Fish Passage in the Upper Mississippi River System

Annual Report

Sara Tripp and Jim Garvey

Fisheries and Illinois Aquaculture Center
Department of Zoology
Center for Ecology
Southern Illinois University
Carbondale, IL 62901

January 2011

Executive Summary

- To quantify passage of adult fish through lock and dam complexes (L&Ds) of the Upper Mississippi River (UMRS), paddlefish, white bass, blue catfish, shovelnose sturgeon, and invasive silver carp were implanted with sonic tags during 2006 through 2010. Passage, primarily through L&Ds 22 and 26, was monitored using stationary, data logging receivers both affixed to navigation buoys and submerged on stands. In L&D 26 during fall 2007 and 2008, a receiver was emplaced in both the small- and large-craft lock chambers, respectively.
- Passages through L&Ds were analyzed relative to open (gates out of the water) versus closed (water retained in upstream pool with gates lowered) river conditions.
- Since we started recording sampling effort in 2006, 8,382 hours of effort have been expended to capture 1129 fish that were tagged and released for this study; roughly 25% of fish were released above L&Ds 22 and 26 and 75% below.
- The Missouri Department of Conservation (MDC) and Western Illinois University (WIU) have also tagged 86 lake sturgeon in pools 20, 24, 26, and the open river, most of which moved into the study area, so they were also included in the data set.
- Both buoyed and submerged receivers were successful; however, loss occurred for both due to natural river effects (i.e., flooding) and human effects (i.e., navigation damage and vandalism). Still the array appears to be quite cost effective for the information produced.
- 81% of tagged and released fish specific to this project were detected by stationary receivers multiple times during 2006 through 2010; some tag loss was due to harvest, as confirmed by returns from fishermen. Other losses were likely due to downriver movement of individuals and some natural mortality.
- Almost 5.5 million detections were logged on receivers since 2006.

- Across species and L&Ds (including the lowhead), 1036 (33% of tagged fish) successful passages were tallied, of which overall (including both closed and open river conditions) upriver (49%) movement was slightly less common than downriver (51%) movement.
- Across all pools, lake sturgeon and paddlefish exhibited impeded upriver passages (4% and 9%) during closed river conditions relative to other species. Overall, across all species, only 20% of upriver passages occurred during closed river conditions.
- The pattern of upriver versus downriver movement depended on location in the UMRS, with fish tagged upstream of L&D 24 moving more frequently upstream through subsequent upstream dams and those tagged below L&D 24 moving more frequently downstream (see Figure 12). The mechanism underlying this result is unknown but suggests that two separate groups (i.e., an upstream and downstream population) might exist in the UMRS; movement behavior may be related to reproduction.
- All species passed through L&Ds multiple times (e.g., up to 32% of tagged fish passing were shovelnose sturgeon), and all species except bighead carp and American eel had individuals that entered the lock chamber.
- Silver carp were far more frequently detected in lock chambers than other species; however, full passages via lock chambers for all species appeared to be relatively rare (N=29 total of which 20 were by silver carp). The true number of lock-induced passages is difficult to quantify without having loggers in all lock chambers. Lock chambers may be an important vector for upstream movement of silver carp and these areas could be candidates for selective fish barriers.
- Seasonal movement differed among species, with lake sturgeon, paddlefish, and shovelnose sturgeon moving more during spring when discharge was high; conversely blue catfish moved considerably downstream into the open river during winter and fall. White bass/hybrids and sauger/walleye moved more frequently in the spring and fall, with the majority of this

movement being in the downriver direction. Silver carp moved frequently, with less dependency on season; however the majority of downriver movement occurred in the winter and fall.

- More frequent downstream movement occurred for fish released below L&D 26 than in other locations, suggesting that some movement is restricted by the dams in the pools above this first true impoundment of the UMRS.
- These data provide a meaningful baseline by which the percent passages, frequency of passages, distance traveled, and seasonal patterns of movement may be compared after implementation of the fishways at L&Ds 22 and 26. Multiple years of data are necessary to bracket the varied conditions that occur in the UMRS.
- Because some movement occurred for all fishes during closed river conditions (i.e., when the gates are closed to some extent to retain water in the pools), how gates are managed (e.g., distance from bottom, configuration of gate openings across the channel) might influence the behavior of fish interacting with them (see Figure 13). Thus, this coming year (spring 2011 through fall 2011), the behavior of tagged fish around Lock and Dam 26 gates will be explored in great detail with the experimental gate array.

Introduction

Ensuring passage of native fishes in the pooled portions of the Upper Mississippi River System (UMRS) is necessary for maintaining the ecological integrity of the river and surrounding ecosystems (Holland et al. 1984, Wilcox et al. 2004, Garvey et al. in press). Modified management of locks and dams (e.g., changes in gate openings) in addition to the construction of fish passage devices at potential barriers will likely improve opportunities for long-range movement of migratory species as well as facilitate local movement of non-migratory fishes (Wilcox et al. 2004). However, improving fish movement by increasing connections between navigation pools also may enhance the ability for invasive fish species such as Asian carps to invade novel reaches (Kolar et al. 2005). Thus, the construction of taxa-selective barriers (e.g., strobes, bubble curtains) at key conduits (e.g., locks) may be necessary to reduce the rate and extent of movement of these nuisance species while still facilitating the passage of natives (Kolar et al. 2005, Lohmeyer and Garvey 2009).

Before fish passage improvements and selective barriers are planned and implemented in the UMRS, a strong understanding, building on existing knowledge (e.g., Holland et al. 1984, Ickes et al. 2001), of the interactions between environmental conditions and fish movement is needed. A baseline by which responses to improvements are measured also is necessary. This report summarizes nearly 5 years of data collected using a prototype monitoring system for fish with surgically implanted ultrasonic transmitters above and below Lock and Dams 22, and 26 of the UMRS as part of a broader project quantifying movement of fishes among Pools 19-26 and continuing into the open Middle Mississippi River (MMR).

We designed the research primarily around Lock and Dams 22 and 26 to determine how a series of stationary logging hydrophones emplaced in the UMRS could be used to quantify the frequency and extent of movement of common fishes. Further, we could begin to use this system to test the null hypothesis that movement is unaffected by structures. If true, then the distribution of sonically tagged fishes would become fully mixed some time following the initial effort. If false, then fish would not move across the structures, remaining isolated on either side of each. Of course, the final analysis will be more complex given the effects of factors such as river conditions, season, and changing sample size (e.g., as transmitters are added and others expire).

Objectives

- Maintain a prototype ultrasonic monitoring array around potential barriers in the UMRS
- Surgically implant common native and non-native fishes with ultrasonic transmitters above and below barriers
- Quantify frequency and extent of movement
- Emplace an experimental gate array to determine passage through specific gates at L&D 26
- Refine methodology and experimental design

Goals

- Determine the effects of lock and dam complexes on the movement of fishes under differing river conditions
- Set baseline conditions before implementation of fish passage improvements
- Develop framework for basin-wide monitoring network for fishes
- Provide management guidance for fishes in the UMRS

Approach

Stationary Receiver System

The monitoring system currently emplaced in the UMRS includes the Mississippi River (from Keokuk, IA to Caruthersville, MO), the Illinois River (from the confluence of the Mississippi to below Starved Rock Dam), Des Moines River, Missouri River, Meramec River, and Ohio River (Figure 1). The monitoring array consists of stationary, data logging, omnidirectional hydrophones (model VR2W, Vemco) that are used to detect individually unique ultrasonic transmitters implanted in fishes. These receivers must be retrieved and downloaded manually via a Bluetooth wireless connection. Maintenance and data retrieval is a cooperative effort between SIUC and MDC. VR2W loggers are currently deployed in one of three ways; affixed to navigation buoys with the hydrophone pointing down, submerged on rebar stands with the hydrophone oriented up, or mounted to bridge piers with the VR2W enclosed in PVC piping (Figure 2). All three methods seem to be most efficient in specific settings, all having both positive and negative aspects, but when used in conjunction with one another the monitoring system has been maintained with minimal loss.

Navigation buoys were initially used in all locations because of the ease in retrieval and data downloads and their location are ideal for transmitter detection; however loss occurred in some areas due to flooding, navigation damage, and vandalism. In areas where navigation buoys were not successful or often lost, VR2Ws were placed on the bottom set stands. These stands are much more difficult to retrieve and have the potential to be buried, but are in less danger of loss due to navigation, ice, flotsam, and vandalism. Bottom set stands are retrieved with a grappling hook rig that is lowered to the riverbed near the stand and is dragged until it snags a retrieval cable between the stand and an anchor (Figure 3). In areas where receivers cannot be attached to navigation buoys (e.g. below L&D 26) and submerged stands were often buried by shifting bedload, VR2Ws have been mounted onto bridge piers.

PVC pipe sections with windows for data retrieval at various water stages are clamped to the bridge piers; however in some locations the noise created by flow interferes with detection rates. Bridge pier mounts are more permanent and the threat of loss is greatly reduced.

Throughout this five year study we have continued to search for ways to best deploy and retrieve the stationary receivers. We have modified the stand configuration to consist of elongated rebar legs with feet (Figure 4). The taller more stable stands proved to be easier to retrieve than the earlier stands, but still were sometimes buried enough to prevent retrieval in areas where heavy deposition occurred. In 2007, we purchased two Sonardyne acoustic releases to determine their efficacy for retrieving VR2W receivers. The acoustic release system was affixed to each stand, and when an acoustic signal is sent to it, it releases a pop-up buoy which rises to the surface and allows the stand to be retrieved (Figure 5). Each system was deployed, and retrieval was attempted. We successfully retrieved one receiver using the release, but the other did not respond to our attempts to retrieve a partially buried receiver stand. The Sonardyne system doubled the cost of each VR2W receiver deployment and since the stands that the Sonardyne equipment was placed on were still susceptible to be buried, we conclude that the system is too costly and inefficient to include in our budgets. Also in 2007, we assessed the efficacy of using model VR3 receivers in the river. These receivers can be deployed and downloaded remotely using a surface modem. Two units were deployed in the vicinity of Lock and Dam 22. We determined that the level of communication required to fully engage these units ranged from extremely difficult to impossible to obtain. During summer 2008, SCUBA diving was attempted for retrieval of what had been identified in fall 2007 as partially buried stands. SCUBA diving attempts revealed that river levels and flows needed to be minimal in order to negotiate the diver to the river's bottom and that the prolonged 2008 flood completely buried receivers that had previously been only partially buried. We conclude that SCUBA diving was not an effective method to augment retrieval of partially buried receivers. Through all

our attempts and trials we have developed a system that utilizes the combination of bottom set stands, navigation buoy mounts, and bridge pier mounts, which allows us to decrease the risk of loss.

Locations

In 2006, Vemco VR2Ws were initially placed above and below Lock and Dam 22 (Figure 6) and Lock and Dam 26 (Figure 7), and Lock and Dam 19 (Figure 8). Other receivers have been utilized that were already in place from previous projects and also throughout the project we have place VR2Ws in other locations. While these additional VR2Ws provided extended coverage, some of them have been lost since their deployment and moved to prevent loss. Although parts of the array are adaptive, the majority of the monitoring system remains constant. SIUC and MDC, currently maintain a consistent number of at least 22 VR2Ws deployed from above the Keokuk Dam (L&D 19) to below the Alton Dam (L&D 26; Figure 1), including the Missouri, Illinois, and Meramec Rivers. This array allows us to detect passage through both Lock and Dam 26 and 22. Passage occurred when a fish released on one side of the structure is detected on a receiver on the opposite side. Of course, fish are required to move some distance (typically about 0.5 miles) beyond the structure to be detected. Ultrasonic noise and obstructions from navigation currently prohibit placement of VR2Ws closer to the structures. Thus, it is possible that fishes only moving a short distance through structures might not be detected.

There is no definitive information available about how lock chambers affect fish passage. In fall 2006, we suspended a receiver from a cable behind a ladder well located at the midpoint of the large lock chamber of Lock and Dam 26. In short order, the VR2W was sucked through the ladder rungs by a locking barge and crushed. In September 2007, we mounted a thick-walled conduit tube to the ladder such that the conduit was in the ladder well and attached a VR2W to cold-rolled steel connected to a

pulley system to allow retrieval. This deployment method was successful, and the receiver has detected several fish (see results below). In October of 2008, after the deployment method was refined, we place an additional receiver in the small craft lock chamber to ensure that we detect any lock usage for fish passage. We have attempted to obtain permission to deploy a receiver in the lock chamber of Lock and Dam 22, but have yet to receive permission.

While the consistent VR2W array has allowed us to document passage through Lock and Dam 22 and 26, it is advantageous to use as many receivers as our budget will permit in order to increase the likelihood of fish detection. Additional receivers have been provided by MDC and temporarily deployed by MDC and WIU personnel in Pool 20, Pool 22, Pool 24, Pool 25, and the Des Moines River to track lake sturgeon and pallid sturgeon movements. MDC and SIUC also maintain a monitoring system of VR2Ws in the Middle Mississippi River (MMR; Chester, IL and near the confluence of the Ohio River) and Lower Mississippi River (LMR; New Madrid, MO and Caruthersville, MO). These receivers have proven valuable for detecting tagged fish that have left our immediate study areas.

In 2010, one of the main goals was to determine whether Pool 26 and the Illinois River provide sufficient habitat for migratory fish, or if fish passage measures (i.e., a fishway) will just move fish from below L&D 26 to below L&D 25. Since the project at L&D 26 is still in the planning phase, and alternatives to building a fishway are still on the table, we need to determine whether these alternatives may be a more efficient and cost effective process to increase fish passage and movement around L&D 26. To do this, we placed VR2Ws every 20 miles in the Illinois River from the confluence up to below the LaGrange Lock and Dam, including two main tributaries (Apple Creek and Macoupin Creek), and then stationary receivers were place above and below the LaGrange Lock and Dam and Peoria Lock and Dam, and then

one receiver below Starved Rock Lock and Dam. To investigate one of the alternatives (gate manipulation), in spring 2011, we will deploy an experimental array of VR2Ws equipped with new technology (Vemco VPS) that can be used to calculate an accurate position of each fish detected within at least 15m (Figure 9). An additional VR2W was placed on a mooring structure between the lock chambers to monitor movement through those gates (Figure 9). The experimental system may provide information such as which gate the fish most commonly pass through, and when coupled with the existing data and gate position and flow data, we may be able to infer whether gate manipulation is a practical alternative (or in addition) to using fishways to facilitate fish passage at L&D 26. Another goal for 2010 was to determine the importance of tributary use throughout the UMR. In spring 2011, we will deploy VR2Ws in the Des Moines, Fabius, and Salt Rivers. These additional VR2Ws and the experimental gate array will increase our understanding of target species' use of the Mississippi River and its tributaries basin wide, as well as the effects of lock and dam gate management on species ability to navigate these structures.

Surgical Implantation of Transmitters

Ultrasonic transmitters implanted in fish were sized such that they did not typically exceed fish weight in water by 2-3%. Fish were anesthetized using a carbon dioxide and oxygen mixture; river water was circulated over fish gills during surgery. All surgical utensils were sanitized in chlorhexadine. Incisions were made ventrally, anterior to the anal openings. The incision areas were disinfected with betadine. A scalpel and curved hemostats were used to insert the tag and avoid damage to organs. The transmitter was pushed down and away from the incision site to alleviate any added stress on the wound. Incisions were closed with monofilament sutures attached to a curved cutting needle using simple interrupted sutures, as documented by Summerfelt and Smith (1990). The incision and sutures also were sealed with cyanoacrylate resin to prevent infection and to hold the wound and suture knots together securely.

Immediately following the surgical procedure, tagged fish were placed in a recovery tank supplemented with oxygen and released after normal swimming occurred.

Fish

Fish were collected using 2-, 3-, and 4-inch gill nets which were either set or drifted, trammel nets, trot lines or electrofishing. Fish collection and surgical implantation of transmitters occurred at L&D 22 and 26, since these sites were chosen to begin fish passage improvements. Since March 2006, as transmitters become available we have been surgically implanting them into fish (tagging), and have continued in the fall 2006, spring and fall 2007, spring and fall 2008, fall 2009, and fall 2010 (Appendix I). Effort was quantified (hour per set or hour of electrofishing) each year at each location (Appendix II). About 25% of the fish were tagged and released above the structure; the rest were tagged in the pool below. We did this with the expectation that fish moving upstream would be more restricted by dams than those moving downstream. Thus, we wanted to increase our power to detect upstream movement by increasing our sample size of fish at the downstream location. Target fish species initially included silver carp, paddlefish, shovelnose sturgeon, skipjack, and white bass at L&D 22, with the addition of blue catfish at L&D 26. After conducting pilot work in 2006, we determined skipjack were not feasible for implanting transmitters due to poor survival. We originally sought to capture and tag 45 individuals of each species, since then number of individuals have varied due to funding issues and inability to capture certain species. To combat these problems we have expanded the species list to include sauger, hybrid striped bass, and walleye within the white bass category, as well as lower our initial numbers. In 2010 we also experimented with tagging American eel.

Currently the goal is to keep at least 40 fish of each species at each study site by implanting transmitters in fish to replenish the number of active tags at large in the river based on their life expectancies (Appendix I). Transmitter life expectancy depends on battery sizes in the units, frequency output and time interval between transmissions. Battery sizes affect ultimate transmitter size which may in turn limit the length of time some fish species remain at large with active transmitters. Consequently, transmitters surgically implanted in white bass had a battery life estimated at only 140 days; while those used for shovelnose sturgeon were expected to last 360 days. The transmitters' life expectancies are considered a minimal period. For instance, transmitters implanted in all fish during 2006 should have expired prior to November 2007; however, some shovelnose sturgeon and blue catfish were detected after that time. Because there is no way to know which transmitters will last beyond their expected periods, we assume life expectancies to be as specified by the manufacturer. Budget constraints were imminent beginning in 2008. Therefore, all transmitters purchased during and after 2008 for each species (except white bass) had life expectancies of at least one year. Transmitter purchased for 2010, ranged from white bass tags having an estimated battery life of 133 days to blue catfish and paddlefish tags having an estimated battery life of 1470 days. The longer transmitter life is obtained by increasing the period of time that codes are transmitted; consequently, there is more potential for missing fish locations.

Missouri Department of Conservation and Western Illinois University personnel implanted transmitters in lake sturgeon collected from the UMR in 2006, 2007 2008, 2009, and 2010, as well as and in the LMR and MMR that moved into the UMR. Sturgeon collected in the MMR will be acknowledged in portions of this report, but since they were not released in pools specific to this project, we will not include them in our final passage assessments.

Analysis

In this report, we summarize the mean lengths (total or fork, depending on species), numbers of fish tagged and detected passages; we also explored the effects that gate disposition and water levels may have had on passage events. Individual fish characteristics, tagging dates and locations are given in Appendix I. To place results in the context of river stage, we also provide stage data from the Hannibal, Missouri (Lock and Dam 22; Figure 11) and Alton, Illinois (Lock and Dam 26; Figure 10) USGS gages. Water-level management at dams is cross referenced with passage date to quantify directional movement through the structures during open versus closed conditions.

Results

Since fall of 2006, a total of 8382 hours (7806 net hours, 524 trotline hours, and 52 hours of electrofishing) of effort have been expended to collect fish for tagging (Appendix II). We did not quantify fish collection effort during spring 2006. At Lock and Dam 22, a total of 2975 hours of effort have been completed to date. Approximately 140 net hours were completed during fall 2006 (recall this does not include unrecorded effort before this time), 989 net hours during 2007, 770 net hours and 5 hours for electrofishing during 2008 (spring sampling was limited due to flooding), 954 net hours and 8 hours of electrofishing in fall 2009 (spring flooding again eliminated spring sampling) and 95 net hours and 14 hours of electrofishing in 2010. At Lock and Dam 26, a total of 5407 hours of effort have been expended to capture fish for transmitter implantation including 1023 net hours in 2006 (again, only partial data), 1357 net hours during 2007, 1212 net hours and 2 hours of electrofishing during 2008, 746 net hours, 320 trotline hours, and 15 hours of electrofishing in 2009, and 520 net hours, 9 hours of electrofishing, and 203 trotline hours in the fall of 2010. Since March 2006, 1129 fish have been tagged by SIUC personnel, and 74 lake sturgeon have been tagged in the UMR by WIU and MDC personnel (Table 1). The MDC also tagged and released 12 lake sturgeon in the LMR and MMR. Although these lake sturgeon

were not tagged specifically for this study we recognize that several of these fish moved many miles upriver into the UMR, and their passages are noted in the tables.

Demographic and morphological information for each species by pool collected are given in Table 2. In spite of challenging river conditions, we have remained successful in keeping an adequate number of fish implanted with transmitters at large in order to evaluate movement and passage. Paddlefish have been especially difficult to collect, and we recognize that they are most congregated and susceptible to collection during spring. Future efforts to collect paddlefish will be emphasized during spring, and areas of focus will be in tributaries (Fabius and Salt Rivers) and in areas where previous congregations have been found.

Through December 2010, almost 5.5 million fish identifications have been made by the VR2W system. Tagged fish have been identified from river mile 362.8 of the UMR in upper Pool 20 down to river mile 838.7 in the LMR, as well as 39.7 miles up the Illinois River at Pearl, IL. Of the total identifications, 23667 were in the MMR or LMR below where the fish were tagged, and below where the majority of VR2Ws were located. Many fish have been located by receivers in the Illinois, Missouri, Meramec, and Ohio Rivers where over 61963 identifications have been collected. The Illinois and Missouri river confluences are located in pools 26 and 27, respectively, and it is not surprising that many of our study fish have been located by receivers in those rivers. However, the Meramec River is a fairly small, shallow tributary located at MMR river mile 160, and several fish tagged in the UMR entered into the tributary. The fish include six blue catfish, five white bass, one paddlefish, and though not tagged in the pools, two lake sturgeon have been identified in the Meramec River. The number of fish and species suggests that small

tributaries are important habitats for Mississippi River fish. Movement into the Meramec River occurred mostly during spring periods when the fish spawn.

Up to this point, 1129 fish have been tagged specifically for this project; however fish tagged this fall (2010) were not included in the percent detected (Table 1). 702 of the 868 fish tagged through fall of 2009 (81%) were detected multiple times by VR2Ws on at least one date. Detection rates for each species ranged from 63% (sauger/walleye) to 90% (silver carp and bighead carp; Table 1). Detection rates by pool where the fish were released within the study area ranged from 74% (Pool 22) to 83% (Pool 27; Table 3). Detection rates for pools were somewhat higher in 2007 than in 2006 after we added receivers to Pools 21 and 25 in an attempt to detect fish that moved away from the lock and dam structures after being captured, tagged and released. Such was the case when comparing detection rates between 2007 and 2008. The 2008 flood buried several VR2Ws in pools 22 and 24 that resulted in fewer receiver downloads in those pools. The receivers were replaced in late spring and early summer 2008 after flood waters receded. Ice and flooding in 2009 led to several lost VR2Ws, and while they were replaced early summer, many fish were likely undetected during this period. Again in 2010, flooding occurred from March to September with open river conditions the majority of this time. While receiver loss was minimal, the high water may be partially responsible for lower detection rates of some target species that may have higher dispersal during open river conditions.

Detection rates also depend on fish movement, and in some cases, mortality after tagging. If fish are tagged and released either up or down river from the receivers and do not approach the receivers in the pools of their release, the likelihood of detection decreases because we have not been able to maintain receivers located at the opposite ends of our study pools and a few receivers in adjacent pools.

Additionally, for some species that are targeted by anglers or commercial fishermen, mortality can occur prior to detection by receivers. To date, we have been contacted by commercial fishermen on four occasions where tagged female shovelnose sturgeon and paddlefish were harvested for their roe. Extent of the mortality is not known since it depends on the anglers' and fishermen's knowledge of this research project and willingness of fishermen to contact us when tagged fish are harvested. Commercial fishermen are generally informed of this project since they are required to know where our bottom stands are set, and at least some of the fishermen have contacted us when they harvest our tagged fish. While we thought anglers would not likely be aware of the project and would not be expected to recognize when a fish was tagged, recently some fisherman have contacted MDC when they harvested tagged sauger/walleye.

The receiver array cannot provide information about fine-scale, individual daily movement, but it can provide some information about scale and directionality of movement. By first summing the distance of each receiver detection to the next for each individual fish at each reach, we generated maximum, species-specific distance moved (Table 4) and direction propensity (i.e., upriver versus downriver; Table 4). Movement direction and extent depended on fish species and pool tagged. Furthest upriver movement was evident for fish released in pool 24. A shovelnose sturgeon moved the longest distance (600.6 miles). This was not to be expected because more upriver movement is possible from pools in the lower portion of the receiver array. Most of the study species were detected moving furthest downriver when they were also released in pool 27; this downriver movement ranged from 2.8 miles by sauger/walleye to 482.6 miles by shovelnose sturgeon, with all species showing long range movement into the open river, except sauger/walleye. This implies that proximity to the open MMR contributed to the further movement from those pools, and that downriver movement may be reduced by successive locks and dams. Alternatively, species located further upriver in the UMR may have, over time,

developed movement patterns that are more local or a greater propensity to move upriver than those distributed more closely to the open MMR. Thus, in effect, locks and dams may have restricted interpool movement enough over time to have altered migratory behavior of the some of this study's fish species. To test this hypothesis, population-specific markers (genetics, fatty acids, microchemistry of hard parts) would have to be compared between pools and the open river. In the next paragraph, we describe results that provide some compelling patterns that suggest that the fish assemblages are possibly assorting based on location in the UMR.

In order for fish to move large distances throughout the UMR, they obviously must pass through locks and dams. Fish were recorded passing through the structures (Lock and Dam 20, 21, 22, 24, 25 or 26) on a total of 868 occasions. Of the fish relocated, 304 (36%) passed through one dam, of those fish, 199 (65%) passed through the multiple structures. Upriver passages accounted for 49% of the total passages. The frequency of upstream versus downstream passage events depended on location in the UMR (Table 5). Passages at Lock and Dam 22 comprised 25% of the total (Table 5), and 62% were upstream into Pool 21. Similarly, the number of passages through Lock and Dam 26 represented 23% of the total passages; but in contrast to L&D 22, only 38% of passages were upriver (Table 5). Tagged fish were detected passing over the lowhead dam at Chain of Rocks (Lock and Dam 27) a total of 168 times, and 74% were downriver into the MMR. The predominance of downstream movements may imply that the lowhead dam impedes upstream movement. However, those fish moving downstream may simply have continued moving downstream or did not return until their tags had expired. Mortality also may have occurred. In summary, fish above L&D 24 were more likely to move upstream through dams than downstream, while those below L&D 24 had a higher likelihood of passing downstream (Figure 12).

All species tagged had individuals that passed upriver or downriver through one or more locks and dams (Table 6). Lake sturgeon, shovelnose sturgeon and paddlefish passed upriver at numbers greater than those of their downriver passages. Conversely, blue catfish, American eel, silver carp, sauger/walleye, and white bass/hybrids passed through the structures moving downriver more often than upriver. Shovelnose sturgeon passage was documented on 282 occasions, occurring more frequently than any of the other species. While silver carp represented 30% of the fish tagged during this study, they accounted for only 18% of the total passages (Table 6).

Direction and frequency of passages depended on species and season (Table 7). Lake sturgeon passed through structures on 156 occasions and most often during spring (52) and fall (35); 69% and 51% of the passages were upriver in the respective seasons. Similarly, 57 of the 96 white bass passages occurred during spring (16) and fall (41); however 69% and 78% of the passages during the respective seasons were downriver. Paddlefish passages (146) occurred most frequently during spring (50) and summer (33), with 80% of the passages upriver in spring and 55% downriver in the summer. Blue catfish passed through locks and dams on 97 occasions, and most of their passages occurred during winter (32) and fall (45), and 83% of these fall and winter passages were downriver into the open river portion. Sauger/walleye also passed most frequently during winter (6) and fall (15), and the majority (67%) of this passage was again in the downriver direction. Previously, shovelnose sturgeon passage occurred most often in the spring and summer, but potentially due to the prolonged flooding of 2010, we are now seeing equal passage in the spring and fall, as well as increased passage in the summer. When comparing passage percentages within seasons, most of the shovelnose passages during spring were upriver (77%), and were downriver during summer (54%)and fall (65%). While silver carp passages were distributed fairly equally among all seasons, the direction of the passage was more predominately downriver (58%).

Fish passages may be facilitated by elevated water levels and discharge when gates are opened to allow flow or to lower pool levels. Open river dates are given in Table 8 for all of the study pools. Gates were open at Lock and Dam 22 at several intervals throughout 2006 - 2010. Open river conditions between pools 22 and 24 follow closely with dates when water levels approached or exceeded action stages (Figures 10 and 11). Water levels are managed differently at Lock and Dam 26, with high flow allowing Pool 26 to be managed as a tilt and water being deliberately held at the upstream dam and reduced at the downstream dam to facilitate growth of moist soil vegetation (Garvey et al. 2003). The gates at this structure were not lifted during 2006. The gates were lifted for 44 days during 2007, 136 days in 2008, 105 days in 2009, and 161 days in 2010.

By combining date ranges when locks and dams were essentially set for open water conditions, we were able to determine whether or not passages occurred at open or closed river conditions. Passages during closed conditions may be underestimated because, for any period between detections when the fish could have passed during either closed or open conditions, passage was assumed to have occurred during the period of open conditions. For all fish and locks and dams combined, passage downriver during closed river conditions occurred 170 times and 237 times during open river conditions (Table 9). Only lake sturgeon, paddlefish, shovelnose sturgeon, and sauger/walleye had more downriver passages during open versus closed positions. Conversely, only 20% of the 461 upriver passages occurred during closed conditions across all species (Table 9). Lake sturgeon and paddlefish had significantly less upriver passages (4% and 9%) during closed versus open conditions (Table 9), and only 22% of shovelnose sturgeon and 19% of white bass/hybrid upriver passages occurred during closed-gate positions. Conversely, 75% of sauger/walleye, 50% of blue catfish, and 41% silver carp upriver passages were recorded during closed conditions.

For this study, the majority of fish were tagged and released below Locks and Dams 22 and 26 (Table 10). Upriver passage during closed conditions accounted for 21% of the 134 upriver passages through Lock and Dam 22 (Table 10). Upriver passage through Lock and Dam 26 during closed conditions represented 48% of the 77 passages. Silver carp and blue catfish accounted for 26 of those 37 closed pool, upriver passages.

In order to look more specifically at passage during varying degrees of gate openings, we quantified the total openness of all tainter gates at each specific dam during the time period when each passage event occurred, and then divided this quantity by the number of tainter gates for each specific dam (e.g., at L&D 22 there are 10 tainter gates, so the total openness was divided by 10). The total gate openness was provided by the Army Corps of Engineers, this value is the total depth of the dam open (the opening from the bottom of the river to the bottom of the gate), combined across all tainter gates at each dam. We then assumed that the average depth open at each gate for fish to pass through, was the total openness divided by the number of gates. When we combined passage for Locks and Dams 20-26, it appears as though the majority (58%) of fish passage occurs when the average opening for all gates at all dams combined is between 2-4 feet (Figure13, A). Investigating passage specifically at Locks and Dams 22 and 26, the majority of passages occurred at Lock and Dam 22 with an average opening of 3-4 feet (Figure 13, B), and an average opening of 2-4 feet at Lock and Dam 26 (Figure 13, C). At Lock and Dam 22 another small peak in passage occurs at an average gate opening of 11 feet. However, at Lock and Dam 26, there is a more gradual decline in passage with increasing average gate openness, with moderate passage occurring between 5-8 foot gate openings. When we broke passage down by direction, there was a difference ($P = 0.002$) between the average gate opening during upriver (3.98 ft) and downriver (5.79 ft) passage. We also looked at how differing gate openings effected passage by our study species, there was no difference on overall passage or direction of passage ($P>0.05$).

A potentially important issue of fish passage through locks and dams is the pathway used to negotiate through the structures. It is assumed that some portion of passage occurs through navigation lock chambers. We were given permission to place receivers in the lock chambers to detect fish entering and using the chambers for passage. As noted earlier, the initial receiver was placed in the small craft lock chamber in October 2007. An additional receiver was placed in the large lock chamber in October 2008. Every species, except bighead carp and American eel had at least one fish either enter into the locks or were close enough to be detected by the receivers. 491 fish were detected, and 302 were silver carp (Table 11). Only 29 fish actually used the locks for passage, of which 20 were silver carp. It is apparent that, although fish frequent and occasionally use lock chambers for passage through locks and dams, the lock chambers are not routinely used for passage by most species. The high incidence of silver carp passage via this route suggests that locks may serve as a vector for this species through dams.

Summary

The VR2W array has successfully received and decoded signals from transmitters inserted in the fish species used for this study despite the fact that, in each year, the receiver retrieval has been compromised by shifting substrate – especially during high water and fast flow periods. Regardless of the receiver losses, the monitoring system is technologically sound and produces multi-species information about movement with little apparent species-specific bias. When compared to the cost of providing manual tracking to detect passage and movement, the fact that the stationary receivers are continually monitoring and are relatively low cost suggests that this system is economically efficient.

As of December 2010, we have collected a substantial amount of simultaneous data about multi-species movements and fish passage in the Mississippi River. To our knowledge, this is unprecedented. As the

number of fish passages recorded increases over time, our understanding of how locks and dams affect our study species' ability to negotiate the structures increases. Although we predicted that upriver movement would be impeded by structures, this varied among species. The most striking result to date is for lake sturgeon and paddlefish; we are reaching a consensus that lake sturgeon and paddlefish may be more restricted from upriver passage during closed gate positions than other study species. In general, the majority of the fish passages occurred upriver during spring and summer, presumably encompassing periods of spawning migrations, and it is during those periods when dam gates are most often in open river positions. However, we do not know how these upriver movements might be enhanced once passage enhancing structures are emplaced (i.e., will the percentage or frequency of upriver passages increase, facilitating purported spawning?). We are just beginning to determine how gate configuration may affect behavior of these species. For example, perhaps different combinations of gate openings may differently affect passage of these species. After the experimental gate array is in place, we should be able to more accurately pinpoint which gate the fish are going through and now which day and the good estimate of time for each passage event. This detailed information will allow us to more fully understand the specific conditions for each passage.

In contrast to the 91% upriver passages during open river conditions, paddlefish passage downriver depended less on whether gates were open or shut, however 67% of the downriver passage still occurs during open river conditions. Shovelnose sturgeon passages occurred over three times as often during open river conditions in both the upriver and downriver directions and throughout all seasons. Since 77% of their total spring passages were upriver at a time associated with their spawning migrations and 87% of these spring passages occurred during open-river conditions, it appears that shovelnose sturgeon migrations may also be impeded by gates when they are closed. Lake sturgeon passages occurred primarily during spring and fall; 69% and 51% were upriver in the respective seasons. Approximately

78% of the upriver passages occurred when open-river conditions prevailed. Although the passages occurred mostly during open conditions, as noted for paddlefish and shovelnose sturgeon upriver movement would occur when water levels are naturally high. If gates must be closed during purported spring spawning migrations (e.g., during low flow years), then the L&Ds may impede passage and likely compromise reproductive success and recruitment of all these species, and presumably others that rely on upstream movement for reproduction.

Other movement patterns were more complex and likely depended on species-specific life history and perhaps other factors such as foraging behavior. Blue catfish upriver or downriver passage occurred most frequently when the dam gates were in closed positions during fall and winter. We have recorded blue catfish passages that, when combined with directional movement patterns, reveal movements apparently associated with annual migrations into the open river. To illustrate, receivers located in the MMR have recorded blue catfish moving out of Pool 26 and 27 during late fall or early winter and possibly congregating near river mile 44 of the MMR. Several of the catfish were detected returning to pools 26 and 27 in the following late spring and summer, one catfish even continued the upriver migration into pool 24 below L&D 22. When investigating total movement by tagged blue catfish each month, the greatest movement occurred during periods of changing water temperatures and high discharge (Tripp et al. in press). Silver carp tend to move constantly (see DeGrandchamp et al. 2008), and passages occurred throughout the seasons during each year of this study. Most passages occurred during winter and fall, and 63% of this passage occurred in the downriver directions. There was little difference between the number of upriver passages during closed versus open river conditions. White bass/hybrid passages occurred primarily during spring and fall, with over 75% of this seasonal passage being downriver. As with most of our study species, upriver passage occurred more frequently (81%) during open versus closed river conditions. Spring movements of some white bass/hybrids were

indicative of spawning migrations, with downriver movement from pools 26 and 27 down into the MMR and eventually into the Meramec River at MMR mile 160 or the Missouri River at MMR mile 194. White bass/hybrid locations often revealed long-range interpool movements for several of the fish. The movement extent was surprising given the relatively short battery life of white bass/hybrid transmitters.

It is unlikely that our study fish are totally unaffected by the presence of locks and dams in the UMR. However, our data indicate that individuals of each study species had the capability to negotiate dams whether the gates were closed or open. It is difficult to gage the impact of the L&Ds on movement without having a pre-impoundment comparison point. A compelling argument that the L&Ds are impeding "natural" movement among individuals within populations is the greater frequency of downstream movement of fish tagged and released below Lock and Dam 26; we would expect similar distances moved downstream toward the MMR in the upper pools if the structures were not obstructing movement. Similarly compelling is the high frequency of upstream movement of fish in the upper pools (22, 21) relative to counterparts in the lower pools (see Figure 12). Whether this is due to "selection" for two strategies is still unknown. One strategy would be to migrate upstream into the Des Moines River tributary in Pool 20 for reproduction. The other "downriver" strategy would be to move downstream toward locations such as the Meramec River and Chain of Rocks. If true, then management and conservation strategies incorporating routes of fish movement need to consider these differences among populations.

We are on schedule to have sufficient data to allow comparison of fish passage by locks and dams during periods of pre- versus post-fishway construction. These data will compare both the percentage of passages, the distance of movement, and the frequency of passages before and after implementation. If

the fishways are successful, the percentage of passages among individuals, total distance moved, and the frequency of interpool passages should increase. Until sufficient post-construction data are collected, we cannot make definitive conclusions about how lock and dam complexes affect fish movements or how potential fish passways enhance interpool movements.

We recommend continuing monitoring the study fishes' passage and movements across multiple years to supplement our understanding about how water-level management at dams affects movement of these common UMR fishes. To improve detection rates, we recommend increasing VR2W coverage by replacing lost receivers to levels present during mid 2007, particularly above both lock and dam complexes and in tributaries. We also plan to extend the VR2W coverage into the Fabius, Des Moines, and Salt Rivers. Due to limited battery life, the transmitters in several fishes (white bass, hybrid striped bass, sauger, and walleye) will expire before spring 2011, when high water and upstream reproductive migrations are anticipated. Thus, it would be beneficial to increase the number of tagged individuals before spring 2011; if this project is continued, we will return to both Lock and Dam 22 and 26 during March through April and September through October 2011 as necessary to ensure that adequate numbers of each study species is represented for future data collection.

After some experience with these data, it is clear that statistical analysis of these data will be complex given the changing number of fish at large and their non-random movement within pools and between pools and the open river. We suggest developing a spatially explicit simulation model to predict average movement of fish in the hypothetical absence of the lock and dam structures (or installation of fishways). Data from the open river could be used to parameterize this model. From this, a “null model” of movement would be generated for the fishes in the UMRS and compared to the actual observed

movement. Significant deviations between the model expectations for position of fishes at any given model time step and the observations could be analyzed statistically using many different methods (i.e., the simplest being a chi square) and would provide insight into the impact of dam operations, season, year, etc. on movement patterns among species.

Acknowledgements

We would like to thank Dave Herzog and Travis Moore of the Missouri Department of Conservation, Tim Spier of Western Illinois University, and technicians and student volunteers that have helped us implement this project. We also thank USACOE's Captain Terry of the Pathfinder, and Gale Howerton of the USCG for their assistance with navigation buoys. We also thank Mark Cornish, Jason Farmer, and Donovan Henry of USACOE for their assistance in all phases of this project.

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Table 1. Species and number of fish surgically implanted with sonic transmitters during 2006 -2010 in the upper Mississippi River for the purpose of passage detection through locks and dams 19 - 26. Percent detected represents the ratio of tagged fish detected for each year in which they were tagged. Total number of fish tagged in 2010 is reported, however they are not included for the percent detected.

Year	Number of fish tagged per year	Number detected	Percent detected
	Lake Sturgeon		
2006[a]	1	1	100
2007[a]	7	6	86
2008[a]	3	2	67
2006[b]	15	15	100
2007[b]	25	18	72
2008[b]	30	8	27
2009[b]	3	3	100
2010[b]	2		
All years	86	53	63
	Shovelnose Sturgeon		
2006	69	50	72
2007	48	26	54
2008	72	62	86
2009	42	24	57
2010	80		
All years	311	162	70
	Silver Carp		
2006	64	58	91
2007	57	54	95
2008	120	109	91
2009	41	33	80
2010	80		
All years	362	254	90
	Bighead Carp		
2006	10	9	90
	American Eel		
2010	3		

Year	Number of fish tagged per year	Number detected	Percent detected
	Blue Catfish		
2006	39	37	95
2007	27	22	81
2008	13	8	62
2009	13	9	69
2010	15		
All years	107	76	83
	Paddlefish		
2006	5	4	80
2007	55	42	76
2008	27	24	89
2009	12	10	83
2010	6		
All years	105	80	81
	White Bass and Hybrid Striped Bass		
2006	38	30	79
2007	6	3	50
2008	56	46	82
2009	35	30	86
2010	46		
All years	181	109	81
	Sauger/Walleye		
2009	19	12	63
2010	31		
All years	50	12	63

[a] \ Fish tagged and released by Missouri Department of Conservation personnel in the LMR and MMR.

[b] \ Fish tagged and released by Western Illinois University and Missouri Department of Conservation personnel in the UMR.

Table 2. Mean lengths of species collected, tagged with sonic tags, and released in Pools 22, 24, 26, and 27 of the upper Mississippi River during 2006 through 2010.

Species	Capture Pool	N	Mean	Std
Bighead Carp[a]	22	5	917	69
	24	5	915	95
Blue Catfish[a]	26	26	621	59
	27	81	674	118
American Eel[a]	22	1	508	
	24	1	516	
	27	1	481	
Hybrid Striped Bass[a]	22	1	618	
	24	3	565	160
	26	3	502	12
	27	9	517	53
Paddlefish[b]	22	10	1033	151
	24	36	974	129
	26	45	1030	146
	27	14	973	147
Sauger[a]	22	1	504	
	24	19	409	44
	26	2	410	79
	27	11	419	37
Shovelnose Sturgeon[b]	22	32	654	37
	24	112	627	42
	26	32	647	36
	27	132	632	38
Silver Carp[a]	22	31	735	100
	24	103	703	121
	26	63	675	91
	27	164	680	85
Walleye[a]	22	3	429	59
	24	6	425	74
	26	1	469	
	27	7	464	70
White Bass[a]	22	20	336	34
	24	63	322	32
	26	22	334	48
	27	59	341	38

[a]total length (mm)
[b]fork length (mm)

Table 3. Fish species and numbers collected, surgically inserted with sonic transmitters, and released by pool in the Mississippi River during 2006 - 2010. The fish were collected by Southern Illinois University, Carbondale (SIU-C), Missouri Department of Conservation (MDC), or Western Illinois University (WIU) personnel. Fish detected represents the number (percent) of fish released in the pool that were detected. Fish tagged fall 2010 are not included in the percent detected.

		Number tagged						Fish	Percent
Agency	Species	2006	2007	2008	2009	2010	Total	detected	detected
			Pool 20						
MDC/WIU	Lake Sturgeon	0	0	0	1	0	1	1	100
			Pool 22						
SIU-C	Bighead Carp	5	N/A	N/A	N/A	N/A	5	5	100
SIU-C	American Eel	N/A	N/A	N/A	N/A	1	1	N/A	N/A
SIU-C	Paddlefish	1	0	2	7	0	10	9	90
SIU-C	Sauger/Walleye	0	0	0	2	2	4	0	0
SIU-C	Shovelnose Sturgeon	5	3	8	6	10	32	14	64
SIU-C	Silver Carp	5	1	10	5	10	31	16	76
SIU-C	White Bass and Hybrid Striped Bass	5	0	6	3	7	21	11	79
	Total	21	4	26	23	30	104	55	74
			Pool 24						
SIU-C	Bighead	5	N/A	N/A	N/A	N/A	5	4	80
SIU-C	American Eel	N/A	N/A	N/A	N/A	1	1	N/A	N/A
MDC/WIU	Lake Sturgeon	15	25	30	0	1	71	41	59
SIU-C	Paddlefish	1	27	6	2	0	36	32	89
SIU-C	Sauger/Walleye	N/A	N/A	N/A	10	15	25	6	60
SIU-C	Shovelnose Sturgeon	19	23	24	18	30	114	72	86
SIU-C	Silver Carp	14	11	33	16	30	104	60	81
SIU-C	White Bass and Hybrid Striped Bass	19	6	18	11	14	68	44	81
	Total	73	92	111	57	91	424	259	78
			Pool 25						
MDC/WIU	Lake Sturgeon	0	0	0	1	0	1	1	100
			Pool 26						
SIU-C	Blue Catfish	12	8	3	3	0	26	21	81
SIU-C	Lake Sturgeon	0	0	0	1	0	1	1	100
SIU-C	Paddlefish	3	24	11	1	6	45	30	77
SIU-C	Sauger/Walleye	N/A	N/A	N/A	1	2	3	0	0
SIU-C	Shovelnose Sturgeon	12	0	11	0	10	33	8	35
SIU-C	Silver Carp	12	12	24	5	10	63	50	94
SIU-C	White Bass and Hybrid Striped Bass	10	0	1	6	8	25	13	82
	Total	49	44	50	17	36	196	123	77
			Pool 27						
SIU-C	Blue Catfish	27	19	10	10	15	81	55	83
SIU-C	American Eel	N/A	N/A	N/A	N/A	1	1	N/A	N/A
SIU-C	Lake Sturgeon	0	0	0	0	1	1	N/A	N/A
SIU-C	Paddlefish	0	4	8	2	0	14	9	64
SIU-C	Sauger/Walleye	N/A	N/A	N/A	6	12	18	6	100
SIU-C	Shovelnose Sturgeon	33	22	29	18	30	132	68	67
SIU-C	Silver Carp	33	33	53	15	30	164	128	96
SIU-C	White Bass and Hybrid Striped Bass	4	0	31	15	17	67	41	82
	Total	97	78	131	66	106	478	307	83
			Pool 28						
MDC	Lake Sturgeon	1	7	3	0	0	11	9	70

Table 4. Maximum movement (total miles moved by one fish and total miles upriver or downriver) for fish collected, tagged, and released within Mississippi River pools 22, 24, 26, or 27 during 2006 - 2010. Distances included movement within and among all UMR pools and the open Middle Mississippi River for some fish.

Pool Released	Study	Species	Maximum movement Miles	Maximum upriver movement Miles	Maximum downriver movement Miles
20	MDC	Lake Sturgeon	13.9[a]	7.2[a]	6.7[a]
22	Passage	Bighead Carp	121.7	48.6	75.4
	Passage	Paddlefish	327.3	163.7	163.6
	Passage	Sauger/Walleye	122.3	0.0	122.3
	Passage	Shovelnose Sturgeon	437.6	157.1	280.5
	Passage	Silver Carp	683.1[a]	330.2[a]	352.9[a]
	Passage	White Bass and Hybrid Striped Bass	180	38.8	152.4
24	Passage	Bighead	132	55.2	76.8
	Passage	American Eel	98	0.0	98.0
	MDC/WIU	Lake Sturgeon	253.2	128.2	165.2
	Passage	Paddlefish	501.3	202.9	298.4
	Passage	Sauger/Walleye	495.6	197.0	298.6
	Passage	Shovelnose Sturgeon	1203.8	600.6	603.2
	Passage	Silver Carp	130.9	77.3	107.2
	Passage	White Bass and Hybrid Striped Bass	372.3	138.3	234.2
25	MDC	Lake Sturgeon	90	89.7	0.3[a]
26	Passage	Blue Catfish	428.2	204.4	207.9
	MDC	Lake Sturgeon	570.4	164.1	406.3
	Passage	Paddlefish	296.6	186.5	234.2
	Passage	Shovelnose Sturgeon	498.6	258.3	240.3
	Passage	Silver Carp	277	116.9	238.6
	Passage	White Bass and Hybrid Striped Bass	124.6	124.6	77.8
27	Passage	Blue Catfish	428.2	257.1	314.8
	Passage	Paddlefish	586	193.4	392.6
	Passage	Sauger/Walleye	61.2	60.8	2.8
	Passage	Shovelnose Sturgeon	967.8	485.2	482.6
	Passage	Silver Carp	776.9	388.5	388.4
	Passage	White Bass and Hybrid Striped Bass	315.1	188.9	314.7
28	MDC	Lake Sturgeon	1163.9	563.9	599.9

[a] Movement occurred within the pool

Table 5. Fish passage through Mississippi River locks and dams 20 - 27. Sonic transmitters were implanted in the fish during 2006 - 2010. Passage was detected by stationary receivers placed above and below the dams.

Lock and dam	Number of fish	Number of passages	Percent upriver	Percent downriver
20	54	76	75	25
21	68	96	75	25
22	155	216	62	38
24	136	145	42	58
25	98	134	45	55
26	141	201	38	62
27	115	168	26	74
	767	1036	49	51

Table 6. Fish passage through or around Mississippi River locks and dams. Sonic transmitters were implanted in each of the fish species during 2006 - 2010. Passage was detected by stationary receivers place above and below the dam. The numbers depict total number of passages.

Species	Downriver	Upriver	Total passage per species	Percent of passages	Percent tagged
	Locks and Dams 20 - 26				
Bighead Carp	4	3	7	1	1
Blue Catfish	24	12	36	4	9
American Eel	2	0	2	0	0
Lake Sturgeon	42	94	136	16	7
Paddlefish	49	88	137	16	9
Sauger/Walleye	19	8	27	3	4
Shovelnose Sturgeon	126	156	282	32	26
Silver Carp	87	73	160	18	30
White Bass and Hybrid Striped Bass	54	27	81	9	15
Total	407	461	868		
	Lock and Dam 27 (lowhead)				
Bighead Carp	0	0	0	0	1
Blue Catfish	50	11	61	36	9
American Eel	0	0	0	0	0
Lake Sturgeon	9	11	20	12	7
Paddlefish	7	2	9	5	9
Sauger/Walleye	0	0	0	0	4
Shovelnose Sturgeon	19	8	27	16	26
Silver Carp	27	9	36	21	30
White Bass and Hybrid Striped Bass	12	3	15	9	15
Total	124	44	168		

Table 7. Seasonal fish passage through or around upper Mississippi River dams including Lock and Dam 19 through Lock and Dam 27. The fish were implanted with sonic transmitters and released in pools 22, 24 and 26 during 2006 - 2010. The numbers depict species specific passages by season and unknown represents passages through dams where no receivers are located so the date of passage is unknown.

Species	Total passages	Downriver				
		Winter	Spring	Summer	Fall	Unknown
Bighead Carp	4	1	3	0	0	0
Blue Catfish	74	26	7	2	38	1
American Eel	2	1	0	0	1	0
Lake Sturgeon	51	0	16	6	17	12
Paddlefish	56	11	10	18	11	6
Sauger/Walleye	19	3	0	0	11	5
Shovelnose Sturgeon	145	14	14	40	39	38
Silver Carp	114	32	27	15	37	3
White Bass and Hybrid Striped Bass	66	6	11	1	32	16
Total	531	94	88	82	186	81

Species	Total passages	Upriver				
		Winter	Spring	Summer	Fall	Unknown
Bighead Carp	3	0	1	1	0	1
Blue Catfish	23	6	4	2	7	4
American Eel	0	0	0	0	0	0
Lake Sturgeon	105	3	36	19	18	29
Paddlefish	90	4	40	15	2	29
Sauger/Walleye	8	3	0	0	4	1
Shovelnose Sturgeon	164	16	46	34	21	47
Silver Carp	82	17	15	14	27	9
White Bass and Hybrid Striped Bass	30	4	5	1	9	11
Total	505	53	147	86	88	130

Table 8. Dates during 2006 - 2010 when open river conditions prevailed at UMR locks and dams.

Lock and dam	Open river periods		Number of days	Lock and dam	Open river periods		Number of days
	Initial	Final			Initial	Final	
20	4/3/2006	5/29/2006	57	22	4/7/2006	4/28/2006	22
20	3/2/2007	3/4/2007	3	22	3/17/2007	4/23/2007	38
20	3/12/2007	5/18/2007	68	22	4/26/2007	5/10/2007	15
20	6/1/2007	6/11/2007	11	22	8/25/2007	9/4/2007	11
20	6/23/2007	6/26/2007	4	22	10/19/2007	10/24/2007	6
20	8/23/2007	9/6/2007	15	22	3/4/2008	3/7/2008	4
20	10/9/2007	11/7/2007	30	22	3/17/2008	3/27/2008	11
20	1/8/2008	1/11/2008	4	22	4/5/2008	8/2/2008	120
20	3/3/2008	3/9/2008	7	22	9/14/2008	9/19/2008	6
20	3/14/2008	8/3/2008	143	22	12/28/2008	12/30/2008	3
20	9/13/2008	9/18/2008	6	22	3/9/2009	3/19/2009	12
20	12/27/2008	1/2/2009	7	22	3/25/2009	4/16/2009	23
20	2/10/2009	2/20/2009	11	22	4/28/2009	5/12/2009	15
20	2/27/2009	3/3/2009	5	22	5/14/2009	5/22/2009	9
20	3/8/2009	5/25/2009	79	22	6/19/2009	6/21/2009	3
20	5/29/2009	6/15/2009	18	22	6/22/2009	6/27/2009	6
20	6/16/2009	7/1/2009	16	22	8/28/2009	9/2/2009	6
20	8/28/2009	9/3/2009	7	22	10/26/2009	11/9/2009	15
20	10/23/2009	11/21/2009	30	22	11/17/2009	11/20/2009	4
20	12/25/2009	12/30/2009	6	22	12/26/2009	12/29/2009	4
20	1/24/2010	1/29/2010	6	22	1/24/2010	1/27/2010	4
20	3/10/2010	6/11/2010	94	22	3/10/2010	4/21/2010	43
20	6/12/2010	9/8/2010	89	22	4/25/2010	5/1/2010	7
20	9/22/2010	10/25/2010	34	22	5/12/2010	5/29/2010	18
				22	6/6/2010	6/8/2010	3
21	4/6/2006	4/29/2006	24	22	6/13/2010	8/30/2010	79
21	3/2/2007	3/3/2007	2	22	9/23/2010	10/20/2010	28
21	3/16/2007	4/23/2007	39				
21	4/26/2007	5/10/2007	15	24	4/13/2006	4/27/2006	15
21	6/3/2007	6/5/2007	2	24	3/19/2007	4/23/2007	36
21	8/24/2007	9/4/2007	12	24	4/26/2007	5/11/2007	15
21	10/19/2007	11/1/2007	14	24	8/25/2007	9/4/2007	11
21	3/3/2008	3/8/2008	6	24	10/20/2007	10/21/2007	2
21	3/16/2008	3/29/2008	14	24	10/23/2007	10/23/2007	2
21	4/3/2008	8/2/2008	121	24	3/4/2008	3/7/2008	5
21	9/13/2008	9/19/2008	6	24	3/17/2008	3/27/2008	11
21	12/28/2008	1/1/2009	5	24	4/6/2008	8/5/2008	122
21	2/12/2009	2/14/2009	3	24	9/14/2008	9/19/2008	6
21	3/9/2009	3/19/2009	12	24	12/28/2008	12/31/2008	3
21	3/24/2009	4/17/2009	25	24	3/9/2009	3/20/2009	12
21	4/28/2009	5/22/2009	25	24	3/25/2009	4/17/2009	24
21	6/19/2009	6/28/2009	10	24	4/28/2009	5/13/2009	17
21	8/28/2009	9/2/2009	6	24	5/14/2009	5/23/2009	9
21	10/25/2009	11/10/2009	18	24	6/19/2009	6/21/2009	3
21	11/17/2009	11/20/2009	4	24	6/22/2009	6/28/2009	7
21	12/25/2009	12/30/2009	6	24	8/29/2009	9/3/2009	6
21	1/20/2010	1/29/2010	10	24	10/25/2009	11/11/2009	18
21	3/10/2010	5/4/2010	56	24	11/17/2009	11/21/2009	5
21	5/7/2010	5/9/2010	3	24	12/26/2009	12/30/2009	4
21	5/11/2010	5/28/2010	18	24	1/24/2010	1/27/2010	4
21	6/3/2010	6/4/2010	2	24	3/10/2010	4/22/2010	44
21	6/6/2010	6/8/2010	4	24	4/24/2010	5/3/2010	10
21	6/13/2010	9/5/2010	85	24	5/8/2010	5/10/2010	2
21	9/22/2010	10/21/2010	30	24	5/12/2010	5/30/2010	19
				24	6/4/2010	6/4/2010	2
				24	6/6/2010	6/8/2010	3
				24	6/13/2010	9/1/2010	81
				24	9/3/2010	9/4/2010	2
				24	9/23/2010	10/21/2010	28

Table 8 (cont). Dates during 2006 - 2010 when open river conditions prevailed at UMR locks and dams.

Lock and dam	Open river periods		Number of days	Lock and dam	Open river periods		Number of days
	Initial	Final			Initial	Final	
25	4/8/2006	4/30/2006	23	26	3/31/2007	4/20/2007	21
25	3/3/2007	3/3/2007	2	26	4/29/2007	4/30/2007	2
25	3/17/2007	4/25/2007	40	26	5/1/2007	5/2/2007	2
25	4/26/2007	5/13/2007	18	26	5/2/2007	5/7/2007	6
25	6/4/2007	6/4/2007	1	26	5/8/2007	5/16/2007	9
25	8/25/2007	9/5/2007	12	26	8/29/2007	8/31/2007	4
25	10/20/2007	10/25/2007	6	26	3/5/2008	3/9/2008	5
25	1/9/2008	1/9/2008	2	26	3/19/2008	3/26/2008	9
25	3/4/2008	3/9/2008	6	26	4/1/2008	4/3/2008	3
25	3/17/2008	3/30/2008	14	26	4/10/2008	7/17/2008	99
25	3/31/2008	4/2/2008	3	26	7/26/2008	8/5/2008	11
25	4/4/2008	8/7/2008	127	26	9/14/2008	9/22/2008	9
25	9/14/2008	9/20/2008	7	26	3/11/2009	3/20/2009	10
25	12/28/2008	1/1/2009	5	26	3/27/2009	4/6/2009	11
25	3/9/2009	3/23/2009	15	26	4/11/2009	4/17/2009	7
25	3/25/2009	4/21/2009	28	26	4/29/2009	5/31/2009	33
25	4/28/2009	5/24/2009	27	26	6/12/2009	6/14/2009	3
25	6/12/2009	6/13/2009	3	26	6/17/2009	6/29/2009	13
25	6/19/2009	6/29/2009	10	26	10/26/2009	10/26/2009	1
25	8/29/2009	9/3/2009	6	26	10/27/2009	11/11/2009	16
25	10/24/2009	11/13/2009	21	26	11/17/2009	11/23/2009	7
25	11/16/2009	11/21/2009	6	26	12/26/2009	12/29/2009	4
25	12/25/2009	12/31/2009	7	26	1/25/2010	1/29/2010	5
25	1/24/2010	1/29/2010	6	26	3/12/2010	4/18/2010	39
25	3/9/2010	3/10/2010	2	26	4/26/2010	5/2/2010	8
25	3/10/2010	5/6/2010	58	26	5/13/2010	6/1/2010	20
25	5/8/2010	6/1/2010	26	26	6/5/2010	6/12/2010	8
25	6/3/2010	6/5/2010	3	26	6/13/2010	8/27/2010	76
25	6/8/2010	6/10/2010	4	26	9/24/2010	9/28/2010	5
25	6/13/2010	9/8/2010	88				
25	9/21/2010	9/21/2010	2				
25	9/22/2010	10/23/2010	32				

Table 9. Fish passage through Upper Mississippi River locks and dams. Sonic transmitters were implanted in each of the fish species during 2006 - 2010. Passage was detected by stationary receivers place above and below the dams. Open or closed describes river conditions at the dams. The numbers depict total number of passages.

	Downriver		Upriver		Total per
Species	Open	Closed	Open	Closed	species
		Lock and Dam 20 - 26			
Bighead Carp	0	4	3	0	7
Blue Catfish	2	22	6	6	36
American Eel	1	1	0	0	2
Lake Sturgeon	29	13	90	4	136
Paddlefish	33	16	80	8	137
Sauger/Walleye	17	2	2	6	27
Shovelnose Sturgeon	93	33	122	34	282
Silver Carp	36	51	43	30	160
White Bass and Hybrid Striped Bass	26	28	22	5	81
Total	237	170	368	93	868
		Lock and Dam 27 (lowhead)			
Bighead Carp	0		0		0
Blue Catfish	11		50		61
American Eel	0		0		0
Lake Sturgeon	11		9		20
Paddlefish	2		7		9
Sauger/Walleye	0		0		0
Shovelnose Sturgeon	8		19		27
Silver Carp	9		27		36
White Bass and Hybrid Striped Bass	3		12		15
Total	44		124		168

Table 10. Fish passage through Mississippi River lock and dams 20 through 27. Sonic transmitters were implanted in each of the fish species during 2006 - 2010. Passage was detected by stationary receivers place above and below the dams. Open or closed describes the dams' gates positions.

Species	Lock and Dam 20 Upriver Closed	Lock and Dam 20 Upriver Open	Lock and Dam 20 Downriver Closed	Lock and Dam 20 Downriver Open	Total per species
Lake Sturgeon	1	18	0	5	24
Paddlefish	0	16	0	7	23
Shovelnose Sturgeon	0	17	0	6	23
Silver Carp	0	1	0	1	2
White Bass and Hybrid Striped Bass	0	4	0	0	4
Total	1	56	0	19	76

Species	Lock and Dam 21 Upriver Closed	Lock and Dam 21 Upriver Open	Lock and Dam 21 Downriver Closed	Lock and Dam 21 Downriver Open	Total per species
Lake Sturgeon	1	23	2	4	30
Paddlefish	0	18	3	4	25
Shovelnose Sturgeon	0	24	1	8	33
Silver Carp	0	2	1	1	4
White Bass and Hybrid Striped Bass	0	4	0	0	4
Total	1	71	7	17	96

Species	Lock and Dam 22 Upriver Closed	Lock and Dam 22 Upriver Open	Lock and Dam 22 Downriver Closed	Lock and Dam 22 Downriver Open	Total per species
Bighead Carp	0	1	2	0	3
Lake Sturgeon	1	35	5	5	46
Paddlefish	2	17	5	5	29
Sauger/Walleye	0	0	0	1	1
Shovelnose Sturgeon	17	37	8	23	85
Silver Carp	6	12	9	10	37
White Bass and Hybrid Striped Bass	2	4	7	2	15
Total	28	106	36	46	216

Species	Lock and Dam 24 Upriver Closed	Lock and Dam 24 Upriver Open	Lock and Dam 24 Downriver Closed	Lock and Dam 24 Downriver Open	Total per species
Bighead Carp	0	1	1	0	2
Blue Catfish	0	1	0	0	1
American Eel	0	0	0	1	1
Lake Sturgeon	0	6	0	7	13
Paddlefish	3	14	2	8	27
Sauger/Walleye	1	1	1	7	10
Shovelnose Sturgeon	6	15	8	23	52
Silver Carp	2	6	5	7	20
White Bass and Hybrid Striped Bass	1	4	4	10	19
Total	13	48	21	63	145

Table 10 (cont). Fish passage through Mississippi River lock and dams 20 through 27. Sonic transmitters were implanted in each of the fish species during 2006 - 2010. Passage was detected by stationary receivers place above and below the dams. Open or closed describes the dams' gates positions.

	Lock and Dam 25				
Species	Upriver		Downriver		Total
	Closed	Open	Closed	Open	per species
Bighead Carp	0	1	1	0	2
Blue Catfish	0	1	0	0	1
American Eel	0	0	1	0	1
Lake Sturgeon	0	4	1	5	10
Paddlefish	3	14	2	8	27
Sauger/Walleye	2	1	1	7	11
Shovelnose Sturgeon	5	16	7	17	45
Silver Carp	2	6	2	8	18
White Bass and Hybrid Striped Bass	1	4	4	10	19
Total	13	47	19	55	134

	Lock and Dam 26				
Species	Upriver		Downriver		Total
	Closed	Open	Closed	Open	per species
Bighead Carp	0	0	22	2	24
Blue Catfish	6	4	1	1	12
Lake Sturgeon	1	4	5	3	13
Paddlefish	0	1	4	1	6
Sauger/Walleye	3	0	0	2	5
Shovelnose Sturgeon	6	13	9	16	44
Silver Carp	20	16	34	9	79
White Bass and Hybrid Striped Bass	1	2	12	3	18
Total	37	40	87	37	201

	Lock and Dam 27				
Species	Upriver		Downriver		Total
	Closed	Open	Closed	Open	per species
Blue Catfish	11	--	50	--	61
Lake Sturgeon	11	--	9	--	20
Paddlefish	2	--	7	--	9
Shovelnose Sturgeon	8	--	19	--	27
Silver Carp	9	--	27	--	36
White Bass and Hybrid Striped Bass	3	--	12	--	15
Total	44		124		168

Table 11. Fish use of lock chambers to pass through Mississippi River Lock and Dam 26 during 2007 thorugh 2010. Passage was detected by stationary receivers place inside the lock chambers. Numbers depict number of fish entering the locks and passages either upriver or downriver.

Species	Number of Entrances	Upriver Passage	Downriver Passage	Total Passage
Bighead Carp	0	0	0	0
Blue Catfish	12	0	1	1
Lake Sturgeon	5	2	0	2
Paddlefish	2	0	1	1
Sauger/Walleye	61	3	0	3
Shovelnose Sturgeon	75	1	1	2
Silver Carp	302	17	3	20
White Bass and Hybrid Striped Bass	35	0	0	0
Total	491	23	6	29

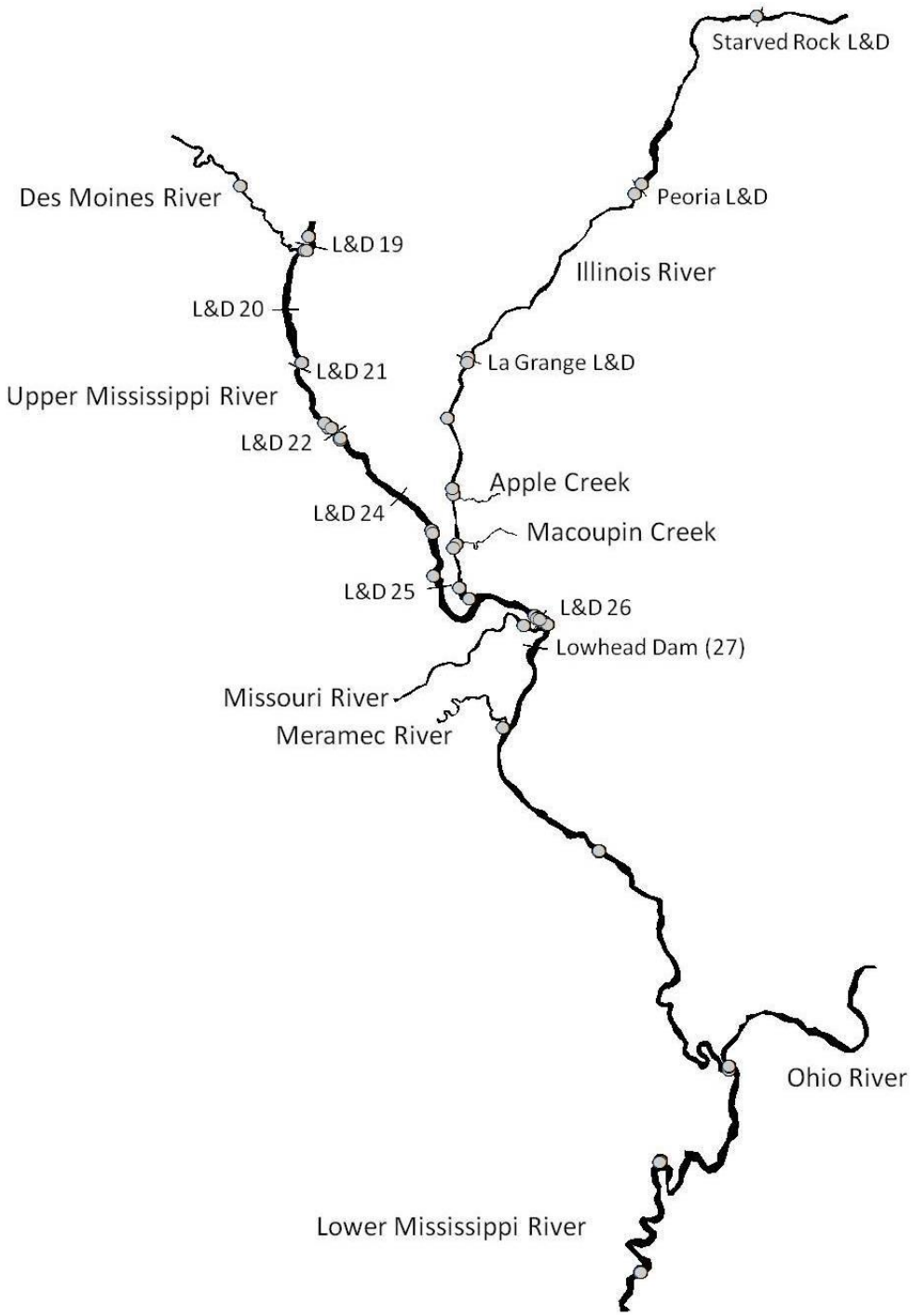
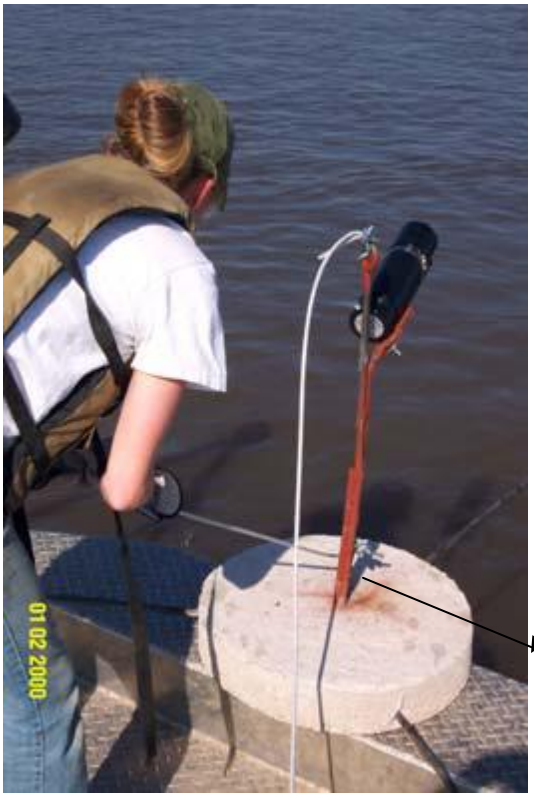


Figure 1. Locations of the VR2W receivers (grey circles) in the Upper Mississippi River System during 2010.

Figure 2. VR2W deployment methods, showing the modified bottom set stand configuration (top left), the navigation buoy (top right), and bridge pier mount (bottom).



Anchor Line

Figure 3. Rig (top) used to grapple cable between anchor and original bottom set stand (with VR2W attached; below).

Figure 4. Modified VR2W stand with longer legs and feet for stability.

Figure 5. Sonardyne acoustic release system with pop-up buoys.

Figure 6. VR2W locations (yellow circles) in the vicinity of Lock and Dam 22, Upper Mississippi River.

Figure 7. VR2W locations (yellow circles) in the vicinity of Lock and Dam 26, Upper Mississippi River.

Figure 8. VR2W locations (yellow circles) in the vicinity of Lock and Dam 19, Upper Mississippi River.

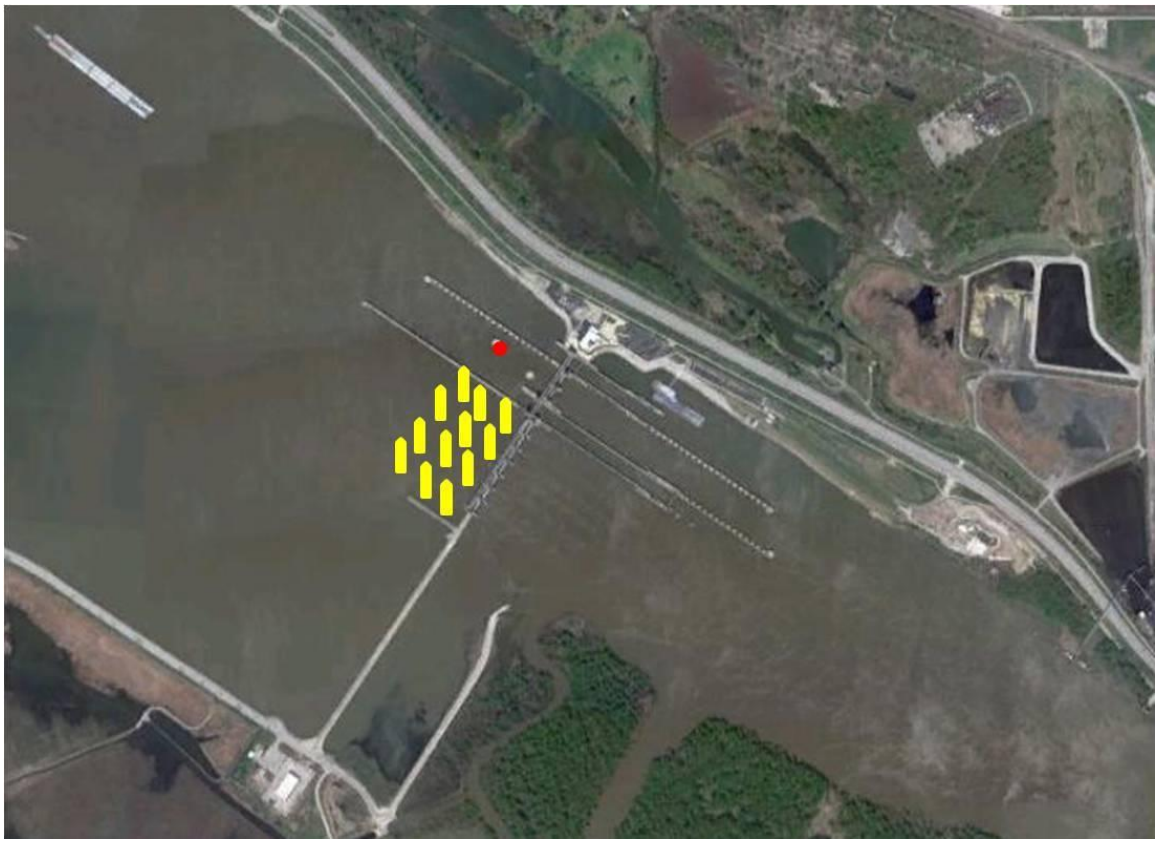


Figure 9. Design for the experimental gate array with yellow markers representing navigation buoys that will be painted yellow and set in place to hang the stationary receivers and the red dot representing the stationary receiver already present on the mooring station between the two lock chambers.

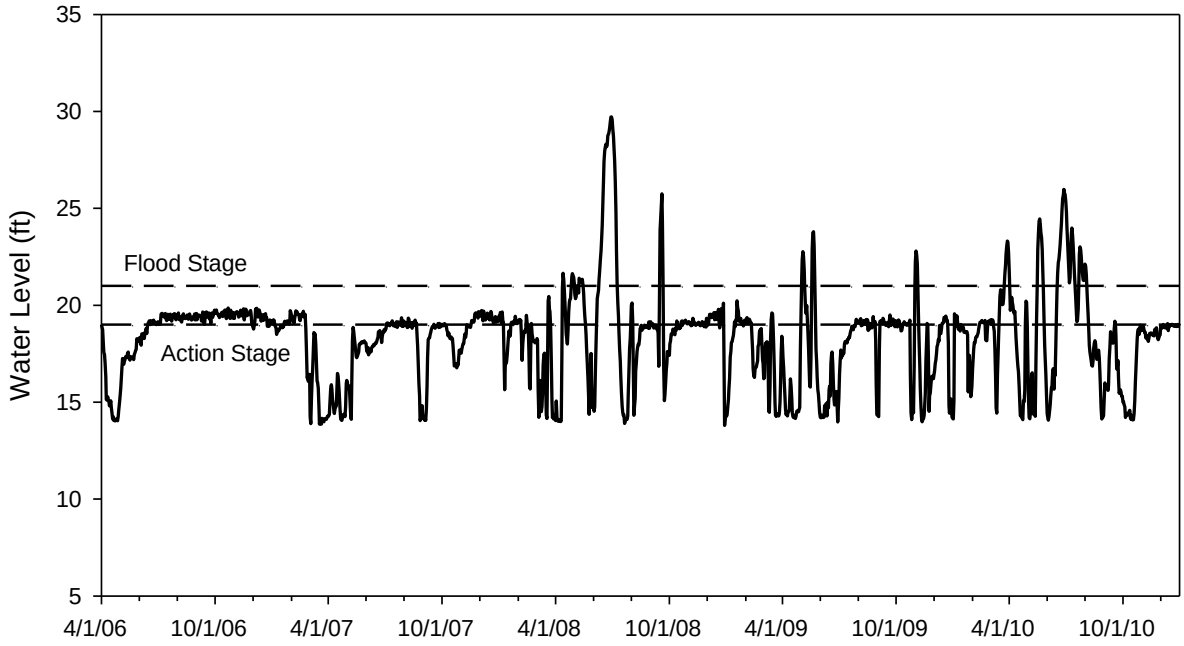


Figure 10. Daily water levels (feet) at the Alton USGS gages during 2006 through 2010.

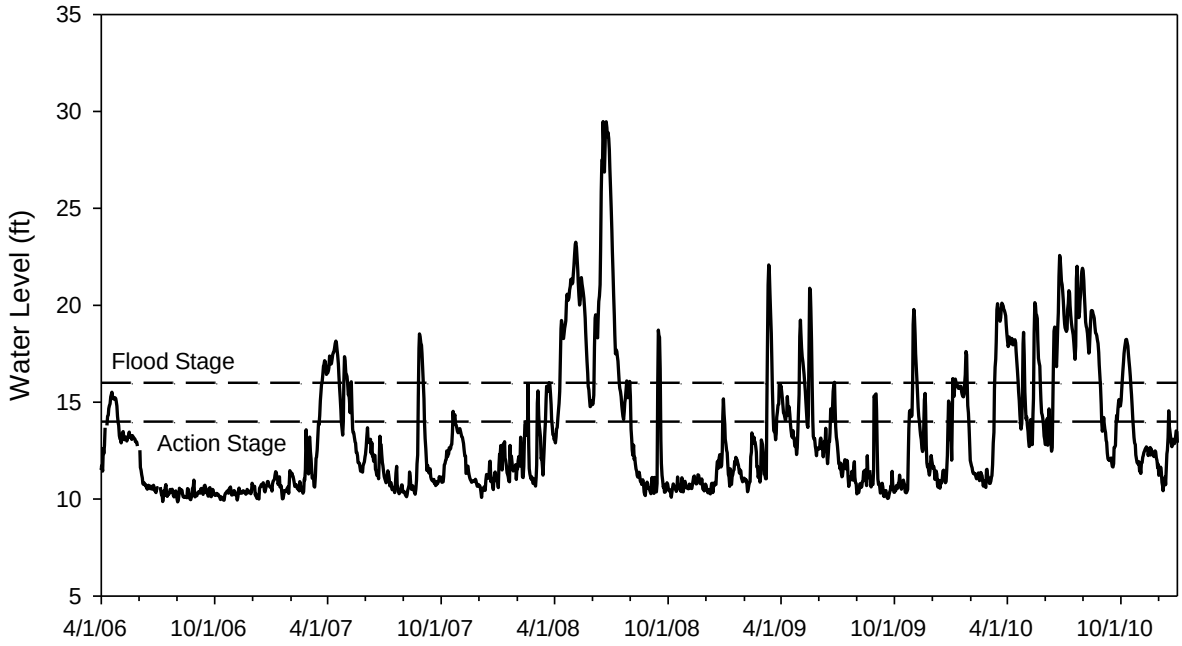


Figure 11. Daily water levels (feet) at the Hannibal USGS gages during 2006 through 2010.

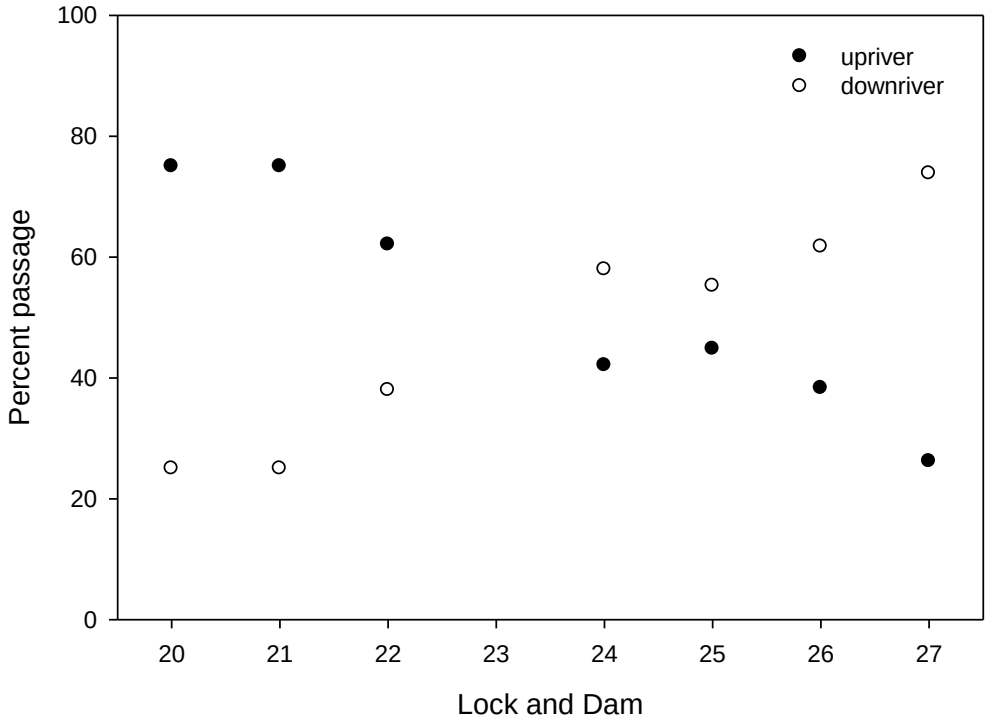


Figure 12. Percent passages of tagged fish either confirmed as upstream or downstream through lock and dams of the UMRS during 2006 through 2010 (see Table 5). Note: There is no Lock and Dam 23.

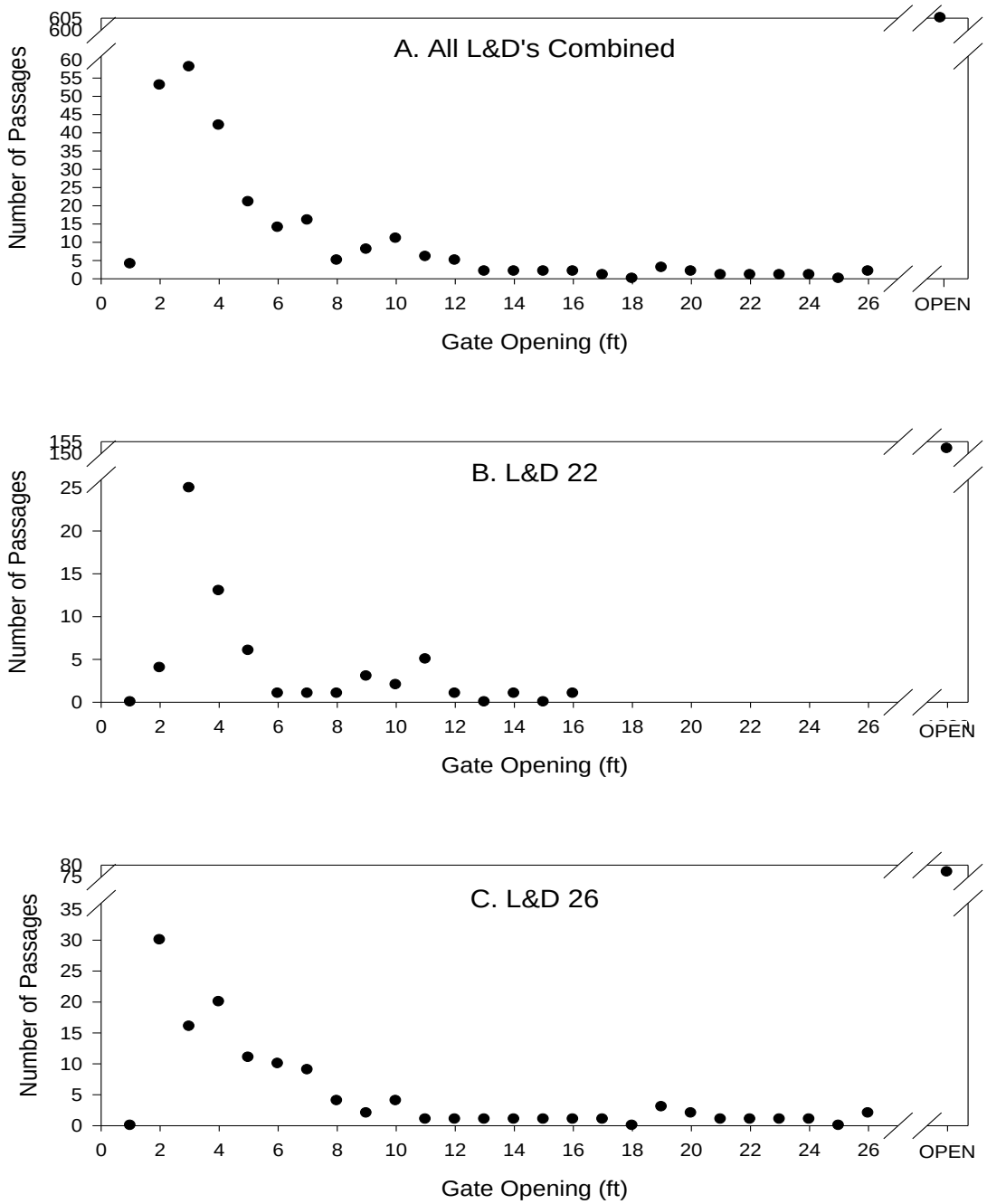


Figure 13. Number of passages made at all ranges of gate openings. A) Shows data for all Lock and Dams (20-26) combined, the total number of passages that occurred with the average tainter gate opening (for all L&D's combined) during the time period in which each passage occurred. B) Shows passage at Lock and Dam 22, and the total number of passages that occurred with the average tainter gate opening for Lock and Dam 22 during the time period in which each passage occurred. C) Shows passage at Lock and Dam 26, and the total number of passages that occurred with the average tainter gate opening for Lock and Dam 26 during the time period in which each passage occurred.

Appendix 1. Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
22	Bighead Carp	1-May-06	940	1011	220	Expired
			950	1012	220	Expired
			853	1014	220	Expired
			1002	1016*	220	Expired
			840	1017*	220	Expired
22	American Eel	6-Oct-10	508	38797	131	02/14/11
22	Hybrid Striped Bass	21-Oct-10	618	38818	131	03/01/11
22	Paddlefish	11-Oct-06	1219	196*	220	Expired
		21-Oct-08	772	53115*	334	Expired
			883	53124*	334	Expired
		2-Apr-09	870	53072*	334	Expired
		3-Apr-09	1168	12136*	334	Expired
			1028	53062*	334	Expired
			1007	53067*	334	Expired
			1190	53068*	334	Expired
			1132	53070*	334	Expired
			1060	53071*	334	Expired
22	Sauger	27-Oct-09	504	61556	131	Expired
22	Shovelnose Sturgeon	24-May-06	671	1024	360	Expired
			699	1026	360	Expired
			695	1032	360	Expired
			674	1034	360	Expired
			691	1007*	360	Expired
		23-Oct-07	650	7109	360	Expired
			615	7110	360	Expired
			590	7111	360	Expired
		20-Oct-08	672	53156	591	Expired
			685	53160	591	Expired
			647	53163	591	Expired
			633	53157*	591	Expired
			588	53158*	591	Expired
			653	53159*	591	Expired
			602	53161*	591	Expired
			632	53162*	591	Expired
		26-Oct-09	694	61561	591	06/09/11
			611	61562	591	06/09/11
			679	61563	591	06/09/11
			609	61565	591	06/09/11
			679	61566	591	06/09/11
			689	61568*	591	06/09/11
		21-Oct-10	614	38676	591	06/03/12
			630	38677	591	06/03/12
			645	38679	591	06/03/12
			592	38680	591	06/03/12
			630	38682	591	06/03/12
			679	38683	591	06/03/12
			675	38686	591	06/03/12
			688	38689	591	06/03/12
			709	38692	591	06/03/12
			695	61578	591	06/03/12
22	Silver Carp	29-Mar-06	903	1015	220	Expired
			840	1019	220	Expired
			860	1020	220	Expired
			790	1006*	220	Expired

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
22	Silver Carp	29-Mar-06	901	1013*	220	Expired
		23-Oct-07	556	6971*	220	Expired
		21-Oct-08	910	53113	334	Expired
			800	53122	334	Expired
			602	53128	334	Expired
			657	53130	334	Expired
			668	53125*	334	Expired
			656	53126*	334	Expired
		30-Oct-08	776	53121*	334	Expired
			658	53123*	334	Expired
			791	53129*	334	Expired
			689	53131*	334	Expired
		26-Oct-09	684	61652	334	Expired
			604	61654	334	Expired
		27-Oct-09	563	61655	334	Expired
			737	61656	334	Expired
			631	61657	334	Expired
		6-Oct-10	767	47226	1133	11/12/13
			623	47227	1133	11/12/13
			773	47228	1133	11/12/13
			808	47229	1133	11/12/13
			705	47230	1133	11/12/13
			697	47231	1133	11/12/13
			773	47232	1133	11/12/13
			870	47259	1133	11/12/13
			737	47261	1133	11/12/13
			744	47263*	1133	11/12/13
22	Walleye	26-Oct-09	491	61559	131	Expired
		18-Oct-10	373	38781*	131	02/26/11
		21-Oct-10	424	38914	131	03/01/11
22	White Bass	11-Oct-06	305	125	140	Expired
			370	128	140	Expired
			336	126*	140	Expired
			377	127*	140	Expired
			321	133*	140	Expired
		20-Oct-08	338	1711	140	Expired
			313	1724	140	Expired
			326	1726	140	Expired
			326	1710*	140	Expired
			300	1715*	140	Expired
			371	1720*	140	Expired
		26-Oct-09	286	61558*	131	Expired
			337	61560*	131	Expired
		27-Oct-09	416	61557	131	Expired
		18-Oct-10	320	38782	131	02/26/11
			300	38778*	131	02/26/11
		21-Oct-10	315	38813	131	03/01/11
			311	38823	131	03/01/11
			365	38902	131	03/01/11
			381	38907	131	03/01/11
24	Bighead Carp	1-May-06	1007	1010	220	Expired
			990	1025	220	Expired
			800	1027	220	Expired

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
24	Bighead Carp	1-May-06	830	1029	220	Expired
			950	1018*	220	Expired
24	American Eel	5-Oct-10	516	61517*	131	02/13/11
24	Hybrid Striped Bass	5-Oct-10	595	38798	131	02/13/11
		19-Oct-10	707	38784	131	02/27/11
			392	38780*	131	02/27/11
24	Paddlefish	5-Oct-06	1257	180*	220	Expired
		29-Jan-07	842	181	220	Expired
			950	182	220	Expired
			1040	184*	220	Expired
		7-Mar-07	1044	167	220	Expired
			988	168	220	Expired
			1040	169	220	Expired
			982	170	220	Expired
			826	171	220	Expired
			943	172	220	Expired
			810	173	220	Expired
			904	176	220	Expired
			1000	177	220	Expired
			1057	178	220	Expired
			1225	186	220	Expired
			817	189	220	Expired
			1050	190	220	Expired
			915	185*	220	Expired
			1080	187*	220	Expired
		13-Mar-07	941	194	220	Expired
			806	195	220	Expired
			944	191*	220	Expired
		1-Oct-07	1053	6991	220	Expired
		27-Nov-07	880	1519	220	Expired
		28-Nov-07	1020	1520	220	Expired
			1125	1527	220	Expired
			814	1553	220	Expired
		29-Nov-07	1171	1523	220	Expired
		12-Mar-08	967	7019	220	Expired
		29-Mar-08	1046	7032	220	Expired
		14-Oct-08	855	12082	204	Expired
			1135	12081*	204	Expired
		16-Oct-08	681	53095*	334	Expired
		17-Oct-08	1092	53099*	334	Expired
		26-Mar-09	880	12130	204	Expired
			881	12128*	204	Expired
24	Sauger	18-Nov-09	423	61523	131	Expired
			442	61525	131	Expired
			476	61534	131	Expired
			454	61535	131	Expired
			461	61531*	131	Expired
			486	61533*	131	Expired
		5-Oct-10	370	38790	131	02/13/11
			434	38791	131	02/13/11
			448	38792	131	02/13/11
			376	38793	131	02/13/11
			402	38794	131	02/13/11

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
24	Sauger	5-Oct-10	365	38799	131	02/13/11
		6-Oct-10	422	38795	131	02/14/11
			350	38800	131	02/14/11
			373	38801	131	02/14/11
			373	38796*	131	02/14/11
		20-Oct-10	377	38906	131	02/28/11
		10-Nov-10	347	38760	131	03/21/11
			385	38761	131	03/21/11
24	Shovelnose Sturgeon	11-May-06	735	1005	360	Expired
			703	1028	360	Expired
			517	1031	360	Expired
			678	1035	360	Expired
			661	1037	360	Expired
			650	1038	360	Expired
			655	1039	360	Expired
			675	1040	360	Expired
			694	1033*	360	Expired
		12-May-06	715	1030	360	Expired
			622	1036	360	Expired
		2-Oct-06	588	203	360	Expired
			609	204	360	Expired
		3-Oct-06	620	200	360	Expired
			598	201	360	Expired
		4-Oct-06	612	198	360	Expired
			700	199	360	Expired
			596	202	360	Expired
			638	197*	360	Expired
		5-Mar-07	654	132*	360	Expired
		6-Mar-07	572	131	360	Expired
		9-Mar-07	522	129	360	Expired
			532	134	360	Expired
			592	135	360	Expired
			539	136	360	Expired
			580	138	360	Expired
			615	139	360	Expired
			613	140	360	Expired
			625	141	360	Expired
			586	137*	360	Expired
			624	143*	360	Expired
		2-Oct-07	699	7098	360	Expired
			565	7103	360	Expired
			630	7097*	360	Expired
			575	7099*	360	Expired
			623	7100*	360	Expired
			668	7101*	360	Expired
			599	7102*	360	Expired
			678	7104*	360	Expired
			575	7105*	360	Expired
			635	7106*	360	Expired
			600	7107*	360	Expired
		11-Mar-08	581	7086*	360	Expired
			638	7108*	360	Expired
		15-Oct-08	619	12156	353	Expired

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
24	Shovelnose Sturgeon	15-Oct-08	584	12154*	353	Expired
			608	12155*	353	Expired
			618	12157*	353	Expired
			589	12158*	353	Expired
			581	12159*	353	Expired
		16-Oct-08	633	12160	353	Expired
			638	12162*	353	Expired
			676	12163*	353	Expired
			664	12164*	353	Expired
			632	12165*	353	Expired
			631	12166*	353	Expired
			609	12173*	353	Expired
			586	12174*	353	Expired
			599	12175*	353	Expired
			599	12176*	353	Expired
			721	12178*	353	Expired
		29-Oct-08	624	53152	591	Expired
			595	53145*	591	Expired
			596	53146*	591	Expired
			667	53148*	591	Expired
			625	53155*	591	Expired
		5-Oct-09	676	53153	591	05/19/11
			584	61608	591	05/19/11
			616	61605*	591	05/19/11
			651	61607*	591	05/19/11
		6-Oct-09	591	61600*	591	05/20/11
			.	61603*	591	05/20/11
			649	61604*	591	05/20/11
			679	61606*	591	05/20/11
		7-Oct-09	.	61570	591	05/21/11
			588	61576	591	05/21/11
			639	61564*	591	05/21/11
			589	61567*	591	05/21/11
			643	61573*	591	05/21/11
			645	61597*	591	05/21/11
			589	61598*	591	05/21/11
			631	61599*	591	05/21/11
			616	61601*	591	05/21/11
			596	61602*	591	05/21/11
		5-Oct-10	645	61571	591	05/18/12
			610	61574	591	05/18/12
			622	61577	591	05/18/12
		19-Oct-10	590	38675	591	06/01/12
			655	38678	591	06/01/12
			661	38681	591	06/01/12
			656	38684	591	06/01/12
			600	38685	591	06/01/12
			704	38687	591	06/01/12
			670	38688	591	06/01/12
			675	38690	591	06/01/12
			613	38691	591	06/01/12
			663	38729	591	06/01/12
			616	38730	591	06/01/12

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
24	Shovelnose Sturgeon	19-Oct-10	605	38731	591	06/01/12
			700	38732	591	06/01/12
			690	38733	591	06/01/12
			598	38737	591	06/01/12
			643	38738	591	06/01/12
			575	38739	591	06/01/12
			626	38740	591	06/01/12
			632	38741	591	06/01/12
			614	38742	591	06/01/12
			640	38743	591	06/01/12
			611	38744	591	06/01/12
			616	38745	591	06/01/12
			626	38746	591	06/01/12
			688	38734*	591	06/01/12
			620	38735*	591	06/01/12
			660	38736*	591	06/01/12
24	Silver Carp	22-Apr-06	820	1001	220	Expired
			845	1003	220	Expired
			923	1008	220	Expired
			960	1002*	220	Expired
			860	1004*	220	Expired
			940	1009*	220	Expired
		25-May-06	540	1021	220	Expired
			862	1022	220	Expired
			605	1023	220	Expired
			910	1576	220	Expired
			950	1598	220	Expired
			920	1592*	220	Expired
			920	1596*	220	Expired
		2-Oct-06	.	183	220	Expired
		7-Mar-07	926	188	220	Expired
			856	179*	220	Expired
			699	192*	220	Expired
		9-Mar-07	851	193*	220	Expired
		14-Mar-07	686	1546*	220	Expired
		1-Oct-07	870	6993	220	Expired
		3-Oct-07	595	6990	220	Expired
			540	6992	220	Expired
			553	6994	220	Expired
		4-Oct-07	727	6996*	220	Expired
		22-Oct-07	740	6968	220	Expired
		11-Mar-08	755	1521	220	Expired
			775	1522	220	Expired
			715	7014	220	Expired
			817	7015	220	Expired
			910	7016	220	Expired
			739	7017	220	Expired
			829	1554*	220	Expired
		13-Oct-08	649	12067	204	Expired
		14-Oct-08	591	12068	204	Expired
			603	12075	204	Expired
			849	12076	204	Expired
			636	12077	204	Expired

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
24	Silver Carp	14-Oct-08	611	12078	204	Expired
			631	12083	204	Expired
			614	12084	204	Expired
			646	53098	334	Expired
			567	53106	334	Expired
			779	12079*	204	Expired
			621	12080*	204	Expired
			589	53104*	334	Expired
		16-Oct-08	583	53108	334	Expired
			733	53101*	334	Expired
		17-Oct-08	623	53085	334	Expired
			606	53105	334	Expired
			628	53111	334	Expired
			587	53112	334	Expired
			588	53114	334	Expired
			593	53117	334	Expired
			841	53118	334	Expired
			594	53097*	334	Expired
			589	53103*	334	Expired
			990	53109*	334	Expired
			864	53116*	334	Expired
		5-Oct-09	622	53063	334	Expired
			713	53065	334	Expired
			652	53061*	334	Expired
			849	53064*	334	Expired
			657	53066*	334	Expired
		6-Oct-09	668	12124	334	Expired
		7-Oct-09	533	12118	334	Expired
			666	12122	334	Expired
			635	12133	334	Expired
			589	53060	334	Expired
			664	53082	334	Expired
			786	61659	334	Expired
			686	12125*	334	Expired
			899	12127*	334	Expired
		18-Nov-09	519	61617	334	Expired
			660	61619	334	Expired
		4-Oct-10	755	61609	334	09/03/11
			870	61610	334	09/03/11
			655	61611	334	09/03/11
			500	61612	334	09/03/11
			630	61613	334	09/03/11
			655	61614	334	09/03/11
			670	61615	334	09/03/11
			690	61618	334	09/03/11
			740	61620	334	09/03/11
			512	61647	334	09/03/11
			641	61648	334	09/03/11
			628	61649	334	09/03/11
			556	61650	334	09/03/11
			672	61616*	334	09/03/11
		5-Oct-10	685	47233	334	09/04/11
			651	47234	334	09/04/11
			653	47235	334	09/04/11

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
24	Silver Carp	5-Oct-10	702	47236	334	09/04/11
			681	47237	334	09/04/11
			570	53028	334	09/04/11
			775	53038	334	09/04/11
			674	61639	334	09/04/11
			660	61640	334	09/04/11
			592	61641	334	09/04/11
			636	61642	334	09/04/11
			692	61643	334	09/04/11
			660	61644	334	09/04/11
			656	61645	334	09/04/11
			619	61646	334	09/04/11
			678	61658	334	09/04/11
24	Walleye	18-Nov-09	364	61526	131	Expired
			435	61527	131	Expired
			437	61524*	131	Expired
			368	61530*	131	Expired
		19-Oct-10	387	38779	131	02/27/11
		20-Oct-10	561	38901	131	02/28/11
24	White Bass	3-Oct-06	338	165	140	Expired
			336	166	140	Expired
		4-Oct-06	.	160	140	Expired
			315	161	140	Expired
		5-Oct-06	319	162	140	Expired
			.	163	140	Expired
			319	164*	140	Expired
		6-Oct-06	367	154	140	Expired
			318	155	140	Expired
			324	156	140	Expired
			410	158	140	Expired
			327	159	140	Expired
			378	157*	140	Expired
		9-Oct-06	321	119	140	Expired
			323	120	140	Expired
			341	121	140	Expired
			352	122	140	Expired
			309	123	140	Expired
			327	124	140	Expired
		7-Mar-07	336	130	140	Expired
		13-Mar-07	412	147*	140	Expired
		14-Mar-07	325	148*	140	Expired
		1-Oct-07	355	1744	140	Expired
		27-Nov-07	335	3883	140	Expired
		28-Nov-07	349	1713	140	Expired
		14-Oct-08	283	151	140	Expired
			318	1698	140	Expired
			284	1706	140	Expired
			285	1719	140	Expired
			306	1725	140	Expired
			316	1730	140	Expired
			274	7130	140	Expired
			281	7136	140	Expired
			301	1699*	140	Expired
			306	1700*	140	Expired
			310	1705*	140	Expired

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
24	White Bass	15-Oct-08	347	7138*	140	Expired
			309	1704	140	Expired
			292	1708	140	Expired
			291	1709	140	Expired
			352	7126	140	Expired
			312	7132	140	Expired
			376	1703*	140	Expired
		5-Oct-09	375	53136	131	Expired
			351	53140	131	Expired
		6-Oct-09	306	53132	131	Expired
			313	53133	131	Expired
			321	53134	131	Expired
			308	53138	131	Expired
			394	53139	131	Expired
		18-Nov-09	302	61522	131	Expired
			348	61528	131	Expired
			267	61532	131	Expired
			281	61529*	131	Expired
		19-Oct-10	303	38783	131	02/27/11
		20-Oct-10	312	38911	131	02/28/11
		10-Nov-10	306	38767	131	03/21/11
			297	38768	131	03/21/11
			332	38769	131	03/21/11
			293	38772	131	03/21/11
			276	38773	131	03/21/11
			295	38774	131	03/21/11
			311	38765*	131	03/21/11
			294	38766*	131	03/21/11
		11-Nov-10	328	38762	131	03/22/11
26	Blue Catfish	17-Oct-06	620	1608*	350	Expired
			640	1609*	350	Expired
			536	1610*	350	Expired
			630	1612*	350	Expired
			619	1614*	350	Expired
			565	1616*	350	Expired
			560	1618*	350	Expired
			579	1619*	350	Expired
		19-Oct-06	595	1611*	350	Expired
			685	1613*	350	Expired
		20-Oct-06	738	1615*	350	Expired
			512	1617*	350	Expired
		17-Oct-07	671	7066*	350	Expired
			639	7068*	350	Expired
			623	7069*	350	Expired
			648	7070*	350	Expired
		20-Nov-07	614	7071	350	Expired
			561	7060*	350	Expired
			651	7063*	350	Expired
		21-Nov-07	728	7073*	350	Expired
		13-Mar-08	580	7048*	350	Expired
		27-Mar-08	610	7046	350	Expired
			630	7062	350	Expired
		31-Mar-09	742	53039	334	Expired
			566	53042	334	Expired
		28-Oct-09	616	53034	350	Expired

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
26	Hybrid Striped Bass	17-Nov-09	516	61540	131	Expired
			494	61537*	131	Expired
		27-Oct-10	496	38776	131	03/07/11
26	Paddlefish	19-Oct-06	1016	1565	220	Expired
			.	1606	220	Expired
			1295	1517*	220	Expired
		15-Mar-07	1075	1580	220	Expired
			1195	1581	220	Expired
			805	1582	220	Expired
			1089	1583	220	Expired
			997	1584	220	Expired
			1064	1585	220	Expired
			1129	1586*	220	Expired
		16-Mar-07	1131	1594	220	Expired
		22-Mar-07	996	1577	220	Expired
			854	1578	220	Expired
			910	1590	220	Expired
			929	1592*	220	Expired
		23-Mar-07	1093	1529	220	Expired
			782	1569	220	Expired
			1290	1587	220	Expired
			1075	1589*	220	Expired
			1037	1591*	220	Expired
		20-Nov-07	886	6967	220	Expired
			1085	7024	220	Expired
			920	6966*	220	Expired
			781	6969*	220	Expired
		21-Nov-07	695	7025	220	Expired
			974	7022*	220	Expired
			1184	7023*	220	Expired
		13-Mar-08	1060	7020	220	Expired
			922	1524*	220	Expired
			1115	7018*	220	Expired
		27-Mar-08	1055	1525*	220	Expired
			1045	1571*	220	Expired
			1055	1573*	220	Expired
			1015	7021*	220	Expired
		28-Mar-08	1139	7037	220	Expired
			950	7034*	220	Expired
			875	7035*	220	Expired
			1027	7036*	220	Expired
		31-Mar-09	845	53069	334	Expired
		3-Nov-10	1250	44952	1633	04/24/15
			1100	44953	1633	04/24/15
			1215	44954	1633	04/24/15
			920	44961	1633	04/24/15
			1082	44962	1633	04/24/15
			1370	44967	1633	04/24/15
26	Sauger	17-Nov-09	466	61536	131	Expired
		11-Nov-10	354	38814	131	03/22/11
26	Shovelnose Sturgeon	19-Oct-06	695	1664	360	Expired
			690	1670*	360	Expired
		23-Oct-06	666	1654	360	Expired
			630	1655	360	Expired
			623	1656	360	Expired

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
26	Shovelnose Sturgeon	23-Oct-06	610	1657	360	Expired
			624	1658	360	Expired
			704	1659	360	Expired
			650	1660	360	Expired
			593	1661	360	Expired
			628	1667	360	Expired
			677	1653*	360	Expired
		13-Mar-08	624	7090	360	Expired
			719	7085*	360	Expired
		28-Mar-08	625	7089	360	Expired
			578	7093*	360	Expired
		6-Nov-08	659	53149	591	Expired
			659	53153	591	Expired
			725	53154	591	Expired
			621	53143*	591	Expired
			694	53144*	591	Expired
			631	53147*	591	Expired
			603	53151*	591	Expired
		22-Oct-10	635	38701	591	06/04/12
			642	38704	591	06/04/12
			640	38706	591	06/04/12
			640	38707	591	06/04/12
			648	38709	591	06/04/12
			623	38710	591	06/04/12
			610	61569	591	06/04/12
			587	61572	591	06/04/12
			673	61575	591	06/04/12
		11-Nov-10	664	38703	591	06/24/12
26	Silver Carp	17-Oct-06	657	1555	220	Expired
			656	1556	220	Expired
			655	1558	220	Expired
			652	1562	220	Expired
			850	1557*	220	Expired
			660	1560*	220	Expired
		18-Oct-06	695	1563	220	Expired
			756	1564	220	Expired
			677	1559*	220	Expired
			649	1561*	220	Expired
			657	1566*	220	Expired
		19-Oct-06	665	1604	220	Expired
		16-Oct-07	729	6975	220	Expired
			729	6977	220	Expired
			704	7003	220	Expired
			674	7004	220	Expired
			730	7005	220	Expired
			720	7007	220	Expired
			691	6976*	220	Expired
			655	7002*	220	Expired
		17-Oct-07	754	6970	220	Expired
			679	6974	220	Expired
			687	6972*	220	Expired
			748	6973*	220	Expired
		29-May-08	790	12086	204	Expired
			735	12087	204	Expired
			690	12089	204	Expired
			680	12090	204	Expired

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
26	Silver Carp	29-May-08	686	12093	204	Expired
			715	12094	204	Expired
			671	12095	204	Expired
			655	12085*	204	Expired
			665	12088*	204	Expired
			746	12091*	204	Expired
			631	12092*	204	Expired
			672	13531*	204	Expired
		22-Oct-08	558	53127	334	Expired
		31-Oct-08	547	53076	334	Expired
			701	53079	334	Expired
			737	53081	334	Expired
			788	53073*	334	Expired
			604	53074*	334	Expired
			726	53075*	334	Expired
			661	53077*	334	Expired
			634	53078*	334	Expired
			730	53080*	334	Expired
			703	53083*	334	Expired
			725	53084*	334	Expired
		16-Oct-09	546	61633	334	Expired
			583	61634	334	Expired
			492	61636	334	Expired
			525	61637	334	Expired
			731	61635*	334	Expired
		25-Oct-10	916	47276	1133	12/01/13
			512	47277	1133	12/01/13
			823	47278	1133	12/01/13
			536	47279	1133	12/01/13
			632	47280	1133	12/01/13
			550	47281	1133	12/01/13
			541	47283	1133	12/01/13
			930	47285	1133	12/01/13
			545	47287	1133	12/01/13
			502	53047	334	09/24/11
26	Walleye	11-Nov-10	469	38913	131	03/22/11
26	White Bass	17-Oct-06	398	1702*	140	Expired
		18-Oct-06	303	1737	140	Expired
			331	1742*	140	Expired
		19-Oct-06	384	1707	140	Expired
			374	1712*	140	Expired
			392	1732*	140	Expired
		20-Oct-06	350	1717	140	Expired
			359	1714*	140	Expired
		24-Oct-06	408	1731*	140	Expired
			390	1736*	140	Expired
		22-Oct-08	293	1729*	140	Expired
		16-Oct-09	411	61543	131	Expired
		28-Oct-09	279	61555	131	Expired
		17-Nov-09	263	61542	131	Expired
			274	61541*	131	Expired
		22-Oct-10	306	38770	131	03/02/11
			306	38771	131	03/02/11
			295	38775	131	03/02/11
		28-Oct-10	331	38777	131	03/08/11

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
26	White Bass	11-Nov-10	304	38819	131	03/22/11
			287	38824	131	03/22/11
			310	38912	131	03/22/11
27	Blue Catfish	26-Oct-06	511	1620*	350	Expired
			633	1621*	350	Expired
			490	1622*	350	Expired
			508	1649*	350	Expired
		27-Oct-06	918	1623*	350	Expired
			550	1625*	350	Expired
		31-Oct-06	659	1627	350	Expired
			544	1644	350	Expired
			541	1646	350	Expired
			787	1629*	350	Expired
			611	1631*	350	Expired
			512	1647*	350	Expired
			522	1648*	350	Expired
			610	1651*	350	Expired
		1-Nov-06	567	1624*	350	Expired
			573	1645*	350	Expired
			537	1650*	350	Expired
			562	1652*	350	Expired
		2-Nov-06	557	1626	350	Expired
			632	1638	350	Expired
			622	1628*	350	Expired
			600	1630*	350	Expired
			686	1640*	350	Expired
		3-Nov-06	654	1637	350	Expired
			610	1639*	350	Expired
			583	1641*	350	Expired
			674	1643*	350	Expired
		19-Mar-07	612	1632	350	Expired
			667	1636	350	Expired
			611	1642	350	Expired
			576	1633*	350	Expired
			575	1635*	350	Expired
		24-Sep-07	657	7057	350	Expired
		25-Sep-07	646	7052	350	Expired
			611	7054	350	Expired
			644	7056	350	Expired
			806	7055*	350	Expired
		26-Sep-07	620	7051	350	Expired
			696	7050*	350	Expired
			582	7053*	350	Expired
		27-Sep-07	710	7047*	350	Expired
		28-Sep-07	621	7075	350	Expired
			606	7074*	350	Expired
		15-Oct-07	573	7061	350	Expired
		16-Oct-07	682	7058	350	Expired
			595	7059*	350	Expired
		8-Apr-08	792	7049	350	Expired
			925	12117	350	Expired
			634	12119*	350	Expired
			744	12120*	350	Expired
		9-Apr-08	730	7067	350	Expired
		8-Oct-08	744	7072	350	Expired
			642	12121*	335	Expired

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
27	Blue Catfish	8-Oct-08	632	12126*	335	Expired
			775	12134*	335	Expired
		3-Nov-08	611	12135*	334	Expired
		12-Oct-09	814	7064	350	Expired
			692	12116	350	Expired
			912	53026	350	Expired
			1025	53035	334	Expired
		13-Oct-09	664	53033	350	Expired
			553	53037	350	Expired
			773	53040	350	Expired
		15-Oct-09	996	53027*	350	Expired
			658	53030*	350	Expired
		12-Nov-09	680	53029*	350	Expired
		11-Oct-10	930	47321	1133	11/17/13
			695	47323	1133	11/17/13
		12-Oct-10	736	47170	1470	10/21/14
		13-Oct-10	697	47171	1470	10/22/14
			692	47172	1470	10/22/14
			723	47174	1470	10/22/14
			702	47176	1470	10/22/14
		14-Oct-10	835	47178	1470	10/23/14
			805	47180	1470	10/23/14
		15-Oct-10	891	47177	1470	10/24/14
			751	47179	1470	10/24/14
			873	47181	1470	10/24/14
			767	47175*	1470	10/24/14
		23-Nov-10	632	53032	350	11/08/11
			533	53043	350	11/08/11
27	American Eel	11-Oct-10	481	38899	131	02/19/11
27	Hybrid Striped Bass	12-Nov-09	453	61550	131	Expired
			452	61552	131	Expired
			594	61553	131	Expired
		13-Nov-09	503	61548	131	Expired
		19-Nov-09	599	61519	131	Expired
		8-Oct-10	483	38896*	131	02/16/11
		11-Oct-10	525	38788	131	02/19/11
			530	38821	131	02/19/11
		14-Oct-10	513	38905*	131	02/22/11
27	Lake Sturgeon	23-Nov-10	1170	47284	1133	12/30/13
27	Paddlefish	19-Mar-07	1157	1575*	220	Expired
		25-Sep-07	1165	7045	220	Expired
		15-Oct-07	920	7008*	220	Expired
		16-Oct-07	932	7006	220	Expired
		7-Oct-08	888	12071*	204	Expired
		8-Oct-08	1069	12064	204	Expired
			816	12072	204	Expired
			810	12073	204	Expired
		9-Oct-08	1060	12063	204	Expired
			866	12065	204	Expired
			1128	12066	204	Expired
		4-Nov-08	958	53050	334	Expired
27	Paddlefish	14-Oct-09	713	61629*	334	Expired
		15-Oct-09	1134	61651*	334	Expired
27	Sauger	13-Nov-09	450	61538	131	Expired
			469	61539*	131	Expired
		19-Nov-09	433	61518	131	Expired
		8-Oct-10	392	38810	131	02/16/11
			373	38897	131	02/16/11

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
27	Sauger	11-Oct-10	384	61516	131	02/19/11
			374	38789*	131	02/19/11
			452	38904*	131	02/19/11
		12-Oct-10	393	38811	131	02/20/11
			426	38816	131	02/20/11
			463	38786*	131	02/20/11
27	Shovelnose Sturgeon	26-Oct-06	629	1662	360	Expired
			655	1663	360	Expired
			614	1666	360	Expired
			642	1686	360	Expired
		27-Oct-06	646	1665	360	Expired
			625	1668	360	Expired
			669	1669	360	Expired
			659	1689	360	Expired
			672	1690	360	Expired
			629	1692	360	Expired
			624	1693	360	Expired
			604	1695	360	Expired
			606	1696*	360	Expired
		31-Oct-06	643	1671	360	Expired
			610	1672	360	Expired
			629	1673	360	Expired
			635	1674	360	Expired
			658	1675	360	Expired
			653	1677	360	Expired
			656	1678	360	Expired
			670	1680	360	Expired
			627	1681	360	Expired
			578	1683	360	Expired
			619	1687	360	Expired
			622	1691	360	Expired
			742	1694	360	Expired
			675	1697	360	Expired
			681	1684*	360	Expired
		1-Nov-06	716	1676	360	Expired
			610	1679	360	Expired
			608	1682	360	Expired
			679	1685	360	Expired
			575	1688	360	Expired
		25-Sep-07	586	7112	360	Expired
			666	7113	360	Expired
			614	7114*	360	Expired
			631	7115*	360	Expired
		26-Sep-07	611	7076	360	Expired
			688	7077	360	Expired
			680	7095	360	Expired
			610	7116	360	Expired
		27-Sep-07	688	7078	360	Expired
			590	7079	360	Expired
			619	7080	360	Expired
			695	7081	360	Expired
			603	7082	360	Expired
			611	7083	360	Expired
			612	7094	360	Expired
			671	7096	360	Expired
			633	7118	360	Expired
			629	7119	360	Expired
			645	7120	360	Expired
			622	7117*	360	Expired

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
27	Shovelnose Sturgeon	28-Sep-07	615	7084	360	Expired
			588	7087	360	Expired
		8-Apr-08	534	12167	360	Expired
			570	12169	360	Expired
			599	12171	360	Expired
			613	17331	360	Expired
			677	12168*	360	Expired
			623	12170*	360	Expired
		7-Oct-08	573	12177*	353	Expired
			639	12181*	353	Expired
		8-Oct-08	592	12137	353	Expired
			600	12139	353	Expired
			575	12141	353	Expired
			646	12142	353	Expired
			679	12145	353	Expired
			592	12146	353	Expired
			644	12147	353	Expired
			638	12148	353	Expired
			600	12149	353	Expired
			700	12150	353	Expired
			628	12153	353	Expired
			660	12161	353	Expired
			561	12180	353	Expired
			545	12138*	353	Expired
			645	12140*	353	Expired
			578	12143*	353	Expired
			595	12144*	353	Expired
			565	12151*	353	Expired
			725	12152*	353	Expired
			592	12179*	353	Expired
			656	12182*	353	Expired
		12-Oct-09	715	61581	591	05/26/11
			714	61584	591	05/26/11
			586	61587	591	05/26/11
		13-Oct-09	666	61579	591	05/27/11
			617	61580	591	05/27/11
			636	61582	591	05/27/11
			640	61583	591	05/27/11
			594	61585	591	05/27/11
			705	61586	591	05/27/11
			631	61589	591	05/27/11
			669	61591	591	05/27/11
			626	61592	591	05/27/11
			647	61593	591	05/27/11
			598	61594	591	05/27/11
			635	61595	591	05/27/11
			659	61596	591	05/27/11
			593	61588*	591	05/27/11
			645	61590*	591	05/27/11
		12-Oct-10	671	38750	591	05/25/12
			667	38751	591	05/25/12
			662	38753	591	05/25/12
			554	38754	591	05/25/12
		13-Oct-10	613	38747	591	05/26/12
			648	38748	591	05/26/12
			635	38749	591	05/26/12
			665	38752*	591	05/26/12
		14-Oct-10	610	38713	591	05/27/12
			620	38716	591	05/27/12
		15-Oct-10	631	38695	591	05/28/12

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
27	Shovelnose Sturgeon	15-Oct-10	618	38698	591	05/28/12
			624	38711	591	05/28/12
			610	38712	591	05/28/12
			593	38714	591	05/28/12
			618	38715	591	05/28/12
			615	38717	591	05/28/12
			630	38718	591	05/28/12
			663	38719	591	05/28/12
			615	38720	591	05/28/12
			662	38721	591	05/28/12
			625	38722	591	05/28/12
			580	38723	591	05/28/12
			624	38724	591	05/28/12
			625	38725	591	05/28/12
			610	38726	591	05/28/12
			602	38727	591	05/28/12
			638	38728	591	05/28/12
		23-Nov-10	684	38693	591	07/06/12
			660	38694	591	07/06/12
27	Silver Carp	25-Oct-06	576	1526	220	Expired
			568	1528	220	Expired
			844	1530	220	Expired
		26-Oct-06	698	1568	220	Expired
			679	1603	220	Expired
			710	1567*	220	Expired
			656	1570*	220	Expired
			573	1572*	220	Expired
			568	1574*	220	Expired
			543	1605*	220	Expired
			526	1607*	220	Expired
		27-Oct-06	595	1540	220	Expired
			550	1541	220	Expired
			554	1599	220	Expired
			568	1602	220	Expired
			590	1539*	220	Expired
			567	1600*	220	Expired
			575	1601*	220	Expired
		30-Oct-06	672	1535	220	Expired
			554	1531*	220	Expired
			563	1533*	220	Expired
			599	1537*	220	Expired
			668	1542*	220	Expired
		31-Oct-06	565	1532	220	Expired
			600	1593	220	Expired
			566	1595	220	Expired
			583	1596	220	Expired
			577	1597	220	Expired
			591	1598	220	Expired
			597	1534*	220	Expired
			564	1536*	220	Expired
			585	1538*	220	Expired
		2-Nov-06	583	1579	220	Expired
		24-Sep-07	665	1545	220	Expired
		25-Sep-07	688	1550	220	Expired
			566	1552	220	Expired
			614	7038	220	Expired
			715	7039	220	Expired
			659	7040	220	Expired
			620	7041	220	Expired
			630	7042	220	Expired

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
27	Silver Carp	25-Sep-07	722	7043	220	Expired
			616	7044	220	Expired
		26-Sep-07	600	6988	220	Expired
			561	6989	220	Expired
			661	6995	220	Expired
			710	6997	220	Expired
			659	6998	220	Expired
			610	7001	220	Expired
		10-Oct-07	601	6978	220	Expired
			625	6980	220	Expired
			760	6981	220	Expired
			615	6982	220	Expired
			620	6983	220	Expired
			660	6985	220	Expired
			600	6986	220	Expired
			650	6987	220	Expired
			620	6999	220	Expired
			594	7000	220	Expired
			815	6979*	220	Expired
			675	6984*	220	Expired
		15-Oct-07	595	7009	220	Expired
			643	7010	220	Expired
			589	7011	220	Expired
			719	7012	220	Expired
			601	7013	220	Expired
			725	12101	204	Expired
			580	12103	204	Expired
			649	12111	204	Expired
			715	12112	204	Expired
			758	12115	204	Expired
		21-May-08	610	12100*	204	Expired
			811	12102*	204	Expired
			738	12104*	204	Expired
			691	12113*	204	Expired
			732	12114*	204	Expired
		22-May-08	692	12099	204	Expired
			712	12110*	204	Expired
		28-May-08	648	7027	220	Expired
			655	7028	220	Expired
			685	7030	220	Expired
			607	7031	220	Expired
			629	12096	204	Expired
			691	12097	204	Expired
			685	12098	204	Expired
			772	12105*	204	Expired
			651	12106*	204	Expired
			701	12107*	204	Expired
			760	13521*	204	Expired
			644	13525*	204	Expired
			691	13527*	204	Expired
			682	7026*	220	Expired
			625	7029*	220	Expired
			736	7033*	220	Expired
		8-Oct-08	810	12070	204	Expired
			687	12074	204	Expired
			762	12069*	204	Expired
		9-Oct-08	895	53100	334	Expired
			590	53102	334	Expired
		10-Oct-08	794	53107	334	Expired
			673	53119	334	Expired

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
27	Silver Carp	3-Nov-08	744	53088	334	Expired
			801	53091	334	Expired
			672	53092	334	Expired
			797	53110	334	Expired
			765	53086*	334	Expired
			685	53087*	334	Expired
			768	53089*	334	Expired
			776	53090*	334	Expired
			846	53093*	334	Expired
			746	53094*	334	Expired
			626	53096*	334	Expired
			641	53120*	334	Expired
		4-Nov-08	694	53049	334	Expired
			651	53054	334	Expired
			704	53051*	334	Expired
			821	53056*	334	Expired
		5-Nov-08	779	53052	334	Expired
			765	53058*	334	Expired
		12-Oct-09	675	61631	334	Expired
			733	61632	334	Expired
			746	61622*	334	Expired
		14-Oct-09	745	53053	334	Expired
			754	53055	334	Expired
			739	53057	334	Expired
			804	61624	334	Expired
			751	61627	334	Expired
			847	61630	334	Expired
			742	53059*	334	Expired
			676	61621*	334	Expired
			646	61623*	334	Expired
			623	61625*	334	Expired
			735	61626*	334	Expired
			771	61628*	334	Expired
		8-Oct-10	573	47251	1133	11/14/13
			635	47254	1133	11/14/13
			875	47255	1133	11/14/13
			736	47256	1133	11/14/13
			795	47257	1133	11/14/13
			645	47258	1133	11/14/13
			661	47260	1133	11/14/13
			863	47262	1133	11/14/13
			587	47298	1133	11/14/13
			903	47299	1133	11/14/13
			602	47300	1133	11/14/13
			696	47301	1133	11/14/13
			688	47302	1133	11/14/13
			675	47303	1133	11/14/13
			682	47304	1133	11/14/13
			674	47306	1133	11/14/13
			584	47307	1133	11/14/13
			750	47308	1133	11/14/13
			772	47309	1133	11/14/13
			714	47310	1133	11/14/13
			743	47311	1133	11/14/13
			794	47252*	1133	11/14/13
			793	47305*	1133	11/14/13
		11-Oct-10	656	47240	1133	11/17/13
			720	47313	1133	11/17/13
			826	47314	1133	11/17/13
			910	47315	1133	11/17/13

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
27	Silver Carp	11-Oct-10	652	47317	1133	11/17/13
			772	47318	1133	11/17/13
			656	47319	1133	11/17/13
27	Walleye	19-Nov-09	523	61513	131	Expired
			478	61514*	131	Expired
			356	61515*	131	Expired
		11-Oct-10	464	38787	131	02/19/11
			463	38908	131	02/19/11
		14-Oct-10	564	38807	131	02/22/11
			402	38817	131	02/22/11
27	White Bass	26-Oct-06	332	1723	140	Expired
		27-Oct-06	367	1721	140	Expired
			381	1722	140	Expired
		2-Nov-06	325	1727	140	Expired
		8-Apr-08	314	150	140	Expired
			359	152	140	Expired
			368	153	140	Expired
			354	7124	140	Expired
			343	7125	140	Expired
			365	7128	140	Expired
			374	7129	140	Expired
			368	7131	140	Expired
			371	7133	140	Expired
			366	7134	140	Expired
			350	7135	140	Expired
			370	7137	140	Expired
			353	7139	140	Expired
			375	12172*	140	Expired
		9-Apr-08	346	144	140	Expired
			328	7122	140	Expired
			334	7127	140	Expired
		9-Oct-08	396	145	140	Expired
			311	146	140	Expired
			373	1734	140	Expired
			277	1735	140	Expired
			264	7121	140	Expired
		10-Oct-08	294	1701	140	Expired
			345	1716	140	Expired
			285	1738	140	Expired
			307	1739	140	Expired
			330	1740	140	Expired
			299	1741	140	Expired
			386	1718*	140	Expired
		3-Nov-08	339	7123	140	Expired
			356	53142*	131	Expired
		4-Nov-08	318	53141	131	Expired
		12-Oct-09	324	53137	131	Expired
			312	61547	131	Expired
			452	61546*	131	Expired
		15-Oct-09	426	61545	131	Expired
		12-Nov-09	289	61551	131	Expired
			335	61554	131	Expired
		13-Nov-09	260	61544	131	Expired
			337	61549	131	Expired
		19-Nov-09	326	61520	131	Expired
			288	61521	131	Expired
		8-Oct-10	325	38805	131	02/16/11
			326	38815	131	02/16/11
			321	38820	131	02/16/11
			328	38895	131	02/16/11
		11-Oct-10	315	38898	131	02/19/11

Appendix 1 (cont). Individual fish sampled, surgically tagged, and released in Pools 22, 24, 26 and the open river below Lock and Dam 26 Mississippi River.

Release Location	Species	Release Date	Length (mm)	Tag ID	Tag Life	Tag Expiration Date
27	White Bass	12-Oct-10	338	38785	131	02/20/11
		13-Oct-10	401	38806	131	02/21/11
			321	38900	131	02/21/11
			397	38909	131	02/21/11
			398	38903*	131	02/21/11
		14-Oct-10	316	38812	131	02/22/11
			322	38822	131	02/22/11
			311	38910	131	02/22/11

* Moved through a structure

Appendix II. Sampling effort (hr) for each individual pool by gear type for each year.

Gear	Pool 22	Pool 24	Pool 26	Pool 27	Total effort
		2006			
2" Gill Net	15	31	213	409	667
2" Gill Net Drifting	<1	<1	2	<1	3
3" Gill Net	15	3	80	221	320
3" Gill Net Drifting		<1			<1
Trammel Net	50	25	56	42	173
Trammel Net Drifting			<1		<1
Total	80	60	352	672	1,163
		2007			
2" Gill Net	6	321	109	168	604
2" Gill Net Drifting	<1				<1
3" Gill Net	6	400	196	676	1,278
3" Gill Net Drifting		<1			<1
4" Gill Net	3	210	83	68	363
Trammel Net		43		58	101
Total	15	974	387	970	2,346
		2008			
2" Gill Net	9	160	117	250	535
2" Gill Net Drifting	1		<1	<1	2
3" Gill Net	30	271	216	183	699
3" Gill Net Drifting			<1		<1
4" Gill Net	47	191	163	200	600
4" Gill Net Drifting	<1			<1	1
Trammel Net	16	46	19	37	117
Triple-Float Line Trammel				27	27
Electrofishing	2	3		2	7
Total	105	671	516	698	1,989
		2009			
2" Gill Net	4	86	99	65	254
2" Gill Net Drifting	<1		<1		<1
3" Gill Net	259	295	128	148	830
3" Gill Net Drifting	<1		<1		1
4" Gill Net	93	173	119	153	538
Trammel Net	6	38		33	77
Electrofishing	3	5	6	9	23
Trot Line			117	203	320
Total	365	597	470	611	2,043
		2010			
2" Gill Net	24	16		16	56
3" Gill Net		21	8	128	157
4" Gill Net	13	21	72	225	331
Trammel Net			69		69
Electrofishing	4	10	2	7	23
Trot Line				204	204
Total	41	68	152	579	840
			Grand Total		8,382