Annual Report for 2008

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

Progress Report for 2008
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: shannonmiller@vandals.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 Resources
University of Idaho
Moscow, ID 83843-1136

and

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

December 1, 2008

ABSTRACT

The 2008 spring migrations of adult paddlefish *Polyodon spathula* in the Missouri River between Fort Peck Reservoir and the Marias River, Montana were monitored by radio telemetry to examine the stock's migratory patterns and spawning activity. In general, radio-tagged fish of both sexes exhibited greater total movement, greater movement rates and moved further upriver in 2008 than in 2007 or 2006. Peak discharge in 2008 was of much greater magnitude (903 m^3/s) than in 2007 (450 m^3/s) or 2006 (589 m^3/s). The number of days above 396 m^3/s, the minimum flow postulated to be required for sustained upriver movement, was substantially greater in 2008 (50 days) than in 2007 (six days) or 2006 (seven days). Although paddlefish exhibited greater movement rates in 2008, flows did not appear to oscillate enough to result in the repeated upriver and downriver movements observed in 2006 and 2007. This abrupt and sustained rise likely resulted in less exposure of fish to the harvest corridor (Lower Peggy's Bottom to the FRB). This study's results to date provide insight on the direction and longitudinal distribution of migratory movements and the resulting harvest exposure of the Fort Peck paddlefish stock during the spring spawning migration. The apparent connection between upriver movements by paddlefish to potential spawning habitats with rising flows observed in 2008 suggests that spring discharge levels have a strong influence on migratory behavior and perhaps, the reproductive success of Fort Peck paddlefish. Plans for 2009 are to implant 30 more adult fish with radio-transmitters and continue monitoring of all radio-tagged fish.

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). Overharvest 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 between Fort Peck Dam and Lake Sakakawea) and the Fort Peck stock (inhabiting the Missouri River above Fort Peck Dam and Fort Peck Reservoir). 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 popular recreational snag fishery occurs each year in the area from the Fred Robinson Bridge (FRB) at the James Kipp campground to selected sites downriver. 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. As of 2008, a harvest cap of 500 fish has been placed on the Fort Peck paddlefish stock.

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. 2008). 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 (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 upriver migrants, the migration distance and the migration duration 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.

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 2008 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 inter-annual distance of ascent, total movement and rate of movement of radio-tagged fish in relation to the magnitude and duration of spring discharge, and 3) Investigate if sex-specific differences exist in migratory behavior.

STUDY AREA

The Fort Peck paddlefish stock inhabits the MRAFP between Fort Peck Dam upriver to Morony Dam, 24 km downstream of Great Falls, Montana. The riverine portion from Morony Dam to the reservoir headwaters is 336 km in length. Two major tributaries enter the river in this reach, the Marias River from the north and the Judith River from the south. Berg (1981) reported that 49 species of fish in 14 families were present in the combined river and reservoir areas. Gardner and Berg (1980) described the river reach as consisting of two fishery zones. The upper zone is a coldwater/warmwater transitional zone extending from Morony Dam to the mouth of the Marias River. Sauger *Sander canadensis* is the predominant game fish in the upper zone. The lower zone is a warmwater zone extending from the mouth of the Marias River downstream to the headwaters of Fort Peck Reservoir. Paddlefish are more common in the lower zone. Areas of the lower zone below the FRB are characterized by a wide meandering channel, with numerous sand bars, large islands, side channels and back waters. Areas of the lower zone above the FRB have coarser substrate types than below the FRB.

Runoff in the MRAFP typically peaks in June, associated with snowmelt. Mean monthly discharge in the MRAFP at the Virgelle gauging station (USGAS 10040101) over the period 1935 to 2006 has been highest in June (mean, 510 m^3/s) followed by May (mean, 377 m^3/s) and July (mean, 280 m^3/s).

METHODS

Fish Capture and Tag Implantation

Paddlefish migrations into the MRAFP were investigated with radio-telemetry. Drifted, floating gill nets 25 m in length (mesh size 12.7 cm) were used to capture mature paddlefish between May 14 and May 22, 2008. All capture sites were located below the FRB from river kilometer (rkm) 3075 (Slippery Ann area) down river to rkm 3044.

Nineteen paddlefish (16 males and 3 females) were selected for tagging. Males ranged in eye-to-fork length (Ruelle and Hudson 1977) from 86.4 cm to 111.8 cm (mean, 95.4 cm) and ranged in weight from 9.8 kg to 21.8 kg (mean, 13.4 kg). Females ranged in length from 111.8 cm to 123.2 cm (mean, 116.0 cm) and ranged in weight from 25.0 kg to 28.4 kg (mean, 27.0 kg; Table 1). A unique number, based on its transmitter code was assigned to each fish. A numbered, colored plastic jaw tag or uncolored metal jaw tag (poultry band) was also 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.

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. Seventeen of nineteen tags implanted during 2008 were individually coded to operate continuously on a radio frequency of 149.540 kHz. Two fish (males) were implanted with tags operating on the 149.500 kHz frequency; these tags were previously implanted during the 2006 and 2007 seasons and recovered during harvest. Each tag had an estimated battery-life of 4.5 years. 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 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 pumped 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 Department of 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 3170.5 (Stafford Ferry), rkm 3192 (Judith Landing), rkm 3272.8 (Virgelle), the mouth of the Marias River, and 4.8 km up 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 extended from the headwaters of Fort Peck Reservoir to the FRB (rkm 3000 to rkm 3090). Section 2 extended from the FRB to 13 rkm above the Powerplant Ferry (rkm 3090 to 3190). Section 3 extended from 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. During fluctuating flows on the ascending limb of the hydrograph (discharge period 1: May 1 - May 24) tracking was concentrated on sections 1 and 2. During the peak of spring discharge (discharge period 2: May 25 – June 15) tracking was concentrated further upriver on sections 2 and 3. After peak discharge (discharge period 3: June 16 and later), tracking was concentrated further downriver on sections 1 and 2. Less effort was applied to manual tracking in 2008 than in 2006 or 2007 for two reasons. First, flow conditions made gillnetting fish for radio-tag implantations and jaw tagging inefficient. Therefore, more time and effort was expended towards gillnetting than in previous years. Second, efforts to collect larval fish and eggs during the peak flow period reduced the area that was manually monitored for radio-tagged fish.

Once a radio-tagged fish was located, a global positioning unit (GPS) was used to record latitude, longitude, and the approximate rkm of contact sites. At each contact 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 contact, or if the structure induced an observed change in the current pattern at the contact, 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 upriver of the FRB.

Data Analysis

Telemetry contacts were assigned a river kilometer and date to reconstruct the longitudinal distribution of each fish's spring migration. Each individual migration was then graphed to assess migration patterns in relation to changes in river discharge. The distance moved between contacts was calculated as the absolute value of the difference between the river kilometer locations of consecutive contacts. Movement rates (km/day) were calculated as the distance moved between consecutive contacts divided by the number of days between contacts. Only movements for which the number of days elapsed between contacts was less than or equal to seven days were included in analyses. Total movement was calculated for each fish as the sum of the distances between all consecutive contacts. The furthest upriver contact of each individual fish was recorded and a mean for females and males was calculated. The three response variables (movement rate, total movement and furthest upriver contact) were assessed for normality and the differences in means were assessed between sexes and years with two-sample t-tests. The SAS 9.1 computer software program (SAS Institute Inc., Cary, NC) was used to perform statistical analyses; a significance level of $\alpha = 0.05$ was used for hypothesis testing.

RESULTS

Fate of Tags

All 19 fish (three females, 16 males) tagged in 2008 were contacted at least once during the 2008 field season (Table 1). Eighteen fish (six females, 12 males) tagged in 2006 were contacted during the 2008 season (Table 2). One of these fish (a 28-kg female) was only contacted at the Virgelle fixed station. Seven fish (two females, five males) tagged in 2007 were contacted during the 2008 season (Table 3). Two of these fish (a 25-kg female, a 28-kg female) were only contacted at the Virgelle fixed station. Manual tracking yielded 92 contacts and the fixed stations recorded 355 contacts for a total of 447 telemetry contacts.

Distance of Ascent

Mean location site for all telemetry contacts in 2008 was rkm 3115.7, approximately two kilometers downriver of the fixed receiving station at the Powerplant Ferry. More contacts (combined fixed station and manual) were made in river section 1 (rkm 3000 – 3090, 244 contacts) than in river section 2 (rkm 3090 -3130, 138 contacts) or river section 3 (rkm 3130 – 3192, 65 contacts). Combining fixed station and manual tracking data, more contacts were made during discharge periods 2 (peak discharge; 221 contacts) and 3 (post-peak discharge; 139 contacts) than discharge period 1 (pre-peak discharge; 87 contacts). The furthest upriver fixed station contact was at rkm 3272.8 (Virgelle). Sixteen of 31 males (52%) and nine of 10 females (90%) contacted by telemetry during 2008 were contacted at least once at the Virgelle fixed station. The furthest upriver manual relocation was at rkm 3137.5 (30 rkm upriver of the Powerplant Ferry). This contact was recorded for a 27 kg female on June 9. The furthest downriver manual contact was at rkm 3052 (three rkm downriver of Turkey Joe launch). Three males were contacted at this site on May 21.

Direction and Rate of Movement

Directional movements of telemetered paddlefish in the MRAFP were associated with changes in discharge. The relationship between changes in discharge and directional movements evidently weakened when the distance between relocations increased. For example, 83 of 102 (81%) upriver movements greater than 10 rkm occurred during periods of increasing discharge whereas 22 of 28 (79%) upriver movements greater than 40 km occurred during increasing flows. A similar pattern was observed for downriver movements. For example, 42 of 75 (56%) downriver movements greater than 10 rkm occurred during falling discharges while only 11 of 23 (48%) of downriver movements greater than 40 km occurred during decreasing flows.

Telemetered paddlefish exhibited greater rates of movement during increasing and peak discharges (tracking periods 1,2) than during periods of sustained decreases in discharge (tracking period 3). Mean rate of movement for males and females combined over the entire 2008 tracking period was 15.5 km/day. A combined (males and females) mean movement rate of 17.5 km/day was observed during period 1 (May 1-May 24). This rate changed little during period 2 (May 25-June 15, 17.4 km/day) but decreased substantially during period 3 (June 16 and later, 11.3 km/day).

Migratory Patterns

Two general migratory patterns for telemetered fish were observed in 2008. Only general patterns are presented here; individual migration histories are provided in Appendix 1. Pattern 1 included fish categorized as *peak- flow upriver migrants* (Figure 1). Peak flow upriver-migrants were not contacted more than 5 km above the FRB until flows surpassed 300 m^3/s (10600 cfs) during discharge period 1. These fish either remained above the FRB during peak discharge (discharge period 2), or made repeated upriver/downriver movements during discharge periods 1 and 2. Twenty-seven of 33 males (82%) and nine of 10 females (90%) exhibited this pattern.

Pattern 2 included fish categorized as *static migrants* (Figure 2). Static migrants either made no observed upriver movements or if upriver movement did occur, it did not extend more than 5 km past the FRB. Six of 33 males (18%) and one of 10 females (10%) exhibited this pattern.

Paddlefish Congregations

Congregations of fish were observed in specific areas above the Fred Robinson Bridge during 2008. Three main congregation areas were identified in 2008:

- **Two Calf Island / Heller Rapids Area (rkm 3100 -3110)**

  On June 5, four of 33 males (12%) were contacted just upriver of Two Calf Island. All four fish were congregated within 1 km of one another. These contacts occurred after flows had remained above 700 m^3/s for 10 days. On June 16, three of 33 males (9%) were contacted immediately below Heller Rapids. These contacts occurred two days after discharge had peaked for the year at 903 m^3/s.

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

  On May 25, eight of 33 males (24%) and one female were contacted just downriver of the Powerplant ferry. These contacts occurred on the first day of discharge period 3 when flows surpassed 400 m^3/s for the first time during the hydrograph's steep incline towards peak flow. On June 9, six of 33 males (18%) were contacted downriver of the Powerplant Ferry. These contacts occurred after flows had remained above 700 m^3/s for 14 consecutive days.

- **Cow Island Area (rkm 3125 – 3133)**

  On June 9, two males and one female were found congregated near Cow Island. Similar to the congregation that occurred near the Powerplant Ferry, these contacts were made after flows had remained above 700 m^3/s for 14 consecutive days.

Macrohabitat Use

Of the 92 manual telemetry contacts, 74 were assigned a specific habitat type. A majority of contacts were made either in CHXO (31%) or OSB (28%) habitat types. Approximately one third of contacts were associated with either islands or ISB habitat types (11 contacts each). Eighteen of the 92 (19.5%) manual contacts occurred very near shore in flooded vegetation and were not assigned a specific habitat type.

Sex-specific Migratory Behavior

Male fish were typically contacted more often, exhibited greater cumulative movement and ascended the MRAFP further upriver than female fish. Females exhibited consistently higher rates of movement than did males. Males (n=31) were contacted 391 times and exhibited a total cumulative movement of 7880 km (mean 252 km/individual).

Females (n=10) were contacted 56 times and exhibited a total cumulative movement of 1114 km (mean 111.4 km/individual). Mean contact site was similar for males (rkm 3111) and females (rkm 3124) but males were found further upriver (mean maximum upriver contact rkm 3180) than females (mean maximum upriver contact rkm 3161). Mean movement rate for all males across all tracking periods was 16.9 km/day compared to 21.4 km/day for females.

Inter-annual Differences

In general, radio-tagged fish of both sexes exhibited greater total movement, greater movement rates and moved further upriver in 2008 than in 2007 or 2006. For both sexes combined, fish contacted in 2008 showed significantly greater movement rates (t-test, $p < 0.0001$) and maximum upriver contact (t-test, $p < 0.0001$) than fish in 2006. Cumulative movement between 2008 and 2006 was not significantly different (t-test, $p = 0.29$). Fish contacted in 2008 exhibited significantly higher movement rates (t-test, $p < 0.0001$), cumulative movement (t-test, $p = 0.002$) and maximum upriver contact (t-test, $p < 0.0001$) than in fish 2007.

Distinct differences in the MRAFP spring hydrograph were evident among the three years as well. Peak discharge in 2008 was of much greater magnitude (903 m^3/s on June 14) than in either 2007 (450 m^3/s on June 10) or 2006 (589 m^3/s on June 14). Mean discharge levels for the months of May (307 m^3/s) and June (749 m^3/s) 2008 were also greater than in 2007 (May, 264 m^3/s; June, 303 m^3/s) or 2006 (May, 293 m^3/s; June, 334 m^3/s). Moreover, the number of days above 396 m^3/s, the minimum flow required for sustained upriver movement postulated by Berg (1981), was substantially greater in 2008 (50 days) than in 2007 (six days) or 2006 (seven days). The prolonged high flows in

2008 were also less flashy than flows in 2007 or 2006. For example, the coefficient of variation for discharge in June 2008 ($C_v = 0.16$) was less than in June 2007 ($C_v = 0.27$) or June 2006 ($C_v = 0.35$) indicating a lesser occurrence of abrupt rising and falling discharges in 2008 than in 2007 or 2006.

DISCUSSION

The greater total movement, rate of movement and upriver distance of ascent of paddlefish observed in 2008 (a high water year) compared to 2007 and 2006 (low water years) is a phenomenon in accord with some studies but not with others. Paukert and Fisher (2001) found that paddlefish ascended further up the Arkansas and Salt Fork rivers of Oklahoma in a year when discharges exceeded 1500 m^3/s but that fish remained further downriver during lower flow years. Purkett (1961) observed more fish in upriver areas of the Osage River, Missouri during a year with prolonged high discharges than in a year of rapidly rising and falling spring discharges. Conversely, Firehammer and Scarnecchia (2007) did not find significant inter-annual differences in the distance of ascent of fish in the Yellowstone River despite inter-annual variations in the spring hydrograph. In their study, peak flows for all four study years failed to surpass the 50 year median peak flow recorded for the Yellowstone River. In our study, however, peak flow during 2008 (903 m^3/s) surpassed the 74 year median peak flow by nearly 300 m^3/s. Moreover, peak flow in 2008 represented an approximate two fold increase over that of 2007 (450 m^3/s) or 2006 (589 m^3/s). Such extreme inter-annual differences in discharge may have elicited migratory responses from paddlefish not observed by Firehammer and Scarnecchia (2007).

A decrease in the occurrence of repeated bi-directional movements by paddlefish during 2008 compared to 2007 and 2006 may also be related to inter-annual differences in discharge in the MRAFP. Firehammer and Scarnecchia (2006) and Miller and Scarnecchia (2008) reported that the rate of change rather than the magnitude of discharge had a stronger influence on repeated upriver and downriver movements of paddlefish in the Yellowstone River. In our study, spring flows during 2008 monotonically increased towards the peak of the hydrograph and exhibited fewer abrupt increases and decreases in comparison to 2007 and 2006. Thus, although paddlefish exhibited greater movement rates in 2008, flows did not appear to oscillate enough to result in the repeated upriver and downriver movements previously observed.

The bi-directional movements of telemetered fish in response to rising and falling discharge may have implications on the exploitation by the fishery. Fluctuations in discharge in 2006 and 2007 prior to the June rise 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. These discharge fluctuations likely resulted in greater exposure of fish to the harvest corridor (Lower Peggy's Bottom to the FRB) in those years than 2008, when discharge rose steadily to a peak.

The likely use of the Two Calf Island, Powerplant Ferry and Cow Island areas as spawning habitats indicated in this study is consistent with the findings of a previous study. Berg (1981) identified these areas, in addition to others as likely spawning grounds. Moreover, the prevalence of fish contacted by the fixed receiving station near Virgelle (rkm 3272.8) indicates that during high flow years fish may utilize spawning areas further upriver than previously expected. However, manual tracking did not occur above Judith Landing (rkm 3192) during 2008 and thus specific congregations of paddlefish were not recorded for that river section.

Presumed staging areas below the FRB (e.g. Swirl Hole area, rkm 3060 and Slippery Ann area, rkm 3080) identified from telemetered fish in 2006 and 2007 were not made evident from telemetered fish in 2008. Again, these differences may be related to inter-annual differences in discharge patterns. The lack of repeated rises and declines in discharge as well as relatively low discharge levels prior to the abrupt, ascending limb of the hydrograph in 2008 may not have cued fish to congregate for extended periods downriver of the FRB. This idea is supported by the extremely low catches observed during gillnetting efforts prior to peak flows during 2008 (< 40 fish) compared to 2006 and 2007 (> 400 fish each year).

The high proportion of fish observed to make prolonged ascensions above the FRB in 2008 conflicts with results from 2006 and 2007. In the earlier years, fish exhibiting the static migrant pattern (e.g. little or no movement upriver of the FRB) represented nearly one half of the total telemetered fish. In 2008, only 18% of males and 10% of females exhibited this pattern of a limited migration range. Moreover, a third pattern was observed in the earlier years described as *early upriver migrants*. These fish made early movements above the FRB before peak flows then made repeated upriver/downriver movements during later discharge periods. This pattern was not evident in 2008. These results suggest that sudden, sustained high flows such as those observed in 2008 may not only encourage fish to move further upriver but may also discourage premature movements to presumed spawning areas.

In addition to larger scale migratory behaviors, it is likely that high flows may influence microhabitat use by paddlefish as well. In 2008, a greater proportion of fish were associated with microhabitats that provide a current break than in 2007 or 2006. In 2006 and 2007 for example, approximately 75% of manual contacts were made in deepwater, main channel habitat types (e.g. OSB or CHXO). In 2008, on the other hand, only 60% of contacts were made in such areas. Moreover, nearly 20% of manual contacts in 2008 were made in near shore in areas of flooded vegetation, a phenomenon not seen in 2006 or 2007.

The results from this study, although not final and not integrated with results of reproductive success as indicated by larval fish sampling, 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 and 2007. 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 causal 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 2008, 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 (e.g. 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.

ACKNOWLEDGMENTS

Funding for this project is provided by the Montana Department of Fish, Wildlife, and Parks (MFWP). We thank Bill Wiedenheft and Bill Gardner of MFWP for providing logistical support and the use and maintenance of fixed radio-telemetry receiving stations. We also thank Steve Leathe and PPL Montana for their interest in and support for this work. Tim Roth and Holly Dennis provided field assistance.

REFERENCES

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.

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.

Firehammer, J.A., and D.L. Scarnecchia. 2007. The influence of discharge on duration, ascent distance, and fidelity of the spawning migration for paddlefish of the Yellowstone-Sakakawea stock, Montana and North Dakota, USA. Environmental Biology of Fishes 78: 23-36.

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.

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.

Miller, S.M. and D.L. Scarnecchia. 2008. Adult paddlefish migrations in relation to spring river conditions of the Yellowstone and Missouri Rivers, Montana and North Dakota, USA. Journal of Applied Ichthyology 24: 221-228.

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., L.F. Ryckman, B.J. Smitz, S. Gangl, W.Weidenheft, L.L. Leslie, and Y. Lim. 2008. Management plan for the Montana and North Dakota paddlefish stocks and fisheries. A Cooperative Interstate Plan. Montana Department of Fish, Wildlife and Parks and North Dakota Game and Fish Department. Helena, MT and Bismarck, ND.

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 radio-tagged in the Missouri River above Fort Peck Reservoir in 2008 and tracked in 2008. Number of contacts does not include initial capture. First letter in jaw tag number indicates color of jaw tag; S denotes use of a metal poultry band. M represents male, F represents female. All tags were operating on the 149.540 kHz frequency except codes 52 and 19 (149.500 kHz).

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*
19	Y-1836	M	92.7	14.5	9	3272.9	3074 8	62 3	498.5	at large
40	S-1359	M	86.4	10.0	8	3127.5	3074.8	8.5	132.9	at large
41	Y-1834	M	86.4	14.1	12	3117 4	3066.1	6.7	153 1	at large
42	Y-1845	M	99 0	14.3	16	3113.4	3074.8	6.4	153.7	at large
43	Y-1841	M	100.3	14.1	14	3098.0	3074.8	5.4	75.0	at large
44	Y-1842	F	123.2	28.4	5	3117.4	3074.8	13.1	71.6	at large
45	Y-1839	F	111.8	25.0	5	3117.4	3074.8	7 2	71.6	at large
46	Y-1840	M	92.7	10.0	18	3117.4	3074.8	7.4	216.6	at large
47	S-1361	M	95.3	11.4	8	3272.9	3074.8	43.1	404.2	at large
48	Y-1835	M	87.6	9.8	16	3272.9	3074.8	20.2	451 2	at large
49	Y-1843	M	95.3	11.4	10	3120.6	3113.4	0.40	11.3	at large
50	Y-1844	M	86 4	14.5	17	3117.4	3052.2	24.0	522.2	at large
51	Y-662	M	100.3	14.1	12	3272.9	3074.8	28.6	632 8	at large
52	Y-1837	M	91.4	11.4	11	3192.3	3074 8	26.1	445 2	at large
53	Y-1846	M	101.6	14.1	6	3272.9	3055 5	11.2	217 4	at large
54	Y-1848	M	99.0	15.2	15	3088.5	3074 8	1.3	20.9	at large
56	Y-1850	M	111.8	48	8	3114 7	3074 8	7 5	128 7	at large
58	Y-1849	F	113.0	27.7	4	3272.9	3074 8	49.5	198 0	at large

Table 3. Summary statistics for paddlefish radio-tagged in the Missouri River above Fort Peck Reservoir in 2006 and contacted in 2008. First letter in jaw tag number indicates color of jaw tag. M represents male, F represents female. All codes on 149.500 kHz frequency. Movement rates calculated only for fish with more than two contacts. Contacts seperated by more than seven days not included in movement rate calculations.

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*
11	Y1011	M	85	10.4	2	3117.4	3088.4	N/A	N/A	at large
12	Y1013	M	89	9.9	12	3117.4	3074.8	7.5	158.0	
14	Y1014	M	99	15.9	17	3117.4	3072.9	7.1	171.8	
15	Y1008	M	93	10.6	9	3272.8	3074.8	29.6	420.3	
16	Y1016	M	86	8.1	13	3104.6	3070.3	4.5	68.1	
17	Y1019	M	92	9.5	2	3126.3	3073.2	N/A	N/A	at large
18	Y1024	M	104	16.3	14	3272.8	3074.8	22.5	442.3	
20	Y1004	M	88	6.8	8	3272.8	3074.8	46.4	808.4	
21	Y1010	M	89	10.4	11	3105.4	3073.2	7.5	142.9	
23	Y1005	F	126	28.3	2	3272.8	3272.8	N/A	N/A	at large
24	Y1025	F	116	23.4	2	3088.4	3088.4	N/A	N/A	at large
25	Y1009	M	83	5.7	9	3272.8	3073.6	23.3	416.6	
28	G0379	M	117	24.0	6	3192.2	3088.5	14.8	197.9	at large
29	Y1046	F	118	30.0	6	3117.4	3088.4	11.6	115.8	
32	Y1041	F	119	27.3	3	3117.4	3088.4	N/A	32.3	
34	Y1057	F	119	27.2	7	3272.8	3088.4	36.8	553.2	at large

Table 4. Summary statistics for paddlefish radio-tagged in the Missouri River above Fort Peck Reservoir in 2007 and contacted in 2008. First letter in jaw tag number indicates color of jaw tag. M represents male, F represents female. All codes on 149.500 kHz frequency. Movement rates calculated only for fish with more than two contacts. Contacts seperated by more than seven days not included in movement rate calculations.

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*
42	R850	F	115.5	25.0	2	3272.8	3272.8	N/A	N/A	
43	R848	M	83.8	9.0	13	3117.4	3058.7	8.5	152.8	
46	R841	M	92.7	12.3	6	3088.4	3074.8	9.1	41.0	
50	R836	F	111.7	28.0	2	3272.8	3272.8	N/A	N/A	
56	R844	M	96.5	12.7	9	3117.4	3074.8	8.0	73.5	at large
59	R860	M	92.7	13.2	4	3170.5	3088.4	14.5	82.0	at large
69	R856	M	89.0	10.0	3	3170.5	3090.8	N/A	106.2	at large

Figure 1. An example of the spring migration of a paddlefish in Missouri River above Fort Peck Reservoir categorized as an "peak-flow upriver migrant". Open triangles indicate a manual tracking contact; closed symbols are fixed station contacts. The horizontal line represents the approximate location of the Fred Robinson Bridge.

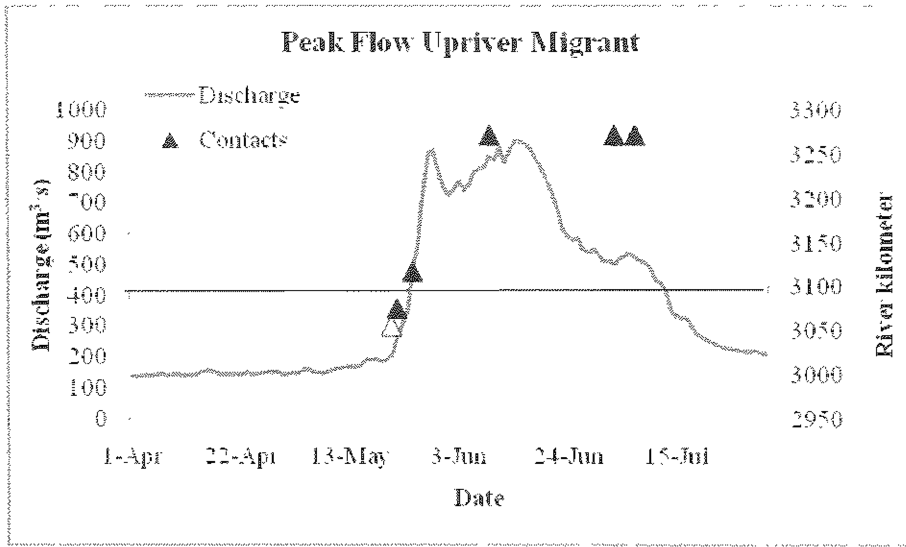
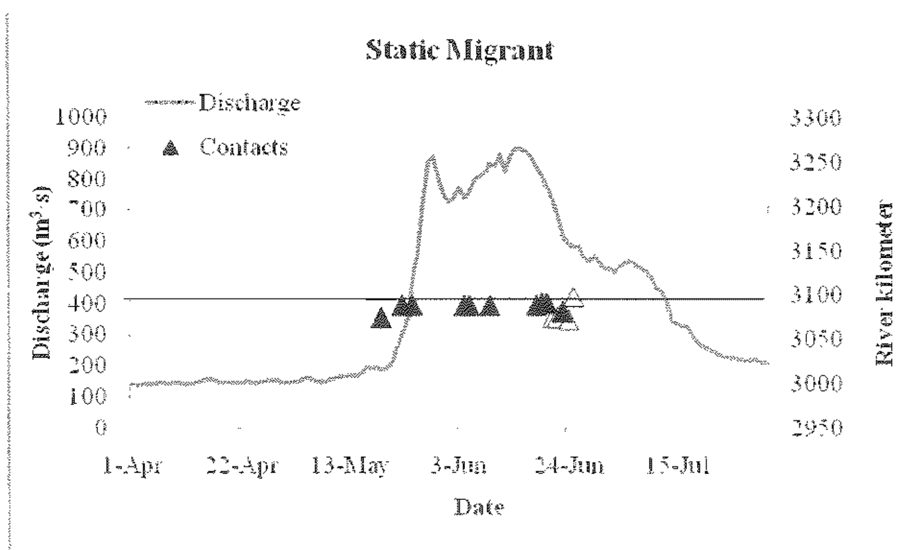
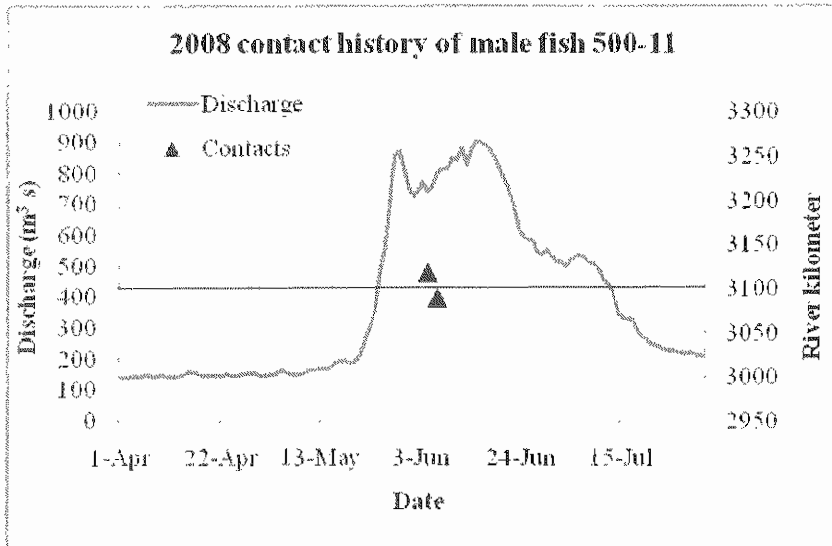
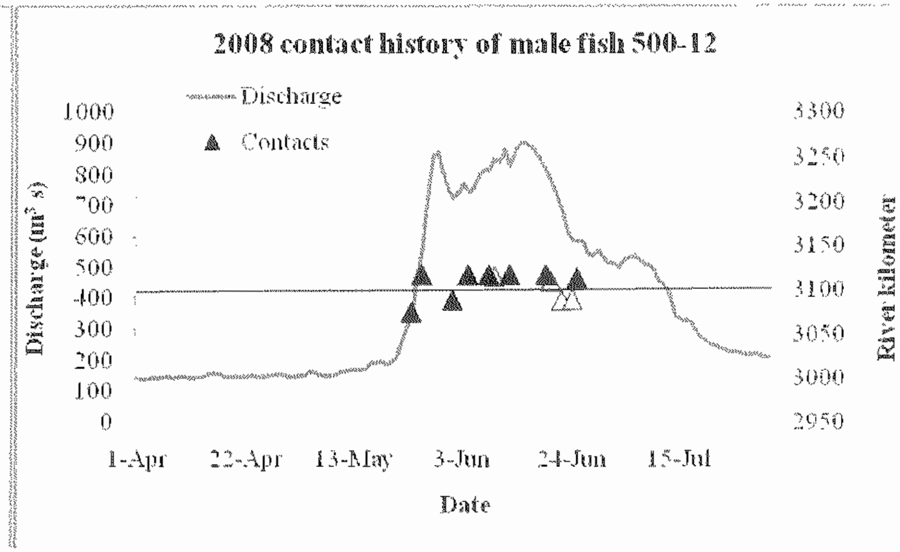


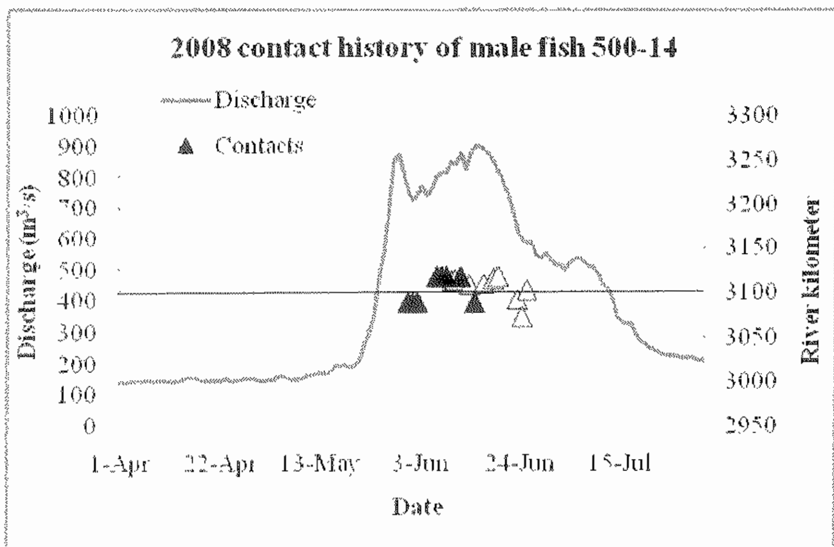
Figure 3. An example of the spring migration of a paddlefish in Missouri River above Fort Peck Reservoir categorized as a "static migrant". Open triangles indicate a manual tracking contact; closed symbols are fixed station contacts. The horizontal line represents the approximate location of the Fred Robinson Bridge.

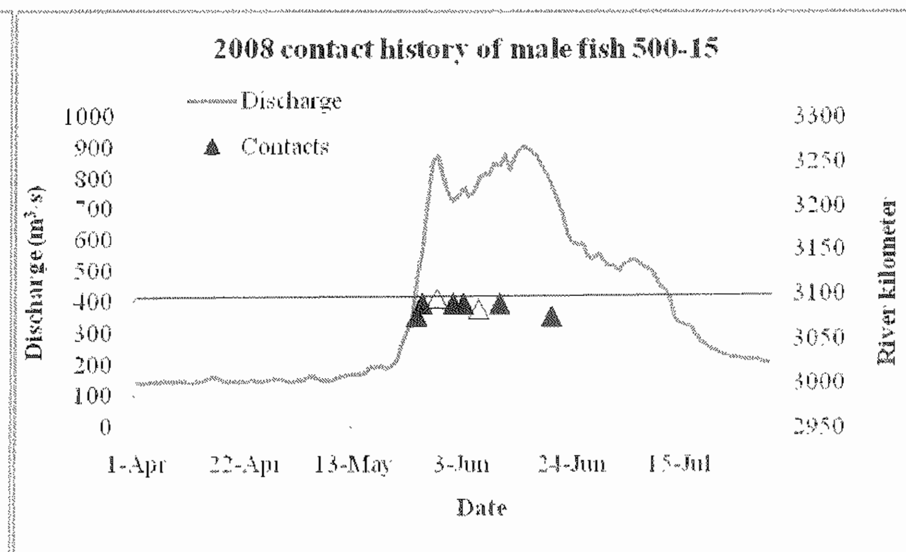


Appendix 1. Contact histories of paddlefish monitored with radio-telemetry in the Missouri River above Fort Peck Reservoir in 2008. The three digit number refers to the frequency (e.g. 500 for 149.500 kHz) and the two digit number refers to the fish code. Closed symbols denote a fixed station contact; open symbols denote a manual contact. Discharge is for the Missouri River near the Fred Robinson bridge (position denoted by solid horizontal line).

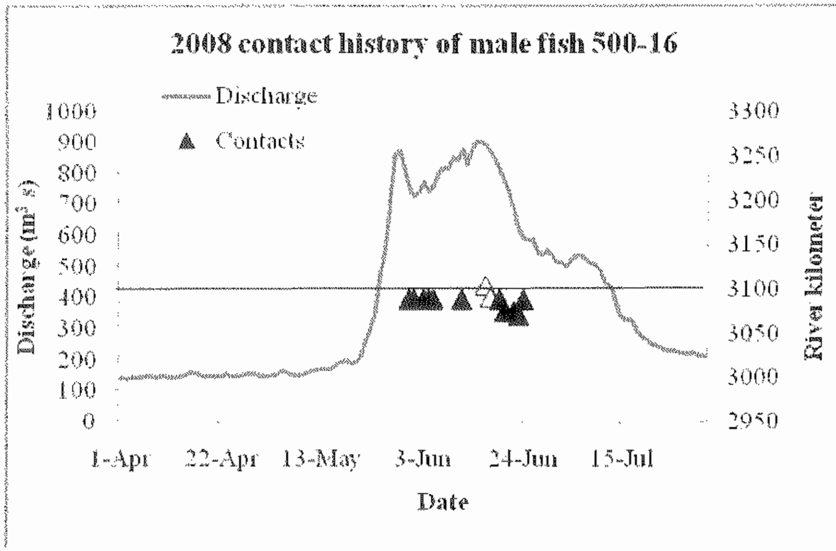


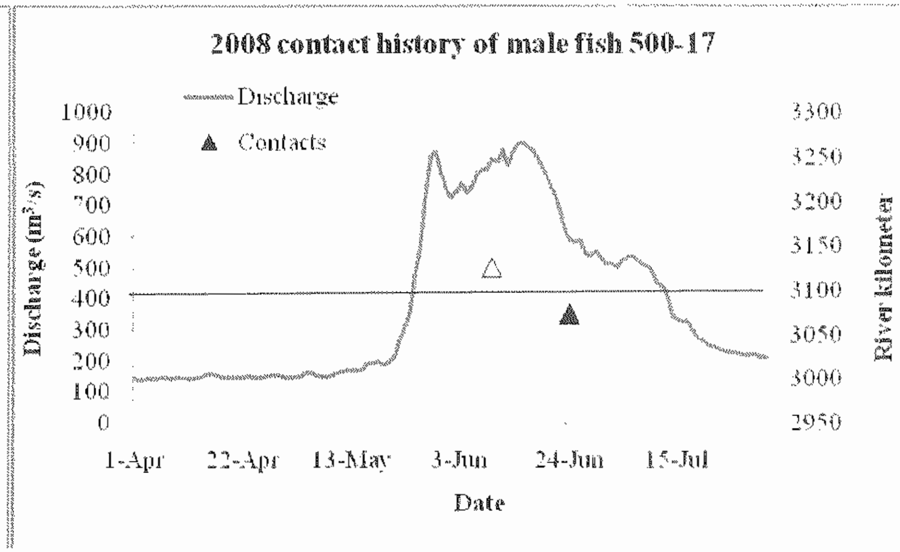


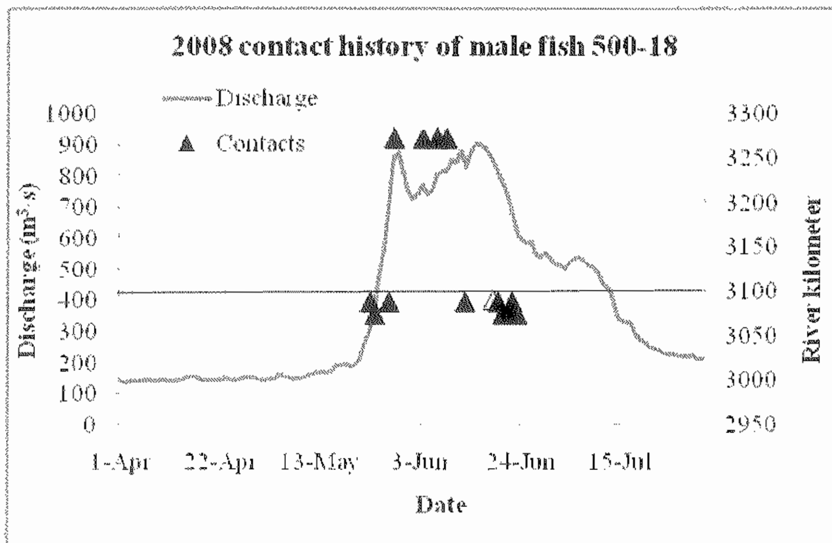


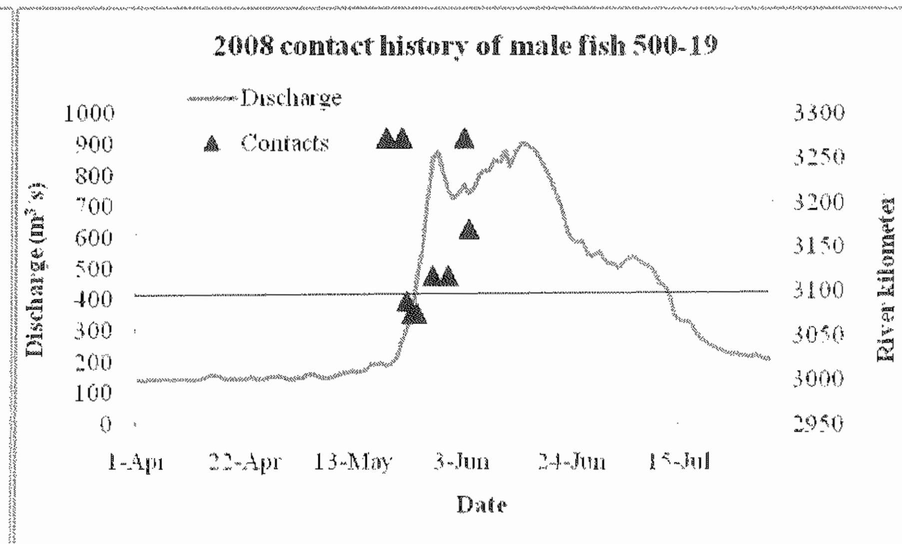


Appendix 1. Contact histories of paddlefish monitored with radio-telemetry in the Missouri River above Fort Peck Reservoir in 2008. The three digit number refers to the frequency (e.g. 500 for 149.500 kHz) and the two digit number refers to the fish code. Closed symbols denote a fixed station contact; open symbols denote a manual contact. Discharge is for the Missouri River near the Fred Robinson bridge (position denoted by solid horizontal line).

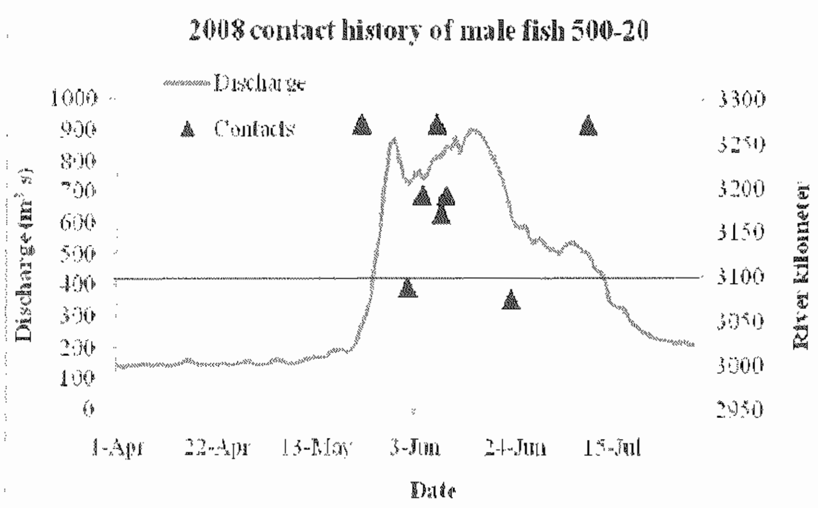


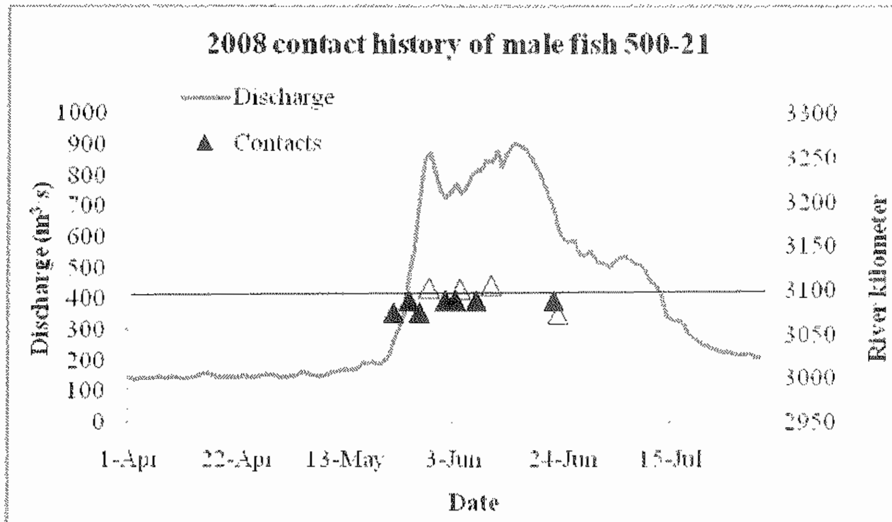


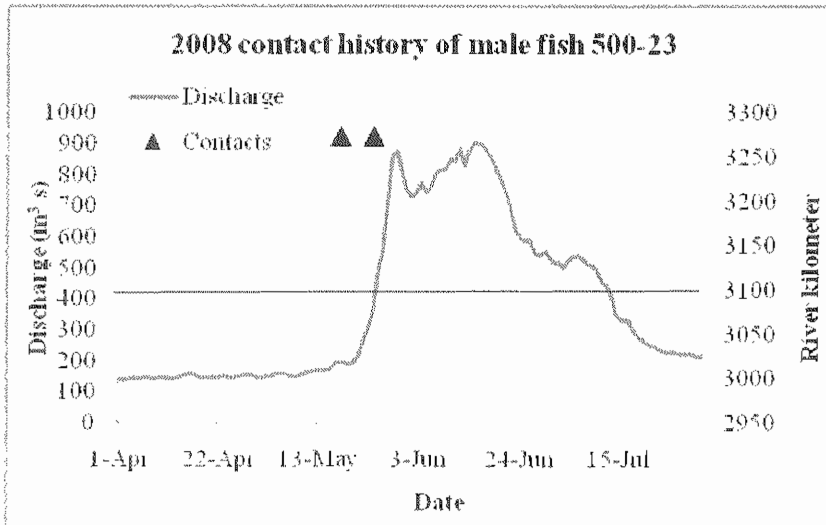


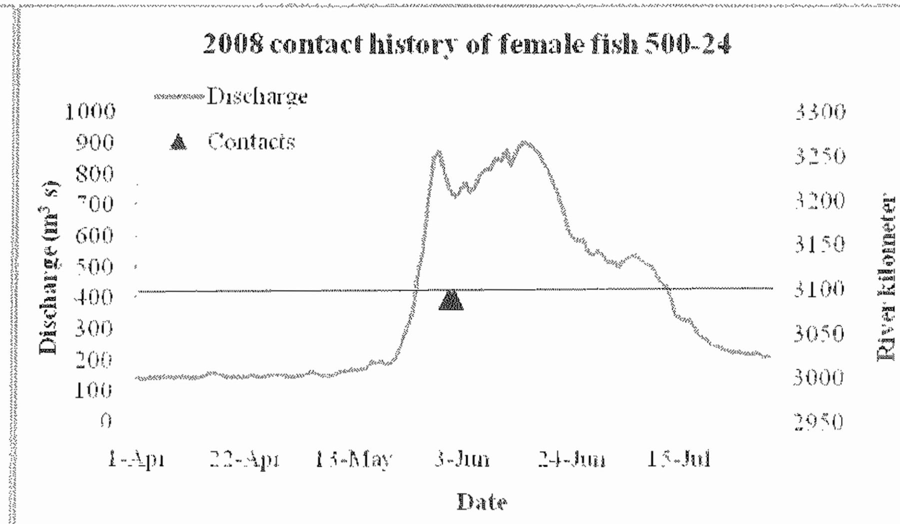


Appendix 1. Contact histories of paddlefish monitored with radio-telemetry in the Missouri River above Fort Peck Reservoir in 2008. The three digit number refers to the frequency (e.g. 500 for 149.500 kHz) and the two digit number refers to the fish code. Closed symbols denote a fixed station contact; open symbols denote a manual contact. Discharge is for the Missouri River near the Fred Robinson bridge (position denoted by solid horizontal line).

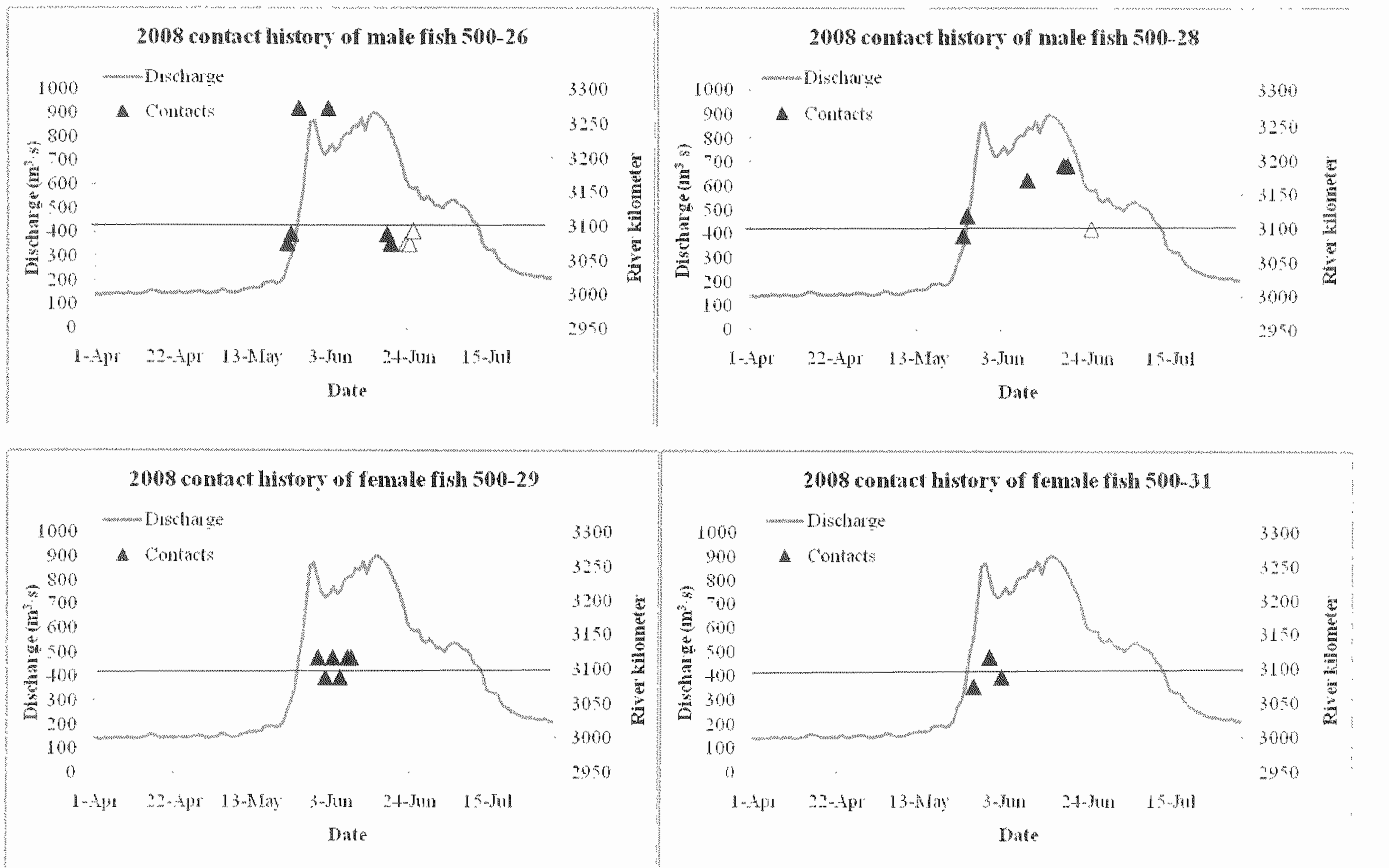




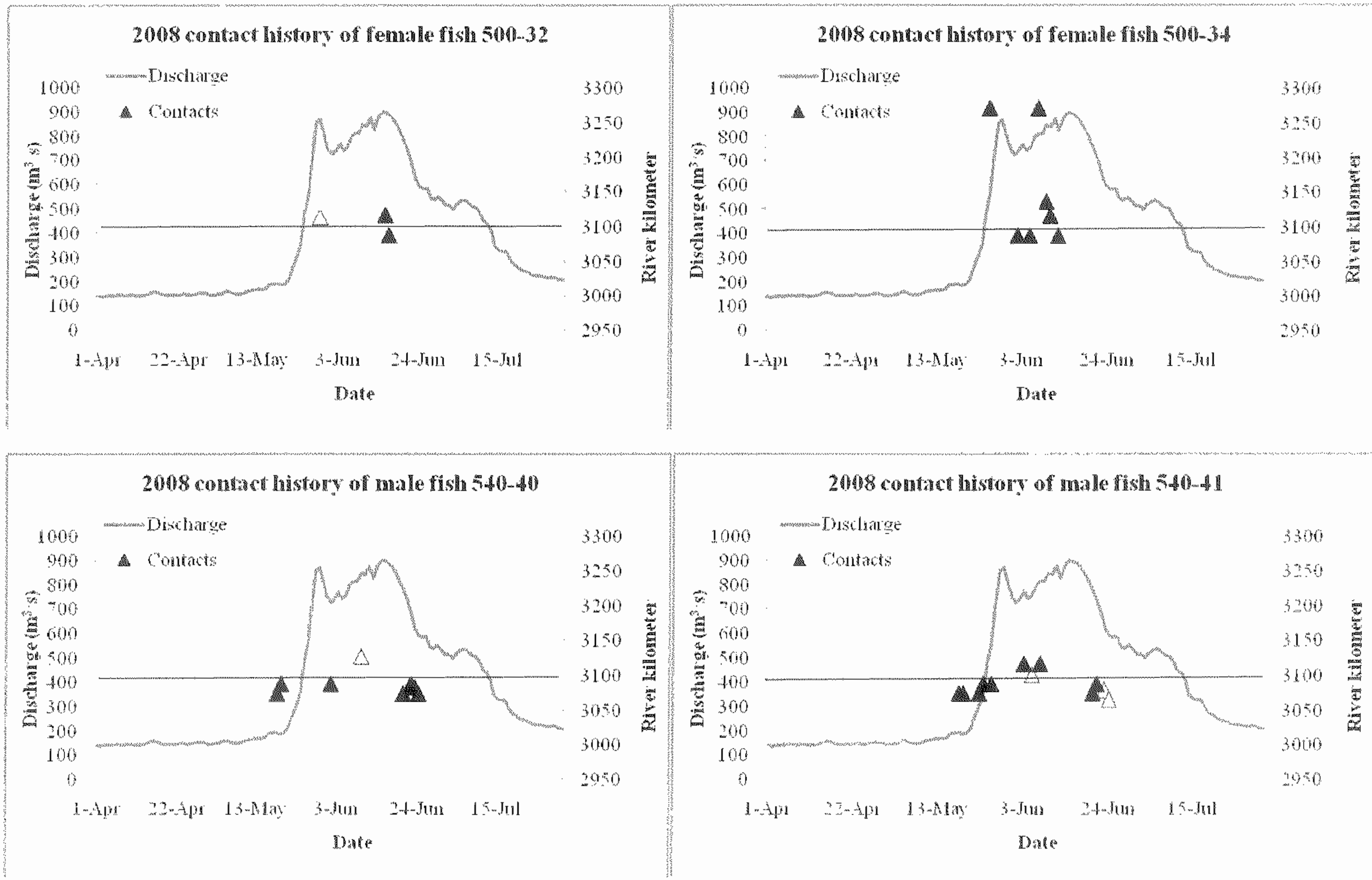




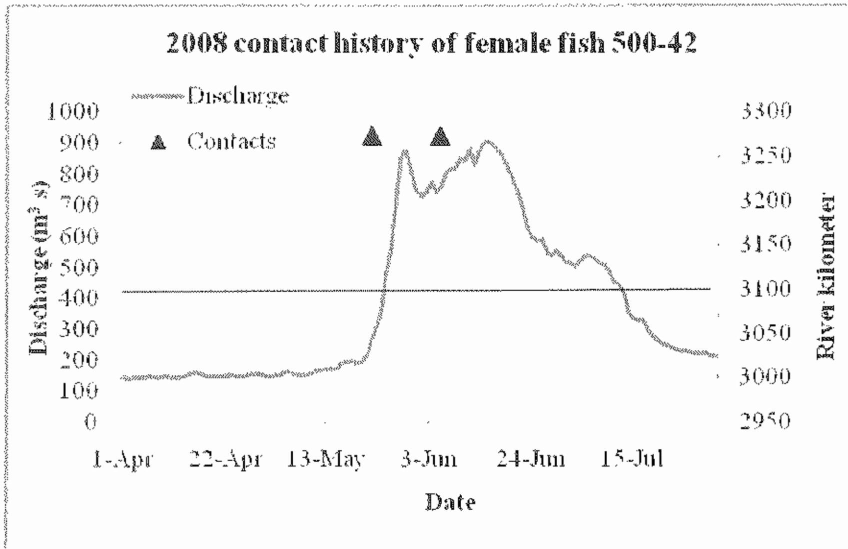
Appendix 1. Contact histories of paddlefish monitored with radio-telemetry in the Missouri River above Fort Peck Reservoir in 2008. The three digit number refers to the frequency (e.g. 500 for 149.500 kHz) and the two digit number refers to the fish code. Closed symbols denote a fixed station contact; open symbols denote a manual contact. Discharge is for the Missouri River near the Fred Robinson bridge (position denoted by solid horizontal line).

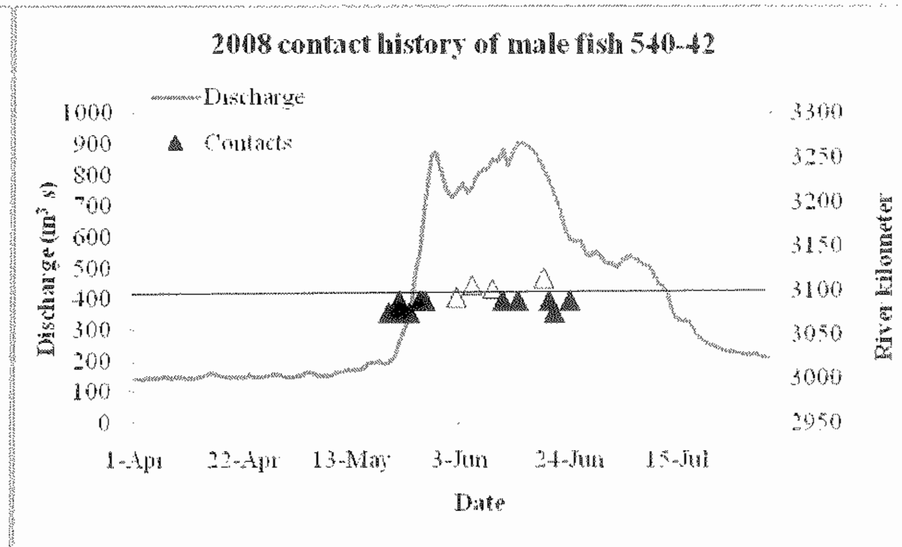


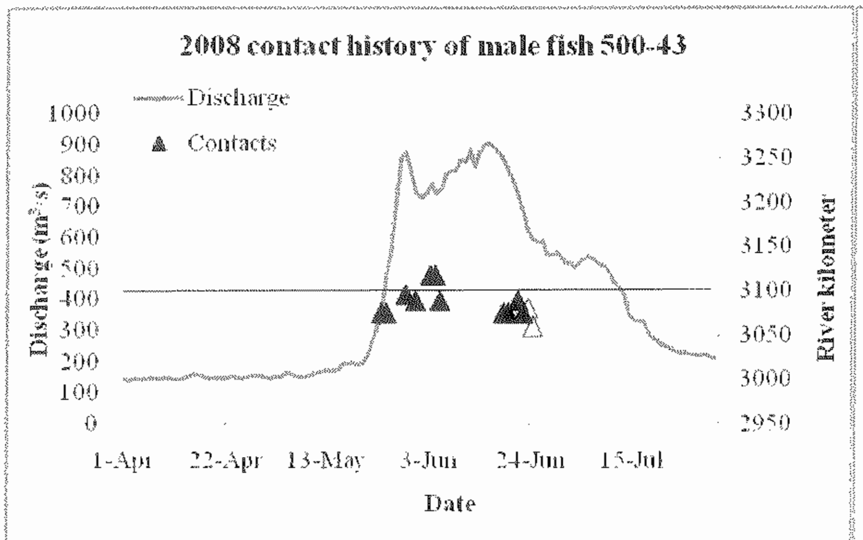
Appendix 1. Contact histories of paddlefish monitored with radio-telemetry in the Missouri River above Fort Peck Reservoir in 2008. The three digit number refers to the frequency (e.g. 500 for 149.500 kHz) and the two digit number refers to the fish code. Closed symbols denote a fixed station contact; open symbols denote a manual contact. Discharge is for the Missouri River near the Fred Robinson bridge (position denoted by solid horizontal line).

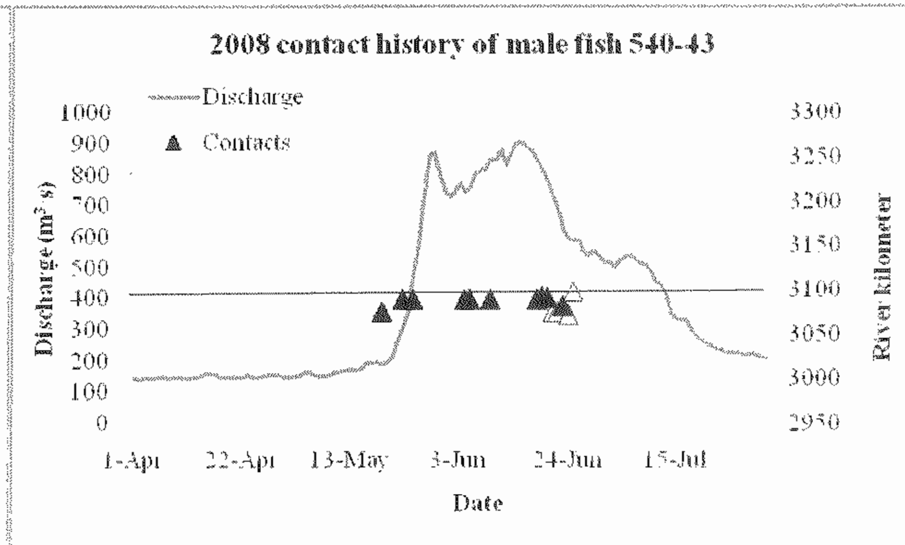


Appendix 1. Contact histories of paddlefish monitored with radio-telemetry in the Missouri River above Fort Peck Reservoir in 2008. The three digit number refers to the frequency (e.g. 500 for 149.500 kHz) and the two digit number refers to the fish code. Closed symbols denote a fixed station contact; open symbols denote a manual contact. Discharge is for the Missouri River near the Fred Robinson bridge (position denoted by solid horizontal line).

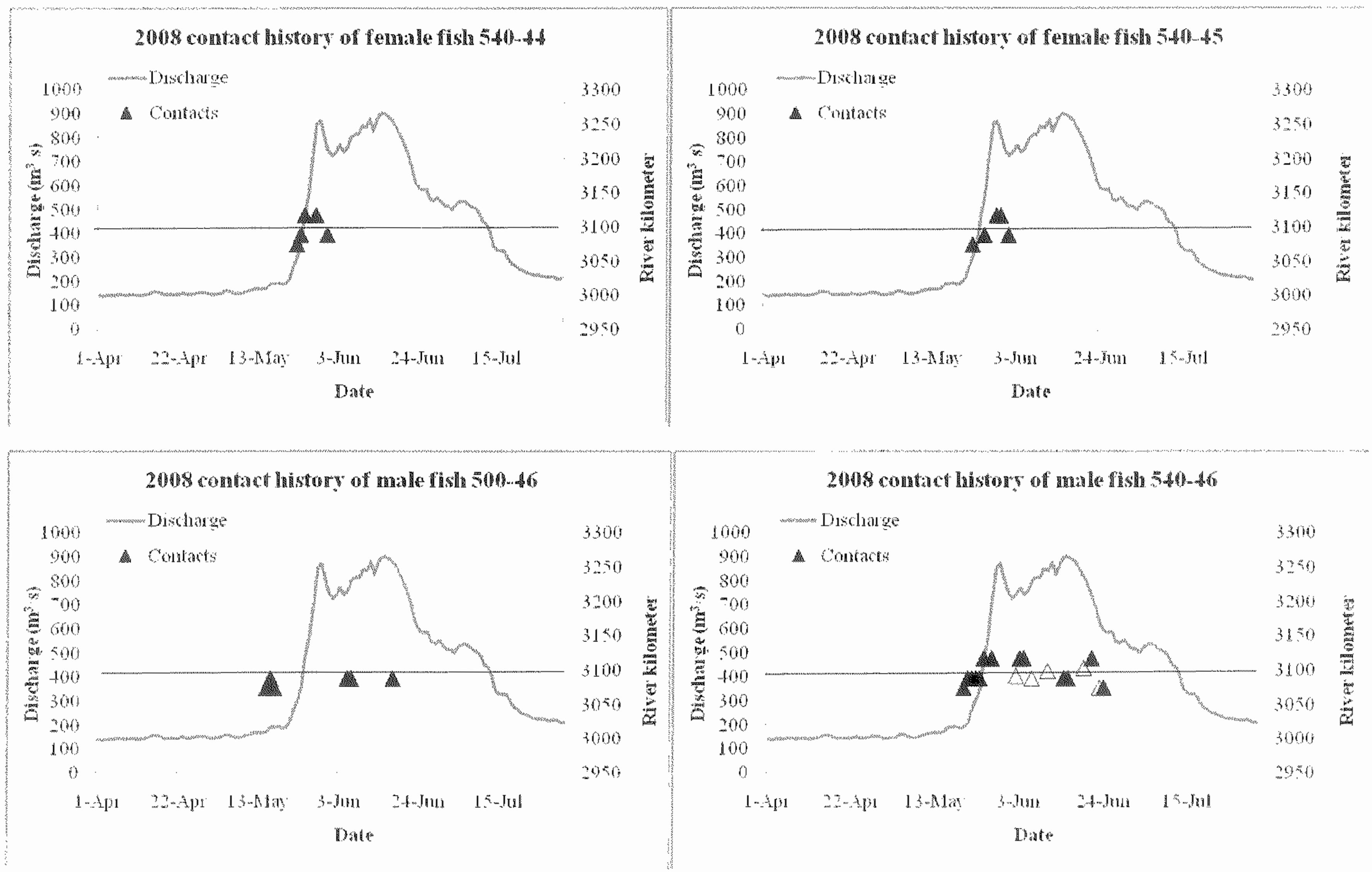




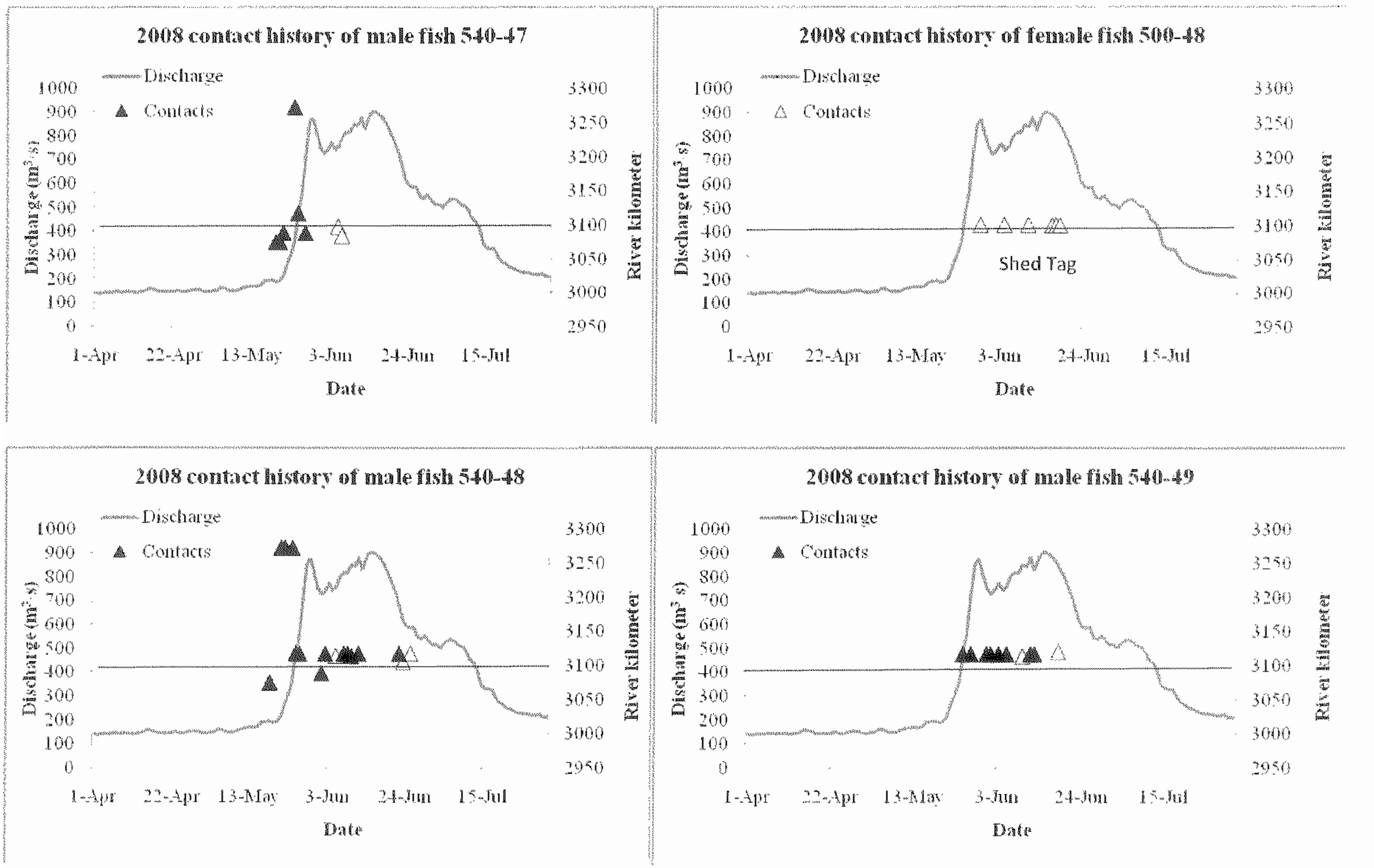




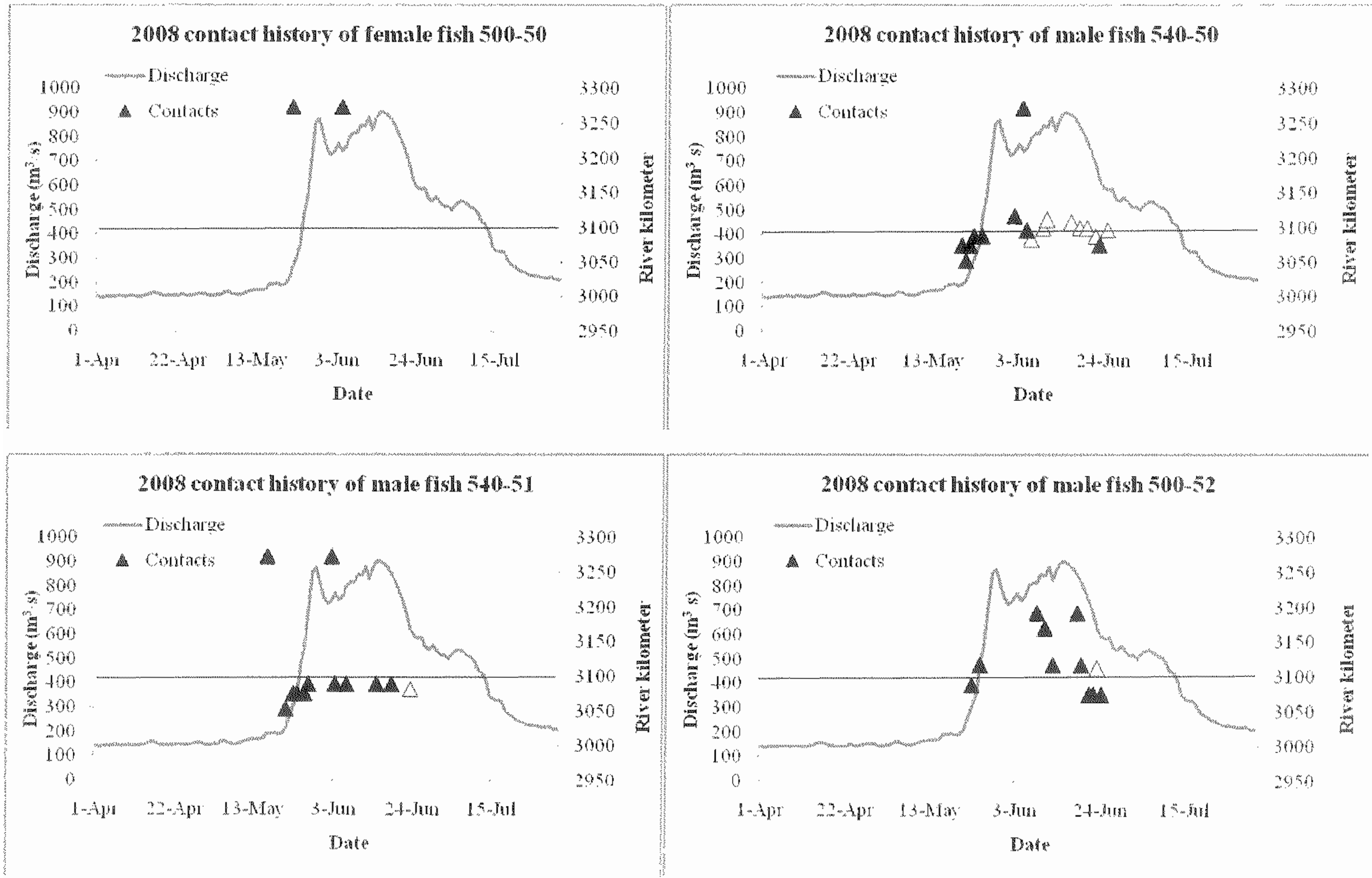
Appendix 1. Contact histories of paddlefish monitored with radio-telemetry in the Missouri River above Fort Peck Reservoir in 2008. The three digit number refers to the frequency (e.g. 500 for 149.500 kHz) and the two digit number refers to the fish code. Closed symbols denote a fixed station contact; open symbols denote a manual contact. Discharge is for the Missouri River near the Fred Robinson bridge (position denoted by solid horizontal line).



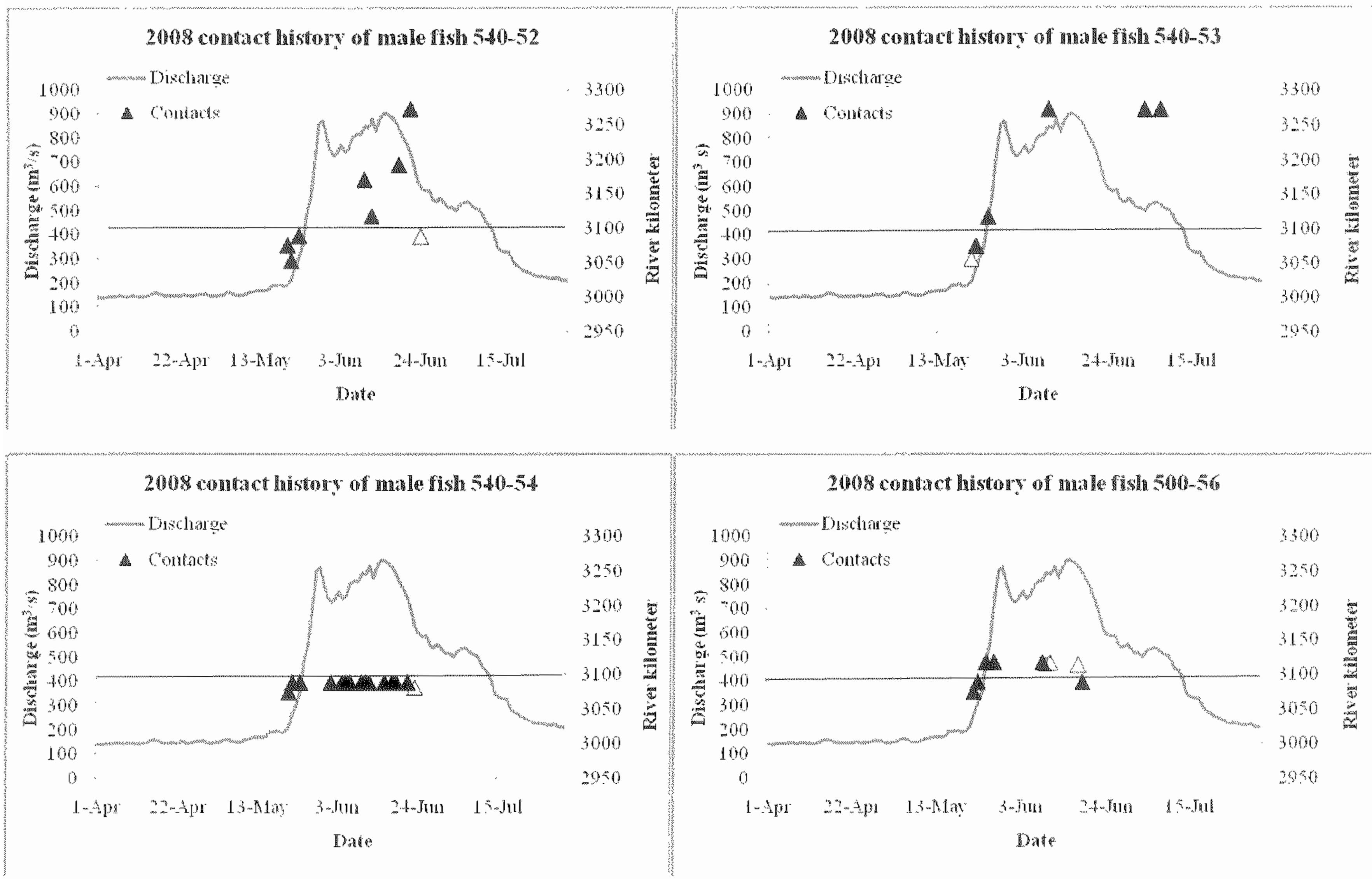
Appendix 1. Contact histories of paddlefish monitored with radio-telemetry in the Missouri River above Fort Peck Reservoir in 2008. The three digit number refers to the frequency (e.g. 500 for 149.500 kHz) and the two digit number refers to the fish code. Closed symbols denote a fixed station contact; open symbols denote a manual contact. Discharge is for the Missouri River near the Fred Robinson bridge (position denoted by solid horizontal line).



Appendix 1. Contact histories of paddlefish monitored with radio-telemetry in the Missouri River above Fort Peck Reservoir in 2008. The three digit number refers to the frequency (e.g. 500 for 149.500 kHz) and the two digit number refers to the fish code. Closed symbols denote a fixed station contact; open symbols denote a manual contact. Discharge is for the Missouri River near the Fred Robinson bridge (position denoted by solid horizontal line).



Appendix 1. Contact histories of paddlefish monitored with radio-telemetry in the Missouri River above Fort Peck Reservoir in 2008. The three digit number refers to the frequency (e.g. 500 for 149.500 kHz) and the two digit number refers to the fish code. Closed symbols denote a fixed station contact; open symbols denote a manual contact. Discharge is for the Missouri River near the Fred Robinson bridge (position denoted by solid horizontal line).



Appendix 1. Contact histories of paddlefish monitored with radio-telemetry in the Missouri River above Fort Peck Reservoir in 2008. The three digit number refers to the frequency (e.g. 500 for 149.500 kHz) and the two digit number refers to the fish code. Closed symbols denote a fixed station contact; open symbols denote a manual contact. Discharge is for the Missouri River near the Fred Robinson bridge (position denoted by solid horizontal line).