MANAGEMENT PLAN FOR THE PADDLEFISH STOCKS IN THE YELLOWSTONE RIVER, UPPER MISSOURI RIVER, AND LAKE SAKAKAWEA

PREPARED BY:

DENNIS L. SCARNECCHIA
DEPARTMENT OF FISH AND WILDLIFE RESOURCES
UNIVERSITY OF IDAHO
MOSCOW, ID 83843
(208) 885-5981

PHILLIP A. STEWART
MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS
P.O. Box 1630
MILES CITY, MT 59330
(406) 232-4365

and

L. FRED RYCKMAN
NORTH DAKOTA GAME AND FISH DEPARTMENT
P.O. Box 2476
Williston, ND 58802-2476
(701) 774-4320

TABLE OF CONTENTS

Table of Contents -- continued

EXECUTIVE SUMMARY

This document reviews life history, ecology, management, and status of the paddlefish stocks inhabiting North Dakota and Montana, and outlines a plan for the cooperative management of paddlefish in this region by the states of Montana and North Dakota in consultation with federal and tribal agencies. The goals of the paddlefish plan include providing for an orderly and sustainable recreational harvest, providing a basis for cooperative interstate management, facilitating data collection for stock assessments, conducting relevant research, protecting and improving habitat quality in the rivers and reservoirs, defining the role of artificial propagation, and increasing public awareness. A key component of the plan is the development of an age structure model with yield forecasting capabilities based on indices of abundance of young-of-the-year, yearling, and early-recruited paddlefish. Other objectives are to increase our knowledge of paddlefish population sizes and harvest rates, increase our knowledge of paddlefish ecology and habitat requirements, maintain and improve habitat quality, develop a standardized data collection system, design and implement an experimental paddlefish stocking plan, establish the basis for a rational harvest quota, and expand information efforts on paddlefish.

OVERVIEW OF PADDLEFISH

The paddlefish *Polyodon spathula*, an ancient, cartilaginous fish native to the Mississippi, Missouri, and several Gulf coast drainages (Gengerke 1986), is one of North America's largest and most distinctive freshwater fishes (Forbes and Richardson 1920). This long-lived, highly migratory (Russell 1986) species of large rivers and reservoirs is a source of commercial and trophy recreational fishing, high-quality food, and expensive caviar (Dillard et al. 1986).

Although paddlefish are still found in portions of 22 states (Gengerke 1986), mere remnant populations remain in several states where they were once abundant, and their peripheral range has shrunk in the 20th century. Some of the formerly large natural-spawning populations have declined greatly in abundance (e.g. in the Osage River in Missouri (Graham 1992) and Missouri River in South Dakota (Unkenholz 1986)). Lack of suitable spawning habitat in regulated rivers is evidently the major cause of decline (Sparrowe 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). Although paddlefish feed and grow well in reservoirs (Houser and Bross 1959; Graham 1992), their requirement of free-flowing rivers for spawning limits their production in many areas.

Overfishing has also contributed to the decline of paddlefish in many locations. Paddlefish mature late in life (9-15 years in Montana; Rehwinkel 1978), do not spawn annually (Meyer 1960), and are particularly subject to overharvest, especially inasmuch as the most sought-after fish are large, mature females (Scarnecchia et al. 1989). Commercial harvest of paddlefish has occurred for about a century, and, as of 1991, paddlefish is still a commercial species in 11 states (Combs 1986; U. S. Fish and Wildlife Service, Draft CITES proposal, Unpublished). Recreational fisheries, based primarily on snagging the fish below migration barriers or hindrances, have become popular since the 1950s. Yet despite the paddlefish's economic value, management regulations for both commercial and recreational harvests are relatively recent. Combs (1986) reviewed paddlefish regulations, which include size limits, seasons, area closures, and, in one case, an incidental quota. Current recreational regulations also vary by state, but typically involve creel limits (often 2 per day), season closures, and prohibitions against high-grading. Combs (1986) reported that the main rationales for the regulations were to regulate harvest, prevent overharvest and excessive mortality, and to protect broodstock.

Illegal fishing (poaching) of paddlefish for caviar has become a serious problem in several states as supplies of sturgeon caviar from the Caspian Sea have dwindled and political issues have impeded international trade in caviar. Retail prices of paddlefish caviar can reach several hundred dollars per pound. Inasmuch as the sex of a paddlefish cannot be reliably determined by external inspection (Russell 1986), both males and females are typically killed by poachers in their quest for eggs.

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, those wild populations badly depleted or extirpated by loss of spawning habitat (Graham 1992). Increasing interest is also being shown nationally in raising paddlefish for human consumption as well as caviar.

RATIONALE FOR A COOPERATIVE, COORDINATED MANAGEMENT PLAN

For several reasons, paddlefish fisheries do not have a history of careful management. Paddlefish have often been perceived as low-valued or undesirable fish. Secondly, development of useful stock assessment methods has been slow because of the paddlefish's long life span and late maturity. Thirdly, the inaccessibility of their large river habitats has hindered investigations. Fourthly, the paddlefish's migratory nature combined with the historical independence of state management has resulted in little coordination in management regulations among states, even for a given stock. As a result, paddlefish management traditionally has been fragmented.

More recently, however, in response to dwindling stocks and deteriorating habitat, 19 of 22 states where paddlefish still occur have found it necessary to make changes in the classification, stock status, or regulatory status of the species during the period 1983-1991 (U. S. Fish and Wildlife Service, Unpublished). At the regional and national levels, recent interest has developed in coordinating paddlefish management either nationally (Paddlefish Workshop, Atlanta, GA, 1992, Unpublished), regionally (Dillard et al. 1986) or at least for discrete management units that cross jurisdictional boundaries (this report). The paddlefish's highly migratory nature makes interjurisdictional management preferable for most stocks.

Paddlefish inhabiting the Upper Missouri River, Yellowstone River, and Lake Sakakawea support important recreational fisheries in eastern Montana and North Dakota (Rehwinkel 1978; Stewart 1990; Owen and Hendrickson 1992). Three distinct and easily identifiable paddlefish management units, evidently stocks

(Ricker 1972), are found in North Dakota and Montana. A comprehensive, coordinated management plan is proposed for the Yellowstone-Sakakawea stock, which is currently the stock fished most heavily and of greatest economic importance. This stock spends portions of its life in both North Dakota and Montana (Stewart 1990). Some paddlefish from this stock are also taken in the Missouri River below Fort Peck reservoir along the Fort Peck Indian Reservation. Although the second stock (located above Fort Peck Dam) is entirely within Montana, a management plan for that stock is proposed that would parallel management for the Yellowstone-Sakakawea stock. The third stock inhabits the Missouri River and Lake Oahe downstream of Garrison Dam. The paddlefish population in this portion of the Missouri River system has declined in abundance significantly over the past 20-30 years (Gengerke 1986). This decline can be attributed to habitat alteration, especially loss of spawning areas. No fishery exists for this stock, but fish are occasionally netted, seen by boaters, or even hit by boat propellers. Biologists hope to collect enough age-growth information to reconstruct the age structure of this stock. However, inasmuch as no fishery exists, stock size is small, natural spawning opportunities are minimal or nonexistent, and future maintenance would depend entirely on hatchery production, a plan for this stock will not be considered in this report.

Development of an interjurisdictional management plan between North Dakota and Montana will benefit the paddlefish resource in both states. An effective plan should provide a sustainable harvest while the fishery itself provides data necessary to better understand the stock, refine stock assessments, and hence improve management. The plan should also be consistent with broader (regional or national) paddlefish conservation and management goals. This document reviews known life history, ecology, management and stock status of the Yellowstone-Sakakawea and Upper Fort Peck stocks, and provides a 10-year plan for cooperative management and stock assessment.

DESCRIPTION OF RIVERS AND RESERVOIRS

Yellowstone and Missouri Rivers (Upstream from Lake Sakakawea)
(from Power et al. 1994)

The Yellowstone River flows 678 miles from its headwaters in Yellowstone Park, Wyoming to its confluence with the Missouri River in North Dakota, and drains 70,396 square miles of Wyoming, Montana and North Dakota. Several tributaries enter the Yellowstone as it traverses southeastern Montana, including the Bighorn, Tongue and Powder Rivers. The Powder River in particular provides considerable sediment to the mainstem

Yellowstone during periods of high discharge. Once the Yellowstone River leaves Montana, it runs thirteen miles through North Dakota to its confluence with the Missouri River at river mile 1577. From the confluence, the Missouri River flows until it meets the headwaters of Lake Sakakawea. Depending upon Lake Sakakawea's elevation this stretch may be as short as 15 miles (e.g. at full pool) to as long as 50 miles, as in May 1991 when Lake Sakakawea reached its historic low.

The Missouri River between the confluence and Lake Sakakawea exhibits the characteristics of two dissimilar rivers. The Yellowstone River is largely unregulated, displaying seasonally high discharge and turbidity. The average annual flow of the Yellowstone River at Sidney, MT is 13,020 cfs (based on 73 years of record), and the all-time maximum instantaneous flow was estimated at 159,000 cfs on June 2, 1921. Unfortunately, due to upstream water depletion projects, the flows of the Yellowstone River have decreased approximately 24% from historical flows (Peterman, 1977).

In contrast, the Missouri River upstream of the confluence is regulated by Fort Peck Dam, Montana, and summer flows are relatively clear and cool. Since closure of Fort Peck Dam in 1937, annual flows of the Missouri River at Culbertson, MT have averaged 10,970 cfs. The peak post-impoundment flow of 78,200 cfs occurred on this stretch of the Missouri River on March 23, 1943.

Lake Sakakawea (from Power, et al. 1994)

Garrison Dam located at river mile 1390, was closed in April 1953, creating the largest of the Missouri River mainstem reservoirs, Lake Sakakawea. At a maximum surface elevation of 1855 feet mean sea level (msl), the lake has a storage capacity of approximately 24.7 million acre feet and covers 385,615 surface acres. Approximate dimensions of the lake at 1838 ft. msl (base of flood control pool) include: total length of nearly 200 miles, shoreline of 1346 miles, average depth of 62 feet, and maximum depth of 177 feet. The drainage basin covers approximately 181,400 square miles. The historic exchange rate of water for Lake Sakakawea is 1.4 years. The average annual summer surface temperature is 66° F which is colder than all other mainstem reservoirs.

Since Lake Sakakawea reached full pool in 1967, the reservoir has fluctuated from a high of 1854.9 ft. msl in July 1975, to a low of 1815.0 ft. msl in May, 1991. This 40 foot fluctuation amounted to a difference between high and low water marks of 148,880 surface acres and 12,141,750 acre-feet of water. At 1815 ft. msl there was less than one-half of the volume of water in Lake Sakakawea than at 1854.9 ft msl. Major tributaries into Lake Sakakawea include Tobacco Garden Creek, White Earth

Creek, Little Knife Creek, Shell Creek, Deepwater Creek, Little Missouri River and Douglas Creek.

Extreme sediment deposition, at an estimated annual rate of 26,000 acre-feet (35 to 40 million tons), occurs in the upper end of Lake Sakakawea (generally between river miles 1510 and 1555). This is equivalent to a total loss of approximately three percent of the reservoir's gross storage capacity (USACOE 1993).

Missouri River (above Fort Peck Reservoir)

The headwaters of the Missouri River near Three Forks, Montana is approximately 420 miles from Fort Peck Reservoir. The Missouri River above Fred Robinson bridge drains approximately 40,987 square miles. The average daily flow (at Landusky) over a 59-year period is 9,219 cfs. A maximum instantaneous flow of 137,000 cfs was recorded on June 3, 1953 (USGS 1993)

The 207 mile section of the Missouri River from Morony Dam to the headwaters of Fort Peck Reservoir is the last major free-flowing segment of the Missouri River. The land adjacent to the Missouri in this area has retained most of its primitive characteristics and is part of the National Wild and Scenic Rivers System. Flows have been reduced in this section of the Missouri due to upstream impoundments at Canyon Ferry, Clark Canyon, Hebgen, Gibson, Hauser, and Holter dams. The major tributaries in this area are the Marias and Judith Rivers.

Fort Peck Reservoir

Fort Peck Dam construction was completed in 1940. The dam is approximately 1,770 miles upstream from the mouth of the Missouri River and nearly 11 miles upstream from the mouth of the Milk River. The reservoir at its maximum operating pool (2250 feet msl) has a storage capacity of roughly 18 million acre feet and a surface area of 246,000 acres. The maximum depth is 220 feet and average depth is 79 feet. The dam backs water up the Missouri Arm approximately 134 miles from east to west, and 30 miles up the Big Dry Arm, north to south. The shoreline of the reservoir is greater than 1500 miles.

The drainage basin of Fort Peck is roughly 57,725 square miles with an average annual inflow of 10,200 cfs. The exchange rate of water for the reservoir is 2.8 years. The average annual summer surface water temperature is 66.6° F.

The estimated annual average sediment deposition rate has been 17,750 acre-feet (averaged over 49 years of operation), which has reduced the original lake volume by 4.4 percent (USACOE 1993) The major sediment deposition occurs at the headwaters, where the Missouri and Musselshell Rivers join the reservoir.

BACKGROUND ON THE STOCKS AND FISHERIES

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). Although the population genetics of these fish are not yet well understood, and intraspecific genetic variation in paddlefish is low (Carlson et al. 1982), a preliminary genetic study (Epifanio et al. 1989) and life history differences tentatively indicates the existence of two stocks.

One stock, designated Yellowstone-Sakakawea, inhabits Lake Sakakawea,the Missouri River from Lake Sakakawea to Fort Peck Dam, the "Dredge Cuts" below Fort Peck, and the Yellowstone River. These fish migrate from Lake Sakakawea (where they spend the majority of their life) to spawning areas in the Yellowstone River and Missouri River (and perhaps the Milk River) below Fort Peck reservoir. A few fish in this stock also evidently remain over winter, and perhaps for years, in the Dredge Cuts, large backwater areas below Fort Peck reservoir (Needham 1969). Fish tagged and released below Fort Peck reservoir are recaptured at Intake, on the Yellowstone River, and vice versa (Needham and Gilge 1986; Stewart 1990), indicating that at least some mixing of fish occurs between these areas. In addition, numerous paddlefish recently tagged below the confluence in North Dakota have been recovered at Intake, and a few have also been recovered below Fort Peck Dam.

The second stock, designated Upper Fort Peck, is a physically isolated population spawning in the Missouri River above Fort Peck Dam, and rearing in Fort Peck reservoir (Berg 1981). 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.

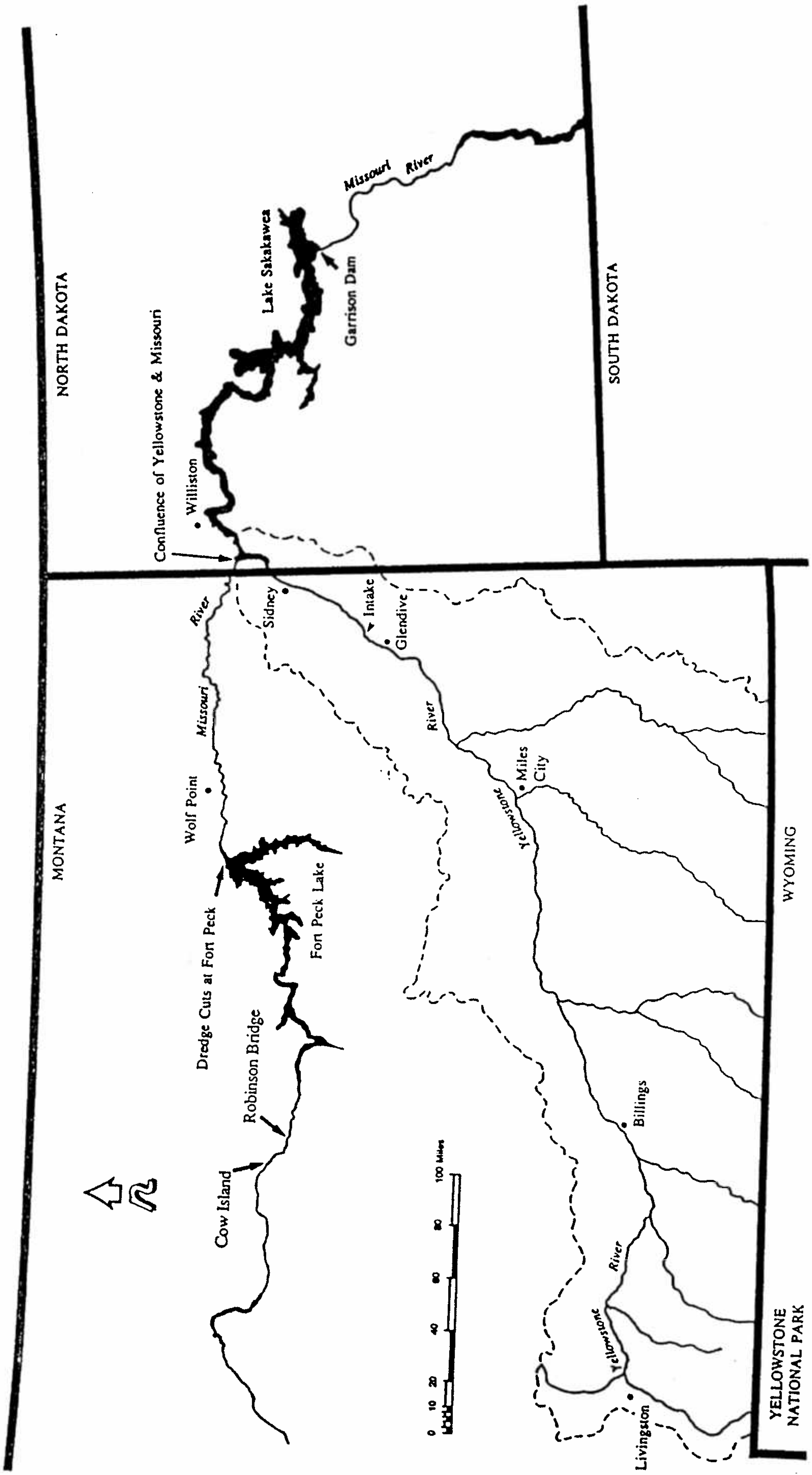
Life history/ecology, fisheries, and management issues for each stock are discussed below.

Yellowstone-Sakakawea Stock

Life history and ecology

This stock, in contrast with most others (Carlson and Bonislawsky 1981; Gengerke 1986) has evidently increased in numbers in the past 40 years. It is hypothesized that fish of this stock became more abundant and widespread after Garrison Dam was closed in 1953 (Van Eeckhout 1980) and Lake Sakakawea began filling in the mid-1950s. Year classes of paddlefish spawned in the Yellowstone and Missouri Rivers at that time had better

Figure 1.



NORTH DAKOTA
SOUTH DAKOTA
MONTANA
WYOMING
YELLOWSTONE NATIONAL PARK
Missouri River
Lake Sakakawea
Garrison Dam
Confluence of Yellowstone & Missouri
Williston
Sidney
Intake
Glendive
Wolf Point
Miles City
Yellowstone River
Dredge Cuts at Fort Peck
Fort Peck Lake
Robinson Bridge
Cow Island
Billings
Livingston
0 10 20 40 60 80 100 Miles

survival and growth in the newly formed and more productive Lake Sakakawea than previously, when they relied mainly on river habitats for growth. Maturing paddlefish would then migrate upriver in large numbers to spawn. Several pieces of evidence support the idea of recently expanded range and increased abundance. Tagging studies (Van Eeckhout 1980; Stewart 1990) indicate that many, probably most, fish caught at Intake on the Yellowstone River and at sites below Fort Peck Dam, rear in Lake Sakakawea. 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, nearly all paddlefish caught at Intake were maturing 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. Age 9 is the approximate minimum age of mature males in this stock (Rehwinkel 1978). Females, which mature later (ages 15-20; Russell 1986; Rehwinkel 1978), first appeared in significant numbers at Intake several years later.

Although definitive studies remain to be done, the life history of paddlefish of the Yellowstone-Sakakawea stock has been tentatively reconstructed (Stewart 1990; Montana Department of Fish, Wildlife and Parks, Undated). Fish stage in the Missouri River, downstream of the Confluence, beginning in October (Fred Ryckman, personal communication), migrate up the Yellowstone and Missouri Rivers in April, May and June, spawn over gravel bars during high water periods, and return down river into Lake Sakakawea in early summer. Fish moving up the Yellowstone consist almost entirely of mature fish ready to spawn, whereas the Dredge Cuts contain both migratory and resident fish. Most immature fish evidentally remain year-round in Lake Sakakawea. There is some recent evidence to suggest that at least some paddlefish may reside in the Missouri River, downstream of the Yellowstone River Confluence, throughout most of the year, or that adult paddlefish group together or "stage" in the fall prior to their spawning migration the following spring. Recently-hatched larvae are carried downriver into the reservoir where they spend 9-15 years growing before sexual maturation occurs. Recoveries of tagged fish have indicated that individual paddlefish may ascend the Missouri in one spawning migration and the Yellowstone in another. Individual paddlefish seldom migrate each year, although males evidently migrate at more frequent yearly intervals than females. The exact spawning periodicity is unknown, but tag returns suggest that females mature every 3-4 years and males every 1-2 years. Fish tagged at Intake are rarely captured the following year. A few fish are recaptured two years after tagging, but tag returns are maximized 3 years after tagging. As a result, only a portion of the adult population is available for harvest in a given year. At the Dredge Cuts, however, some tagged fish are captured the following year, which suggests that some fish may remain in that area rather than migrate down the Missouri River.

Evidence of spawning of the Yellowstone-Sakakawea stock comes from several sources. Ripe female paddlefish with flowing eggs were first observed at Intake in 1985 and have been observed in subsequent years. Gillnets drifted downstream from Intake have also yielded a few ripe females and in fact a few spawned-out females regularly appear in the angler catch at Intake.

In 1989, Gardner (1992) began a major effort to quantify paddlefish spawning in the Yellowstone and Missouri Rivers through collections of eggs and larvae. In 1991, 21 larval paddlefish and 13 eggs were collected with fine-meshed plankton nets. A total of 53 larvae were collected in 1992. In the Yellowstone, all larval paddlefish were collected near the Confluence from late May through early July. Fishes were typically one day post-hatching, which indicated that spawning areas must have been somewhere in the vicinity. In the Missouri, the young paddlefish were also taken near the Confluence, but later in the summer (July 2-17). Two-thirds of all the young paddlefish caught were sampled near the bottom.

It is also believed that paddlefish also spawn in the Milk River, which enters the Missouri River a few miles downstream from Fort Peck Dam (Gardner 1992). Needham (1980a) reported that 5 larval paddlefish were collected at the mouth of the Milk river in 1978.

In Lake Sakakawea, juvenile paddlefish have been seen at numerous locations throughout the upper portion of the reservoir, and downstream in the lake as far as the New Town area. Young-of-the-year can be seen near the surface fleeing from approaching motorboats. These young paddlefish are initially fairly translucent, and, based on field observations during 1991-1993, form loose feeding assemblages. Yearlings can also be seen in a similar manner. Mero, et. al. (1994) reported that young paddlefish were important in the diets of walleye and sauger in White Earth Bay (Lake Sakakawea) in October 1991.

The quantitative distribution of adult paddlefish in Lake Sakakawea is not well known, but paddlefish have been seen and sampled at many locations throughout the lake. Greatest catches have been with gillnets in the Van Hook Arm and Beaver Bay (G. Power, North Dakota Game and Fish, letter to S. Dyke, June 4, 1990). Samples taken each year averaged from 20 in the early to mid-1970s to 5-7 from the late 1970s to the present. Too few paddlefish have been caught, and factors affecting catch rates too poorly understood, for firm conclusions on abundance to be drawn.

Fisheries

The Yellowstone-Sakakawea stock is harvested by snagging at several locations. Historically most fish have been taken at Intake, a low-head diversion dam 17 miles northeast (downriver) of Glendive, MT. Fish are also snagged at a several sites in Montana downstream from Intake (e.g., "The fenceline", near Cottonwood Creek, and near Sidney). Paddlefish are also taken with bow and arrow, and snagged, from Montana below Fort Peck Dam and at scattered locations down the Missouri to the confluence with the Yellowstone. In North Dakota, paddlefish are snagged mainly at the Confluence area, with fewer fish caught in the Fairview bridge area and at the Pumphouse area, near Williston.

From creel censuses at Intake in 17 of 19 years from 1972 to 1990, Stewart (1991) reported that average catch was 3,000 fish per year, with a range from 550 fish in 1985 to more than 5,000 fish in 1981. Fishing pressure over this period has ranged from 1,745 angler days in 1985 to 6,130 angler days in 1978. In most years, fishing pressure has been 2,000-4,000 angler days. Average catch rates over the length of the season at Intake have ranged from 0.34 to 1.91 fish per angler day from 1972 to 1990. In most years, catch rates have been between 0.75 and 1.25 fish per angler day. The catch at Intake is dependent on paddlefish concentrating below the diversion dam. Concentrations of fish occur with increasing river flows in May and June. According to Stewart (1991b, p. 3), "The catch is greater in years when mountain snowpack is large and the Yellowstone River discharge remains high for an extended period". In some years of high discharge, paddlefish are also harvested upstream of Intake, as far as the Cartersville Diversion Dam at Forsyth. Considerable annual variation in catches at these upstream sites may occur. In 1991, for example, which was a high water year, many paddlefish ascended past Intake, and perhaps several hundred were caught just below the railroad bridge at Glendive, at a site not known to hold paddlefish in years with lower river flows. Essentially no paddlefish were caught above Intake in 1992 and 1994, which were years of low discharge.

Stewart (1992) summarized the most up-to-date information on catch rates, exploitation, and stock status for the fishery in the Yellowstone River. Of the 5,990 paddlefish jaw-tagged at Intake and points downstream since 1964, at least 1,389 (22.5%) have been harvested by anglers. In 1991, 49 tags were returned, 14 from fish tagged in 1984, 7 from 1986, 11 from 1988, and 4 from 1990. The remaining fish had been tagged in other years, one fish as long ago as 1965. The years of most recoveries were mainly a result of more fish being tagged during those years (1984, 1986, 1988, and 1990). For those four groups, average annual exploitation rates ranged from 3.3 to 8.4%. Stewart (1992) noted that these figures are minimal. Because of the compounding effects of natural mortality, tag loss and lack of reporting of tagged fish, true exploitation rates could be higher, perhaps 10%. Stewart (1992) concluded that these rates were probably not excessive. Also, the high percentage of small males in 1991 suggested to him that significant recruitment was occurring.

In the early 1960s, a bow and arrow fishery developed for paddlefish in the Dredge Cuts below Fort Peck Dam. Paddlefish are also taken by snaggers at various points below Fort Peck Dam (Needham 1985). According to Stewart (1991b, p. 1), "In the 1970s and 1980s, there was an apparent increase in angler interest and paddlefish harvest in the Missouri river at points downstream of Fort Peck Dam. The actual harvest... has never been measured, but is thought to be significantly less than the Yellowstone River harvest." Annual harvest rates before 1974 were estimated to be only 1%. In subsequent years, the estimated average annual harvest rate for 817 fish tagged from 1974 to 1986 varied from 0 to 2.7%. According to Needham (1986), "The largest groups of paddlefish tagged in a single season are 189 in 1974, 162 in 1978, and 151 in 1979, and after 13, 9 and 8 years of fishing they have exhibited an average annual rate of harvest of 1.4, 1.9, and 1.7% respectively." As of 1987, highest overall harvest rates were 28% for 40 fish tagged in 1977, 21% for 48 fish tagged in 1976, and 19% for 189 fish tagged in 1974.

Harvest rates for fish tagged below the Milk River confluence are especially low: of 150 fish tagged there from 1979 to 1982, only 6 were returned after an exposure to the fishery of 5-8 years, for annual exploitation rates of 0.0 to 1.0%. Needham (1986) concluded that these exploitation rates were low enough to avoid overharvest. All harvest rates above assume no tag loss, full compliance in returning tags, and ignore the compounding effects of natural mortality. The actual rates may be higher.

Needham and Gilge (1986) also summarized tagging results by area of recovery. As of 1987, of 111 recaptured paddlefish originally tagged in the Dredge Cuts from 1974 to 1984, 53% of the recoveries have been in the Dredge Cuts and 47% from the Yellowstone River, mainly at Intake. Over the period 1982 to 1986, 81% (35 of 43) of the recoveries were taken at Intake. This increase from previous years coincided with a change in harvest regulations at Intake (in 1981) requiring retention of snagged paddlefish.

North Dakota sanctioned its first snag fishery in 1976, and from 1976 through 1980, the season ran from early May into the fall. Since 1981, paddlefish snagging has taken place each May and early June on fish migrating upriver into the Missouri and Yellowstone to spawn (Tenney and Power 1992). This fishery, pursued mainly at the Confluence of the Missouri and Yellowstone Rivers, catches fish before they have ascended upriver and thus occurs 1 to 3 weeks before the Intake fishery. Only since 1988 have creel or telephone surveys been conducted (Table 1). Effort in 1992 increased to 4.2 times that of 1988 and to 1.9 times that of 1991 (Owen and Hendrickson 1992). In 1992, more than 80% were harvested at the Confluence, 17% at Fairview, and 1% at the Pumphouse. The 1993 harvest was estimated to total 2,039 fish, with most of these again harvested in the Confluence area. This harvest represents a 30.8% increase over the 1992 harvest. In 1994, the harvest was estimated to be 1,360 (decrease of 33% from 1993) fish with the majority again taken in the Confluence area. Licensed angler numbers increased to 4,600 in 1993, while estimated snagger days increased to 14,316. In 1994, there were 5,718 tags issued to 3,489 licensed anglers. This is a 38% decrease in tags issued and a 24% decrease in anglers compared to the 1993 totals (Fred Ryckman, personal communiciation).

Biological data were collected from 857 paddlefish caught by North Dakota snaggers in 1994. Sex ratios remained near 50:50 with 70% of all female paddlefish harvested during the first 3 weeks of the 7 week season.

Snagging Season Regulations

Montana

The Montana Department of Fish, Wildlife and Parks first began regulating paddlefish snagging in 1963, a year after significant numbers of paddlefish were first caught at Intake. The daily limit was 2 fish per day, with 4 in possession. The area from which paddlefish could be snagged was the Missouri River below Moroney Dam and the Yellowstone River downstream of Custer.

Regulation changes through the remainder of the 1960s and the 1970s were mostly minor. In 1965, the Montana legislature changed the status of paddlefish to that of a game fish (Robinson 1966). Beginning in 1975, boat fishing was prohibited for the area from the Intake dam 1/4 mile downstream during May, June and July. This prohibition was designed to reduce conflicts between boat-based snaggers and walleye/sauger anglers and those snagging from the bank. In 1978, the daily limit was reduced to one fish and a possession limit of two.

TABLE 1.

NORTH DAKOTA PADDLEFISH HARVEST INFORMATION						
YEAR	SNAGGING HOURS	SNAGGING DAYS	PADDLEFISH HARVESTED PER HOUR	PADDLEFISH HARVESTED PER SNAGGER PER YEAR	NUMBER HARVESTED	TAGS ISSUED
1988[a]	3,761		0.17		635	Not Needed
1990[b]	8,083		0.09		762	Not Needed
1991[b,c]	15,636		0.09		1,460	Not Needed
1992[c,d]		9,272		0.53	1,559	7,748
1993[c,d]		14,316		0.57	2,037	9,200
1994[c,d]		14,010		0.43	1,360	5,718

[a] - Not an intensive survey. Represents catch only between 6:00 a.m. and 8:00 p.m.

[b] - Estimates made between 6:00 a.m. and 10:00 p.m.

[c] - Presumably a new widespread occurrence of boats to gain access to other river sites. Apparently, boats were not commonly used prior to 1991.

[d] - Methodology changed from creel to phone survey.

A major change in paddlefish regulations for the Yellowstone River came in 1981 with the institution of a two fish per season limit and prohibition of catch and release. The two fish per year limit and the prohibition of catch and release were aimed at eliminating or reducing an overcrowding problem in the most popular fishing area, immediately downstream of the Intake Diversion Dam. No longer could an individual paddlefish snagger occupy prime snagging spots day after day. These spots became available for other anglers.

Montana has continued to adjust the snagging regulations as needed to meet both social and biological issues. Before 1982, there was no closed season, but in 1982 the Yellowstone season was set from May 1 through the second Sunday in July. This season corresponded with the seasonal availability of paddlefish, and did not significantly impede the fishery. 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 Cottonwood Creek. Cottonwood Creek is about 5 miles downstream of Intake. The later opening date upstream accommodated sauger and walleye anglers in boats near the diversion dam. In most years, paddlefish are not plentiful in the Intake area before May 15 or after June 30, which, since 1990 has been the duration of the season at Intake. In the area downstream of Intake, from Cottonwood Creek to North Dakota, the season opens May 1. The Missouri River has remained open year-round.

Bag limits for the Missouri River below Fort Peck were not the same as for the Yellowstone until 1992, when a tagging system and a limit of two fish per person per year were instituted consistent with regulations on the Yellowstone. In previous years, there had been a daily limit of 1 fish, a possession limit of two, and no annual limit for individual anglers or bowfishers.

In 1994, the seasonal limit on the Yellowstone and the Missouri Rivers downstream of Fort Peck was reduced to one fish per person per year. This change responds to data indicating a need to reduce the paddlefish harvest.

<u>North Dakota</u>

In 1992, North Dakota also instituted a tagging system for this stock, with a limit of two fish per person per year. Bag limits had previously been one paddlefish per day and one in possession, with no annual limit. Since North Dakota's first paddlefish season in 1976, high-grading has been prohibited. A summary of North Dakota regulations is included in Table 2.

TABLE 2.

NORTH DAKOTA
SUMMARY OF PADDLEFISH
SNAGGING SEASON REGULATIONS

YEAR	ONE HOOK ONLY	SEASON DATES	ILLEGAL FROM BOAT	LIMIT DAILY-POSSESSION	ILLEGAL TO RELEASE	ILLEGAL TO SELL EGGS	ILLEGAL TO FISH IF WITH LIMIT
'76*	---	5/1-11/14	No	2 - 2	Yes	---	---
'77*	---	5/7-11/13	No	2 - 2	Yes	---	---
'78*	Yes	5/6-9/9	Yes	2 - 2	Yes	---	---
'79*	Yes	5/5-9/14	Yes	2 - 2	Yes	---	---
'80*	Yes	5/3-11/16	Yes	2 - 2	Yes	---	---
'81	No	5/2-7/12	No	1 - 2	Yes	Yes	---
'82	No	5/1-7/11	No	1 - 2	Yes	Yes	---
'83	Yes	4/30-7/1	Yes	1 - 2	Yes	Yes	---
'84	Yes	5/5-7/1	Yes	1 - 2	Yes	Yes	---
'85	Yes	5/4-7/1	Yes	1 - 1	Yes	Yes	---
'86	Yes	5/3-7/1	Yes	1 - 1	Yes	Yes	---
'87	Yes	5/2-7/1	Yes	1 - 1	Yes	Yes	---
'88	Yes	5/7-7/1	Yes	1 - 1	Yes	Yes	Yes
'89	Yes	5/6-7/1	Yes	1 - 1	Yes	Yes	Yes
'90	Yes	5/5-7/1	Yes	1 - 1	Yes	Yes	Yes
'91	Yes	5/4-7/1	Yes	1 - 1	Yes	Yes	Yes
'92	Yes	5/2-6/30	Yes	Season limit 2 - tags required	Yes	Yes	illegal to fish without tags
'93	Yes	5/1-6/30	Yes	Season limit 2 - tags required	Yes	Yes**	illegal to fish without tags
'94	Yes	5/1-6/15	Yes	Season limit 2 - tags required @ $3.00/tag	Yes	Yes**	illegal to fish without tags

* "Experimental" seasons
** One permitted commercial (caviar) operation was allowed.
footnote: Legal area has always been the same, "In that area of the Missouri River lying west of the US Highway 85 Bridge and that portion of the Yellowstone River in North Dakota".

Upper Fort Peck Stock

Life History and Ecology

This stock was surveyed by tagging and creel census intermittently, starting in 1973, by Needham (1974) and was studied intensively for three years (1977-79) by Berg (1981) through a creel census and population sampling with electro-fishing. Fish from this stock migrate upriver from Fort Peck reservoir in March, April, and May to spawn in May, June and early July. Time and extent of upstream migration are evidently strongly influenced by river discharge. Berg (1981) noted that significant movements of paddlefish to the spawning sites did not occur until discharge at the Virgelle gauging station, east of Fort Benton, exceeded 14,000 cubic feet per second. In two years with typical river discharges (1978 and 1979), fish migrated as far upriver as the Three Islands area, 240 km above Fort Peck reservoir. In 1977, when discharges were much lower (a maximum of about 7800 cubic feet per second), and no real flood peak developed, fish migrated only as far upriver as the Slippery Ann-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-Robinson Bridge Area) and 9 probable spawning sites (Upper and Lower Two Calf Islands, Cow Island-Powerplant Ferry, Bullwhacker Creek, Dauphine Rapids, Holmes rapids, Deadman Rapids, Little Sandy Creek, Virgelle Ferry-Boggs Island, and Three Islands). Highest concentrations of fish found from electrofishing surveys in 1977, 1978, and 1979 were in three areas: the Slippery Ann-Robinson bridge area, the Upper and Lower Two Calf Islands area, and the Cow Island-Powerplant Ferry area. An egg (positively identified) and two larvae were found. Splashing by adult paddlefish over sites with spawning gravel provided strong circumstantial evidence of paddlefish spawning in some or all of the above 9 locations.

Berg (1981) and Gilge (1994) summarized average weights and lengths of paddlefish caught above Fort Peck Reservoir for the years 1965, 1966, 1970-71, 1973-75, 1977-78, 1986, and 1991-93. Mean weight of females ranged from 33.7 to 39.9 kg (sample sizes 7 to 96) for all years up to and including 1986. In the most recent years, 1991-93, sample sizes of female paddlefish were larger (n= 124-168), however mean weights were lower, and ranged from 27.1 to 33.2 kg. Mean weight of males ranged from 14.6 to 20.0 kg (the latter figure in both 1970 and 1971), but inasmuch as only a total of three male fish were weighed in these two years, those data are misleading. Without those two years, mean weights for males also varied little among years (14.6 to 17.8 kg). Although there was some overlap in weights between the sexes, males were generally much smaller than females. As in the Yellowstone-Sakakawea stock, males evidently grew in weight more slowly, and matured earlier than females.

Fisheries

Needham (1979) provided a map with popular snagging locations from the head of Fort Peck Reservoir to Robinson Bridge. The dispersed nature of the snagging and relatively few catches makes a creel census more costly and less efficient than at more concentrated fishing sites such as Intake. As a result, data are less complete for this stock. The harvest consists of nearly all mature, spawning fish. The fishery begins earlier than that at Intake; March or April into June, depending on weather and river discharge conditions. Detailed creel censuses were conducted for this stock from 1973 to 1975, 1977, 1986, and 1991-1994 in a 37 km stretch of the river immediately above the reservoir. This section includes the Slippery Ann-Robinson Bridge area, a popular snagging area. Paddlefish harvest during these years ranged from 254 in 1992 to 666 in 1977. Inasmuch as some fish were released, total catches exceeded harvest. In 1977, for example, 900 fish were caught, and 234 released. Berg (1981) provided a detailed summary of the 1977 creel census. Likewise in 1993, Gilge (1994) reported a 40-50% release rate. Unlike Intake, where female paddlefish have constituted a majority of harvested fish every year from 1974 to 1991, (Stewart 1991), the sex ratio of fish caught above Fort Peck has generally favored males. In the years 1976, 1979, 1986, and 1993, males constituted 52, 63, 65 and 59 percent of fish censused.

In 1993, 422 fish were caught by anglers expending 2,253 angler-days, split between snagging from boats (44% of total effort) and from shore (56% of total effort). Overall catch rate was 0.19 fish per angler day. Creel data from 1987 indicated that 88% of the anglers were Montana residents, and 91% were residents in 1993.

Results of tagging studies indicated an annual harvest rate over the period 1973-1993 of only 1.5 to 4.5%, which Needham (1986) concluded was sustainable.

Snagging Season Regulations

Regulations for this stock have been the same as those for the area below Fort Peck Reservoir. Nowhere on the Missouri River are snaggers required to keep paddlefish that they snag. Needham (1980b) did not recommend the same restrictive regulations as were enacted on the Yellowstone in 1981 because creel censuses and tagging results indicated low fishing pressure and low harvest rates. As of 1994, the bag limit is two fish per person per year, without the high-grading prohibition.

HABITAT REQUIREMENTS AND PROTECTION

A primary habitat requirement for successful paddlefish reproduction is the maintenance of adequate river flows during the spawning season. Paddlefish migrating into the Yellowstone and Missouri Rivers from the downstream reservoirs require gravel substrates and increased streamflows in late spring and early summer for successful spawning (Russell 1986). Since the mid-1970s, two applications for water reservations by the Montana Department of Fish, Wildlife, and Parks (MDFW&P) were made to the Montana Board of Natural Resources and Conservation (MBNR&C) 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 and, in response to this request, flows were granted by the MBNR&C (Table 3).

The requested June 8-30 flow was based on investigations of Peterman (1979), in which it was determined that 45,000 cfs was required for paddlefish to move upstream of the Intake diversion dam, where large amounts of suitable spawning gravel are available.

A second application, this one for water reservations for paddlefish in the Missouri River, was made by MDFW&P to the MBNR&C in 1991. A Missouri river flow of 15,302 cfs was requested for the period May 19 - July 5 for the reach from Fort Peck Reservoir to the Judith River. Gardner and Berg (1982) found this flow was needed for paddlefish migration to spawning areas upstream of Fort Peck Reservoir. In 1992, in response to this application, the MBNR&C granted a flow of only 4,652 cfs.

The instream flows granted thus provide only partial protection for paddlefish spawning on the Yellowstone River and very little protection on the Missouri river. Furthermore, even the granted flows are not fully guaranteed, but are subject to senior (earlier) water rights. In addition, natural hydrologic conditions may cause river flows to reach levels less than the granted reservation. The main value of the instream reservations 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.

Table 3. Requested and granted flows for the Yellowstone River at Sidney, MT.

Requested [2]		Granted[3]	
Time period	cfs[1]	Time period	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[4]	45,000		
July 1 -20	20,000	July	10,526

[1] cfs = cubic feet per second
[2] Montana Fish and Game Commission, 1976
[3] Montana Board of Natural Resources and Conservation, 1978
[4] Time period to include 1 day of bankfull flow at 52,000 cfs.

Two state laws give MDFW&P considerable authority to modify or deny river projects that could negatively affect paddlefish habitat. The Stream Protection Act covers projects by state agencies and county or municipal governments. The Natural Streambed and Land Preservation Act covers projects proposed by private parties.

Both the Yellowstone and Missouri Rivers presently have relatively good water quality. 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.

Paddlefish in Montana are evidently affected very little by pesticides and other toxic substances. Paddlefish roe from 10 females weighing 43 to 70 pounds, collected at Intake in June 1990, has been tested for concentrations of 20 different chlorinated hydrocarbon pesticides and their metabolites and two polychlorinated biphenyl 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. North Dakota paddlefish were collected from the Confluence area for mercury analysis in 1993. Nine fish were collected. Muscle tissue concentration of mercury was less than 0.14 mg/g in all nine fish. These values were well below levels of concern.

THE MANAGEMENT PLAN

This paddlefish management plan is a proposed course of intervention in and direction for the paddlefish fisheries, and embodies an articulated philosophy, goals, and objectives. The management plan also describes how goals and objectives will be achieved through the sampling plans and stock assessments.

Philosophy

Several premises underlie the development and direction of this plan. First, the paddlefish is recognized to be an important species historically, recreationally, commercially, and aesthetically in the Mississippi and Missouri River drainages. 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. Those people familiar with paddlefish recognize them to be an important part of the natural heritage of the region. Paddlefish demonstrate some unique anatomical features (e.g. the rostrum and gill rakers) and behavioral traits (e.g. migrations, foraging method), as well as other distinctive adaptations to their large river habitats. Well managed, they can also provide considerable recreational benefits (Unkenholz 1986). The species is also a good indicator of habitat quality in large river systems.

Second, the two paddlefish stocks reviewed here constitute some of the last, self-sustaining wild stocks which may provide a sizeable annual harvest. Inasmuch as paddlefish stocks have declined in many locations throughout their range, and reproduction of paddlefish is poor in most locations, maintenance of the health of these stocks may be critical to the long-term survival of the species.

Third, primary emphasis should be on maintaining natural habitat conditions and numbers of fish adequate to sustain natural reproduction and growth, rather than emphasizing hatchery programs as is done, for example, in Missouri (Graham 1992). Because inadequate spawning success is a serious problem for paddlefish populations throughout their range, it is critical to long-term paddlefish survival that adequate quantity and quality of flows, as well as other aspects of habitat quality, are maintained in the free-flowing, relatively unmodified Yellowstone River and in the Missouri River. River flows of adequate quality and quantity, of natural timing and duration, and without major contaminants are the best insurance for paddlefish perpetuation.

Prioritizing the need to maintain habitat conditions and natural reproduction is critical. Stocking of hatchery-reared paddlefish is not precluded, however, if done in a well designed manner. It must be stressed that stocking will be done in a scientific manner to complement, not replace, natural reproduction and recruitment. Experimental stocking is proposed to provide valuable information on survival rates and age validation and to determine its potential for augmenting future year classes of fish (see Objective 7 discussion).

Fourth, it is assumed that a sustainable recreational harvest of the species is desirable, consistent with the productive capacity of the two stocks.

Fifth, the uniqueness, high value, and irreplacability of the paddlefish resource calls for controlling and stabilizing the harvest until the ecology, stock-recruitment relations, and hence productive capacity of the stocks are better understood. Paddlefish are a long-lived, late-maturing species with a low frequency of reproduction and a low natural mortality rate after their first few years (Scarnecchia et al. 1989). High annual harvest rates cannot be justified on the basis of catching them before they die because their low natural mortality rate means that fish not caught in a given year may be caught in subsequent years. Also, too many gaps exist in our understanding of the fish to allow higher harvest rates. The group spawning of paddlefish in their turbid spawning habitats, occasionally observed (Purkett 1961) but not well understood, may, for example, 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, depending on the nature of the predation. Paddlefish ecology in the rapidly-changing Lake Sakakawea and Fort Peck reservoirs, as well as in the Yellowstone and Missouri Rivers, is still poorly understood. The effects of reservoir aging and recent supplemental walleye stockings on paddlefish are not known. These points underscore our lack of basic information relative to the stock-recruitment relation for paddlefish, and support the need for action to prevent any increase in harvest at this time.

This management plan for the Yellowstone-Sakakawea stock and the Upper Fort Peck stock provides uniformity of provisions and actions where possible and if needed, but remains sensitive to stock-specific fisheries constraints and conditions. Most parts of the plan will apply to both stocks.

Goals

The goals of the management plan are to:

G1. Provide for an orderly and sustainable recreational harvest of paddlefish consistent with the productive capacity of the stock. This goal should include, to the extent possible, similar regulations between the two states.

G2. Provide a basis for cooperative, coordinated management and allocation of Yellowstone-Sakakawea paddlefish between Montana and North Dakota in cooperation with the appropriate Indian Tribes and in consultation with appropriate federal agencies.

G3. Facilitate the collection of data from the harvest useful for stock assessment and yield forecasting.

G4. Conduct research necessary for successful long-term management.

G5. Maintain and enhance existing paddlefish habitat and obtain additional information to better define and provide for paddlefish habitat requirements.

G6. Integrate and define the role of paddlefish stocking in the successful long-term management.

G7. Increase public awareness of the paddlefish and its habitat requirements.

G8. Incorporate public acceptance and compliance with the regulatory framework established for long-term management.

Objectives

The objectives of the plan are to be implemented immediately and accomplished over the 10-year period from 1995 to 2004. The sampling plan should be in place by 1994 and the initial stock assessment by 1995.

OBJ 1. Develop an age-structured paddlefish harvest model that will consider reproductive success and recruitment to the fishery in estimating stock status and sustainable harvests.

OBJ 2. Develop a method of forecasting paddlefish stock abundance three or more years before a fishing season.

OBJ 3. Significantly increase our knowledge of paddlefish population sizes and harvest rates in all harvest areas.

OBJ 4. Significantly increase our knowledge of paddlefish ecology and habitat requirements throughout their life cycle.

OBJ 5. Use, change or attempt to change existing federal and state laws and rules to maintain or enhance river flows, water quality, physical habitat, and reservoir levels for all life stages of paddlefish.

OBJ 6. Design and implement a data collection system using the existing paddlefish fisheries and tagging systems in Montana and North Dakota.

OBJ 7. Design and implement an experimental paddlefish stocking plan for Lake Sakakawea.

OBJ 8. Establish and provide a rationale and basis for an aggregate quota on paddlefish harvest for the Yellowstone-Sakakawea stock.

OBJ 9. Annually prepare a joint North Dakota/Montana report on the overall status and information on the paddlefish populations.

OBJ 10. Expand our public information activities on paddlefish through an organized information program and assessments of attitudes, values, and preferences.

SAMPLING PLAN AND ANALYSIS PROCEDURES BY OBJECTIVE

OBJ 1 and OBJ 2 - Age Structure Model and Yield Forecasts

To insure a sustainable and acceptable harvest of paddlefish, we need to be able to forecast the stock strength, preferably well before the fishing season. We propose to develop a year-class strength model similar to, but more complex than, those developed for Pacific and Atlantic salmon. In those models, potential yields or abundances of fish of older ages were forecasted one or more years before the fishing season by estimating the abundances of fish of the same year class that returned upriver to spawn or were harvested in earlier years. This forecasting method 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 *(Oncorhynchus 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. (1989) used the method to forecast yields of Atlantic salmon for Icelandic rivers. The method has worked for salmon because most annual variations in mortality evidently occur early in life before the salmon go to sea. Once they reach a weight of perhaps 1 kg, year class strength is generally established before the youngest age fish is harvested or sampled for use in a forecast.

The approach for paddlefish would be to sample them at three life stages and develop indices of abundance for each: 1) as advanced young-of-the-year juveniles in Lake Sakakawea after larval and early juvenile mortality have acted, 2) as yearlings and 3) as migrating, spawning fish contributing to fisheries in the Missouri and Yellowstone Rivers.

The Young-of-the-Year Index (YYI)

This index involves the development of quantitative sampling methods for providing an early assessment of the year-class strength of age 0 fish late in their first summer and fall. Considerable gear development may be necessary before a consistent and reliable quantitative method is found. Methods will include, but not be limited to, trawling, visual counts along transects, and dip-netting. Based on results from 1992 (Fredericks 1994), two methods that will be useful for quantifying young paddlefish are visual surface counts along transects and standard trawls along transects. Both methods yield paddlefish in sufficient numbers that indices of relative abundance can be developed.

A preferred approach is to sample for such an index at the oldest age possible. Sampling late in the first summer and fall, after initial larval and fry mortality has acted, but before fish become unavailable to sampling with current techniques, may provide the best opportunity to sample a year class for several years. The YYI would be a function of the catch per unit effort (CPUE) of the young paddlefish, and would be adjusted, if necessary, in relation to environmental factors such as water levels, turbidities, and other factors. It is therefore necessary to investigate the ecology of these young-of-the-year fishes in the reservoir so that factors influencing the YYI are identified. Factors include turbidity in the reservoir by area, zooplankton abundance and distribution and the overall extent of area utilized by age 0 paddlefish in the reservoir. This work is in progress.

The age (in years) of the fish should be obvious from their size, so the only aging necessary may be for daily growth rings and seasonal growth patterns. The use of daily growth rings is currently being investigated. Growth rates may significantly influence ultimate year class strength if predation on young paddlefish is highly size-dependent. Young paddlefish in the reservoir are poor swimmers (they can be easily caught in dipnets), translucent, and, instead of schooling tightly, appear to exist in loose aggregations. These observations and the occurrence of young paddlefish in walleye and sauger stomachs in the reservoir suggest that paddlefish are highly vulnerable to predation as young fish. Attainment of large size may afford protection, and thus growth rates may influence year class strength. All fish captured should be tagged with coded-wire tags before being released.

The Yearling Index (YI)

Preliminary sampling results from 1992 and 1993 (Fredericks 1994) indicate that visual counting of yearlings is also a possibility. Yearling paddlefish have been counted along established transects, and several have been trawled along transects. The apparently large numbers of yearlings in 1992 may be the result of highly successful reproduction of the 1991 year class associated with high flows in the Yellowstone River. In any case, it appears that a yearling index is also obtainable with only slightly more effort than it will take to develop the Young-of-the-Year Index. Ecological factors influencing these fish will also be investigated, inasmuch as it appears from sampling in 1992 and 1993 that the distributions of young-of-the-year and yearlings overlap but do not necessarily coincide. All yearling fish collected will be tagged with coded-wire tags and released. These yearling fish would soon after, and for several years thereafter, become much less vulnerable to sampling. Any possibilities for documenting ecology of these fish after their second year, but prior to sexual maturity, should be investigated. This segment of the paddlefish life history is presently unknown.

The Spawning Adult Index (SAI)

The next good sampling opportunity would be several years later in snag fisheries as paddlefish migrate up the Yellowstone and Missouri rivers to spawn. Fortunately, paddlefish have life history traits that make the age structure model especially applicable. Because paddlefish males mature at a younger age than females (Russell 1986), and evidently spawn more frequently, they are harbingers of the future runs of females, which will follow 6 to 10 years later. Females are critical to paddlefish spawning success, and females of a given year class will first arrive at the Confluence, below Fort Peck, or at Intake several years after the males of the same cohort. Sampling at each of these sites will provide an index of abundance of paddlefish by age.

Use of the age structure model requires a comprehensive aging program, however, because unlike salmon, preliminary analysis indicates that large paddlefish cannot be aged with the required accuracy by weight or length. What is particularly needed is an index of abundance of the younger recruits by sex and age. The first step will be to conduct a comprehensive assembly and re-analysis of historical paddlefish data on catch and effort by sex, size, and, where available, age. Most of the historical data is from Intake, which may not be representative of the entire paddlefish stock, so results will need to be interpreted cautiously.

Next, the fisheries at Intake, the Confluence, and elsewhere will be sampled in 1995 and subsequently for catch, effort, size, age, and sex of paddlefish so that the age structure of the population can be characterized. We will seek to obtain indices of abundance (from CPUE) and to develop accurate methods of age determination. The estimates of catch and effort will be obtained from a creel census at Intake, the Confluence, and at other sites, in person, by mail, or by phone if necessary. These estimates will need to be accurately corrected for factors affecting fishing effectiveness, especially Yellowstone and Missouri river flows, so research will be conducted on how these flows affect catch of paddlefish, by age and size if feasible. This work is in progress. The Spawning Adult Index will be a function of the age-specific catch of young but mature paddlefish at various sites, the fishing effort, and the flow, season length, and other factors known to affect the catch.

If it proves unreliable to age paddlefish by weight (as it currently appears), accurate aging of paddlefish will be needed, and this aging will involve potentially a large fraction of paddlefish harvested from every fishery if there are many age classes (Russell 1986). More optimistically, it may also be sufficient to establish, e.g., 3-year "groups" of fish rather than knowing the exact age of individual fish. If so, the grouping will make it easier to age the fish by weight alone. If weight-based aging becomes possible, at least for the younger fish, it will be possible to curtail sampling for dentaries in future years. Recoveries of coded-wire tagged fish would also permit the validation of the dentaries for age determination, which has not been done for paddlefish. Age validation is an important aspect of this program. For this reason, young paddlefish sampled on Sakakawea as part of the YYI and YI Indices will be microtagged, as will any fish released from hatcheries. All sampling of catches will be closely coordinated between North Dakota and Montana to insure uniformity and compatibility of data collection.

The Paddlefish Stock Index (PSI)

The Paddlefish Stock Index (PSI) will be a function of three variables: the Young-of-the-Year Index (YYI), the Yearling Index (YI), and the Spawning Adult Index (SAI). The exact form of this function is not known at this time, but it will be developed with statistical validity and parsimony in mind. Confidence intervals around any estimates will be developed. It may also prove feasible to describe the PSI in probabilistic terms, e.g., an 85% probability of a harvestable stock size between N1 and N2.

Development of the Paddlefish Stock Index (PSI) may require 5 or more years. In an attempt to expedite its development, existing data from sampling in 1981-1990 will be analyzed. Unfortunately, few samples of dentaries for aging paddlefish are available in most of these years, so development of the age structure model will be difficult. It may be possible, however, to use a size structure model of the same type until more data comes from the fisheries.

In addition to the development of the Paddlefish Stock Index, some more obvious signs of possible overharvest (such as sex-specific size changes and sex ratios) will also be monitored.

OBJ 3 Population Sizes and Harvest Rates

The tagging program for adult migratory paddlefish (using individually-numbered poultry bands around the dentaries) will be expanded during the next 10 fishing seasons. Over the past 25 years, paddlefish to be tagged have been obtained using gillnets (at several sites), and with "experimental" snagging (at Intake). Sampling in the Montana portion of the Yellowstone with gillnets resulted in the tagging of more than 200 paddlefish in 1992 and 275 fish in 1993. In addition, North Dakota tagged a total of approximately 500 fish downstream of the Confluence in late April 1993 and 1994. An additional 600 paddlefish were tagged in this same area in late September - early October 1993 and 1994. Montana has set a target of 300 tagged fish per year. For the immediate future, the North Dakota target is to tag 400 paddlefish in the spring and another 400 in the fall in the Missouri and Yellowstone Rivers upstream of Lake Sakakawea. Tagging larger fish in Lake Sakakawea is also a possibility, perhaps with netting. Recoveries of tagged fish provide important information on harvest rates, population size, movements, and reproductive periodicity. It is recommended that estimates of fishing (gillnetting) effort be made while sampling the fish for tagging. Such estimates will provide checks against CPUE estimates at recreational fishing sites. Population estimates and harvest rates will be used in conjunction with the Paddlefish Stock Index as the key numbers influencing harvest management. Historic tag returns will be investigated by year and by age and sex of fish, as will all subsequent recoveries. This work is in progress.

Microtagging of all hatchery-reared young-of-the-year fish and all wild young-of-the-year fish caught will in time result in a significant number of tagged fish. By having tag detectors at main fishing sites, a significant percentage of tagged fish can eventually be recovered, which will provide estimates of survival rates as well as relative survival of hatchery-reared and wild fish. Intensive efforts will be needed to microtag wild age 0+ and yearling fish, but these efforts will be incorporated into research and monitoring activities on Lake Sakakawea.

OBJ 4 Ecology and Habitat Use

Reservoirs-- As part of the development of the Young-of-the-Year Index (YYI) and Yearling Index (YI), considerable insight will be gained on the ecology, habitat use, and habitat requirements of young paddlefish in Lake Sakakawea. It will also be possible to relate the relative abundance of older paddlefish in the reservoir to habitat factors. Information on paddlefish distribution and abundance will be related to such factors as turbidity, zooplankton abundance, distribution and significance of predators, habitat variability, and reservoir aging. Similar work in Fort Peck should be undertaken once effective sampling methods are developed on Lake Sakakawea.

Inasmuch as young paddlefish appear to be highly vulnerable to predation, the effects of an expanding stocking program for walleye and northern pike needs to be considered with reference to paddlefish. More investigation is needed on the role of predation on year-class strength of paddlefish. Also, gull and other avian predation on age 0+ paddlefish has been documented and this impact should be further explored.

Rivers-- The relation of river flows to spawning success and subsequent year class strength is poorly understood. It is important to identify and characterize spawning areas, and to determine if such areas are consistently used for spawning or if spawning sites change yearly. Habitat requirements for larval paddlefish are also poorly understood. The instream flow reservations requested for the Missouri and Yellowstone Rivers (See Habitat Requirements and Protection Section) provide some protection for spawning, and probably for needs of age 0+ paddlefish. Spawning success at lower river flows is unknown, but should be assessed. Also poorly understood are the relative contributions to paddlefish year class strength from fish spawning in the Milk River and Yellowstone River upstream of Intake in years when paddlefish are able to reach these areas. Spawning areas upstream of Fort Peck reservoir are relatively well-defined (Berg 1981), but few specific spawning sites have been identified on the Yellowstone River. Efforts will be made to identify potential spawning sites based on substrate and larval fish presence.

Additional sampling of spawners on the Yellowstone and Milk rivers as well as sampling for larval fish at key locations are needed to improve understanding of paddlefish spawning. Development of YYI and YI indices for reservoirs will also help indicate the success of spawning at various river flows.

Paddlefish tend to spawn when rivers are high and turbid. The importance of turbidity is unknown, but it may facilitate spawning or decrease predation on larval paddlefish drifting in the rivers before reaching the reservoirs. It may also shield paddlefish from predators in the reservoir. If so, turbidity may be an important component of paddlefish habitat for spawning and early life history. Important sources of sediment (such as tributaries and geological formations) need to be identified and their relative contributions quantified. Maintenance of adequate flows in sediment-laden tributaries (e. g., the Powder River) also would then become important for maintenance of paddlefish spawning and early rearing habitat.

Paddlefish require a minimum temperature of 55-60 F° for spawning (Russell 1986), but actual spawning temperatures in the Yellowstone and Missouri Rivers are not well understood. Continuous recording thermographs should be placed at key river locations during the migration and spawning periods. A thermograph should also be placed in the upper end of Lake Sakakawea during the summer and fall period.

OBJ 5 Habitat Protection

Habitat protection, a cornerstone of this plan, will involve consultation and coordination with the U. S. Army Corps of Engineers, 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 utilization information should be used to defend all aspects of paddlefish habitat.

Of highest priority should be the protection of paddlefish from any immediate threats to habitat degradation. Oil production facilities adjacent to, or underlying the Missouri and Yellowstone Rivers and upper Lake Sakakawea must be closely monitored. Contingency plans in case of spills should be developed.

Spawning flows are partially protected by law, but any new water uses, especially new dams, that could decrease Yellowstone and Missouri River flows during the migration-spawning period should be opposed. Maintenance of both high flows and 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 migration of spawners.

OBJ 6 Data Collection System

Development of a stock assessment method will require intensive sampling of paddlefish for several years until methodologies are refined and population age structure is characterized. Fortunately, most paddlefish in the Yellowstone-Sakakawea stock are taken at a few locations, and intensive sampling for CPUE and age information at those sites will be possible at relatively low cost. These sites will be sampled heavily. In areas such as on the Missouri River (above and below Fort Peck Dam to the North Dakota border) where fishing effort is more dispersed, other methods for obtaining fish information will be devised. It is proposed that statewide paddlefish harvest surveys be developed through mail and/or telephone. Such surveys would provide critically important information on catch and effort, as well as information on attitudes, values and preferences (Objective 8).

OBJ 7 Paddlefish Stocking Plan

Based on tagging studies, the current annual rate of paddlefish exploitation during the spawning run is thought to be 5-10%. Although this rate is not necessarily high, long-term concerns other than exploitation exist. These concerns include highly variable reproductive success, late age of maturity (9 to 15 years), and an aging paddlefish population. For these reasons, there is a need to determine the feasibility of supplementing natural reproduction with hatchery raised fish. An experimental stocking program may also be needed to assess the success of stocking paddlefish in a population that is known to reproduce naturally.

Current studies by University of Idaho have shown high variability in natural reproduction; however, a standard sampling procedure is being developed which will enable biologists to determine the abundance of YOY in the headwaters of Lake Sakakawea. Because natural reproduction of paddlefish does occur in the Yellowstone River, it is desirable to design a stocking plan which will minimize competition with naturally produced paddlefish and which will complement natural reproduction in years when conditions do not exist for good paddlefish reproduction. Because hatchery requests must be received almost a year in advance, a stocking design for this study will be developed independent of data on natural reproductive success.

Beginning in 1995, attempts to stock approximately 30,000 paddlefish that are 8-10 inches in length will be made every other year until three stocking events have occurred (1995, 1997 and 1999). The number of fish to be stocked and the years in which they are planted may be adjusted based on newly available information, hatchery success, or unforeseen events. All stocked paddlefish will be microtagged in order to ascertain, in future years, the success of stocking. Tagged fish will permit the differentiation of stocked and naturally produced fish, and provide fish of known age for age and growth verification. To ensure genetic diversity, a minimum of 10 male (or sperm from 10 males) and 5 female paddlefish will be needed for spawning. The source of these fish will be the Yellowstone-Sakakawea stock of paddlefish. Stocking evaluations (scanning for microtags) will be conducted yearly at the Confluence (ND) and Intake (MT) caviar operations beginning by the year 2002.

Paddlefish will be raised at the Garrison Dam National Fish Hatchery and planted in Lake Sakakawea in late September at sites considered conducive for rearing.

OBJ 8 A Quota -- Justification, Rationale and Alternatives

Excessive harvest is of great concern, especially in the face of rapidly increasing interest in paddlefish. The present season limit of two fish per year (one fish per year for the Yellowstone-Sakakawea stock in Montana beginning in 1994) helps to limit the harvest but may not be sufficient when tags are sold to an unlimited number of anglers.

Although the status of both stocks is not well understood, there are some negative "signals" in existing data for the Yellowstone-Sakakawea stock: young females (age 15-20) were relatively uncommon in the 1991 and 1992 angler harvest at Intake; total harvest has generally increased and catch per unit effort at Intake has decreased in recent years; exploitation rate appears to have increased. Although the paddlefish production today may equal or exceed that of 25 years ago, it is very likely, based on productivity considerations as reservoirs age, that paddlefish habitat quality is declining. Without a quota limiting total harvest, expansion of the fisheries and increased harvest are likely, and development of a rational management plan at the inter-state level may be pre-empted.

For the present time a quota is planned only for the Yellowstone-Sakakawea stock. Harvest of the Fort Peck stock is much lower and much more information on which to base a quota is needed before similar action is pursued for the Fort Peck stock.

The total harvest quota will be divided equally between Montana and North Dakota, based upon historical and recent paddlefish harvest on this stock in each state. The harvest quota will be reviewed for possible revision every two years, based on new biological information generated from research and management surveys.

The initial quota will be based on knowledge of historical harvest, known angler exploitation and success rates and the age structure of the paddlefish population. Later quotas will be based on the paddlefish stock index model (page 30).

Once a quota is set and allocated, several possible methods could be used for implementation. Four approaches discussed here are the Tag-Limit System, the Inseason-Closure System, the Long-Term Quota System, and the Reduced Season Limit System With Inseason Closure or Triggered Second Tag Options

Tag Limit System-- With the required fish tagging system in place, one approach would be to limit the number of paddlefish tags sold so that, based on historical catch rates per tag, the yearly catch would approximate the quota. Individual and group applications could be accepted. These could be issued first come-first served, or through a computer drawing, depending on laws in each state. Anglers could be informed through normal public information outlets. The Tag-Limit system may have significant advantages over other alternatives. First, it would require little or no extra inseason quantification of catch than now occurs. Second, data on catch and effort from the fishery, important in the stock assessment, would be comparable with that collected in past years. Third, the current season length could be maintained. The system would not result in excessive shifts in effort (e.g. more early-season fishing and much last-minute fishing as a quota was approached). Implementation costs may also be lower than most other alternatives. Negative aspects of this system are added administrative expenses and inconvenience for anglers.

Inseason-Closure System-- Under this system, any number of tags could be sold, but catches would be monitored inseason with "real-time" accounting, and the fishery closed when the quota was reached. Although this method has been used in many fisheries, its implementation here would have several disadvantages. It would require a fairly precise accounting of fish taken. Such precise counting is difficult even at areas of intense fishing such as Intake or the Confluence, and presents serious difficulties in more remote areas. This system would also create crowding and other social problems at confined fishing sites such as Intake and the Confluence. It would probably shift fishing effort to earlier in the season as people sought to catch their fish before closure. Catch and effort data generated by the fishery would thus be incomparable with that generated in earlier years. A mechanism currently exists in both states for immediate closure of the snag fishery if necessary to prevent overharvest.

Long-Term Quota System-- A third approach would be to set a 5-year quota for total harvest over that time period. If the quota were not approached to, say 80-95% by year 4, the fishery would remain open in year 5. No tag limitation would be implemented. This system has the advantage of minimal, perhaps no, changes in existing regulations (if the quota is not reached). It would allow different regulations in the two states, if desired, but could result in the fishery being open in one state and closed in the other in some years if one state's quota was reached more rapidly than the other. This would cause unusually high angler fishing pressure in the state with an open season and could result in the quota being significantly exceeded.

Other disadvantages would occur if the quota were reached before year 5. Closing a fishery for a year would generate the kind of instability fishermen and economies dislike, and a total year's closure would probably generate resistance. It would also alter our stock assessment data and make these closure years blanks as far as data were concerned.

Perhaps the worst disadvantage of this system is that it would likely lead to controversy. For example, should the season be open in year 5 when 85% of the quota has been reached in year 4? In that situation, if the season is closed in year 5, significant recreation is foregone. If the season is open and conditions lead to a large harvest, the quota would be significantly exceeded.

Reduced Season Limit System With Inseason Closure or Triggered Second Tag Options -- This system would initially limit anglers in both states to one fish per season (limited to the purchase of a single tag). Based on historical data, this seasonal limit would probably reduce harvest sufficiently that the total quota would seldom be exceeded.

If, in any year, the creel information indicated the quota was being exceeded, the states could implement an immediate closure to prevent excessive harvest. The advantages of this system are: 1. All interested anglers would be allowed to fish as opposed to a tag limited system where tags are issued through a drawing system; 2. the system for issuing tags would be less complex for the angler and for the administrative agencies; 3. the common season limit in each state would avoid shifting pressure from one state to another. The primary disadvantage with this system is the difficulty in determining when a quota has been reached as discussed above under the Inseason-closure system.

Unlike the Inseason Closure option, if the annual harvest is projected (well into the season) to be low, then snaggers would be able to purchase a second tag (potentially relevant to North Dakota only). Triggering the issuance of a second tag would be done in those years when the quota will not be met, even with an optional second tag. When used, this system would assist in more closely approaching the desired quota. The biggest disadvantages of this system are 1) procuring the needed in-time harvest data to make the decision whether or not to trigger the issuance of a second tag, and 2) developing an equitable tag distribution system for the second tag through county auditors and vendors.

OBJ 9 Joint State Annual Report

To assure coordination and complete information for making management decisions, fisheries personnel from Montana and North Dakota will annually prepare a joint report outlining the status of the paddlefish populations in these states. The report will provide a summary of data collected and analyzed during the year. This information will be made available to interested parties.

OBJ 10 Public Information

Paddlefish are not well understood by the public compared to other game fishes such as walleye and bass. In order to increase public awareness of the paddlefish resource, information displays were prepared by the Montana Department of Fish, Wildlife, and Parks in 1992 for display at Intake during the fishing season, at the Region 7 office at Miles City, and at county fairs and similar functions. Two paddlefish information brochures were also prepared, one a comprehensive summary of the paddlefish resource and fisheries in Montana, and the other a briefer, question-and-answer brochure addressing most of the questions commonly asked by the public at Intake. The information displays and brochures will greatly aid in the dissemination of information on paddlefish. North Dakota has developed similar brochures and may develop similar displays (e.g. at the Confluence). Brochures will be updated and revised as more research results become available. Activities under this objective will also include the presentation of talks on paddlefish to various sports groups and service clubs throughout Montana and North Dakota. The completed national paddlefish video will be shown at all opportunities. Also North Dakota recently developed a two minute paddlefish video which will be aired throughout western North Dakota and eastern Montana.

In addition, more information is needed on the values, attitudes, and preferences of snaggers and the public at large toward paddlefish. This need will be addressed through mail-surveys in the off-season and on-site surveys during the fishing seasons. Contacts will be obtained from license dealers selling paddlefish tags. Results will aid in formulating policies and in modifying the paddlefish management plan.

LITERATURE CITED

Berg, R. K. 1981. Fish populations of the wild and scenic Missouri River, Montana. Montana Department of Fish, Wildlife, and Parks. Federal Aid to Fish and Wildlife, Restoration Project FW-3-R, Job Number 1-A, Helena.

Carlson, D. M., and P. S. Bonislawsky. 1981. The paddlefish *(Polyodon spathula)* fisheries of the midwestern United States. Fisheries (Bethesda) 6(2):17-22, 26-27.

Carlson D. M., M. K. Kettler, S. E. Fisher, and G. S. Whitt. 1982. Low genetic variability in paddlefish populations. Copeia 1982(3):721-725.

Combs, D. L. 1986. The role of regulations in managing paddlefish populations. Pages 68-76 *in*: J. G. Dillard, L. K. Graham, and T. R. Russell, editors. The paddlefish: status, management, and propagation. North Central Division, American Fisheries Society, Special Publication 7.

Dillard, J. G., L. K. Graham, and T. R. Russell editors. 1986. The paddlefish: status, management and propagation. North Central Division, American Fisheries Society, Special Publication Number 7.

Epifanio, J., M. Nedbal, and D. P. Phillip. 1989. A population genetic analysis of paddlefish *(Polyodon spathula)*. Illinois Natural History Survey, Aquatic Biology Technical Report 89/4.

Forbes, S. A., and R. E. Richardson. 1920. The fishes of Illinois. Illinois Natural History Survey, Champaign, IL.

Fredericks, J. P. 1994. Distribution, abundance, and feeding ecology of young-of-the-year paddlefish in upper Lake Sakakawea, North Dakota. M.S. Thesis. University of Idaho. 97 pp.

Gardner, W. M., and R. K. Berg. 1982. An analysis of the instream flow requirements for selected fishes in the wild and scenic portion of the Missouri River. Montana Department of Fish, Wildlife, and Parks, Helena.

Gardner, W. M. 1992. Yellowstone River paddlefish spawning study. Montana Department of Fish, Wildlife and Parks. Federal Aid Project F-46-R-5, Job IIIe, Helena.

Gengerke, T. W. 1986. Distribution and abundance of paddlefish in the United States. Pages 22-35 *in*: J. G. Dillard, L. K. Graham, and T. R. Russell, editors. The paddlefish: status, management and propagation. North Central Division, American Fisheries Society, Special Publication Number 7.

Gilge, K. W. 1994. Survey and Inventory of Coldwater and Warmwater Ecosystems. Federal Aid Project, F-46-R7, Job V-e., Helena

Graham, L. K. 1986. Establishing and maintaining paddlefish populations by stocking. Pages 96-104 *in*: J. G. Dillard, L. K. Graham, and T. R. Russell, editors. The paddlefish: status, management, and propagation. North Central Division, American Fisheries Society, Special Publication 7.

Graham, L. K. 1992. A management plan for paddlefish in Missouri. Missouri Department of Conservation, Jefferson City.

Grande, L., and W. E. Bemis. 1991. Osteology and phylogenetic relationships of fossil and recent paddlefishes (Polyodontidae) with comments on the interrelationships of Acipenseriformes. Journal of Vertebrate Paleontology 11 (Supplement to Number 1):1-121.

Gunsolus, R. 1978. The status of Oregon coho and recommendations for managing the production, harvest, and escapement of wild and hatchery-reared stocks. Unpublished Report, Oregon Department of Fish and Wildlife, Clackamas.

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

Jacobsson, J. P., and A. C. Johansen. 1921. On the causes of fluctuations in the yields of some of our fisheries. Medd. Komm. Havunders. 4(5):1-48.

MacAlpin, A. 1947. *Paleopsephurus wilsoni*, a new polyodontid fish from the Upper Cretaceous of Montana, with a discussion of allied fish, living and fossil. Contributions to the Museum of Paleontology, University of Michigan 6:167-234.

Mero, S. W. 1992. Food habits of walleye, sauger, and their hybrids in Lake Sakakawea, North Dakota. North Dakota Game and Fish Department. Federal Aid Project F-2-R-38, Job 6b., Bismarck.

Mero, S. W, D. W. Willis and G. J. Power. 1994. Walleye and sauger predation on paddlefish in Lake Sakakawea, North Dakota. North American Journal of Fisheries Management 14: 226-227.

Meyer, F. P. 1960. Life history of *Marsipometra hastata* and the biology of its host, *Polyodon spathula*. Doctoral Dissertation, Iowa State University, Ames.

Montana Board of Natural Resources and Conservation. 1978. Order of the Board of Natural Resources establishing water reservations (Yellowstone River Drainage). Helena.

Montana Board of Natural Resources and Conservation. 1992. Final order of the Board of Natural Resources and Conservation establishing water reservations above Fort Peck Dam. Helena.

Montana Department of Fish, Wildlife, and Parks. Undated. The paddlefish: senior citizen of the Yellowstone and Missouri rivers. Information brochure. Helena.

Montana Fish and Game Commission. 1976. Application for reservation of water in the Yellowstone river basin. Helena.

Needham, R. G. 1969. Paddlefish investigations. Montana Fish and Game Department. Project No. F-11-R-15, Job 4.

Needham, R. G. 1974. Paddlefish investigations. Montana Fish and Game Department. Project No. F-11-R-22, Job II-a.

Needham, R. G. 1979. Paddlefish investigations. Montana Fish and Game Department. Project No. F-11-R-26, Job II-a.

Needham, R. G. 1980b. Paddlefish investigations. Montana Department of Fish, Wildlife, and Parks. Project No. F-11-R-27, Job II-a.

Needham, R. G. 1980b. Paddlefish investigations. Montana Department of Fish, Wildlife, and Parks. Project No. F-11-R-28, Job II-a.

Needham, R. G. 1985. Paddlefish investigations. Montana Department of Fish, Wildlife and Parks. Project No. F-11-R-33, Job II-a.

Needham, R. G., and K. W. Gilge. 1986. Paddlefish investigations. Montana Department of Fish, Wildlife and Parks. Project No. F-11-R-34, Job II-a.

Owen, J. B., and J. C. Hendrickson. 1992. Creel survey information for Lake Sakakawea, Garrison Dam Tailrace, Missouri-Yellowstone River (Paddlefish), and Lake Audubon. North Dakota Fisheries Investigations Report Number 2, Bismarck, ND.

Peterman, L.G. 1977. Ecological implications of the Yellowstone River flow reservations. Quarterly Rpt. Montana Department of Fish, Wildlife and Parks. Helena, MT (mimeo) 13pp.

Peterman, L. G. 1979. The ecological implications of Yellowstone River flow reservations. Montana Department of Fish and Game. Helena.

Peterman, R. M. 1982. Model of salmon age-structure and its use pre-season forecasting and studies of marine survival. Canadian Journal of Fisheries and Aquatic Sciences. 39:14444-1452.

Power, G.J., J.C. Hendrickson, J.D. Lee and F. Ryckman. 1994. Missouri River System Fishery Reference and Operational Management Document. North Dakota Game and Fish Department, Div. Rpt. 10, 72pp.

Purkett, C. A., Jr. 1961. Reproduction and early development of the paddlefish. Transactions of the American Fisheries Society 90:125-129.

Rehwinkel, B. J. 1978. The fishery for paddlefish at Intake, Montana during 1973 and 1974. Transactions of the American Fisheries Society 107:263-268.

Ricker, W. E. 1972. Hereditary and environmental factors affecting certain salmonid populations. Pages 19-160 *in*: R. C. Simon and P. A. Larkin, editors. The Stock concept in Pacific salmon. H. R. MacMillan Lectures in Fisheries, University of British Columbia, Vancouver.

Robinson, J. W. 1966. Observations on the life history, movement, and harvest of the paddlefish, *Polyodon spathula*, in Montana. Proceedings of the Montana Academy of Science 26:33-44.

Russell, T. R. 1986. Biology and life history of the paddlefish -- a review. Pages 2-20 *in*: J. G. Dillard, L. K. Graham, and T. R. Russell, editors. The paddlefish: status, management and propagation. North Central division, American Fisheries Society, Special Publication Number 7.

Ryckman, F. Personal Communications. District Biologist. North Dakota Game and Fish Department.

Scarnecchia, D. L. 1984. Forecasting yields of two-sea-winter Atlantic salmon *(Salmo salar)* from Icelandic rivers. Canadian Journal of Fisheries and Aquatic Sciences 41:1234-1240.

Scarnecchia, D. L., A. Isaksson, and S. E. White. 1989. New and revised catch forecasts for two-sea-winter Atlantic salmon *(Salmo salar)* in Icelandic rivers. Journal of Applied Ichthyology (Berlin): 5:101-110.

Scarnecchia, D. L., T. W. Gengerke, and C. T. Moen. 1989. Rationale for a harvest slot limit for paddlefish in the Upper Mississippi River. North American Journal of Fisheries Management 9:477-487.

Semmens, K. J., and W. L. Shelton. 1986. Opportunities in paddlefish aquaculture. Pages 106-113 *in*: J. G. Dillard, L. K. Graham, and T. R. Russell, editors. The paddlefish: status, propagation, and management. North Central Division, American Fisheries Society, Special Publication 7.

Sparrowe, R. D. 1986. Threats to paddlefish habitat. Pages 36-45 *in*: J. G. Dillard, L. K. Graham, and T. R. Russell, editors. The paddlefish: status, management and propagation. North Central Division, American Fisheries Society, Special Publication Number 7.

Stewart, P. A. 1990. Yellowstone River paddlefish investigations. Montana Department of Fish, Wildlife, and Parks. Federal Aid to Fish and Wildlife Project F-46-R-3, Job III-c., Helena.

Stewart, P. A. 1991a. Yellowstone River paddlefish investigations. Montana Department of Fish, Wildlife, and Parks. Federal Aid to Fish and Wildlife Project F-46-R-4, Job III-c., Helena.

Stewart, P. A. 1991b. Paddlefish history, biology and management-Garrison Reservoir population. Unpublished file report. Montana Department of Fish, Wildlife and Parks.

Stewart, P. A. 1992. Yellowstone River paddlefish investigations. Montana Department of Fish, Wildlife and Parks. Federal Aid Project F-46-R-5, Job IIIc., Helena.

Tenney, B., and G. Power. 1992. The paddlefish: North Dakota's living fossil. North Dakota Outdoors 54(8):10-14.

United States General Accounting Office. 1983. The Oregon Production Index: a sound fishery management tool that can be improved. GAO/RCED-83-185.

United States Army Corps of Engineers. 1993. Preliminary Draft Environmental Impact Statement. Missouri River Water Control Manual Review and Update Study. U.S. Army Corps of Engineers, Missouri River Division, Omaha, Nebraska.

United States Army Corps of Engineers. 1992. Master plan, Fort Peck Dam/Fort Peck Lake, Missouri River, MT MRD. COE. 200pp.

United States Geological Survey. 1993. Water resources data for Montana. U.S. Department of Interior. 512pp.

Unkenholz, D. G. 1986. Effects of dams and other habitat alterations on paddlefish sport fisheries. Pages 54-61 *in*: J. G. Dillard, L. K. Graham, and T. R. Russell, editors. The paddlefish: status, management and propagation. North Central Division, American Fisheries Society, Special Publication Number 7.

Van Eeckhout, G. 1980. Investigations of selected fish populations by the mark-recapture method. North Dakota State Game and Fish Department. Dingell Johnson Project F-2-R-27, Study 4, Job 4-A, Bismarck.

APPENDIX A

DISTRIBUTION AND PUBLIC COMMENTS

Distribution of the Draft Plan

The Draft Paddlefish Management Plan (DPMP) was made available for public comment in North Dakota and Montana during March, April and May 1994.

In North Dakota, copies of the DPMP as well as the Executive Summary were available at Game and Fish Department offices in Bismarck and Williston and copies were placed in the Williston City Library and the State Library in Bismarck. A press release requesting public input and notification of a public meeting held in Williston on March 22, 1994 was issued statewide.

The Montana Department of Fish, Wildlife and Parks issued a statewide press release announcing the availability of the DPMP at all regional offices and at the Chamber of Commerce offices in Glendive and Sidney. Open meetings were held to receive public comments and discussion in Glasgow, Glendive, Sidney and Billings on March 4, 23, 24 and 28th, 1994 respectively.

Public Comments

North Dakota. The Game and Fish Department received two requests for the DPMP and five requests for the DPMP executive summary. Three letters with comments and one phone call were received. The public meeting in Williston was attended by eight individuals. Comments received at the public meeting were general in nature.

The written comments received have been paraphrased as follows:

- North Dakota should implement a one fish per season limit but allow for a second 'B' tag that would allow the angler to snag a second fish if the first was under 20 lbs.
- Implement a lottery system, if needed [for distribution of tags].
- Use a lottery system with a $1 non-refundable application fee.
- Current system adequate; just need better enforcement.
- Open legal area to the entire Missouri River System

Montana. The Fish, Wildlife and Parks Department received six letters plus some written comments from persons attending public meetings. Attendance at the public meetings was 6 individuals in Billings, 3 in Sidney, 9 in Glendive, and 0 in Glasgow.

Verbal comments offered at the public meetings have been paraphrased as follows:

- Some concerns were expressed about the one fish limit; it was felt that the one fish limit in Montana and a two fish limit in North Dakota is counter to the purpose of the plan.
- Prefer tag limit system for implementing quota.
- Should allow catch and release, depending on fish size.
- Expand range of paddlefish by planting new areas and building fish ladder.
- Surgically remove roe (eggs) and release fish.
- Indicate in plan how public comment was used; if a suggestion was not used, tell why.
- Should say in the plan what the regulations for angler will be.

Paraphrased written comments are as follows:

- Discontinue the paddlefish season if fish are in danger.
- Paddlefish fishery has suffered due to caviar operation.
- Support one tag per snagger and quota.
- Montana should implement a one fish per season limit but allow for a second 'B' tag that would allow the angler to snag a second fish if the first was under 20 lbs.
- Support lottery drawing (if needed) but not first-come, first-served.
- If needed, close down portions of river to snagging.
- Stocking plan might supplement the natural population.
- Not able to snag for paddlefish if successful the previous year.
- Concern about long-term population projections.
- Require snaggers to supply harvest information.
- Feasibility of a fish ladder at Intake.
- Concern about different limits in Montana and North Dakota.
- Handling of public comments.
- Use of length or weight limits and include catch and release.
- Possibility of surgically removing paddlefish eggs then return the fish to the river.
- Concerned about providing written comments.
- Don't use a tag-limit system.
- Institute a one paddlefish per season limit statewide.
- Keep the same paddlefish regulations in both states.

<u>Responses to Public Comments</u>

Respective state responses to all comments and questions are available upon request. Requests for responses should be sent to: Fisheries Division, Montana Fish, Wildlife, and Parks, 1420 East 6th Ave., Helena, MT 59620 or Fisheries Division, North Dakota Game and Fish Department, 100 N. Bismarck Expressway, Bismarck, ND 58501-5095.