Minnesota
F-29-R(P)-26
Area F317
Study 4

MINNESOTA DEPARTMENT OF NATURAL RESOURCES
SECTION OF FISHERIES

Completion Report

Effects of winter angling on sauger and flathead catfish in the Upper Mississippi River.

by

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Funded Under Federal Aid by the Sport Fish Restoration Act,
F-29-R(P)-26

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ABSTRACT

Winter hooking mortality of sauger (*Sander canadensis*) and flathead catfish (*Pylodictus olivaris*) was assessed in the upper reaches of Pool 4 of the Mississippi River by attaching sonic tracking tags to 12 sauger and 10 flathead catfish. We also evaluated sauger catch and release mortality by holding fish for 72 h in a net-pen. All of the sonic tagged flathead catfish survived and were located up to 66 d later. Five flathead catfish were transported 816 m downstream and all moved back to the overwintering areas where they were caught within 24 h. Two of the 12 tagged sauger were declared dead upon fixation of the sonic tags. One tagged sauger was never relocated. The remaining 9 tagged sauger were located and all were alive 21 d later (18% mortality; 2 of 11). The mortality rate for saugers observed in the net-pen was 26.6% (57 of 214). Sauger winter catch and release mortality was significantly influenced by the depth of capture. Twenty-one to thirty-eight percent of sauger caught from ≥ 9.1 m died, while only 2.4% died when caught from < 9.0 m. There was no relationship between size of fish caught and mortality; however, fish caught from <9.0 m were significantly larger. Using estimates of catch and release sauger angling mortality from < 9.0 m (2.4%), ≥ 9.1 m (33%) and past creel data, about 400-3,000 fish die annually from winter angling. Based on sauger annual mortality estimates and historical gill netting data, we believe that the winter sauger mortality estimates do not substantially influence the entire population. However, anglers may reduce the amount of sauger winter angling mortality by restricting the amount of time fishing in depths greater than 9.1 m.

INTRODUCTION

Sauger (*Sander canadensis*) are the most sought after sportfish and annually represent 35 to 49% of the total pounds harvested in Pool 4 of the Mississippi River (Hoxmeier 2002). Flathead catfish (*Pylodictus olivaris*), although not as popular with anglers as sauger, are one of the largest sportfish in the upper Mississippi River and are gaining popularity (Jackson 1999). Both of these species concentrate during the winter months and become vulnerable to exploitation. Anglers and biologists have voiced concerns about high hooking mortality during winter months for sauger and flathead catfish. The tailwater area of Lock and Dam 3 (LD 3) receives substantial fishing pressure by anglers targeting walleye and sauger. Boat anglers are able to effectively target winter concentrations of sauger in the tailwater, because thermal effluent from a nuclear power generating facility causes this area to remain ice-free during most winters. Perceived high hooking mortality of sauger was the impetus for more restrictive regulations on the Mississippi River in Iowa and Wisconsin (Kirk Hansen, Iowa Department of Natural Resources, personal communication). Similarly, foul hooking of flathead catfish during the winter months is a growing concern in several states.

Flathead catfish are metabolically not as active as sauger during winter and concentrate in deep water areas, many of which are historically significant. These overwintering areas protect them from the adverse effects of flowing water during a relatively dormant period of their life history. Flathead catfish are most often caught during winter by foul hooking. Illegal snagging of flathead catfish has been a concern in the Mississippi River during the winter months, particularly in the river reach between LD 3 and Lake Pepin (personal communication, WI conservation officers). Similarly, there have been news accounts of anglers targeting and setting up guided trips for flathead catfish in the winter.

In Minnesota hooking mortality for walleye has been studied and recently revisited (Payer et al. 1989; K. Reeves, unpublished data). However, it is not known how these results apply to sauger or to a riverine environment. A similar study was conducted on the Tennessee River after complaints of high release mortality of sauger (Bettoli et al. 2000). This study concluded that hooking mortality of sauger in a riverine environment was low, regardless of gas bladder overinflation. However, water temperatures in their study averaged 10 °C and air temperatures averaged 9.2 °C; much warmer than average water (3.6 °C) and air (-7.4 °C) temperatures in Minnesota in December. Affects of winter angling on flathead catfish have never been studied in Minnesota.

The primary objective of this study was to estimate short (72 h) and long-term (> 29 d) hooking mortality of winter angled sauger and flathead catfish below LD 3 of the Mississippi River. We also collected information on movement of fish and the effects of flathead catfish downstream displacement from capture locations. Another objective of the study was to provide information to anglers so they can make informed decisions on where and when to fish for these species to minimize mortality.

STUDY AREA

Pool 4 of the Mississippi River is located along the Minnesota and Wisconsin border in Goodhue and Wabasha counties of southeast Minnesota and Pierce, Buffalo, and Pepin counties of western Wisconsin (Figure 1). The MN-WI portion of the Mississippi River is the only water in MN that has a year-round season for all gamefish species. The continuous open season was initiated by Wisconsin in 1967 on its portion of the Mississippi River and Minnesota followed suit in 1969. In 1985 a change in the operating procedure of EXEL's nuclear power plant allowed warm-water discharge into Pool 3, which has a direct impact on ambient water temperatures in upper Pool 4. The result has been a much longer period of open water below LD 3 during winter months. Consequently, a popular winter open water walleye and sauger fishery has developed below LD 3.

METHODS

Sauger and Flathead Catfish Telemetry

Sauger were caught with conventional fishing gear below LD 3 in late December and late February (Figure 2). All angling was performed by MNDNR staff. Once a sauger was caught, water depth was recorded using a boat mounted Garmin GPSmap 168 Sounder. Baits were always fished within 1 meter of the river bottom, thus we assumed that the depth of capture was known within 1 meter. Once fish were aboard, total length (TL, mm) was recorded and fish were fitted with a Sonotronics IBT-96 series external transmitter (69-83 kHz; range of 500 m) just below the dorsal fin. Based on a length-weight regression model for Mississippi River sauger, the weight of the smallest sonic tagged sauger (254 mm) was 144 g; therefore, sonic tags weighed no more than 2.4% of the total body weight. Twelve sauger were caught and tagged during two separate tagging events. Two of the twelve fish suffered from severe depressurization and never regained stability. Those two fish were considered dead and sonic tags were reattached to other sauger. Therefore, a total of ten sauger were tagged for the study, five of those were tagged between January 22 and 27, 2006 and five additional fish were tagged on February 28, 2006.

MNDNR staff snagged ten flathead catfish with a weighted treble hook in a known over-wintering location in depths ranging from 7.6-8.5 m on January 31, 2006 (Figure 2). Depth at capture (m) was recorded and all fish were snagged while resting on the river bottom. Once fish were aboard, total length (TL, mm) was recorded and fish were fitted with Sonotronics CT series external transmitters (32-83 kHz; range of 1000 m) just below the dorsal fin. The weight of the smallest sonic tagged catfish (584 mm) predicted from a length-weight regression model for Mississippi River flathead catfish was 2,402 g; therefore, sonic tags weighed no more than 0.6% of the total body weight. All ten flathead catfish snagged were fitted with sonic tags. Five of the sonic tagged fish were released at their point of capture immediately upon fixation of the sonic tag, while the remaining five were displaced approximately 816 m downstream.

Fish were located daily for two to three days after release and then periodically up to 29 days for sauger and up to 77 days for flathead catfish (Table 1 and 2). Locations of fish were recorded using a Garmin GPSmap 168 Sounder and waypoints were converted to shapefiles using ArcMap software. The distance each fish moved between location dates was calculated using the measuring tool in ArcView. On occasion, fish location only slightly varied from previous recording and the same waypoint was used for both observations. Movement was not estimated on days when no new waypoint was taken. Depth of target fish was also recorded using the Garmin unit.

Sauger Winter Angling - Net Pen Study

Post release hooking mortality (72 h) was evaluated using a vertical net pen (1.8 x 1.8 x 10 m) on three separate occasions during winter 2005-2006 and on three occasions during winter 2006-2007 (Table 3). Sauger were caught by MNDNR staff and volunteer anglers with conventional fishing gear in the tailwater of LD 3. Once a sauger was hooked, the depth of capture (m) was recorded and the fish was marked by a hole punch in either the dorsal, caudal, or anal fin, depending on what depth range the fish was caught from (3.05 meter intervals between 6.1 and 24.1 m). Fish were transported in water filled coolers to the vertical net pen and held for 72 h. Handling time (i.e., elapsed time between the fish coming out of the water and being unhooked, marked, and transported to net pen) was estimated during several trials and all fish were transported to the net pen within 15 minutes. The net pen was placed in an area where current was negligible. River discharge in winter 2005-2006 was relatively high (376-560 cubic meters per second (cms)); therefore, net pen was placed approximately 1,200 m downstream from angling locations below the island separating the lock and dam and the lift gates in 5.5 meters of water (Figure 2). More typical discharge levels were present in winter 2006-2007 (139-218 cms) and the net pen was placed about 60 to 300 m from where most angling occurred in 8.5 m of water (Figure 2). The net pen was slowly raised following the 72 hr holding period and the disposition of each sauger was checked. Total length (mm) and depth of capture (m) based on location of fin punch of individual sauger were recorded. The number of sauger suffering from severe gas bladder overinflation (gas bladder extending out of the bucal cavity) was recorded prior to placing fish in the net pen and after the 72 h holding period in winter 2006-07.

Statistical Analysis

Mean length of dead, alive, and all sauger caught in various 3.05 m depth intervals were compared using Tukey’s pairwise comparison (SAS 1999). Binary logistic regression was used to determine the probability of a sauger to live at various sizes and depth ranges and to test the goodness-of-fit of the model (SAS 1999). Since exact depth of capture was estimated, I used the median value of each depth range (e.g. 7.6 m for fish caught between 6.1-9.0 meters) for the independent variable depth. If the dependent variable, which measures the status of a sauger (i.e. dead or alive), was equal to one, the fish lived and 0 if otherwise. The logit distribution of the model to estimate probabilities was calculated by using the following formula:

$$Pi = e^{(Bo + (Bi)x)}/1 + e^{(Bo + (Bi)x)}$$

where Bo equals the intercept of the model parameter and Bi equals the slope of the model parameter. All statistical analysis was performed at 0.05 alpha level.

RESULTS AND DISCUSSION

Sauger and Flathead Catfish Telemetry

Snagging flathead catfish from known overwintering habitats proved to be an effective method to collect and sample adult (580-1270 mm) individuals. We were able to collect and sonic tag ten flathead catfish (average length 909 mm; SE $\pm$ 84) in less than four hours. Each fish snagged and brought to the surface was in good condition and actively swimming. We were able to uniquely identify and detect movement on all sonic tagged flathead catfish for 66 d post-tagging and up to 77 d post-tagging on three fish (Table 1). Therefore, according to this study, catch-and-release hooking mortality was 0%.

The five flathead catfish transported 816 m downstream traveled an average of 655 m (SE $\pm$ 43) upstream in one day and one fish returned to where it was caught (Table 1; Figure 3). All fish returned to the known overwintering area where they were captured (Figure 5). We expected that there would be some movement of flathead catfish to deeper areas with flows and habitat similar to where they were caught, but the degree and direction of movement observed in this study showed a direct affinity to the established overwintering area. To our knowledge, this was the first tracking study that intentionally moved tagged flathead catfish a considerable distance downstream during winter. Other studies that have tracked seasonal movement of sonic or radio tagged flathead catfish have observed little or no movement during winter months, regardless of latitude (Pugh and Schramm 1999; Weller and Winter 2001; Daugherty and Sutton 2005; Vokoun and Rabeni 2005). We were surprised at the amount of movement of the displaced fish just after one day of being released.

Another objective of the study was to answer questions related to metabolic demand of caught and released flathead catfish during winter and the effect of that demand on survival. Towards this end, flathead catfish captured from the Mississippi River drainage were sent to the University of Connecticut to evaluate the feeding habits and metabolic demand of flathead catfish at various water temperatures. Results from this study showed that flathead catfish had a reduced metabolism at typical winter temperatures (15 °C and below) and stopped feeding at 7 °C (Jason Vokoun, personal communication). Catching flathead catfish using conventional angling techniques instead of snagging gears during winter in Minnesota seems improbable since winter water temperatures were always below 4.4 °C. Our tracking study demonstrated that water temperature did not hinder the ability of flathead catfish to move effectively and home in on a particular wintering area, even though fish may have stopped feeding. Although all fish survived, the metabolic costs to the overall fitness of the animal are unknown and warrant farther investigation.

All five flathead catfish released on-site moved less than 33 m (SE $\pm$ 5.7) after 15 days of being tagged (Table 1; Figure 3). No significant movements of flathead catfish occurred in February and March for nine of the ten-tagged fish and those fish remained in historic overwintering areas in depths ranging from 4.6-11.3 m (Table 1; Figure 3). Hawkinson and Grunwald (1979) investigated habitat variables (i.e., flow, depth, and substrate) using SCUBA gear in traditional flathead catfish wintering areas in the upper portion of Pool 4. According to their observations, flathead catfish were most abundant in large areas with widely scattered rock over a silt-sand substrate. Flow velocities in these areas were generally one-third to one-fourth of the velocity measured in unprotected areas. The depth range and location of wintering habitats in this study were consistent with findings from other tracking studies in various systems (Pugh and Schramm 1999; Weller and Winter 2001; Daugherty and Sutton 2005). Similar to those studies, movement was greatest in late-March and early-April for most flathead catfish and some fish in our study moved up to 2,400 m (Table 1; Figure 3). One fish (F70) moved 724 m upstream to a deeper overwintering area between two and eight days after being tagged and remained in that area the duration of the study (Table 1; Figure 5).

The importance of catfish species to anglers is high throughout the entire Mississippi River basin except in Minnesota (Michaletz and Dillard 1999); however they have been gaining popularity in the southern portions of the state. Because snagging is not allowed in Minnesota, angling success for flathead catfish during winter using conventional gear would be low, given their low feeding rates observed at low water temperatures. Direct mortality from inadvertent catch and release snagging would be low and little effects to the population would be expected if fish were immediately released. Because fish were tracked for more than 66 d, the long-term mortality rate also appeared to be low.

Ten sauger were caught and tagged from depths ranging from 9.1-19.9 m (mean of 13.3 m) in December 2005 and February 2006 (Table 3). The mean length of tagged sauger was 328 mm (SE ± 15.1) and fish ranged from 254 to 409 mm (Table 3). All caught and tagged sauger appeared healthy and had no visual signs of gas bladder overinflation (except for the two fish that were tagged, released, and never regained stability, as described in Methods section). One fish (S74) was never relocated after 24 hours and that fish was excluded from the analysis since it was impossible to determine the fate of that fish (i.e., caught and harvested, tag malfunction, avian mortality, etc).

Tagged sauger generally moved only short distances during the study (overall mean of 70 m), but we were able to detect enough movement to determine whether or not the fish had survived (Table 2; Figure 4; Figure 6). Given that sauger generally concentrate below large river dams in winter, we did not expect to see extensive movement (Pegg et al. 1997; Ickes et al. 1999). Most fish either stayed in the deep hole below the dam or concentrated below wing dams (Figure 6). Based on the movement data we collected, each of the nine remaining tagged sauger survived until the transmitter batteries expired (>21 days; Table 2). However, the initial mortality we observed during the tagging events (n = 2) indicated a total catch and release mortality rate of 18.2% (2 of the 11). Bettoli et al. (2000) conducted a similar study with similar sized sauger on the Tennessee River and found comparable sauger mortality rates in a 12 d tracking period (Table 3).

Sauger Winter Angling - Net Pen Study

Post release hooking mortality during winter 2005-06 ranged from 12.1-35.1% and averaged 26.7% (Table 3). River discharge during winter 2005-06 was well above normal and net pen location was limited to a 5.5 m slack water area below the island separating the lock and the lift gates, thus substantially increasing sauger transport time to the net pen (Figure 2; Table 3). During the January 2006 angling event, many volunteer anglers participated and we were able to transport fish to the net pen relatively quickly (1-10 min). However, during the March 2006 angling events, fewer volunteer anglers were available and transport time increased substantially (15 min; Table 3). We hypothesized that the increased transport time elevated our mortality estimates during the March angling events; therefore, we repeated three additional angling events in 2006-07 when environmental conditions were more suitable.

Post release hooking mortality during winter 2006-07 ranged from 16.7-32.3% and averaged 26.6% (Table 3). We were able to position the net pen near LD 3 in a slack water area, thus greatly reducing transport time (~ 1.5 min) and providing greater depth availability (8.5 m). Results from winter 2006-07 were nearly identical to those from winter 2005-06. Therefore, we concluded that transport time or depth of net pen did not substantially increase winter sauger catch and release mortality during our study. In addition, Bettoli et al. (2000) held and transported sauger in similar sized coolers for up to 45 min during their study and reported low mortality (Table 3). Combined sauger angling mortality from both winters was 26.6% (57 dead of 214 fish). Because we did not immediately release our fish back into the water, but rather held them in a cooler for 1-15 minutes, our estimates of mortality likely represent the upper limits.

Only three of the 109 sauger (2.7%) caught in winter 2006-07 suffered from severe gas bladder overinflation and all three fish died. Gas bladder overinflation was evident in 38% of sauger caught on the Tennessee River, but only one of the fish died (Bettoli et al. 2000). We were unsure as to why the frequency of gas bladder overinflation was so much lower and mortality was more common in the Mississippi River, even though fish were caught out of deeper water than that of the Tennessee River study. The results of this study and that of Bettoli et al. (2000) suggest that a series of factors (i.e., water temperature, depth of capture, etc.) regulate gas bladder inflation. Further research examining these relationships using a hyperbolic chamber in the laboratory should be conducted in order to understand the physiology of these processes.

Often, the only time an angler observes physical impairments to deeply caught sauger is when the gas bladder becomes extended through the bucal cavity of the fish. Deflating the gas bladder using a hypodermic needle or “fizzing” has been suggested as a way to improve survival for an array of fish species (Shasteen and Sheehan 1997; Keniry et al. 1996; Lee 1992). Although we did have a few sauger that suffered from gas bladder overinflation, we did not attempt to puncture the air bladder before placing each fish in the net pen. Kerr (2001) suggested that fizzing should be discouraged as significant damage can result from the procedure, particularly if an untrained individual was performing the procedure. According to MNDNR fishing regulations, any fish that is caught and not planned on being harvested must be immediately released, unharmed into the water; therefore any attempt by an angler to deflate the gas bladder would be illegal. The objective of the study was to simulate catch and release fishing as accurately as possible and given that fizzing is not allowed, we did not investigate its effectiveness.

The fate of sauger caught below LD 3 in winter was significantly related to depth of capture (logistic regression; df = 1; P = 0.0006; Table 4). No significant relationship was observed with size of fish (logistic regression; df = 1; P = 0.6237), however, including sauger length in the logistic regression model provided the highest probability level for the goodness-of-fit-test. Therefore, the best model to predict the fate of winter angled sauger was:

$$\text{Logit}(Y) = 2.6216 + 0.00125(\text{total length}) - 0.1365(\text{depth of capture})$$

For example, using the predictive model and the logit formula, a 305mm sauger caught in the 9.1-11.9 meter depth range would have a 82% chance of survival, whereas the same size fish caught from 18.3-21.0 meters would have a 57% chance of survival. A 432mm sauger caught from the same depth ranges would have an 85% and 61% chance of living, respectively. Given this model, an angler could predict the probability for released fish survival during winter and make more informed decisions on whether or not to release or harvest the fish.

There were significant differences among the size of sauger caught from shallow ($\leq$12.0 m) versus deep (> 12.0 m) water ($P < 0.05$; Table 4). However, the pooled lengths of dead and alive sauger in each depth category were not statistically significant and the size range of dead and alive sauger in each depth range was similar, thus supporting the logistical regression model that stated size was not a significant factor regulating sauger mortality. In addition, the percent angling mortality from sauger caught in the shallowest water (2.4%) was much less than that of the 9.1-11.9 m depth range (21.4%) and size of fish caught was similar, also suggesting that depth of capture was the major contributor to sauger catch and release angling.

Winter creel surveys have been periodically conducted below LD 3 since 1962. Using the six most recent creel surveys, the estimated number of sauger released by anglers from December to March ranged from 11,140 to 86,596 (Stevens 1990; Stevens 1996; Hoxmeier 2002). However, these sauger release estimates apply to the entire open water area in upper Pool 4, which encompasses the main and side-channel habitats (720 ha) and extends to the upper end of Lake Pepin. Although the deep scour hole directly below the dam does attract many anglers, angling pressure occurs throughout the entire open water area. Because the hooking mortality rate we observed was related to depth, we could not accurately extrapolate this rate to estimated number of released sauger from previous creel surveys. Alternatively, we did attempt to extrapolate mortality rates we observed to creel estimates by examining the distribution of depths in the fishable area of Upper Pool 4.

On a per area basis, only 7.9 ha (1.1%) of the fishable area in winter was 9.1 m or greater and sauger mortality rates were 33% when caught out of those depths. Therefore, if we assume that pressure is directly proportional to area, we would predict about 41-314 dead sauger from ≥9.1 m ([0.011 * creel estimate range] * 0.33) and 264-2,055 dead sauger from < 9.1 m ([0.989 * creel estimate range] * 0.024) on an annual basis. It is unlikely that pressure is directly proportional to area, especially when including all depth types. However, if we assume that all fishing occurred in 3.05 m or more, we reduce the fishable area to 231 ha and provide for a more representative estimate. Given this percentage of area ≥9.1 m (3.4%), about 383-2,979 sauger die annually from catch and release angling. Even if 10% of the sauger caught and released came from ≥9.1 m, annual winter mortality estimates would still be relatively low (608-4,728 fish) when compared to total annual sauger harvest for Pool 4 (36,903-64,430 sauger). Future winter creel survey on upper Pool 4 of the Mississippi River should be designed to incorporate a depth of released fish question in order to accurately estimate catch and release mortality.

Data from the annual Large Lake program does not indicate any decline in walleye or sauger populations since the inception of the continuous open-water fishing season (Hoxmeier 2005). Catch curve analysis from age 2-6 sauger gill netted in Lake Pepin, annual mortality rates range from 26% to 82% and average about 51% (unpublished data). Sauger annual mortality in Pools 11 and 13 of the Mississippi River commonly exceed 80% and more restrictive regulations have been established during the winter angling season to reduce mortality and increase size structure (Kirk Hansen, personal communication). Based on sauger annual mortality estimates and historical gill netting data, we believe that the winter sauger mortality estimates in Pool 4 of the Mississippi River do not substantially influence the entire population. However, anglers can reduce sauger winter angling mortality by limiting the amount of time fished in depths greater than 9.1 m. In addition, anglers that are interested in harvesting quality fish (≥300mm) would want to avoid fishing deeper (≥9.1 m) water.

Table 1. Flathead catfish tagging (T) and tracking dates, movement in meters (distance), and fish depth (meters) from sonic telemetry tagging study in Upper Pool 4 of the Mississippi River, January 31, 2006 to April 18, 2006. Distance is movement in meters from the previous location. Distances denoted as NA are during those occasions when the fish was located but a GPS reading was not taken.

	Date of Positive Identification																				
Fish ID	1/31	2/1	2/2	2/8	2/10	2/15	3/1	3/3	3/6	3/9	3/15	3/20	3/23	3/28	3/31	4/4	4/10	4/11	4/12	4/18	Mean
F69																					
Distance (m)	T	20	NA	41		37	35	NA	33	NA	18		104	NA				2399		NA	336
Depth (m)	8.3	7.0	6.1			9.2	6.6		6.6		7.2		4.6					6.5			6.9
F70[a]																					
Distance (m)	T	689	124		724	25	36	NA	35	NA	84	NA	37	NA	30	81	86	70	NA		168
Depth (m)	7.9					11.4	9.7		12.7		11.3		12.5		11.9	11.3	6.7	8.5			10.4
F71[a]																					
Distance (m)	T	589	4	29		55	56	NA	118	176	36	NA	109	NA	172	299		2408		NA	338
Depth (m)	7.6	6.8				8.0	6.6		7.7	6.4	6.7		5.8		5.6	8.5		6.5			6.9
F72																					
Distance (m)	T	21	NA	18		28	65	NA	38	NA	194	NA	144	NA	8	337					95
Depth (m)	8.3	7.0				9.2	6.5		6.8		5.4		6.7		7.3	6.8					7.1
F73																					
Distance (m)	T	20	NA	33		41	140	NA	5	NA	476	NA			530	102	1724	NA	NA	NA	341
Depth (m)	8.3	7.0				9.2	6.3		6.2		9.4				7.5	4.9	8.3				7.5
F74[a]																					
Distance (m)	T	786	85	72		112	57	NA	12	72	6	NA			743	893	71	NA	NA		264
Depth (m)	8.5	8.0				9.2	7.2		7.2	7.4	7.7				11.3	5.2	8.3				8.0
F75																					
Distance (m)	T	20	NA			84	139	NA	89	NA	12	NA	101	NA	32	25					63
Depth (m)	8.3	7.0				9.8	5.0		6.2		6.4		6.7		7.4	5.1					6.9
F76[a]																					
Distance (m)	T	634	55	151		109	8	NA	121	NA	54	NA	33	NA	6	27	160	NA	NA		123
Depth (m)	7.6	7.2				9.2	6.6		7.3		8.0		5.2		5.9	5.6	7.4				7.0
F77																					
Distance (m)	T	20	NA	70		5	64	NA	72	NA	8	NA	6	NA	10	79	101				44
Depth (m)	8.3	7.0				9.9	6.1		6.5		7.0		5.8		7.5	8.4	8.9				7.5
F78[a]																					
Distance (m)	T	576	34	48		27	62		37		82		78		29	30	224				112
Depth (m)	7.6	5.7				9.2	7.1		6.7		8.0		5.5		5.6	5.2	6.2				6.7

[a] denotes fish that were transported downstream approximately 816 m

Table 2. Sauger tagging (T) and tracking dates, movement in meters (distance), and fish depth (meters) from sonic telemetry tagging study in Upper Pool 4 of the Mississippi River, December 22, 2005 to January 1, 2006 and February 28, 2006 to March 23, 2006. Distance is movement in meters from the previous location.

	Date of Positive Identification																	
Fish ID	12/22	12/27	12/28	12/29	12/30	1/3	1/9	1/11	1/20	2/28	3/1	3/3	3/6	3/9	3/15	3/20	3/23	Mean
S69																		
Distance (m)		T	61	40	43	116	18	90	83									64
Depth (m)		11.6	2.9	10.6			4.0	3.9	15.2									8.0
S70																		
Distance (m)		T	181	91	30	21	10	28	333									99
Depth (m)		9.1	7.3	9.4	14.4		4.6	8.2	16.4									9.9
S71																		
Distance (m)	T	219	30	12	19	14	11	32	17									44
Depth (m)	9.5	5.3	4.2	5.9	15.4		4.8	5.5	5.2									6.6
S77																		
Distance (m)		T	55	150	132	8	17	9	11									55
Depth (m)		11.6	7.9	7.3	10.1		8.2	8.6	7									8.7
S78																		
Distance (m)		T	33	8	77	80	9	57	44									44
Depth (m)		11.6	9.4	9.3			7.4	10.0	18.8									11.1
S72																		
Distance (m)										T	15	45	9	11	7	67	37	27
Depth (m)										19.9	13.5	11.5	15.8	17.9	17.4	3.2		14.2
S73																		
Distance (m)										T	64	72	38	44	26	166		68
Depth (m)										17.0	17.0	15.2	16.2	20.2	14.7	5.5		15.1
S74																		
Distance (m)										T								
Depth (m)										13.4								13.4
S75																		
Distance (m)										T	47	31	32	25	308	334	20	114
Depth (m)										12.7	9.3	21.1	16.4	19.8	9.2	7.5	5.5	12.7
S76																		
Distance (m)										T	92	59	52	6	270	275	41	114
Depth (m)										17.0	12.7	19.1	12.7	11.4	8.4	5.3	11.0	12.2

Table 3. Date of angling, number of sauger caught or tagged, number of live sauger, percent mortality, mean size of fish caught (mm), depth range of capture (m), range of transport time in seconds, average discharge (cms), and range of water temperatures (°C) where sauger were angled below Lock and Dam 3 of the Mississippi River in winter 2005-06 and winter 2006-07 and in the Tennessee River (from Bettoli et al. 2000). Range of water temperatures and mean cms for the Mississippi River were provided by the USACE.

Date	Number of Fish Caught	Number of Live Fish	Percent mortality	Mean Size of Fish (mm)	Depth Range of capture (m)	Range of Transport Time (s)	Mean CMS	Range of Water Temperatures
				Net Pen: Winter 2005-06				
1/6/2006	33	29	12.1	343	6.1-12.0	45-660	543	1.3-1.7
3/5/2006	35	24	31.4	315	9.1-21.0	<900	390	2.2-2.6
3/9/2006	37	24	35.1	295	12.0-21.0	<900	446	2.6-4.7
Combined	105	77	26.7	317	6.1-21.0	45-<900	459	1.3-4.7
				Net Pen: Winter 2006-07				
12/18/2006	36	30	16.7	335	6.7-15.0	30-150	207	2.2-3.8
2/20/2007	31	21	32.3	267	8.5-21.1	70-130	141	2.2-2.7
3/9/2007	42	29	31.0	279	6.1-23.1	25-250	181	1.1-3.2
Combined	109	80	26.6	294	6.1-23.1	25-250	176	1.1-3.8
				Net Pen: Tennessee River				
Jan and Mar-99	74	71	4.0	341	5.0-18.0	<2700	-	7.0-12.0
				Tagged Sauger: Dec-05 and Feb-06				
Dec-05 and Feb-06	11	9	18.2	328	9.1-19.9	-	-	1.3-2.2
				Tagged Sauger: Tennessee River				
3/25-26/1999	17	15	12.0	350	5.0-18.0	-	-	7.0-12.0

Table 4. Number and mean total length (TL, mm) of dead, alive, and all sauger, and percent and range (TL, mm) of alive and dead sauger from various 3.05 m depth intervals caught in winter below Lock and Dam 3 of the Mississippi River. Superscript denotes significant differences among size (P<0.05).

	All Caught Sauger					Alive Sauger			Dead Sauger		
Depth Range	Mean TL	N	N Dead	Percent Alive	Percent Dead	Mean TL	Range	N	Mean TL	Range	N
6.1-9.0	353[a]	41	1	97.6	2.4	353[a]	163-485	40	363[a]	na	1
9.1-12.0	330[a]	42	9	78.6	21.4	337[a]	201-495	33	306[a]	188-445	9
12.1-15.0	284[b]	42	16	61.9	38.1	279[b]	178-386	26	294[b]	188-389	16
15.1-18.0	279[b]	43	14	67.4	32.6	276[b]	180-340	29	289[b]	175-381	14
18.1-21.0	284[b]	39	13	66.7	33.3	287[b]	172-414	26	280[b]	180-348	13
21.1-24.1	279[b]	6	4	33.3	66.7	283[b]	198-368	2	278[b]	196-345	4

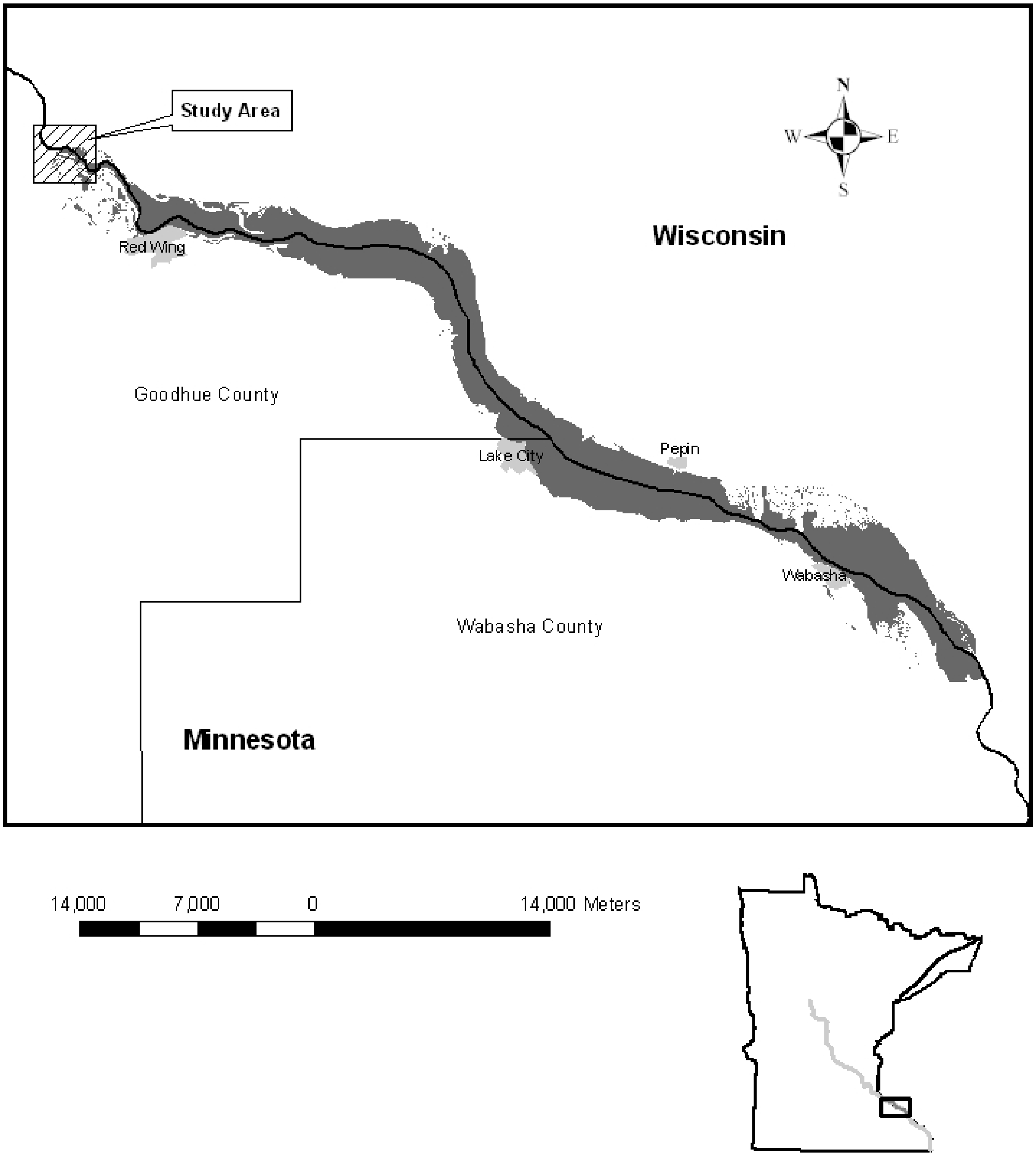
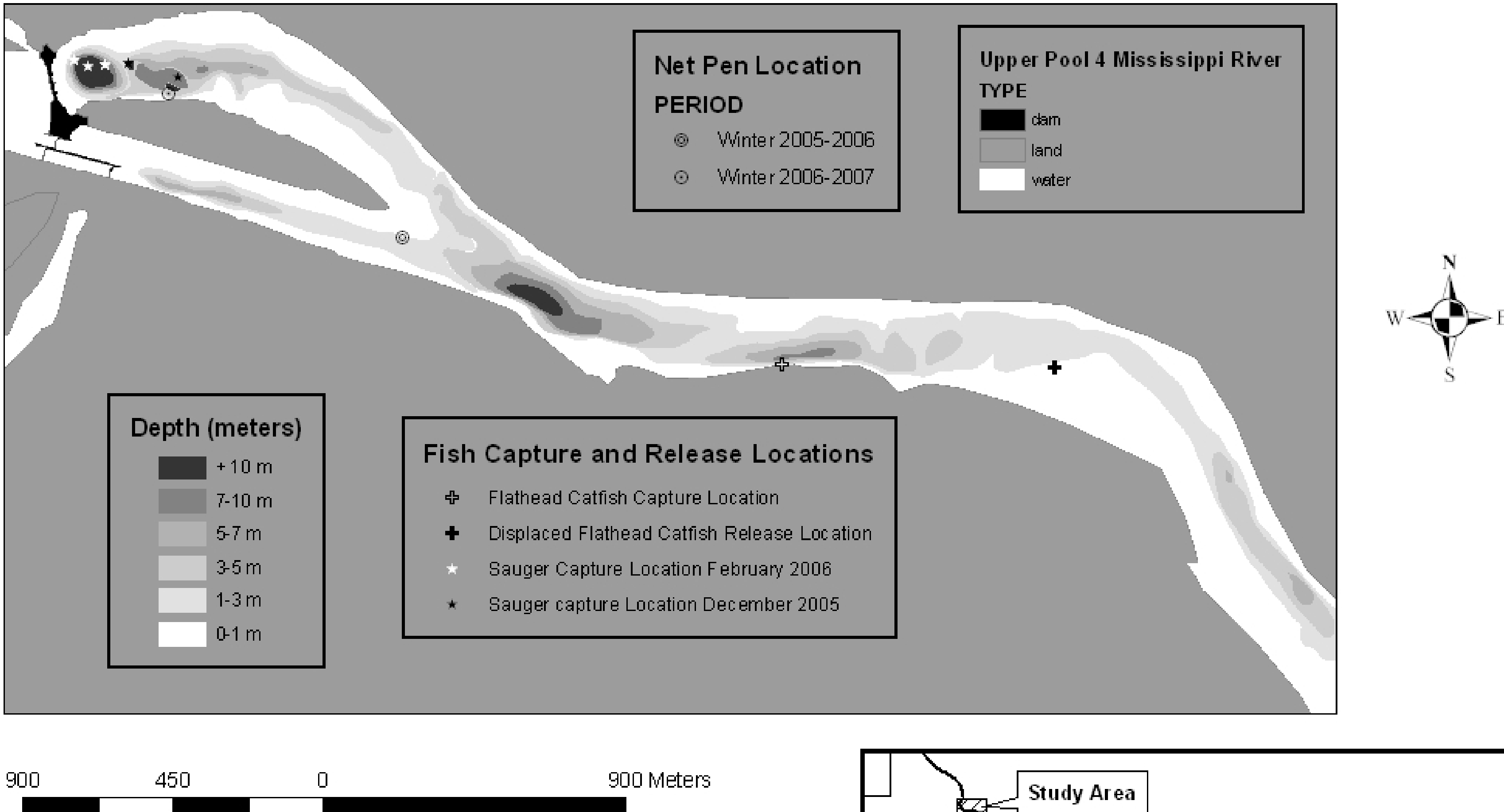


Figure 1. Location of sauger and flathead catfish telemetry and winter angling study on Pool 4 of the Mississippi River.



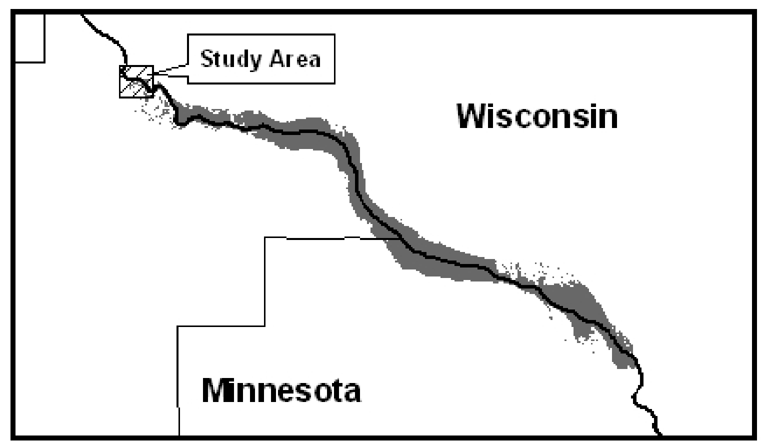


Figure 2. Study area and detailed figure of the Upper Pool 4 Mississippi River, sauger and flathead catfish capture and release locations for the telemetry study, and net pen locations used during the sauger winter angling study.

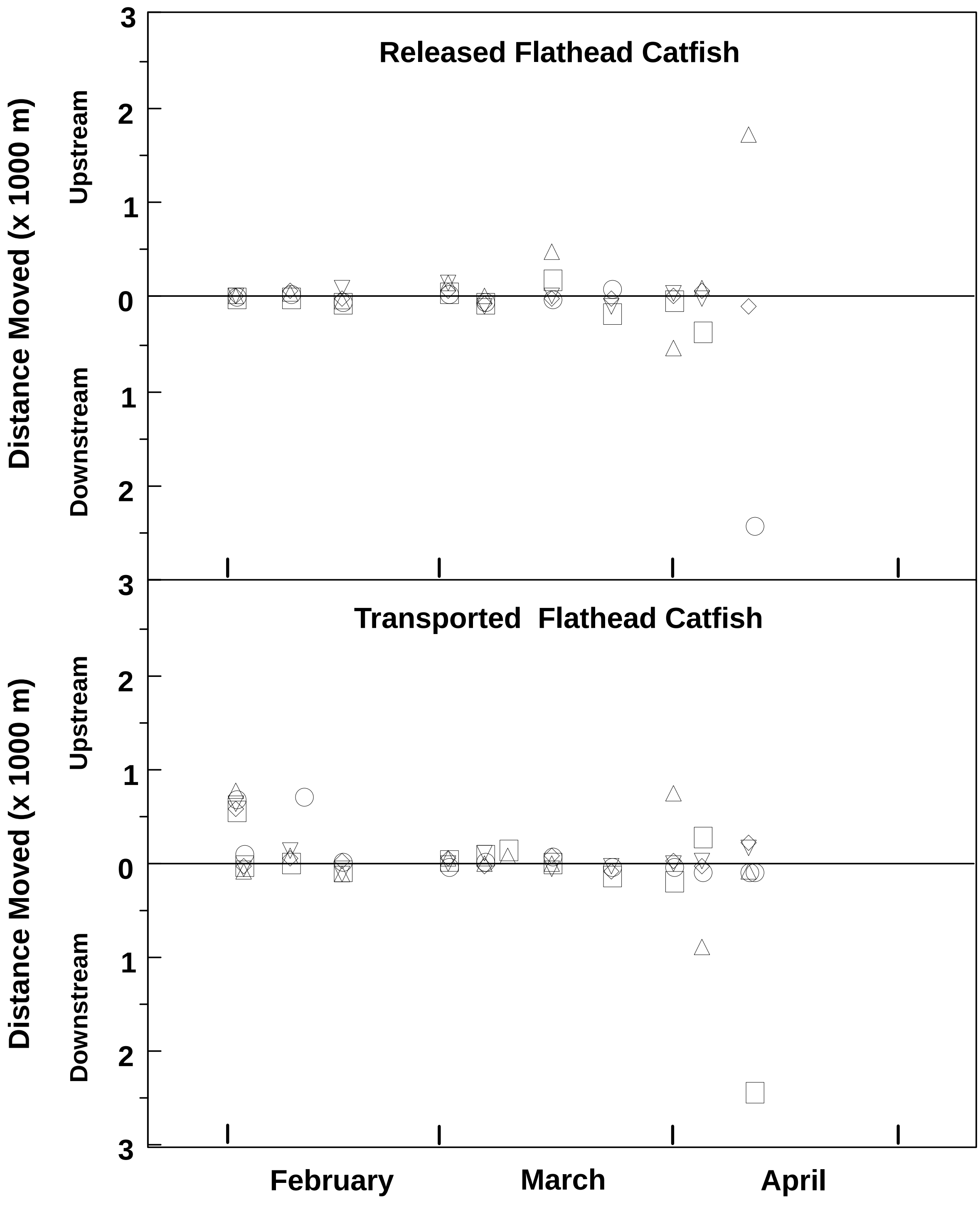


Figure 3. Upstream and downstream movement (meters) of released (caught, tagged, and immediately released; n = 5) and transported (caught, tagged, and transported downstream 816 m; n = 5) sonic tagged flathead catfish in Pool 4 of the Mississippi River in February, March, and April, 2006.

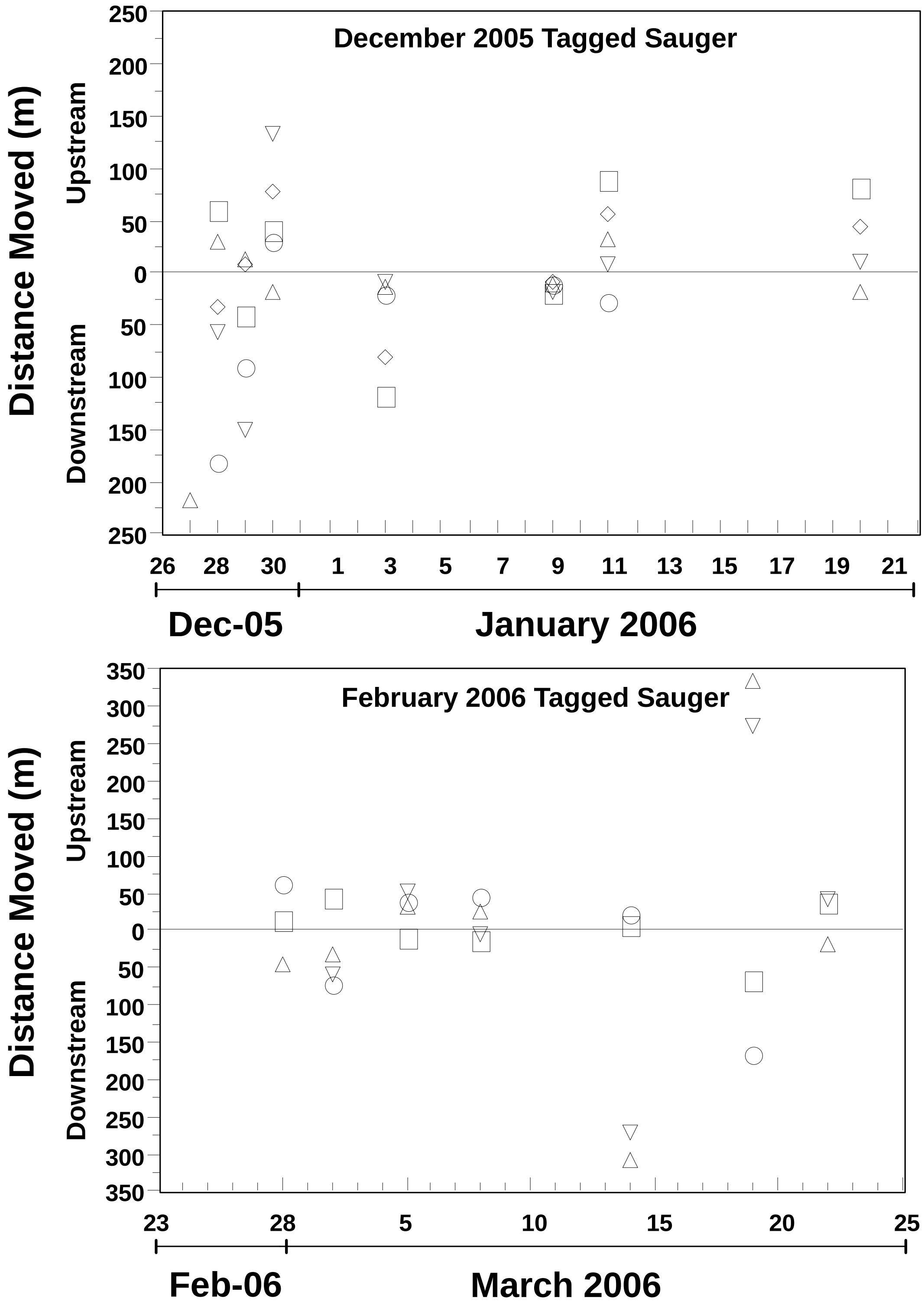


Figure 4. Upstream and downstream movement (meters) of December 2005 (n = 5) and February 2006 (n = 4) sonic tagged sauger in Pool 4 of the Mississippi River.

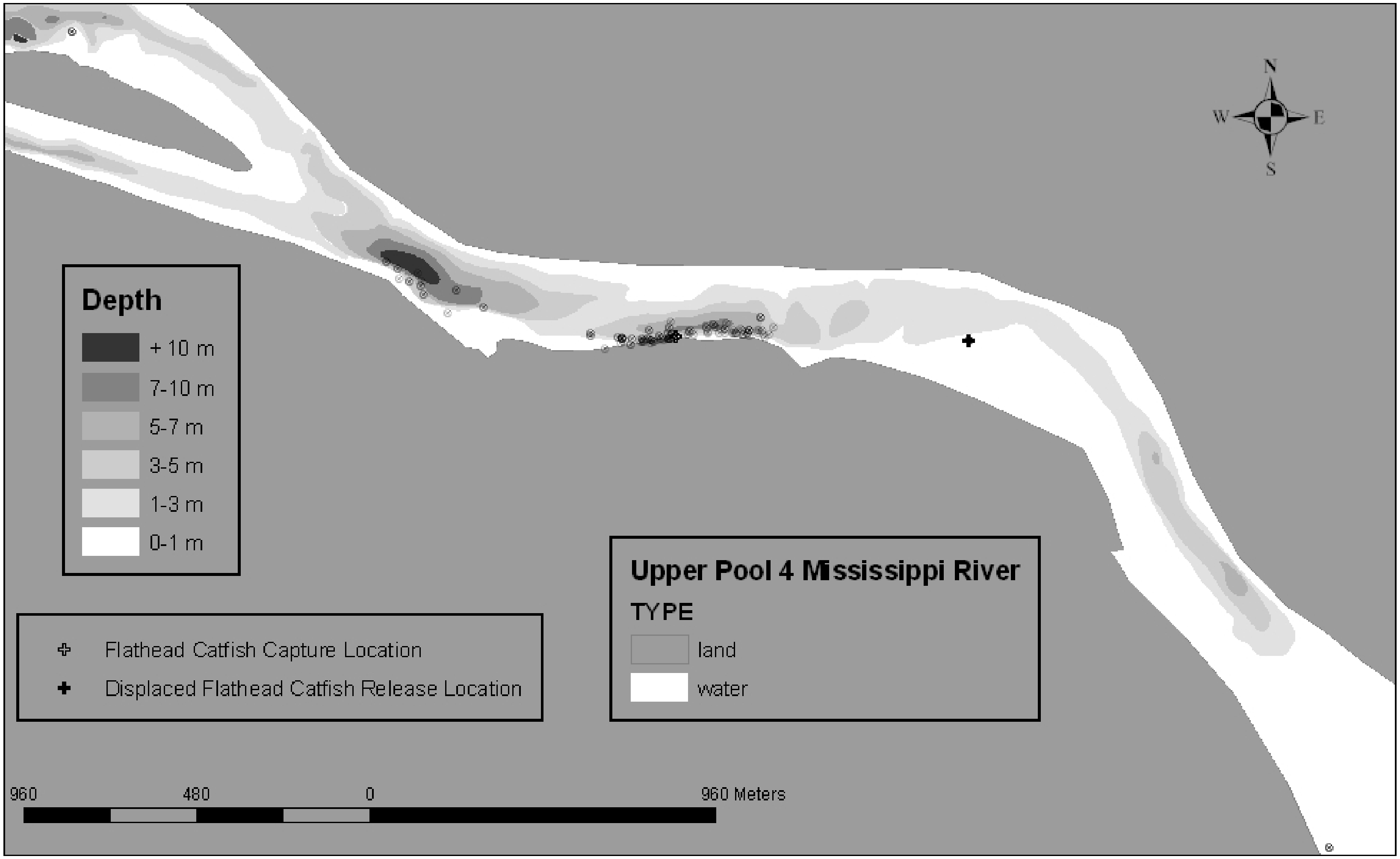


Figure 5. GPS marked locations of sonic tagged flathead catfish from 31 January 2006 to 18 April 2006 in Upper Pool 4 of the Mississippi River.

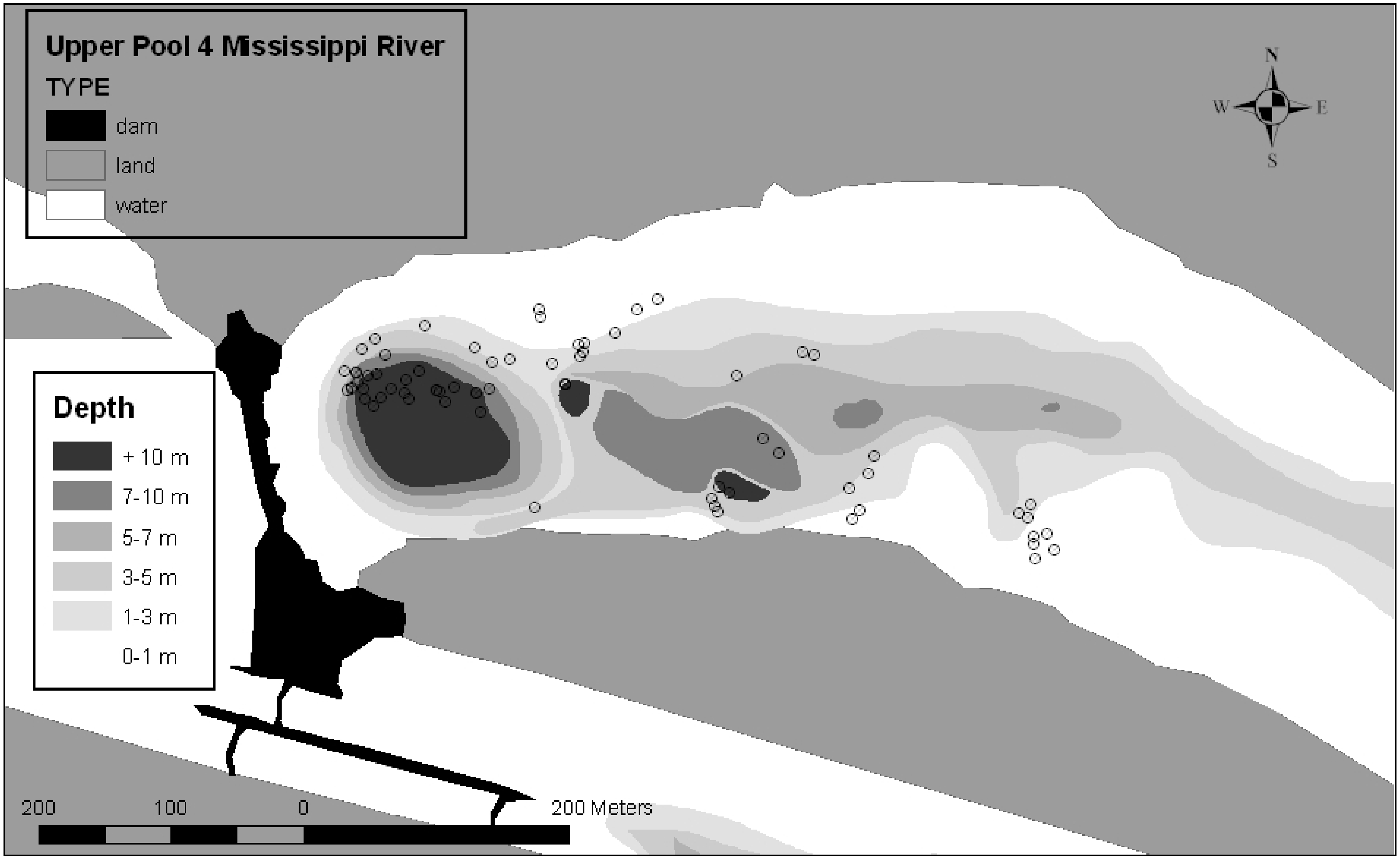


Figure 6. GPS marked locations of sonic tagged sauger from 22 February 2005 to 23 March 2006 in Upper Pool 4 of the Mississippi River.

ACKNOWLEDGEMENTS

The Sport Fish Restoration Act provided funding for the project. Special thanks are extended to Dean Marshall at Evert's Resort for allowing us to use their facilities and also organizing volunteer help. Many volunteer anglers donated fish that were used for the study and their help was crucial to the success of the project. I would also like to thank Dale Solga and Dan Dieterman for their many hours spent locating fish and preparing equipment. Kevin Stauffer, Al Schmidt, Dan Dieterman, Randy Binder, Dale Solga, and John Hoxmeier provided assistance angling, lifting net pens, and recording fish data. Kevin Stauffer, Dan Dieterman, and John Hoxmeier also provided editorial comments that improved the manuscript.

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Completion Report

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