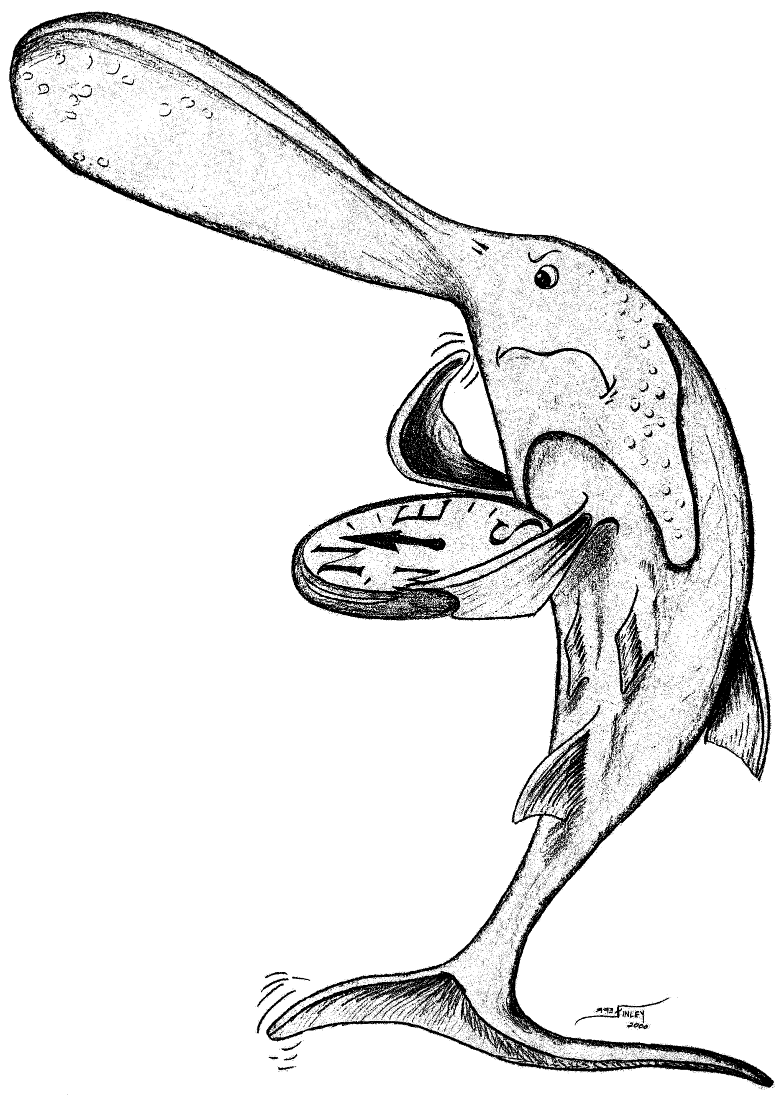
Mississippi River Basin Paddlefish Research Coded-Wire Tagging Project

1998 Annual Report



Artwork courtesy of Jeff Finley.

ICRA

Mississippi Interstate Cooperative Resource Association
P.O. Box 774 - Bettendorf, IA 52722 - (309) 793-5811

Mississippi River Basin Paddlefish Research Coded-Wire Tagging Project 1998 Annual Report

Greg A. Conover and Joanne M. Grady

U.S. Fish and Wildlife Service
Region 3
Fishery Resources Program

April 2000

ACKNOWLEDGEMENTS

This project was made possible by the generous donations of time and money provided by each of the participating agencies. A study of this magnitude could not be accomplished without the combined efforts of all involved. MICRA would like to thank Cabela's, Coleman, Miller Net and Twine, Plano Tackle Company, and SeaArk Boat Company for their generous donations of gifts for the reward and recovery aspect of this program. The U.S. Fish and Wildlife Service would like to thank Mike Thomas, a volunteer who dedicated several hundred hours of his time assisting with the processing of coded-wire tags and MICRA paddlefish data.

TABLE OF CONTENTS

DATABASE MANAGEMENT

Regional Tag Coordinators (RTC) have made substantial progress improving the paddlefish database and developing a Geographic Information System (GIS). This report summarizes MICRA paddlefish data collected during 1998 and received through January 31st, 1999, including more than 5,700 coded-wire tags and data sheets from 191 sampling trips and 52 hatchery stockings.

Sport and commercial harvest data collected since 1995 has been incorporated into the database. Harvest data have been sent to several different locations since the study was initiated. The RTC have made every effort to gather all harvest records and compile them into the database. As a measure of quality assurance, biologists should review their respective state's harvest data. Harvest data are summarized for each state and sub-basin in Appendix A. When reporting harvest data please include the total number of rostrums wanded as well as the number of recaptures.

At the request of project participants at the 1999 spring Paddlefish/Sturgeon Sub-Committee meeting, more than 80 reports summarizing each states paddlefish data were generated and distributed for review. Responses to these reports have been minimal. Participants are again requested to review these files and notify the RTC whether or not discrepancies exist.

An issue of concern that repeatedly arises while processing and analyzing the MICRA paddlefish data is incomplete data sheets. Missing or incomplete data can influence results and compromises the conclusions based on those results. Biologists are encouraged to use caution when recording data and ensure that all data fields are complete. Area Tag Coordinators (ATC) are asked to review data sheets for completeness before forwarding them to the RTC.

Population Modeling Consultation

Two of the long-term goals of the paddlefish project have been to assess paddlefish abundance and the extent of harvest and exploitation by stock. These goals were identified by the MICRA Paddlefish/Sturgeon Committee while working out protocols for the tagging program. Classic mark and recapture techniques do not appear to readily answer these questions due to low recapture numbers and assumptions about population boundaries. And unlike salmon, large numbers of paddlefish do not return to the same locations in predictable quantities of time for recapture. Consultations with Northwest Marine Technologies, the company that makes the coded-wire tags, led us to Lars Mobrand of Mobrand Biometrics, Inc. in Vashon, Washington.

Lars uses the Ecosystem Diagnosis and Treatment Method (EDT) to model salmon populations through their ecosystem. The method uses a species or population and information about its life history to diagnose an ecosystem's condition for sustainability (Lestelle et al. 1996; Mobrand et al. 1997).

Lars met with the committee at the spring meeting in St. Louis, Missouri. He reviewed where the project sits and the stated goals. Lars identified the following data needs and objectives for our project:

- A lack of knowledge of young fish needed for cohort analysis
- Need for significant multiple recaptures to make population estimates
- Need to determine natural spawning areas and habitat within spawning areas
- Need to identify and map discrete population boundaries and core populations of fish
- Determine reproductive success
- Determine "limiting factors" and habitat requirements for paddlefish throughout their life history
- Develop routed spatial network (to capture geography in database).

Conversations with Lars identified the need to continue the paddlefish tagging project for another five years. The additional time may allow for identification of multiple recapture fish. Recapture rates of hatchery fish are expected to increase as it generally takes 3-5 years for hatchery fish to be susceptible to sampling and commercial gear. State biologists agreed to work on maps of their sub-basins to identify distinct paddlefish populations. The ATC agreed to work on basemaps for the project to map sampling sites, hatchery stocking sites, recapture sites, and the identified population boundaries.

In addition to consulting with Lars Mobrand, the RTC will be attending a course on TAG Return Models at the National Conservation Training Center in June 2000. This course is designed to be a primer to allow us to then train to use Program MARK. Program MARK was written by Gary White of Colorado State University. Program MARK provides parameter estimates from marked animals when they are re-encountered at a later time. Re-encounters can be from dead recoveries (e.g., the animal is harvested), live recaptures (e.g. the animal is re-trapped or re-sighted), radio tracking, or from some combination of these sources of re-encounters (White, 1999).

Sampling Effort

State and federal agencies in 17 states conducted 191 sampling trips during 1998, exerting more than 4,100 hours of effort sampling paddlefish. Sampling effort increased during winter months and decreased during summer months in 1998 (Figure 1). Catch

was highest during the intensified sampling period from January through April and peaked again in June and November (Figure 2).
Sampling effort increased in main channel habitats and decreased in backwaters, side

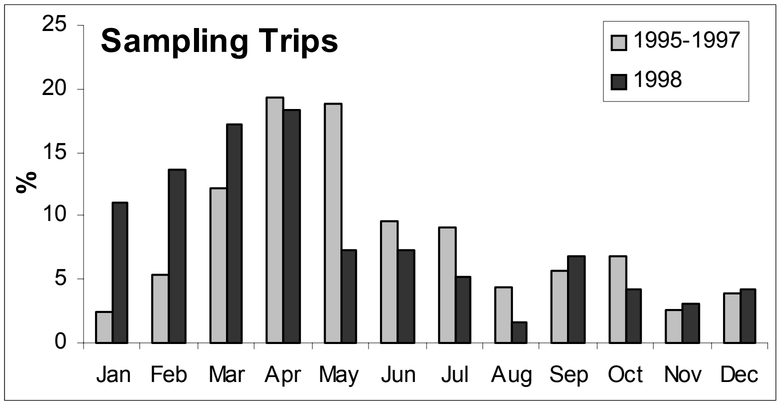


Figure 1. Percent of the total sampling trips by month from 1995-1997 and in 1998.

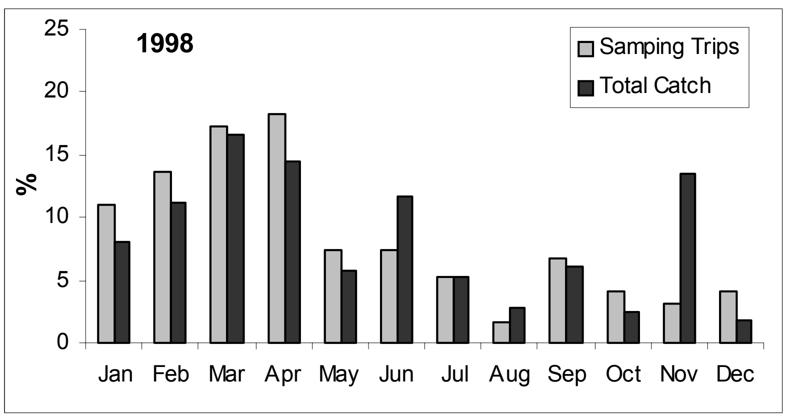


Figure 2. Percent of the total sampling trips and catch by month in 1998.

channels, and impoundments in 1998 (Figure 3). Sixty-four percent of all sampling trips and 71.3% of the total catch occurred in main channel and tailwater habitats (Figure 4). Missing stratum data increased to a high of 18.3% in 1998, much higher than the average 10.6% during previous years. Excluding sampling efforts with missing stratum data, main channel and tailwater habitats each accounted for 39.1% of the sampling effort, however catch was higher in tailwaters (52.8%) than in main channel habitats (25.3%). Sampling effort varied by habitat in the different sub-basins, however tailwaters were the most frequently sampled habitat in all but the Gulf sub-basin (Figure 5).

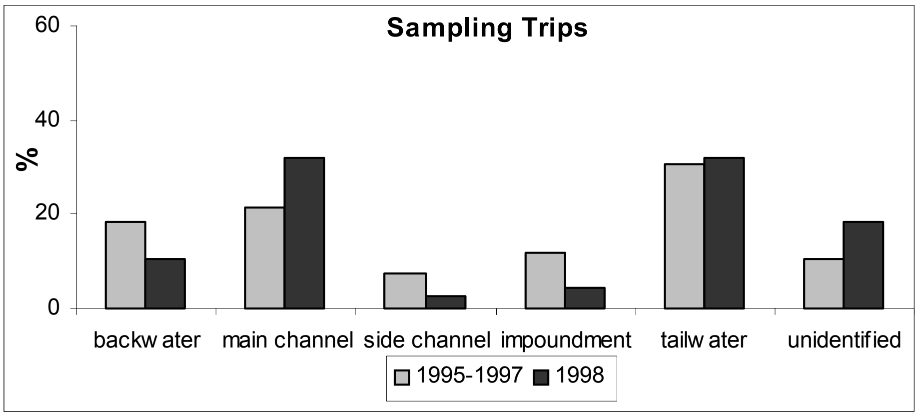


Figure 3. Percent of the total sampling trips by habitat (stratum) from 1995 - 1997 and in 1998.

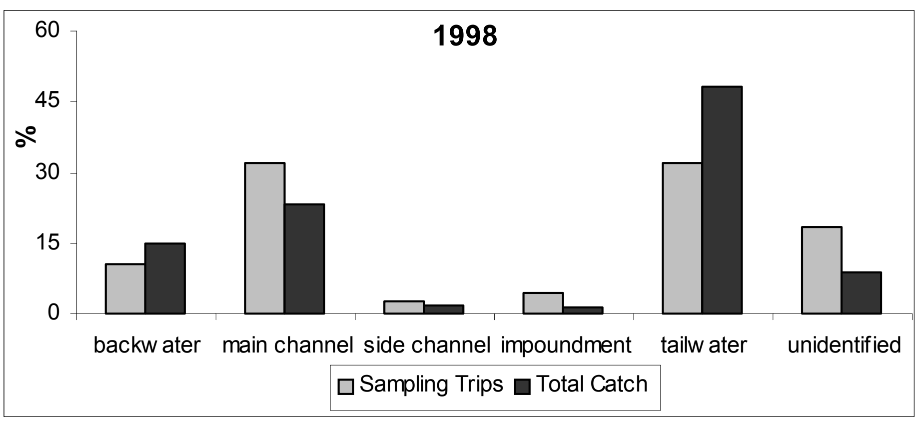


Figure 4. Percent of the total sampling trips and catch by habitat (stratum) in 1998.

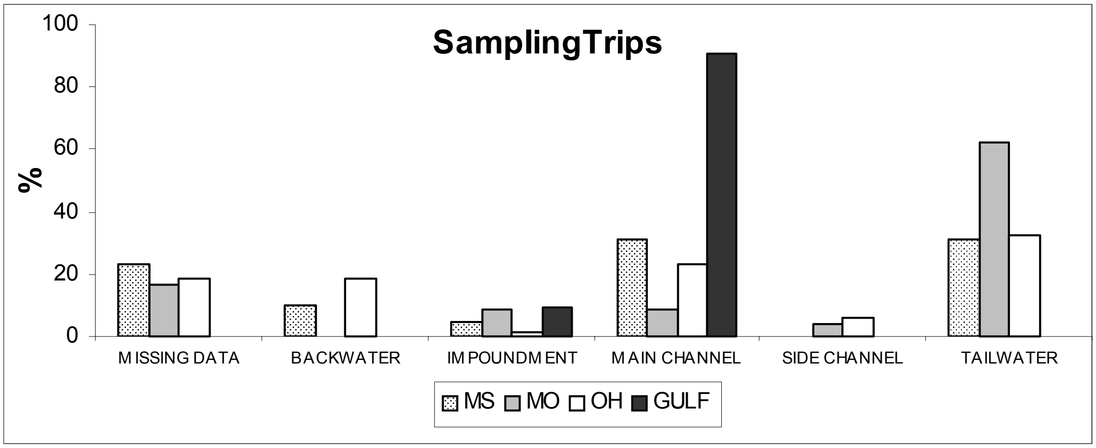


Figure 5. Percent of the total sampling trips in 1998 for each sub-basin and by habitat (stratum).

Biologists collected paddlefish with a variety of gears in 1998; including trammel nets, gill nets, hobbled gill nets, snagging, electrofishing, hoop nets, and rotenone. CPUE for all gear types averaged 0.6 fish/hour in 1998, a slight increase from the previous three year average of 0.5 fish/hour. CPUE in the Missouri River sub-basin has averaged 3.6 fish/hour throughout the study, much higher than the 0.4 fish/hour average for the remainder of the basin.

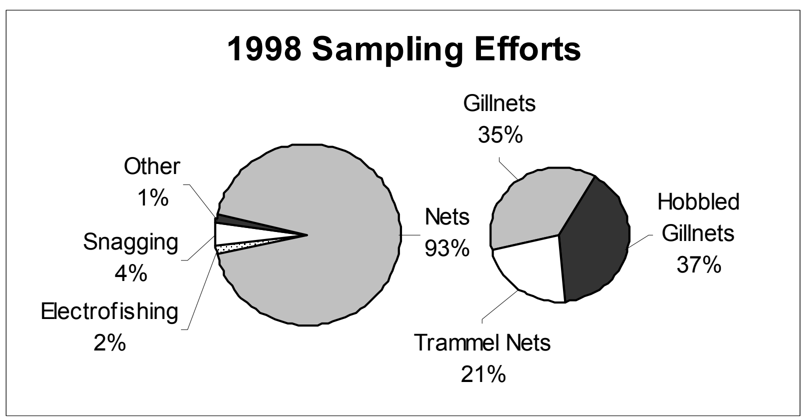


Figure 6. Percent of the total sampling efforts by gear in 1998.

Nets (gill nets, hobbled gill nets, and trammel nets) were the most frequently used gear types, being fished 3,865.7 hours and accounting for 93% of all efforts (Figure 6). Nets were fished in all sub-basins and all habitat types during 1998. Net CPUE has averaged 0.5 fish/hour from 1995 -1997 and was 0.5 fish/hour in 1998. Gill nets and hobbled gill nets have been the most frequently fished nets each year, yet trammel nets have consistently produced much higher CPUE's. Average catch rates for nets vary considerably between sub-basins and type of net (Table 1). Average net CPUE increased in the Ohio and Missouri River sub-basins, but decreased in the Gulf sub-basin from 0.2 to 0.001 fish/hour. Net CPUE's have been highest in the Missouri River sub-basin throughout the study, averaging 6.5 fish/hour.

Table 1. Catch per unit effort (fish/hour) of paddlefish from 1995 - 1998 by sub-basin and net.

Trammel Nets

Sub-basin	**1995**	**1996**	**1997**	**1998**	**1995-1998**
All	0.4	5.8	2.5	2.8	2.1
Mississippi	0.3	2.5	0.9	1.2	0.9
Missouri	11.4	52.8	7.8	37.6	13.7
Ohio	0.0	--	--	1.0	0.1
Gulf	--	--	--	--	--

Gill Nets

Sub-basin	**1995**	**1996**	**1997**	**1998**	**1995-1998**
All	0.7	0.3	0.3	0.4	0.4
Mississippi	0.3	0.1	0.1	0.1	0.1
Missouri	3.2	5.3	0.0	25.1	3.9
Ohio	0.5	0.2	0.6	0.9	0.4
Gulf	--	0.3	0.5	0.1	0.4

Hobbled Nets

Sub-basin	**1995**	**1996**	**1997**	**1998**	**1995-1998**
All	0.3	0.4	0.3	0.4	0.4
Mississippi	0.1	0.2	1.6	2.9	0.5
Missouri	3.0	5.8	15.5	4.1	5.7
Ohio	0.2	0.3	0.2	1.0	0.4
Gulf	--	--	0.005	0.001	0.002

Snagging was the second most commonly used sampling gear in 1998. Biologists conducted 152 hours of snagging during 28 sampling trips in the Mississippi River sub-basin. Snagging was also employed during two sampling trips in the Missouri River sub-basin, however effort was not recorded. The majority (86.7%) of snagging effort was conducted in the tailwaters of Locks and Dams 12 and 13 in the Mississippi River. Snagging CPUE averaged 1.9 fish/hour in the Mississippi River sub-basin, up from the previous three years average of 1.3 fish/hour and considerably higher than the basin average of 0.7 fish/hour through 1997.

Biologists also used electrofishing gear to sample paddlefish in the Ohio and Missouri River sub-basins during 1998. Backwater (30.8%) and tailwater (23.1%) were the most frequently reported habitats sampled with electrofishing gear, however habitat data were not recorded for the majority (46.2%) of electrofishing sampling trips. CPUE varied greatly between sub-basins averaging 8.8 fish/hour during 12 sampling trips in the Ohio River sub-basin and 56.0 fish/hour for a single effort conducted below Rocky Ford Dam on the Blue River in the Missouri River sub-basin. Electrofishing CPUE data are only available for the Ohio River sub-basin prior to 1998, averaging 7.4 fish/hour.

Paddlefish Body Lengths and Relative Condition

Comparisons of mean body lengths and relative weights (Wr) of paddlefish collected between 1995 and 1998 were made using analysis of variance (ANOVA). When models indicated differences ($p \leq 0.05$), Duncan's multiple-range tests were used for post hoc comparisons.

Body lengths of paddlefish collected by nets, snagging, and electrofishing in 1998 averaged 769.3 mm and were larger (df=3, F=30.34, $p<0.0001$) than those collected during earlier study years (Table 2). Average body lengths of fish collected in 1997 ($\bar{x}$=757.7 mm) and 1996 ($\bar{x}$=748.0 mm) were larger (df=3, F=30.34, $p<0.0001$) than fish collected in 1995 ($\bar{x}$=721.2 mm). Sizes of paddlefish collected through 1998 have varied by gear and even the type of net employed (Figure 7).

Mean body lengths of paddlefish collected through 1998 differed between sexes (df=2, F=171.65, $p<0.0001$), habitat (df=6, F=28.34, $p<0.0001$), sub-basins (df=4, F=157.52, $p<0.0001$), gear (df=2, F=395.85, $p<0.0001$), net-type (df=2, F=100.91, $p<0.0001$), and mesh size (df=7, F=23.90, $p<0.0001$). Females ($\bar{x}$=884.1 mm) have been larger than males ($\bar{x}$=789.9 mm). Paddlefish collected in impoundments and natural lakes have had the longest mean body lengths (Table 3). Fish collected in the Missouri River sub-basin ($\bar{x}$=796.16 mm) have been larger than fish collected in other sub-basins and fish collected in the Mississippi River sub-basin ($\bar{x}$=688.0 mm) have had shorter mean body lengths than other sub-basins (Table 4). Paddlefish collected in nets ($\bar{x}$=772.8 mm) had the largest average body lengths and fish collected by snagging ($\bar{x}$=627.2 mm) had the smallest (Table 5). Among net types, fish collected in hobbled nets ($\overline{x}$=798.1 mm) have larger mean body lengths, while fish collected in trammel nets ($\overline{x}$=730.2 mm) were smaller (Table 6). Paddlefish have been collected in 2.75, 3.00, 3.25, 3.50, 4.00, 5.00, 6.00, and 8.00-inch mesh nets. Fish collected by 8.00-inch mesh ($\overline{x}$=945.6 mm) have been larger than paddlefish collected in all other mesh sizes (Table 7).

Table 2. Mean lengths (mm) of paddlefish collected by nets, snagging, and electrofishing by year.

Year	N	Mean Length	Duncan Grouping
1998	2595	769.3	A
1997	2648	757.7	B
1996	2503	748.0	B
1995	2074	721.2	C

Table 3. Mean lengths (mm) of all paddlefish collected from 1995 - 1998 by habitat (stratum).

Habitat	N	Mean Length	Duncan Grouping
Impoundment	557	791.8	A
Natural Lake	52	789.0	A
Unknown	1287	779.6	AB
Tailwater	5368	756.0	BC
Side Channel	363	743.1	C
Backwater	1708	729.3	CD
Main Channel	1095	705.9	D

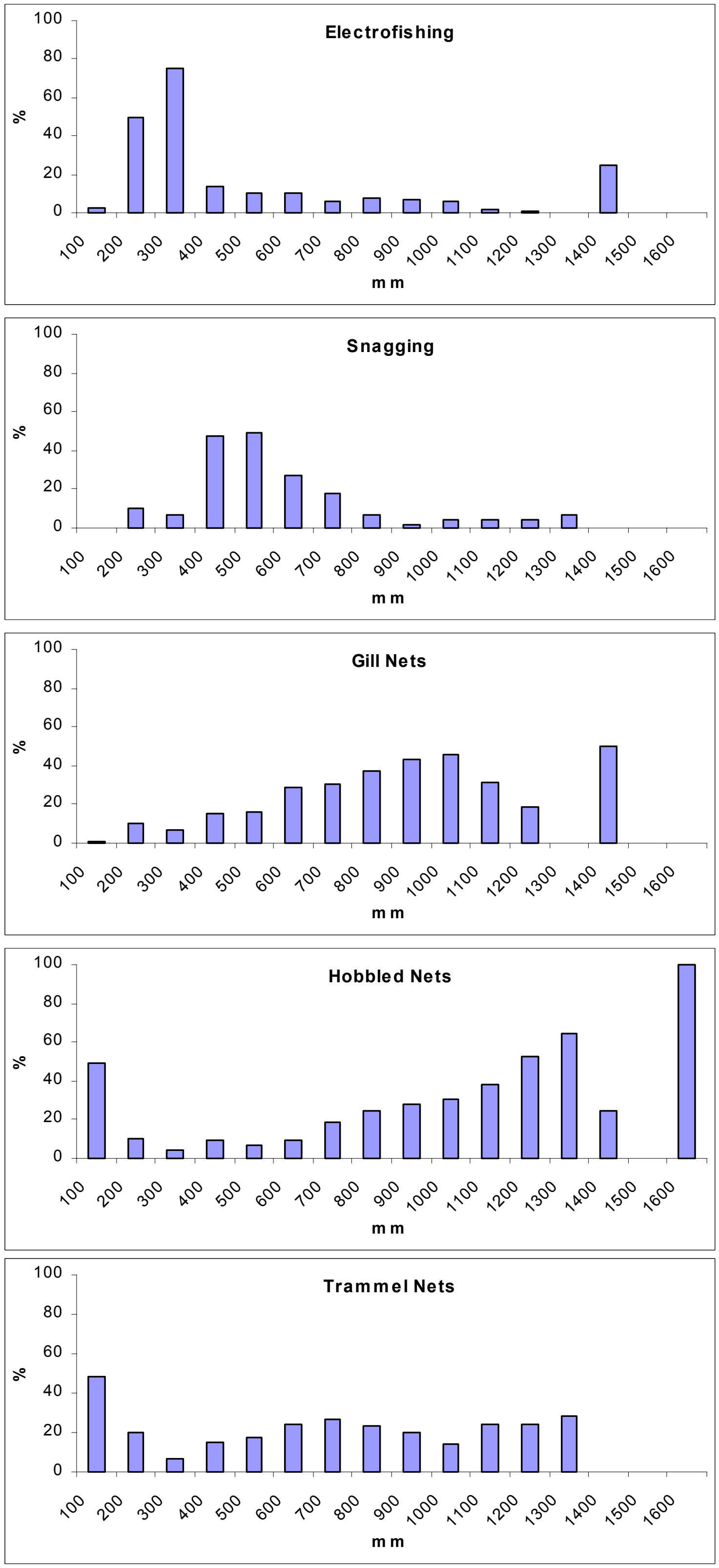


Figure 7. Percent of the total paddlefish catch in 100 mm length groups collected by the different sampling gears.

Table 4. Mean lengths (mm) of all paddlefish collected from 1995 - 1998 by sub-basin.

Sub-basin	N	Mean Length	Duncan Grouping
Missouri	3546	796.2	A
Ohio	3251	756.6	B
Gulf	786	750.8	B
Mississippi	2812	688.0	C

Table 5. Mean lengths (mm) of paddlefish collected from 1995 - 1998 by gear.

Gear	N	Mean Length	Duncan Grouping
Nets	7976	772.8	A
Electrofishing	710	698.1	B
Snagging	1134	627.2	C

Table 6. Mean lengths (mm) of paddlefish collected from 1995 - 1998 by net type.

Net	N	Mean Length	Duncan Grouping
Hobbled	2338	798.1	A
Gill	3449	782.7	B
Trammel	2189	730.2	B

Table 7. Mean lengths (mm) of paddlefish collected in nets from 1995 - 1998 by mesh size.

Mesh	N	Mean Length	Duncan Grouping
8.00	116	945.6	A
5.00	912	791.5	B
2.75	8	790.5	B
3.00	3535	783.1	B
6.00	45	778.3	B
4.00	760	760.4	B
3.50	1254	747.1	B
3.25	86	737.5	B

Condition was calculated as relative weight, using standard weight formulas proposed by Brown and Murphy (1993) for male, female, and unknown sex paddlefish. Relative weights were calculated for all paddlefish collected during field sampling with reported lengths and weights. Differences in relative weights for paddlefish collected through 1998 were tested between sexes, sub-basins, and habitat, as well as between study years.

Relative weights of males ($\bar{x}$=82.9) did not differ (p=0.1630) from females ($\bar{x}$=80.7). The average relative weight for all paddlefish collected through 1998 was 82.7 (n=9809). Mean relative weight for all fish has been lower (df=3, F=32.44, p<0.0001) each year, decreasing from 86.6 to 80.1 (7.5%) between 1995 and 1998 (Table 8). Mean relative weights differed between sub-basins (df=4, F=280.87, p<0.0001), with the Ohio River ($\bar{x}$=83.8) and Gulf ($\bar{x}$=82.6) sub-basins ranked between the Mississippi ($\bar{x}$=92.4) and Missouri River ($\bar{x}$=74.4) sub-basins (Table 9). Mean relative weights also differed between habitat (df=6, F=432.87, p<0.0001). Paddlefish collected in impoundments had a much higher relative weight ($\bar{x}$=119.6) than fish collected in all other habitat types (Table 10).

Table 8. Mean relative weight (Wr) of all paddlefish collected from 1995 - 1998.

Year	N	Mean Wr	Duncan Grouping
1995	1808	86.6	A
1996	2516	83.2	B
1997	2563	81.8	C
1998	2639	80.1	D

Table 9. Mean relative weight (Wr) of all paddlefish collected from 1995 - 1998 by sub-basin.

Sub-basin	N	Mean Wr	Duncan Grouping
Mississippi	2698	92.4	A
Ohio	2825	83.8	B
Gulf	772	82.6	B
Missouri	3487	74.4	C

Table 10. Mean relative weight (Wr) of all paddlefish collected from 1995 - 1998 by habitat (stratum).

Habitat	N	Mean Wr	Duncan Grouping
Impoundment	530	119.6	A
Backwater	1611	89.7	B
Unknown	1235	83.6	C
Main Channel	1023	83.2	C
Side Channel	348	82.6	C
Tailwater	5010	76.4	D
Natural Lake	52	72.9	E

Tagging Effort

Eight states released 173,655 coded-wire tagged hatchery-reared paddlefish in 1998. The database contains more than 1.2 million records of coded-wire tagged paddlefish stocked by 12 states; 576,757 released as part of stocking programs in place before the MICRA project and 643,036 stocked since the paddlefish study was initiated in 1995. The numbers of paddlefish stocked has varied remarkably between sub-basins and across years (Table 11).

Biologists in 15 states captured, tagged and released 2,383 wild-ranging paddlefish during 1998. A total of 9,156 wild paddlefish have been coded-wire tagged by biologists in 18 states, since the study began in 1995. The number of wild-ranging paddlefish tagged in each sub-basin through 1998 ranges from 451 in the Ohio River sub-basin to 3,330 in the Missouri River sub-basin (Table 12).

Jawtags have been used to mark paddlefish throughout the basin. Jawtags were used in studies conducted prior to the MICRA project and have continued to be used by several agencies since. Considerable effort has gone into collecting current and historic jawtag records with plans to incorporate these data into the MICRA paddlefish database over the next year. Please contact the ATC if you have jawtag data that could be incorporated into the MICRA paddlefish database.

Table 11. Hatchery releases by sub-basin of coded-wire tagged paddlefish from 1988 - 1994 and MICRA coded-wire tagged paddlefish from 1995 - 1998.

Sub-basin	1988-1994	1995-1997	1998	1995-1998	1988-1998
Gulf	359,852	286,046	92,349	378,395	738,247
Ohio	--	37,797	1,568	39,365	39,365
Mississippi	22,284	26,473	29,428	55,901	78,185
Missouri	194,621	119,065	50,310	169,375	363,996
Total	576,757	469,381	173,655	643,036	1,219,793

Table 12. Number wild-ranging paddlefish captured, coded-wire tagged, and released from 1995 - 1998 by sub-basin.

Sub-basin	1995	1996	1997	1998	1995-1998
Gulf	--	204	193	54	451
Ohio	570	809	789	980	3,148
Mississippi	362	651	600	614	2,227
Missouri	840	791	964	735	3,330
Total	1,772	2,455	2,546	2,383	9,156

Recaptures

MICRA participants have recaptured 980 coded-wire tagged paddlefish since the study began in 1995. More recaptures were collected during 1998 (n=281) than during any previous study year (Table 13). The number of wild recaptures has gradually increased each year, totaling 113 in 1998. Hatchery recaptures in 1998 totaled 162, higher than the previous three year average of 150.

Table 13. Number of coded-wire tagged paddlefish recaptured from 1995 - 1998 by sub-basin.

Sub-basin	1995	1996	1997	1998	1995-1998
Gulf	--	4	4	--	8
Ohio	4	16	54	48	122
Mississippi	5	20	26	23	74
Missouri	181	235	150	210	776
Total	190	275	234	281	980

Data could not be recovered from six recaptures in 1998; errors included four recapture envelopes received without coded-wire tags enclosed, one unreadable tag (cut too short), and one tag encoded with the MICRA practice batch-code. Data has not been recovered from 24 recaptures since the study was initiated in 1995 (Table 14). Comparisons of wild-tagged and hatchery-released recaptures were made from the remaining 956 coded-wire tag returns.

Table 14. Errors associated with recaptured coded-wire tagged paddlefish.

Year	No Tag	Tag Lost	Unreadabl e	Batchcode	Total
1995	4	--	--	--	4
1996	4	3	1	--	8
1997	3	--	--	3	6
1998	4	--	1	1	6
Total	15	3	2	4	24

A total of 614 hatchery-tagged paddlefish have been recaptured through 1998. As predicted, recaptures of hatchery released paddlefish with MICRA coded-wire tags (those stocked since 1995) have increased each year as cohorts recruit to sampling gears (Grady and Conover 1998). The percentage of recaptures stocked prior to 1995 decreased from 98% in 1997 to 89% in 1998. The 1995 year class, which comprised 1% and 4% of the hatchery returns in 1996 and 1997, respectively, increased to 35% of the catch in 1998 (Table 15). Hatchery recaptures from the 1995 year class collected during 1998 averaged 739 mm.

Sport and commercial anglers collected 41.2% of the paddlefish recaptured during 1998. All 99 paddlefish recaptured by sport anglers in 1998 were harvested below Gavins Point Dam, 69 were hatchery-tagged and 30 were wild-tagged. Commercial anglers collected four recaptures in the Mississippi River sub-basin and nine in the Ohio River, all were wild-tagged fish. Of the 112 recaptures collected by sport and commercial anglers, all but two paddlefish collected in Pool 26 on the Mississippi River, were harvested below dams. Sport and commercial anglers are a crucial source of data for the paddlefish project. It is important that MICRA take full advantage of each opportunity throughout the basin to collect data from these anglers.

Table 15. Number of hatchery released, coded-wire tagged paddlefish recaptured from 1995 - 1998 by year class. The heavy black line divides year classes of MICRA coded-wire tagged paddlefish (paddlefish stocked since 1995) from earlier year classes

Year Class	**1995**	**1996**	**1997**	**1998**	**1995-1998**
1988	1	--	--	--	1
1989	1	4	1	2	8
1990	114	123	43	32	312
1991	28	29	27	26	110
1992	--	3	6	5	14
1993	--	3	7	16	26
1994	10	14	27	23	74
1995		2	5	57	64
1996			--	--	0
1997			2	--	2
1998				1	1
Total	154	178	118	162	612

Movements

Movement data are available from 111 wild-ranging and 161 hatchery stocked MICRA coded-wire tagged paddlefish recaptured in 1998. Similar to 1996 and 1997, 11.7% of wild recaptures and 93.8% of hatchery recaptures made notable movements. Movements of wild and hatchery tagged recaptures differed substantially in the extent of recaptures making movements, the direction of movements, and the types of dams passed. Many movements documented during previous study years were repeated in 1998, evidence that these movements may be established patterns and not simply random events.

A majority (88.3%) of the 1998 wild recaptures were collected at the same sites they were tagged. Time at liberty for these recaptures ranged from 8 days to 41 months, with a mean of 18.2 months. Sport and commercial anglers collected 42 (37.8%) of the 1998 wild recaptures.

Thirteen wild tagged paddlefish moved between tagging and recapture locations; four (3.6%) remained in the same pool or river reach and nine (8.1%) made interpool movements. Two paddlefish that made interpool movements also made large-scale open river migrations (Table 16). Movements of wild recaptures are mapped in Appendix B.

The majority (77.8%) of interpool movements in 1998 occurred in the Ohio River. Five fish moved upstream past a total of six dams and two fish moved downstream past a total of three dams. These are the first paddlefish documented during this study to make downstream interpool movements in the Ohio River sub-basin.

Two additional wild recaptures made downstream interpool movements in 1998. Both paddlefish passed Locks and Dam 27, the lower most navigation locks and dam on the upper Mississippi River. Paddlefish can either negotiate over the low-water rock-fill dam or around it via an 8 mile canal with two lock chambers which provides a navigation bypass around the obstructive chain-of-rocks reach of river near St. Louis, Missouri.

Since the MICRA study was initiated in 1995, 39 recaptured wild-tagged paddlefish have made interpool movements; 29 moved upstream and 10 moved downstream. Except for one recapture that passed downstream through Gavins Point Dam, all interpool movements by recaptured wild-tagged paddlefish have been past navigation locks and dams on the Mississippi and Ohio Rivers. On the Mississippi River, all interpool movements have been past the two lowermost navigation locks and dams; one paddlefish moved upstream and one downstream past Locks and Dam 26 (Melvin Price) and six paddlefish have moved downstream past Locks and Dam 27. Interpool

Table 16. Movements by wild-ranging coded-wire tagged paddlefish recaptured in 1998.

Release Sub-Basin\Location	Recapture Sub-Basin\Locaction	Distance Traveled (miles)	Number of Dams Passed	Direction of Movement	Months at Liberty
Ohio\McAlpine Dam	Ohio\Cannelton Dam	116	1	down river	11
Ohio\Cannelton Dam	Ohio\Cannelton Pool	43	1	up river	25
Ohio\Hovey Lake	Ohio\Cannelton Dam	119	1	up river	15
Ohio\Uniontown Dam	Ohio\Hovey Lake	6	1	up river	42
Ohio\McAlpine Dam	Ohio\Hovey Lake	235	2	down river	19
Ohio\McAlpine Dam	Ohio\Meldahl Dam	170	2	up river	24
Ohio\Cannelton Dam	Ohio\McAlpine Dam	115	1	up river	25
Missouri\Gavins Point Dam	Missouri\Missouri River	97	0	down river	8
Missouri\Missouri River	Missouri\Gavins Point Dam	24	0	up river	30
Mississippi\Illinois River, Swan Lake	Mississippi\Pool 26	16	0	both	9
Mississippi\Illinois River, Swan Lake	Mississippi\Pool 26	16	0	both	20
Missouri\Bagnell Dam	Mississippi\Kaskaskia Dam	218	1	down river	38
Missouri\Gavins Point Dam	Mississippi\Kaskaskia Dam	889	1	down river	29

movements on the Ohio River have been past navigation locks and dams near the lower reaches of the river. Smithland Locks and Dams, which lies 62.5 miles above the confluence with the Mississippi River, is the lowermost high-head gated dam which presents paddlefish with a permanent high-head obstruction to passage up and down the river. Interpool movements in the Ohio River have occurred at the five navigation locks and dams immediately upstream of Smithland Locks and Dam. Paddlefish have moved upstream past all five locks and dams, but downstream past only two. Movement data past Smithland Locks and Dam is not available due to a paucity of paddlefish sampling in the lower 135 miles of the Ohio River. Understanding paddlefish passage at Smithland Locks and Dam is crucial as it is the primary obstruction to movement between the Ohio and Mississippi Rivers. Scientifically sound conclusions regarding paddlefish movements between these two rivers cannot be reached until fish passage at Smithland Locks and Dam is understood. Increased sampling, as well as the collection of data from the substantial sport and commercial fisheries within the lower Ohio River sub-basin, are needed.

Two wild tagged paddlefish were recaptured in 1998 after making large-scale open river movements between the Missouri and Mississippi River sub-basins. Both paddlefish were tagged in 1995, one below Gavins Point Dam and the other below Bagnell Dam on the Osage River. Both paddlefish moved down the Missouri River, entered the Mississippi River, moved down river past Locks and Dam 27, and were recaptured in the tailwaters below the Kaskaskia Lock and Dam. Similar movements were made by wild-tagged paddlefish recaptured in 1996 and 1997.

Nine recaptures have made large-scale open river movements through 1998. Seven of the nine paddlefish were recaptured below the Kaskaskia Lock and Dam by commercial anglers. One paddlefish was also recaptured by a commercial angler in the tailwaters of Locks and Dam 26 and a snagger recaptured a paddlefish below Bagnell Dam on the Osage River in Missouri. Not only were these nine recaptures collected by sport and commercial anglers, but they were collected from sites not sampled by biologists during 1998. Very little effort has been directed at sampling paddlefish in the 200-mile reach of the middle Mississippi River throughout this study. The middle Mississippi River provides a link between the sub-basins and is the crux to our understanding of paddlefish movement throughout the basin. As with the lower Ohio River, intensified sampling and the collection of sport and commercial data from the middle Mississippi River are required.

In contrast to the wild recaptures, only 6.2% of the hatchery recaptures were collected in the same reservoir that they were originally stocked. Included were five paddlefish collected in the Arkansas River drainage of the Mississippi River sub-basin, two in Lake Kaw and three in Lake Oolagah. Five other paddlefish were collected in Lake Francis Case on the Missouri River. The remaining 151 hatchery recaptures collected in 1998 escaped past at least one reservoir dam before being recaptured. Movements of hatchery recaptures are mapped in Appendix C.

Only one hatchery recapture was collected in the Ohio River sub-basin. The paddlefish was recaptured during a lock rotenone survey at a Belleville lock chamber less than one month after being stocked into the Racine Pool. One other hatchery stocked paddlefish was recaptured in the Ohio River sub-basin prior to 1998. That fish was collected during a lock rotenone survey at a Racine lock chamber less than one month after being stocked into the Gallopolis Pool.

The remaining 150 hatchery recaptures not only were stocked and collected in the Missouri River sub-basin, but were all collected within 12 miles of Gavins Point Dam. Twenty-eight paddlefish stocked into Lake Francis Case and 58 stocked into Lewis and Clark Reservoir were recaptured in the tailwaters below Gavins Point Dam. These 86 paddlefish, stocked between 1989 and 1994, averaged 791 mm in length, an average increase of 441 mm from their size at stocking. A total of 365 hatchery-tagged paddlefish stocked into Lewis and Clark Reservoir and 29 stocked into Lake Francis Case were recaptured below Gavins Point Dam during previous study years.

Sixty-five paddlefish stocked into Tuttle Creek Reservoir on the Big Blue River in Kansas were also recaptured below Gavins Point Dam, 64 in the tailwaters immediately below the dam and one approximately 12 miles downstream. These fish had to pass through outlet tubes at Tuttle Creek Dam, move downstream nearly 150 miles and pass over two low-head dams before reaching the Missouri River and migrating 450 miles upstream to Gavins Point Dam. Nine of the recaptures were stocked in 1994 at an average length of 200 mm and averaged 705 mm at recapture. The remaining 56 paddlefish were stocked in 1995 and averaged 740 mm at recapture. No size at release data are available for the paddlefish stocked in 1995. Two hatchery paddlefish in 1995, one in 1996, and 11 in 1997 were also recaptured at Gavins Point Dam after escaping from Tuttle Creek Reservoir.

Understanding paddlefish movements throughout the basin is one of the principal objectives of the MICRA paddlefish study. Much has been learned about the movements of wild and hatchery paddlefish, but mostly on a small-scale or local level. The limited number of sampling locations throughout the basin has restricted our knowledge regarding long-range migrations. Although 18 states comprising much of the interior of the basin have been involved with sampling wild paddlefish populations through 1998, many biologists sample just a handful of sites within the hundreds of miles of rivers within their respective state (Figure 8). Consider the Missouri and Mississippi Rivers. On the Missouri, biologists in four states have conducted 18 sampling trips in the 811 miles of open river below Gavins Point Dam during 1998. Only two trips were at sites more than 12 miles down river of the dam. Twenty-nine sampling trips were conducted on the Mississippi River during 1998. These 29 sampling trips were not only limited to three navigation pools (13, 14, and 26) in the upper Mississippi River, but were conducted at only five different sites within these three pools. No sampling trips were conducted in the middle or lower Mississippi River, approximately 1150 miles.

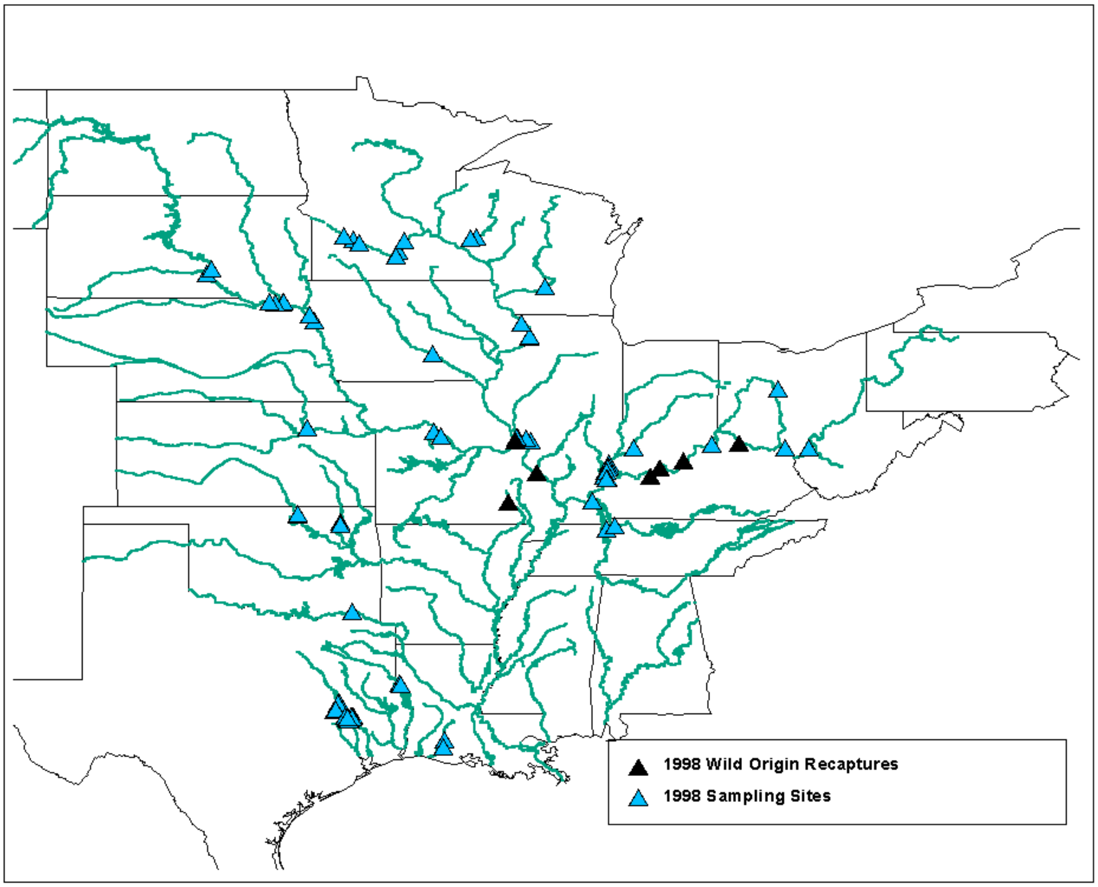


Figure 8. Biologists sampling sites and recapture collection sites of the 13 wild-tagged paddlefish that made movements in 1998. Recaptures were collected by biologist and sport/commercial anglers, notice that the majority of recaptures are in locations not sampled by biologist in 1998.

Sampling differences for hatchery and wild-tagged paddlefish may best explain why movements of recaptures have been so disparate. Although all paddlefish stocked into the Missouri River have been released into reservoirs and tributaries above Gavins Point Dam, more than 90% of biologist sampling trips in the Missouri River have been conducted below Gavins Point Dam. It is inherent that the majority of hatchery recaptures will have moved since the majority of sampling sites are different from release locations. Sampling of wild-ranging paddlefish populations has been quite different. Biologists frequently repeat sampling trips to a limited number of preferred sites. The result is a local area saturated with wild-tagged paddlefish and recaptures frequently collected from the same site they were tagged. While these recaptures do provide some insight, no information is learned about their movements away from the area. The mean time at liberty for 111 wild-tagged paddlefish recaptured in 1998 was 18 months, yet only 13 were collected at a site different from where they were tagged. Distributing sampling sites throughout the basin should increase the percent of recaptures collected at locations other than where they were tagged, providing more information regarding if and where paddlefish move after they are tagged.

Another of the many possible explanations for the contrasts in movements could be related to the difference in size when hatchery and wild origin fish were tagged. Hatchery paddlefish stocked into the Mississippi and Missouri River sub-basins average 289 mm and 270 mm, respectively, while wild-ranging paddlefish in these same sub-basins average 663 mm and 799 mm at the time they were tagged. Life history requirements may be sufficiently different for these two size classes of paddlefish to have discrete habitat requirements resulting in different movement patterns. However, in the Ohio River, where hatchery releases have averaged 340 mm, both hatchery recaptures have been collected from inside lock chambers at the upper end of the pools they were released less than one month earlier. Tagging juvenile wild-ranging paddlefish and recapturing them multiple times throughout their life history will help us to make giant steps forward in our understanding of paddlefish movements.

While a great deal has been learned regarding paddlefish movements, an increasing number of questions remain to be answered. Distributing sampling effort throughout the basin in an attempt to fill identified data gaps, attempting to tag wild-ranging paddlefish earlier in their life history, and making a concerted effort to gather more complete creel data from the numerous sport and commercial fisheries throughout the basin are some of the more significant adaptations MICRA should consider in order to achieve the long-term goals of the paddlefish project.

BASEMAP DEVELOPMENT

Acquiring Basemap Data Layers

Basemap data layers were obtained from the BASINS analysis system. Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) is a multipurpose environmental analysis system for use by regional, state, and local agencies in performing watershed and water-quality-based studies. BASINS was developed by the U.S. Environmental Protection Agency's Office of Water, Office of Science and Technology in Washington, D.C.

BASINS is a free product that can be ordered directly from the EPA web site (http://www.epa.gov/OST/BASINS/). The software is delivered in 2-6 CD sets for each EPA region. In addition to the BASINS program, each CD set contains an assortment of data layers including spatially distributed data such as land use/land cover, dam sites, and state boundaries, environmental monitoring data such as water quality observation data, and USGS gaging stations, and point source data.

The data layers added to the MICRA paddlefish basemap include the following:

State Boundaries in the United States

This coverage is of the state boundaries of the United States. It was derived from the U.S. Geological Survey State Boundaries, which were derived Digital Line Graph (DLG) files representing the 1:2,000,000-scale map in the National Atlas of the United States

National Inventory of Dams

This dataset provides a locational map of 75,187 dams in the conterminous United States. The U.S. Army Corps of Engineers and the Federal Emergency Management Agency originally developed the NID to track dam related problem areas. This database shows the age of the dam, the number of people living downstream, and some inspection information. The dam inspection data also includes location information (such as latitude, longitude and nearest town), a description of a dam's size, reservoir capacity, the owner and the regulatory oversight agency.

Reach File, version 1

Reach file 1 (RF1) is a representation of streams in the conterminous United States at a scale of approximately 1:500,000. The original file was prepared by the

USEPA. This is an accurate translation of the RF1 version on the USEPA mainframe computer as of October 17, 1994 into an ARC/INFO coverage.

Reach File, version 3 Alpha

Reach file 3 (RF3) is national hydrologic database containing 3.2 million networked reaches. It is based upon the 1988 USGS Digital Line Graph 1:100,000 scale linework for national surface water features.

USGS Gage Stations

This dataset is an inventory of surface water gaging station data including gage location (latitude, longitude) and 7-Q-10 low and monthly stream flow. The gage data was obtained from the US EPA Gage File database.

Land Use and Land Cover

This is land use/land cover digital data collected by USGS and converted to ARC/INFO by the EPA. This data is useful for environmental assessment of land use patterns with respect to water quality analysis, growth management, and other types of environmental impact assessment. Data are meant to be used by quadrangle, or among adjacent quadrangles where temporally contiguous. Each quadrangle has a different representative date. Dates range from mid 1970s to early 1980s. Edges of adjoining maps may not meet. Land use was mapped and coded using the Anderson classification system (Anderson et al 1976) which is a hierarchical system of general (level 1) to more specific (level 2) characterization

Managed Area Database

This database includes all types of managed areas existing in the conterminous United States, including land held by federal, state, tribal and private agencies and organizations. MAD was developed at an approximate map scale of 1:2,000,000, with a Minimum Mapping Unit (MMU) of about 100 hectares. The database is divided into two separate GIS coverages. The first is a data layer containing polygons showing the boundaries of managed areas. The second is a layer containing data points that represent managed areas that are not large enough to meet the MMU requirements for the polygon coverage. This database will allow researchers to being assessing the degree of protection given certain species or ecosystems at regional or national scales.

Modifying Basemap Data Layers

ArcView GIS version 3.1 was used to produce the MICRA Paddlefish Basemap. Individual data layers from each EPA Region dataset were added as theme coverages (Figure 9). Like themes were merged together and then clipped to include only the MICRA states using ArcView's GeoProcessing Wizard (Figure 10). Complex queries were written for each data layer to separate and map the data components essential to the MICRA project. The query that provides the rivers and streams coverage for the range of the paddlefish contains over 200 "if" statements. Rivers with unique names such as Missouri or Atchafalya could be selected on the basis of their names alone. Rivers with common names such as White River or Big Creek had to be identified by name and hydrologic unit codes. The final data layer produced only those data items important to the paddlefish project with the MICRA states (Figure 11).

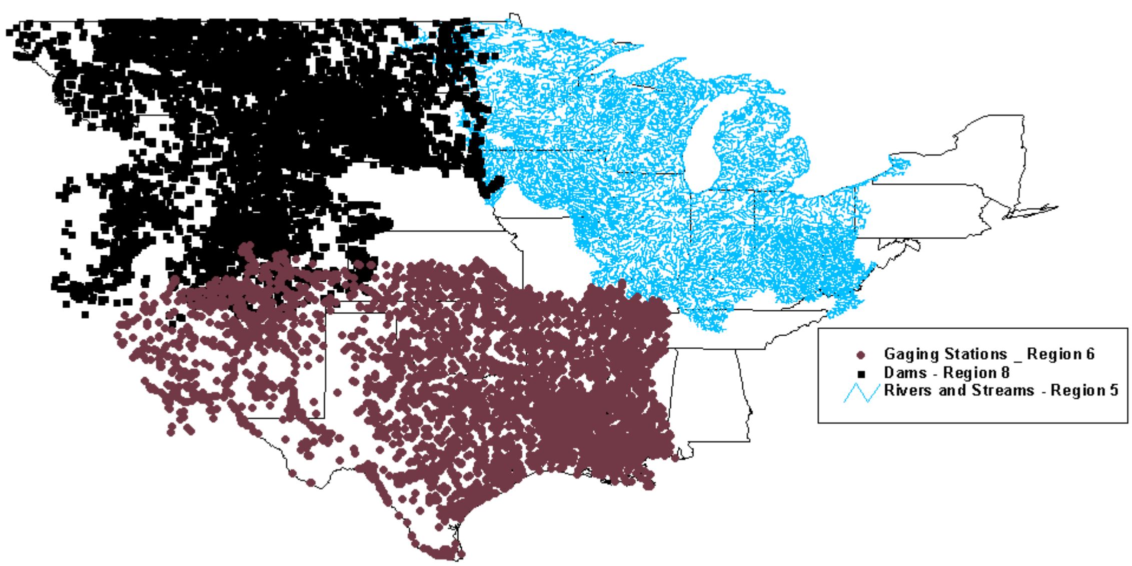


Figure 9. Initial EPA Basins Data Layers.

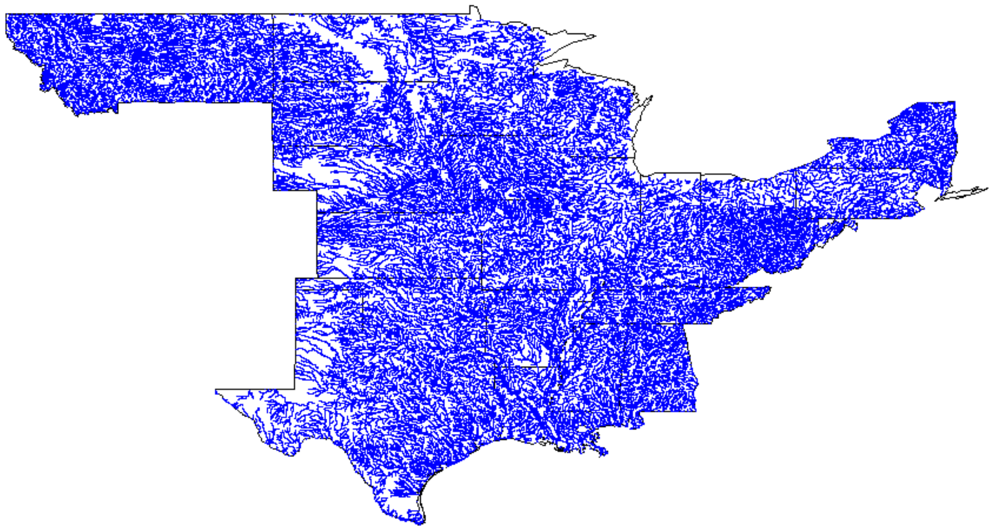


Figure 10. Rivers and streams coverages merged across EPA Regional Boundaries and clipped to MICRA states boundaries.

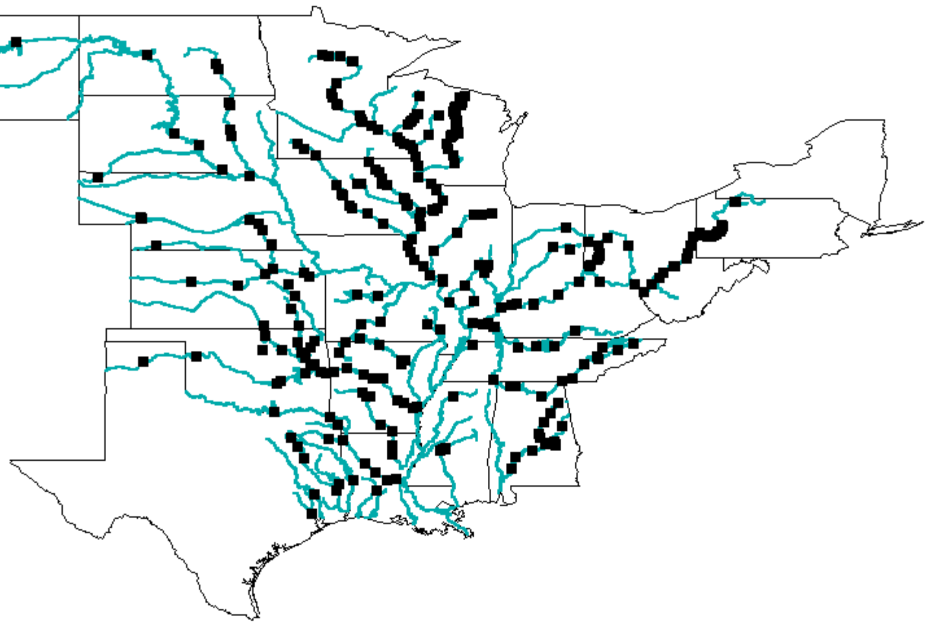


Figure 11. Final rivers and streams and dams data layers within the MICRA project boundaries.

Paddlefish Coordinates

State ATC were contacted to provide coordinate data for paddlefish sampling sites and hatchery release sites. Original hatchery release datasheets did not include boxes to record coordinates for stocking locations. Where needed coordinates were approximated by the RTC based on location names, habitat descriptions, navigation charts, and other paper and computer maps. All coordinates were individually converted to decimal degrees with the Geographic Calculator Software licensed by BlueMarble Geographics.

Spreadsheet tables were added to the list of tables in the mapping project file. Each table was then added to the project as a point theme. Wild fish sampling sites and recapture sites are represented by triangles. Hatchery fish stocking sites and recapture sites are represented by circles (Figure 12).

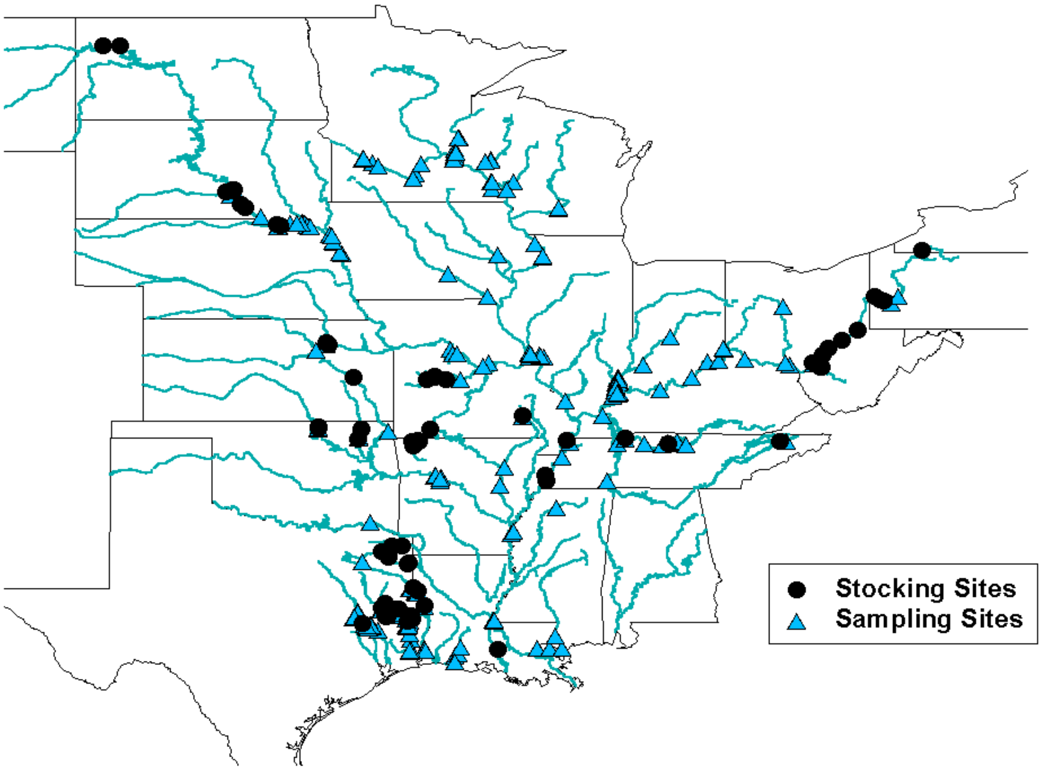


Figure 12. Locations of paddlefish sampling sites (triangles) and hatchery stock release sites (circles).

The completed paddlefish data layers can be queried to identify specific types of data. Any available variable in a given spreadsheet can be used within a query. In Figure 13, the hatchery stocking site data layer was queried to locate all paddlefish stocked that originated with Missouri River broodstock. This dataset can also be queried by state, hatchery, release site, or even tag retention rates. In Figure 14, the wild recapture coverage was queried to identify female paddlefish. This data layer can be queried with any variable or combination of variables on the paddlefish measurement/tagging sheet. A complex query would involve a combination of variables such as paddlefish over 600-mm body length with rostrum damage.

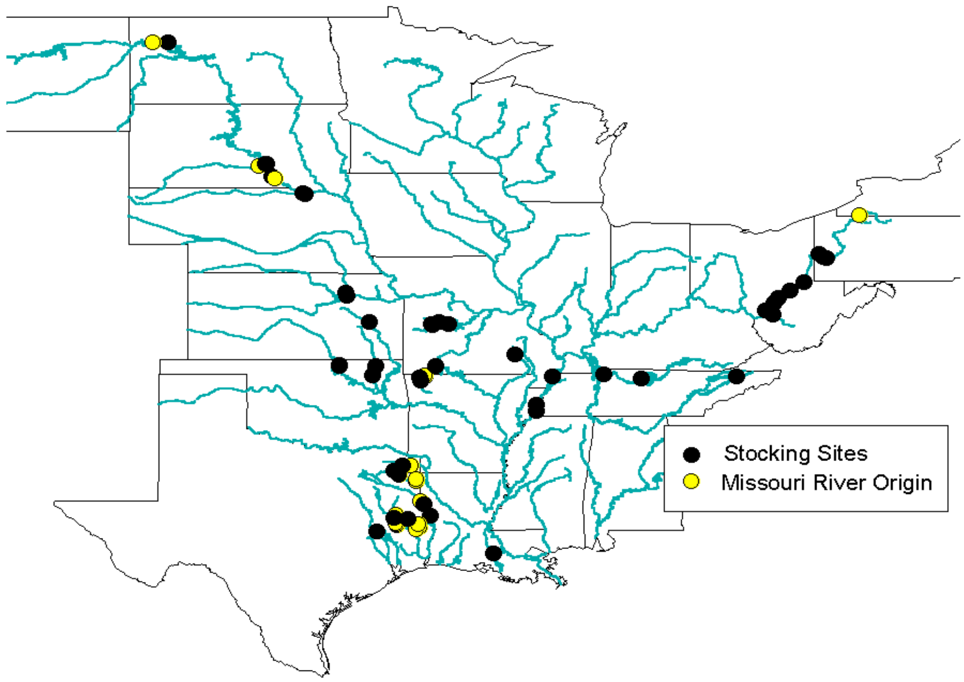


Figure 13. Query of stocking sites data layer to indicate stocks that originated with Missouri River broodstock.

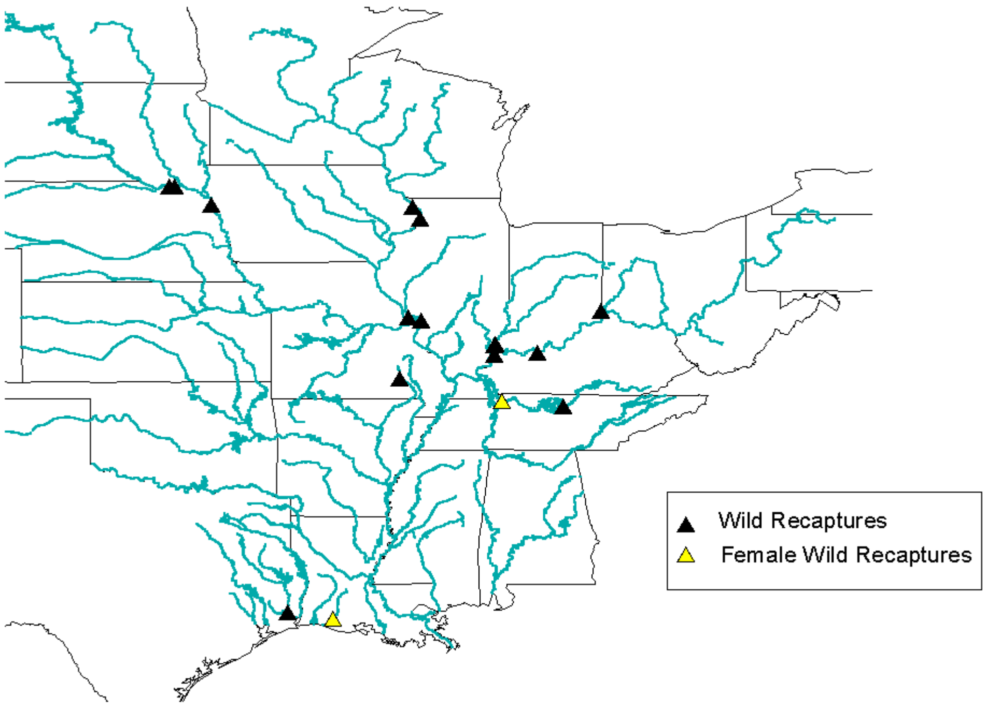


Figure 14. Query of wild recaptures data layer to identify fish identified as female by field biologists.

Future Goals

After further data cleaning and basemap organization, copies of the mapping project will be delivered to the state ATC on CDS. Each CD will contain the mapping project file, all data layer files, and a copy of ArcExplorer. ArcExplorer is a free shareware package that allows biologists without access to ArcView software to access the map. The current mapping product includes data collected through 1998. Agreement needs to be reached among state ATC regarding data distribution before the mapping product is moved to the MICRA web page.

One of the next steps in our mapping process will be to digitize the boundaries of the individual paddlefish populations identified by the MICRA biologists. Figure 15 is an example of four population boundaries identified by the Lower Mississippi River Basin biologists. This coverage currently exists as a drawing and not a geo-referenced object.

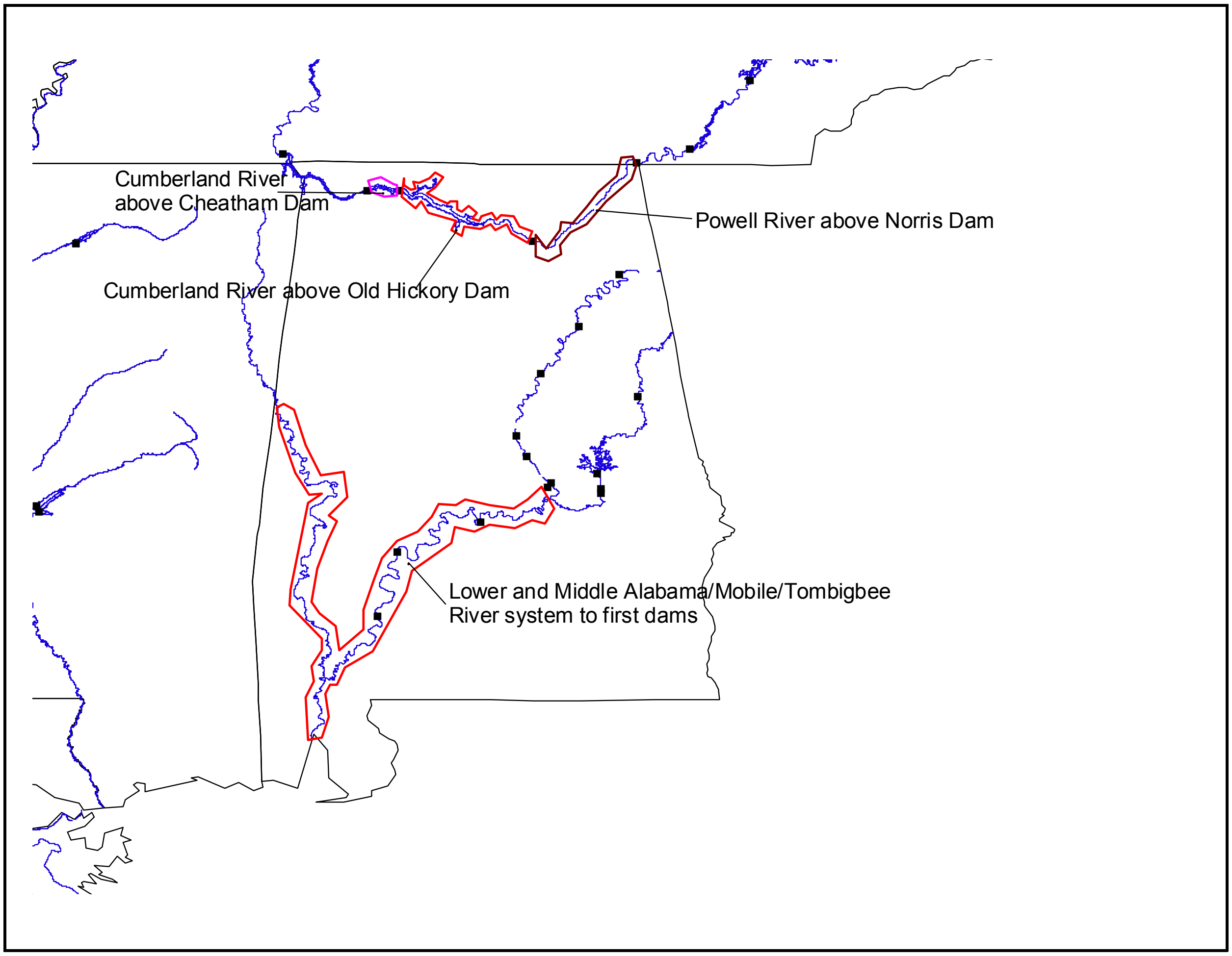


Figure 15. Paddlefish population boundaries as identified by Lower Mississippi River Basin biologists.

The third long-term goal of the mapping project involves linking the paddlefish recapture dataset to the hatchery and sampling datasets. The mapping project would produce a summary table including information such as: original and recapture locations, time a fish was at large, and changes in length and weight (Figure 16).

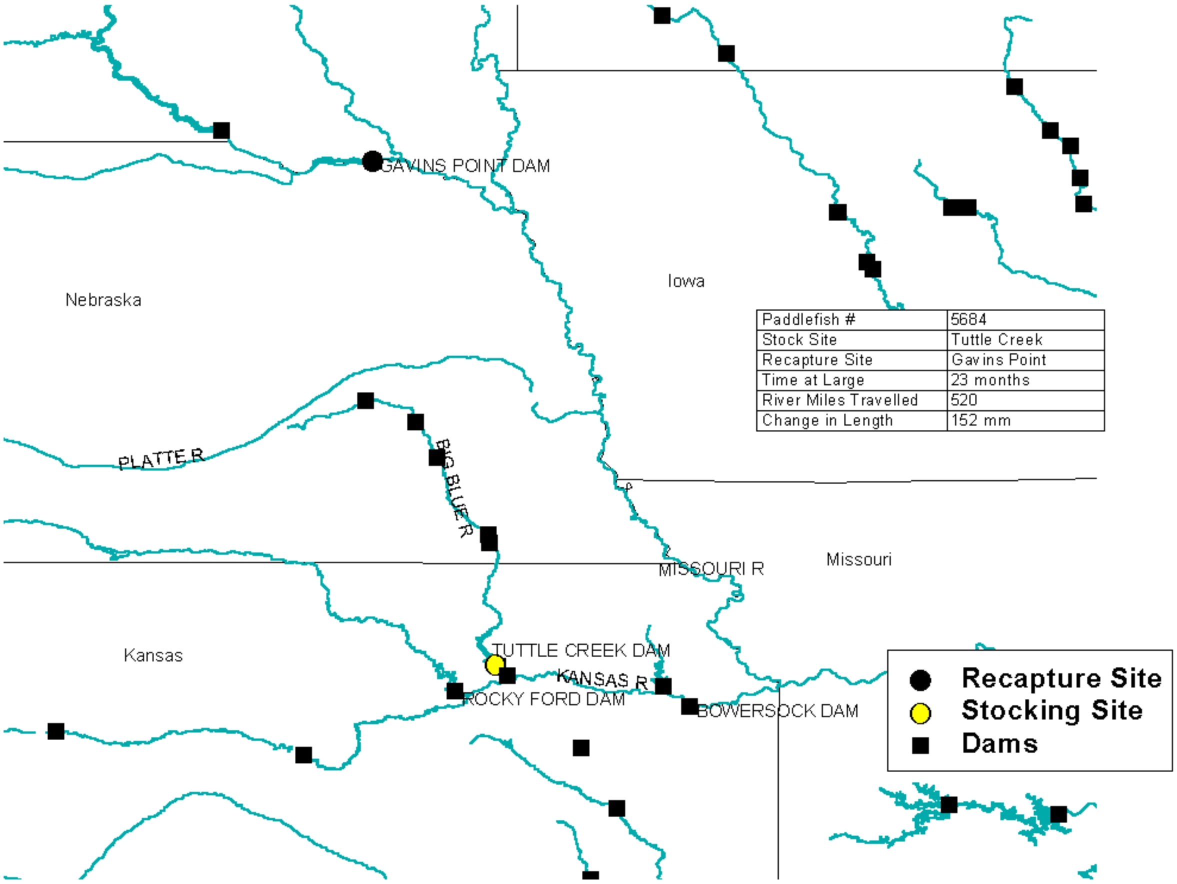


Figure 16. Example of future potential of mapping project. Summary table indicates distance the fish traveled between stocking and recapture sites and changes in length and weight.

Literature Cited

Brown, M.L., and B.R. Murphy. 1993. Management evaluation of body condition and population size structure for paddlefish: a unique case. Prairie Naturalist 25(2): 93-108.

Grady, J.M. and G.A. Conover. 1998. Mississippi River basin paddlefish research coded-wire tagging project: 1997 Annual Report. Mississippi Interstate Cooperative Resource Association (MICRA). U.S. Fish and Wildlife Service, Region 3, Fisheries Resources Program.

Lestelle, L.C., L.E. Mobrand, J.A. Lichatowich, and T.S. Vogel. 1996. Applied ecosystem analysis – a primer, EDT: the ecosystem diagnosis and treatment method. Project No. 94044600, Bonneville Power Administration, Portland, Oregon.

Mobrand, L.E., J.A. Lichatowich, L.C Lestelle, and T.S. Vogel. 1997. An approach to describing ecosystem performance “through the eyes of salmon”. Can. J. Fish. Aquat. Sci. 54: 2964-2973.

White, G.C. (1999). Program MARK [Online]. Available: http://www.cnr.colostate.edu/~gwhite/mark/mark.htm [2000, March 31].

APPENDIX A

MICRA Paddlefish Harvest Data

ARKANSAS: MISSISSIPPI BASIN

Sport Harvested Paddlefish

Year	# Rostrums	# Recaps	% Recaps
1995	--	--	--
1996	4	0	0.0
1997	--	--	--
1998	--	--	--
1999	--	--	--

Commercial Harvested Paddlefish

Year	# Rostrums	# Recaps	% Recaps
1995	--	--	--
1996	127	0	0.0
1997	--	--	--
1998	--	--	--
1999	--	--	--

Illegally Harvested and Dead Paddlefish

Year	# Rostrums	# Recaps	% Recaps
1995	--	--	--
1996	1	0	0.0
1997	--	--	--
1998	--	--	--
1999	--	--	--

ILLINOIS: MISSISSIPPI BASIN

Sport Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	39	0	0.0
1997	12	0	0.0
1998	--	--	--
1999	9	0	0.0

Commercial Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	215	1	0.5
1996	989	5	0.5
1997	569	5	0.9
1998	361	2	0.6
1999	1113	22	2.0

Illegally Harvested and Dead Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	8	1	12.5
1998	--	--	--
1999	1	0	0.0

ILLINOIS: OHIO BASIN

Sport Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	--	--	–

Commercial Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	121	0	0.0

Illegally Harvested and Dead Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	2	0	0.0
1999	3	0	0.0

INDIANA: OHIO BASIN

Sport Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	20	0	0.0
1999	--	--	--

Commercial Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	2065	5	0.2
1997	1951	18	0.9
1998	1726	5	0.3
1999	635	4	0.6

Illegally Harvested and Dead Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	2	0	0.0
1998	--	--	--
1999	--	--	–

KANSAS: MISSOURI BASIN

Sport Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	--	--	–

Commercial Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	--	--	–

Illegally Harvested and Dead Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	4	4	100.0
1996	5	5	100.0
1997	--	--	--
1998	--	--	--
1999	--	--	--

KENTUCKY: MISSISSIPPI BASIN

Sport Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	--	--	--

Commercial Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	--	--	--

Illegally Harvested and Dead Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	--	--	–

KENTUCKY: OHIO BASIN

Sport Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	5	2	40.0

Commercial Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	113	0	0.0

Illegally Harvested and Dead Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	1	0	0.0

MISSOURI: MISSOURI BASIN

Sport Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	2	0	0.0
1996	203	0	0.0
1997	23	0	0.0
1998	--	--	--
1999	--	--	--

Commercial Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	--	--	--

Illegally Harvested and Dead Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	226	0	0.0
1997	4	0	0.0
1998	--	--	--
1999	--	--	–

MISSOURI: MISSISSIPPI BASIN

Sport Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	59	0	0.0
1997	1935	3	0.2
1998	962	2	0.2
1999	--	--	--

Commercial Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	2609	8	0.3
1997	--	--	--
1998	--	--	--
1999	--	--	--

Illegally Harvested and Dead Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	--	--	--

NEBRASKA: MISSOURI BASIN

Sport Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	6	6	100.0
1997	142	60	42.3
1998	264	27	10.2
1999	--	--	–

Commercial Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	1	1	100.0
1997	--	--	--
1998	--	--	--
1999	--	--	--

Illegally Harvested and Dead Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	--	--	--

SOUTH DAKOTA: MISSOURI BASIN

Sport Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	177	177	100.0
1996	160	160	100.0
1997	136	42	30.9
1998	654	76	11.6
1999	118	17	14.4

Commercial Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	--	--	--

Illegally Harvested and Dead Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	--	--	–

TENNESSEE: MISSISSIPPI BASIN

Sport Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	--	--	–

Commercial Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	6	0	0.0
1997	--	--	--
1998	47	0	0.0
1999	--	--	--

Illegally Harvested and Dead Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	519	3	0.6
1996	2	0	0.0
1997	--	--	--
1998	--	--	--
1999	--	--	--

WEST VIRGINIA: OHIO BASIN

Sport Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	--	--	--

Commercial Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	--	--	–

Illegally Harvested and Dead Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	2	1	50.0

Sport Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	102	0	0.0
1997	1947	3	0.2
1998	962	2	0.2
1999	9	0	0.0

Commercial Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	215	1	0.5
1996	3731	13	0.4
1997	569	5	0.9
1998	408	2	0.5
1999	1113	22	2.0

Illegally Harvested and Dead Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	519	3	0.6
1996	3	0	0.0
1997	8	1	12.5
1998	--	--	--
1999	1	0	0.0

MISSOURI BASIN

Sport Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	179	177	98.9
1996	315	166	52.7
1997	301	102	33.9
1998	918	103	11.2
1999	118	17	14.4

Commercial Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	1	1	100.0
1997	--	--	--
1998	--	--	--
1999	--	--	–

Illegally Harvested and Dead Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	6	6	100.0
1996	253	27	10.7
1997	4	0	0.0
1998	--	--	--
1999	--	--	–

Sport Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	--
1997	--	--	--
1998	--	--	--
1999	5	2	40.0

Commercial Harvested Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	2065	5	0.2
1997	1951	15	0.8
1998	1726	5	0.3
1999	869	4	0.5

Illegally Harvested and Dead Paddlefish

YEAR	# ROSTRUMS	# RECAPS	% RECAPS
1995	--	--	--
1996	--	--	–
1997	2	0	0.0
1998	1728	5	0.3
1999	6	1	16.7

APPENDIX B

Movements of Wild-Ranging Coded-Wire Tagged Paddlefish Recaptured in 1998

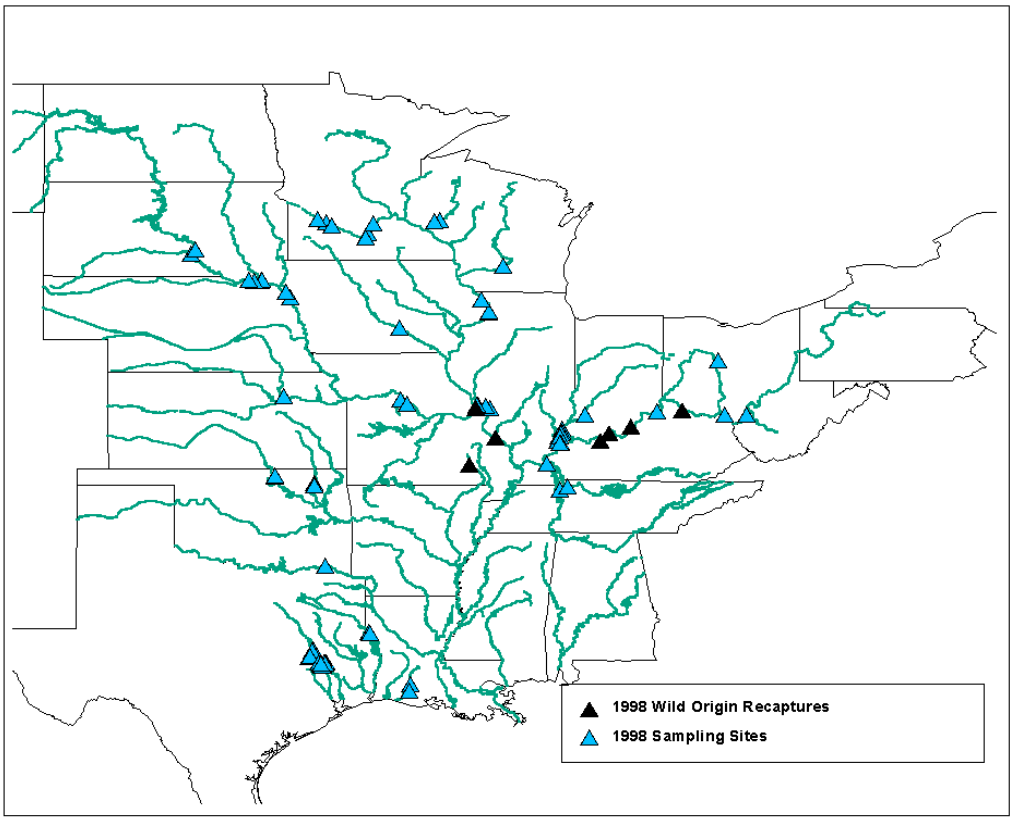


Figure B1. Locations of all 1998 field sampling efforts and wild origin recaptures.

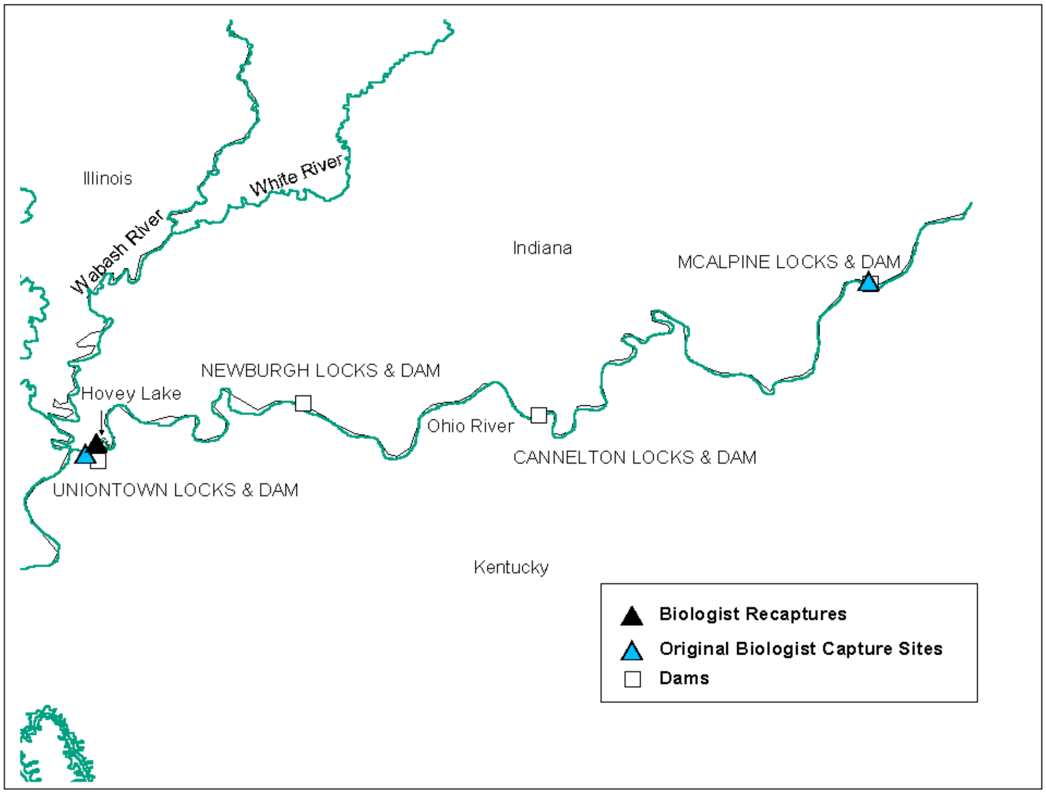


Figure B2. Movements of two wild origin paddlefish recaptured by biologists in the Ohio River sub-basin. One paddlefish was tagged in the tailwaters below Uniontown Locks and Dam and the other in the tailwaters below McAlpine Locks and Dam. Both fish were recaptured in Hovey Lake.

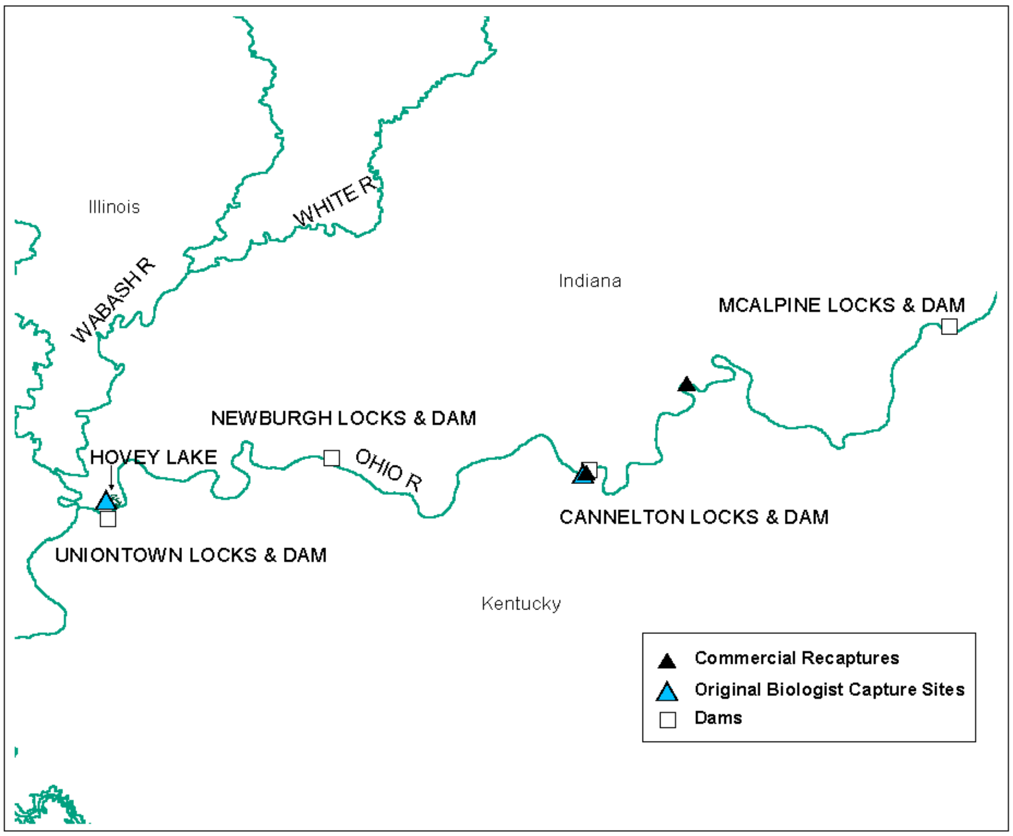


Figure B3. Movements of two wild origin paddlefish recaptured by commercial anglers in the Ohio River sub-basin. One fish tagged in Hovey Lake was recaptured in the tailwaters below Cannelton Locks and Dam, the other fish was tagged in the tailwaters below Cannelton Locks and Dam and was recaptured in Cannelton Pool.

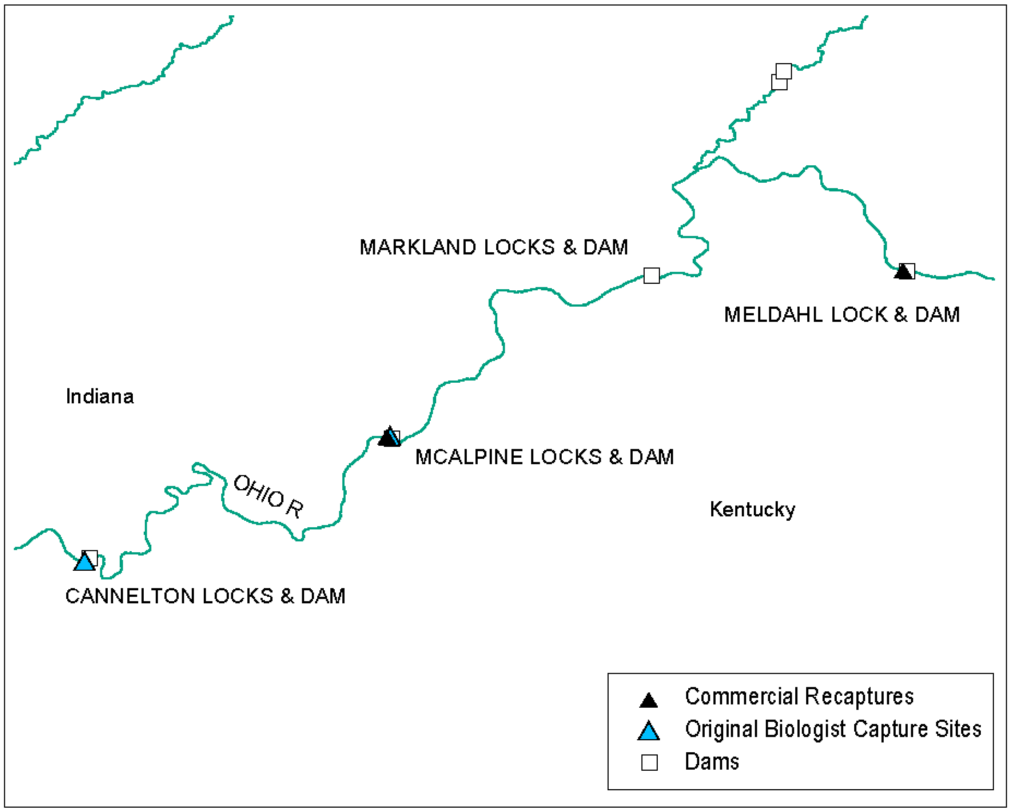


Figure B4. Movements of two wild origin paddlefish recaptured by commercial anglers in the Ohio River sub-basin. One fish was tagged in the tailwater below Cannelton Locks and Dam and recaptured below McAlpine Locks and Dam, another fish tagged below McAlpine Locks and Dam was recaptured in the tailwaters below Meldahl Locks and Dam.

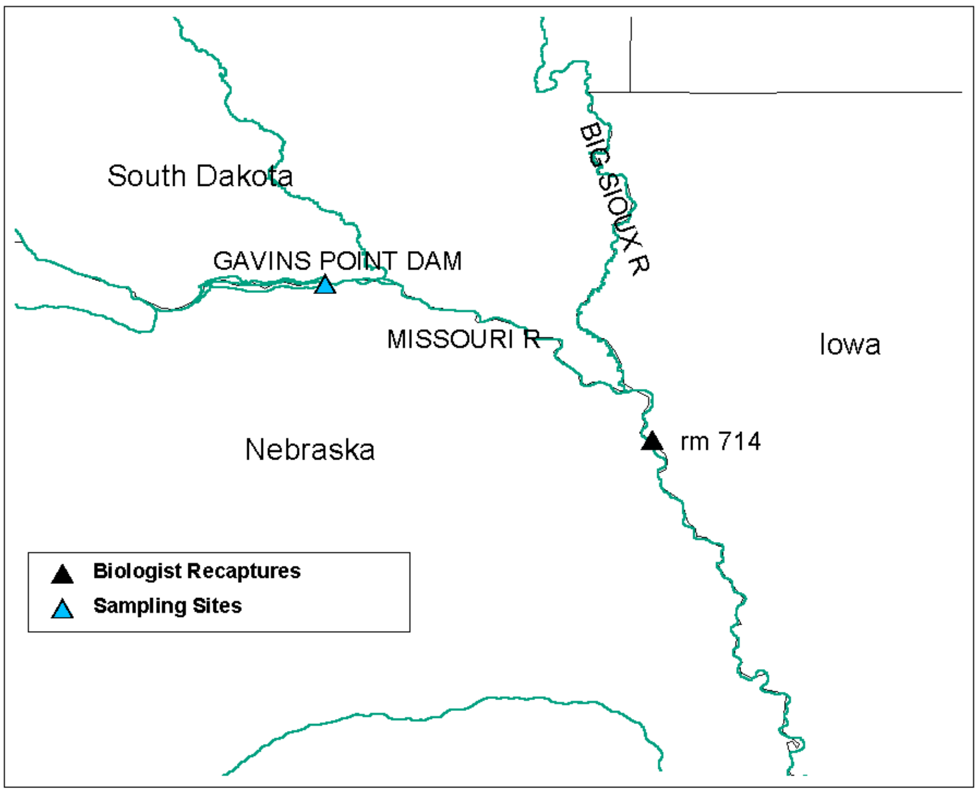


Figure B5. Movement of one wild ranging paddlefish recaptured by biologist in the Missouri river sub-basin. The fish was tagged in the tailwaters below Gavins Point Dam (River Mile 811).

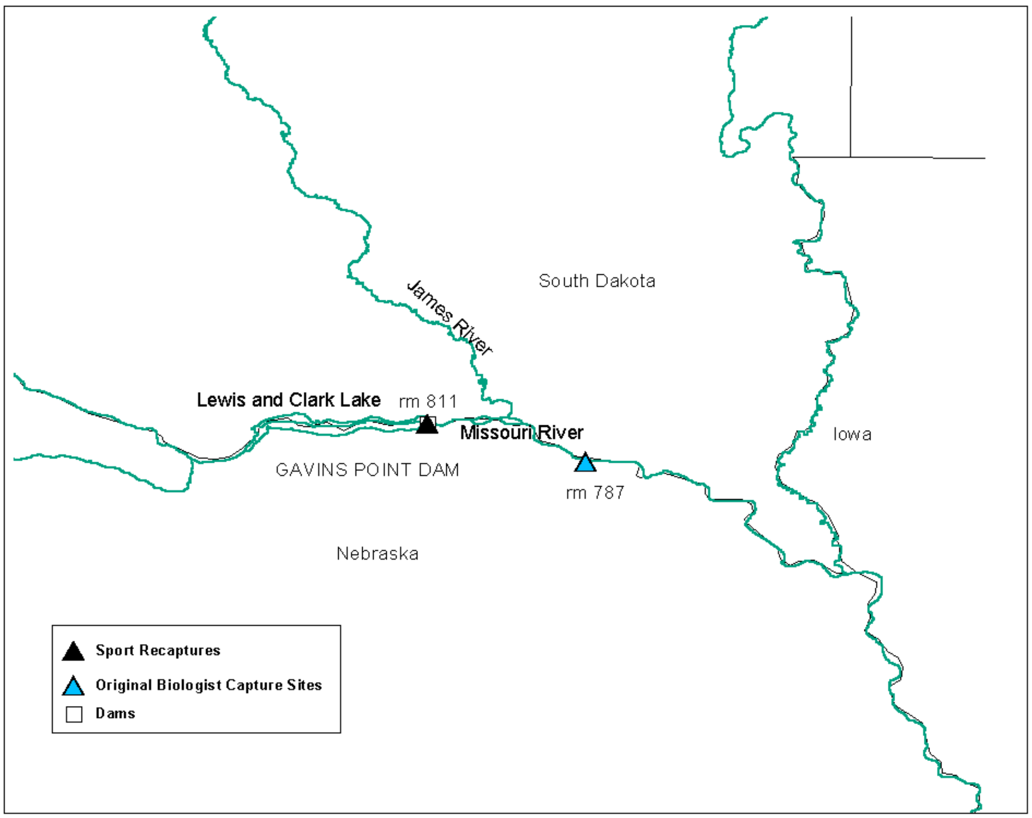


Figure B6. Movement of one wild origin paddlefish recaptured by a sport angler in the Missouri River sub-basin. The fish was recaptured in the tailwaters below Gavins Point Dam.

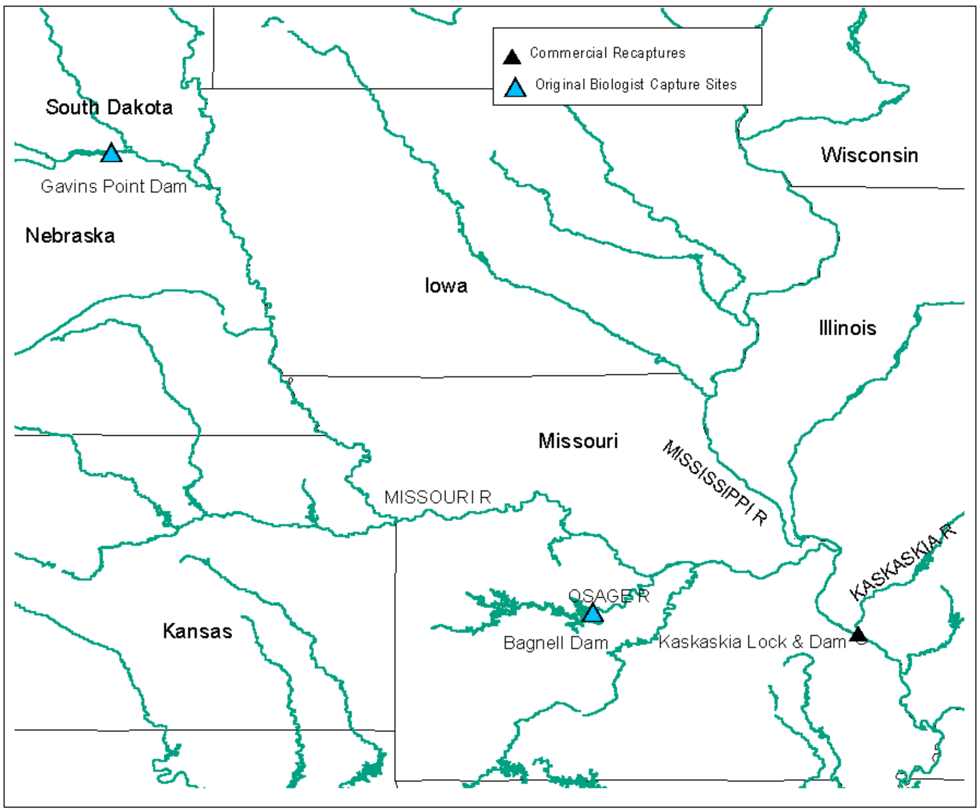


Figure B7. Movements of two wild origin paddlefish tagged in the Missouri River sub-basin and recaptured by a commercial angler in the Mississippi River sub-basin. One fish was tagged in the tailwaters below Gavins Point Dam and the other in the tailwaters below Bagnell Dam. Both paddlefish were recaptured in the tailwaters below the Kaskaskia River Lock and Dam. The fish passed Locks and Dam 27 on the Mississippi River to reach the Kaskaskia River.

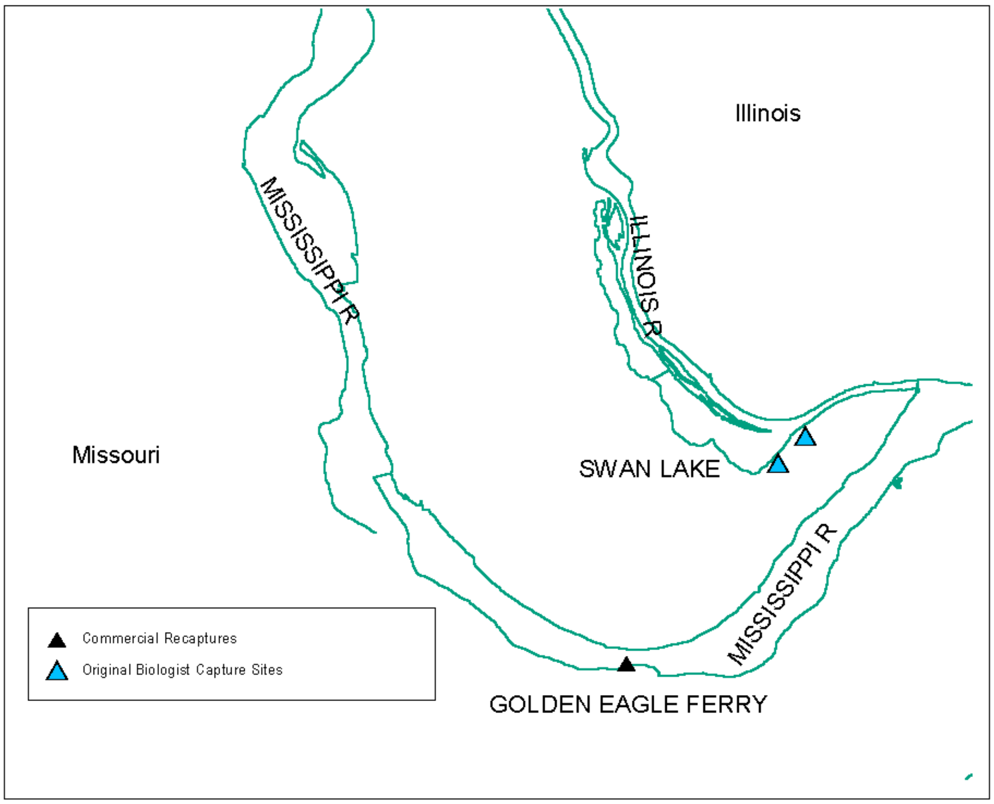


Figure B8. Movements of two wild origin paddlefish recaptured in the Mississippi River sub-basin by a commercial angler. Both fish were tagged in Swan Lake, Illinois River and were recaptured below a wing dam in Pool 26 the Mississippi River.

APPENDIX C

Movements of Hatchery-Released Coded-Wire Tagged Paddlefish Recaptured in 1998

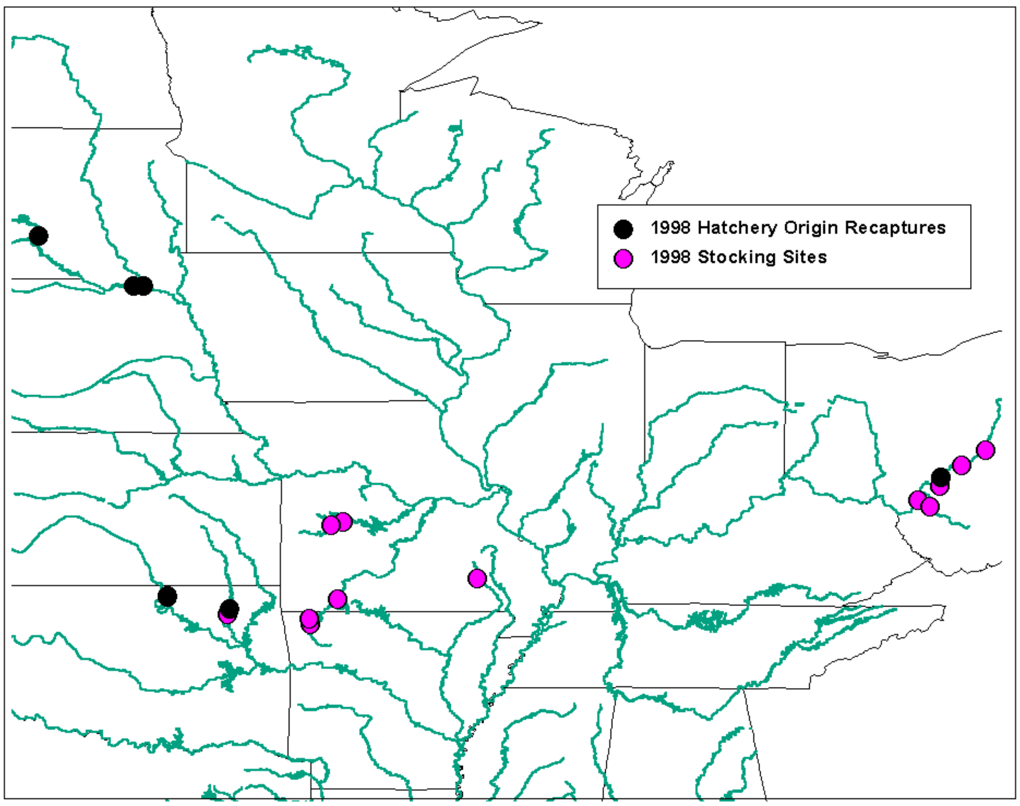


Figure C1. Locations of all 1998 hatchery releases of MICRA coded-wire tagged paddlefish and recaptures of hatchery origin paddlefish.

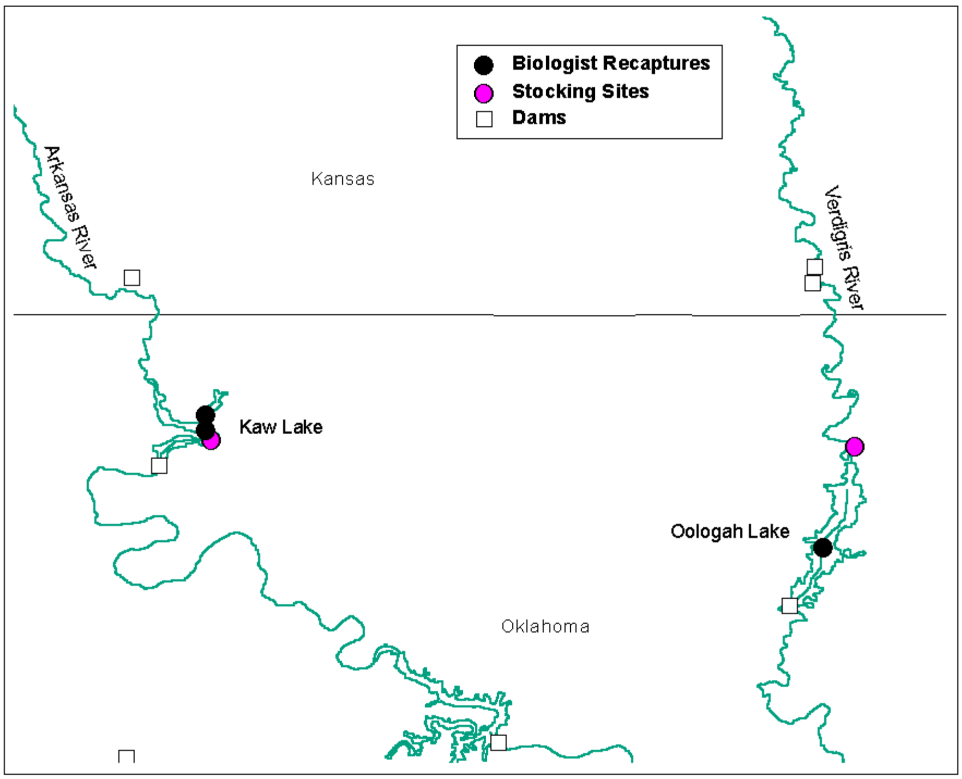


Figure C2. Movements of five hatchery origin paddlefish recaptured by biologist in the Mississippi River sub-basin. Two fish were stocked and recaptured in Lake Kaw and thre were stocked and recaptured in Oolagah Lake.

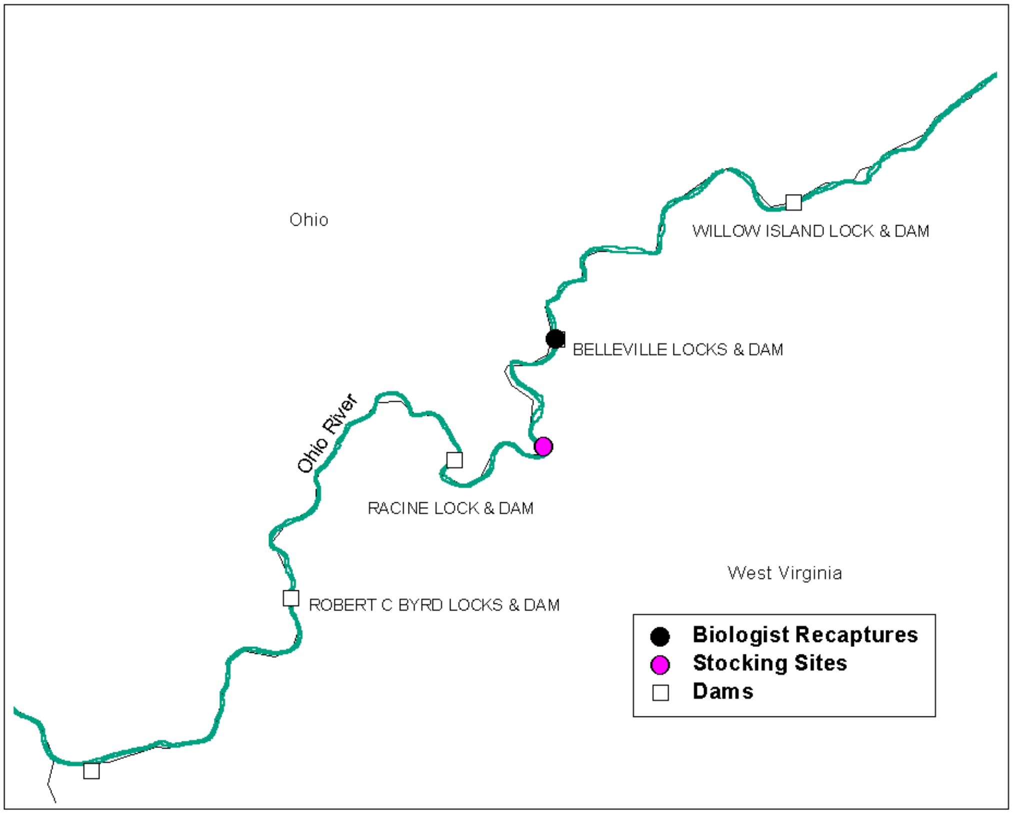


Figure C3. Movement of one hatchery origin paddlefish recaptured by biologist in the Ohio River sub-basin. The paddlefish, stocked into Racine Pool, was recaptured in a lock chamber during a lock rotenone survey less than one month after the paddlefish was released.

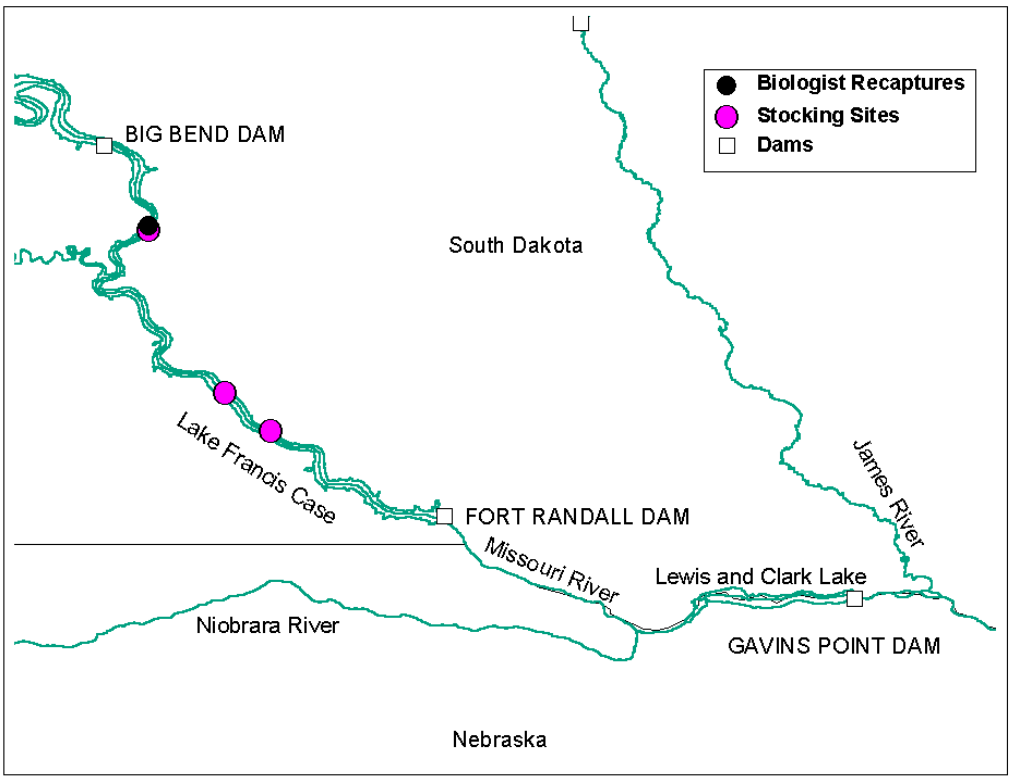


Figure C4. Movements of five hatchery origin paddlefish recaptured by biologists in the Missouri River sub-basin. The fish were stocked and recaptured in Lake Francis Case.

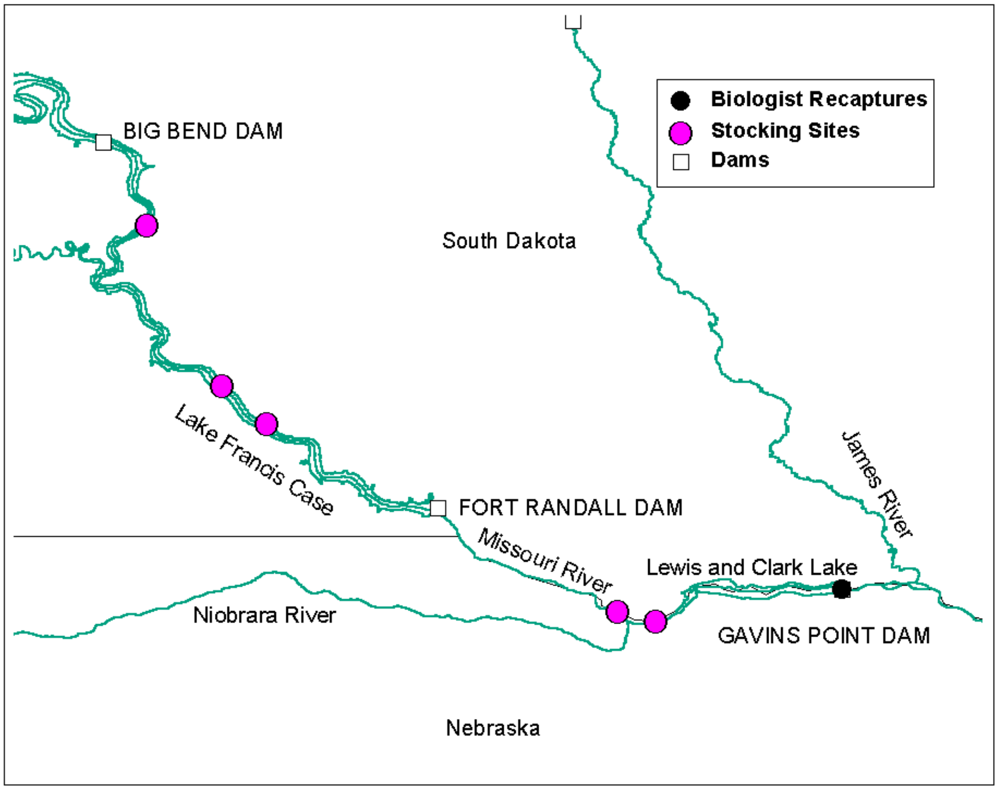


Figure C5. Movements of 37 hatchery origin paddlefish recaptured by biologist in the Missouri river sub-basin. Twelve fish stocked into Lake Francis Case and 25 released into Lewis and Clark Lake were all collected in the tailwaters below Gavins Point Dam.

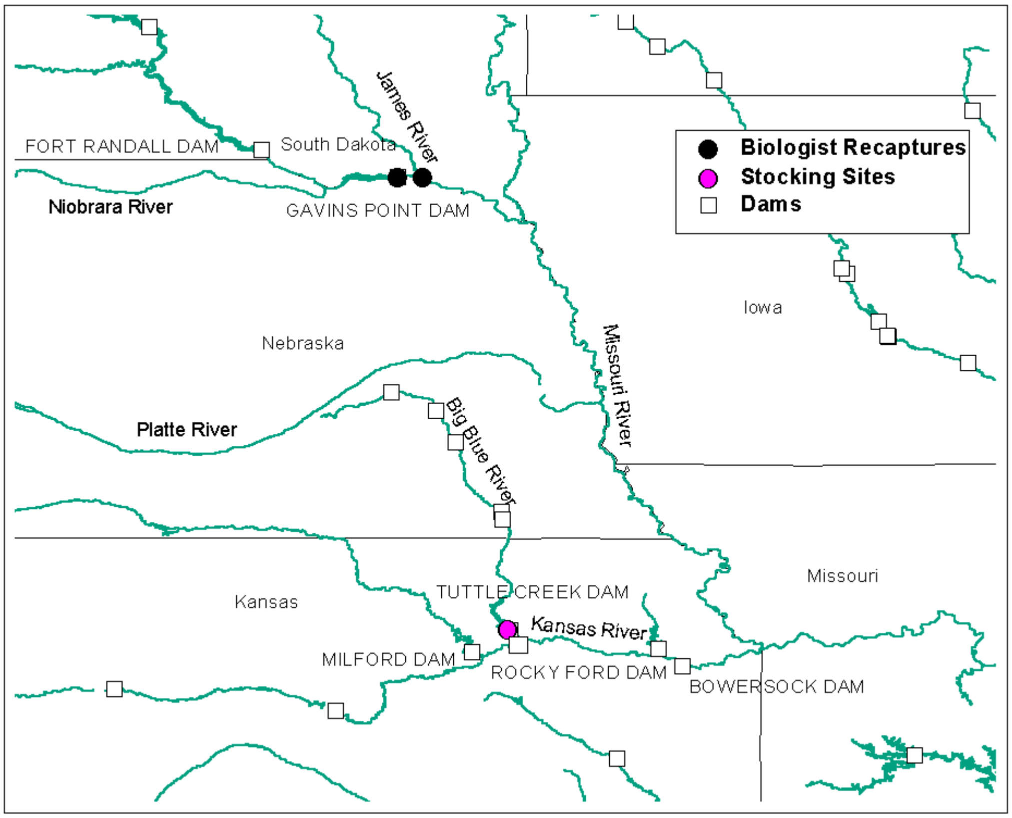


Figure C6. Movements of 44 hatchery origin paddlefish recaptured by biologists in the Missouri River sub-basin. Forty-three fish were collected in the tailwaters below Gavins Point Dam (River Mile 811) and one was collected 12 miles below the dam near the James River confluence (River Mile 799). The fish, which passed through Tuttle Creek Dam and over Rocky Ford and Bowersock Dams, traveled down stream 150 miles and upstream another 450 miles.

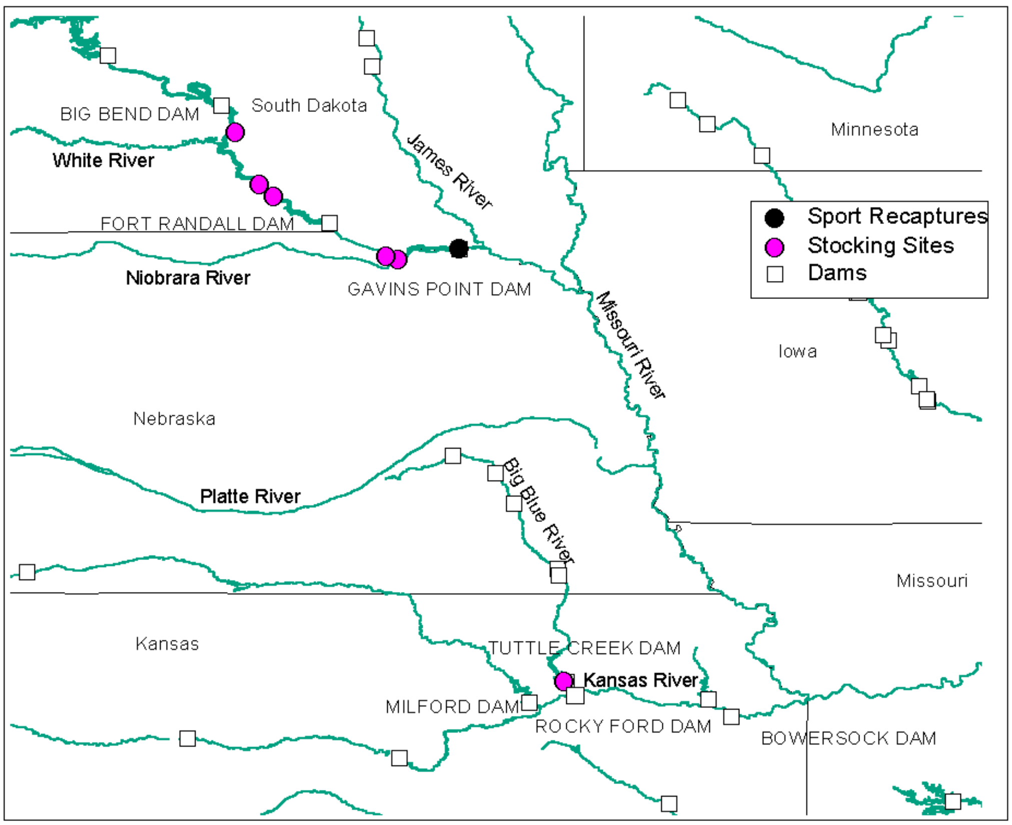


Figure C7. Movements of 69 hatchery origin paddlefish recaptured by sport anglers in the Missouri River sub-basin. Fifteen fish stocked into Lake Francis Case, 33 in Lewis and Clark Lake, and 21 in Tuttle Creek Reservoir were all recaptured in the tailwaters below Gavins Point Dam.