2007.

PAH YOY TRANSECT & TAGGING ANNUAL SUMMARY INFORMATION

Year	August 15 SAK elevation	Transect survey period & weeks	Date most YOY counted	Transect river miles surveyed	Total transect miles (approx)	Total # of YOY counted	Transect with most YOY	# of YOY on best 4 weeks & transects	# of YOY per mile on best 4 weeks & transects	# of wild YOY netted	# of wild YOY tagged	# of YRL counted	# of YRL netted
1992	1824.2	8/14-9/04 = 4	8/21	1506-1521	12.4	27	1512&21	27	0.72	0	0	4	0
1993	1836.9	7/20 - 9/25 = 6	8/30&31	1506-1527	16.7	205	1512	172	5.29	0	0	0	0
1994	1842.4	7/22 - 7/26 = 2	NA	1506-1527	16.7	0*	NA	0*	0*	0	0	0*	0
1995	1851.2	7/20-9/28 = 10	8/30&31	1512-1539	18.1	96	1521&30	39	1.36	0	0	5	0
1996	1847.7	8/01 = 1	8/01	1512-1539	18.1	96*	1524	94*	11.12*	2,361	2,348	6*	60
1997	1851.2	7/22 - 9/08 = 8	8/20&21	1512-1539	18.1	361	1527	220	6.84	712	543	52	54
1998	1843.0	7/23 - 9/18 = 9	7/29	1512-1539	18.1	444	1524	213	6.62	1,805	1,719	93	26
1999	1846.6	7/19 - 9/09 = 8	8/03	1512-1539	18.1	356	1527	235	6.74	2,082	1,975	8	4
2000	1836.2	7/26 - 9/14 = 8	8/09	1512-1524	10.2	621	1518	402	11.84	3,724	3,624	1	4
2001	1834.0	7/30 - 9/14 = 7	8/13	1506-1521	12.4	27	1512	20	0.62	0	0	2	0
2002	1830.2	7/25 - 9/06 = 7	8/14	1506-1521	12.4	359	1515	233	6.22	2,043	2,007	2	0
2003	1825.0	7/28 - 9/03 = 6	7/28&29	1500-1515	13.7	87	1509	72	1.93	409	408	1	1
2004	1815.7	7/29 - 8/31 = 6	8/03	1494-1509	11.5	30	1503	24	0.79	0	0	0	0
2005	1816.7	7/26 - 9/06 = 6	8/02	1494-1509	11.5	203	1503	152	4.63	178	176	0	0
2006	1814.2	7/25 - 9/06 = 7	7/25	1494-1509	11.5	61	1503	48	1.56	16	13	3	0
2007	1816.0	7/30 - 9/07 = 6	8/16	1494-1509	11.5	5	1503	5	0.16	0	0	0	0
Totals										13,331	12,813	177	149

NOTES: In some of these years a few additional transects were undertaken upstream or downstream of the indicated river miles, no YOY PAH were observed when undertaking these additional transects, however. Totals of 9093, 9944 and 23956 hatchery reared YOY were tagged and stocked into upper Sakakawea in 1995, 1997 and 2007, respectively. Date as marked with an asterisk (*) is from less than four weeks of transects.

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). A series of 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 summarizes annual research and management efforts. The most recent studies were conducted before 1990, however. 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 (1978) 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. In 2007, a fish tagged in 1978 in the Dredge Cuts was recaptured at the Confluence, 29 years after tagging. 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. He 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. In his efforts at documenting seasonal movements of Dredge Cuts paddlefish, fish were typically found in the upper Dredge Cuts (i.e., the smaller ponds) most of the year but moved down into the dam's tailrace pool (called the tailpool) in the fall. He attributed this movement into the tailpool in fall as possible responses to seasonally warmer water in the tailpool and seasonally higher concentration of the large zooplankton species such as *Daphnia* and *Diaptomis* (although not smaller zooplankton species, which 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).

Life History Strategy

The life history of the Yellowstone-Sakakawea stock can be explained in terms of the costs of reproduction (Scarnecchia et al. 2007b). Males and females grow at similar rates to at least age-5. Over the ensuing decade, life histories of males and females diverge greatly (Figures 4, 5) as males begin diverting production away from somatic growth into sexual maturation. Validated ages indicate that males become sexually mature starting at about age-8, and are fully recruited from age-10 to age-12 (Tables 2, 3). 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. 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 4, 5). Females are fully recruited from age-17 to age-19. 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 4. von Bertalanffy growth curves for a) Montana paddlefish and b) North Dakota paddlefish, 2003.

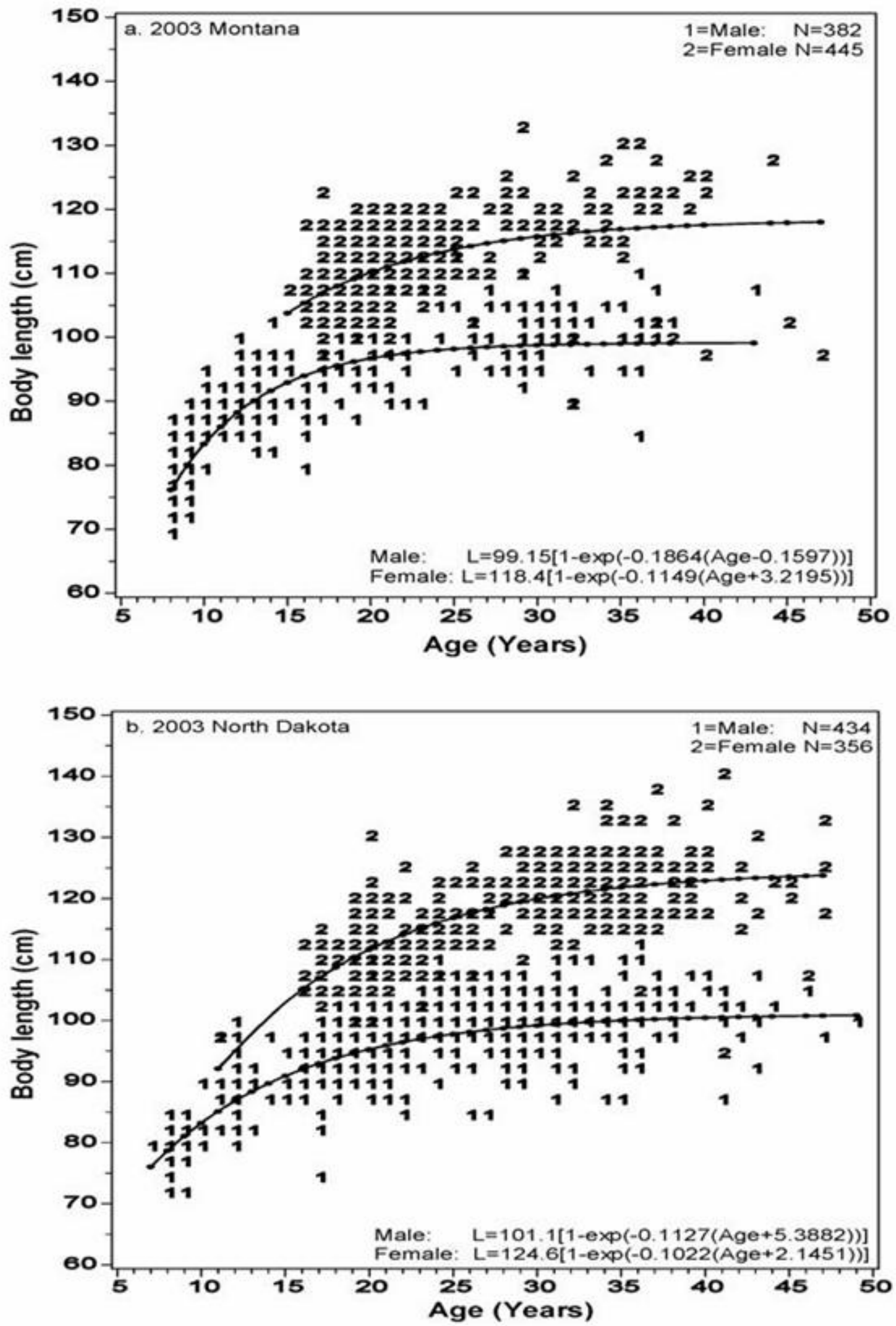


Figure 5. Weight-converted von Bertalanffy growth curves for a) Montana paddlefish b) North Dakota paddlefish, 2003.

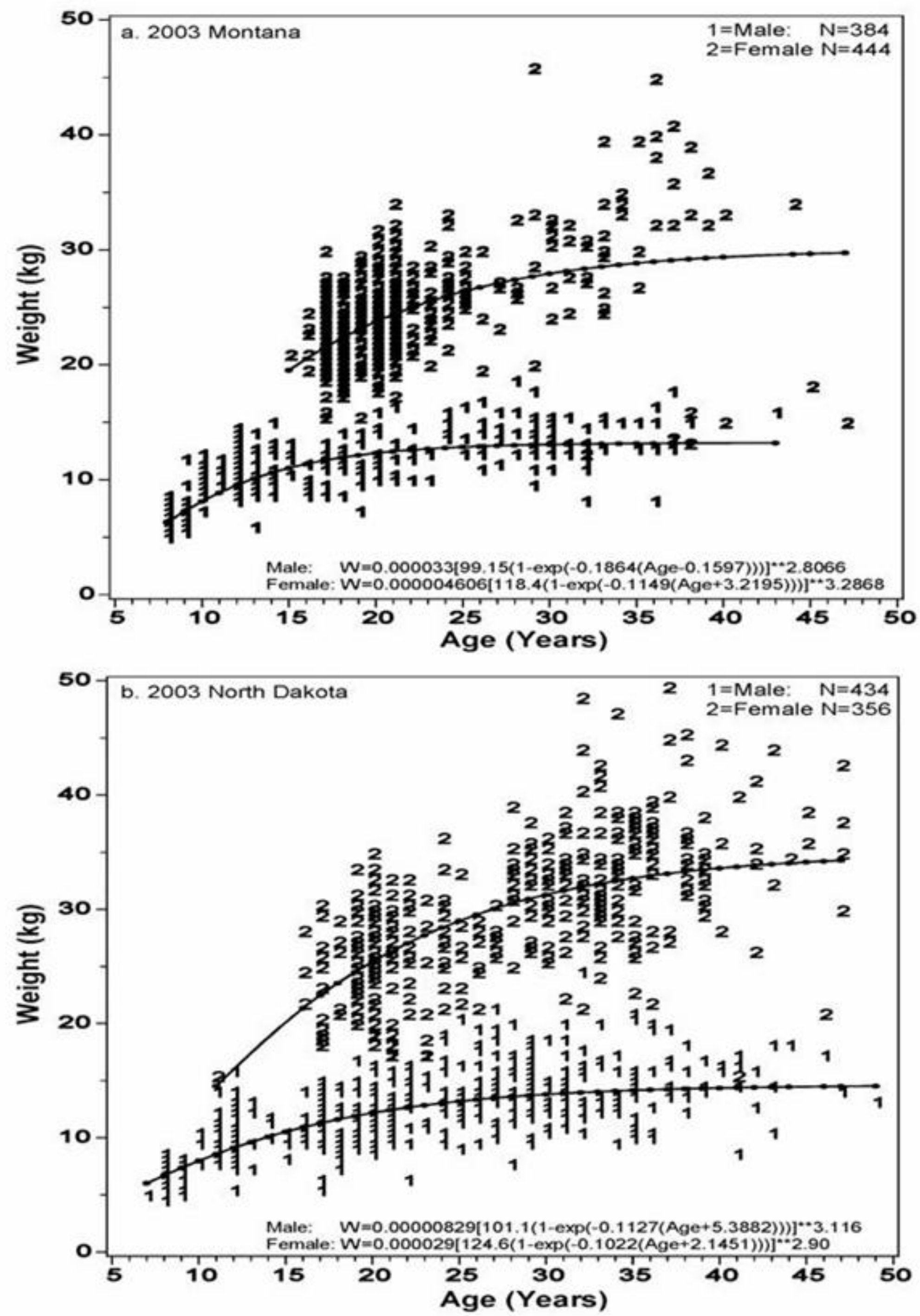


Table 2. Age (years) summary for paddlefish caught in North Dakota, 1991-2004.

Table 2. Age (years) summary for paddlefish caught in North Dakota, 1991-2004. Asterisk (*) denotes a significant difference ($p < 0.01$) in mean age between males and females.

	Males							Females					
Year	No. of fish	Mean age (yr)	% fish < 8 yr	% fish < 16 yr	% fish ≥ 30 yr	No. fish ≥ 30 yr	Max. age (yr)	No. of fish	Mean age (yr)	% fish < 16 yr	% fish ≥ 30 yr	No. fish ≥ 30 yr	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
Total	5688					660		4988				1707	
ercent age ≥ 30						11.6						34.2	

Table 3. Age (years) summary for paddlefish caught in Montana, 1991-2004.

Table 3. Age (years) summary for paddlefish caught in Montana, 1991-2004. Asterisk (*) denotes a significant difference ($p < 0.01$) in mean age between males and females.

	Males							Females					
Year	No. of fish	Mean age (yr)	% fish < 8 yr	% fish < 16 yr	% fish ≥ 30 yr	No. fish ≥ 30 yr	Max. age (yr)	No. of fish	Mean age (yr)	% fish < 16 yr	% fish ≥ 30 yr	No. 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
Total	6215					240		5909				1080	
Percent age ≥ 30						3.9						18.3	

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 (Figure 6). Increases in fecundity among young adult males and females, as indicated by the gonadosomatic index (GSI; Figures 7, 8) are concurrent with decreases in the weight of GFBs (Figures 9, 10). Males typically spawn every one or two years (Figures 11a, 12a) and deplete the lipid reserves gradually over several spawns. Females typically spawn every two or three years (Figures 11b, 12b) and deplete the lipid reserves more rapidly, over two or three spawns, so that it is largely depleted by age-25. After the females' depletion of the gonadal fat, fecundity remains steady and reproductive effort is maximized for another decade, until about age-35, when on average it begins 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 2, 3) as a result of an earlier harvest and higher natural mortality on younger mature males (at a time when females are 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 13). By age-40, mortality (natural or fishing) has removed most fish of both sexes, although both male and females occasionally exceed age-50 (Tables 2, 3).

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 14). 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 and natural mortality leaving few of the oldest fish. GSI of some of the oldest females decreases, however;

Figure 6. Ratio of total GFB weight to GFB weight plus green egg weight in relation to the age of female paddlefish, Montana-caught fish, 2001-2003.

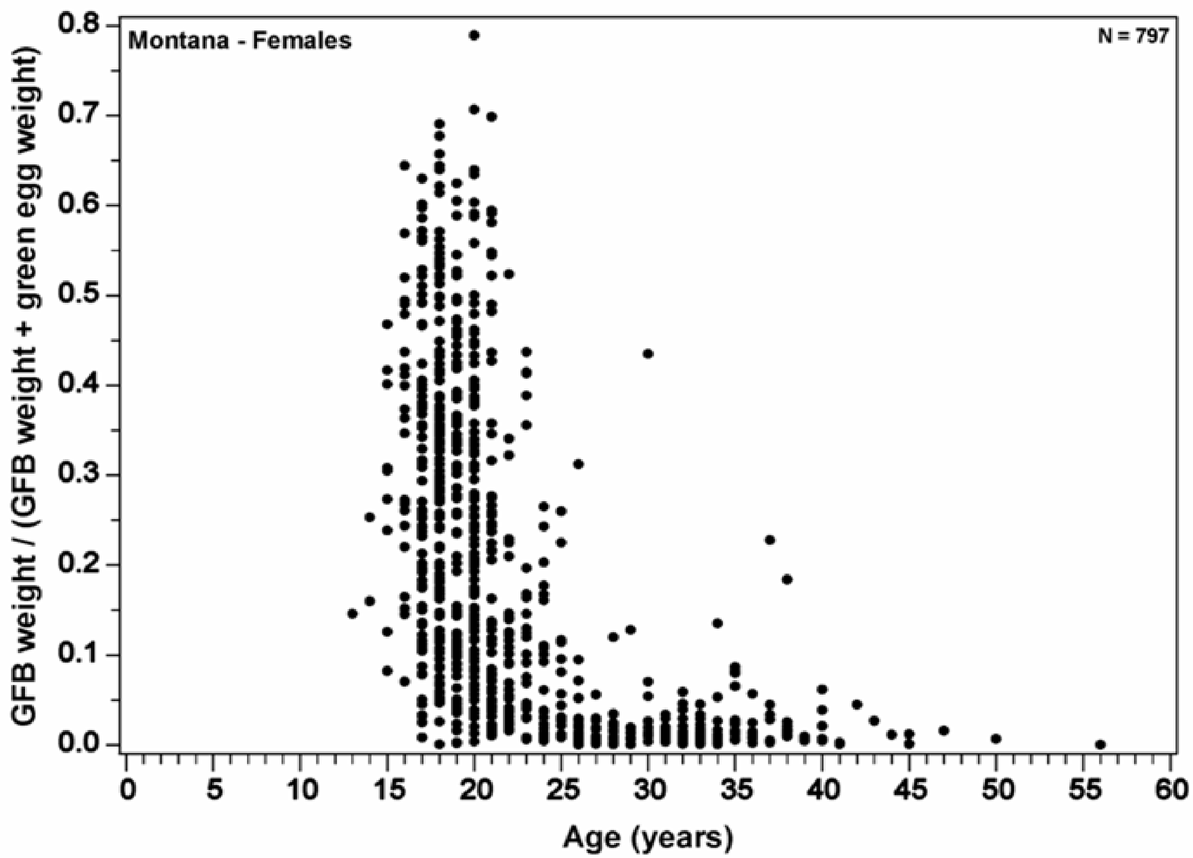


Figure 7. Gonadosomatic index (mean, median, and inter-quartile range) for female paddlefish caught in 2001-2003 in Montana and North Dakota.

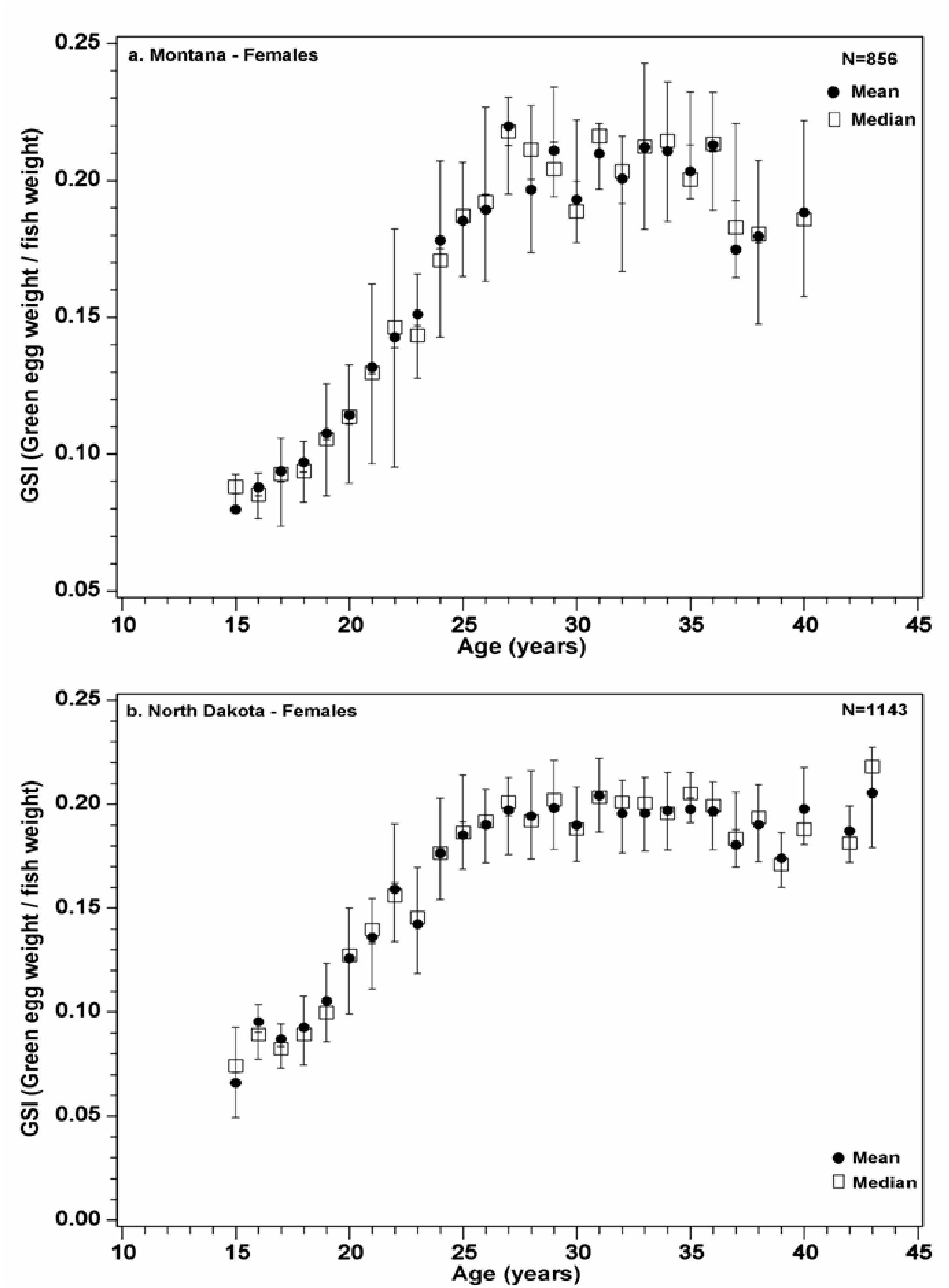


Figure 8. Gonadosomatic index (mean, median, and inter-quartile range) for male paddlefish caught in 2001-2003 in Montana and North Dakota.

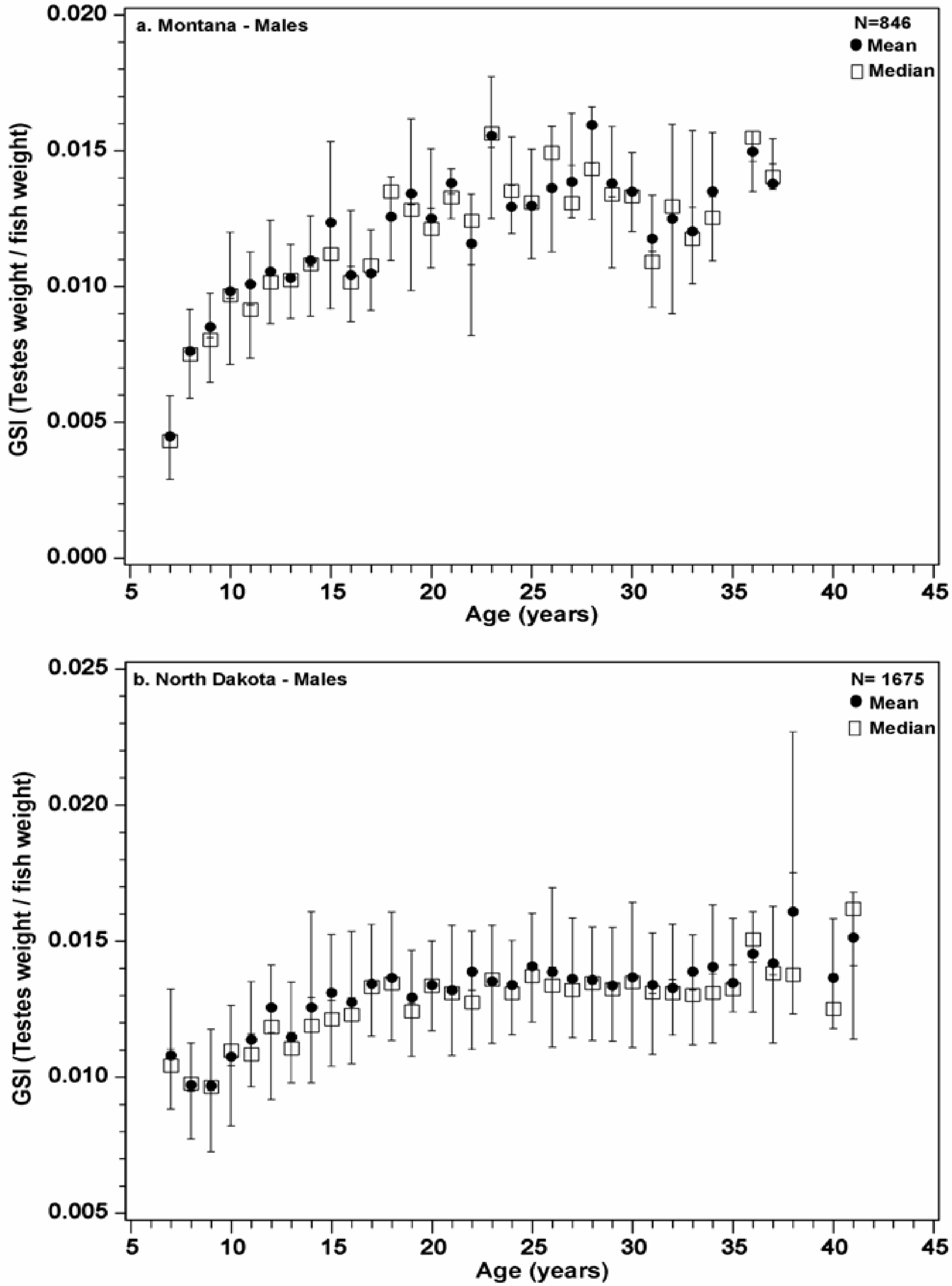


Figure 9. Ratio of gonadal fat body (GFB) weight to total fish weight (mean, median, and inter-quartile range) versus age for female paddlefish 2001-2003 from Montana and North Dakota.

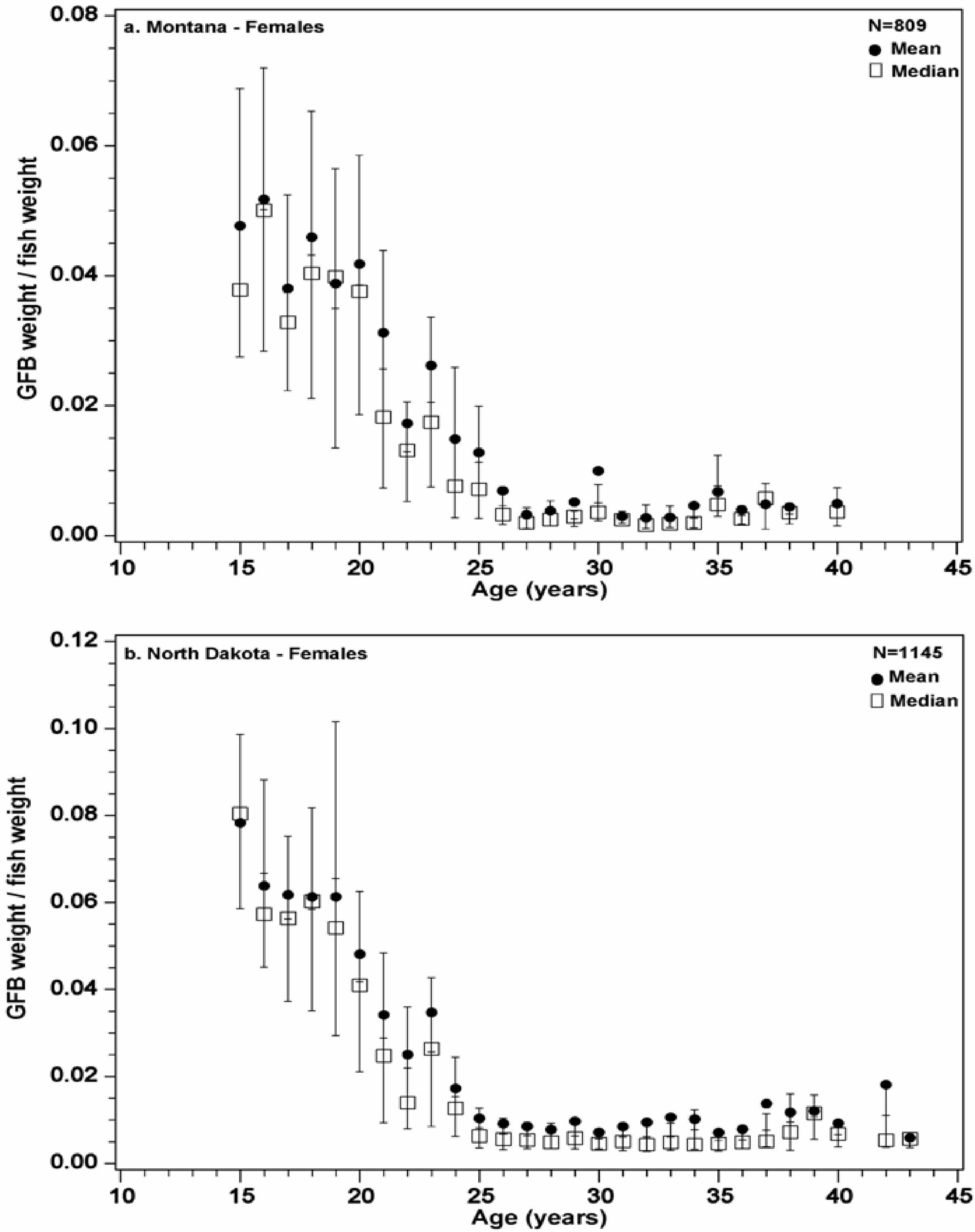


Figure 10. Ratio of GFB weight to total fish weight (mean, median, and inter-quartile range) versus age for male paddlefish 2001-2003 from Montana and North Dakota.

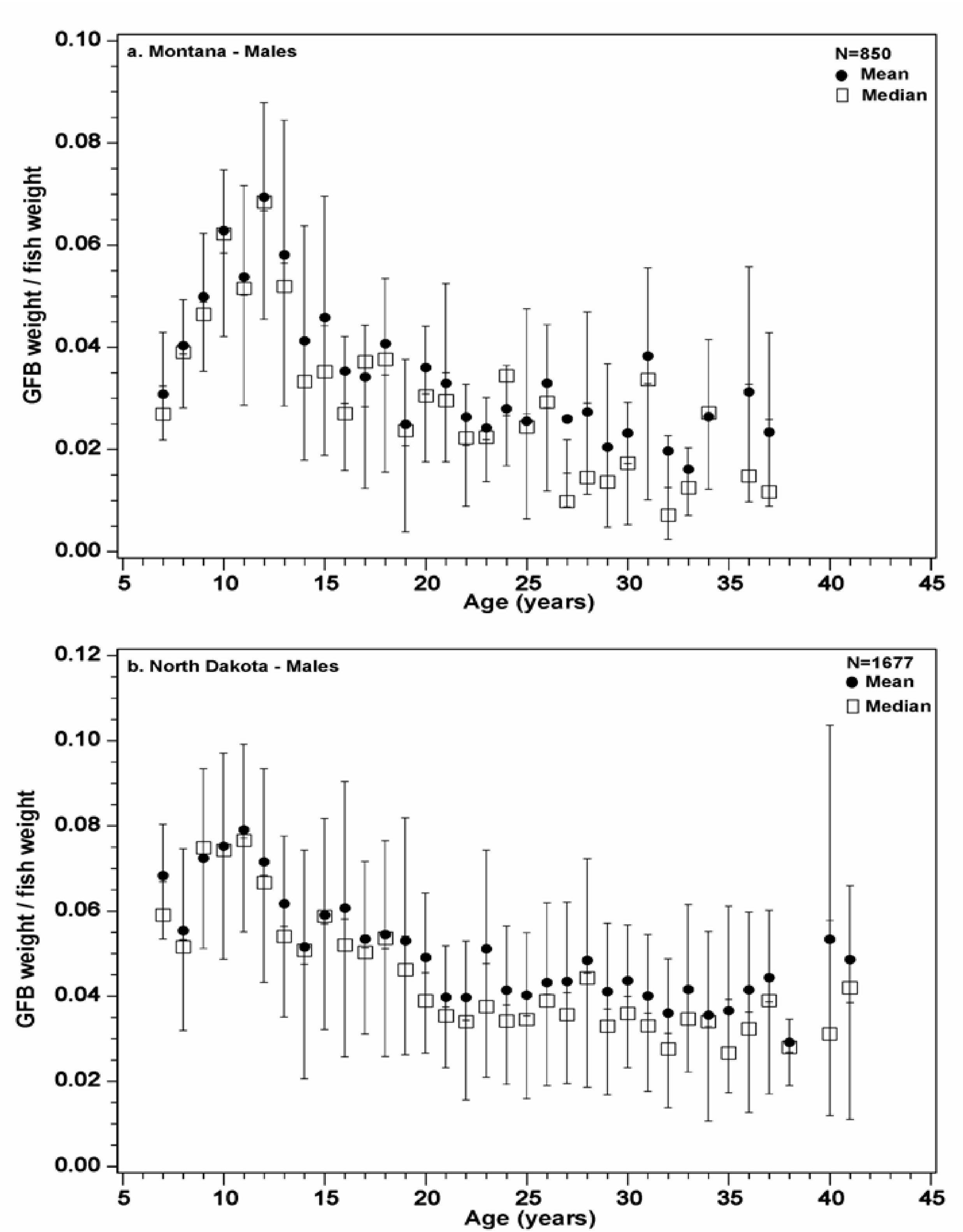


Figure 11. Frequency distribution of the number of years between tagging and recovery for Montana-caught fish, 1964-2004.

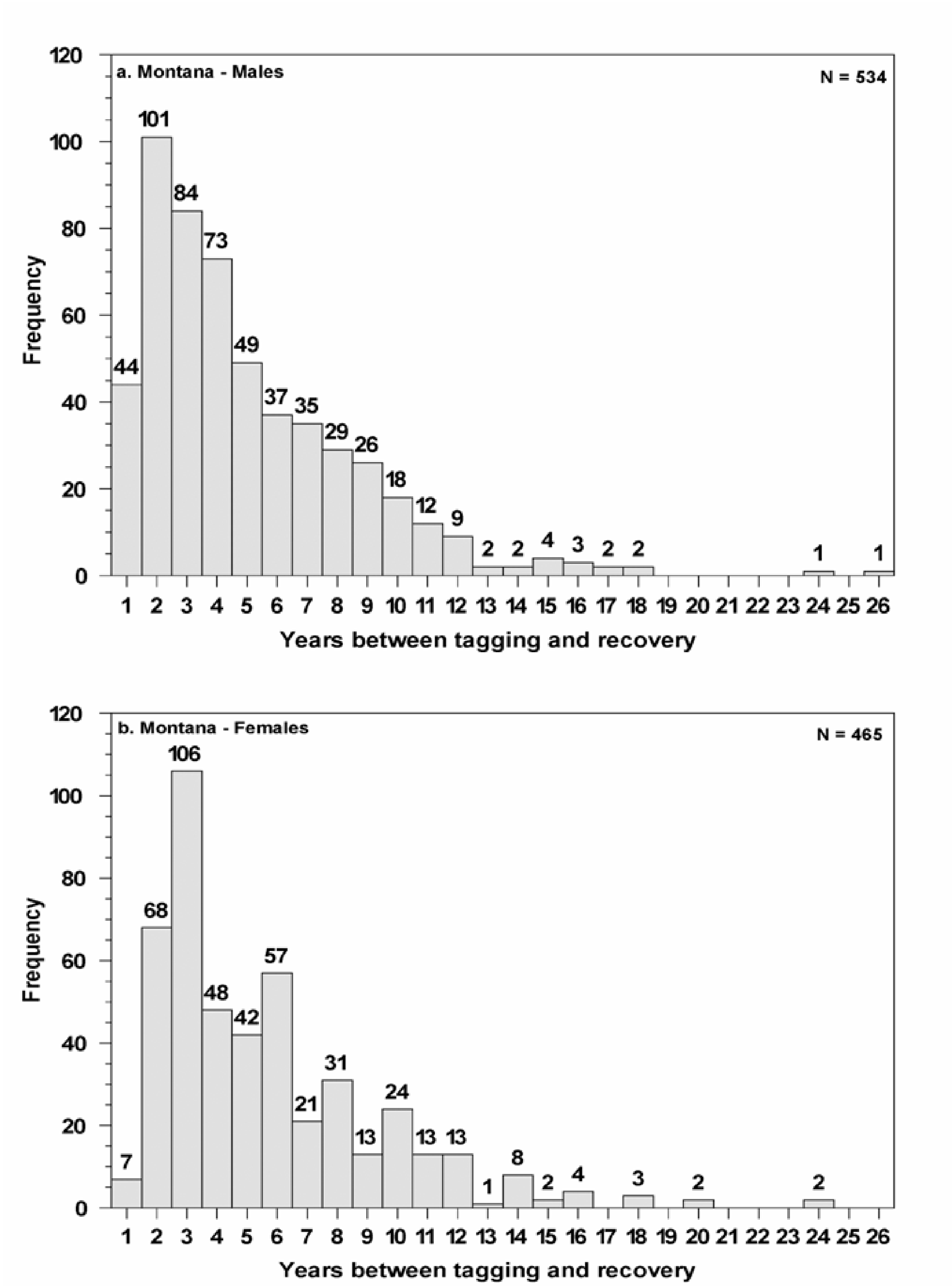


Figure 12. Frequency distribution of the number of years between tagging and recovery for North Dakota-caught fish, 1993-2004.

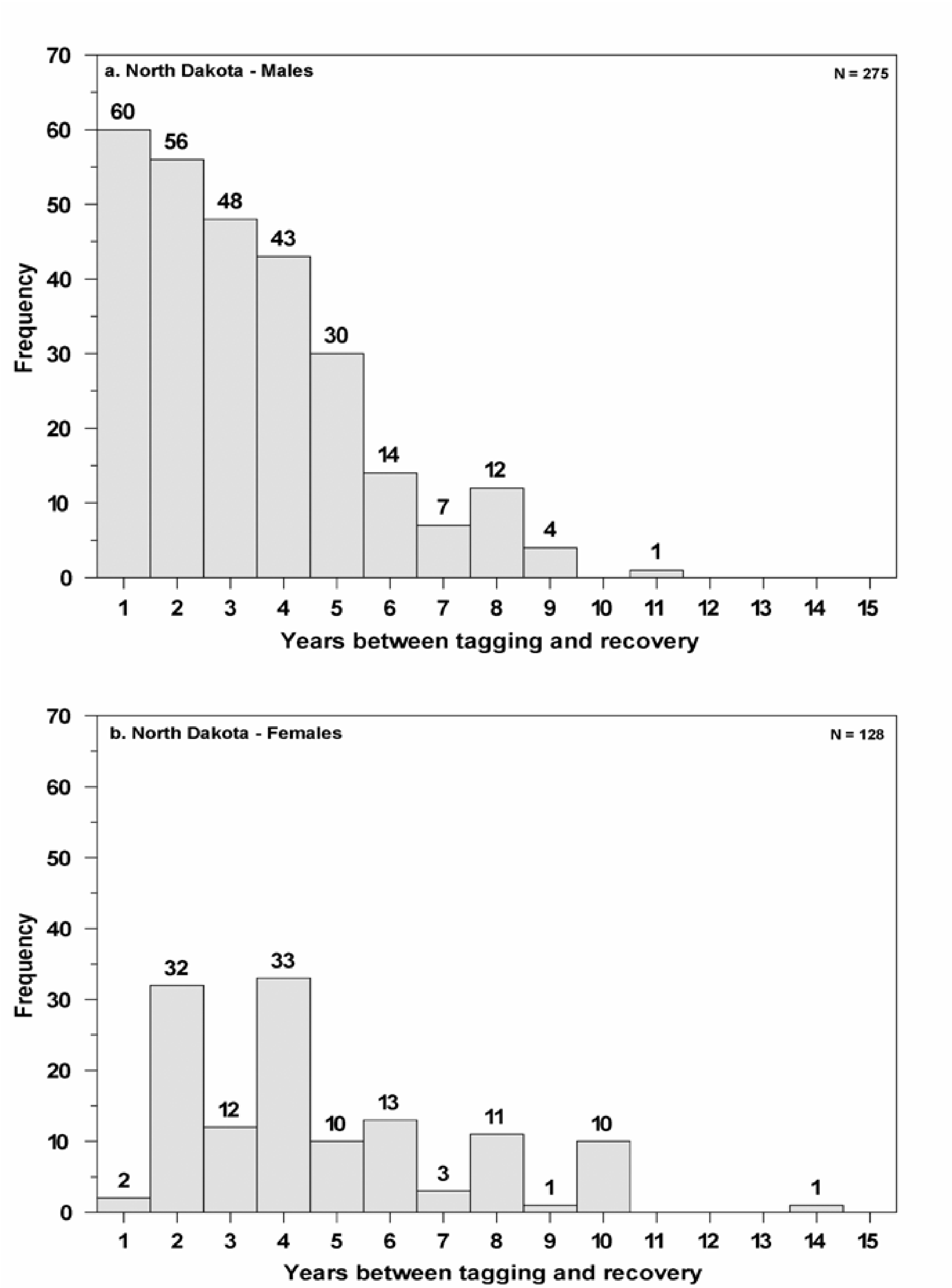


Figure 13. Catch curves and instantaneous rates of mortality for male and female paddlefish, Montana and North Dakota caught fish, 1991-2004.

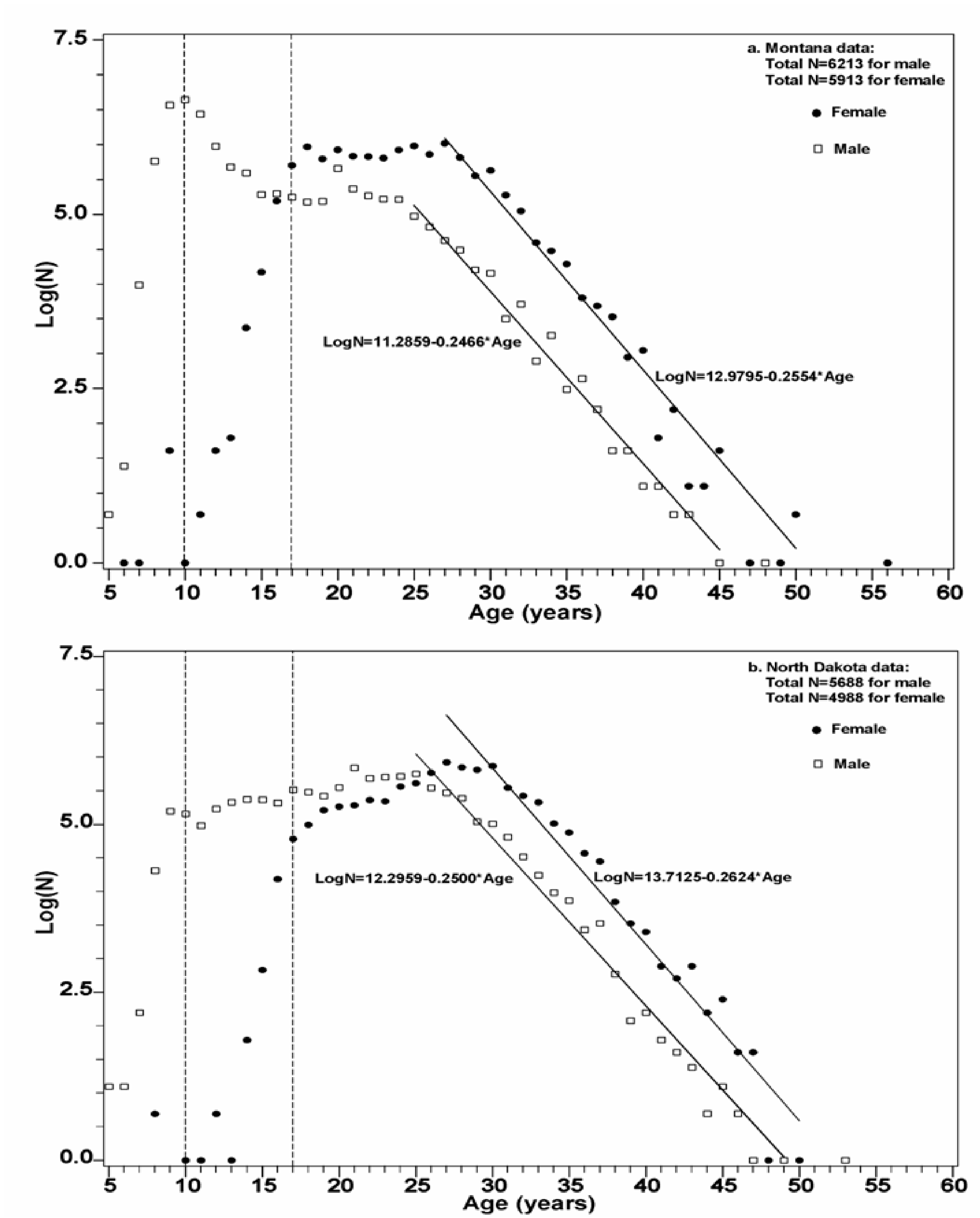


Figure 14. Five paddlefish juvenile and adult life stages and their characteristics.

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

the oldest males have few energy reserves and are observed to be typically long and lean. Additional detail about the life history and its evolutionary significance are discussed in Scarnecchia et al. (2007b).

Ecology

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). Similarly, the exceptional strength of the 1995 year class (Figure 15) was associated with the sharp rise in reservoir level beginning in August, 1993 and extending through 1995. The 1993-1995 period was the longest and greatest period of rising reservoir since the initial filling (Figure 3) and the only period since the reservoir filled when reservoir levels rose substantially in three consecutive years (Figure 16). Recruitment from the 1996 and 1997 year classes, when the reservoir was near its maximum, is not nearly as strong as in 1995 (Figure 15). The development of the fishery at Intake in the early 1960s and the strength of the 1995 year class 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 3, 17), 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 (Figure 3, 17) and age-0 fish had been forced down-reservoir to feed below Rkm 2428 in White Earth Bay and beyond.

Age-0 paddlefish are subject to heavy predation losses until they reach a size large enough to reduce their vulnerability. 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 walleye and sauger 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 18). Age-1 paddlefish may also be eaten (Unpublished data, NDGFD). In addition to predation, observations of dead young paddlefish indicate that overwinter mortality may be significant in some years.

Fishery

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 Missouri and Yellowstone rivers. Snaggers use long, heavy spinning rods with 6/0 to 10/0 treble hooks and heavy test line to snag the fish as they congregate at known holding sites. Important snagging sites in North Dakota include (in order, progressively upriver) the Pumphouse (MR Rkm 2503) near Williston, the Confluence (MR Rkm 2542, YR Rkm 0; Figure 19a), and Sundheim Park (YR Rkm 14.5).

Figure 15. Strong 1995 year of Yellowstone-Sakakawea paddlefish contributing to fisheries, 2003-2006.

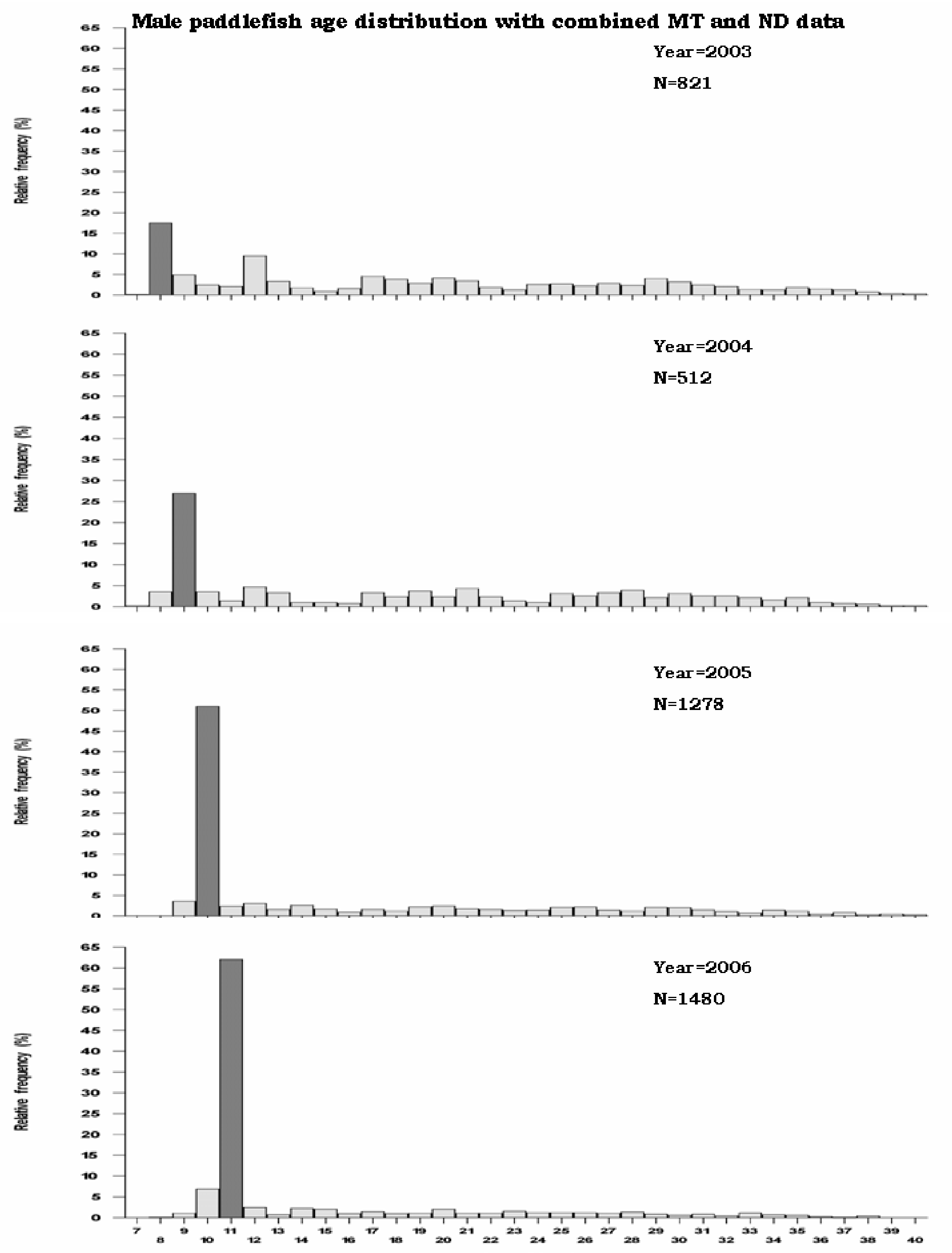


Figure 16. Year-to-year reservoir water level changes in Lake Sakakawea.

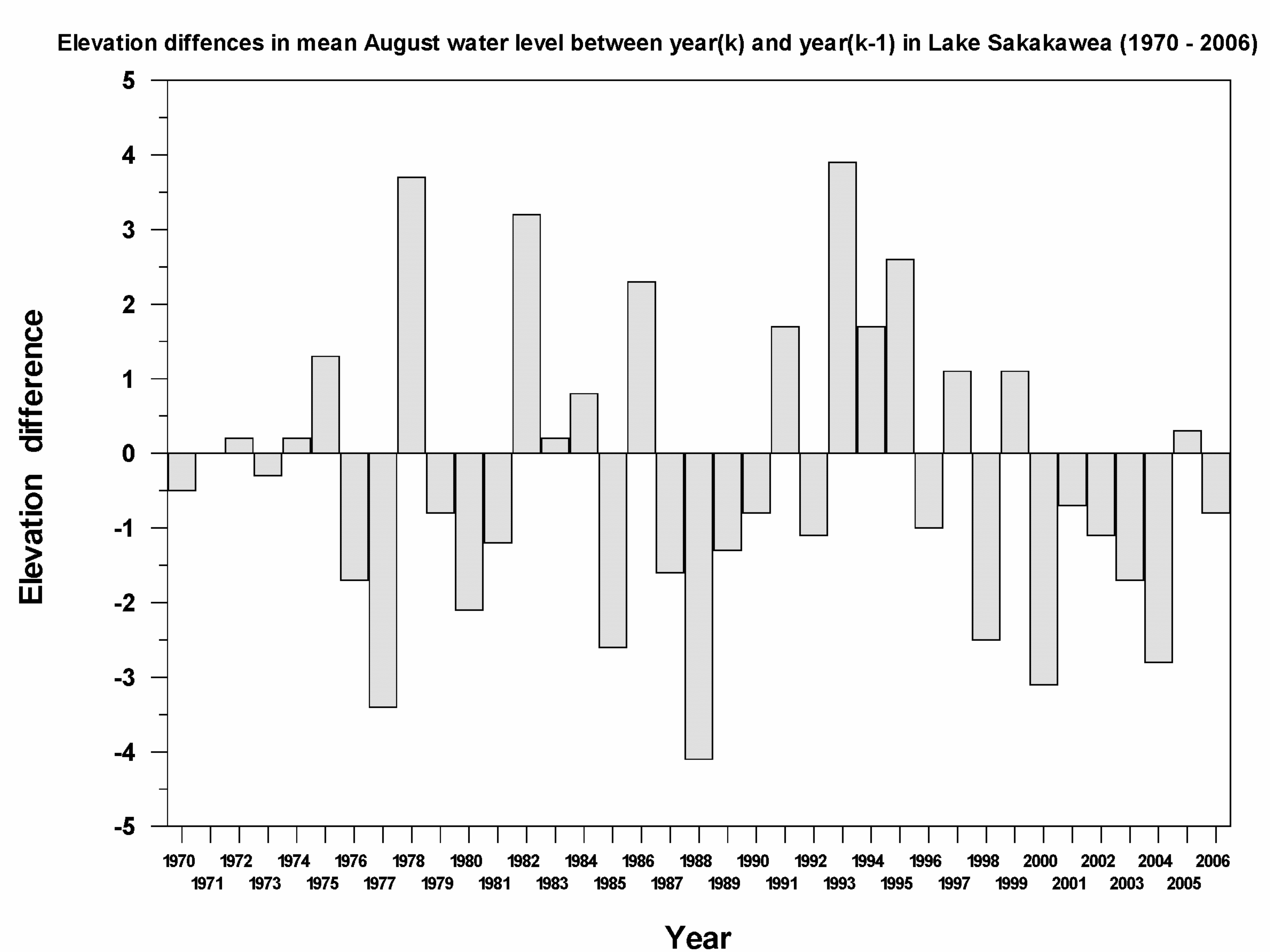


Figure 17. Upper end of Lake Sakakawea during drought showing largely dewatered depositional areas and completely de-watered backwater.

Figure 18. Probability of walleye and sauger containing an age-0 paddlefish increases with age; netted Lake Sakakawea walleye containing age-0 paddlefish.

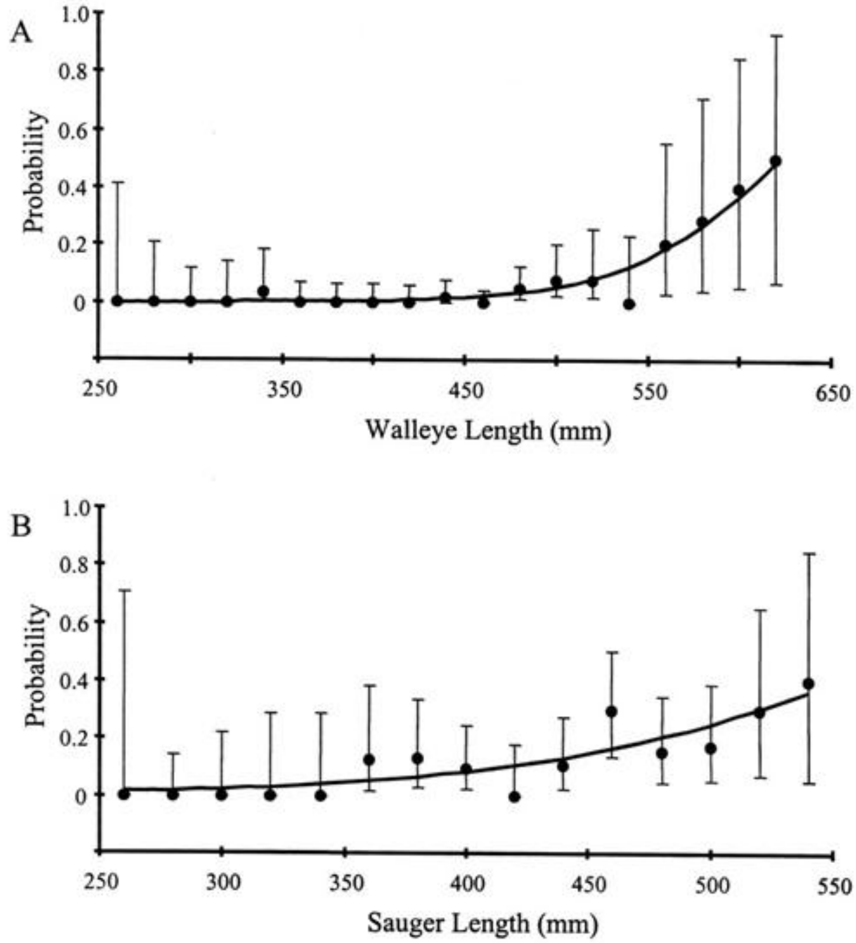


Figure 19. Paddlefish snagging at Pumphouse and Intake.

The most important snagging site in Montana is at Intake (YR Rkm 114; Figure 19b). Other snagging sites in Montana include the Sidney Bridge (YR Rkm 46.6), Richland Park (YR Rkm 35.5) and two snagging sites on Fort Peck Tribal lands on the Missouri River (Wolf Point, Rkm 2744; Frazer Rapids, Rkm 2813.3). A modest archery fishery also exists in the Dredge Cuts (MR Rkm 2846; Needham and Gilge 1986). Additional details about historical aspects of the snag fishery as well as its socio-economic characteristics of snaggers are documented (Scarnecchia et al. 1995b; Scarnecchia et al. 1996a; Scarnecchia and Stewart 1997b). Contrary to some expectations that paddlefish snaggers were strictly harvest-driven, their values, attitudes, and preferences were found to be similar to those of Montana anglers in general (Scarnecchia et al. 1996a).

Catch and effort statistics for both fisheries are compiled annually. Catches in the Montana fishery, with emphasis on the Intake site, are reported in Riggs (2004). Estimated harvest over the period 1972-2006 has ranged from 278 fish in 1994 to 5,318 fish in 1981. Catch (fish) per angler day has ranged from 0.27 in 1994 to 1.91 in 1973. The number of angler days has ranged from 1,037 in 1994 to 6,130 in 1978 (Figure 20). For the North Dakota fishery, harvest has ranged from 800 fish in 1997 to 2,205 fish in 2000 (Figure 21). Differences in annual catches are a result of a number of variables, primarily differential availability of fish associated with variations in spring discharge and increasingly restrictive regulations.

Management Chronology

The detailed management history of the Yellowstone Sakakawea stock that follows is divided into four periods based on stock trends and differences in regulations. The regulation chronologies are summarized in Table 4 and 5.

Period 1 (1963-1977)

Period 1 was characterized by an increase in the numbers of recruited paddlefish and the beginning of fisheries, which were conducted with liberal regulations.

<u>Montana</u>

Although fishing for paddlefish and other river species in the lower Yellowstone River has a century-long history with European settlers (Figures 22, 23) and a longer history with tribal inhabitants, MTFWP 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 snagging 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

Figure 20. Harvest, fish per angler day and anger days, Yellowstone-Sakakawea paddlefish by year in Montana, 1972-2005.

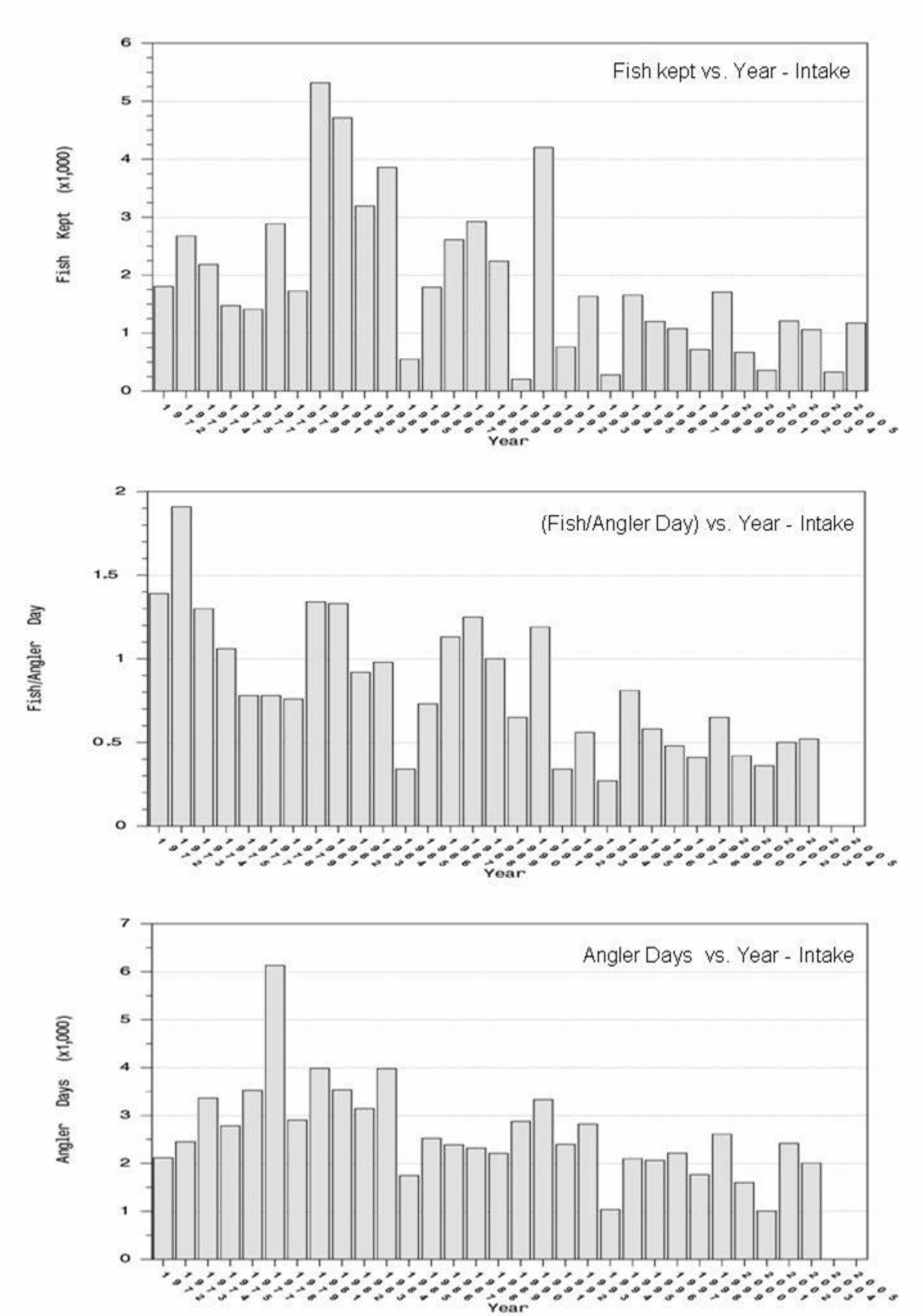


Figure 21. Harvest of Yellowstone-Sakakawea paddlefish by year in North Dakota, 1992-2007.

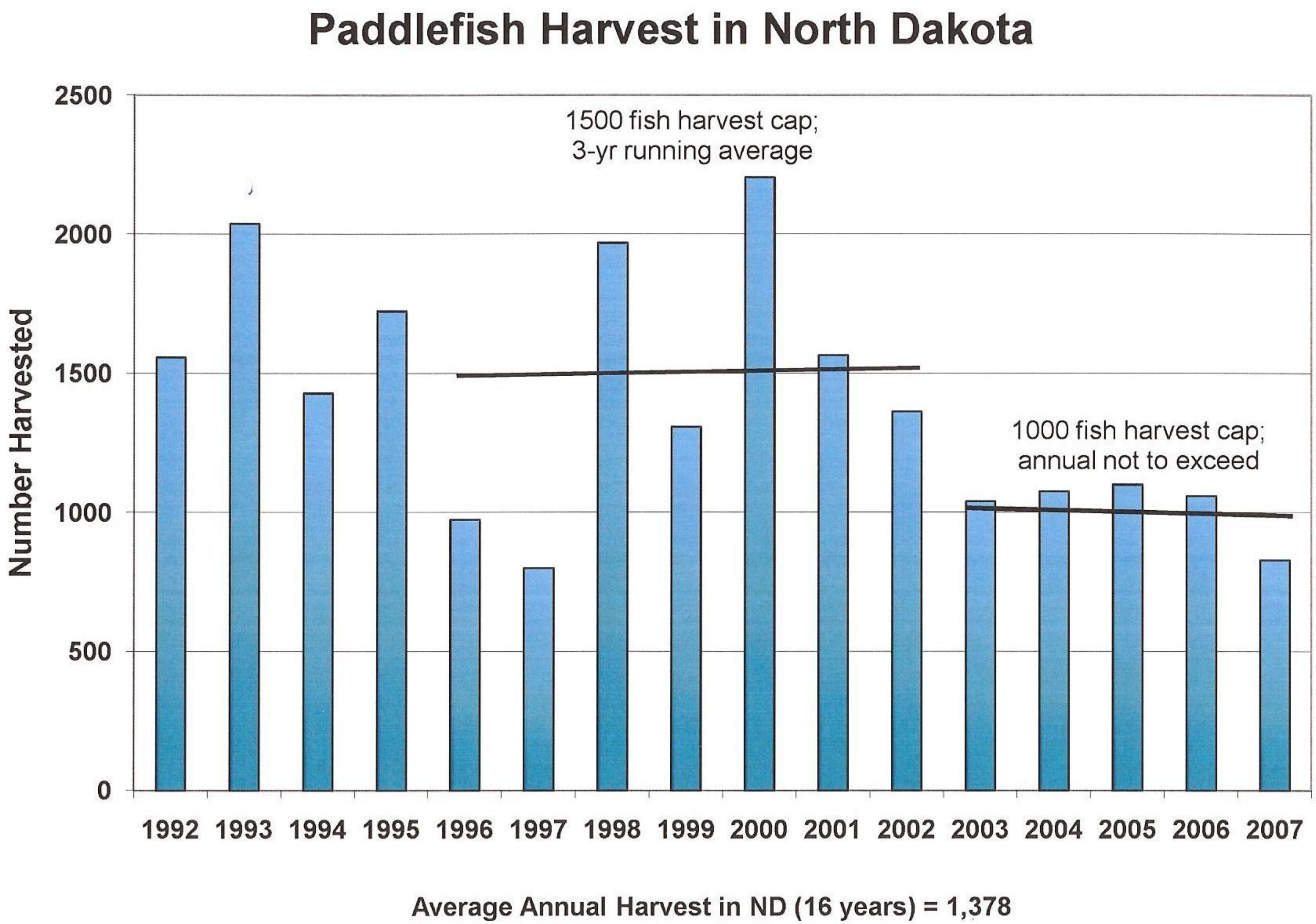


Table 4. Summary of North Dakota paddlefish regulations for Yellowstone-Sakakawea stock, 1976-2007.

YEAR	SEASON DATES & LENGTH (DAYS)	LIMIT DAILY	POSSESSION	SEASON	Snagging Hours/Day	LEGAL TO RELEASE?	LEGAL TO SNAG IF WITH LIMIT?
1976	5/01 - 11/14 (198)	2	2		24	No	No
1977	5/07 - 11/13 (191)		2	2	24	No	No
1978	5/06 – 9/09 (127)		2	2	24	No	No
1979	5/05 – 9/14 (133)		2	2	24	No	No
1980	5/03 - 11/16 (198)		2	2	24	No	No
1981	5/02 - 7/12 (72)		1	2	24	No	No
1982	5/01 - 7/11 (72)		1	2	24	No	No
1983	4/30 - 7/01 (63)		1	2	24	No	No
1984	5/05 - 7/01 (58)		1	2	24	No	No
1985	5/04 - 7/01 (59)		1	1	24	No	No
1986	5/03 - 7/01 (60)		1	1	24	No	No
1987	5/02 - 7/01 (61)		1	1	24	No	No
1988	5/07 - 7/01 (56)		1	1	24	No	No
1989	5/06 - 7/01 (57)		1	1	24	No	No
1990	5/05 - 7/01 (58)		1	1	24	No	No
1991	5/04 - 7/01 (59)		1	1	24	No	No
1992	5/02 - 7/01 (61)			2	24	No	illegal w/o an unused tag
1993	5/01 - 6/30 (61)			2	24	No	illegal w/o an unused tag
1994	5/01 - 6/15 (46)			2	24	No	illegal w/o an unused tag
1995	5/01 - 6/15 (46)			2	24	No	illegal w/o an unused tag
1996	5/01 - 6/15 (46)			1	24	No	illegal w/o an unused tag
1997	5/01 - 6/15 (46)			1	24	No	illegal w/o an unused tag
1998	5/01 - 6/15 (46)			2	24	No	illegal w/o an unused tag
1999	5/01 - 6/15 (46)			2	24	No	illegal w/o an unused tag
2000	5/01 - 6/15 (46)			2	24	No	illegal w/o an unused tag
2001	5/01 - 6/15 (31 S&H)			1	24	No	illegal w/o an unused tag

Table 4. Summary of North Dakota paddlefish regulations for Yellowstone-Sakakawea stock (continued).

YEAR	SEASON DATES & LENGTH (DAYS)	LIMIT DAILY POSSESSION SEASON	Snagging Hours/Day	LEGAL TO RELEASE?	LEGAL TO SNAG IF WITH LIMIT?
2002	5/01 - 5/31 (19 S&H)	1	16.5	No	illegal w/o an unused tag
2003	5/01 - 5/31 (23 S&H + 8 S&R)	1	16.5	Yes	illegal w/o an unused tag
2004	5/01 - 5/31 (20 S&H + 8 S&R)	1	14	Yes	illegal w/o an unused tag
2005	5/01 - 5/31 (10 S&H + 4 S&R)	1	14	Yes	illegal w/o an unused tag
2006	5/01 - 5/31 (9 S&H + 4 S&R)	1	14	Yes	illegal w/o an unused tag
2007	5/01 - 5/31 (7.4 S&H + 10 S&R)	1	14	Yes	illegal w/o an unused tag

Notes: Since the 1992 season, snaggers have been required to obtain a tag or tags to legally snag for PAH. A harvest cap of 1500 was implemented in 1996; the cap was further reduced to 1000 fish in 2003. Except for the 2003 season, an in-season closure was invoked each year since 2001 to avoid exceeding the harvest cap. Since 2003 mandatory release of all snagged fish has been required each Monday and Tuesday of the open season; mandatory snag and harvest has continued for all other days of the week. Beginning with the 2002 snagging season, legal snagging hours were 5:30 AM to 10 PM (night fishing was eliminated). For the 2004 through 2007 snagging seasons, legal snagging hours were further reduced to 8 AM to 10 PM. Newly implemented in 2007 was a 7-day snag & release only extension following the in-season harvest closure.

Table 5. Chronology of Montana paddlefish regulations, 1980-2007.

YEAR	FISHING DISTRICT	DAILY AND POSSESSION	WATERBODY	REGULATIONS
1980-81	4 Central	(1) daily and (2) in possession	Upper Missouri	All waters open to angling are open to bow and arrow and snagging of paddlefish.
1980-81	5 South Central	(1) daily and (2) in possession	Upper Yellowstone	All waters open to angling are open to bow and arrow and snagging of nongame fish.
1980-81	6 Northeastern	(1) daily and (2) in possession	Lower Missouri	All waters open to angling are open to bow and arrow and snagging of paddlefish.
1980-81	7 Southeastern	(1) daily and (2) in possession	Lower Yellowstone	All waters open to angling are open to bow and arrow and snagging of paddlefish. ¼ mile downstream from Intake diversion closed to snagging from boats from May 1-July 31.
1981-82	4 Upper Missouri	(1) daily and (2) in possession		All waters open to angling are open to bow and arrow and snagging of paddlefish.
1981-82	5 Upper Yellowstone	Not listed		All waters open to angling are open to bow and arrow and snagging of nongame fish.
1981-82	6 Lower Missouri	(1) daily and (2) in possession		All waters open to angling are open to bow and arrow and snagging of paddlefish.
*1981-82	7 Lower Yellowstone	(2) per year Tags required		Downstream from the mouth of the Bighorn River: Any paddlefish caught must be **tagged** immediately and counted in this limit. All waters open to angling are open to bow and arrow and snagging of paddlefish. ¼ mile downstream from Intake diversion closed to fishing or snagging from boats from May 1- July 31.
1982-83	4 Upper Missouri	(1) daily and (2) in possession		All waters open to angling are open to bow and arrow and snagging of paddlefish.
1982-83	5 Lower Yellowstone	Not listed		All waters open to angling are open to bow and arrow and snagging of nongame fish.

Table 5. Chronology of Montana paddlefish regulations, 1980-2007 (continued).

1982-83	6 Lower Yellowstone	(1) daily and (2) in possession		All waters open to angling are open to bow and arrow and snagging of paddlefish.
1982-83	7 Lower Yellowstone	(2) per year Tags required		Downstream from the mouth of the Bighorn River: Any paddlefish caught must be **tagged** immediately and counted in this limit. From May 1- July11 snagging of paddlefish shall be allowed. ¼ mile downstream from Intake diversion closed to fishing or snagging from boats from May 1- July 11.
1983-84	Eastern Missouri R.	(1) daily and (2) in possession	Missouri River	Open entire year.
	Eastern Lower Yellowstone	2 per year Tags required	Yellowstone River	From May 1- July 10 snagging of paddlefish shall be allowed. Any paddlefish caught must be **tagged** immediately and counted in this limit. ¼ mile downstream from Intake diversion closed to fishing or snagging from boats from May 1- July 10.
1984-85	Eastern	(1) daily and (2) in possession	Missouri River	Open entire year.
	Eastern	2 per year Tags required	Yellowstone River	From May 1-July 8 snagging of paddlefish allowed downstream from the mouth of the Bighorn River. Any paddlefish caught must be **tagged** immediately and counted in this limit. ¼ mile downstream from Intake diversion closed to fishing or snagging from boats from May 1- July 8.
1985-86	Eastern	(1) daily and (2) in possession	Missouri River	Open entire year.
	Eastern	2 per year Tags required	Yellowstone River	From May 1 - July14 snagging of paddlefish allowed downstream from the mouth of the Bighorn River. Any paddlefish caught must be **tagged** immediately and counted in this limit.
1986-88	Eastern	(1) daily and (2) in possession.	Missouri River	Open entire year. No tags required.

Table 5. Chronology of Montana paddlefish regulations, 1980-2007 (continued).

		(2) per year Tags required	Lower Yellowstone River	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. ¼ mile downstream from Intake diversion closed to fishing or snagging from boats from May 15- July 10. Any paddlefish caught must be **tagged** immediately.
1988-90	Eastern	(1) daily and (2) in possession.	Missouri River	Open entire year. No tags required.
1990-92	Eastern	(1) daily and (2) in possession.	Missouri River	Open entire year. No tags required.
		(2) per year Tags required	Lower Yellowstone River	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 Cr. ¼ mile downstream from Intake diversion closed to fishing or snagging from boats from May 15-June 30. Any paddlefish caught must be **tagged** immediately.
1992-93	Eastern	(2) Total Tags required: Either 2 on the Missouri above Ft Peck or 1 above Ft Peck and 1 on the lower Missouri/ Yellowstone	Missouri River	Open entire year. All paddlefish anglers must **tag or release** a paddlefish immediately.
			Lower Yellowstone River	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 Cr. ¼ mile downstream from Intake diversion closed to fishing or snagging from boats from May 15-June 30. Any paddlefish caught must be **tagged** immediately.

Table 5. Chronology of Montana paddlefish regulations, 1980-2007 (continued).

1994-95	Eastern	(2) Total Tags required: Either 2 on the Missouri above Ft Peck or 1 above Ft Peck and 1 on the lower Missouri/ Yellowstone	Missouri River upstream of Fort Peck Dam	All paddlefish anglers must **tag or release** a paddlefish immediately upstream of Fort Peck Dam.
	Eastern		Missouri River below Fort Peck Dam and the Yellowstone River	Tags required. For the Yellowstone R. only 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 Cr. ¼ mile downstream from Intake diversion closed to fishing or snagging from boats from May 15-June 30. Any paddlefish caught must be **tagged** immediately.
1996-97	Eastern	(2) Total Tags required: Either 2 on the Missouri above Ft Peck or 1 above Ft Peck and 1 on the lower Missouri/ Yellowstone	Missouri River upstream of Fort Peck Dam	All paddlefish anglers must **tag or release** a paddlefish immediately upstream of Fort Peck Dam.
	Eastern		Missouri River below Fort Peck Dam Yellowstone River	Tags required. For the Yellowstone R. only 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 Cr. ¼ mile downstream from Intake diversion closed to fishing or snagging from boats from May 15-June 30. 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.

Table 5. Chronology of Montana paddlefish regulations, 1980-2007 (continued).

1998-99	Eastern	(2) Total Tags required: Either 2 on the Missouri above Ft Peck or 1 above Ft Peck and 1 on the lower Missouri/ Yellowstone	Missouri River upstream of Fort Peck Dam Missouri River below Fort Peck Dam Yellowstone River	All paddlefish anglers must **tag or release** a paddlefish immediately upstream of Fort Peck Dam. Open entire year. Paddlefish may be harvested using hook and line and/or bow and arrow in the Fort Peck Dredge Cuts. For the Yellowstone R. only 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 Cr. ¼ mile downstream from Intake diversion closed to fishing or snagging from boats from May 15-June 30. Any paddlefish caught must be **tagged** immediately unless accomplished in accordance with the specific catch-and-release regulations at the Intake FAS.
2000-01	Eastern	(2) Total Tags required: Either 2 on the Missouri above Ft Peck or 1 above Ft Peck and 1 on the lower Missouri/ Yellowstone	Missouri River upstream of Fort Peck Dam Missouri River below Fort Peck Dam Yellowstone River	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. Paddlefish may be harvested using hook and line and/or bow and arrow in the Fort Peck Dredge Cuts. For the Yellowstone R. only 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 Cr. ¼ mile downstream from Intake diversion closed to fishing or snagging from boats from May 15-June 30. Any paddlefish on the Yellowstone R. and downstream of Fort Peck Dam must be caught and **tagged** immediately unless accomplished in accordance with the specific catch-and-release regulations at the Intake FAS on Wed. and Sun. Downstream of Fort Peck Dam open entire year. Any paddlefish caught must be **tagged** immediately. For the Yellowstone R. and Missouri R. downstream of Fort Peck Dam FWP can close the season if the annual harvest approaches 1500 fish.

Table 5. Chronology of Montana paddlefish regulations, 1980-2007 (continued).

2002-03	Eastern	(2) Total Tags required: Either 2 on the Missouri above Ft Peck or 1 above Ft Peck and 1 on the lower Missouri/ Yellowstone	Missouri River upstream of Fort Peck Dam Missouri River below Fort Peck Dam Yellowstone River	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. For the Yellowstone R. and Missouri R. downstream of Fort Peck Dam FWP can close the season if the annual harvest approaches 1000 fish. Downstream of Fort Peck Dam open entire year. Any paddlefish caught must be **tagged** immediately. For the Yellowstone R. only 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 Cr. downstream to the N. Dakota border. Intake Fishing Site closed May 15-June 30 to fishing or snagging from boats. Any paddlefish on the Yellowstone R. and downstream of Fort Peck Dam must be caught and **tagged** immediately unless accomplished in accordance with the specific catch-and-release regulations at the Intake FAS on Wed. and Sun.
2004	Eastern	(2) Total Tags required: Either 2 on the Missouri above Ft Peck or 1 above Ft Peck and 1 on the lower Missouri/ Yellowstone	Missouri River upstream of Fort Peck Dam Missouri River below Fort Peck Dam Yellowstone River	Yellow tag required for the Yellowstone R. or Missouri R. downstream from Fort Peck Dam. 2 White tag/s required for Missouri R. above Fort Peck Dam or 1 yellow and 1 white. 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. Downstream of Fort Peck Dam open entire year or until closed. For the Yellowstone R. and Missouri R. downstream of Fort Peck Dam FWP can close the season if the annual harvest approaches 1000 fish. For the Yellowstone R. only open to the snagging of paddlefish May 15- June 30 from the downstream from the mouth of the Bighorn R.

Table 5. Chronology of Montana paddlefish regulations, 1980-2007 (continued).

				Intake Diversion Dam to ¼ mile downstream closed May 15-June 30 to fishing or snagging from boats. Any paddlefish on the Yellowstone R. and downstream of Fort Peck Dam caught must be **tagged** immediately unless accomplished in accordance with the specific catch-and-release regulations at the Intake FAS on Wed. and Sun.
2005	Eastern	(2) Total Tags required: Either 2 on the Missouri above Ft Peck or 1 above Ft Peck and 1 on the lower Missouri/ Yellowstone	Missouri River upstream of Fort Peck Dam Missouri River below Fort Peck Dam Yellowstone River	Yellow tag required for the Yellowstone R. or Missouri R. downstream from Fort Peck Dam. White tag required for Missouri R. above Fort Peck Dam or 1 yellow and 1 white for two fish harvested. 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. Downstream of Fort Peck Dam open entire year or until closed. For the Yellowstone R. and Missouri R. downstream of Fort Peck Dam FWP can close the season if the annual harvest approaches 1000 fish. For the Yellowstone R. only open to the snagging of paddlefish May 15- June 30 from the downstream from the mouth of the Bighorn R. Intake Diversion Dam to ¼ mile downstream closed May 15-June 30 to fishing or snagging from boats. Any paddlefish caught must be **tagged** immediately unless accomplished in accordance with the specific catch-and-release regulations at the Intake FAS on Wed. and Sun.

Table 5. Chronology of Montana paddlefish regulations, 1980-2007 (continued).

2006	Eastern	(2) Total Tags required: Either 2 on the Missouri above Ft Peck or 1 above Ft Peck and 1 on the lower Missouri/ Yellowstone	Missouri River upstream of Fort Peck Dam to Fort Benton Missouri River below Fort Peck Dam Yellowstone River	Yellow tag required for the Yellowstone R. or Missouri R. downstream from Fort Peck Dam. White tag required for Missouri R. above Fort Peck Dam or 1 yellow and 1 white for two fish harvested. 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. Downstream of Fort Peck Dam open entire year or until closed. For the Yellowstone R. and Missouri R. downstream of Fort Peck Dam FWP can close the season if the annual harvest approaches 1000 fish. For the Yellowstone R. only open to the snagging of paddlefish May 15- June 30 from the downstream from the mouth of the Bighorn R. Intake Diversion Dam to ¼ mile downstream closed May 15-June 30 to fishing or snagging from boats. Any paddlefish on the Yellowstone R. and downstream of Fort Peck Dam caught must be **tagged** immediately unless accomplished in accordance with the specific catch-and-release regulations at the Intake FAS on Wed. and Sun.

Table 5. Chronology of Montana paddlefish regulations, 1980-2007 (continued).

2007	Eastern	Paddlefish Limit: (1) per year	Missouri River upstream of Fort Peck Dam Missouri River below Fort Peck Dam Yellowstone River	Anglers may select only **one** of the following areas: Upper Missouri River, upstream from Fort Peck Dam to Fort Benton-white tag/ Yellowstone R., or Lower Missouri R. downstream form Fort Peck-yellow tag/ Fort Peck Dredge Cuts (west of Park Grove Bridge and Nelson Dredge) on the lower Missouri River-blue tag. 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. For the Yellowstone R. and Missouri R. downstream of Fort Peck Dam FWP can close the season if the annual harvest reaches 800 fish but catch- and release can continue on the designated days until June 30. The harvest quota is still 1,000. 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 the Intake Diversion Dam to ¼ mile downstream closed May 15-June 30 to fishing or snagging from boats.

Figure 22. Fishing at Intake, ca.1910 and nearly a century later.

Figure 23. Paddlefish and sturgeon catch near Glendive, Montana, ca. 1910.

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 snagging was prohibited for the area from the Intake dam 0.40 km (1/4 mile) downstream during May, June and July in an effort to reduce conflicts between boat-based anglers (snaggers and walleye or sauger anglers) and those snagging 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.

North Dakota

Occasional early references to paddlefish exist in North Dakota, including an early photograph 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 brief 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. The few fish thought to have been harvested during this period were caught with nets, traps, seines, setlines, and unbaited hooks. Snagging was illegal (Carufel 1954). Commercial fishing records for Lake Sakakawea document an allowed incidental harvest of paddlefish from 1953 to 1981, the last year of 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; NDGFD, 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 (the release of a fish after it has been creeled but later discarded after a larger fish was caught) 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.

Limited paddlefish investigations were begun 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).

<u>Montana</u>

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 snagging pressure and harvest should not be allowed to continue. In an effort to gain tighter control on harvest, in 1979, a proposal was made to the Montana Legislature to require a paddlefish tag “similar to a deer tag” (HB 173; 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 interests 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 MTFWP 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. Information collected that year indicated that females made up more than 80% of documented fish cleaned, as a result of the concessionaire selectively cleaning them. 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. In their enthusiasm to creel a large fish, snaggers 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 snaggers were practicing delayed high-grading, resulting in many paddlefish being released in poor condition and washing up on the river bank 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 paddlefishing 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. Snaggers 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 specifically for biological reasons but in response to what were perceived by the public and MTFWP as social issues (Elser 1981). In addition to better control over the harvest, the changes resulted in reduced crowding in the most popular snagging 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 prohibited (Table 5).

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 (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, in spite of mandatory retention requirements (Stewart 1984). The high percentage of females was a natural result of the female fish from the reservoir filling period of 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. 2007b). 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 significantly with 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 (Figure 20). 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. Catches from 1985 to 1989 never reached 3,000 fish, and ranged from 550 to 2923 fish (Figure 20; Stewart 1990). As a result, major changes in regulations were not pursued (Stewart, 1986; 1987; 1988; 1989; 1990) and 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). The later opening date upstream accommodated early season sauger and walleye anglers fishing in boats near the 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 5).

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 was collected on harvest, effort, or the effects of the regulations in the 1980s (Ryckman 1995; Table 4).

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 trophic depression, natural and harvest mortality, 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 entity 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 2007) 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 (which provides regional community improvement grants of diverse kinds), and a lesser portion to MTFWP (initially 50% of net income, most recently 30%) 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 data base 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 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).

In 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 and intermediate discharges in 1993 resulted in 1635 fish (Figure 16). 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 older than expected and older than other paddlefish stocks nationwide. Mean age of the stock had increased steadily since the mid-1970s, and a high percentage of fish harvested was larger, older females. The 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 (Table 5).

In 1995, a year after the reduction in the bag limit, mandatory catch-and-release snagging 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). An evaluation of catch-and-release snagging (Scarnecchia and Stewart 1997a) 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 MTFWP 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). Evidence of a declining stock and an increase in the snag fishery harvest in North Dakota, however, led to discussions of the need for an annual harvest cap.

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 effort to provide snagging regulations consistent with angler interests.

North Dakota

In 1992, NDGFD 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 for residents and $7.50 for non-residents in 1994 (Table 4).

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 North Star Caviar) was developed between the Williston Chamber of Commerce and the Friends of Fort Union Trading Post, 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 NDGFD. 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- 2007)

The fourth period, from1996 to 2007, has been characterized by the implementation of an equitable annual harvest cap in each state, a response by snaggers to shift their snagging effort earlier in the season (to insure harvest of a fish), and a counter response by managers with several regulations designed to spread out effort more during the season. These regulations have included prohibition of night snagging and increased opportunities for catch and release.

In 1996, a harvest cap for the Yellowstone-Sakakawea stock was set at 1,500 fish per state under the previous 10-year management 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. The cap of 1,500 fish per state remained in place through the 2002 season (with several resulting in-season closures), until a stock assessment rationale for a harvest cap was developed through a straightforward analysis of population estimates, catches, and age structure. Over the period 1999-2002, NDGFD interpreted the harvest cap of 1,500 as a three year running average cap. Since 2002, the harvest cap has since been set at 1,000 fish per state and considered strictly an annual cap.

Fisheries in both Montana and North Dakota have provisions for early in-season closure. No limit is set on the number of tags sold, but catches are monitored in-season, and closures are implemented to coincide with the projected attainment of the harvest cap. Effective use requires an accurate in-season harvest estimate, which is obtained by tallying catches brought into the fish cleaning/caviar stations. Off site harvest is estimated based on previous years' estimates of the off-site non-tribal harvest (i.e., the number of harvested fish not delivered to cleaning stations), obtained from a uniformly-designed phone creel survey in each state. Off-site harvest in Montana is typically higher because of the more dispersed fishery, although off-site harvest is low in years of high success rates at Intake. Harvest by Fort Peck tribal fisheries is not yet well documented, but is typically low (<100 fish), except in years such as 2005 when higher spring discharges in the Missouri River than Yellowstone River increase migration up the Missouri.

The 1,000 fish harvest cap in each state has resulted in more intensive snagging earlier in the season, and progressively shorter seasons have resulted (Figure 18). In 2007, the North Dakota season had only 7.4 harvest days and the Montana fishery only 3.5 harvest days. This in-season closure system has created some crowding problems at confined snagging sites such as Intake and the Confluence. However, at current levels of snagging effort, these effects have been manageable, and stock assessment data collected from this system have in general been compatible with that from years without in-season closure.

Although both states have the same harvest cap allocation, they do not necessarily have similar harvests 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. Harvest in Montana over the period 2000-2005 ranged from 329 fish in 2004 to 1,208 fish in 2002 (Figure 16). Harvest in North Dakota from 2000 to 2007 ranged from 829 fish in 2003 to 2,205 fish in 2000 (Figure 17).

Montana

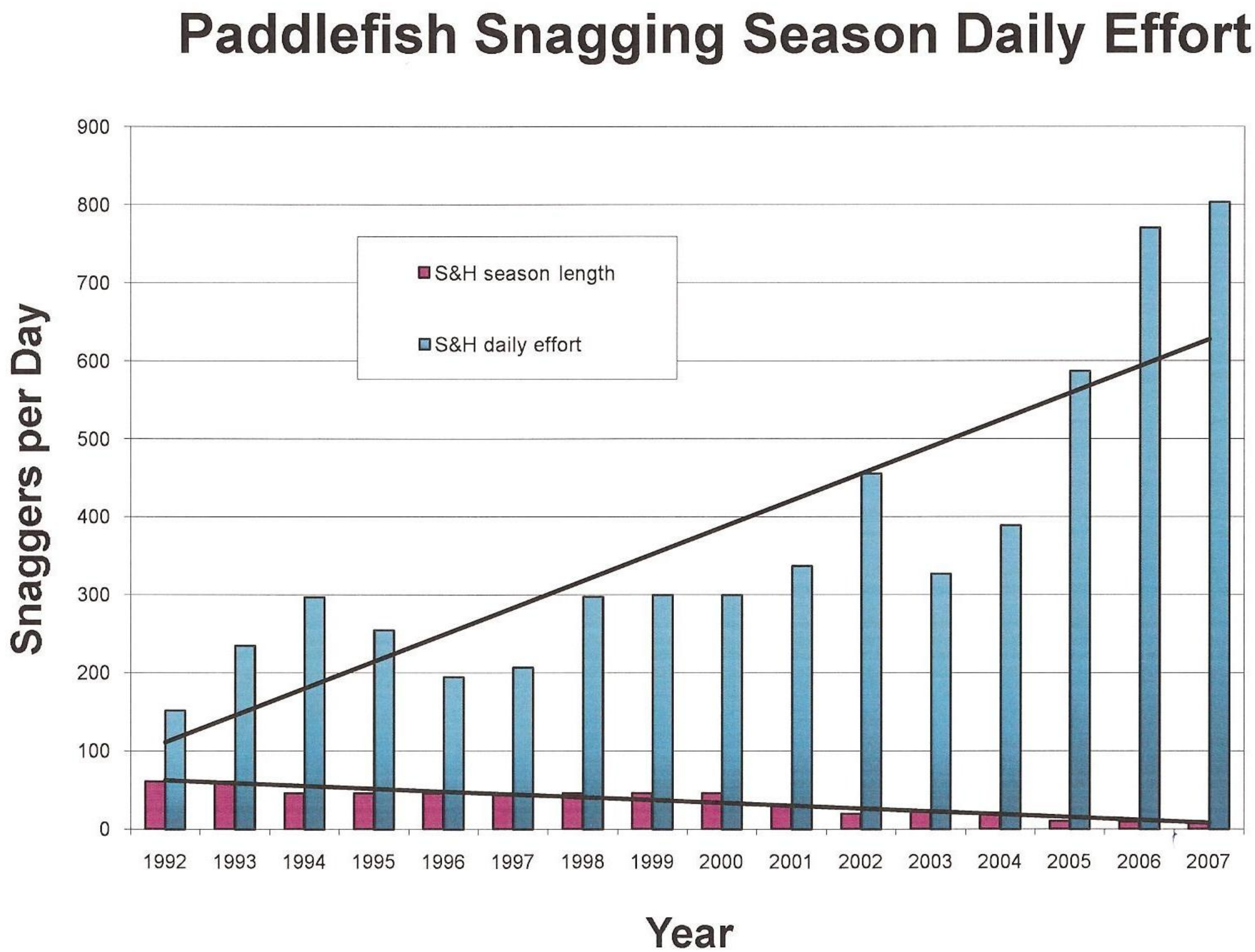
Montana's bag limit has remained at one fish per person per year since 1994. Catch-and-release opportunities (Wednesday and Sunday 3-9 PM) remained the same through 2006. After closure of the harvest fishery, catch-and-release snagging has typically been allowed until June 30 at the Intake Site. In 2007, in response to rapid attainment of the harvest cap in 2006, three days of mandatory catch-and-release snagging were implemented (Sunday, Monday and Thursday). Following harvest closure, catch and release was permitted for three days per week, not restricted to the Intake site. In 2007, snagging was also restricted to daylight hours of 6AM to 9 PM (Table 5). Snagging for paddlefish in Montana had previously always been permitted 24 hours per day during the season. The increase in catch-and release snagging and prohibition of night snagging were anticipated to prolong the harvest season. Prohibition of night snagging was also implemented in an effort to reduce nighttime violations (e.g., illegal snagging, high-grading, tag switching) and improve the accuracy of harvest estimates.

North Dakota

North Dakota's regulations have become somewhat more restrictive to insure that the harvest cap is not being exceeded. Under the 1,500 fish harvest cap, a snagger's annual bag limit was reduced to one fish in 1996 and 1997, but was raised to 2 fish in 1998 through 2000. Since 2001, the annual bag limit has been one fish (Table 4). 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 were typically low, so the impact of this change was minimal.

More recent regulations have been designed to spread out snagging effort and facilitate enforcement. In 2002, night snagging was eliminated, and snagging was allowed from 5:30 AM to 10 PM CST. The change reduced daily harvest and reduced the potential for violations such as high-grading and tag switching, which were more common at night. Beginning in 2003, catch and release of all fish became mandatory every Monday and Tuesday during the open season. In 2004, the daily snagging period was reduced to 8AM to 10 PM (Table 4). Despite these regulatory changes, 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 7.4 days in 2007 (Figure 24; Table 4). The number of snaggers per harvest day more than doubled from 2003 to 2006, which has resulted in increased crowding and pressure on facilities at snagging sites (L.F. Ryckman, Memo to G. J. Power, October 11, 2006).

Figure 24. Paddlefish snagging season daily effort, North Dakota, 1992-2007.



From 2003 through 2006, catch-and-release snagging also ended with the closure of the harvest season. Total estimated number of catch-and-release snagging hours has ranged from 244 in 2005 to 842 in 2004. In 2007, limited catch-and release snagging was continued for 7 days (at the Confluence) after the harvest season closure to provide additional snagging opportunity. Only an estimated 175 total hours of effort occurred during this extended period (mostly as a result of poor success because most fish had moved upriver into Montana).

Other Fishery Components

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

Non-tribal snag and archery fisheries

The snag and archery fisheries in the Missouri River below Fort Peck Dam 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 snaggers or archers (Table 5). 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 it was closed in response to the harvest cap being met. As of 2007, however, this stretch of the Missouri River is managed consistently for snagging under the same season closure and harvest cap applied to the Yellowstone-Sakakawea stock. Also as of 2007, the archery fishery is open from July 15 to August 31, only in the Dredge Cuts. The season in 2008 will extend from July 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 snagging below Fort Peck or in the Yellowstone River (yellow tag) or above Fort Peck (white tag) to be eligible for the archery fishery (Table 5). In 2007, a phone creel survey indicated a harvest of only 10 fish. The fishery is largely self-regulating based on the availability of fish.

Tribal fishery

The Tribal fishery has historically been of small magnitude. 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 downstream 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 2006, 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. Snaggers 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. Each person must cast for and hook his/her own fish. Immediate high-grading is allowed. The fishery is largely self-limiting according to the availability of fish.

Hatchery Production

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 were stocked into Lake Sakakawea, the Missouri River above the reservoir, and in the Yellowstone River by NDGFD (Table 6; Figure 25). The survival and fate of those fish is unknown. In August 1995 and 1997, 9,093 and 9,994 fingerling age-0 fish, batch-tagged with coded wire tags, were stocked into Lake Sakakawea (Table 6). The mean weight of the stocked fish was 84 g in 1995 and 38 g in 1997. Male fish of the 1995 year class have recruited to the fishery, beginning in 2002 (Scarnecchia et al. 2006). As of 2007, about 90 tagged fish (all males) have been recovered at the cleaning stations. Dentaries from these known-age fish have been used for age-validation (Scarnecchia et al. 2006). Over the period 2005-2006, hatchery-reared fish constituted about 3% of the young male recruits at the cleaning stations. No stocking occurred between 1997 and 2006. However, in response to persistent low reservoir levels and low indices of reproduction, a stocking of 23,870 large fingerlings occurred in 2007. Recovery of these fish in future years will be useful for age validation but more importantly for assessing the value of stocking juvenile paddlefish during a low reservoir period.

Stock Assessment

The paddlefish snag fishery for the Yellowstone-Sakakawea stock is the most intensively monitored in North America. Harvest is monitored under a uniform protocol designed by NDGFD and MTFWP in conjunction with the University of Idaho to provide information for comprehensive stock assessment (Scarnecchia et al. 1996c). Both states use the snagger tag system as the cornerstone of the data base. When a fish is caught during mandatory retention periods, the tag must be immediately attached to the fleshy tissue at the front portion of the base the paddlefish's dorsal fin (Figure 26). This tag number stays with the fish (and the caviar) thereafter. Retention of snagged paddlefish is mandatory in both states, except during specified catch-and release periods, when release of fish is mandatory (Scarnecchia and Stewart 1997a). The catch consists almost entirely of sexually mature, pre-spawn migratory fish (Scarnecchia et al. 1996b) and is generally indicative of the actual run.

Figure 25. Paddlefish eggs incubating at Garrison Dam National Fish Hatchery, 2007.

Table 6. Historical paddlefish stocking summary.

Historical Stocking Summary For Paddlefish

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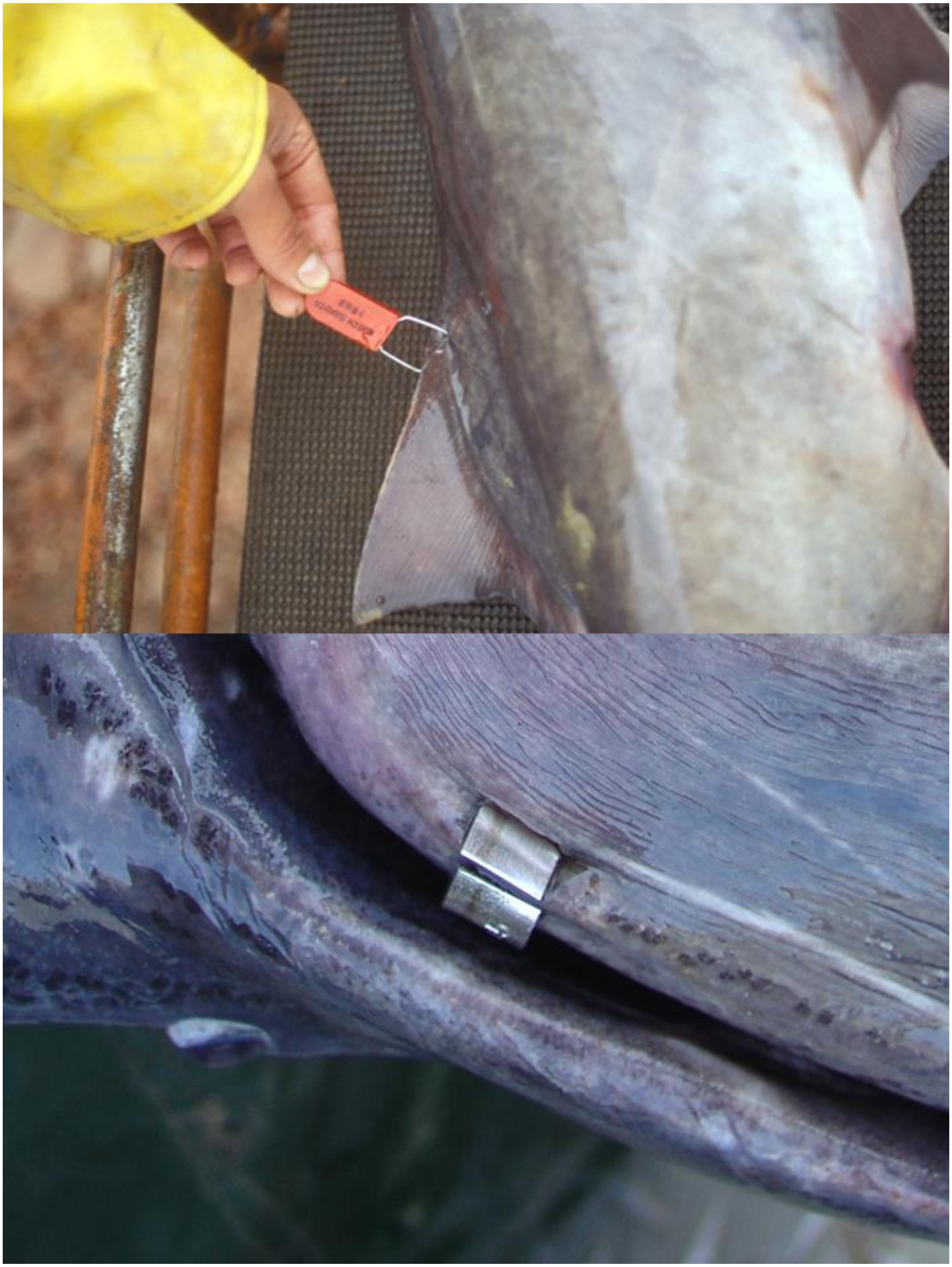
January 25, 2008

2007	Sakakawea, Lake	23,956	FGL	0.1 #/Acre	3,871 Lbs.	6 #/lb
1997	Sakakawea, Lake	9,944	FGL	0.0 #/Acre	1,040 Lbs.	10 #/lb
1995	Sakakawea, Lake	9,093	FGL	0.0 #/Acre	2,082 Lbs.	4 #/lb
1992	Missouri River	400	FGL	0.0 #/Acre	14 Lbs.	28 #/lb
1991	Sakakawea, Lake	7,253	FGL	0.0 #/Acre	346 Lbs.	21 #/lb
1991	Sakakawea, Lake	315,000	FRY	0.9 #/Acre		
1990	Sakakawea, Lake	7,762	FGL	0.0 #/Acre	210 Lbs.	37 #/lb
1990	Upper Missouri River	3,914	FGL	1.9 #/Acre	154 Lbs.	25 #/lb
1989	Upper Missouri River	33,649	FGL	16.7 #/Acre	517 Lbs.	65 #/lb
1988	Upper Missouri River	22,202	FGL	11.0 #/Acre	431 Lbs.	52 #/lb
1988	Upper Missouri River	372,500	FRY	184.9 #/Acre		
1988	Yellowstone River	200,000	FRY	0.0 #/Acre		
1987	Missouri River	1,000	FGL	0.1 #/Acre	30 Lbs.	33 #/lb
1987	Upper Missouri River	8,748	FGL	4.3 #/Acre	243 Lbs.	36 #/lb
1986	Oahe, Lake	9,420	FGL	0.1 #/Acre	453 Lbs.	21 #/lb
1986	Upper Missouri River	11,780	FGL	5.8 #/Acre	680 Lbs.	17 #/lb
1986	Yellowstone River	732,400	FRY	0.0 #/Acre		
1985	Sakakawea, Lake	26,559	FGL	0.1 #/Acre	624 Lbs.	43 #/lb

Figure 26. Individually-numbered paddlefish angler tag and monel (metal) jaw tag.



The sampling program is designed to collect information useful in determining stock size, age structure, growth and mortality rates, reproductive and recruitment success, distribution, migrations and movements, reproductive periodicity, harvest, and several other stock attributes. The database includes information from catches, adult fish tagging and recapture sampling, reservoir fish and habitat sampling data in Lake Sakakawea, and in-season (in person) and post-season (telephone) creel censuses. The data collected are 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 is used to set a harvest cap for the stock, which is then allocated equally between the two states.

Biological and Fisheries Data from Cleaning Stations

The Confluence and Intake cleaning stations are the main sources of biological and fisheries data , processing a high percentage of harvested fish (from 65 to 98% of the annual harvest, depending on the year NDGFD and MTFWP, Unpublished Data; Figure 27). 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, and dentaries (lower jaw bones) for age determination (Adams 1942; Scarnecchia et al. 2006). Over the period 1991-2006, age was determined for a total of 26,809 fish, 14,368 fish (7,832 males, 6,536 females) from the Montana harvest and 12,441 fish (6,829 males, 5,612 females) from the North Dakota harvest. Age determination is necessary because the allowable harvest (i.e., harvest cap) is based on a model which uses the 5-year recruitment of known-age fish (Figure 28).

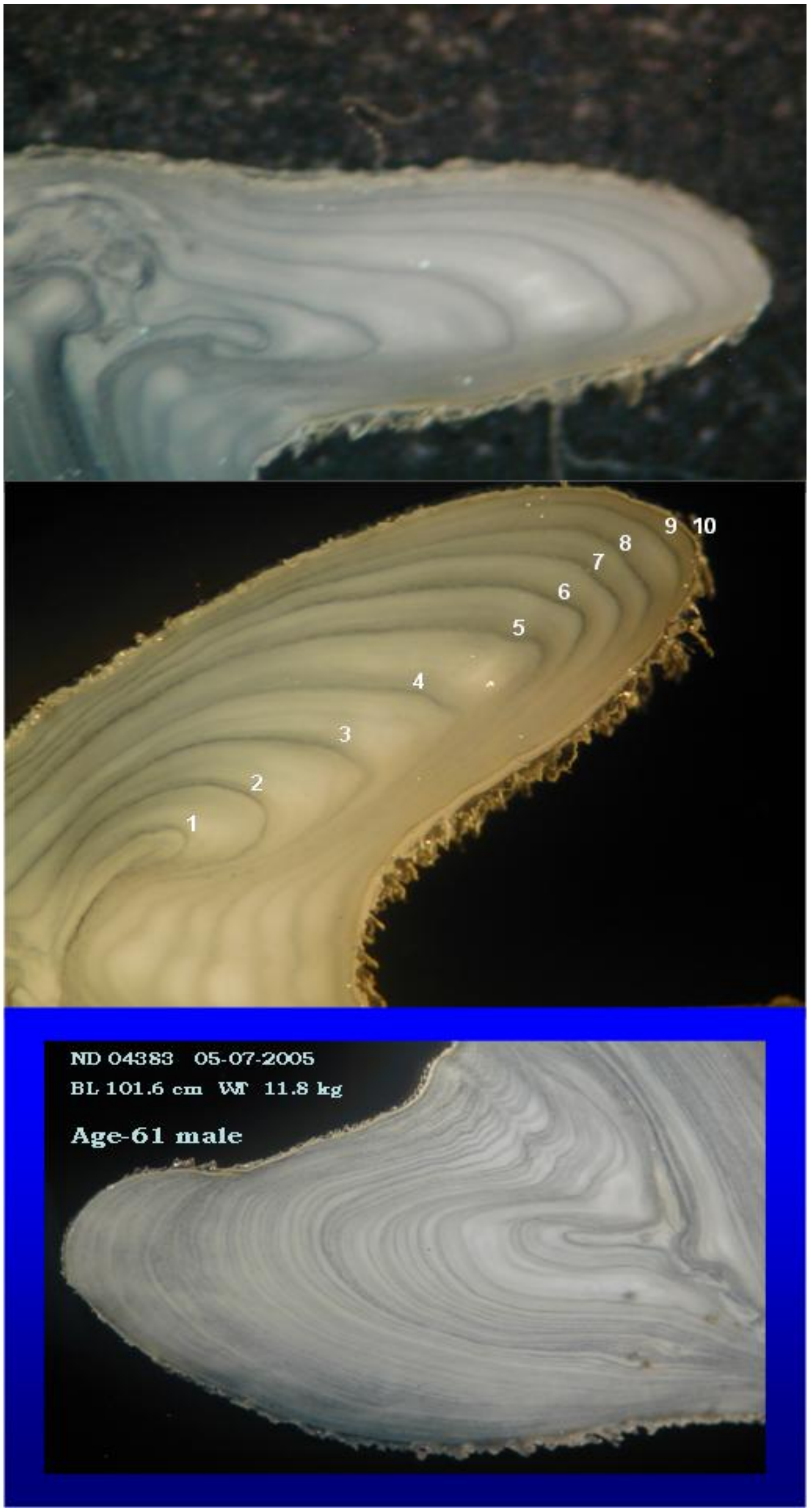
Several other types of information are collected at the fish cleaning stations. Data on snagger success rate, snagging effort, and other angler data are collected at the Intake site. MTFWP and NDGFD conduct comparable phone surveys to supplement on-site creel information. All fish brought to cleaning 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.

Adult Fish Jaw Tagging

NDGFD and MTFWP also supervise and conduct the collection of adult fish for jaw-tagging. In North Dakota, adult fish have been captured with drifted gillnets by NDGFD in the Missouri and Yellowstone rivers during spring and fall. In Montana, fish have been captured with gillnets by MTFWP in the Yellowstone River and by snaggers at Intake during standard catch-and-release periods in May and June. Captured fish are measured, weighed (except for snagged fish), tagged with jaw tags (Figure 26a) and released. Over the period 1964-2006, 19,530 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. Tags are recovered from fish subsequently gillnetted by state fisheries agencies, harvested by recreational

Figure 27. Collecting creel information on paddle (clockwise from top) at The Confluence, Intake, and Fred Robinson Bridge.

Figure 28. (Top to bottom) Dentary from known age-7 paddlefish reared at Garrison Dam National Fish Hatchery in 1995, released in 1995, and harvested in 2002; dentary from known age-10 paddlefish, and old male fish estimated to be age 61 (bottom).



snaggers and brought to the Confluence or Intake for cleaning, captured during catch-and-release snagging, or from other incidental reports. Beginning in 1991, dentaries were also removed from most tagged fish brought into the cleaning stations. 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. Population estimates and harvest rates for adult migratory fish are estimated from conventional jaw tagging. Over the period 1995-2007, comprehensive historical data bases were completed and verified for all fish previously tagged. The data base is updated and error-checked annually with records from newly-tagged fish and recoveries of previously tagged fish.

Reservoir Sampling of Age-0 and Age-1 Fish, Zooplankton, and Reservoir Habitat

The third main 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 age-1 fish are conducted, in additional to sampling several limnological characteristics 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 can be easily caught in dip nets from the bow or sides of a slow-moving boat (Scarnecchia et al. 1997; Figure 29a). This method allows for the capture and tagging of large numbers of age-0 fish in years when they are abundant. It also allows for sampling for food habits and other data (Fredericks 1994; Figure 29d). Over the period 1996-2006, 12,813 age-0 fish have been caught and tagged with batch (by year) coded wire tags (Figure 29 b, c). These fish should prove to be useful in age validation (Figure 28) and for making estimates of 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. 2007b). Indices of abundance of 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 9-11) contributing to fisheries several years before females of their year class, and 4) the Five-Year Recruitment Estimate, from which the harvest cap is set.

Figure 29. (Clockwise from upper left) Dip netting age-0 paddlefish in Lake Sakakawea, weighing and measuring the fish, inserting coded-wire tag in rostrum with hand-held tagger, and *Leptodora kindtii*, predaceous cladoceran and preferred food for of age-0 paddlefish.

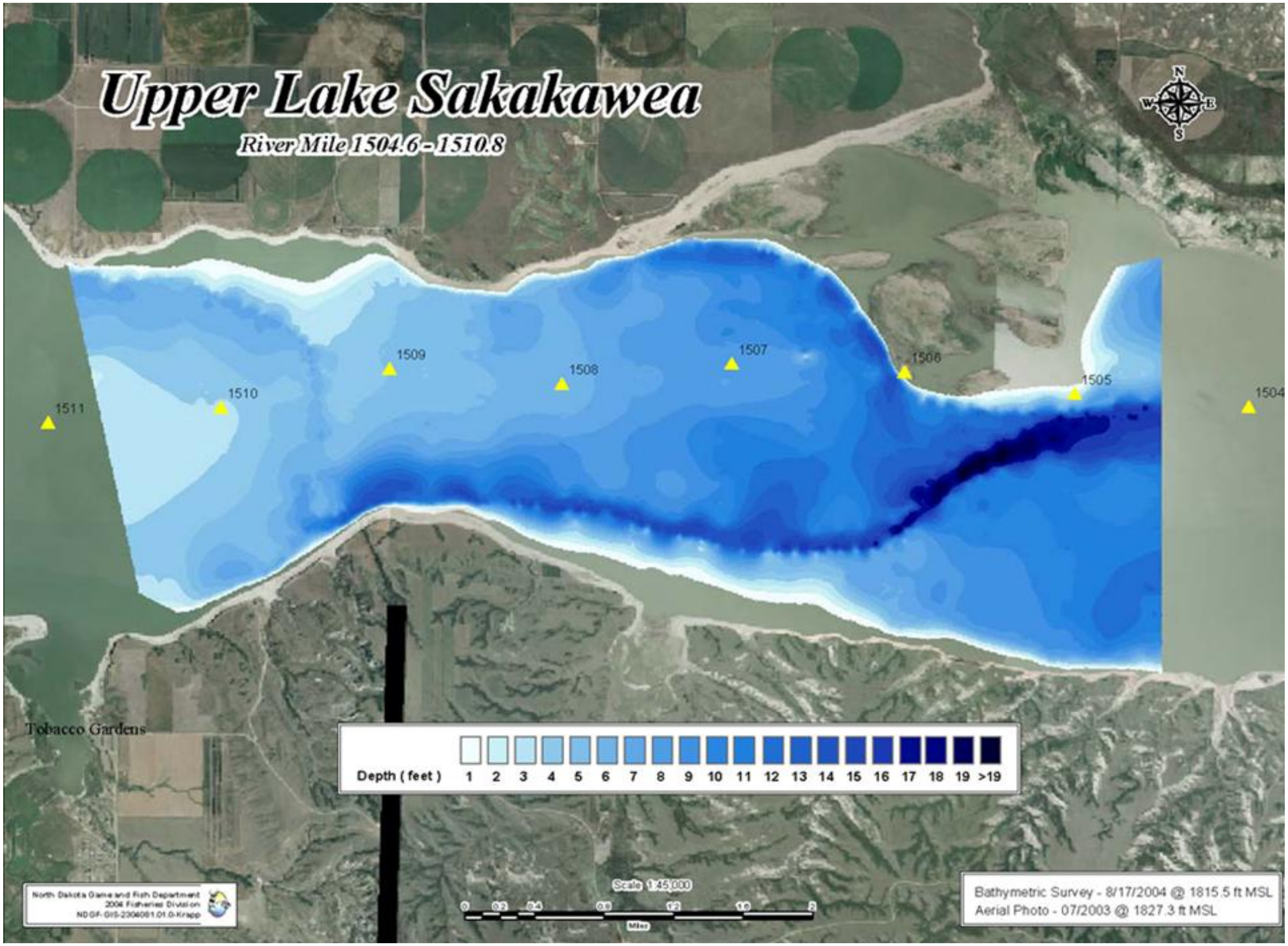
The Age-0 Index

This index of reproductive success has been developed based on relative abundance of age-0 fish along standard transects of Lake Sakakawea in late July through mid-September. Sampling at that time, after initial larval and fry mortality, provides the best opportunity to sample immature fish. The method consists of surface visual counts along perpendicular transects at 4.8-km (3-mi.) intervals in the reservoir headwaters. As a two-person crew boats at 8 km/hour per hour along the transects, age-0 paddlefish in the upper part of the water column are startled by the boat. 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).

In Lake Sakakawea, transect counts have been conducted each year since 1992, except for 1996, when counts were conducted for only one week (Table 6). In that year, thousands of age-0 fish were observed, and the decision was made to capture and tag fish rather than conduct transect observations. The wide fluctuations in water levels in Lake Sakakawea over the period (1992-2006) have unfortunately made it impossible to use the same transects in every year (Table 1); transects have moved upriver and downriver as necessitated by the fluctuating water levels. In 2004, a low water-level year, for example, six transects from Rkm 2403 (RM 1494) to Rkm 2428 (RM 1509) were sampled (Figure 30). In contrast, in 1996 and 1997, high water level years, transects extended from Rkm 2433 (RM 1512) to Rkm 2476 (RM1539).

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 throughout the water column, and major biases in vertical abundance of age-0 fish are less likely. Fredericks (1994) reported that visual counts in Lake Sakakawea were correlated with experimental trawl catches. Counts of age-0 fish in 1995 have also been associated with high catches of ages-9-11 fish in 2004-2006. Visual counts are less expensive and less laborious than trawls and cause almost no incidental mortality.

Figure 30. Depth profile of upper end of Lake Sakakawea, 2004. During the period of low water levels, the farthest up-reservoir transect sampled for age-0 paddlefish was RM 1509.



The Sub-adult Index

Putative age-1 and age-2 immature paddlefish are also counted along transects. In only a few years, however, have age-1 fish been of sufficient numbers that any sort of index of abundance could be determined. This index has proven useful, however, for identifying large year classes. High counts and catches of yearlings, such as in 1996, and two year olds, such as in 1997, accurately forecasted the strong 1995 year class contributing to the fisheries in 2005-2007 (Table 6; Figure 14; Scarnecchia et al. 2007a). After age-1, juvenile paddlefish become much less vulnerable to sampling, and no effort has been made to quantify them until they are recruited to the fishery. Although counts of sub-adult and adult fish along transects are kept incidentally to the other indices, to date these data have not proven useful for stock assessment.

The Young Male Recruit Index

The next sampling opportunity that has been employed for a particular year class of paddlefish occurs 8 or 9 years after birth, as young male paddlefish migrate up the Yellowstone and Missouri rivers to spawn and become vulnerable to 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. 2007b). The method of using younger recruits to forecast older recruits of the same year class has a long history. Jacobsson and Johanssen (1921) estimated abundance of two-sea-winter Atlantic salmon *Salmo salar* in the Gudenaa River, Denmark from the number of grilse (one-sea-winter salmon) that returned to the river the year before. In Oregon, Gunsolus (1978) predicted returns of coho salmon O*ncorhynchus kisutch* from returns the previous year of precocious males ("jacks") of the same year class. His approach later developed into the Oregon Production Index (OPI; United States General Accounting Index 1983), which was used successfully for management in Oregon and Washington. Peterman (1982) used age structure models to forecast yields of sockeye salmon, *O. nerka* and Scarnecchia (1984) and Scarnecchia et al. (1989b) used the method to forecast yields of Atlantic salmon for Icelandic rivers. The method has worked well because once fish reach a large size, year class strength is generally established before the youngest age fish is harvested or sampled for use in a forecast. The strong 1995 year class moving through the fishery (Figure 14) therefore portends high recruitment of females (as yet immature and unharvested) several years later, unless other mortality factors intervene.

Five-Year Recruitment Estimate and Harvest Cap

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. With mandatory retention, age structure of the catch is assumed to be indicative of the population age structure. This estimate is then used to set a harvest cap such that allowable harvest does not exceed recruitment. The harvest cap can be adjusted to match the recruitment of young, mature fish entering the stock over the 5-year period. 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 intent is to not allow stock size to fall below its current abundance. This objective of not allowing the population size of recruits to decrease is based on information that the adult paddlefish stock had decreased in abundance from more than 120,000 fish in 1978 to no more than 50,000 fish in 2007, as a result of past harvest and declines in reservoir productivity. Inadequate understanding of the stock-recruitment relationship makes it important to maintain the number of spawners until the necessary spawning stock size is known.

The harvest cap is not a harvest target but an annual cap designed to prevent excessive harvest in years when fish are especially vulnerable. For example, low flow years in North Dakota (such as 2006) and moderate or high flow years in Montana (such as 1991) can result in daily harvests of 200-300 fish or more. The maximum harvest is also not a target because natural and other causes of mortality, although not high (Scarnecchia end Stewart 1997a) have not been adequately quantified. It is expected that the cap may not be reached in some years.

A Combination of Methods

Present stock status is assessed using a combination of the three indices and the Five-Year Recruitment Estimate. 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. Similarly, strong year classes of females anticipated in those harvest years (compared to males) would result in greater numbers of females. The harvest cap can then be adjusted accordingly.

In addition to the above methods, each year it is desirable that a wide range of ages of fish continues to be present in the harvest. A wide range of ages in the recruited stock, from age-9 to age 40 or higher, is considered a critical aspect of maintaining the health of the stock (Francis et al. 2007). Studies have indicated that the prime female spawners in the Yellowstone-Sakakawea paddlefish stock are typically at least 25 years old. For a sustainable fishery, the stock must not only have reproductive success and recruitment, but an age structure with long-lived fish characteristic of the stock (Scarnecchia et al. 2007b). The number of older fish (>30 years) is also monitored; low numbers of fish or a low percentage is considered a warning sign for excessive harvest.

<u>Fort Peck Stock and Fishery</u>

Habitat

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. 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 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. 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) 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 in the area 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 2006 has been highest in June (mean, 510 m^3/sec, 18,000 cfs), followed by May (mean, 377 m^3/sec, 13,300 cfs) and July (mean, 280 m^3/sec, 9,890 cfs).

Fort Peck Reservoir is the fifth largest reservoir in the United States, and is 202 km long and 980 km^2 in area at maximum normal operating pool. It drains an area of 26,418 km^2 (10,200 mi^2). Although the reservoir stores 18.7 million acre feet of water at a maximum operating pool of 684.7 m (2250 ft) msl, elevations in the reservoir have typically resulted in water levels within the annual flood control and multiple use zone during normal water periods and in the carryover multiple use zone during drought periods.

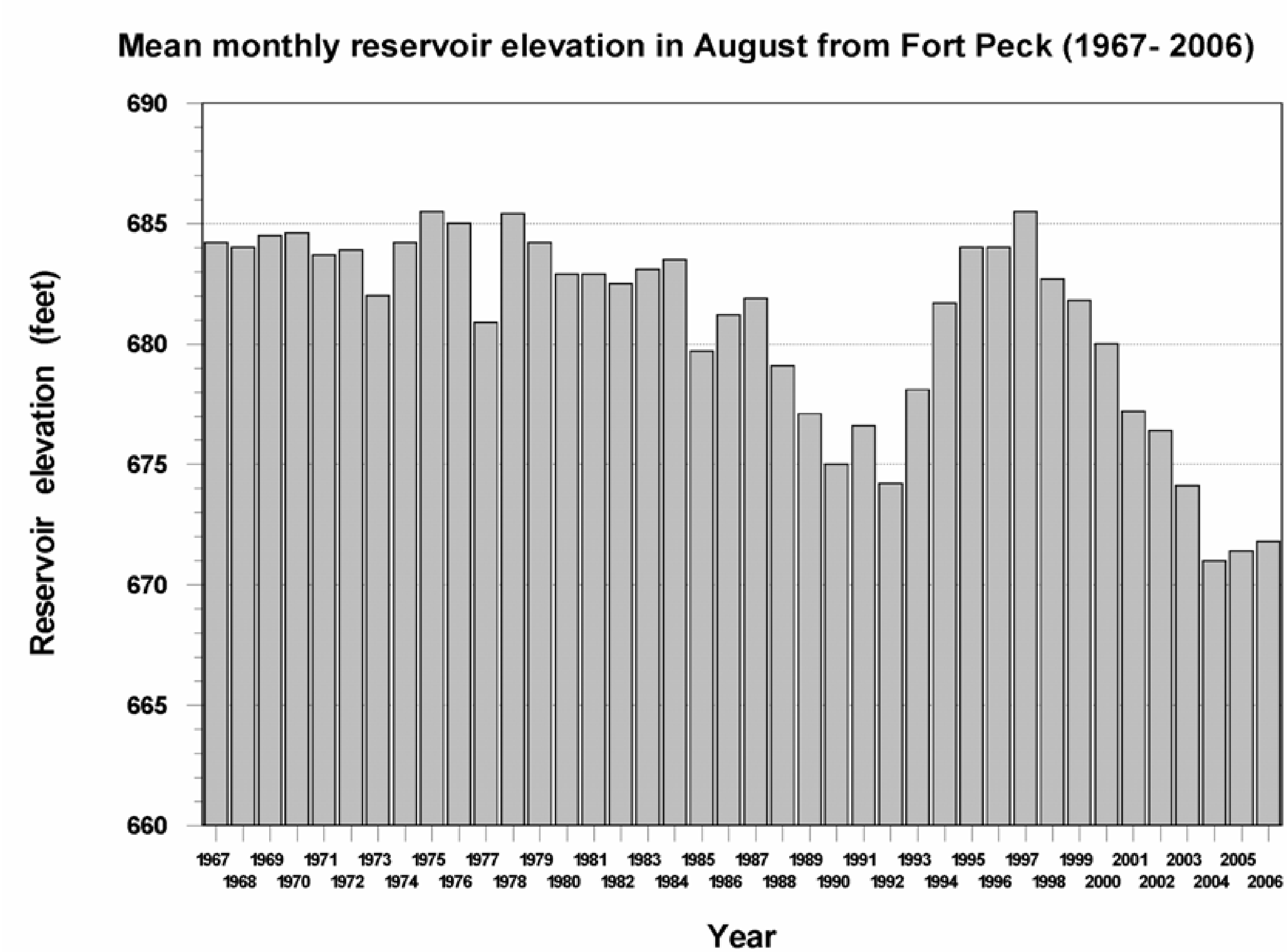
Upon closure of the dam in 1937 (Fort Peck Reunion Committee 1977), the reservoir took 10 years to reach maximum normal operating pool (683.5 m; 2246 ft msl), only to experience a rapid decline in level in the late 1950s (Figure 20), due mainly to high releases designed to fill Lake Sakakawea. In the 1970s through the mid 1980s, the reservoir levels fluctuated moderately, remaining between 680 and 686 m msl. Sharp declines in water levels to below 677.5 m msl occurred in the periods 1990-1993 and 2002-2007 associated with drought conditions and water releases based on multiple use decisions (Figure 31). As of mid-2007, water level remains low at 670.1 m (2202 ft) msl.

Several species may interact with paddlefish in Fort Peck Reservoir. Walleye were first stocked into Fort Peck Reservoir in 1951, but a sport fishery for them did not develop until the 1970s (Liebelt 1993). Northern Pike *Esox lucius* were not found until after 1951, which suggested to Cooper (1971) that the pike population which subsequently developed resulted from the stockings in 1949 and 1951. Cisco *Coregonus artedi* were introduced into the reservoir in 1984-1986 to improve forage opportunities for walleye, pike, and lake trout *Salvelinus namaycush* (Mullins 1991; Montana Department of Fish, Wildlife and Parks 2002). Cisco abundance has fluctuated widely since their introduction. Although cisco have been credited with improving the forage base and condition for walleye, and perhaps other species (Montana Department of 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, however, been evaluated.

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 was studied to any extent during the first three decades of reservoir impoundment. It was not documented, for example, 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 as well as in the ‘cuts’ below the dam… (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 in 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 cisco.

Figure 31. Mean monthly (August) reservoir elevation of Fort Peck Reservoir, 1967-2006.



Life History and Ecology

This stock was first surveyed by tagging and creel census in 1973 by Needham (1973) 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 and excessive mortality; Needham 1977b; Scarnecchia et al. 1999).

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 in the vicinity of the Fred Robinson Bridge. Some fish travel much farther upriver, however. 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.

The timing and extent of upstream migration are strongly influenced by river discharge (Berg 1981; Miller et. al. 2006). Berg (1981) noted that significant movements of paddlefish to the spawning sites did not occur until flow at the Virgelle gauging station, east of Fort Benton, exceeded 396 m^3/sec. In two years with typical river discharges (1978 and 1979), 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 as a paddlefish) and two larvae were found. Splashing by adult paddlefish over several sites with spawning gravel provided strong circumstantial evidence of paddlefish spawning.

Since the late 1970s, efforts have been made to identify spawning sites and migration of Fort Peck paddlefish with radio telemetry studies (Gardner and Berg 1980; Wiedenheft 1992). In the past 15 years, however, improvements in telemetry technology and increased information on life histories have aided more recent investigations. New studies of movements and spawning of adult fish were begun in 2006 (Miller et al. 2006). For 29 fish (14 males, 15 females) radio-tagged in 2006, mean contact site for all relocations was rkm 3088.23, near King Island. Combining fixed station and manual tracking relocations, predominately more relocations were made in river section 1 (rkm 3000 – 3090, 266 relocations) than in river section 2 (rkm 3090 - 3130, 105 relocations) or river section 3 (rkm 3130 – 3192, four relocations). The furthest upriver fixed station relocation was at rkm 3192 (Judith Landing). This relocation was made on a

27 kg female (code 34) on May 20. The furthest upriver manual relocation was at rkm 3169 (Dauphine Rapids).

As in the Yellowstone-Sakakawea stock, directional movements of telemetered Fort Peck paddlefish were associated with changes in discharge. For example, 62 of 100 (62%) 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 falling 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.

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 habitat: downriver of Lower Peggy’s Bottom (rkm 3052 and downriver) and Slippery Ann (rkm 3076-3080). Two areas were probable spawning habitat: 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. 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 relocations 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). Studies begun in 2007 are expected to clarify details about spawning, egg deposition, and distribution of larval fish.

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 (Kozfkay and Scarnecchia 2002), and numbers of age-0 fish observed in transects have remained low since that time (Table 7).

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 displayed strongly size-selective food habits characteristic of selective feeding (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.

After the early period in the reservoir, very little is known of the species life history until recruitment of migratory adults to the fisheries. 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.

A report in preparation (Scarnecchia et al. 2007c) summarizes what is known about the life history of the Fort Peck paddlefish. Berg (1981) and Needham (1986) presented 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 reproductive periodicity of harvested fish is 1-2 years for males and 2-3 years for females, very similar to the periodicity of the North Dakota catch component of Yellowstone-Sakakawea paddlefish.

Table 7. Counts of age-0 and age 1+ paddlefish in upper Fort Peck Reservoir.

Table 7. Counts of age-0 and age-1+ paddlefish in upper Fort Peck Reservoir (1997 - 2006)

Year	No. of Counts Conducted	No. YOY	No. age-1+
1997	69	113	3
1998	216	97	54
1999	174	3	10
2000	90	0	11
2001	90	1	0
2002	NA		
2003	54	2	4
2004	54	0	3
2005	36	1	0
2006	36	2	1

Information on age structure of adult migratory paddlefish has been available since the study by Berg (1981), who estimated the age of 132 paddlefish caught by snaggers 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 over several years have clarified the age structure of the stock (Scarnecchia et al. 2007b). 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 a few years (Scarnecchia et al. 2007b). In 2006, ages of 127 male fish ranged from 9 to 38, with one fish at 52 (Figure 32). Ages of 110 female fish ranged in age from 14 to 56 (Figure 33).

Fishery

Fort Peck paddlefish are caught at several sites in 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) of the bridge are utilized. The fishery begins earlier than that at Intake; March or April into June, depending on weather and river discharge conditions, but most catches occur from mid-April through the end of June. The harvest consists of nearly all mature, spawning fish. The more dispersed nature of the snagging (compared to Intake) and absence of a centralized cleaning station makes a creel census less efficient and the data base less comprehensive than for the Yellowstone-Sakakawea stock.

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 has ranged from 787 fish in 2004 to 1,067 fish in 2006 (Leslie 2007; Figure 34). The number of angler days has ranged from 1,326 in 1998 to 9,172 in 2004. Harvest (fish) per angler day has ranged from 0.07 in 2000 to 0.31 in 1973. With the option to release snagged fish, snaggers released 29% to 53% of fish caught over the period 2003-2006 (mean, 40%; Leslie 2007).

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 similar to Montana anglers in general. Their primary motivations were to be outdoors, to experience the thrill of catching a paddlefish, to experience with natural surroundings, and to be with friends. Although harvest and consumption of meat were secondary considerations, and snaggers were in favor of catch-and-release opportunities, snaggers did not favor mandatory catch and release without a harvest opportunity (Scarnecchia et al. 2000).

Figure 32. Age composition of Fort Peck male paddlefish in creel sample.

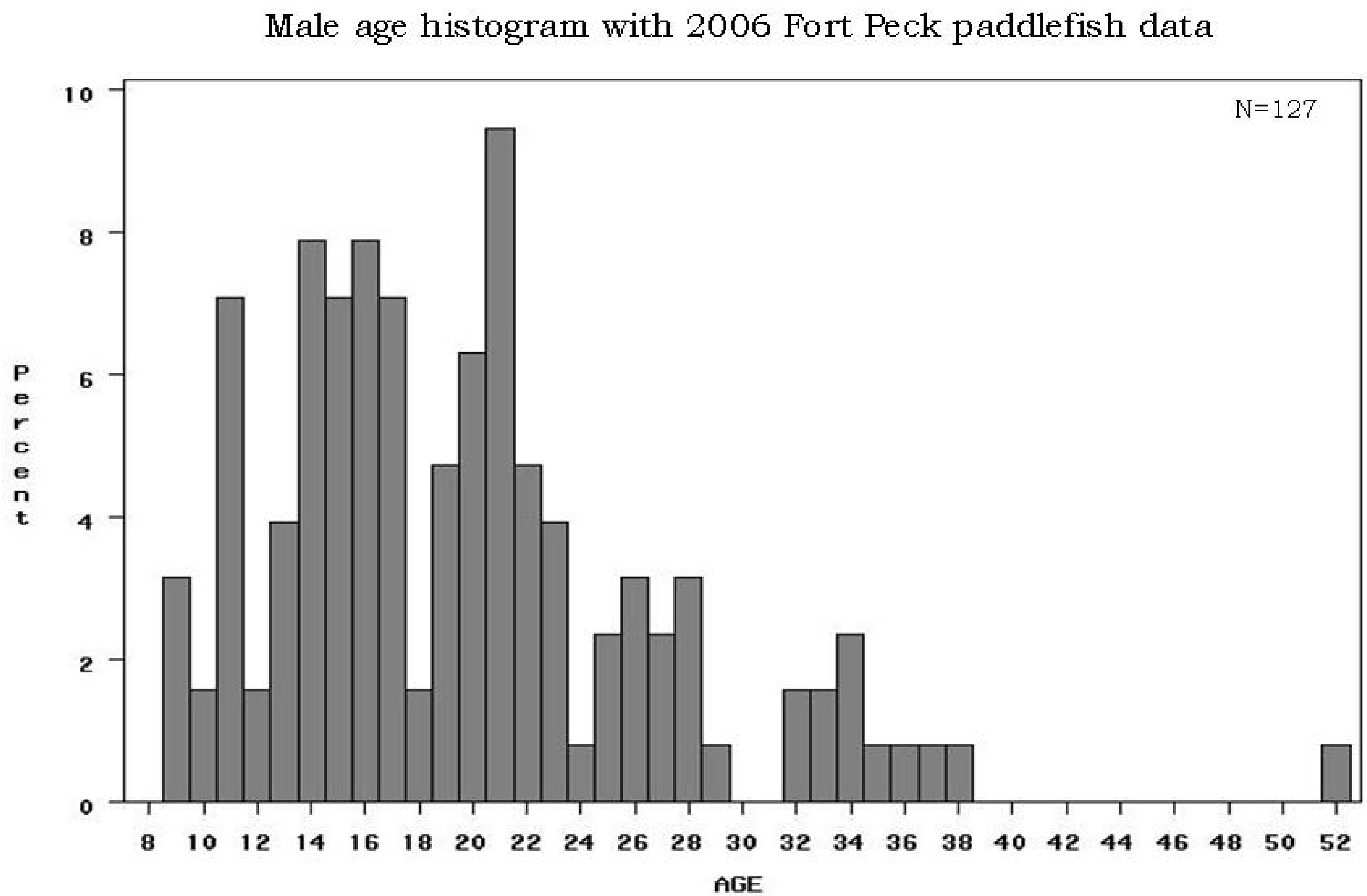


Figure 33. Age composition of Fort Peck female paddlefish in creel sample.

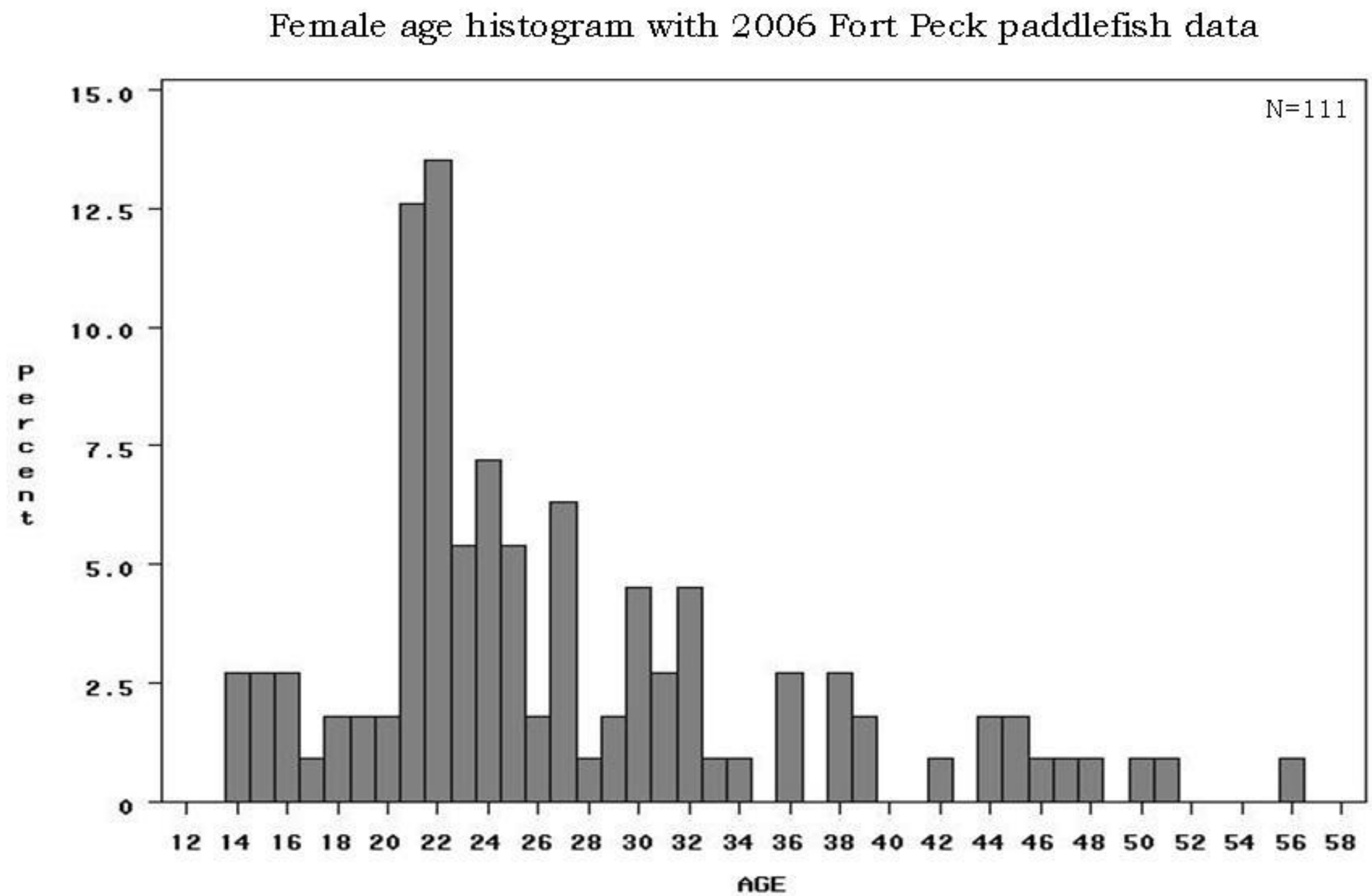
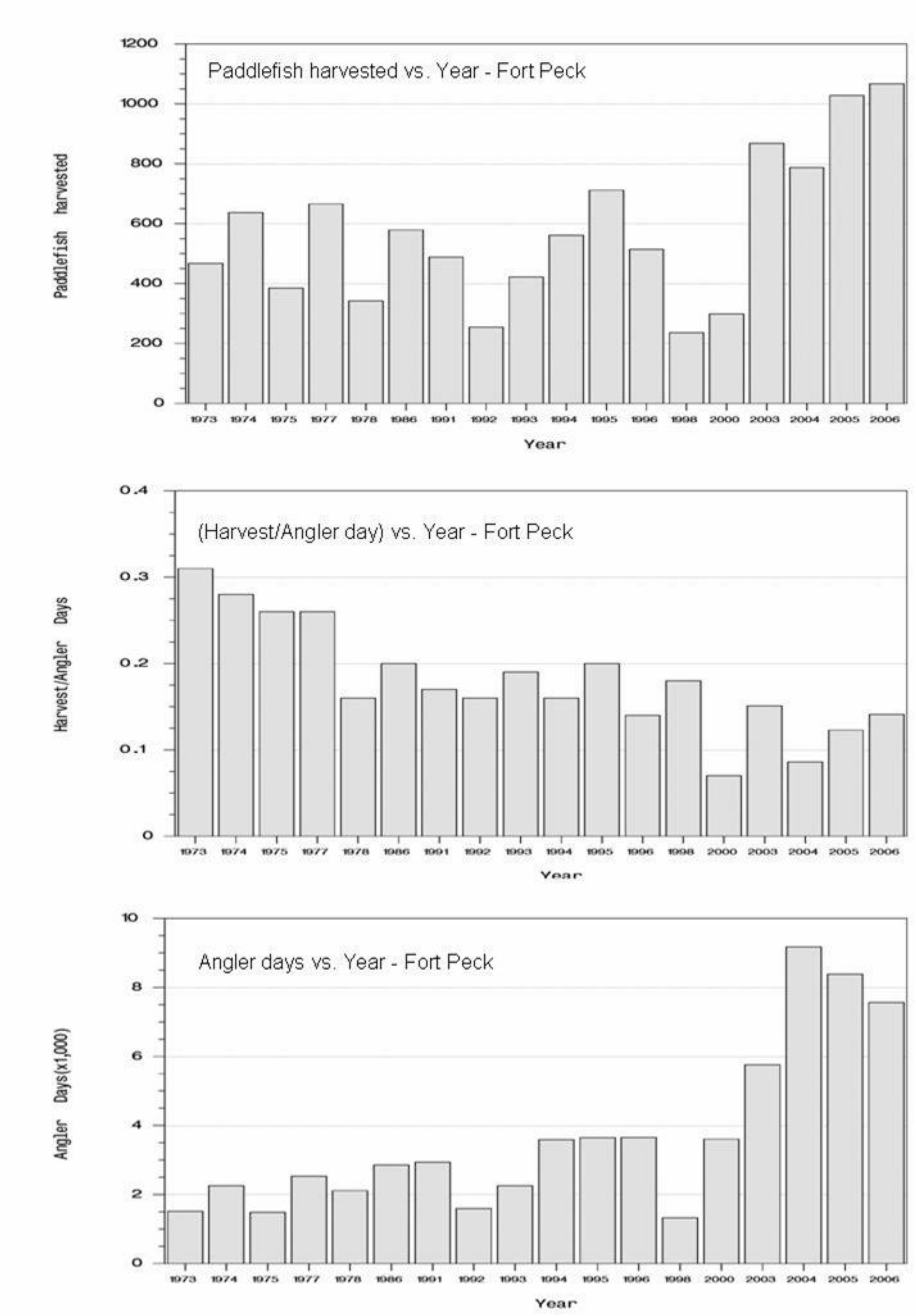


Figure 34. Harvest, fish per angler day and angler days, Fort Peck paddlefish by year in Montana, 1973-2006.



Management Chronology

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 snagging 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. Historical regulations since 1980 are summarized in Table 5.

Stock assessment investigations of the Fort Peck paddlefish have been conducted 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). 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 since 2000. In those years the harvest was estimated and the age structure determined. In recent years, sampling has become more intensive as concerns about adequate recruitment have developed (Leslie 2005, 2006, 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 … Information 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 until recently has been 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 snagging 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 recent years, indications of low reproduction and recruitment along with increasing effort and catch (Figure 34) have resulted in concerns about the sustainability of the fishery (Leslie 2007). 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 and the other three days with 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 from, and purchase the appropriate tag. In an effort to provide a sustainable fishery, more restrictive regulations are proposed for the 2008 season, including a season limit (May 1-June15) and a 500-fish harvest cap. The option to release fish will be reinstated.

Hatchery Production

There are no known records of hatchery-reared fish being released above Fort Peck Dam.

Stock Assessment

The approach to assessing the stock status of the Fort Peck paddlefish has been similar to that for Yellowstone-Sakakawea stock. Instead of cleaning stations, however, data on length, weight sex of fish, and jaw-tag recovery information have been collected with a roving creel census at the various snagging sites.

Population size

In spring, jaw tagging of adult migratory fish by MTFWP provides information for estimating population size and reproductive (migratory) periodicity. Netting typically occurs downriver of the Fred Robinson Bridge in spring (April, May and June). Point estimates of population size and confidence intervals have been developed using two approaches: a modified Peterson estimate and a modified Schnabel estimate. Modifications are necessary because only a fraction of the recruited stock matures and thus migrates upstream in a given year. Both estimates indicate that the population size of recruited adult fish is about 20,000 fish. Population size of adult recruits in the Fort Peck Stock is estimated to be 38% of the size of the recruited Yellowstone-Sakakawea stock.

Age structure

Age structure information has been collected in 1977-78 by Berg (1981), and since 1993 during all years when a creel census was conducted. 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 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 simply due to the low catch rate. Results from 2007, with mandatory retention, confirm those of 2005 and 2006, that recruitment of the Fort Peck stock is modest. 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 river flows and reservoir levels in the last half of the decade of the 1990s.

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). Season-long counts of age-0 paddlefish in transects have declined steadily to near zero (Table 7) associated with reduced river flows and declining water levels in Fort Peck Reservoir (Figure 31), indicating that reproductive success of year classes spawned during the drought years since 2000 is very low. Reproductive success and year class strength are expected to remain low until increases occur in both river discharges in spring and reservoir water levels. As of 2006, too few age-1 and age-2 fish have been counted to develop a Sub-adult Index.

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. However, 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. The mandatory retention regulation enacted in 2007 will result in improved catch data and a more reliable stock assessment to be developed, similar to the Five-year Recruitment Estimate used for the Yellowstone-Sakakawea stock.

Oahe Stock

Habitat

The Oahe stock is found in the Missouri River downriver of Garrison Dam into Oahe Reservoir (Figure 1). 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 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 caught or snagged incidentally by anglers, netted incidentally, or noted when hit by boat propellers. The Oahe stock has declined in abundance significantly over the past 20-30 years (Gengerke 1986). Most of this decline can be attributed to habitat alteration, especially loss of spawning areas. 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 of the fish ranged from age 20 to age 33, and there was no indication of significant numbers of young recruits (D. L. Scarnecchia, letter to G. J. Power September 27, 1994). It is not known how many Oahe paddlefish were produced naturally in the section, and how many originated above Garrison Dam.

Preliminary results of tagging indicate that Oahe paddlefish make a similar spring pre-spawning migration upriver as those of the Yellowstone-Sakakawea and Fort Peck stocks. In spring 2007, P. Bailey, (South Central District Fisheries Supervisor, NDGFD, letter to NDGFD, June 26, 2007) reported that paddlefish large enough to be adult fish were all gillnetted in the Missouri River below the mouth of the Heart River, but by June, 129 of 131 fish were captured in the Missouri River above the mouth of the Heart River. Spawning success is unknown but suspected to be poor and to result in low recruitment.

Management

No fishery exists for this stock, stock size is small, and natural spawning opportunities are evidently poor.

Hatchery Production

In 1985, 9,420 unmarked fingerling paddlefish raised at Garrison National Fish Hatchery were stocked into Oahe Reservoir (Table 6). The fate of these fish is unknown. Future health of this stock, and a viable fishery, would probably depend on additional hatchery production and stocking.

Stock Assessment

As of 2007, the population size of the Oahe stock is unknown. The population is being sampled with gillnets and tagged with jaw tags by the NDGFD in order to estimate the population size and assess stock status.

Habitat Requirements and Protection

Habitat requirements and protection for the three paddlefish stocks is 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 potential future issues.

River Water Quantity

Overview

A primary habitat requirement for successful paddlefish reproduction and long-term sustainability is the maintenance of adequate river flows. The natural, gradual rise and fall of the hydrograph is considered an 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). Actual spawning in paddlefish is associated with the flood pulse (Russell 1986), and may occur with rising flows, peak flows, or declining flows. Once deposited eggs have hatched, higher flows provide more effective conveyance for larval fish to their reservoir habitats. High turbidities associated with higher flows may also protect young paddlefish from predation by sight-feeding predators. Higher river inflows throughout summer also provide the source of water and nutrients to keep reservoir water levels high and productive for paddlefish. 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. 2007a). Additional evidence (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 diverted by humans for other purposes. Water withdrawals from the Yellowstone River and its tributaries have been increasing steadily in recent decades, and future projections are that water withdrawals will continue to increase, even if individual irrigation operations become more efficient. 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 limiting water 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 (1970) and with regard to tribal water rights by Veeder (1976). Several aspects of water quantity management are discussed below.

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 intergovernmental cooperation and remove causes of controversy over distribution and use of water" (Http://cr.water.usgs.gov/YRCC/). The rivers covered by the Compact include the Yellowstone River (exclusive of Yellowstone 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" (Http://cr.water.usgs.gov/YRCC/). 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" (Http://cr.water.usgs.gov/YRCC/). North Dakota, a Compact signatory, was thus not 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).

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 is currently underway (D. Scarnecchia, University of Idaho). 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 first 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." (http://www.usbr.gov/dataweb/html/lowyel.html).

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

Protecting flows for paddlefish

Since the mid-1970s, two applications for water reservations by MTFWP were made to the Montana Board of Natural Resources and Conservation (MBNRC) to protect spawning flows for migrating paddlefish, one for the Yellowstone River (1976) and the other for the Missouri River (1991). In 1976, 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 1,274 m^3/sec (45,000 cfs) was required for paddlefish to move upstream of the Intake Diversion Dam, where large amounts of suitable spawning gravel are available. In 1978, in response to this application, the MBNRC granted much more limited flows during the months of May, June and July (Table 8).

A second application, this one for water reservations for paddlefish in the Missouri River, was made by MTFWP to the MBNRC in 1991. A Missouri River flow of 433 m^3/sec (15,302 cfs) was requested for the period May 19 - July 5 for the reach from the mouth of the Judith River to Fort Peck Reservoir. 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 132 m^3/sec (4,652 cfs; Table 8). Furthermore, even the granted flows are not fully guaranteed, but are subject to senior (earlier) water rights.

The instream flows granted thus provide little if any protection for paddlefish spawning on the Yellowstone River or the Missouri River. 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 reservation. The situation for instream flows on the Yellowstone River is made potentially even more limited because the Conservation Districts were granted a reserved 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 the reserved water and thereby take advantage of the Districts' December 15, 1978 priority date (Montana Department of Natural Resources 1995). These reserved rights have precedent over instream flows for fish.

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 the past a reality in the future. Irrigation withdrawals are continually increasing. It would be wise to assume that requests for additional irrigation water will 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 by approximately 24% from historical levels. Declines in peak flows have been observed in both the Yellowstone River (Figure 35) and the Missouri River (Figure 36). 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 instream flows for paddlefish and other native species.

Table 8. Requested and granted flows for the Yellowstone River.

Table 8. Requested and granted flows for the Yellowstone River at Sidney.

Time period	Requested flow (cfs)	Time period	Granted flow (cfs)
May 1 - 20	11,000	May	11,964
May 21 -31	20,000		
June 1- 7	26,000	June	25,140
June 8 -30	45,000		
July 1 -20	20,000	July	10,526

Montana Fish and Game Commission (1976)
Montana Board of Natural Resources and Conservation (1978)
Time period to include 1 day of bankfull flow at 52,000 cfs.

Figure 35. Peak discharge (cfs) of Yellowstone River at Sidney, Montana, 1911-2006.

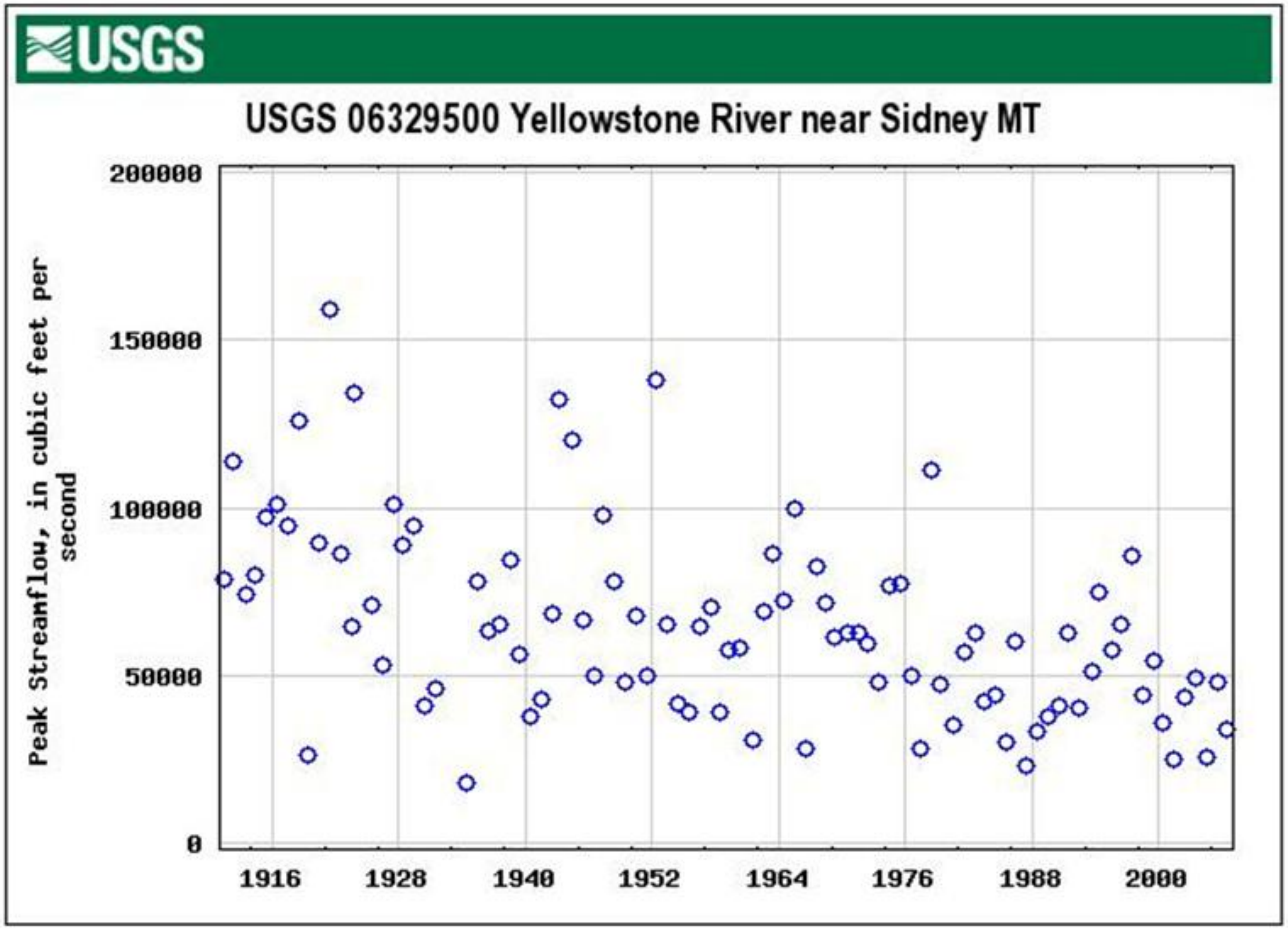
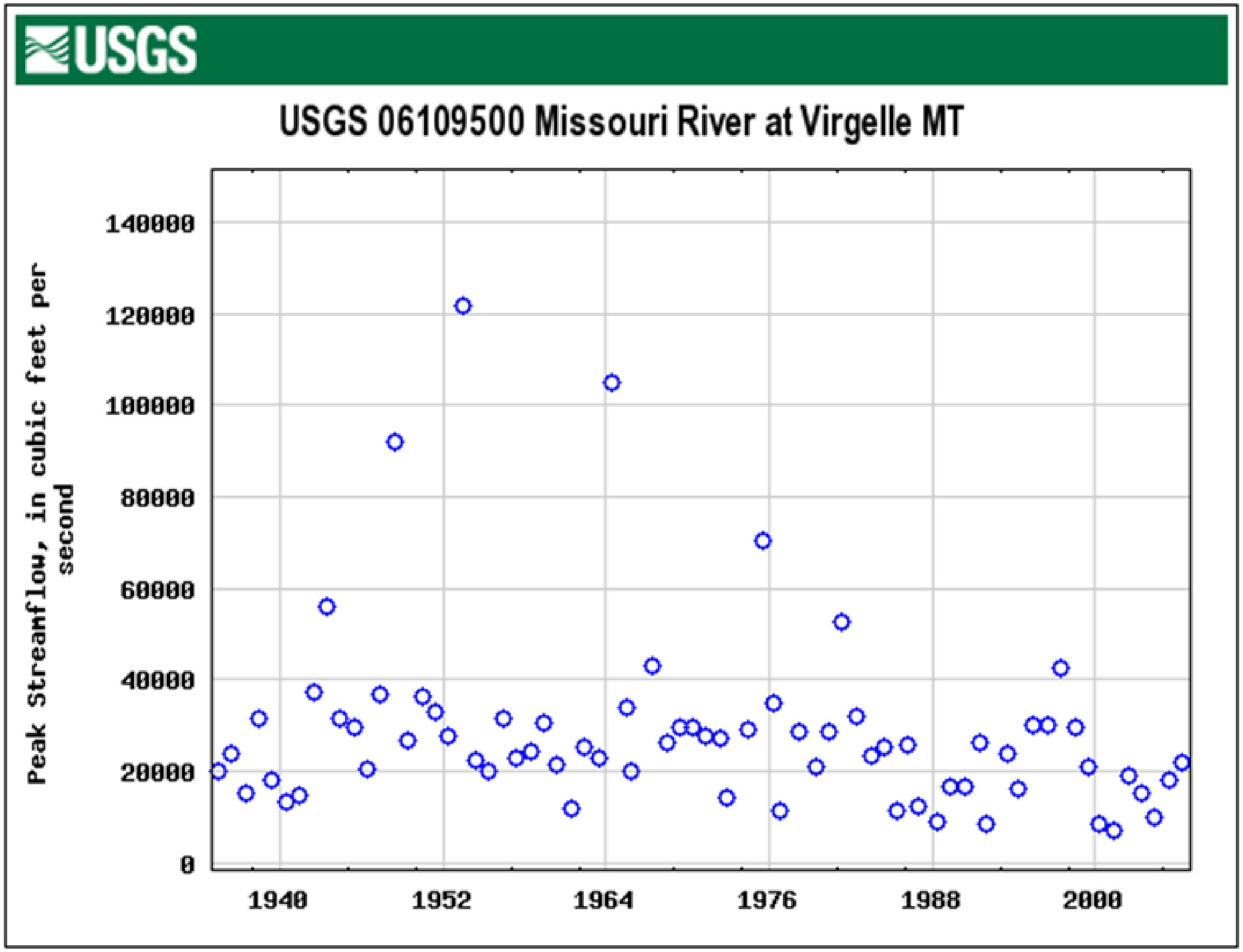


Figure 36. Peak discharge (cfs) of Missouri River at Virgelle, Montana, 1937-2006



It is critical for the fishery resources of the rivers that water depletions be accurately monitored and their effects on native fishes assessed. Instream flow strategies for Montana and North Dakota should be re-evaluated for potential effectiveness (Nelson et al. 1978).

Fort Peck Dam flow releases

In response to concerns for spawning of pallid sturgeon, recommendations have been made to increase flows (and water temperatures) out of Fort Peck Dam in spring. According to the 5-Year Pallid Sturgeon Plan: "Recommendations … are based on snow pack, 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 snow pack 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). Insufficient water levels in Fort Peck Reservoir and unfavorable water management decisions by the U. S. Army Corps of Engineers (USACE) have also hindered the improvement of spawning conditions.

The potential effects of the envisioned Fort Peck flow releases on paddlefish may not be favorable. It is not clear that very modest changes in the discharge, temperatures, and turbidities will result in suitable spawning and rearing habitat for either pallid sturgeon or paddlefish.

However, 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; Braaten et al. 2007).

Other flow releases

There have also been some significant changes in reservoir operations on tributaries of the Missouri River from Fort Benton to Fort Peck Reservoir. According to the 5-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. … The BOR is conducting a 5-year study to evaluate how operations of their four dams in the upper Missouri River system (including Tiber) affect pallid sturgeon recovery." (U. S. Fish and Wildlife Service 2007).

River Water Quality

Overview

Overall, both the Yellowstone and Missouri Rivers presently have relatively good water quality (White and Bramblett 1993). Much of the credit for this result comes from the high-elevation sources of much of the runoff and limited inputs from industry and municipalities. 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. 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, however, as in the main-stem (Faraq et al. 2007). Several developments have the potential to decrease water quality in the future.

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. Western coal production has increased steadily over the period 1970 to 2007, and the U. S. Department of Energy projects that it will continue to increase continually through at least 2030 (Http://www.eia.doe.gov/oiaf/aeo/coal.html). According to the report, "much of the expected growth is in output from the Powder River Basin, where producers are well positioned to increase production from the vast remaining surface-mineable reserves".

Depending on how the coal is delivered and utilized as energy, water demands for the increased mining and delivery may be moderate to very high. For example, movement of coal through coal slurry pipelines could require considerable amounts of additional water from this water-limited basin.

Recent increases in energy prices, particularly oil and natural gas, have resulted in development of coal bed methane resources, a valuable source of natural gas associated with the Powder River coal fields. The extraction of methane from coal seams often involves removing large quantities of water from the seam (as much as 64,000 L (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. Investigations are underway to assess the potential impacts of increased sodium bicarbonate on fishes and other aquatic life in the Powder River basin (Farag et al. 2007).

Oil and gas wells and spills

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. More than 20 wells and numerous pipelines are within the active floodplain, and on occasion are completely submerged during periods of high river flows or high lake levels (Figure 37). Although several fairly minor oil spills have occurred in recent years, no major spills have yet impacted this reach. However, a major spill within this reach has the potential to cause severe negative impacts. Most of the oil field companies have oil spill contingency plans. Many of these same companies have purchased some of the needed equipment and supplies and have had their employees complete mock oil spill cleanup activities. The U. S. Fish and Wildlife Service developed an oil spill contingency plan in response to a spill on the west side of Erickson Island in the mid 1990's (U. S. Fish and Wildlife Service 1997). This plan contains a detailed listing of all oil wells, pipeline locations, and detailed information regarding the proper reporting and cleanup of any spill which might occur in the future. This plan should be revised in view of numerous new wells in the past 15 years.

Pesticides and other contaminants

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.

The limited information available suggests that Yellowstone-Sakakawea paddlefish are not yet heavily impacted by pesticides and other toxic substances, at least as indicated by analyses of fish flesh and roe. In 1990, paddlefish roe from ten females weighing 19.5 to 31.8 kg (43 to 70 pounds) collected at Intake was tested for concentrations of twenty different chlorinated hydrocarbon pesticides and their metabolites and two polychlorinated biphenyl (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 MTFWP 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. Follow-up evaluations to the 1990 study should be conducted periodically on the fish flesh and roe of Yellowstone-Sakakawea and Fort Peck paddlefish periodically using samples from harvested fish.

Figure 37. Oil well on floodplain during high water period of Lake Sakakawea, 1997.

Legislation and regulations

In North Dakota, water quality issues regarding all surface and ground waters within the Missouri River basin are under the purview of the North Dakota Department of Health. 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).

Riverine Habitat Features

Overview of paddlefish riverine habitat

In the past century, paddlefish riverine habitat has deteriorated in most localities throughout their range 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). 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). In most cases, however, such benefits have been greatly overshadowed by greater losses in river spawning and other habitats.

As a highly 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 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 have become an important, and sometimes critical, component 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, 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.

Characterizations of paddlefish riverine habitat

Although the typical habitats for nearly all healthy wild paddlefish populations are well understood (natural or quasi-natural river hydrograph, temperature, and sediment regimes, adequate lentic rearing habitat), efforts to accurately and precisely characterize 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 during 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 at least a few decades before quantitative assessment efforts 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 areas, 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 HSI curves. Neither of these studies was followed up by field testing and the methodology has fallen into disuse.

At present, the most commonly used methods 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.

With the present inadequacies of paddlefish quantitative habitat models, one of the most useful approaches has been studies of paddlefish. 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 of successful reproduction and ongoing fisheries, habitats below mainstem 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 snow-melt 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 comparatively clear and cool.

The Missouri River from the Confluence to Lake Sakakawea (often called the Williston Reach) is unique to the entire Missouri River 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 (federally endangered), 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 lake bed 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. All of 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 owned by the USACE; a substantial portion of this area is managed for fish and wildlife by NDGFD. Public ownership and management have resulted in the maintenance, and in some areas even the reestablishment, of 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.

Land use on privately owned property along the lower Yellowstone and Missouri rivers throughout most of the Williston Reach floodplain upstream of the Erickson Island area consists of high intensity agriculture; mostly irrigated sugar beets, alfalfa, and increasingly, corn. Adoption of agricultural best 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 area

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 NDGFD has funded a 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.

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). The following is a description of the key aspects of paddlefish habitat of the Yellowstone and Missouri Rivers in Montana and North Dakota, and their modifications, as they relate to river function.

Bank stabilization and shoreline management

Most of the aquatic habitat in the Yellowstone and Missouri rivers is continually being 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 38). 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 up sediment from unstabilized areas and the river bottom. The result is the development of new erosion problems, riverbed degradation, and the demands by some for still more bank stabilization.

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. By comparison, approximately 30% of the Garrison Reach of the Missouri below Garrison Dam has been directly stabilized (Power and Ryckman, 2002).

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 developed, funded and implemented to help alleviate the demand for additional bank stabilization. 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

Figure 38. Riprap and bank stabilization restrict river function.

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 $ 375,000-625,000 per km ($600,000 to $1 million per mile). As an example, in 1996 the Corps stabilized approximately 1,217 m (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 $371 per meter ($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 $56 per meter ($17 per lineal foot) (Power and Ryckman, 2002).

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, and only under extreme circumstances should any additional rip-rapping or bank stabilization be allowed. At the very least, no additional public funds should be spent if the sole intent of the project is to protect adjoining private property.

Downriver and upstream 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 specific needs for each reach.

Some specific characteristics of adequate river function

Several 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 of* *sufficient magnitude to improve paddlefish and pallid sturgeon 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.

Maintaining river function

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 sustaining healthy and functioning rivers.

Legislation and regulations

In Montana, two state laws give MTFWP considerable authority to modify or deny river projects that could negatively affect paddlefish habitat. The Stream Protection Act 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 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 addition to these two laws which result in review of applications by MTFWP, there are several other laws affecting paddlefish habitat reviewed by other state agencies (Montana Association of Conservation Districts et al. 2005).

In North Dakota, the laws are much weaker. NDGFD 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).

Also in North Dakota, the issue of private interests and rights (e.g., requests and demands for bank stabilization and other habitat alterations) versus public interests and rights in the riparian zone of navigable rivers such as along the Yellowstone and Missouri rivers is being addressed through the North Dakota Sovereign Lands Management Plan (North Dakota State Engineer 2007). Under the North Dakota Century Code (N.D.C.C.) § 61-533-05, the State Engineer has the authority to "manage, operate, and supervise" sovereign land, defined as "those areas, including beds and islands, lying within the ordinary high watermark of navigable lakes and streams" pursuant to the Public Trust Doctrine (p.1; North Dakota State Engineer 2007). A critical aspect of this authority is the ability to identify and delineate the sovereign lands and associated high watermarks; both are often inadequately defined. How the Office of the State Engineer, in consultation with several other interest groups, including NDGFD, ultimately delineates them and how they reconcile short-term private interests with long-term public interests in their use will have a significant impact on future fish habitat in the Yellowstone and Missouri rivers.

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, provides a major, but not total impediment (at least at high flows) to upstream migration of pre-spawning paddlefish, and results in the concentrated fishery at Intake; (Figure 39a). Water diverted into the main canal for irrigation results 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 plans are proceeding towards implementation (U. S. Army Corps of Engineers 2007). The passage planning is a joint effort involving the LYIP, MTFWP, USACE, BOR, USFWS, and The Nature Conservancy. 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 in the canal. The projected time line is that fish passage and entrainment features will not be constructed at Intake for at least another 3 to 5 years.

No passage is currently planned for the Cartersville Diversion Dam at Forsyth, the only other potentially significant barrier to paddlefish movements (Figure 39b).

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 higher reservoir levels compared to years of lower levels, and greater in years of rising water levels than falling ones (Figure 40). 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 39)

Figure 39. Low head irrigation diversion dams at Intake and Cartersville (Forsyth), Montana.

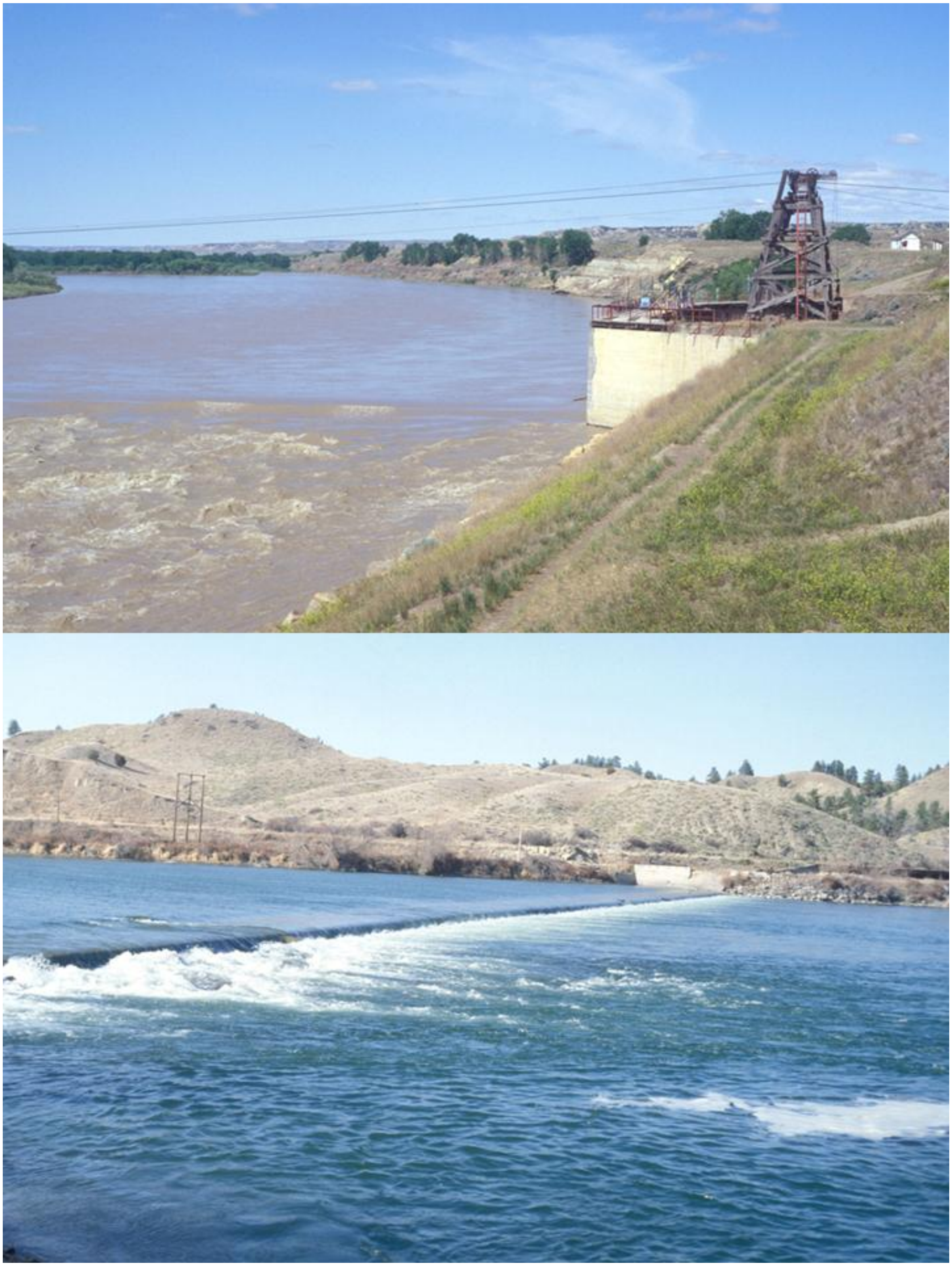
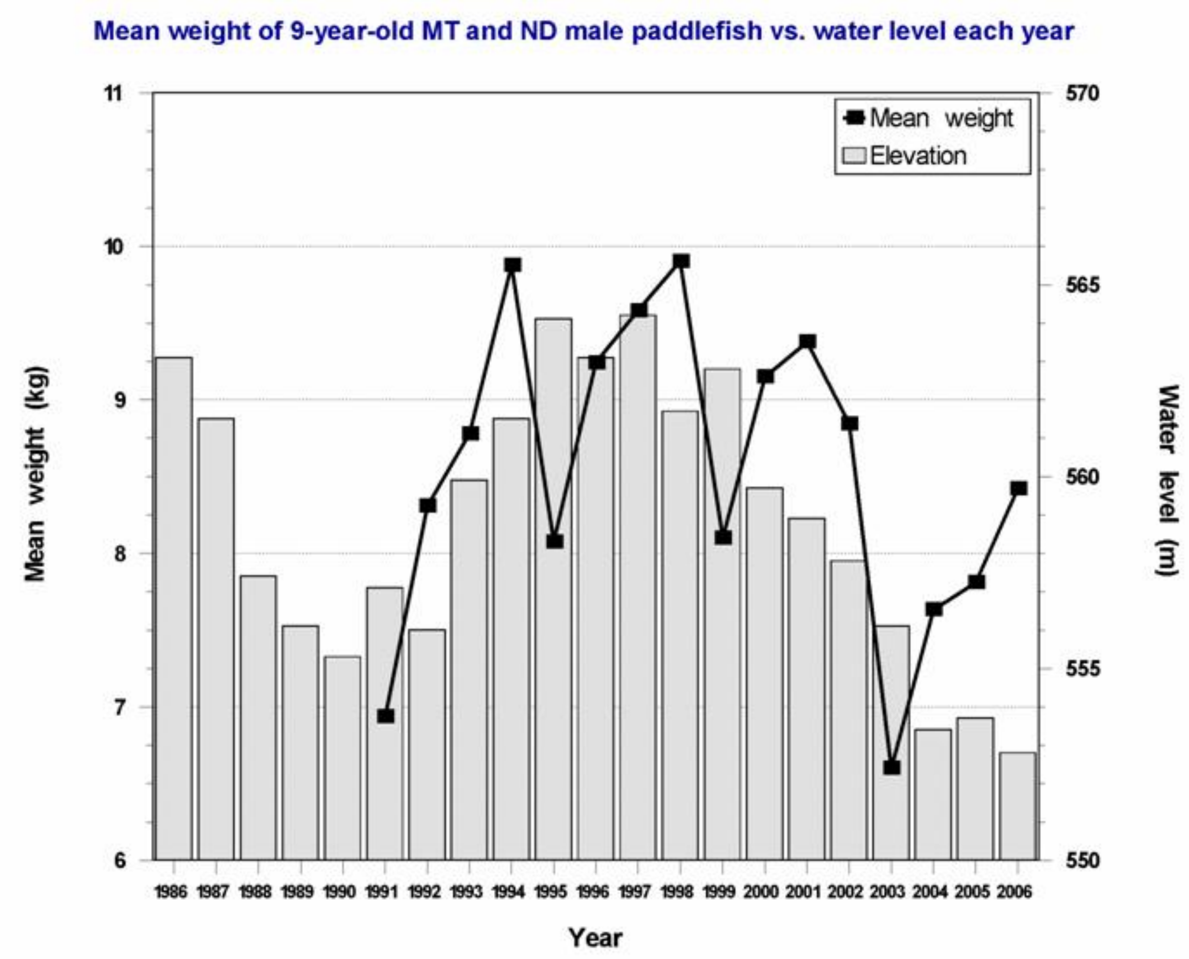


Figure 40. Mean weight of age-9 paddlefish and Lake Sakakawea water level, 1991-2006.



water levels from 2002 through at least 2007 (Figure 17) has resulted in extensive re-vegetation around the shoreline. If climatic factors such as occurred in 1992-1993 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. At the existing water levels, it is not yet known if it would be preferable in terms of paddlefish recruitment to have one rapid rise in the reservoir to full pool (in a year or two) or rather step like rises of several feet per year over several years to full pool. However, any increases in water levels will be favorable for paddlefish, as well as for many other fish stocks (Hendrickson 2003; Hendrickson et al. 2007).

Higher water in Lake Sakakawea and Fort Peck must be considered a high priority for paddlefish, even if benefits for other species may 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 are well documented (Scarnecchia et al. 2007a).

Reservoir Water Quality

Basic water quality measurements are made in Lake Sakakawea by the North Dakota Department of Health in conjunction with the NDGFD (Elstad 2001; North Dakota Department of Health 2005). Overall, as of 2007 water quality is not considered a major issue for paddlefish. However, persistent low water levels and high rates of accumulated sedimentation in the upper end of Lake Sakakawea may pose problems for food supplies critical for recently hatched paddlefish.

Potential Future Issues

Increased non-harvest mortality of adult paddlefish from boat traffic

Paddlefish are susceptible to being hit by fast-moving motorboats (Rosen and Hales1980; Figure 41). Fortunately, to date neither the Yellowstone-Sakakawea stock nor the Fort Peck stock inhabits areas with a high volume of boat traffic. In North Dakota, there are only three boat ramps on the Missouri and Yellowstone rivers upstream of the headwaters of Lake Sakakawea. There are no boat ramps on the Missouri in nearly 48 km between the Highway 85 boating access site (RM 1552) and the Confluence boating access area (RM 1581). In addition, there are few good access areas between Sidney and Intake. Boat traffic in the upper portions of Lake Sakakawea was low even during high water levels of the mid-1990s. 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. Above the Fred Robinson Bridge, seasonal boating restrictions on segments of the designated Wild and Scenic River from the Saturday before Memorial Day through the Sunday after Labor Day greatly reduces boating mortality concerns in this river reach.

Figure 41. Chopped off rostrum and boat propeller scars on Yellowstone-Sakakawea paddlefish.

In recent years, however, increased boat traffic around the Confluence associated with spring and fall walleye and sauger fishing has posed an increasing hazard to adult paddlefish. Monitoring of scarred paddlefish from propeller damage is ongoing at the fish cleaning stations for the Yellowstone-Sakakawea stock and will be continued. Oahe stock paddlefish seasonally stage in the Bismarck/Mandan area, an area with very intensive and annually increasing amounts of boat traffic during much of the open water period. Some boating caused mortality to this stock is known to occur in this area.

Aquatic nuisance species

Aquatic nuisance species are not considered an immediate threat to paddlefish in North Dakota and Montana. However, any of several species may rapidly pose threats if they find their way into Lake Sakakawea and the Yellowstone and Missouri rivers. Asian carp (bighead carp *Hypophthalmichthys nobilis* and silver carp *Hypophthalmichthys molitrix)* are filter-feeding zooplantivorous fish that may be competitive for food with paddlefish in situations where food is limited (Schrank et al. 2003). Zebra mussels *Dreissena polymorpha* 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. The New Zealand mudsnail *Potamopyrgus antipodarum* may pose a similar threat (Hall et al. 2006). A combination of exotic mussels and Asian carp 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 of such aquatic nuisance species into North Dakota and Montana (Missouri Basin “River Watch” Newsletter 2007). The long term success of these programs is uncertain.

Lead sinkers

There is currently no indication of any significant impacts of the loss of lead sinkers on the habitat in the Yellowstone and Missouri rivers. The impacts of lead sinkers lost in the river from paddlefish snagging is thus considered a minor issue, but one that may need to be addressed in the future. The Intake site presents the greatest potential problem because of the high concentration of snaggers at that site for more than 40 years. Debris in the channel below the dam also results in woody debris and tree snags that collect the 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. Several states have enacted regulations banning small lead sinkers (e.g. ½ ounce or less, in New York; one ounce or less, New Hampshire). Canada is pursuing a regulation to eliminate lead sinkers (Environment Canada 2005).

Global warming

If global warming scenarios are accurate, the many potential impacts on paddlefish are difficult to foresee. 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. These effects will be exacerbated by increased water use in the basin as higher temperatures increase demand for water.

The Management Plan

This plan provides direction and a course of action for management of the paddlefish stocks and fisheries, and embodies a philosophy, expressed as fundamental hypotheses, as well as goals, objectives and actions, or tasks. The management plan also describes how goals and objectives will be achieved through actions involving habitat management, fish sampling and monitoring, fish stock assessments, a harvest model, and implementation. The plan for all three stocks is based on one fundamental approach. 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 15 years. The intent is to develop the information bases and management structures for the other stocks consistent with those of the Yellowstone-Sakakawea stock.

Although the caviar programs in both states have proven to be beneficial to the regional economies, have provided useful services to snaggers, and have also provided (through fish cleaning stations) important sources of stock assessment data, emphasis in this plan is on the implementation of a program for a sustainable fish stock and fishery, with the caviar as an added beneficial by-product of that effort.

Philosophy and Fundamental Hypotheses

Ten fundamental hypotheses guide the development and direction of this plan. These fundamental hypotheses are philosophical statements and rationales motivated by human values and strongly supported by 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.

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

The North American paddlefish, a remnant of an ancient lineage, is one of only two living paddlefish species (Grande and Bemis 1991). Fossil paddlefish have been found in eastern Montana near Fort Peck from the Upper Cretaceous period (MacAlpin 1947; Grande and Bemis 1991), and the species is one of North America's oldest vertebrate animals. The distinctiveness of paddlefish 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, and

Zebulon Pike (Coues 1895) James Atkinson (Atkinson 1864), as well as by early scientists (Alexander 1914; McKinley 1984).

The paddlefish is now appreciated for its unique evolutionary design (Miller 2004) as an irreplaceable part the natural heritage of North America and the Great Plains region. Paddlefish demonstrate highly distinctive anatomical features such as their long, blade-like rostrum (Thompson 1934) and gill rakers (Imms 1904), distinctive physiological features such as their electrosensory system (Kistler 1906; Nachtrieb 1906; Russell et al. 1999; Wilkins 2001; Hofman et al. 2002 Wilkins et al. 2002), ram ventilation (Burggren and Bemis 1992; Sanderson et al. 1994) and unusual behavioral traits such as extensive migrations (Russell 1986; Firehammer and Scarnecchia 2006) and foraging methods (Fredericks 1994; Kozfkay and Scarnecchia 2002) that are uniquely adapted to their complex large river environments.

The species is also a good indicator of habitat quality in large river systems. Their requirements for successful spawning include a natural or quasi-natural hydrograph, turbidity, and thermal regimes characteristic of unimpounded or lightly to moderately altered large rivers (Jennings and Zigler 2000). Modifications of large river habitats are responsible for the decline of the species in most locations (Sparrowe 1986), and the presence of a healthy, wild-spawning paddlefish population capable of supporting a fishery is typically associated with high-quality riverine habitat.

Paddlefish also provide important recreational and commercial benefits (Graham 1997), 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. These recreational fisheries have expanded since the early 1960’s (Robinson 1966; Rehwinkel 1978; Berg 1981; Scarnecchia et al. 1996b), to where Montana and North Dakota are known nationally for their recreational paddlefishing. Each spring, communities in the two states gain significant commercial benefits from the presence of the recreational snag fisheries.

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. From their inception through 2006, the programs have generated total gross revenues of more than $2.5 million in Montana and $2.7 million in North Dakota, a significant fraction of which has been used for community development grants (more than one-half million dollars in Montana and $1.1 million in North Dakota). These totals, although not large by regional economy standards, and not the target of management, are an added benefit of well-managed recreational fisheries. Funds from the programs to MTFWP and NDGFD have also been important in paddlefish stock assessment and fisheries management.

Paddlefish stocks have declined in many locations throughout their range, 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. The primary emphasis should thus be on sustaining these stocks, allowing a sustainable harvest if possible.

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

Emphasis should be focused on maintaining and improving habitat conditions and managing the harvest of the wild stock. This approach differs from emphasizing artificial production, as is done, for example, in locations where most habitat has been degraded or lost (e.g., Missouri: Graham 1988, 1992; South Dakota: Unkenholz 1977; Texas: Pitman 1992). Because inadequate spawning success is a serious problem for paddlefish populations throughout their range, species survival depends on natural hydrographs, turbidity, and other aspects of water and habitat quality. Habitat conditions in the free-flowing, relatively unmodified Yellowstone River and the Missouri River above Fort Peck are especially important.

Habitat in the Missouri River below Fort Peck Dam is sufficiently altered that the Milk River may now provide the main spawning area in the Missouri River between the dam and the Confluence. River flows of adequate quantity, of natural timing and duration, with natural levels of turbidity, and without major contaminants are the best insurance for paddlefish perpetuation. Increased water depletions from the Yellowstone and Missouri rivers and their tributaries rivers pose major potential threats to paddlefish. Adequate water levels in Lake Sakakawea, as well as occasional rising water levels to create production pulses (Scarnecchia et al. 2007a) are also necessary for successful paddlefish recruitment.

The stocking of just under 10,000 age-0 paddlefish in 1995 has yielded only 3% of the total harvest of that year class in 2005 and 2006. Stocking into poor habitat (low reservoir levels) such as in 2007 is expected to result in a lower survival rate and yield fewer recruits.

Numerous other reasons exist for the emphasis on sustainable wild fish production over hatchery stocking, and some important reasons are listed here. Most of the strongest supporting scientific evidence comes from studies on Atlantic and Pacific salmons, where significant negative impacts of hatchery production on long-term sustainability of wild stocks have been documented. First, numerous studies indicate that hatchery-reared salmon exhibit different behaviors, different growth rates, and different survival rates than wild fish. Some studies found that hatchery fish did not survive as well as wild fish adapted to the habitat (Reisenbichler and McIntyre 1977; Fleming et al. 1996). In other cases, hatchery fish have effectively competed with wild fish (Einum and Fleming 1997; McGinnity et al. 1997), at least over the short term (as age-0 fish), as a result of their greater size at stocking, some pre-adaptations to existing conditions, or other factors. Other studies have documented different spawning timing (Lura and Saegrov 1993), differential defense and mating behaviors (Jonsson 1997) and reduced reproductive success (Fleming et al. 1996). Most evidence indicates that wild fish in good quality habitat are more likely to successfully sustain the stock than are hatchery-reared fish in degraded habitats.

Second, the small number of parents frequently used in fish culture (especially for large fish such as paddlefish) may result in significant loss of genetic diversity, making the stock more vulnerable to effects of environmental change (Jonsson and Fleming 1993).

Third, disease transmission from hatchery introductions may impact wild fish (Stewart 1991a). Paddlefish in culture ponds have become infected with the larval nematode *Hysterothylacium dollfusi* to the extent of causing ulcers, tissue degeneration, and the production of granulation tissue (Miyazaki et al. 1988). Other diseases have been reported in paddlefish reared in confinement (e.g., *Aeromonas salmonicida*: Ford et al. 1994). Pallid sturgeon stocking in the Great Plains region has been hindered by potential transmission of iridovirus. Examples of problems from other fish taxa are common. Wild Atlantic salmon in many of Norway's rivers have been decimated by the parasite *Gyrodactylus* resulting from hatchery and pen-rearing operations (Johnson and Jensen 1991).

Fourth, loss of future management options is often a neglected consideration for those promoting stocking of hatchery fish. It is often possible to introduce hatchery-reared paddlefish fish but it is not necessarily possible to remove them or reestablish a wild stock. Once natural habitat maintenance and protection are sacrificed for hatchery programs and stocking, the expansion of fisheries dependent on the hatchery fish may force even more stocking of hatchery fish. Wild stock management may thus no longer be an option. Actions that seriously limit future management options should be implemented cautiously, if at all, because knowledge and societal values change over time.

Fifth, once stocking of large numbers of hatchery fish of any species is pursued, there is typically perceived to be less of a need to maintain existing habitats for wild fish, even though that habitat may be crucial for long-term survival of the species (Scarnecchia 1988; Jonsson and Fleming 1993; Lichatowich 1999). The long-term benefits of relying on hatchery stocking over maintaining wild fish habitat are thus dubious and should be avoided (Meffe 1992; Hilborn 1992) in favor of maintaining the wild stocks and their natural habitats.

Stocking hatchery fish is therefore a poor substitute for natural reproduction. Production of hatchery-reared paddlefish, if any, should be only as a last resort under conditions of sustained recruitment failure, and complement or supplement natural reproduction and recruitment, not replace or supplant them. The primary role of hatchery fish should be to maintain the capability of producing high-quality hatchery fish if habitat loss necessitates it. Experimental stocking of hatchery reared paddlefish may in some instances 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 and adequately justified and thoroughly evaluated. With effective habitat and harvest management, hatchery production is unnecessary.

3. Benefits from the paddlefish resource should accrue to the entire public, rather than to just a few individuals or groups.

This philosophy is rooted in concepts of managing for the public trust (Nielsen 1999). The more people that benefit directly and indirectly from the public resource, the more broadly 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 tended to emphasize low individual bag limits distributed over many interested snaggers, rather than concentrating the benefits for a few users. Similarly, commercial benefits from the two roe donation (caviar) programs have accrued to a broad spectrum of the public, outdoor enthusiasts and not, through grant programs, rather than to a few individuals. It also avoids a problem commonly arising when a few people, such as commercial fishers, become critically dependent economically on a species or a fishery. Such people and their industry can exert undue pressure on resource decisions and adversely impact sustainable management efforts for the public. For conservation reasons, it is thus highly desirable to avoid concentrating benefits of the public resource in the hands of a few.

Similarly, agencies charged with providing sustainable management for the public trust must obtain sufficient funds for management. Those funds should come from the public and the users of the resource. In this case, funds generated from the sale of caviar roe and licenses should be allocated to management agencies in amounts sufficient to allow the agencies to fulfill obligations to the public trust. In many North American fisheries, this policy of adequately funding management (especially by commercial and industrial interests benefiting most) has not been adhered to, and the outcome has often been inadequate management, resulting in damage to public resources and to the reputations of agencies charged with managing them.

In managing for the public trust, agencies must have the authority to implement necessary regulations when the scientific evidence requires it. The history of successful implementation of effective management plans for fisheries is not exemplary when viewed on a national or international level (McHugh 1970). It is incumbent on the agencies themselves, once empowered with adequate financial resources and professional expertise, to implement sound management policies for the benefit of the public trust. Too often, global fisheries are knowingly under-managed or mismanaged, and over harvest allowed, based on short-term economic or social pressures, when stock assessments call for a lower harvest. MTFWP and NDGFD should be supported when implementing scientifically-justified management regulations such as bag limits, season duration limits, and harvest caps required for sustainable management.

4. Sustainable recreational harvest and non-harvest fishing opportunities are desirable at the level appropriate within the productive capacity of the stocks.

Paddlefish recreational harvest is a popular sport in several states (Combs 1986; Graham 1997). A sustainable paddlefish recreational fishery can be useful in sustaining or increasing interest in the species by snaggers and the public at large. Studies of paddlefish snaggers indicate that although the harvest of fish is not the primary motivation for participating in paddlefishing, the ability to harvest at least one fish is an important part of the experience for most snaggers (Scarnecchia et al. 1996a; 2000). The sustainable, orderly harvest itself becomes a measure of success. As a partial compensation for limiting harvest, opportunities for catch-and-release snagging should be provided in situations where its implementation is not detrimental to the stock (Scarnecchia and Stewart 1997a).

5. ***The management plan for harvest and habitat should lead to sustainability of the resource and be matched to the evolved life history of the species.***

The cornerstone of the management plan is long term sustainability of the paddlefish stocks. The fish has evolved a life history strategy characterized by a long lifespan, late age-at-maturity, and non-annual spawning (Scarnecchia et al. 2007b). Paddlefish and sturgeons have been shown to be more sensitive than most other species to the loss of reproductive potential caused by increased mortality (fishing and other) of age-1 and older females, both in theory (Boreman 1997) and in practice. A large part of this sensitivity involves their life history. The management plan should be designed in a manner consistent with this life history. In the absence of serious habitat problems, post-juvenile natural mortality of the species is low, and there is no need to risk overharvest in the short term at the expense of the long term. The harvest strategy should be on the conservative side, designed to allow the persistence of multiple spawning, older aged fish, known as prime spawners (Scarnecchia et al 2007b) 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).

6. ***High quality data is critical to stock assessment and sustainable management; fish harvest should be a key source of necessary data.***

In this positive feedback strategy, better monitoring will lead to better management, which in turn will provide better information for management. Because paddlefish inhabit large rivers and reservoirs and sampling fishes in these areas is expensive and time-consuming, it is far preferable that the fisheries provide most of the data necessary for management. Harvest management should be designed accordingly (Williams 1977). When harvest occurs outside of the management and monitoring structure, harvest activities hinder stock monitoring and management rather than aid them. A well designed management system will be designed to use any allowable harvest as an instrument in support of sustainable management, rather than in opposition to it. The data collected should meet the needs for adequate short term and long term management.

7. ***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 a cooperative plan, uniformity of actions among entities is generally beneficial to all parties. Harvest regulations that are similar and equitable between states will result in less conflict. Even within states, regulations among stocks that are consistent will generally result in less angler dissatisfaction and confusion. Similarly, if harvest management data collected are uniform and consistent within and among stocks, comparative analyses within and between data sets may provide valuable information for management. Most monitoring activities should thus be uniform and apply to all stocks. Special conditions may make it necessary, however, to set special regulations or obtain specialized information for optimal management of that stock. For example, the Dredge Cuts archery fishery may provide a special case. Similarly, a closer monitoring of the portion of the Yellowstone-Sakakawea stock in the Dredge Cuts may provide meaningful data for management of the entire stock. Uniformity, although highly desirable, should be complemented by the needs arising from special circumstances.

8. A thorough knowledge of the stock-recruitment relationship should be a pre-requisite for allowing the numbers of each stock to drop below present levels.

The uniqueness, high value, and irreplacability of paddlefish stocks necessitate cautiously regulating the harvest to sustain healthy stocks until their ecology, stock recruitment relationships, and productive capacities are thoroughly understood. High annual harvest rates are unjustified on the basis of "catching them before they die" (a logic used on salmon) because their low natural mortality rate means that fish not caught in a given year will probably live to be caught in subsequent years. Studies from the Yellowstone-Sakakawea stock indicate that the number of adult fish has dropped from about 120,000 in the late 1970's to about 50,000 as of 2007. This continual decrease has been the result of natural and harvest mortality, lower recruitment compared to mortality, and declines in reservoir productivity associated with the natural processes of reservoir sedimentation and aging. Recent evidence also indicates that Lake Sakakawea reservoir levels and Yellowstone River discharges may strongly influence paddlefish reproductive success and recruitment (Scarnecchia et al. 2007a). It is not known how many adult fish are needed annually as spawners to sustain the paddlefish stock, or to provide a strong year class of fish under variable river and reservoir conditions. Spawning of paddlefish in their turbid spawning habitats, which has seldom been observed (Purkett 1961) may proceed much more effectively with large numbers of spawners. Young paddlefish, which are known to be highly vulnerable to predation, may survive at a much higher rate in larger numbers than in smaller numbers, depending on the nature of the predation. Although paddlefish ecology in the rapidly changing Lake Sakakawea and Fort Peck Lake is much better understood than a decade ago (Fredericks 1994, Kozfkay and Scarneccchia 2002; Scarnecchia et al. 2007a), some critical information, such as the stock recruitment relationship, is lacking. Until knowledge improves, it is wise to implement a harvest strategy that will prevent further decreases the stock size. An adequate understanding of the stock-recruitment relationship necessitates an ecosystem based understanding of the paddlefish, i.e., an understanding of not only the internal dynamics of the stock itself but an understanding of the relationship of paddlefish to the biological-physical-chemical aspects of habitat, predators, prey, competitors, and a wide range of potential influences on the species (Francis et al. 2007).

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 also 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. The Montana-North Dakota Paddlefish Management Plan considers plans in states lower in the Missouri River basin, as well as in the Ohio and Mississippi rivers, such that management efforts upriver do not negatively impact efforts downriver. 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.

The Montana-North Dakota Paddlefish Management plan should be consistent with, and if necessary reconciled with, other state management plans such as MFWP's warmwater fisheries management plan (Montana Fish, Wildlife and Parks 1997), the Fort Peck Reservoir Fisheries Management Plan (Montana Department of Fish, Wildlife and Parks 2002), and the NDGFD's Missouri River System Plan (Hendrickson et al. 2002).

10. Evaluation, regulation, enforcement, 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 evaluation of implemented actions, adequate translation of recommendations into regulations, and adequate enforcement of regulations. Actions implemented to improve a fish stock or its habitat must be evaluated afterward for the success or failure of the action. Similarly, recommendations designed to maintain or improve stock status must be translated into regulations, and the implemented regulations must be vigorously enforced. For example, high-grading of paddlefish is antithetical to wise harvest management (because most snaggers, given the choice, would harvest the largest fish, all of which are females), regulations must be designed to prevent it, and enforcement must act to enforce the regulation.

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 of the basis and rationale for those regulations. Similarly, public receptiveness to conservation efforts will be more positive if they are provided clearly presented, accurate information on the value and significance of the paddlefish and the management efforts undertaken on its behalf. Frequent communication and interaction with the public regarding the paddlefish and the management plan are critical to the success of the plan and the long term survival of the species. This effort requires presence on site by management and monitoring personnel during major snagging activities.

Goals and Objectives

The eight goals of the management plan indicate statements of desirable directions or progress consistent with the ten fundamental hypotheses. The outcome of a goal is not necessarily a specific endpoint, but is often improved knowledge or management capabilities. 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 of the plan are statements of planned results to be achieved by a specified date, in this case to be implemented and accomplished over the 10-year period from 2008 to 2017. 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 appropriate federal agencies and Native American Tribes.

OBJ 1.1 Coordinate among relevant interested parties in spring before the season and in autumn after the season.

OBJ 1.2 Develop in-season harvest and stock status estimates for use in evaluating season status.

OBJ 1.3 Consult with tribal biologists, especially the Fort Peck Tribal Fisheries Office, for information exchange and data acquisition.

OBJ 1.4 Compile an annual joint North Dakota-Montana report on the past year's snagging seasons and current stock status, with recommended actions.

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

GOAL 2. Provide for an orderly, equitable, and sustainable recreational fishery for paddlefish and a harvest consistent with the productive capacity of the stocks. This goal should include similar regulations between the states, to the extent possible.

OBJ 2.1 Improve the existing age-structured harvest model for estimating stock status and allowable annual harvest.

OBJ 2.2 Improve methods of forecasting reproductive and recruitment success.

OBJ 2.3 Improve and refine population estimates.

OBJ 2.4 Improve estimates of harvest and harvest rates in all areas.

OBJ 2.5 Estimate natural mortality rates for each stock.

OBJ 2.6 Provide controlled snag-and-release opportunities for paddlefish.

OBJ 2.7 Formulate uniform regulations between states wherever possible.

GOAL 3. Develop and maintain a standardized data base.

OBJ 3.1 Revise and adhere to a uniform sampling procedures document.

OBJ 3.2 Improve the data collection system using the existing paddlefish fisheries and tagging systems in Montana and North Dakota.

OBJ 3.3 Obtain accurate data from harvest from Tribal fisheries.

OBJ 3.4 Establish and regularly update a centralized data base.

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 and rules 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 Identify and implement additional laws, administrative rules, and other decisions as needed to safeguard the future of each stock.

OBJ 4.3 Use existing data to identify and define critical habitat needs and requirements for paddlefish at all life stages.

OBJ 4.4 Assess the historical pattern and status of water withdrawals from the entire Yellowstone River and tributaries and the prognosis for paddlefish spawning and rearing.

GOAL 5. Conduct research necessary for successful long-term management.

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

OBJ 5.2 Assess the impacts of Fort Peck spring releases on migration of adult paddlefish and spawning success of juvenile paddlefish.

OBJ 5.3 Assess the potential effects of coal-bed methane and other energy development on paddlefish in the Lower Yellowstone River.

OBJ 5.4 Assess the effects of projected climate change, and reservoir aging, drawdowns, and refilling on paddlefish reproductive success, growth, and survival.

OBJ 5.5 Continue investigations on factors affecting paddlefish reproductive success.

OBJ 5.6 Periodically review and discuss with working group new literature on paddlefish and sturgeon for relevance to management.

OBJ 5.7 Assess contaminant concentrations in paddlefish flesh and roe.

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

OBJ 6.1 Evaluate the success of experimental hatchery releases into Lake Sakakawea.

OBJ 6.2 Review status of paddlefish aquaculture from production and stock enhancement perspectives.

OBJ 6.3 Articulate specific rationales for stocking in response to reservoir depletion, persistent low river and reservoir water levels, invasive species, or other potential ecological threats to the species.

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

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

OBJ 7.2 Publish peer-reviewed scientific publications of research and management efforts for the scientific community.

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

OBJ 8.1 Reassess values, attitudes, and preferences of paddlefish snaggers.

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

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

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

Actions by Goals and Objectives

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 appropriate federal agencies and Native American Tribes.

OBJ 1.1 Coordinate among relevant interested parties in spring before the season and in autumn after the season.

Technical coordination meetings will typically be held in late April before the snagging seasons and in late November after the snagging seasons, but at least once per year, to review management and monitoring issues and present stock assessment and research results. The meeting site will typically rotate between Montana and North Dakota. A meeting site will be determined and an agenda will be prepared and distributed before the meeting by the host state. Meeting minutes will be taken. Other *ad hoc* meetings and impromptu sessions will occur as needed, and as opportunities arise at various other meetings within the region.

A standard mailing list and e-mail list will be established for working group management personnel on paddlefish and caviar-related matters.

OBJ 1.2 Develop in-season harvest estimates for use in evaluating season status.

During snagging seasons, MTFWP and NDGFD managers will monitor information from the fish cleaning stations on total number of fish cleaned, trends in effort, flow projections, harvest projections and any other information needed for assessing when closure may be necessary. This information will allow managers to assess progress of the fisheries and plan for closures if necessary. Timely updates will be forwarded to central and regional offices in both states.

OBJ 1.3 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. Harvest data from the tribal fishery will be collected as needed (OBJ 3.2 below).

OBJ 1.4 Compile an annual joint North Dakota-Montana report on the past year's snagging seasons and current stock status, with recommended actions.

A succinct summary of stock status should be prepared no later than February of each year describing stock size, stock age structure, recent recruitment, and recent harvest, so that adjustments in the acceptable harvest can be made when necessary. This report will include dentary and other data analyses and results from the previous year.

OBJ 1.5 Periodically attend and participate in MICRA, CITES, IUCN-SSG, downriver Missouri River fisheries and paddlefish and sturgeon workgroups, and any other pertinent meetings.

Periodic attendance at selected meetings by NDGFD, MTFWP and University of Idaho personnel will be useful for information exchange and cooperation both within the group and between the group and other management entities.

GOAL 2. Provide for an orderly, equitable, and sustainable recreational fishery for paddlefish and a harvest consistent with the productive capacity of the stocks. This goal should include similar regulations between the states, to the extent possible.

OBJ 2.1 Improve the existing age-structured harvest model for estimating stock status and allowable annual harvest.

Because the harvest model is critical in establishing appropriate regulations, continual refinement in the methodology and population estimates is an important ongoing task. One approach that will be evaluated will be to base the harvest cap of fish on the recruitment of 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 females to a specified number of fish consistent with 5-year recruitment, as is now used in the harvest model.

Use of the age structure model requires a comprehensive and accurate data collection program. Age determination and adult tagging programs will be continued. Paddlefish cannot be aged strictly on length or weight (Scarnecchia et al. 2007b). Recruitment will be estimated annually and used to provide a recommended harvest cap to maintain population size. This approach will be used for both the Yellowstone-Sakakawea and Fort Peck stocks. For the Oahe stock, population size data will be analyzed to assess stock size and the ability to support a fishery.

OBJ 2.2 Improve methods of forecasting paddlefish reproductive and recruitment success.

Forecasting and characterizing success or failure of reproduction and recruitment are critically important for effective management. Data will 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/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 include 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). Plankton sampling at depths will also be considered.

Sampling of age-0 and age-1 fish will occur when numbers are sufficient to warrant the effort. All fish captured will be measured and a subsample weighed. All age-0 fish will be tagged with batch coded wire tags before being released. 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 more difficult to interpret in 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 low river flows and declining reservoir levels in Fort Peck Reservoir from 1998 to 2004, counts have been near zero. As of 2007, it is unclear if the counts are low primarily because of weakness in methodology or because very little successful spawning or early life stage survival has occurred over the past several years. It would be useful to have a better method to observe and estimate abundance of age-0 fish in Fort Peck Reservoir, such as larval fish production, at least in years of low flows, low reservoir levels, and low reproduction.

It is important to conduct an assessment of the overall sampling methodology and design for obtaining annual estimates of catch, effort, size, sex, and age structure of paddlefish to insure that the most accurate and precise methods are being used. Currently, estimates of catch and effort are obtained from phone creel surveys and/or on-site creel censuses at Intake, the Confluence, and other sites for the Yellowstone-Sakakawea stock (the Dredge Cuts below Fort Peck), and at sites above Fort Peck for the Fort Peck stock. Creel census methods should be reviewed and revised to insure that the methods used are optimal and catch and effort estimates are accurate. Similarly, the Young Male Recruit Index is a function of the age-specific catch of young males at various sites, the snagging effort, and the flow, season length, and other factors known to affect the catch. This Index should be reviewed for accuracy and precision for both the Yellowstone-Sakakawea and Fort Peck stocks.

Fish at cleaning stations will also be inspected for the presence of coded wire tags. Recoveries of coded wire tagged fish will permit the validation of the dentaries for age determination of progressively older paddlefish (Scarnecchia et al. 2006). Mortality rates will also be estimated. Consequently, all immature wild paddlefish sampled as well as any fish released from hatcheries must be coded wire tagged.

In addition to the development of the early warning indices, other possible signs of overharvest (such as changing sex ratios) will also be monitored. A diversity of ages among both male and female spawners will be considered one positive indicator of stock health.

The extensive data base developed will permit the development and testing of more elaborate stock models than the one used, including standard age-structured models. Existing paddlefish data will be analyzed with these methods and compared with the existing harvest model currently in use.

OBJ 2.3 Improve and refine population estimates.

Population estimates are used to set and adjust the harvest cap for the stocks. Estimates for all stocks will be improved and refined. The current estimation method is based on mark-recapture estimation.

Jaw tagging of adult fish will be continued. A goal of tagging a minimum of 400 fish per year per state (800 total fish per year) has been set for the Yellowstone-Sakakawea stock. The minimums for the Fort Peck and Oahe stocks are 400 and 100 fish, respectively. In addition, a goal of tagging of 50 fish per year in the Dredge Cuts is set to obtain information on the status of those fish. These minima can be exceeded, where justified, in years when fish are more easily captured to compensate for years when fish are more difficult to catch and the minimum tagging goals are not attained.

Several assumptions of the current population estimation methodology are either violated or only partially met. Important sources of potential bias for the single mark-recapture method in use are: 1) the tagged fish are not a representative sample of the actual recruited population, 2) the creeled fish are not a representative sample of the actual recruited population, and 3) jaw tag loss has not been quantified. Existing data on size and sex ratios of tagged and creeled fish will be analyzed in an effort to determine the extent of tagging and recapture bias, and how to adjust for it in population estimates. As of 2007, single season mark recapture estimates are used to estimate the total run size for that year. Efforts will be made to estimating the total adult stock size based on two approaches: 1) the use of the single season estimate and estimates of reproductive periodicity, and 2) multiple mark-recapture estimates over more than one season. Results from these two approaches and their confidence intervals will be compared. These approaches will be used for both the Yellowstone-Sakakawea and Fort Peck stocks. For the Oahe stock, this same level of analysis will be undertaken in the future as sufficient mark-recapture data become available. In addition to more traditional mark-recapture population estimates, the use of other techniques such as DIDSON sonar and acoustic equipment (Hale et al. 2003) will be reviewed and evaluated for possible use in assessing the number of paddlefish in the rivers and reservoirs, respectively.

OBJ 2.4 Improve and refine estimates of harvest and harvest rates in all areas.

Population estimates and harvest rates estimated from tag recoveries will be used in conjunction with harvest estimates and age structure to estimate recruitment. Ongoing annual creel activities for the Yellowstone-Sakakawea and Fort Peck stocks will continue. Annual creels will be assessed and modified as needed. Additional creel effort will be expended at off-site areas as needed and as fishing patterns change. A limited phone or mail 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 age-0 fish and all wild age-0 fish caught may result in a significant number of tagged fish being recovered at cleaning stations. Tag detectors will be used at these sites to obtain tag recoveries for use in developing estimates of survival rates as well as relative survival of hatchery-reared and wild fish.

OBJ 2.5 Estimate natural mortality rates for each stock.

Estimation of natural mortality rates (here defined to include all non harvest mortality) is important for the harvest model. A higher than expected natural mortality would necessitate a compensatory drop in allowable harvest for a given recruitment. Natural mortality includes but is not limited to losses from ghost fishing mortality (Harley et al. 2000; Al-Masroori et al. 2004), as might occur when fish lost by the snagger remain entangled in fishing line, losses through irrigation canals, and mortality from being hit by boat propellers (Rosen and Hales 1980).

Two basic approaches will be used to estimate mortality. The first approach will involve use of the existing data base on age structure and adult tag recoveries to estimate non harvest losses. Catch curves will be developed and compared with harvest estimates from tag recoveries to separate harvest from non harvest mortality.

The second approach involves monitoring of losses of paddlefish from information on mortality provided by the snag fishery. Information will continue to be collected on scars and other damage to paddlefish attributed to snagging and other human activities (Rosen and Hales 1980). Information on potential damage to paddlefish from boats will also be obtained from the phone creel and mail creel assessments of boaters using Lake Sakakawea and the Williston Reach of the Missouri River. These data sources may permit the estimation of non harvest losses associated with boating and snagging.

OBJ 2.6 Provide controlled snag-and-release opportunities for paddlefish.

The implementation of the snag-and-release fishery for paddlefish was based on evidence that cautious implementation of a snag-and-release fishery would result in more snagging 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 snagging opportunities and resulted in a source of fish for tagging in Montana. More effort should be given to evaluate several aspects of the fishery, including delineation of snagging areas and times, the extent of monitoring needed, the optimal hook size for catchability while ensuring fish survival, and tagging and tag recovery activities. In addition, the benefits and costs of non lead weights for both harvest and snag-and-release snagging should be assessed.

OBJ 2.7 Formulate uniform regulations between states wherever possible.

Each year at coordination meetings, current and proposed regulations will be discussed between the states for their effectiveness. 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 data base. Efforts at uniformity will be balanced against distinct, state-specific aspects of each fishery.

GOAL 3. Develop and maintain a standardized data base.

OBJ 3.1 Revise and adhere to a uniform sampling procedures document.

The uniform sampling procedures and data collection document for fish in all stocks (Scarnecchia et al. 1996c) will be updated in 2008 and as needed thereafter. The protocol will be adhered to during all sampling.

OBJ 3.2 Improve the data collection system using the existing paddlefish fisheries and tagging methodologies used in Montana and North Dakota.

All sampling of catches will be closely coordinated between North Dakota and Montana to insure uniformity and compatibility of data collection. Implementation of the harvest model requires intensive sampling of paddlefish for estimates of total harvest, population size, and population age structure. Fortunately, most paddlefish for both the Yellowstone-Sakakawea and Fort Peck stocks are taken at a few locations; intensive sampling for the required data at those sites will be possible at relatively low cost. These sites will be sampled heavily during prime usage times. Data from less popular areas will be obtained through annual phone and mail creel censuses. Off-site creel censuses will be implemented as necessary.

OBJ 3.3 Obtain accurate data from harvest from Tribal fisheries.

Efforts will be made to obtain both tribal and non-tribal harvest estimates on reservation lands, as well as biological information from harvested fish. This effort should involve on-site creels at Wolf Point and Frazer snagging sites, either by soliciting the assistance of tribal biologists and wardens, or through University of Idaho or MTWFW staff in cooperation with tribal biologists.

OBJ 3.4 Establish and regularly update a centralized data base.

A centralized data base for all adult jaw tagging, age-0 and age-1 paddlefish sampling and coded wire tagging in the reservoirs, and for all other population sampling records for all three stocks has been developed and is being maintained at the University of Idaho. This data base will be reviewed to insure completeness and accuracy of past records, and will then be updated annually to incorporate all new data. The data base will be made available to MTFWP and NDGFD.

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 and rules for relevance to maintaining or enhancing paddlefish habitat for all life stages, including river flows, water quality, physical habitat, and reservoir levels.

Habitat protection, a cornerstone of this plan, will involve consultation and coordination with the USACE, BoR, water user groups, and other agencies and groups affecting water quantity and quality for paddlefish. Important aspects of paddlefish habitat in need of protection are spawning flows and turbidity, free river passage for migratory fish, spawning gravel, water quality, and reservoir levels. Any new and existing habitat information will be used in an effort to protect paddlefish habitat.

Spawning flows are poorly protected by law. Any new water uses, especially increased irrigation flows, that could decrease Yellowstone and Missouri River flows during the spawning period should be monitored and documented. An emphasis should be to improve the efficiency of irrigation so that total water withdrawals do not increase. Maintenance of both high flows and natural turbidity should be considered important. The Stream Protection Act will be used to defend all physical aspects of paddlefish habitat, especially against projects that could block the migration of spawners.

In addition, efforts should be expended to encourage the development of more restrictive and meaningful laws and administrative rules designed to protect river flows, reservoir levels, and other aspects of paddlefish habitat.

OBJ 4.2 Identify and implement additional laws, administrative rules, and other decisions as needed to safeguard the future of each stock.

Analyze new research information in view of any new and existing legislation so that existing laws related to paddlefish sustainability are adhered to. Promulgate agency administrative rules and other decisions as needed to insure sustainability of the stocks.

OBJ 4.3 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 turbidities, and reservoir levels to assess the relations among these variables (See Goal 5, Objectives 1, 3, 5, and 6 below). Data gaps will be identified, and additional data may be collected to fill the identified gaps (See Goal 5, Research).

OBJ 4.4 Assess the historical pattern and status of water withdrawals from the entire Yellowstone River and tributaries and the prognosis for paddlefish spawning and rearing.

The relation of river flows to spawning success and subsequent year class strength is not adequately understood. A need exists to assess the historical hydrograph of the Yellowstone River in relation to seasonal discharges, with special reference to spring peak flows, minimum summer flows, and over-winter flows. Discharge from U. S. Geological Survey stations at Miles City and Sidney will be analyzed, along with discharges and other water quality data from the Glendive and Williston, North Dakota water treatment plants. Other data utilized will include irrigation water withdrawals from past and present irrigation projects along the Yellowstone River. This study has been approved for funding and was initiated in 2007.

GOAL 5. Conduct research necessary for successful long-term management.

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

The proposed development of fish passage capabilities at the Intake diversion structure is expected to impact paddlefish movements and migrations, as well as the fishery. 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.

Although the effects of the proposed canal fish screen on paddlefish may be less than the effects of the adult fish passage structure, effects of the screen, once installed, should be evaluated along with effects on other species.

OBJ 5.2 Assess the impacts of Fort Peck spring releases on migration of adult paddlefish and spawning success of juvenile paddlefish.

Recent and proposed future releases of water from Fort Peck Dam have the potential to draw migrating paddlefish up the Missouri River during the spring spawning period and to then attempt to spawn in the river. Since the creation of Fort Peck Lake in the late 1930’s and the impoundment of Lake Sakakawea in 1953, the Yellowstone River is generally believed to have been the primary spawning grounds for the species. Unpublished data from ongoing investigations below Fort Peck Dam indicate that paddlefish that spawn up the Missouri River do so later in the year and are smaller by late summer than fish spawned in the Yellowstone River. Partial mitigation of the loss of natural conditions on the Missouri River may assist pallid sturgeon recovery, but may also be detrimental to paddlefish spawning as pre-spawning adults are lured into the Missouri River, only to fail to produce viable recruits.

OBJ 5.3 Assess the potential effects of coal-bed methane and other energy development on paddlefish in the Lower Yellowstone River.

Ongoing studies of the impacts of energy development on native fishes of eastern Montana will be evaluated for their relevance to paddlefish.

OBJ 5.4 Assess the effects of climate change, reservoir aging, drawdowns, and refilling on paddlefish reproductive success, growth, and survival.

A thorough understanding is needed of the effects of water level fluctuations and accompanying habitat changes on paddlefish growth, survival, and year-class strength. Some research has been conducted in this area (Scarnecchia et al. 2007a). It is necessary to continue monitoring the ecology of age-0 fishes in the reservoir so that factors influencing survival, growth, and year class strength are clarified. Factors include turbidity on the reservoir by area and zooplankton abundance and distribution.

Climate change may impact paddlefish in many ways, including accelerated dewatering of the Yellowstone and Missouri rivers, impacts on reservoir water levels and productivity, and impacts on other fish species interacting with the paddlefish. Studies will be initiated as particular issues and problems are anticipated or arise.

OBJ 5.5 Continue investigations of factors affecting paddlefish reproductive success.

Rivers: It is important to identify and characterize spawning areas, and to determine if such areas are used for spawning annually or whether spawning sites change from year to year. 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) would have helped to protect good river conditions for spawning, but were not granted. Spawning success at lower river flows is questionable. The relation between river flows and spawning success needs to be investigated in more detail. Also poorly understood are the relative contributions to year class strengths from fish spawning in the Milk River and in the Yellowstone River upstream of Intake in years of higher flow when paddlefish are able to move upstream past the dam. Spawning areas upstream of Fort Peck Reservoir have been suggested by Berg (1981), and efforts are ongoing to further delineate them. Although two recent studies have documented egg deposition in the lower Yellowstone River, (Firehammer et al. 2006; Miller 2007), much remains to be learned about the main spawning and egg deposition sites in the Yellowstone River, and how deposition may vary by discharge and year. Additional detection or sampling of spawners and sampling of eggs and larval fish at key locations in the Yellowstone and Milk rivers (Braaten and Fuller 2006) are needed to improve understanding of paddlefish spawning and early life history. Improvement of indices of age-0 and age-1 abundance in reservoirs will also help indicate survival, and perhaps indirectly the success of spawning, at various river flows. Better approaches for estimating abundance of eggs and larvae would be especially useful in assessing spawning success. To date, success of egg sampling (Firehammer et al. 2006; Miller 2007) and larval sampling (Braaten and Fuller 2006; Braaten et al. 2007) has been inadequate for developing reliable indices of year class strength.

Paddlefish tend to spawn during periods of high river turbidity as well as high flows. The importance of turbidity is unknown, but it may be an important component of paddlefish habitat for spawning and early life history. Turbidity may facilitate spawning, or it may decrease predation on larval paddlefish drifting in the rivers before reaching the reservoirs. Important sources of sediment (such as tributaries and geological areas and formations) need to be identified and their relative contributions quantified. Maintenance of adequate discharge from sediment laden tributaries (e. g., the Powder River in the Yellowstone River basin and the Redwater River in the Missouri River basin) 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 have not been thoroughly evaluated. Year class strengths may or may not be strongly correlated with spawning temperatures. Future studies will attempt to correlate spawning success with annual thermal regimes as well as discharges. Temperature data collected at standard sites over the past decade by the NDGFD and others will be used in this analysis. Continuous recording thermographs will continue to be placed at key river locations during the migration and spawning periods.

Reservoirs: Little is known about movements of yearling and older fish in the reservoirs. Investigations will be designed to assess movements of yearling and older fish. Analysis of historic catch records of paddlefish in Lake Sakakawea (from standard NDGFD surveys) will provide preliminary information on the most commonly used areas. It will also be possible to relate the habitat use of adult paddlefish in the reservoir to habitat factors. The use of archival tags (Ishida et al. 2001) will be investigated to provide insight into preferred habitat conditions within the reservoir. Information gained will be related to turbidity, zooplankton abundance, distribution and abundance of predators, habitat variability, and reservoir aging. If funds are available, similar work in Fort Peck can be initiated once effective sampling methods are developed on Lake Sakakawea. In particular, little is known about the relationships among Fort Peck paddlefish and known predators such as walleye (Parken and Scarnecchia 2002) and potential competitors such as cisco.

OBJ 5.6 Periodically review and discuss with working group new literature on paddlefish and sturgeon for relevance to management.

Relevant articles and papers will be routed among members of the group for incorporation into the management and stock assessment framework.

OBJ 5.7 Assess contaminant concentrations in paddlefish flesh and roe.

Conduct periodic analyses of the concentrations of a wide range of contaminants in paddlefish flesh and roe. This work will be coordinated with the appropriate state agencies in North Dakota and Montana. Samples for analysis could most efficiently be obtained during creel activities at snagging sites and fish cleaning stations.

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

OBJ 6.1 Evaluate the success of experimental hatchery releases into Lake Sakakawea.

Results from stockings in 1995, 1997 and 2007, as well as wild fish tagged over the past decade, will be evaluated over the next decade and longer, as coded wire tagged fish mature and are sampled or harvested in the snag fisheries. Harvested fish will be screened for the presence of coded wire tags, and all tags will be extracted and decoded for brood year information. Recoveries of coded wire tagged wild paddlefish in Lake Sakakawea, as well as all tagged paddlefish released from hatcheries, has provided and will continue to provide fish of known age for age validation. Dentaries will be removed from tagged fish that are recovered and the age of the fish determined for age validation. Survival rates of hatchery reared fish will be compared with those of wild fish.

All stocked fish will be coded wire tagged (Pitman and Isaac 1995; Fries 2001). If possible, comparisons will also be made regarding the size of fish stocked and the timing of their release. If sufficient recoveries of wild fish are obtained, survival rates of fish tagged during lower reservoir levels will be compared with those tagged during higher reservoir periods.

One concern is whether hatchery reared fish will mature and spawn similarly to wild fish. The presence of hatchery reared fish in the spawning migration and the reproductive state of hatchery reared fish will be documented. The presence of sexually mature and spawned out females will be especially noted.

Another important concern regarding hatchery fish is the need for adequate genetic diversity. It may be desirable to assess the genetics of hatchery reared and wild recruits to compare their genetic diversity.

OBJ 6.2 Review status of paddlefish aquaculture from production and stock enhancement perspectives.

Although the emphasis of paddlefish management in this plan is to maintain wild stocks of fish without the need for hatchery augmentation, the status and results of hatchery programs elsewhere will be monitored in the event that declining stock status appears to necessitate a more definitive stocking program. Additional experimental releases may also be undertaken to test specific hypotheses regarding the performance or value of hatchery reared fish. Continued low river flows and reservoir levels, and the resultant low recruitment, may necessitate supplemental stocking even if prospects for survival or successful augmentation of the stock are poor.

OBJ 6.3 Articulate specific rationales for stocking in response to reservoir depletion, persistent low river and reservoir water levels, invasive species, or other potential ecological threats to the species.

Specific stocking policies and guidelines, along with appropriate rationale and criteria, should be jointly developed. In addition, the relationship between a paddlefish stocking program and stocking programs for other species will be evaluated. Because young paddlefish are vulnerable to predation from walleye, sauger and other species (Parken and Scarnecchia 2002), the impacts of stocking programs for other species needs to be considered with regard to potential effects on young wild and hatchery reared paddlefish. If a decision is made to rear and stock paddlefish to augment any of the stocks, a request will be coordinated with appropriate hatchery staff within each state.

GOAL 7. Increase awareness of the public and scientific community 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, and television segments.

Paddlefish have historically been less well understood by the public compared to other more popular game fish species. Some of the most effective information and education activities occur at the fish cleaning stations and involve short question and answer sessions with interested individuals and groups (Figure 42). These activities are 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 for display at Intake during the snagging season, at the Region 7 office at Miles City, and at county fairs and similar functions. NDGFD may develop similar displays at the Confluence or at other appropriate sites. Paddlefish information brochures describing not only basic ecological information on paddlefish, but also new research findings and rationales for current harvest regulations, will be updated at least every other year. A combination paddlefish cookbook/information brochure, free to the public and popular with snaggers, will also be periodically revised and updated in conjunction with the Richland County Cooperative Extension office.

As in the past, popular articles on paddlefish management and research will be prepared and published in *Montana Outdoors* and *North Dakota Outdoors*, the official agency magazines for the MTFWP and the NDGFD. These articles are designed to keep the public informed regarding various aspects of paddlefish biology and management. Other popular outlets will also be considered.

Presentations on paddlefish management and research findings will be made at popular sites such as Makoshika State Park (Montana), and at regional hunting and fishing club meetings.

Figure 42. People of all ages are interested in paddlefish.

Short television information segments will be periodically presented in response to requests. Information and Education specialists will also periodically develop video segments of the fishery and management activities.

OBJ 7.2 Publish 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 component of this plan. Scientific findings will be presented at professional meetings and, most importantly, published in peer-reviewed scientific journals to assist in the verification of the reliability of results and approaches. Results may be synthesized into one or more peer-reviewed books.

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

OBJ 8.1 Reassess values, attitudes, and preferences of paddlefish snaggers.

Information will be periodically obtained regarding the values, attitudes, and preferences of snaggers and the public at large toward paddlefish. Different methods of obtaining the most reliable information will be evaluated. This information may be obtained during the season

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

Information on angler activities and preferences will be obtained through on-site and/or other types of creel surveys. Phone creel surveys used to assess a number of snagger attributes, including catch, effort and site usage, will continue to be conducted. Mail creel surveys may also 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. Results will aid in formulating policies, management actions, and in subsequently updating the paddlefish management plan.

OBJ 8.3 Obtain reviews of regulation recommendations and coordinate regulations 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 snagging season regulations and the overall 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.

The economic desires of the caviar production entities in both states have not and should not affect the implementation of sustainable paddlefish harvest management programs. Both MTFWP and NDGFD will endeavor, however, to maintain open dialogue, effective communications, and positive working relationships with their respective caviar entities. Although some of the short and long term goals and objectives of MTFWP and NDGFD for paddlefish sustainability may not mesh with the short term economic desires of the caviar entities, most of the goals and objectives are compatible. Input from the caviar entities will be sought and considered in areas where the health of the paddlefish stock, the quality of the recreational fishery, and other agency missions of MTFWP and NDGFD are not compromised.

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