Data for fish tagged in 2006 on pg. 25, table 1.

SPRING MIGRATIONS OF ADULT PADDLEFISH IN THE MISSOURI RIVER ABOVE FORT PECK RESERVOIR

Progress Report for 2006
To
The Montana Department of Fish, Wildlife, and Parks
1420 Sixth Ave.
Helena, MT 59620-0701

by
Shannon E. Miller
Scientific Aide
Phone: (208) 874-3174 Fax: (208) 885-6226
E-Mail: mill2834@uidaho.edu

Dennis L. Scarnecchia
Professor of Fisheries
Phone: (208) 885-581 Fax: (208) 885-6226
E-Mail: scar@uidaho.edu

Department of Fish and Wildlife
University of Idaho
Moscow, ID 83843-1136

and

Laura L. Leslie
Regional Fisheries Biologist
Montana Department of Fish, Wildlife and Parks
2165 Hwy 2
Havre, MT 59501
Phone: (406) 265-6177
E-Mail: lleslie@mt.gov

October 20, 2006

ABSTRACT

The 2006 spring migrations of 30 adult paddlefish *Polyodon spathula* in the Missouri River between Fort Peck Reservoir and the Marias River, Montana were monitored via radio telemetry. Most (70%) upriver movements ≥ 20 km occurred during discharge rises and most (68%) downriver movements ≥ 20 km occurred during discharge declines. Three paddlefish migratory patterns, based on the timing and longitudinal distribution of relocations, were identified. *Early upriver-migrants* staged below the Fred Robinson Bridge (FRB) during stable flows, moved upriver in response to early rises in discharge, then moved downriver before the ascending limb of peak discharge. *Peak flow upriver-migrants* staged below the FRB during stable flows, made upriver movements in response to early rises in discharge and remained upriver of the FRB during the ascending limb of peak discharge. *Static migrants* either made no upriver movements after tagging or did not move upriver of the FRB. Congregations of fish were observed above Fort Peck Reservoir in areas likely to be important paddlefish spawning sites (Powerplant Ferry, Dauphine Rapids) and staging sites (Lower Peggy's Bottom, Slippery Ann area). This study's results to date provide insight on the direction and longitudinal distribution of migratory movements and the resulting exposure of the Fort Peck paddlefish stock to the harvest corridor between Fort Peck reservoir and the FRB. Plans for 2007 are to implant 30 more adult fish with radio-transmitters, continue monitoring of all radio-tagged fish and identify egg incubation sites of Fort Peck paddlefish.

INTRODUCTION

During the last century, large river modifications have reduced paddlefish *Polyodon spathula* abundance and distribution throughout the species' range (Gengerke 1986). Channelization, flow regulation, and impoundment have altered or eliminated many of the productive nursery and feeding habitats, inundated spawning grounds, and impeded spawning migrations (Carlson and Bonislawsky 1981; Sparrowe 1986; Unkenholz 1986). Over harvest has also contributed to the depletion of paddlefish in many areas. Effective management of the few remaining self-sustaining, harvestable paddlefish stocks in the United States is important to the long term conservation of the species.

In Montana, two self-sustaining, harvestable populations of paddlefish are managed as separate stocks, the Yellowstone-Sakakawea stock (inhabiting the Lower Yellowstone River and the Missouri River below Fort Peck Dam) and the Fort Peck stock (inhabiting Fort Peck Lake Reservoir and the Missouri River above Fort Peck Dam). Completion of Fort Peck Dam in the late 1930's has resulted in the physical isolation of the Fort Peck paddlefish stock from the Yellowstone-Sakakawea stock down river. The filling of Fort Peck Reservoir created productive rearing habitat, resulting in numerous large paddlefish in the ensuing decades. A valuable recreational snag fishery occurs each year, mainly in spring, mainly in areas down river of the Fred Robinson Bridge (FRB) on U.S. route 191. In recent years, harvest of Fort Peck paddlefish has varied considerably with annual river discharges, but typically has ranged between 300 and 1,000 fish.

The Fort Peck stock (as well as the Yellowstone-Sakakawea stock) is managed under a plan designed to provide a stable recreational fishery while maintaining the population size and historical age structure of the spawning stock (Scarnecchia et al. 1995). For more effective management of the Fort Peck paddlefish stock, a better understanding is needed of several key aspects of their life history. In addition to ongoing investigations of the ecology, age-structure and reproductive success of Fort Peck paddlefish (Kozfkay and Scarnecchia 2002; Bowersox 2004), more information is needed on spawning, including spawning locations, and movements and habitat use of fish during their spawning migrations.

Spawning success has long been recognized as a critical and often limiting factor for paddlefish abundance throughout the species' range. Paddlefish have been shown to require specific environmental conditions involving discharge, photoperiod, temperature and turbidity to cue upriver movements and to initiate spawning (Lein and DeVries 1998; Paukert and Fisher 2001; Stancill et al. 2002). Therefore, the number of migrants, upriver distance and duration of migrations can exhibit substantial inter-annual variations in response to varying river conditions. Drought conditions in the Upper Missouri River watershed combined with reservoir level declines have evidently resulted in poor reproductive success of paddlefish (as indicated by low counts of age-0 fish) in each of the past several years. There is concern among managers that reproduction and recruitment in the Fort Peck stock may be inadequate for current harvest levels.

Since successful reproduction of Fort Peck paddlefish is likely related to environmental conditions of the Missouri River above Fort Peck Reservoir (MRAFP) during the spring spawning season, a thorough understanding of the relationship between

flow conditions and paddlefish movements will provide essential information needed for the long-term perpetuation of this stock. Clarification of the links between annual spring discharge, migration distance, habitat use, and year class strength will allow managers to better interpret the effects of low water years on paddlefish migrations and reproductive success. A better understanding of pre-spawning movements in spring in relation to discharge will also aid managers in forecasting the annual success of the fishery, both prior to and during the harvest season. Any future in-season closures (if necessary) will be able to be better timed if the relation between fish distribution and discharge is better understood.

To meet the research needs described above, a multi-year radio-telemetry study began in the spring of 2006 to examine the Fort Peck paddlefish stock's migratory patterns and spawning activity. This progress report provides results from the 2006 field season.

OBJECTIVES

The objectives of this ongoing investigation are to 1) Describe the directional movements, rate of movement and habitat use of adult migratory paddlefish during spring and summer in relation to river conditions; 2) Compare the interannual distance of ascent of radio-tagged fish in relation to the magnitude and duration of spring discharge; 3) Investigate if sex-specific differences in migratory behavior exist, and 4) Identify and characterize egg deposition (spawning) sites.

METHODS

Fish Capture and Tag Implantation

Paddlefish migrations into the MRAFP were investigated with the aid of biotelemetry. Drifted, floating experimental gill nets 25 m in length (mesh sizes 7.6 cm, 10.2 cm, and 12.7 cm) were used to capture mature paddlefish between April 27 and May 2, 2006. All capture sites were located from just upriver of the FRB downstream to rkm 3076 (near the mouth of Slippery Ann creek). Lotek Model 3L Microprocessor coded radio transmitters (Lotek Inc. Newmarket, Ontario, Canada) were surgically implanted into each fish. Dimensions of each tag were 16 mm x 73 mm and air-dry mass was 26 gm. Tags implanted during 2006 were individually coded to operate continuously on a radio frequency of 149.500 kHz. Each tag had an estimated battery-life of 4.5 years.

Upon capture, eye-to-fork lengths (Ruelle and Hudson 1977) and weights were recorded, and a unique number, based on its transmitter code was assigned to each fish. Thirty paddlefish (15 males and 15 females) were selected for tagging. Males ranged in length from 85 cm to 117 cm (mean, 99.2 cm) and ranged in weight from 6 kg to 24 kg (mean, 14.8 kg). Females ranged in length from 100.3 cm to 128.3 cm (mean, 118.3 cm) and ranged in weight from 19 kg to 36.5 kg (mean, 27.5 kg; Table 1). A numbered, colored plastic jaw tag (poultry band) was affixed to the right dentary of the fish. If a jaw tag was already present, the number and color of the tag was noted. The fish was then placed in a padded cradle on the front deck of the boat and taken to shore for tag implantation.

Tag implantation surgeries followed the procedure outlined in Firehammer (2004). A 3-4 cm incision was made immediately anterior to the pelvic fins along the ventral midline of the fish. At this time, sex and maturation stage was determined, if possible, by observing the gonads through the incision. A large bore catheter needle created an exit for the antennae about five cm posterior of the incision. After tag implantation, the incision was closed with 6-8 non-absorbable sutures. Each surgery took less than 5 minutes during which time river water was continuously poured across the gills and body to enable the fish to respire and remain moist. After implantation, fish were held in the river and released when swimming movements suggested recovery. All release sites were 0.25 km or less from of the point of capture.

Fixed Station and Manual Tracking

Tracking was conducted using fixed receiving stations and by boat (manual tracking). The fixed stations, part of a concurrent Montana Fish, Wildlife, and Parks study of other Missouri River fishes, were located on the MRAFP at rkm 3075 (Big Sandy Island), rkm 3088.5 (King Island), rkm 3117 (Powerplant Ferry), rkm 3192 (Judith Landing) and the mouth of the Marias River. Each station contained a solar powered Lotek SRX 400 model receiver. A 512 kb memory data logger linked to each receiver recorded tag code, signal strength, and time at contact of each passing fish. Fixed station data were downloaded every 1-2 weeks during the paddlefish migration period.

For manual tracking of paddlefish, an open-bow motorboat was equipped with a Lotek SRX 400 receiver and either a four element or three element Yagi antenna (Winter 1996). The MRAFP was divided into three sections for manual tracking. Section 1 was the headwaters of Fort Peck Reservoir (rkm 3000 to the FRB- rkm 3090). Section 2 was

upstream of the FRB to rkm 3130 (13 rkm above the Powerplant Ferry). Section 3 was rkm 3130 upstream to the Judith Landing boat launch (rkm 3192). Manual tracking effort was not divided evenly between sections but was allocated according to discharge levels. Prior to fluctuating rises in discharge levels (defined as discharge period 1: April 28 - May 19) and after peak discharge (discharge period 4: June 15 and later), tracking was concentrated on section 1. During fluctuating flows on the ascending limb of the hydrograph (discharge period 2: May 20 - June 11) tracking was concentrated on sections 1 and 2. During the peak of spring discharge (discharge period 3: June 11 - 14) tracking was concentrated on sections 2 and 3.

Once a telemetered fish was located, a global positioning unit (GPS) was used to record latitude, longitude, and the approximate rkm of relocation sites. At each relocation site, depth and water temperature were recorded using the boat's depth sounder. Macrohabitat types were also identified at each contact site. Macrohabitats were classified into the following types: 1) main channel cross-over (CHXO), 2) outside bend (OSB), 3) inside bend (ISB), 4) secondary channel: non-connected (SCN) and 5) secondary channel: connected (SCC). The presence of in-stream structures, such as channel bars or islands were also recorded. If an in-stream structure was within two channel widths of a relocation, or if the structure induced an observed change in the current pattern at the relocation, the fish was considered to be associated with the structure. Alluvial bars were differentiated from channel islands, which are relatively more stable and exhibit heavier vegetation (Bramblett 1996).

A United States Geological Survey (USGS) gauging station immediately down river of the FRB recorded mean daily river discharge and water temperatures. Turbidity

was measured with a turbidimeter at 1-3 day intervals at the FRB or the Rock Creek boat launch (rkm 3068).

Egg Deposition Sites

No egg sampling was conducted in 2006 but potential egg incubation sites were identified using tracking data (i.e. relocations indicating congregations of fish) and visual observations made after water levels receded to expose gravel bars. The MRAFB from the mouth of the Marias River to the Judith Landing boat launch was investigated for potential spawning locations on July 24 and 25, 2006. Potential egg incubation sites were identified based on a specific morphological characteristic in which the main channel was constricted into an hourglass shaped riffle-pool sequence. Visual observation of these areas confirmed an abundance of gravels and cobble, substrates previously shown to provide incubation sites for paddlefish eggs (Purkett 1961; Firehammer 2004). Each site was assigned a categorical ranking (1-3) based on its similarity to confirmed egg incubation sites sampled in a previous study on the Yellowstone River (Miller and Scarnecchia 2005). A ranking of 1 indicated greatest similarity (i.e. high amounts of hard substrates, noticeable increase in water velocity, and sudden increase in depths below riffle) with a ranking of 3 indicating lowest similarity. A global positioning unit was used to record latitude and longitude of potential egg incubation sites.

RESULTS

Fate of Tags

All females (n = 15), and 14 of 15 males tagged in 2006 were relocated at least once during the 2006 field season. One 10.4 kg male (code 11) was not relocated after

tag implantation. Another male (16 kg; code 14) was only relocated once, eight days after tag implantation. Both fish evidently moved back into Fort Peck Reservoir shortly after tagging, perhaps in response to the stress of surgery. Manual tracking yielded 94 relocations and the fixed stations recorded 281 relocations for a total of 375 relocations. The transmitter of one 29 kg female (code 30) was determined to be stationary by May 26 near the boat launch below the FRB and was evidently expelled or removed after harvest by an angler. An angler reported that he snagged and released a fish with a jaw tag matching radio-tag code 30 on May 22 near the FRB and that the sutures had appeared to have ruptured. The remaining fish were assumed to have retained their tags and be at large.

Distribution of Relocations

Mean contact site for all relocations in 2006 was rkm 3088.23, near the fixed station at King Island. Combining fixed station and manual tracking relocations, predominately more relocations were made in river section 1 (rkm 3000 – 3090, 266 relocations) than in river section 2 (rkm 3090 -3130, 105 relocations) or river section 3 (rkm 3130 – 3192, four relocations). Combining fixed station and manual tracking relocations, more relocations were made during discharge periods 1 (122 relocations) and 2 (199 relocations) than discharge periods 3 (19 relocations) and 4 (35 relocations). The furthest upriver fixed station relocation was at rkm 3192 (Judith Landing). This relocation was made on a 27 kg female (code 34) on May 20. The furthest upriver manual relocation was at rkm 3169 (Dauphine Rapids). The furthest downriver manual relocation was at rkm 3013 (approximately 40 rkm below Lower Peggy's Bottom). This

relocation was made on a 23.5 kg male (code 15) on June 6, two days after MRAFP discharge made a sudden drop to 245 m^3/s.

Direction and Rate of Movement

Directional movements of telemetered paddlefish in the MRAFP were associated with changes in discharge. Moreover, the relationship between changes in discharge and directional movements was stronger when the distance between relocations increased. For example, 62 of 100 (62%) of upriver movements greater than 10 rkm occurred during periods of increasing discharge. Conversely, 68 of 107 (64%) downriver movements greater than 10 rkm occurred during falling discharges. Forty-one of 58 (70%) of upriver movements greater than 20 km occurred during periods of increasing discharge and 39 of 57 (68%) of downriver movements greater than 20 km occurred during periods of decreasing discharge. Twenty-two of 27 (82%) of upriver movements greater than 40 km occurred during increasing flows while 22 of 32 (69%) of downriver movements greater than 40 km occurred during decreasing flows.

A relationship between movement rates of fish and changes in discharge was also apparent. Mean rate of movement for males and females combined over the entire 2006 tracking period was 9.9 km/day (Table 2). The rate of movement during periods of increasing and peak flows (tracking periods 2, 3) was greater than either discharge period 1 or 4. For example, mean rate of movement during tracking period 1 (mean discharge 274 m^3/s) was 7.9 km/day. This rate increased to 10.8 km/day during tracking period 2 (mean discharge 301 m^3/s) and to 17.1 km/day during tracking period 3 (mean discharge

460 m^3/s; Table 2). On the descending limb of the hydrograph (tracking period 4; mean discharge 292 m^3/s), mean rate of movement decreased to 6.3 km/day.

Migratory Patterns

Three general migratory patterns for telemetered fish were observed in 2006. Pattern 1 included fish categorized as "early upriver-migrants". Early upriver-migrants were relocated in staging areas below the FRB during discharge period 1 (stable flows), then made upriver movements above the FRB in response to two early rises in discharge (May 19 - 25, mean discharge = 326 m^3/s; May 27-June 2, mean discharge = 315 m^3/s). These fish then moved downriver before the ascending limb of peak discharge occurred and were not subsequently relocated above the FRB during peak discharge (discharge period 3). Five of 15 males (33%) and six of 15 females (40%) exhibited this pattern.

Pattern 2 included fish categorized as "peak flow upriver-migrants". Similar to early upriver-migrants, peak flow upriver-migrants staged below the FRB during stable flows then made upriver movements in response to early rises in discharge. However, peak flow upriver-migrants remained at least 10 rkm above the FRB during the ascending limb of peak discharge and did not move downriver until the hydrograph began to descend. Two of 15 males (13%) and seven of 15 females (47%) exhibited this pattern.

Pattern 3 included fish categorized as "static migrants". Static migrants either made no upriver movements after tagging or if upriver movement did occur, it did not extend past the FRB. Seven of 15 males (47%) and one female (7%) exhibited this pattern.

Two fish were not placed into a migratory pattern. One of 15 males (7%) moved above the FRB shortly after tagging then moved downriver before any significant rise in discharge and was not subsequently relocated. One of 15 females (7%) shed its tag before the ascending limb of the hydrograph. Appendix 1 (figures 1-29) provides relocation histories of individual fish.

Paddlefish Congregations

Congregations of fish were observed in specific areas above Fort Peck Reservoir during the 2006 migration indicating these areas may be important paddlefish habitats. Depending on the magnitude and rate of change in discharge during the congregation as well as the longitudinal distribution (i.e. above or below the FRB) of relocations, each site was classified as either a potential spawning habitat or a staging habitat/low water refuge. Four such areas were identified:

- **Downriver of Lower Peggy's Bottom (≤ rkm 3052 - staging habitat)**

On May 18, one-third of all telemetered fish (seven females, three males) were relocated between rkm 3031 and rkm 3037. Six of these fish were within 0.25 km of one another. This congregation occurred at the end of a 10-day period during which flows remained stable and below 275 m^3/s.

- **Slippery Ann area (rkm 3076 - rkm 3080 - staging habitat)**

On May 22, five of 30 fish (two females, three males) were relocated between rkm 3076 and rkm 3082. This was during a two-day period when flows surpassed 340 m^3/s for the first time during the spring hydrograph. The majority (three of five) of these fish were previously contacted downriver and evidently had moved up to this site in response to increasing flows. On May 31, four of 30 fish (three males, one female) were

relocated in the Slippery Ann area (rkm 3080). All four of these fish were previously relocated upriver and had evidently moved down to the Slippery Ann area in response to a decrease in flows. On June 8-9, five of 30 fish (three males, two females) were relocated near the mouth of Slippery Ann Creek (rkm 3076). Four of five of these fish were previously located upriver and had evidently moved downriver in response to a temporary decrease in flows.

- **Powerplant Ferry area (rkm 3112 - rkm 3118 - spawning habitat)**

On June 13, three fish (two females, one male) were relocated within three km of one another near the Powerplant Ferry. These relocations occurred the day before spring discharge for the MRAFP peaked at 589 m^3/s. Thirteen of 30 fish (four males, nine males) were relocated in this area during periods of high flows ($\geq$ 350 m^3/s; May 23 and June 12 – June 21). However, these relocations were expansive and did not represent coordinated movements or congregations of more than two fish in the same area on the same day.

- **Dauphine Rapids (rkm 3169 - spawning habitat)**

Three of 15 females (codes 27, 33, 34) were congregated immediately below Dauphine Rapids on June 13, the day before spring discharge for the MRAFP peaked at 589 m^3/s. All three fish moved 51 km downriver to the Powerplant ferry fixed station the next day and may have spawned near Dauphine Rapids on or around June 13.

Macrohabitat Use

Of the 94 manual relocations, 75 provided data on macrohabitat use (Table 4). Most relocations were made either in CHXO (45%) or OSB (29%) habitat types. Two

relocations were associated with sand bars and nine were associated with islands. Approximate depths at site of relocation ranged from 1.5 m to 6 m (mean, 3 m).

Sex-specific Migratory Behavior

In general, female fish were relocated more often, had higher movement rates, exhibited greater cumulative movement and ascended the MRAFP further upriver than male fish (Table 3). Males (n=14) were relocated 182 times and exhibited a total cumulative movement of 2318 km. Females (n=15) were relocated 193 times and exhibited a total cumulative movement of 3965 km. Mean relocation site was similar for males (rkm 3088.6) and females (3087.8) but females were found further upriver (maximum upriver relocation rkm 3192) than males (maximum upriver relocation rkm 3125). Mean movement rate for all males across all tracking periods was 7.8 km/day compared to 11.9 km/day for females. Females exhibited consistently greater movement rates by tracking period, especially during tracking period 3 (hydrograph peak) when females moved an average of 21.5 km/day compared to 1.6 km/day for males. No apparent difference in habitat use was observed between sexes other than females (n=9) were found in ISB habitats more than males (n=4).

Potential Egg Deposition Sites

Nineteen potential spawning sites were documented between the mouth of the Marias River and the Judith Landing boat launch. GPS coordinates for these areas are listed in Table 4; river location (rkm) estimates have yet to be calculated. Four of these areas (three upstream of Flat Creek and one upstream of Judith Landing) were assigned a

rank of one and are more likely to be utilized as spawning habitats than the other sites. In addition, several rapids were observed between Judith Landing and the Stafford Ferry during manual radio-tracking that are potential spawning habitats.

DISCUSSION

The bi-directional movements of paddlefish associated with increasing and decreasing discharges observed in the MRAFP is a phenomenon consistent with other studies. Berg (1981) found that paddlefish in the MRAFP in 1977-1979 did not make substantial movements above the FRB until flows surpassed 396 m^3/s. Firehammer and Scarnecchia (2006) reported that directional movements of paddlefish in the Yellowstone River 1999-2002 were strongly related to changes in discharge. Paukert and Fisher (2001) found that high flows (> 1400 m^3/s) from tributaries to Keystone Reservoir, Oklahoma appeared to direct upstream paddlefish migrations.

The bi-directional movements of telemetered fish in response to fluctuating flows during discharge period 2 may have implications on the exploitation by the fishery. The first two rises in discharge were separated by a sudden decrease in flows. This bimodal distribution of early season flows encouraged fish to move upriver from lower staging areas (i.e. Peggy's Bottom) to areas at or above the FRB and then downriver again. This likely resulted in greater exposure of fish to the harvest corridor (Lower Peggy's Bottom to the FRB) than if flows had steadily increased up to peak discharge. The potential for increased harvest was exacerbated in 2006 since the Slippery Ann area (a popular fishing site) was selected by several fish as an apparent area of retreat against declining discharges.

The likely use of the Powerplant Ferry area and Dauphine Rapids as spawning habitats indicated in this study is consistent with the findings of a previous study. Berg (1981) identified these areas, in addition to five sites upriver of the Powerplant Ferry and two sites downriver, as likely spawning grounds. However, the distribution of telemetry relocations in 2006 may not have adequately characterized the upriver extent of paddlefish movements. The MRAFP between the Powerplant Ferry and Judith Landing was not monitored by a fixed station during 2006. Moreover, only one manual tracking foray was made between Cow Island (rkm 3126) and Judith Landing (rkm 3192) during the seven day period of greatest flow in 2006 (June13-June20, $\leq$396 m^3/s).

The high number of fish classified as static migrants and early upriver-migrants (64% total) in this study may be explained by the magnitude and duration of peak discharge in 2006. Berg (1981) postulated that a minimum flow of 396 m^3/s was needed in 1977-1979 to direct paddlefish out of staging areas below the FRB to upriver spawning locations. In May and June of 2006, discharge met or exceeded 396 m^3/s for a relatively short period (seven days) compared to the 71-year average of 45 consecutive days (USGS 2006). Although the magnitude (589 m^3/s) and timing (June 14) of peak discharge in 2006 was similar to that of the 71-year average (583 m^3/s on June 16), there were only four consecutive days of steadily increasing discharge before the hydrograph peaked. Controlled releases from Tiber Reservoir on the Marias River in mid-June were in part responsible for the magnitude and timing of peak flow in 2006. This artificial discharge increase may not have adequately mimicked the duration of a traditional June rise. The ascending limb of the hydrograph may not have been long enough to provide a

reproductive cue to some fish and thus they ceased upriver migration and returned to the reservoir without spawning.

Another possible explanation for the number of static and early upriver-migrants may be related to the age of migrants and their energetic costs of migration. Scarnecchia et al. (in review), found that paddlefish harvested in lower reaches of the Yellowstone River during the spring were significantly older than those harvested at further upriver locations in 11 of 14 years studied. Older females ($\geq$ age-25) were found to have nearly depleted gonadal fat bodies but higher fecundity than younger females. Moreover, mark-recapture data indicated that older fish made fewer exploratory (i.e. long-range) movements and remained nearer suspected spawning sites. The early upriver-migrants and static migrants observed in the present study may have been older fish less prone to making prolonged upriver migrations. Alternatively, these fish may have utilized spawning habitats below the FRB that have yet to be identified. No age information was available for fish tagged in this study. However observation of the sexual maturation of females was possible during implantation and 14 of 15 fish had stage 4 (mature) eggs. Maturation stage of males was difficult to observe, however.

It is also possible some telemetered fish did not move above the FRB because they were under physiological stress brought on by the tag implantation process. Firehammer (2004) suggested that tagging stress may have suppressed upriver movements of telemetered paddlefish in the Yellowstone River. Hall et al. (1991) and Moser and Ross (1995) reported a similar occurrence in other large-river migratory fishes. Stress related behavior seems a likely explanation for the sudden downriver movement of two male fish (codes 11, 14) observed in the present study.

Although preliminary, the results from this study may provide some insight on the evident lack of reproduction of Fort Peck paddlefish (as indicated by low counts of age-0 fish) in 2006. The abundance of gravels and cobble, substrates previously shown to provide incubation sites for paddlefish eggs (Purkett 1961; Firehammer 2004), in reaches above the FRB make spawning habitat limitation an unlikely factor for recent poor reproduction. Likewise, the relatively high catch rate of paddlefish in 2005 (0.506 fish/hour; Leslie 2006) and number of fish harvested in 2006 (>400individuals) indicate a sizeable spawning stock. The apparent connection between upriver movements by paddlefish to potential spawning habitats with rising flows observed in 2006, on the other hand, suggests that spring discharge levels have a strong influence on migratory behavior and perhaps, the reproductive success of Fort Peck paddlefish. Moreover, low magnitudes and/or short duration of spring discharges may limit reproduction in ways not yet understood (i.e. poor hatching rates and delayed out migration of larvae). Continued research on migratory movements and spawning activity of adult paddlefish in the MRAFP will help identify limiting factors of reproduction.

PLANS FOR 2007

Radio-telemetry

An additional 30 paddlefish (15 males and 15 females) will be implanted with radio-tags in mid to late April, 2007. The radio-tags have been purchased and are the same model (Lotek Model 3L) and frequency (149.500 kHz) as those implanted in 2006. The same protocol for fish capture and tag implantation used in 2006 will be used in 2007.

Egg Deposition Sites

Potential egg incubation sites will be sampled in 2007 using a stratified random sampling approach. Each category 1 site will be defined as a stratum and three transects within each strata will then be sampled at random using a passive egg collection device described by Firehammer (2004) and modified extensively from McCabe and Beckman (1990). Collectors will consist of a 0.75m wide strip of furnace filter material secured around PVC cylinders 0.75m long and 0.15m in diameter. A 5.0 kg grappling anchor will be attached 0.5 m from one side of the cylinder with a 15 m buoyed float-line trailing the opposite side.

Each transect will have five collectors evenly spaced perpendicular to the shoreline across the width of the channel thalweg. Depth, water temperature, turbidity and time of day will be recorded during deployment of each set of collectors. Fishing time of collectors will be approximately 48 hrs. However, during periods of rapidly increasing discharge, collectors will be set for a maximum of 24 hours to avoid entanglement in debris flows.

Collectors will be visually inspected for the presence of eggs immediately after retrieval. Potential paddlefish eggs will be distinguished from most other species by their distinct steel-gray coloration. However, paddlefish eggs are visually indistinguishable from sturgeon eggs (Pasch et al. 1980). Therefore, potential paddlefish eggs will be preserved in 80% ethanol and shipped to the National Fish and Wildlife Forensics laboratory in Ashland, OR for genetic identification.

ACKNOWLEDGMENTS

We thank Bill Wiedenheft of the Montana Department of Fish, Wildlife and Parks (MFWP) for his support of this project. Bill Gardner of MFWP provided logistical support and the use and maintenance of fixed radio-telemetry receiving stations. Tim Roth and Stan Nogalski assisted with the radio-tag implantations. Lara Jarvis assisted in manual tracking and data management.

REFERENCES

Bramblett, R.G. 1996. Habitat and movements of shovelnose and pallid sturgeon in the Yellowstone and Missouri Rivers, Montana and North Dakota. Ph.D. Dissertation Montana State University, Bozeman.

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.

Firehammer, J.A. 2004. Spawning migration of adult paddlefish *Polyodon spathula* of the Yellowstone-Sakakawea stock in the Yellowstone and Missouri Rivers, North Dakota and Montana. Ph.D. Dissertation, University of Idaho, Moscow.

Firehammer, J.A., and D.L. Scarnecchia. 2006. Spring migratory movements by paddlefish in natural and regulated segments of the Missouri and Yellowstone Rivers, North Dakota and Montana. Transactions of the American Fisheries Society 135: 200-217.

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. American Fisheries Society, North Central Division, Special Publication 7, Bethesda, Maryland.

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

Bowersox, B.J. 2004. An investigation of paddlefish *Polyodon spathula* and their prey in Fort Peck Reservoir, Montana. Master of Science Thesis, University of Idaho, Moscow.

Hall, J.W., T.I.J. Smith, and S.D. Lamprecht. 1991. Movements and habitats of shortnose sturgeon *Acipenser brevirostrum* in the Savannah River. Copeia 1991: 695-702.

Kozfkay, J.F. and D.L. Scarnecchia. 2002. Year-class strength and feeding ecology of age-0 and age-1 paddlefish *Polyodon spathula* in Fort Peck Lake, Montana. Journal of Applied Ichthyology 18: 601-607.

Lein, G.M. and D.R. DeVries. 1998. Paddlefish in the Alabama River drainage: population characteristics and adult spawning migration. Transactions of the American Fisheries Society 127: 441-454.

Leslie, L.L. 2006. Middle Missouri River native species creel survey, Progress Report. Montana Department of Fish, Wildlife, and Parks. Helena.

McCabe, G.T. and L.G. Beckman. 1990. Use of an artificial substrate to collect white sturgeon eggs. California Fish and Game 76: 225-234.

Miller, S.M. and D.L. Scarnecchia. 2005. Spring migratory movements and spawning activity of paddlefish *Polyodon spathula* in the Yellowstone and Missouri Rivers

Montana and North Dakota, Annual Report. North Dakota Game and Fish Department. Bismarck.

Moser, M.L. and S.W. Ross. 1995. Habitat use and movements of shortnose and atlantic sturgeons in the lower Cape Fear River, North Carolina. Transactions of the American Fisheries Society 124: 225-234.

Pasch, R. and C.M. Alexander. 1986. Effects of commercial fishing on paddlefish populations. Pages 46-54 *in* J.G. Dillard, L.K. Graham and T.R. Russell, editors. The paddlefish: status, management and propagation. American Fisheries Society. North Central Division, Special Publication 7, Bethesda, Maryland.

Paukert, C.P. and W.L. Fisher. 2001. Spring movements of paddlefish in a prairie reservoir system. Journal of Freshwater Ecology 16: 113-123.

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

Ruelle, R. and P.L. Hudson. 1977. Paddlefish *Polyodon spathula*: growth and food of young of the year and a suggested technique for measuring length. Transactions of the American Fisheries Society 106: 609-613.

Scarnecchia, D.L., P.Stewart, and L.F. Ryckman. 1995. Management plan for the paddlefish stocks in the Yellowstone River, Upper Missouri River, and Lake Sakakawea. North Dakota Game and Fish Department and Montana Department of Fish, Wildlife, and Parks. Bismarck and Helena.

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. American Fisheries Society, North Central Division,

Special Publication 7. Bethesda, Maryland.

Stancill, W., G.R. Jordan, and C.P. Paukert. 2002. Seasonal migration patterns and site fidelity of adult paddlefish in Lake Francis Case, Missouri River. North American Journal of Fisheries Management 22: 815-824.

United States Geological Survey. 2006 Water resources data for Missouri River near Landusky MT retrieved October 18, 2006, from http://waterdata.usgs.gov/mt/.

Unkenholz, D.G. 1986. Effects of dams and other habitat alterations on paddlefish sport fisheries. Pages 54-64 in J.G. Dillard, L.K. Graham and T.R. Russell, editors. The paddlefish: status, management and propagation. American Fisheries Society, North Central Division, Special Publication 7. Bethesda, Maryland.

Winter, J. 1996. Advances in underwater biotelemetry. Pages 555-590 *in* B.R. Murphy and D. W. Willis, editors. Fisheries Techniques. Second Edition. American Fisheries Society, Bethesda, Maryland.

Table 1. Summary statistics for paddlefish tagged in the Missouri River above Fort Peck Reservoir in 2006. Number of contacts does not include initial capture. First letter in jaw tag number indicates color of jaw tag. M represents male, F represents female.

Code	*Jaw Tag*	*Sex*	*Length (cm)*	*Weight (kg)*	*Number of contacts*	*Furthest upriver contact (rkm)*	*Furthest downriver contact (rkm)*	*Mean movement rate (km/day)*	*Total movement (km)*	*Fate*
10	Y1007	M	90	5.6	2	3088.5	3044.2	5.6	87.75	at large
11	Y1011	M	85	10.4	0	-	-	-	-	at large
12	Y1013	M	89	9.9	22	3117.4	3074.8	7.9	266.1	at large
13	Y1012	M	97	13.1	16	3124.7	3036.9	10.1	284.1	at large
14	Y1014	M	99	15.9	1	-	-	-	7.24	at large
15	Y1008	M	93	10.6	20	3094.3	3012.9	6.3	314.2	at large
16	Y1016	M	86	8.1	8	3088.5	3062.4	3.8	70	at large
17	Y1019	M	92	9.5	22	3117.4	3090.9	4.5	184.7	at large
18	Y1024	M	104	16.3	13	3117.4	3052.3	12.9	194.7	at large
19	Y1036	F	109	22.7	22	3117.4	3034.6	6.2	218.6	at large
20	Y1004	M	88	6.8	3	3088.5	3074.8	4.7	13.6	at large
21	Y1010	M	89	10.4	20	3117.4	3072.8	9.4	252.5	at large
22	Y1021	M	93	12.3	5	3117.4	3055.7	17.5	117.9	at large
23	Y1005	F	126	28.3	10	3117.4	3057.7	4.7	145.1	at large
24	Y1025	F	116	23.4	3	3088.5	3074.8	2.8	23.3	at large
25	Y1009	M	83	5.7	5	3117.4	3074.8	17.3	95.9	at large
26	Y1026	M	94	10.2	18	3088.5	3034.6	5	191.1	at large
27	Y1027	F	118	25.0	13	3168.9	3035.1	19.1	434.8	at large
28	G0379	M	117	24.0	13	3117.4	3028.9	5.1	247.3	at large
29	Y1046	F	118	30.0	16	3117.4	3030.6	12.2	358.3	at large
30	Y1056	F	121	29.0	7	3094.9	3034.6	8.5	142.9	**shed**
31	Y1039	F	114	25.4	17	3117.4	3074.8	11.3	235.4	at large
32	Y1041	F	119	27.3	10	3119.4	3034.6	16.3	345	at large
33	Y1028	F	128	36.5	11	3168.9	3074.8	10.5	196.5	at large
34	Y1057	F	119	27.2	9	3192.3	3057.9	26.6	510.1	at large
35	Y1058	F	118	29.7	14	3117.4	3031.4	11.9	359.1	at large

36	Y1034	F	121	27.7	14	3117.4	304.2	10.5	303.8	at large
37	Y1063	F	100	19.1	14	3117.4	3055.5	14	295.4	at large
38	Y1030	F	125	30.2	6	3118.7	3074.8	12.8	98.8	at large
39	Y1065	F	122	30.2	10	3117.4	3034.6	12.9	299.2	at large

Table 2. Summary of river conditions and paddlefish movement rates during four different periods of spring discharge in the Missouri River above Fort Peck Reservoir in 2006.

Discharge period	*Dates*	*Mean discharge (m^3/s)*	*Discharge coefficient of variation*	*Mean temperature (C°)*	*Mean turbidity (ntu)*	*Total mean movement rate*	*Mean movement rate of females*	*Mean movement rate of males*
1	April 28-May 19	273.8	0.031	11.8	64.8	7.9	8.6	7.1
2	May 20-June 10	300.9	0.110	18.1	553.5	10.8	12.5	9.1
3	June 11-June 14	460.2	0.325	Insufficient data	Insufficient data	17.1	21.5	1.6
4	June 15-July 2	292.1	0.401	Insufficient data	Insufficient data	6.3	9.3	4.9

Table 3. Sex-specific radio-telemetry relocation summary for paddlefish tagged and released into the Missouri River above Fort Peck Reservoir in 2006.

Sex	*Total relocations*	*Total movement (km)*	*Mean movement rate (km/day)*	*Mean relocation site (rkm)*	*Furthest upriver relocation (rkm)*	*Furthest downriver relocation (rkm)*
Male	182	2318.2	7.8	3088.6	3124.7	3012.9
Female	193	3964.7	11.9	3087.8	3192.3	3030.6

Table 4. Site description of potential spawning locations observed in the Missouri River between the mouth of the Marias River and Judith Landing.

Site	*Latitude*	*Longitude*	*River Reach*	*Rank*
1	4755.968 N	11028.170 W	Marias to Virgelle	2-3
2	4756.361 N	11027.996 W	Marias to Virgelle	2-3
3	4757.489 N	11025.150 W	Marias to Virgelle	2-3
4	4757.029 N	11022.925 W	Marias to Virgelle	2-3
5	4758.601 N	11021.991 W	Marias to Virgelle	2-3
6	4800.167 N	11018.917 W	Marias to Virgelle	2-3
7	4801.035 N	11016.977 W	Marias to Virgelle	2-3
8	4802.292 N	11011.884 W	Virgelle to Flat Cr.	2-3
9	4800.000 N	11001.241 W	Virgelle to Flat Cr.	2-3
10	4759.115 N	11006.727 W	Virgelle to Flat Cr.	2-3
11	4757.949 N	11005.835 W	Virgelle to Flat Cr.	2-3
12	4755.848 N	11003.790 W	Virgelle to Flat Cr.	2-3
13	4751.580 N	11004.328 W	Virgelle to Flat Cr.	1
14	4750.637 N	11003.982 W	Virgelle to Flat Cr.	1
15	4749.463 N	11004.124 W	Virgelle to Flat Cr.	1
16	4745.650 N	10954.782 W	Virgelle to Flat Cr.	2-3
17	4745.313 N	10953.191 W	Virgelle to Flat Cr.	2-3
18	4742.731 N	10948.327 W	Flat cr. to Judith	1
19	4743.253 N	10941.684 W	Flat cr. to Judith	2-3