Migratory Characteristics and Passage Efficiency of Fishes at Two Dams on the Alabama River, Alabama

by

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Abstract

Fish passage facilities are a widely accepted mitigation tool at many dams in the United States to assist migratory fish species to upstream spawning areas on the U.S. Atlantic and Pacific coasts. Here we investigated the potential to move fish through two locks on the Alabama River-- Millers Ferry Lock and Dam and Claiborne Lock and Dam-- using specialized lock operations. We used manual tracking combined with submersible ultrasonic receivers (SUR) deployed both above and below each dam, as well as inside the navigational lock chamber to determine whether fish passage occurred. We recorded over 359,000 detections of 157 individuals with the SURs and 144 manual detections of 67 individuals. Most fish movement past dams occurred during the spring, when many riverine fish make spawning migrations. Our results suggest that specialized lock operations along the Alabama River increase opportunities for upstream fish passage although relatively few fish moved through the lock chambers.

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SUR	Submersible ultrasonic receiver
ARk	Alabama River kilometer
GPS	Global positioning system
USACE	United States Army Corps of Engineers
EFL	Eye to fork length
GIS	Geographic Information System

Introduction

Dams have been constructed across the United States for recreation, flood control, irrigation, hydroelectric generation, and navigation. As of 1995, only 42 free-flowing rivers ($\geq$ 200 km in length) remained of the original 5,200,000 km of river in the lower 48 states (Lydeard and Mayden 1995). According to the United States Army Corps of Engineers (USACE) National Inventory of Dams (2000), there are approximately 76,500 large dams in the United States. These in-river structures have the potential to adversely affect fish movement (Zigler et al. 2003; Firehammer and Scarnnechia 2006; Mettee et al. 2006, 2009) and can contribute to the decline of species that depend on migration for spawning (Larinier 2001), some of which are of ecological and economic importance. Alabama has approximately 124,000 km of rivers and streams (Bayne 1998) and more navigable channels (2,313 km) than any other state (Mettee et al. 1996). Due to the abundance of water and a wide range of physio-graphy, Alabama has one of the most diverse aquatic faunas in the United States, but also one of the highest numbers of imperiled fishes in the nation (Warren and Burr 1994; Lydeard and Mayden 1995). In a study of 51 southeastern US drainages over 20 years, Warren et al. (2000) attributed a 125% increase in the number of jeopardized species to dam construction and associated habitat modifications (e.g., flow alteration, impoundments, channelization, sedimentation). Extensive damming has led to the imperilment of 10% (31 species) of Alabama fishes (Bayne 1998).

Fish passage facilities are a widely accepted mitigation tool at many dams in the United States to restore connectivity to river reaches. Trapping and hauling, fish ladders, slotted fishways, and fish bypasses are all extensively used to assist migratory fish species in continuing upstream migrations to spawning grounds in rivers on the US Atlantic and Pacific coasts (Cada 1998). However, relatively few of these structures have been constructed in the southeastern United States (U.S. Office of Technology Assessment 1995). Specialized fish passage facilities would require extensive funding for planning, construction, and operation, to the extent that the existing navigation locks represent the most cost effective alternative for providing fish passage (Clay 1995). Recent studies in the Upper Mississippi River (Trip and Garvey 2009) and on the Chattahoochee River on the Alabama-Georgia border (Georgia Department of Natural Resources, Wildlife Resources Division 2008) suggest that lock operations have the potential to connect navigation pools and restore upriver fish spawning migrations. The Geological Survey of Alabama first suggested that navigation locks could be used as a means of fish passage on the Alabama River by observing the movement of a single sonic tagged paddlefish released below Millers Ferry dam, as it moved upstream into Bill Dannelly Reservoir when a United States Army Corps of Engineers snag boat was repeatedly locking upstream removing debris from above the dam (Mettee et al. 2006). Fishes have also been collected inside the lock chambers at Claiborne Lock and Dam and Millers Ferry Lock and Dam; however the ability to actually pass fish has never been assessed (Mettee et al. 2006, 2009).

Paddlefish, *Polyodon spathula*, still occur over much of their native range in the United States, although some populations have been extirpated or are in decline (Graham 1997; Betolli et al. 2009). In Alabama, paddlefish is a species of conservation concern. In 1988, a moratorium was implemented by the Alabama Department of Conservation and Natural Resources on the harvest and possession of paddlefish in the state because of overexploitation and complaints of reduced catch by commercial fisherman (Wood 1989). The Tennessee River in northern

Alabama and the Tombigbee and Alabama Rivers of the mobile drainage has historically supported healthy paddlefish populations. However, paddlefish populations in Alabama are now largely restricted to the main channels of the coastal rivers below the fall line (Mettee et al. 1996).

Paddlefish are highly mobile, making extensive movements within a river system using a variety of habitat types both seasonally and annually. In an unchannelized system along the Missouri River, paddlefish were recorded moving long distances both upstream and downstream, including a paddlefish that was recorded moving over 2000 km downstream (Rosen et al. 1982). Hoxmeier and DeVries (1997) suggest that movement is important because they observed both adult and juvenile paddlefish all using oxbow, backwater and channel habitats along the Alabama River, however timing of habitat use differed. Paddlefish have also demonstrated spawning site fidelity within and across years, as well as annual spawning migrations of both male and females (Lein and DeVries 1998). It has also been suggested that juvenile fish may accompany adults during these annual spawning migrations (Hoxmeier and DeVries 1997). It is not clear how far paddlefish historically moved through Alabama's river corridors, nor the extent of the impact that in-river structures have on the current status of the species; however, migrations are an important characteristic (Jennings and Zigler 2000) contributing to the overall success of the species (Unkenholz 1986).

Paddlefish are not the only species whose movement might be affected by dams. The Geological Survey of Alabama has also shown that quillback *Carpiodes cyprinus*, highfin carpsucker *Carpiodes velifer*, southeastern blue sucker *Cycleptus meridionalis*, and smallmouth buffalo *Ictiobus bubalus* all have the ability to make long distance movements (Mettee et al. 2006), suggesting that fish passage operations could positively influence a number of species.

Several of these species have been negatively affected by extensive daming throughout their range (Hoagstraum et al. 2006, Grabowski and Isley 2007).

Since the implementation of fish locking operations at the two dams on the Alabama River in 2009, passage efficiency has not been quantified. In this study, I examined the migration characteristics of Alabama River fishes, particularly paddlefish, and passage efficiency of the current USACE navigational lock fish passage procedures at Millers Ferry and Claiborne locks and dams.

Study Sites

The Alabama River forms at the confluence of the Coosa and Tallapoosa rivers, from which it flows 507 km and drains approximately 58,500 sq. km of eastern Alabama, northwestern Georgia, and a portion of southeastern Tennessee. The Alabama River is met by the Tombigbee River in southwestern Alabama to form the Mobile River before flowing into the Mobile-Tensaw Delta and eventually into Mobile Bay.

The USACE currently operates three navigation lock and dams along the Alabama River. The two lower most of these, Millers Ferry and Claiborne Locks and Dams, are the sites around which the research is focused (Figure 1). These dams and adjoining locks were constructed in the late 1960s to maintain channel depths for commercial navigation. Millers Ferry Lock and Dam, located at Alabama River km 214, is a hydro-electric dam characterized by seventeen flood gates and an operating lock chamber. Lock operators were on-site 16 hours a day, 7 days a week at the start of the study. In 2011, lock operators were on site only 10 hours a day. Claiborne Lock and Dam is at Alabama River km 117, and is the lowermost dam on the Alabama River, characterized by six flood gates, a crested spillway, and an operating lock chamber. Claiborne lock operators are on-site 24 hr per day, 7 days per week.

Methods

Fish Collection and Tagging

Fish were collected in the vicinity of both Millers Ferry and Claiborne locks and dams using boat mounted pulsed-DC electrofishing gear (Smith-Root Inc. DC Electro-fisher 7.5 GPP) (Lein and DeVries 1997) and floating large-mesh gill nets in tailrace areas and inside the lock chambers in both 2010 (Mar.-Apr.) and 2011 (Oct.-May). My primary target species was paddlefish; however I captured multiple migratory species that may move upstream during spawning migrations. I measured (nearest mm total length, TL plus eye-fork length, EFL, for paddlefish) and weighed (wet weight, nearest kg) fish captured.

Fishes were tagged with an individually numbered laminated internal anchor tag (FM-95W), inserted through a small incision made in the right abdominal wall. A subset of the fishes collected was tagged in the ventral cavity (3-4 cm long incision) with a tag (Sonotronics CT-05-48-I, CT-05-26-I, IBT-96-9-I, PT-4) that emits a unique sonic/acoustic signal. To allow for tracking at greater distances, a subset of fish was also tagged with a coded radio tag (Advanced Telemetry Systems F1850). Total weight of transmitters did not exceed 3% of fish weight in water (Summerfelt and Smith 1990). All surgeries were done using standard tagging protocol as described by Summerfelt and Smith (1990) and incisions were closed with a series of 3-4 simple interrupted sutures. All incisions were reinforced with a cyanoacrylate ester to bond tissue in combination with the sutures. The surgical area, non-absorbable nylon thread, surgical equipment, and each tag were treated with a betadine solution. Fish were allowed to recover in a holding tank and regain full ability to swim, before being released in the approximate area of capture.

Tracking

Movement of fish was documented by recapturing fish with external tags in subsequent sampling efforts, as well as by tracking the signals of sonic and radio tagged fishes using hydrophones, radio-telemetry, and fixed submersible ultrasonic receivers (Sonotronics SUR-3). In 2010, SURs were placed both above and below Claiborne Lock and Dam and Miller's Ferry Lock and Dam, as well as further upstream in the Cahaba River. Because fish at Claiborne Lock and Dam may swim freely over the crested spillway during high flows (i.e., when flows reach a gage height of approximately 10 m), I deployed an additional SUR inside the Claiborne lock chamber to ensure whether fish moved through the lock. Millers Ferry Dam does not regularly become inundated during high flows, so no SUR was placed inside the lock chamber during the 2010 sampling season. Each stationary receiver was attached to a permanently fixed object by a length of cable with a weight attached to the bottom to prevent the receiver from being swept downstream during high flows. Stationary receivers were set to a 1 sec channel delay (e.g., SUR listens for approximately 2 sec on a particular frequency, then powers down for 1 sec) and 1 sec scan delay (e.g. SUR powers down for 1 sec after all frequencies are monitored). Due to this algorithm, the total time for an SUR to check the entire frequency map is:

(15 channels x 2 sec/channel) + (1 sec channel delay x 15 channels) + 1 sec scan delay = 46 sec. to complete sequence.

Receivers were operated continuously and automatically logged any detection event. The tag's unique interval-tolerance combination, date, and time were recorded and stored as raw data for each signal detected by the receiver.

In 2011, I increased my sampling area by deploying 8 additional SURs (Figure 2). SURs were deployed inside Millers Ferry lock chamber, at the Alabama River cutoff, in the Tombigbee River, and in the Mobile River. Passage was documented when a fish was detected on one side of the dam, then subsequently detected in the lock chamber and then on the opposite side of the dam.

Tracking trips were conducted weekly throughout the study area of the Alabama and Cahaba rivers. SURs were checked for maintenance and data were downloaded directly to a handheld Archer field PC or laptop computer once per week as water levels permitted. The SUR raw data files were processed in Sonotronics SURsoft Data Processing Center at an interval tolerance of 5 millisec, which allowed me to detect tags that otherwise may have been missed due to interference (i.e., acoustic disturbances). In order to remove any spurious data, all biologically impossible detections were removed (e.g., fish released below Claiborne dam, then subsequently detected above Millers Ferry dam but not on any SURs between the two) and any singular detection on a single SUR within a 24 hr period was also removed (March et al. 2010).

Manual listening stations were spaced approximately 300-500 m apart. At each station the outboard motor was turned off, and the hydrophone was lowered into the water and rotated 360° in an effort to detect any tags within listening distance. When a fish was detected, the position was then geo-referenced using a handheld global positioning system (GPS) once the tag was equally audible in all directions. Radio tagged fish were tracked in summer 2010, over approximately 310 river km of the Alabama, Tombigbee, Mobile, and Tensaw rivers from a fixed-wing aircraft fitted with a wing-mounted directional yagi antennae.

Detection Probability

Detection probabilities were calculated for the 4 SURs located in the vicinity of each lock and dam (i.e. directly above and below Claiborne and Millers Ferry) in both 2010 and 2011 using methods similar to those used by Smith (2009). Probabilities were calculated for a given receiver with a downstream and upstream detection on either side, by dividing the number of fish detected on the receiver by the total number of fish that moved past the receiver determined by manual tracking or SUR detection.

Retention Time and Passage Attempts

Time spent inside the lock was calculated for all fishes that were detected on the SURs located inside either Claiborne or Millers Ferry lock chambers. Fish were determined to be in the vicinity of the lock when sequential detections were made. If a time period of 10 min or greater was between sequential detections, the fish was determined to have left the vicinity of the lock and a new attempt was calculated if detected again. Each time a fish entered the lock was recorded as an attempt at fish passage.

Fish Passage Operations

The fish passage plan (i.e., use of locks to pass fish both upstream and downstream) at the Millers Ferry and Claiborne locks and dams began in 2009 and ran from 1 February through 31 May. Operations at Claiborne Lock and Dam were on a 6 hr rotation beginning at 4 AM (upper lock gates left open) and ending at 10 PM (lower lock gates left open) daily. Millers Ferry operations ran on 4 hr rotation beginning at 6 AM (lower lock gates left open) and ending at 10 PM (upper lock gates left open) in 2010. Due to changes in personnel hours on-site, lock operations at Millers Ferry in 2011 were modified. The upper lock gates were opened at 10 AM and left open for 5 hr. At 3 PM the lower lock gates were opened for 19 hr (Table 1). Lock operators determined the operational and safety constraints daily to determine the exact timing and whether lockages could be accomplished. Lockages were generally stopped once the gage height below the dam reached 6.1 m. Passage occurred during normal lock operation hours at the discretion of the lock operator, when it did not interfere with normal operations.

Movement Analysis

Location coordinates were plotted using Geographic Information System (GIS) onto water-coverage map in ARC-Map (ESRI 2008). Distance moved was calculated as the shortest distance over water between detections. Differences in minimum upstream and downstream movement between tag sites were compared with a T-test. Linear regression was used to test the relationship between EFL and the minimum upstream and downstream distances moved throughout the course of the study as determined by either manual tracking or fixed station SUR for paddlefish tagged in 2011 only because my sample area in 2010 did not encompass many of the long distance movements made. All statistical data were analyzed using Statistical Analysis System (SAS Institute Inc., Cary, North Carolina, USA). Significance was judged at α-level of 0.05.

Fish Passage Analysis

A t-test was used to indicate whether fish that successfully passed through the lock spent more time inside the lock than did fish that did not pass. A t-test was also used to compare the number of times fish entered the lock for those that successfully passed upstream through the navigation lock versus those that did not pass. Separate analyses were conducted at each dam. Logistic regression was then used to test the probability that fish were successful in passing upstream of both Millers Ferry and Claiborne locks and dams either through the navigational lock chambers or over the dam during high flows at Claiborne. This analysis included only those fish that were found below Claiborne Dam during the spring spawning migration. Logistic regression was used to compare the probability that a paddlefish tagged below Claiborne Lock and Dam would move upstream through the lock chamber versus a paddlefish moving over the spillway during high flows for each sampling year. Logistic regression was then used to test whether the probability of fish that successfully locked upstream during fish passage lock operations differed from fish passing upstream under normal lock operations (i.e., when a boat is moving through the lock). Specialized locking procedures to allow fish to pass through locks only occur during the spring, yet regular locking procedures (e.g., barge and recreational use) still occurs during this time period and continue throughout the year. Therefore, I only tested whether the probability of successful passage through locks increased during specialized locking procedures compared to normal operations during the spring. Only fish that successfully passed through a lock were used in this analysis and were assigned as either passing through during specialized lock procedures or during regular lock procedures. These categories were discriminated based on the time of last detection inside the lock and the subsequent detection on the opposite side of the dam. All data were analyzed using the Statistical Analysis System (SAS Institute Inc., Cary, North Carolina, USA). Statistical significance for all analyses was based on an alpha value of 0.05.

Results

Recaptures and Detections

Of the 254 fishes that I anchor tagged during the study (Table 2), 10 were recaptured. During 2010 two fish that had been tagged at Claiborne and two fish that had been tagged at Millers Ferry were recaptured on the Alabama River in the vicinity of each dam. The longest period between capture and recapture for an individual tagged at Claiborne was an Alabama bass caught by an angler 416 days after release, with the individual moving from river km 116.5, upstream past Claiborne dam to Alabama River km (ARk) 212. The longest period between capture and recapture for fish that had been anchor tagged at Millers Ferry in 2010 was a largemouth bass caught 54 days later, with the individual moving above Millers Ferry dam, 2.6 river km from location of release (Table 3). During 2011, 5 fish tagged at Claiborne were recaptured, with the longest period between capture being for an Alabama bass, 237 days after release, moving 0.43 km. Additionally, a striped mullet moved 101.35 km downstream of Claiborne Dam to the Alabama River cutoff in 130 days. Only 1 fish tagged at Millers Ferry in 2011 was recaptured. A blue catfish was caught 31 days after release at the same location (river km 213) (Table 4). Individual characteristics, tagging dates, and locations are included in Appendix I.

Of the 175 individuals sonic or radio tagged in 2010 and 2011 (Table 5), 162 fish (93%) representing all 11 species were detected at least once after release, either by a submersible ultrasonic receiver or by manual tracking. Fish that were tagged and never relocated were likely a result of downriver movements before all receivers had been deployed, and/or natural mortality outside of the study area. Over the course of the study, 144 detections of 67 individuals and 10 species were recorded by hydrophone or radio tracking equipment. Fixed station SURs logged 359,496 detections of 157 individuals from 11 species. Thirty-eight fish (82%) tagged below Claiborne Dam and all twenty-six fish tagged at Millers Ferry Lock and Dam in 2010 was detected at least once after release. In 2011, 98 fish (45 tagged at Claiborne, 53 tagged at Millers Ferry), including 19 fish tagged in 2010, were detected by manual tracking efforts or stationary receivers. Detections of at least 1 individual were made on all receivers deployed except the SURs located on the Cahaba and Mobile Rivers. However, the SUR deployed on the Mobile River malfunctioned soon after deployment, preventing any data collection.

Movement

Movements of 170 individual fish from 13 species were documented throughout the duration of the study by recaptures made by anglers, manual tracking with hydrophone or radio telemetry equipment, and fixed station SURs. Fish were detected from 1 to 532 days after release, ranging from as far south as Mobile Bay and as far north as ARk 303 where the Cahaba River flows into the Alabama River. Detections were also made on the Tombigbee River, and in the Alabama River cutoff. Nine species (paddlefish, southeastern bluesucker, striped bass, smallmouth buffalo, highfin carpsucker, quillback, white bass, striped mullet, and Alabama bass) were all detected having made large-scale upstream or downstream movements.

Over the duration of the study, I monitored the movements of 89 paddlefish, 24 smallmouth buffalo, 16 highfin carpsucker, 11 southeastern bluesucker, 9 striped bass, 7 quillback, 6 Alabama bass, 3 largemouth bass, 1 white bass, 1 freshwater drum, 1 blacktail redhorse, 1 blue catfish, and 1 striped mullet released below Claiborne and Millers Ferry locks and dams. Detailed information regarding the movements of paddlefish and other species detected is presented in Appendix II. Upstream movements of fish tracked in 2010 at Claiborne and Millers Ferry dams were mostly restricted by the dam. Paddlefish released below Claiborne Dam moved on average approximately 3.9 km upstream after release (Figure 3). Only 3 of the tracked paddlefish were detected upstream of Claiborne Dam near ARk 120 and ARk 212. Paddlefish released at Millers Ferry on average moved 0.9 km upstream of the release site in 2010 (Figure 4). Only 1 paddlefish was tracked above the dam. The distance paddlefish moved upstream from their release site did not differ between Claiborne and Millers Ferry in 2010 (t-test: t=0.67, P=0.50), suggesting that both dams may act as a significant barrier to upstream movement even with fish passage operations. Similar to 2010, the upstream movements of most fish released below Millers Ferry in 2011 were restricted by the dam. Paddlefish on average moved only 3.8 km upstream from release site (Figure 5). Of the 28 paddlefish tracked, only 3 fish continued moving upstream into Bill Dannelly Reservoir. However, paddlefish at Claiborne Dam in 2011 on average moved upstream 41 km of release site (Figure 6). Fourteen paddlefish tracked below Claiborne were successful in moving upstream beyond Claiborne Dam. Unlike 2010, paddlefish at Claiborne during 2011 moved significantly larger distances upstream from their release site than those at Millers Ferry (t-test: t=3.71, P=0.0006), again suggesting that Millers Ferry Dam may be an important barrier to upstream fish movement, while the barrier provided by Claiborne Dam may depend on river conditions.

On average, paddlefish released below Claiborne Dam moved downstream 16 km of the release site in 2010 (Figure 7) to occupy river reaches between ARk 103 to ARk 8. Most of these fish were detected congregated in a bend in the river at ARk 87. Even though I increased the spatial extent of the sampling area in 2011, paddlefish at Claiborne in 2011 moved downstream on average 28 km (Figure 8) to occupy the same reaches between ARk 104, ARk 87 and ARk 16, with 1 fish detected moving up the Tombigbee River. Paddlefish released at Millers Ferry in 2010 on average moved downstream 65 km downstream of release site in 2010 (Figure 9) and 85 km (Figure 10) in 2011 during the spring shortly after release to occupy the reach between Claiborne and Millers Ferry dams. Paddlefish at Millers Ferry moved significantly larger distances downstream from their release site than those at Claiborne in 2010 (t-test: t=-4.83, P=<0.0001) and 2011 (t-test: t= -3.27, P=0.0021). Ten fish continued moving downstream, past Claiborne and were detected in the tailrace area, ARk 104, and the lower reaches of the Alabama River near ARk 16. The furthest distance moved for any paddlefish tagged at Millers Ferry was by 2 fish detected moving approximately 245 km downstream, past Claiborne Dam to the Mobile River, and then up the Tombigbee River. Linear regression showed that there was no relationship between paddlefish EFL and minimum upstream (P=0.57) or downstream (P=0.77) distance moved for fish tagged at Claiborne Dam or Millers Ferry Dam (upstream P=0.55, and downstream P=0.71) in 2011.

Lock operations

Fish passage lock operations at the two dams ran from 1 February through 31 May in both study years. Detailed information concerning days and timing of operations, as well as number of lockages are included in Appendix III. With the implementation of the current fish passage operations, the USACE was able to increase the potential number of days for fish passage, ranging from 52-471%. In 2010, Claiborne lock was operated a total of 33 days, with 122 specialized passage operations conducted. Claiborne's crested spillway was inundated 34 days, allowing for a total of 67 days for potential upstream passage. In 2011, Claiborne Lock chamber was operated 32 days, conducting 125 fish passage lockages. The spillway was only inundated for 13 days, allowing for a total of 45 days of potential fish passage. If current fish passage operations were not in place, opportunities for fish passage at Claiborne in 2010 would have been only 44 days (10 days with boat traffic, and 34 days inundated). In 2011, fish passage would have only been able to take place on 22 days (13 days inundated and 9 days with boat traffic). In 2010, Millers Ferry Lock conducted fish passage operations on a total of 89 days, compared to only 27 days of boat traffic. In 2011, Millers Ferry Lock was operated 80 days, compared to only 14 days with recorded boat traffic (Table 6).

A total of 72 (42%) fish from 9 species were detected entering, or at least close enough to be detected by the SUR, at either Claiborne Lock chamber in 2010 and 2011 or Millers Ferry Lock in 2011 on multiple occasions. Attraction efficiency (e.g., proportion of tagged fish in the vicinity of the dam that entered the lock chamber at least once) for all fishes sonic tagged at Claiborne was 53% (23 of 41; 4 species) in 2010 (Figure 11) and 21% (12 of 56; 2 species) in 2011 (Figure 12). Fish that entered the Claiborne Lock chamber in 2010 on average entered 4.95 times and were detected inside the lock chamber on average for 41 min before exiting. In 2011, fish entered the lock chamber on average 5.25 times for an average of 47 min. Over the duration of the study, a total of 28 different paddlefish were detected entering Claiborne Lock chamber on average 5.48 times for an average of 48 min. The number of times paddlefish entered the Claiborne Lock chamber (t-test: $t=-1.18$, $P=0.25$) and the duration spent inside the lock (t-test: $t=-1.79$, $P = 0.085$) did not differ between paddlefish that successfully passed through versus those that did not.

Attraction efficiency for fishes below Millers Ferry Lock and Dam in 2011 was 54% (37 of 68 individuals from 6 species). Fish were detected entering the lock chamber on average 34 times and remained inside the lock an average of 18 min. In 2011, 23 different paddlefish were detected entering Millers Ferry Lock chamber (Figure 13) on average 46 times for 19 min. Only 2 of the 4 paddlefish that successfully locked upstream passed through when an SUR was located in the lock chamber. The number of times paddlefish that successfully locked through entered the lock chamber differed from those that did not lock through (t-test: t=-3.45, P= 0.003). However, time inside the lock chamber did not differ for fish passing versus not passing (t-test: t=0.29, P=0.78).

Fish Passage

Most fish passage occurred during spring and summer. A total of 51% (44 sonic tagged, 1 anchor tagged) of fishes tracked through the duration of the study were successfully detected passing either upstream or downstream past at least one of the dams on multiple occasions via either the navigational lock chamber or over Claiborne Dam. Most fish passage occurred at Claiborne Dam. A total of 39 fish passed either upstream or downstream over Claiborne spillway. Only 14% of all documented passage occurred during low river conditions through the lock chambers. Paddlefish was the only species I determined to pass through the lock chamber, although a largemouth bass was recaptured above Millers Ferry Dam during low water conditions. A total of 8% of the paddlefish tracked through the duration of the study successfully locked upstream.

Upstream

A total of 26 fish from 4 species passed upstream of Claiborne or Millers Ferry dam in either 2010 or 2011. Upstream fish passage was most frequent during spring, presumably during spawning migrations. Most upstream fish passage occurred during high flows, with some instances of fish passage through the locks. Of the 26 fish that passed upstream, 17 fish (15 paddlefish, 2 smallmouth buffalo) moved upstream past Claiborne during high flow in 2010

(Figure 14-A) and 2011 (Figure 14-B) when the crested spillway was inundated. Passage over Claiborne dam during high flows accounted for 65% (15 individuals) of all upstream passage by paddlefish on the Alabama River. Additionally 2 smallmouth buffalo moved upstream of Claiborne when the dam was inundated, suggesting that other species may depend on high flows for fish passage on the Alabama River.

A total of 7 different paddlefish were detected moving upstream past either Claiborne or Millers Ferry dam through the navigation lock during spring, as determined by both manual tracking and fixed station receivers, throughout the duration of the study. Three of the nineteen paddlefish tagged in 2010 that entered the Claiborne lock chamber moved upstream via use of the navigation lock during specialized lock operations, when otherwise there would have not been any opportunity for fish passage. One paddlefish tagged at Millers Ferry moved upstream of Millers Ferry Lock and Dam via the lock chamber when a boat was locking through (Table 7). Additionally, an anchor tagged largemouth bass released below Millers Ferry was recaptured by an angler above the dam; however the mode of passage could not be determined, although this was during a time of low flow when the only chance for fish passage would have been through the lock chamber. In 2011, a paddlefish (1 of 12 detected in the lock) that successfully locked upstream of Claiborne Dam in 2010, moved back downstream past the dam, and returned to the dam in 2011 and successfully locked upstream again during specialized fish passage operations. Additionally, an Alabama bass that had been anchor tagged below Claiborne Dam in 2010 was recaptured by an angler 95.5 km upstream, near Millers Ferry in 2011, although mode of passage could not be determined. Three paddlefish at Millers Ferry locked upstream via the navigation lock in 2011 during fish passage lock operations (Table 8).

In 2010, there was only a 13.3% (5.1-30.6, 95% CL) chance that a paddlefish would be able to make it upstream of Claiborne Dam (logistic regression: P=0.0005). However, this is likely a result of my initial tagging effort, which took place below Claiborne Dam in late March in 2010, after water levels had already declined. There was only a 5-day window during May that allowed for fish passage, and by then most fish had left the vicinity of the dam. Similar results occurred at Millers Ferry dam in both 2010 and 2011, being 0.07 times as many paddlefish to pass upstream of the dam (logistic regression: P=0.009 in 2010, P=< 0.0001in 2011). However in 2011, I did not see a significant difference in the probability of paddlefish movements being impeded by Claiborne Dam versus upstream passage past the dam (logistic regression: P=0.32). In fact, 1.5 times as many paddlefish moved upstream of Claiborne Dam (60%, 40.25-76.95, 95% CL) than had movement impeded. In 2011, paddlefish that successfully passed upstream of the dam had a significantly higher probability of moving above the dam during high flow (14 of 15) than through the navigational lock chamber (logistic regression: P=0.01). Fourteen times as many paddlefish moved upstream of the dam over the spillway during high flow as through the navigation lock, and if a paddlefish were to move upstream of the dam in 2011, there was a 93% (64.80-99.06, 95% CL) chance that it went over the dam versus through the lock chamber.

Of the 8 occurrences of fish passage occurring through the lock chambers at the two dams during the duration of the study, 7 occurred during specialized lock operations when otherwise no passage opportunities would have been available. The probability of paddlefish passing upstream through the locks using fish passage operations versus normal navigation traffic was marginally significant (logistic regression: P=0.069). This is likely due to low sample size. However, specialized lock operations passed 7 times as many paddlefish upstream through the lock as during normal operations, and if a paddlefish was to pass upstream through the lock, there was an 87.5% (46.272-98.273, 95% CL) chance that it occurred during the fish passage operations.

Downstream

A total of 34 fish from 4 species moved downstream past Claiborne Dam in 2010 and 2011. Downstream passage at Claiborne did not depend on use of navigational lock chambers (i.e., no fish passed downstream of Claiborne through the lock). Only 1 fish, a striped bass, was detected on the SUR located inside Claiborne lock while moving downstream, and it was only detected once on each of two separate occasions. Fish moved downstream either through open flood gates or over the crested spillway. No fish that passed upstream of Millers Ferry successfully returned downstream.

Detection Probability

The probability of paddlefish moving upstream and downstream of both Claiborne and Millers Ferry locks and dams were calculated for the 4 receivers located in the immediate vicinity above and below each dam (Figure 15). Detection probabilities for paddlefish moving both upstream and downstream of the dam were highest in the upper portions of the Alabama River near Millers Ferry lock and dam. Probability of detection for a paddlefish moving upstream into the tailrace area below Millers Ferry was 94% (SUR at rkm 212, 29 of 31) and 100% (SUR at rkm 215, 4 of 4) for all paddlefish detected to have moved upstream above Millers Ferry Dam. Probability of detection was 100% (SUR at rkm 212, 37 of 37) for all paddlefish moving downstream of Millers Ferry for which additional location data were available. No fish were detected moving downstream of Millers Ferry Dam. The probability of paddlefish being detected on an SUR as it moved upstream into the tailrace area below Claiborne Dam was 38% (SUR at rkm 116, 8 of 21) and only 31% (SUR at rkm 118, 5 of 16) on the SUR directly above Claiborne Dam. These numbers were likely low because most fish moved upstream of Claiborne Dam during extremely high flows when the dam was inundated. These high flows simultaneously increased acoustic disturbance in the water, reducing the ability for receivers to detect tags. Detection probabilities for paddlefish moving downstream from above Claiborne Dam were 68% (rkm 118, 17 of 25) and 54% for fish moving downstream of the tailrace area (rkm 116, 20 of 37) from which data were available. Detection probability suggest that multiple receivers would be required to monitor directional movement and passage of sonic tagged fish on the Alabama River at the two locks and dams due to the high variability in the ability of an SUR to detect tags.

Discussion

Fish passage facilities at dams are important in assisting the movement of many anadromous fishes between the ocean and historic spawning grounds along both the US Pacific (Moser et al. 2002; Parsley et al. 2007) and Atlantic coasts (Barry and Kynard 1986). Relatively few of these structures have been constructed to assist the potamodromous fishes found along the large rivers of the Southeastern US. Not only would such structures require extensive funding for planning and construction to retrofit existing dams, but data do not exist to support whether such an approach would work in this region. The success of fish passage depends on characteristics of the dams (Bailey et al. 2004), hydrology of the river (Barry and Kynard 1986), and species-specific capabilities (Gurgens et al. 2000; Baumgartner and Harris 2007) of the fishes attempting to move. Recent research has shown that using navigation locks can serve as a cost effective approach for moving multiple migratory species (Moser et al. 2000; Bailey et al. 2004; Trip and Garvey 2009), and is the current fish passage strategy used on the Alabama River in an effort to reconnect navigation pools for fishes.

Fish Passage

Upon construction of Claiborne and Millers Ferry locks and dams in the 1960s and prior to the implementation of the USACE fish passage operations at the two dams in 2009, fish passage was limited to the periods when the Claiborne spillway was inundated, or when the lock chambers were being used for navigation. I found that conducting fish passage operations during February through May, additional opportunities were provided for multiple fish species to enter the lock chamber. Most fish that entered the lock chambers did so in the spring when specialized passage operations were occurring; however, some fish moved into the lock chambers in the summer after passage operations had ended. Mettee et al. (2006), using data collected by the USACE and the Geological Survey of Alabama from 2000 to 2005 found that a total of 24 different species could be collected inside the Claiborne Lock chamber. Although fish were collected inside the lock, they did not document the first record of fish passage through a lock chamber until 2004 (Mettee et al. 2009).

Paddlefish was the only species that I recorded as successfully locking upstream through either of the two dams, although a single anchor tagged largemouth bass was documented having moved upstream of Millers Ferry Dam during low water conditions (but the mode of passage could not be determined). Additionally, 2 other species (Alabama bass and smallmouth buffalo) were also detected moving upstream past Claiborne Dam, but these movements occurred over the crested spillway at high water. Although paddlefish was the only species determined to successfully use the navigational lock chambers for fish passage in my study, only 7 individuals passed upstream. Trip and Garvey (2009) showed similar results, where only 10% of upstream passage by paddlefish occurred during low flow conditions (i.e., when flood gates were closed). Zigler et al. (2004) also showed that passage by paddlefish through the lock chambers on the upper Mississippi River were infrequent, suggesting that navigation locks contribute only to a small portion of movement beyond the dams. However, there were no specialized lock passage operations being conducted at the locks in their study area. Navigation locks have been shown to successfully pass at high rates two anadromous Clupeid species studied in the southeastern US. In a report produced by the Georgia Department of Natural Resources, Wildlife Resources Division (2008), they estimated that 41% of tagged Alabama shad, *Alosa alabamae.* passed upstream through the Jim Woodruff Lock chamber on the Chatahoochee River during the spawning migration. At the New Savannah Bluff Lock and Dam on the Savannah River in South Carolina, Bailey et al. (2004) determined that over 50% of the tagged American shad *Alosa sapidissima* passed through the lock chamber. Other fish passage structures along the Pacific coast have shown similar relatively higher rates for passing fish upstream. Moser et al. (2002) found passage rates of Pacific lamprey *Lampetra tridentate* through fishways of the Lower Columbia River to range from 38-82% at Bonneville and The Dalles dams. In my study, most upstream fish passage occurred at Claiborne Dam when the spillway was inundated, suggesting that high flows are important for the movement of multiple fish species on the Alabama River. Downstream passage at Claiborne also did not seem to depend on the use of navigation lock chambers. Multiple species showed the ability to pass downstream of Claiborne Dam. All downstream passage detected on the Alabama River occurred at Claiborne Dam with fish moving over the crested spillway or through the flood gates; no downstream passage occurred at Millers Ferry Dam.

At least one Individual from all species that were detected entering the lock chamber entered the lock on multiple occasions. This repeat entry behavior has also been shown to occur in other migratory species such as Pacific lamprey (Moser et al. 2002), American shad (Barry and Kynard 1986; Moser et al. 2000; Bailey et al. 2004), and Atlantic salmon (Gowans 1999), suggesting that some individuals are predisposed to finding fish passage structures, or that they learned how to find the structures. Although the number of times fish that were passed upstream entered the lock chamber at Claiborne did not differ from that for fish that did not pass, paddlefish that locked through entered the lock chamber nearly 3 times more. At Millers Ferry, paddlefish that locked upstream did enter the lock chamber significantly more times than those that were not passed. However, the time that fish spent inside the lock chamber did not differ between fish that successfully locked through versus those that did not, in contrast Moser et al. (2000) has shown that fish that locked upstream spent significantly more time in the chamber than fish that were not locked through.

Movement

Few passage studies have continued to monitor migrations after fish left the fish passage facilities. My data show that multiple fish species are capable of making long distance movements along the Alabama River. However, fish movement may be restricted to the lower portion of the Alabama River below Millers Ferry dam, despite efforts to re-establish long distance migrations by use of navigation locks. Over the duration of my study, no fishes were successful in navigating beyond both dams, and only a few fish released below Millers Ferry Dam moved upstream into the Bill Dannelly Reservoir. My results were similar to those of Mettee et al. (2009), who manually tracked paddlefish on the Alabama River before lock passage operations began; detecting fish moving past either Claiborne or Millers Ferry dams. Similar movements were also documented for paddlefish in the upper Mississippi River by Zigler et al. (2003) and Zigler et al. (2004); paddlefish concentrated in focused areas in the summer and winter, with large-scale movements occurring both upstream and downstream in the spring. These movements are likely associated with high flow and led to increased opportunities for fish passage through the dams.

Conclusions and Management Implications

I did not explore differences between the two fish passage operations at Claiborne and Millers Ferry Dam, nor the effect that passing fish might have on local population biology structure. However my results do suggest that the specialized lock passage operations along the

Alabama River can increase upstream fish passage, enhancing opportunities for long range movements, as well as facilitate localized movements of non-migratory fishes. Although paddlefish were likely to pass upstream through the locks during specialized fish passage operations, navigational lock chambers were not routinely used for fish passage. Passage is likely related to the amount of time fish spend inside or in the vicinity of the lock chamber (Barry and Kynard 1986). Increasing the time fish spend inside the lock has been shown to result in higher passage frequency. Moser et al. (2000) found that closing the outside pivot gate resulted in over a 300% increase in the time that American shad *Alosa sapidissima* remained inside the lock, from less than 30 minutes to 2 hours, increasing the likelihood of being successfully locked through. My research does indicate that these operations can pass fish upstream but will be most important during years of low flow when spillway dams are not inundated. Future research should focus on how the addition of attraction flow and any other lock modifications (i.e., reducing amount of time lock gates are left open, increasing upstream lockages, closing 1 pivot gate) may improve fish passage on the Alabama River, AL.

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Table 1. Summary of fish passage operations at Claiborne and Millers Ferry locks and dams in 2010 and 2011. Claiborne Lock was operated on the same schedule in 2010 to 2011.

Claiborne Lock	Millers Ferry Lock (2010)	Millers Ferry Lock (2011)
4:00AM- Close lower gates Raise water level Open upper lock gates-remain open for 6 hours	6:00AM- Open lower gates remain open for 4 hours	_
10:00AM- Close upper gates Lower water level Open lower lock gates-remain open for 6 hours	10:00AM- Close lower gates Raise water level Open upper lock gates-remain open for 4 hours	10:00 AM- Close lower gates raise water level Open upper lock gates-remain open for 5 hours
4:00PM- Close lower gates Raise water level Open upper lock gates-remain open for 6 hours	6:00PM- Close upper gates Lower water level Open lower lock gates-remain open for 4 hours	3:00 PM- Close upper gates Lower water level Open lower lock gates- remain open for 19 hours
10:00PM- Close upper gates Lower water level Open lower lock gates-remain open for 6 hours	10:00PM- Close lower gates Raise water level Open upper lock gates-remain open for 4 hours	_

Table 2. Summary of fishes anchor tagged in 2010 and 2011 at the two study sites on the Alabama River, Alabama.

Species	Claiborne 2010	Claiborne 2011	Millers Ferry 2010	Millers Ferry 2011
Paddlefish	37	21	15	28
Smallmouth buffalo	4	10	15	13
Highfin carpsucker	-	9	1	7
Southeastern bluesucker	2	3	6	1
Striped bass	3	3	2	1
Quillback	-	6	-	1
White bass	-	-	2	1
Freshwater drum	1	1	3	-
Alabama bass	1	14	6	5
Largemouth bass	1	3	4	1
Blacktail redhorse	-	3		1
Striped mullet	-	6	2	-
Blue catfish	-	-	-	6
Channel catfish	-	-	1	1
Flathead catfish	-	-	1	-
Hybrid striped bass	-	-	-	2

Table 3. Recapture data for fish that were tagged on the Alabama River in the 2010 field season. Columns showing capture date and release location represent the data and locality that an individual was first caught and tagged. Individual fish are identified as anchor tag ID number.

Species	Release Location	I.D. Number	Original Capture Date	Original Capture Site (River km)	Recapture Date	Recapture Site (River km)
Alabama bass	Claiborne	1018	3/31/2010	116.53	5/21/2011	212.04
Largemouth bass	Millers Ferry	1051	4/6/2010	211.96	5/30/2010	214.82
Alabama bass	Millers Ferry	1085	4/7/2010	212.01	?	210.05
Paddlefish	Claiborne	1098	4/13/2010	116.42	4/20/2010	117.19

Table 4. Recapture data for fish that were tagged on the Alabama River for the 2011 field season. Columns showing capture date and release location represent the date and locality that an individual was first caught and tagged. Individual fish are identified as anchor tag ID number.

Species	Release Location	I.D. Number	Original Capture Date	Original Capture Site (River km)	Recapture Date	Recapture Site (River km)
Alabama bass	Claiborne	1103	10/22/2010	116.53	6/16/2011	116.12
Alabama bass	Claiborne	1118	11/22/2010	116.53	4/15/2011	116.36
Striped mullet	Claiborne	1121	11/22/2010	116.53	4/1/2011	15.18
Blue catfish	Millers Ferry	1166	3/1/2011	213.53	6/29/2011	213.53
Alabama bass	Claiborne	1209	4/12/2011	116.4	5/6/2011	116.9
Alabama bass	Claiborne	1210	4/12/2011	116.4	5/13/2011	108.36

Table 5. Summary of fishes sonic and/or radio tagged in 2010 and 2011 at the two study sites on the Alabama River, Alabama.

Species	Claiborne 2010	Claiborne 2011	Millers Ferry 2010	Millers Ferry 2011
Paddlefish	33	20	15	28
Smallmouth buffalo	4	8	1	13
Highfin carpsucker	-	9	-	7
Southeastern bluesucker	2	3	6	1
Striped bass	3	3	2	1
Quillback	-	6	-	1
White bass	-	-	1	1
Freshwater drum	1	1	-	-
Alabama bass	1	-	-	1
Largemouth bass	1	-	1	-
Blacktail redhorse	-	-	-	1

Table 6. Summary lock operation statistics for Claiborne and Millers Ferry Locks and Dams from 1 February to 31 May in both study years.

	Days operated	Days Inundated	Days with Boat Traffic	Fish Passage Lockages	Days for Potential Passage
Claiborne					
2010	33	34	10	122	67
2011	32	13	9	125	45
Millers Ferry					
2010	89	-	27	356	89
2011	80	-	14	162	80

Table 7. Summary of fishes that passed upstream of either Claiborne or Millers Ferry Locks and Dams through the navigational lock chamber in 2010. Passage date is determined as the date detected on opposite side of dam.

Species	Fish I.D.	Release Site	Release Date	Lock Passage	Passage Date	Operation
Paddlefish	PF1002	Claiborne	3/30/2010	Claiborne	4/21/2010	Fish passage
Paddlefish	PF1020	Claiborne	3/31/2010	Claiborne	4/19/2010	Fish passage
Paddlefish	PF1031	Claiborne	3/31/2010	Claiborne	4/23/2010	Fish passage
Paddlefish	PF1049	Millers Ferry	4/6/2010	Millers Ferry	4/28/2010	Navigation

Table 8. Summary of fishes that passed upstream of either Claiborne or Millers Ferry Locks and Dams through the navigational lock chamber in 2011. Passage date is determined as the date detected on opposite side of dam.

Species	Fish I.D.	Release Site	Release Date	Lock Passage	Passage Date	Operation
Paddlefish	PF1020	Claiborne	3/31/2010	Claiborne	5/9/2011	Fish passage
Paddlefish	PF1064	Millers Ferry	4/7/2010	Millers Ferry	3/14/2011	Fish passage
Paddlefish	PF1178	Millers Ferry	3/24/2011	Millers Ferry	5/10/2011	Fish passage
Paddlefish	PF1186	Millers Ferry	3/24/2011	Millers Ferry	5/2/2011	Fish passage

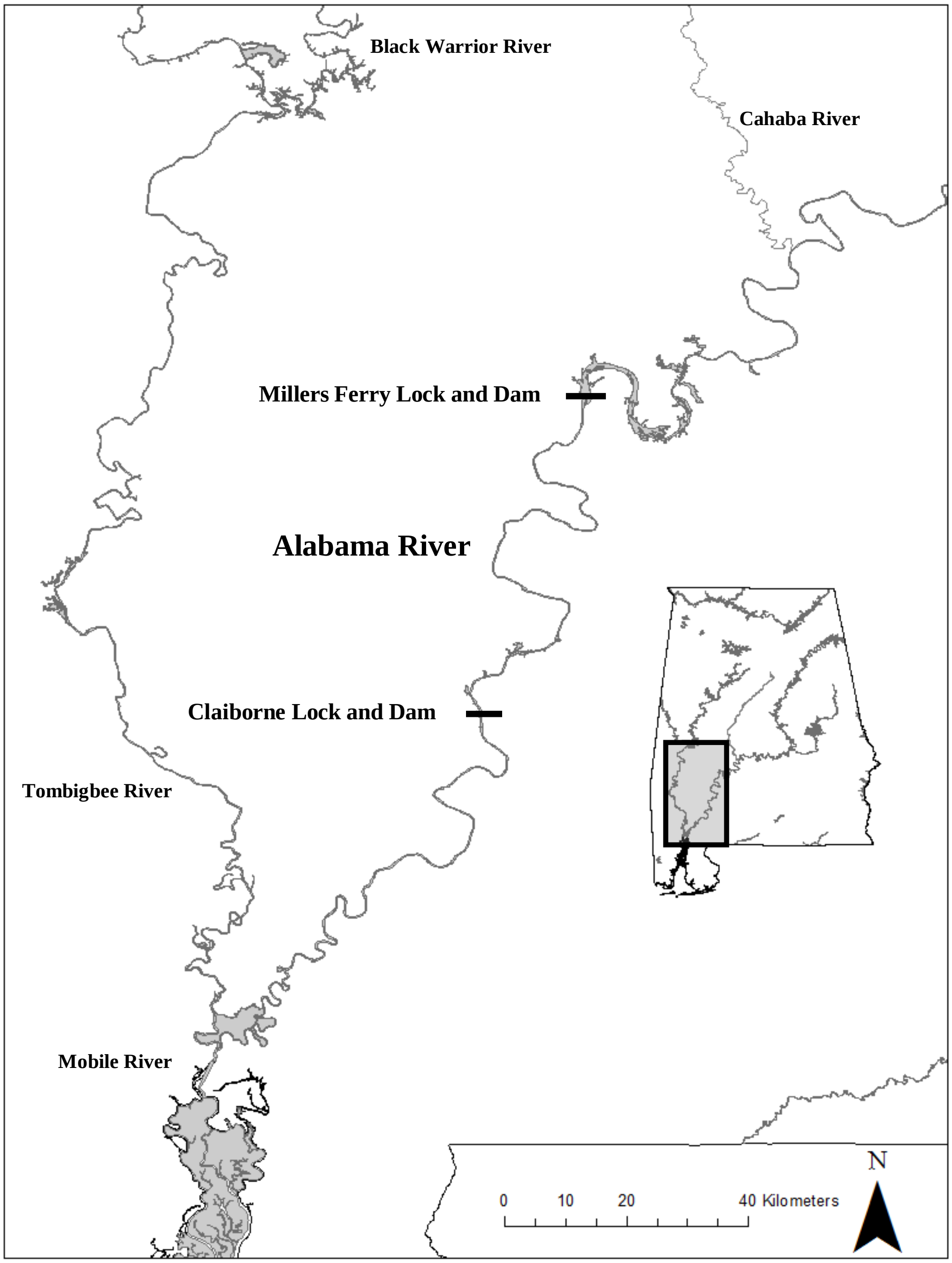

Figure 1. Locations of the two lock and dam structures on the Alabama River, Alabama that formed the focus of the study. Navigation dams are represented as bars.

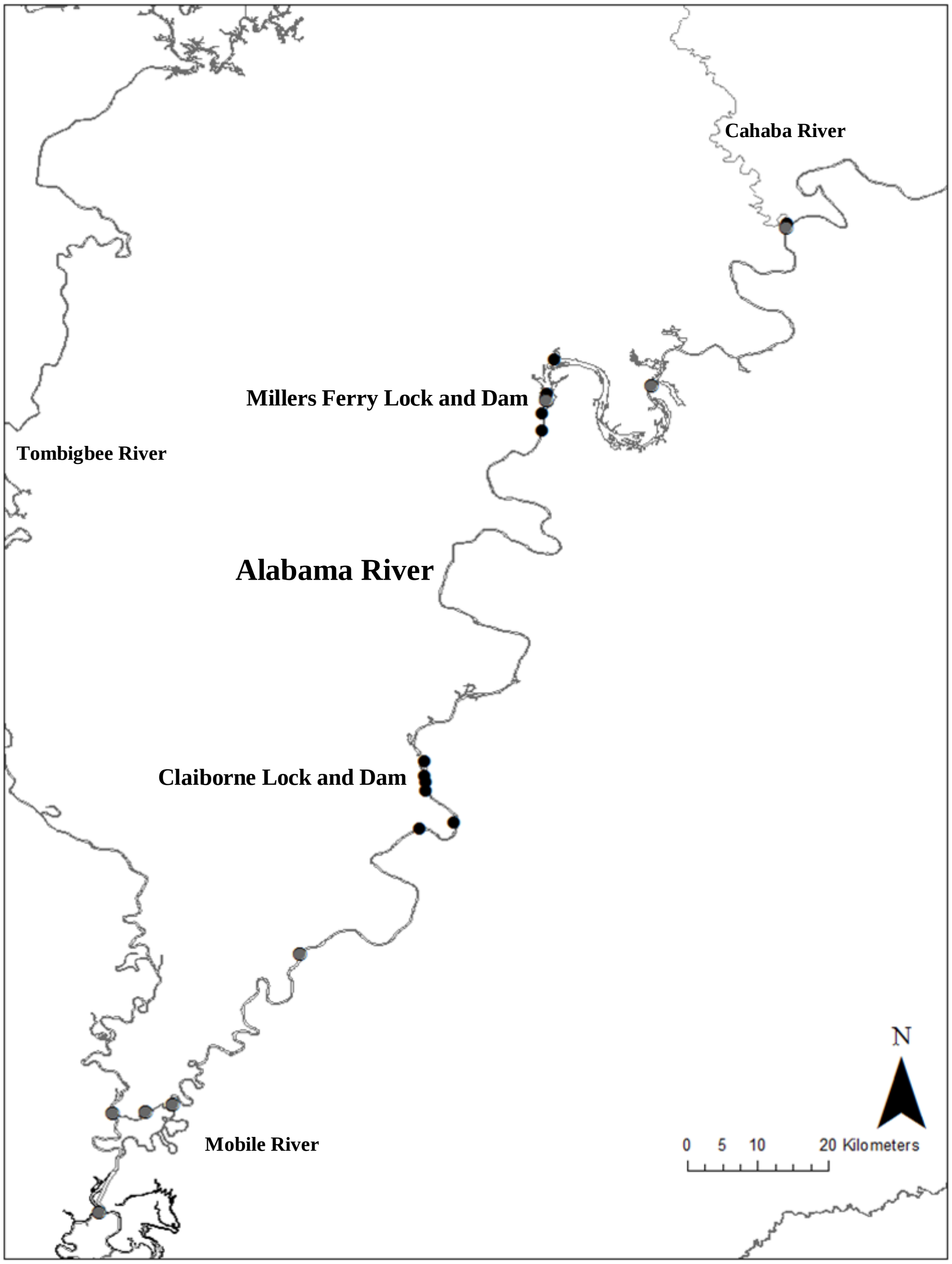

Figure 2. Map showing the locations of Submersible Ultrasonic Receivers (SUR) deployed in 2010 (black) and additional SURs deployed in 2011 (gray).

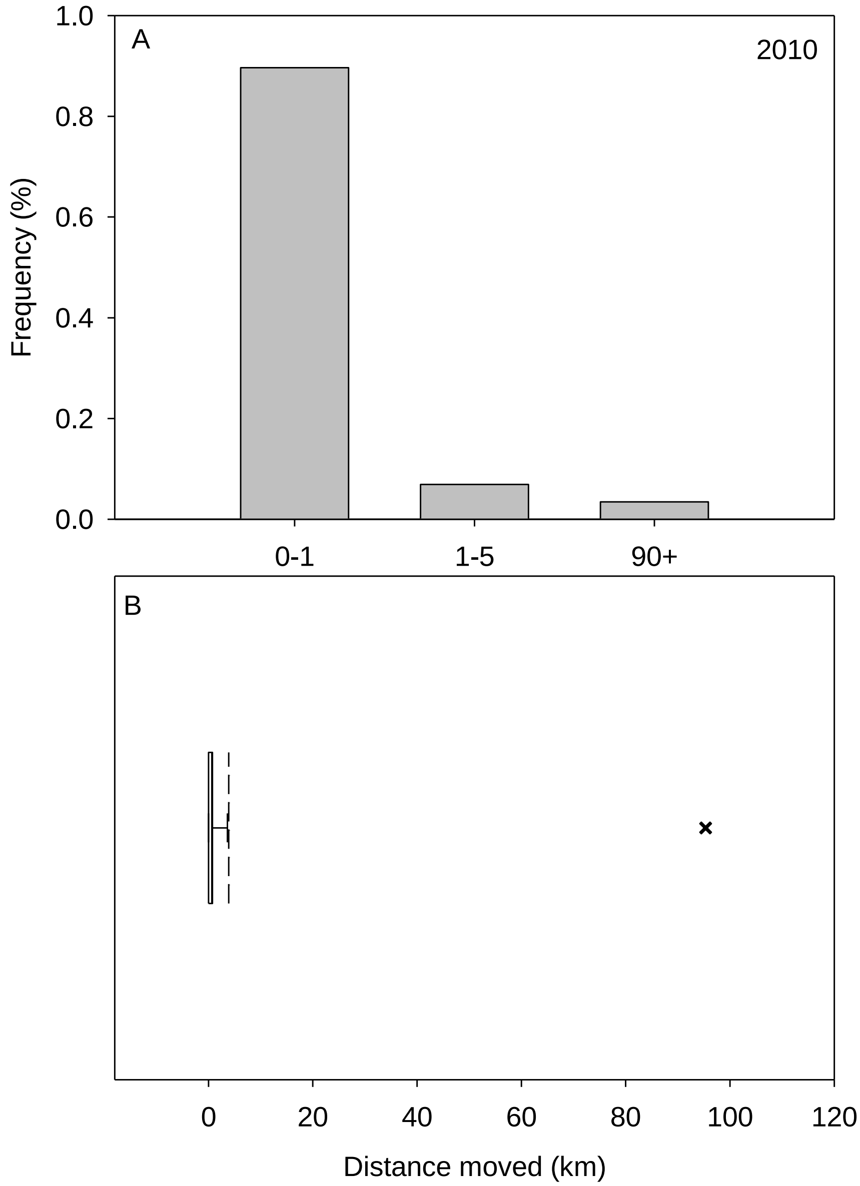

Figure 3. Frequency of minimum upstream distance moved by paddlefish at Claiborne in 2010 (calculated as the distance traveled from an individuals' release site, to the most upstream detection; Panel A), and the minimum, maximum, median, and mean distance moved (Panel B), calculated as the distance between the site of capture and relocation.

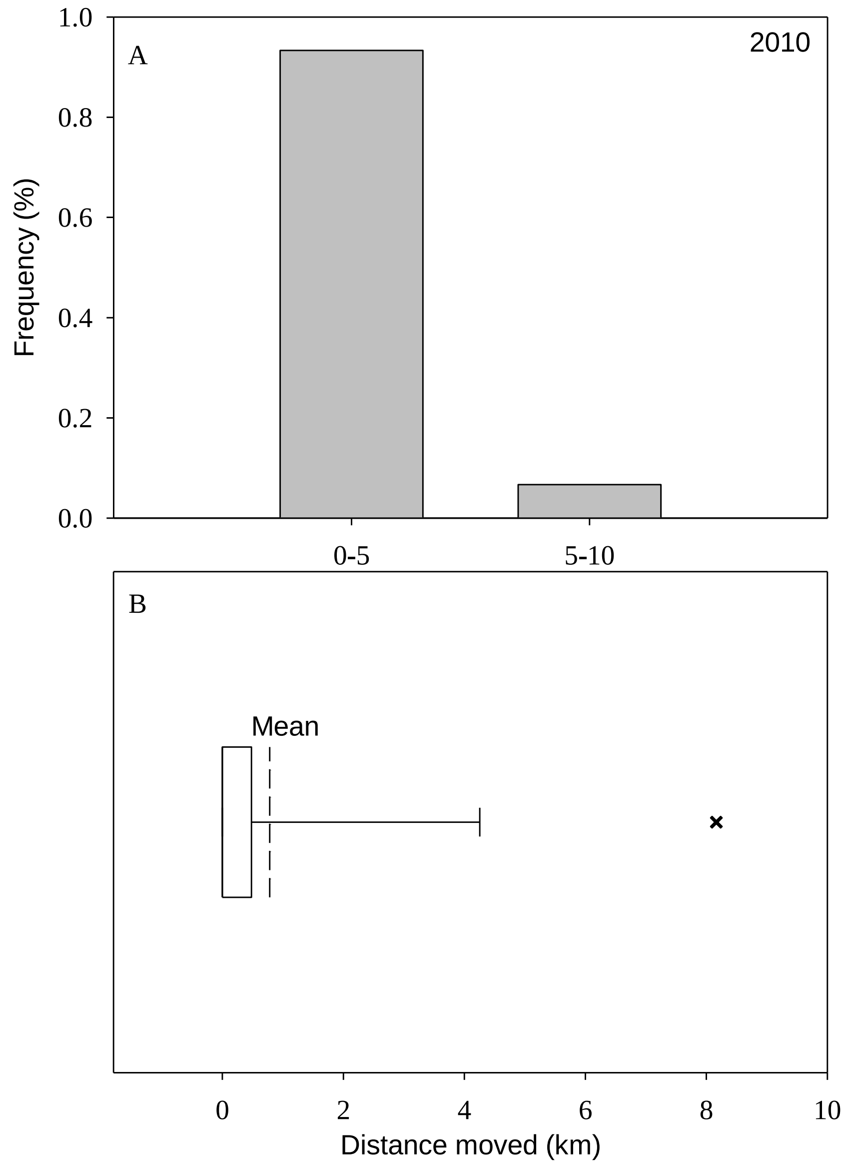

Figure 4. Frequency of minimum upstream distance moved by paddlefish at Millers Ferry in 2010 (calculated as the distance traveled from an individuals' release site, to the most upstream detection; Panel A), and the minimum, maximum, median, and mean distance moved (Panel B), calculated as the distance between the site of capture and relocation.

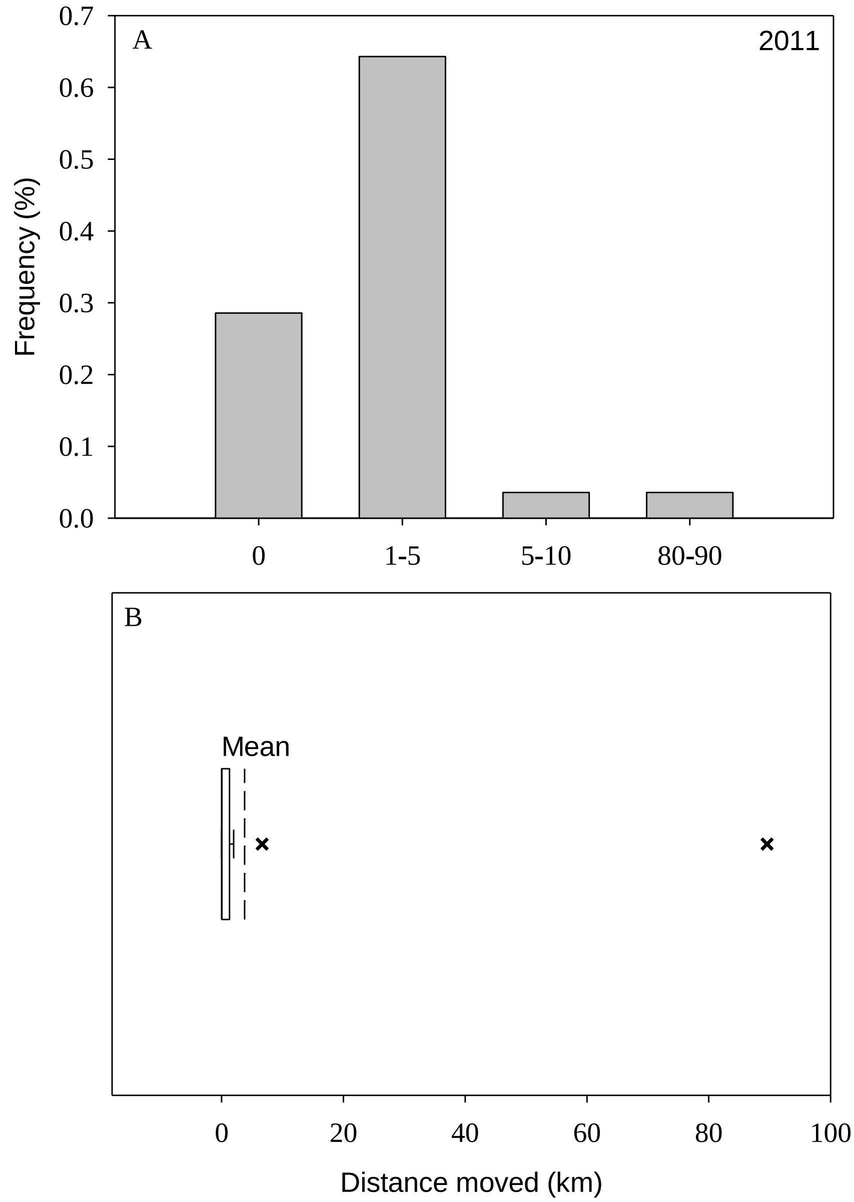

Figure 5. Frequency of minimum upstream distance moved for paddlefish at Millers Ferry in 2011 (calculated as the distance traveled from an individuals' release site, to the most upstream detection; Panel A), and the minimum, maximum, median, and mean distance moved (Panel B), calculated as the distance between the site of capture and relocation.

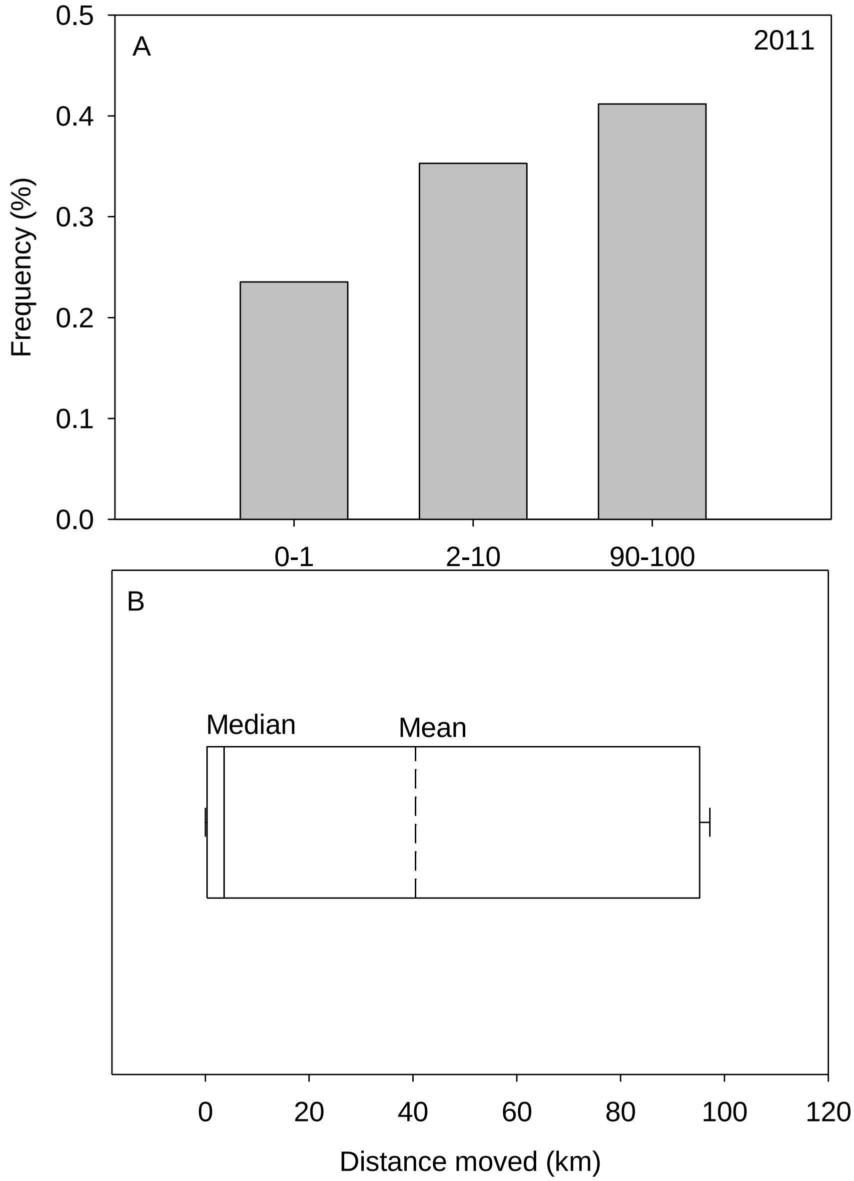

Figure 6. Frequency of minimum upstream distance moved by paddlefish at Claiborne in 2011 (calculated as the distance traveled from an individuals' release site, to the most upstream detection; Panel A), and the minimum, maximum, median, and mean distance moved (Panel B), calculated as the distance between the site of capture and relocation.

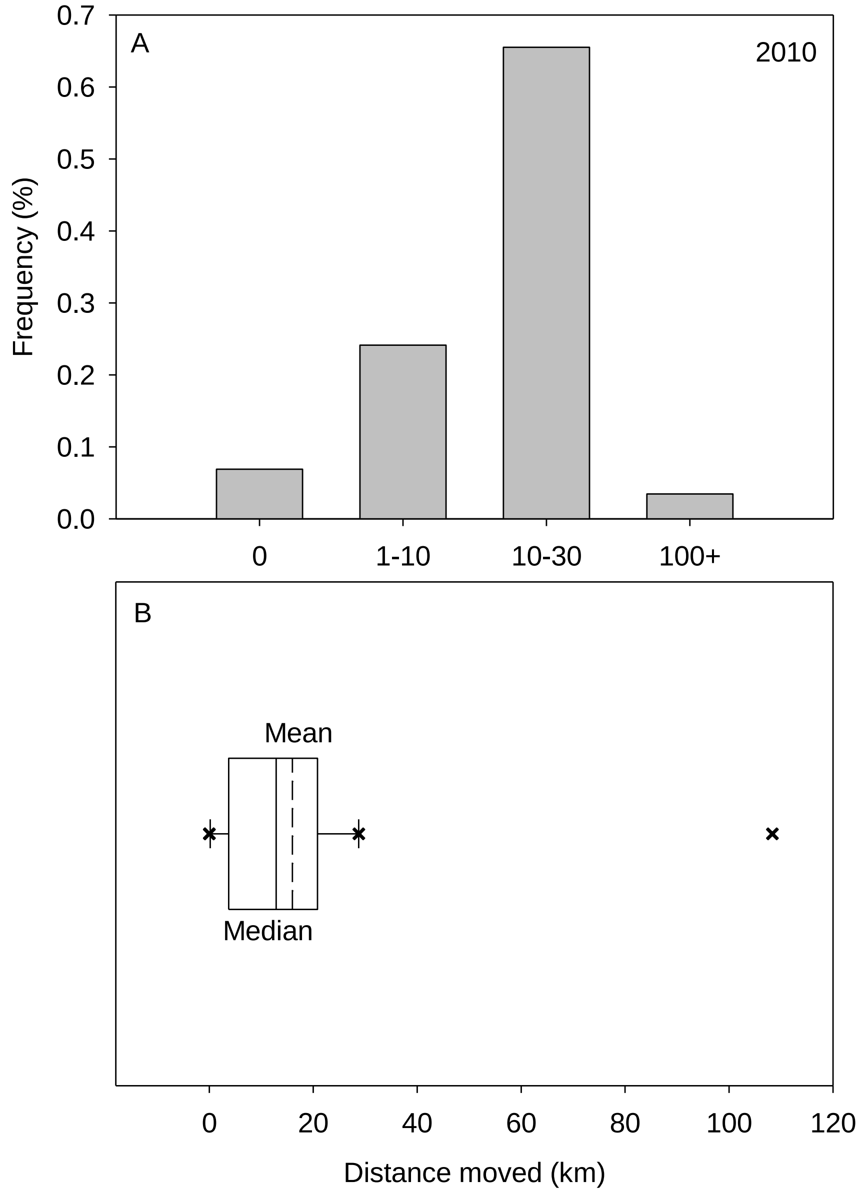

Figure 7. Frequency of minimum downstream distance moved by paddlefish at Claiborne in 2010 (calculated as the distance traveled from an individuals' release site, to the most downstream detection; Panel A), and the minimum, maximum, median, and mean distance moved (Panel B), calculated as the distance between the site of capture and relocation.

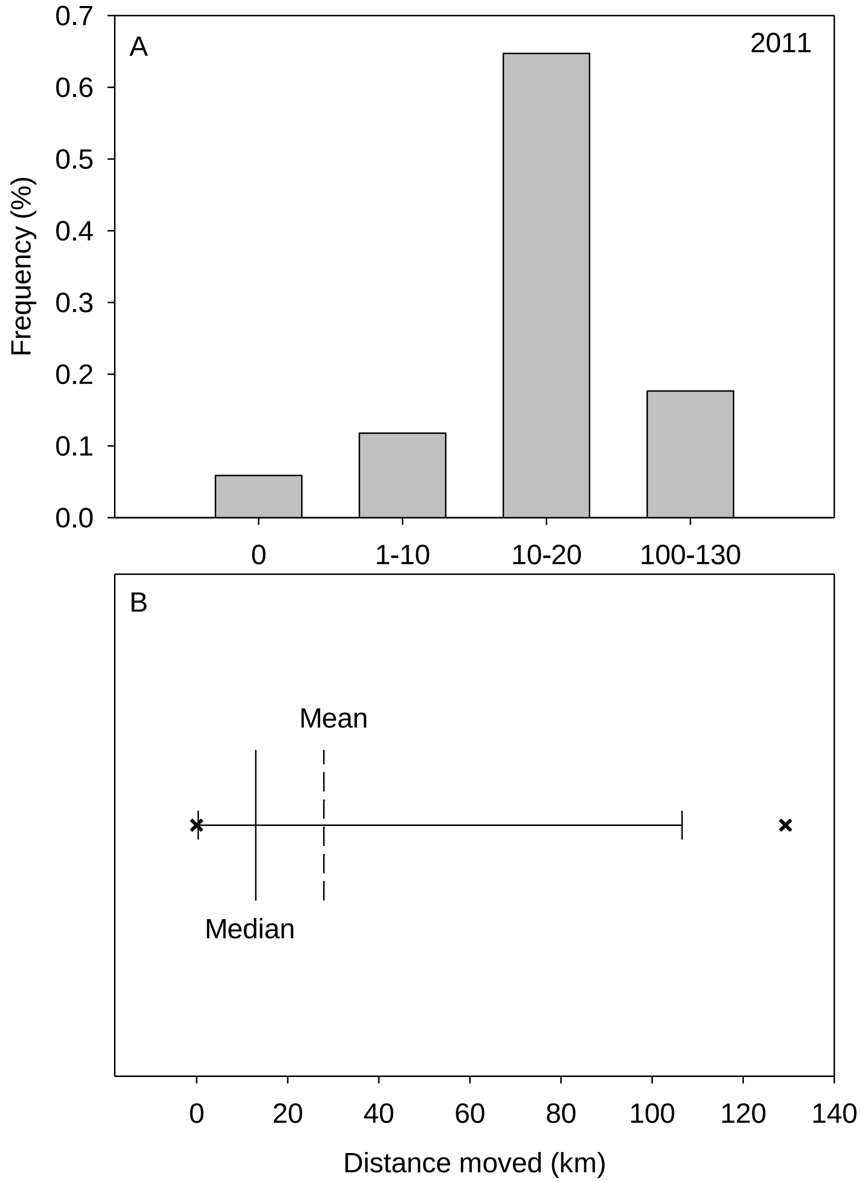

Figure 8. Frequency of minimum downstream distance moved by paddlefish at Claiborne in 2011 (calculated as the distance traveled from an individuals' release site, to the most downstream detection; Panel A), and the minimum, maximum, median, and mean distance moved (Panel B), calculated as the distance between the site of capture and relocation.

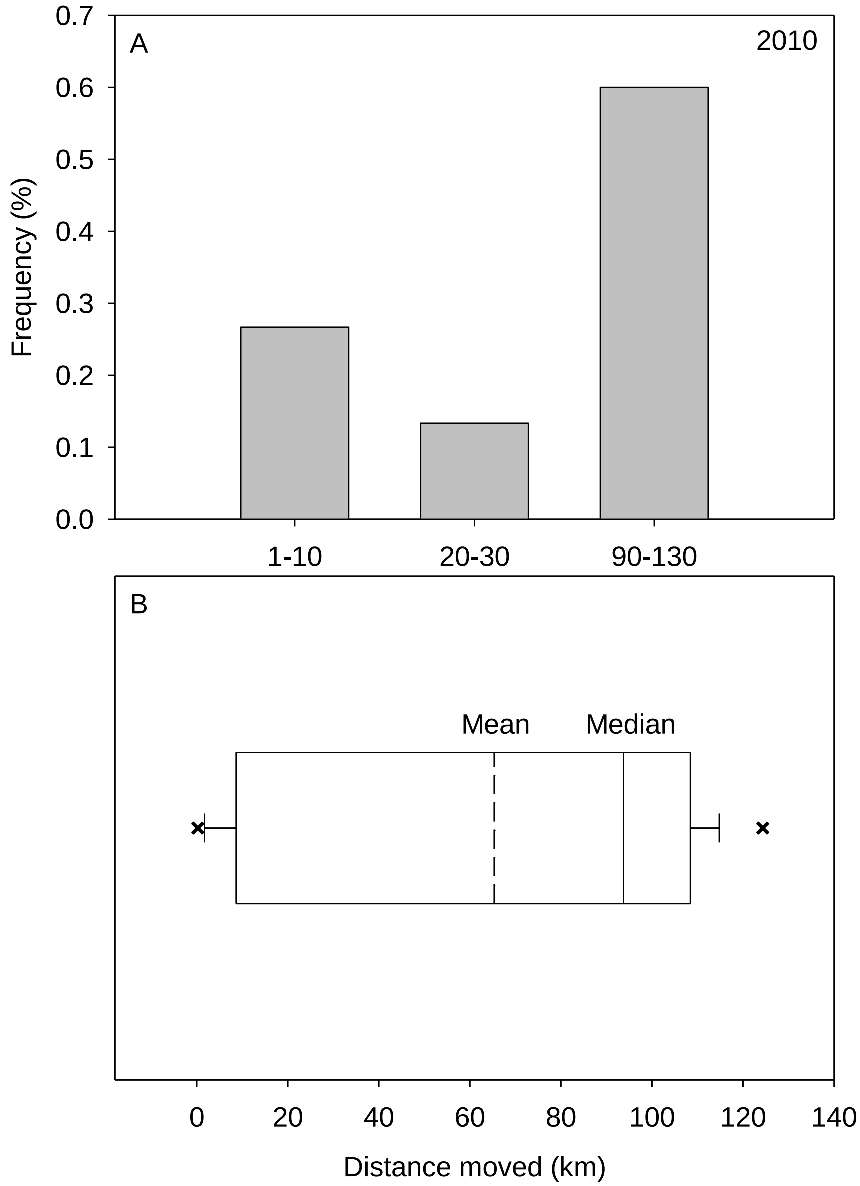

Figure 9. Frequency of minimum downstream distance moved by paddlefish at Millers Ferry in 2010 (calculated as the distance traveled from an individuals' release site, to the most downstream detection; Panel A), and the minimum, maximum, median, and mean distance moved (Panel B), calculated as the distance between the site of capture and relocation.

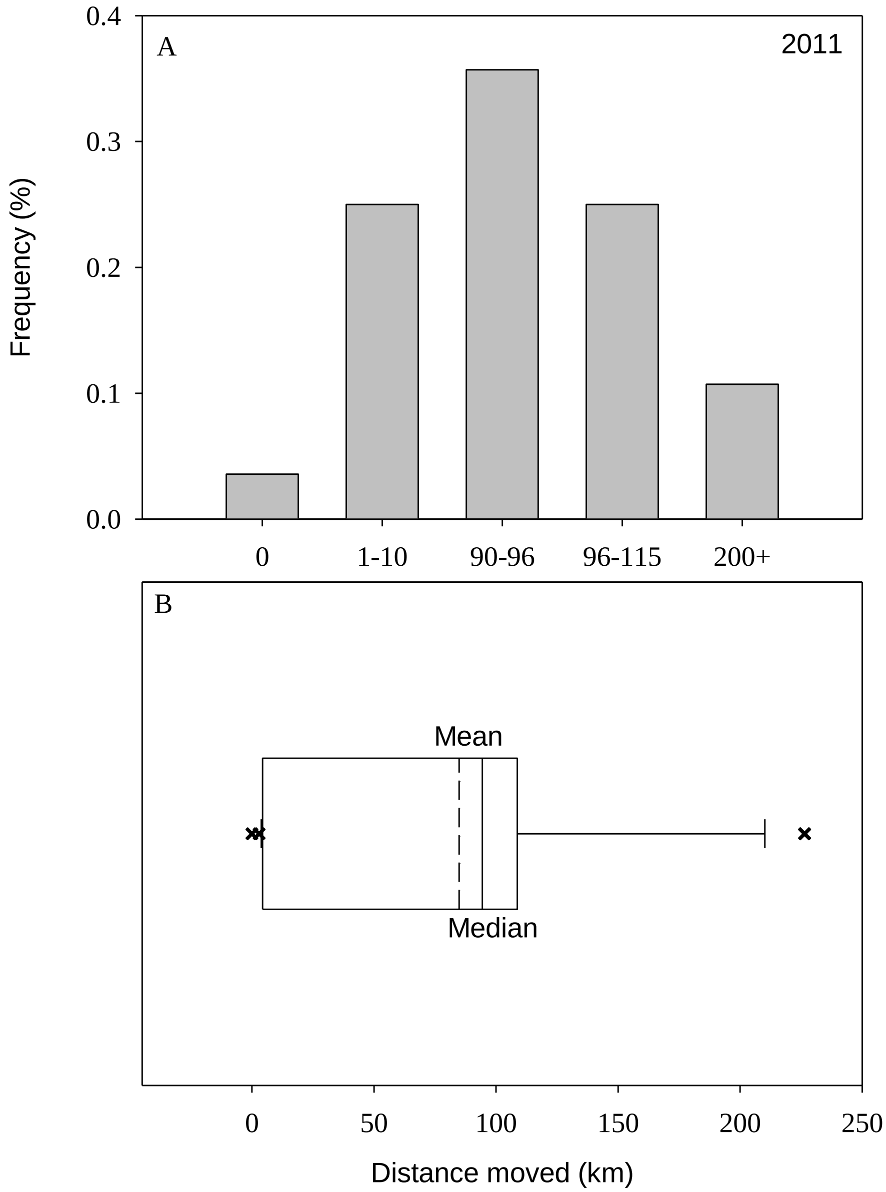

Figure 10. Frequency of minimum downstream distance moved for paddlefish at Millers Ferry in 2011 (calculated as the distance traveled from an individuals' release site, to the most downstream detection; Panel A), and the minimum, maximum, median, and mean distance moved (Panel B), calculated as the distance between the site of capture and relocation.

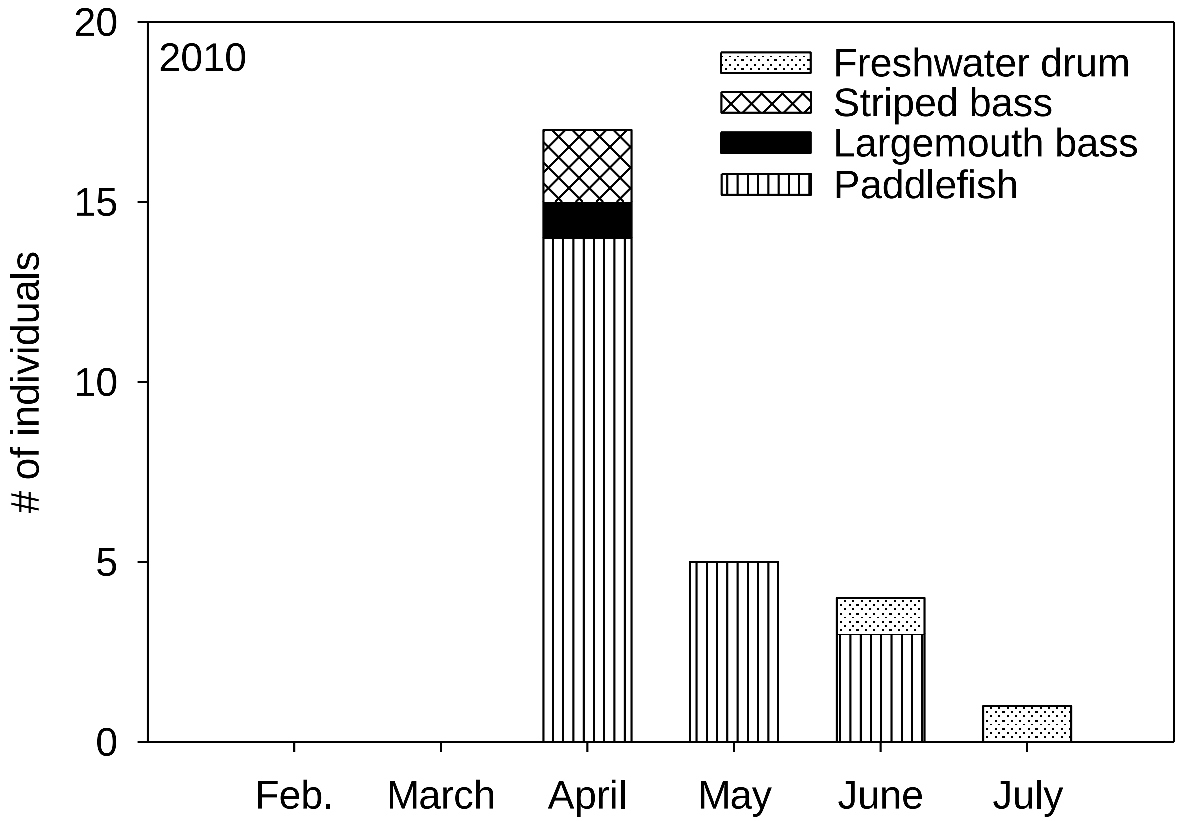

Figure 11. Detections on the submersible ultrasonic receiver in Claiborne Lock in 2010. Fish passage operations began on 1 February and ran through 31 May.

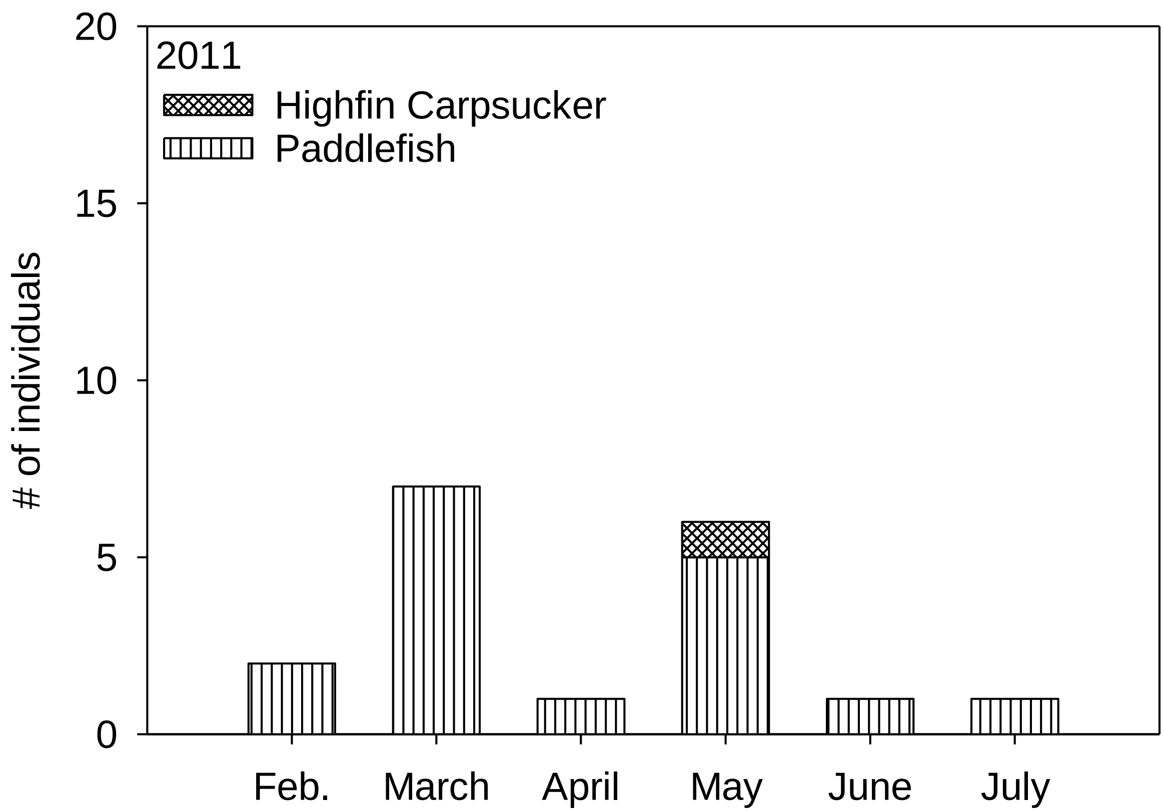

Figure 12. Detections on the submersible ultrasonic receiver in Claiborne Lock in 2011. Fish passage operations began on 1 February and ran through 31 May.

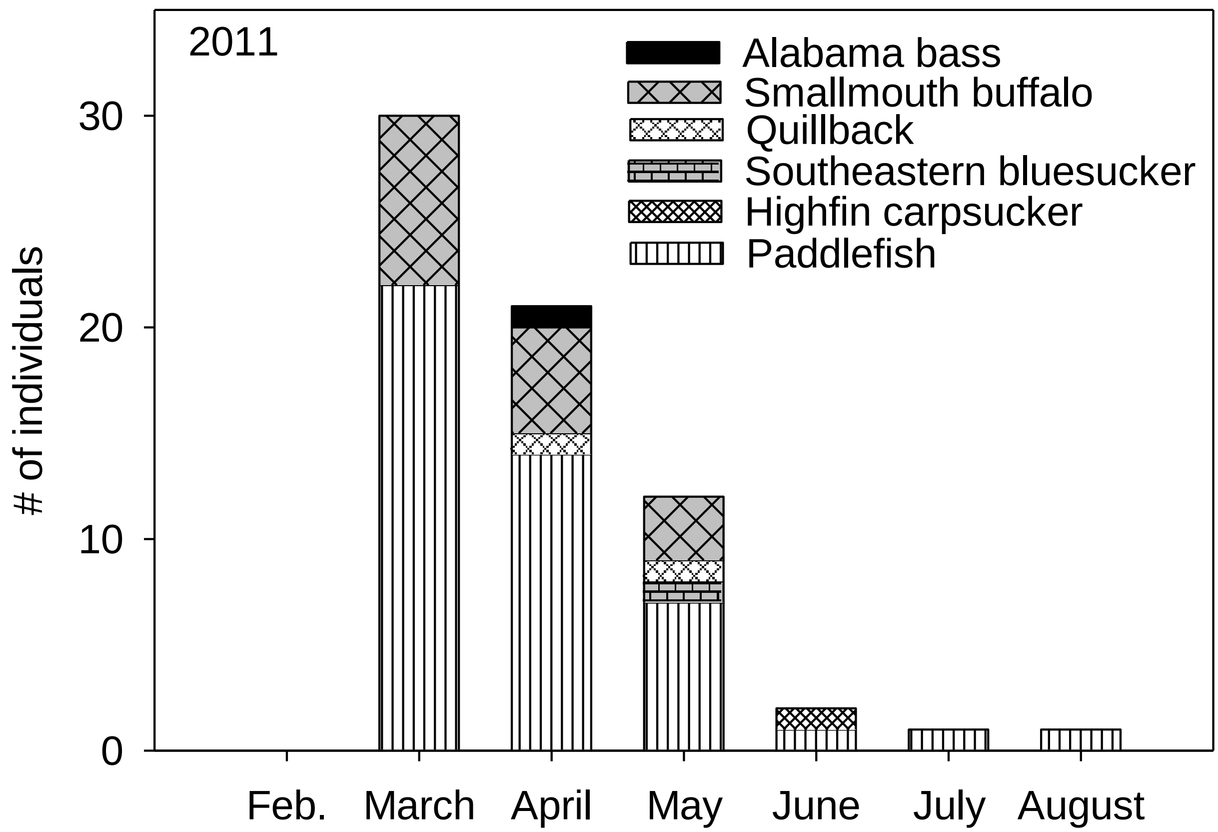

Figure 13. Detections on the submersible ultrasonic receiver in Millers Ferry Lock in 2011. Fish passage operations began 1 February and ran through 31 May.

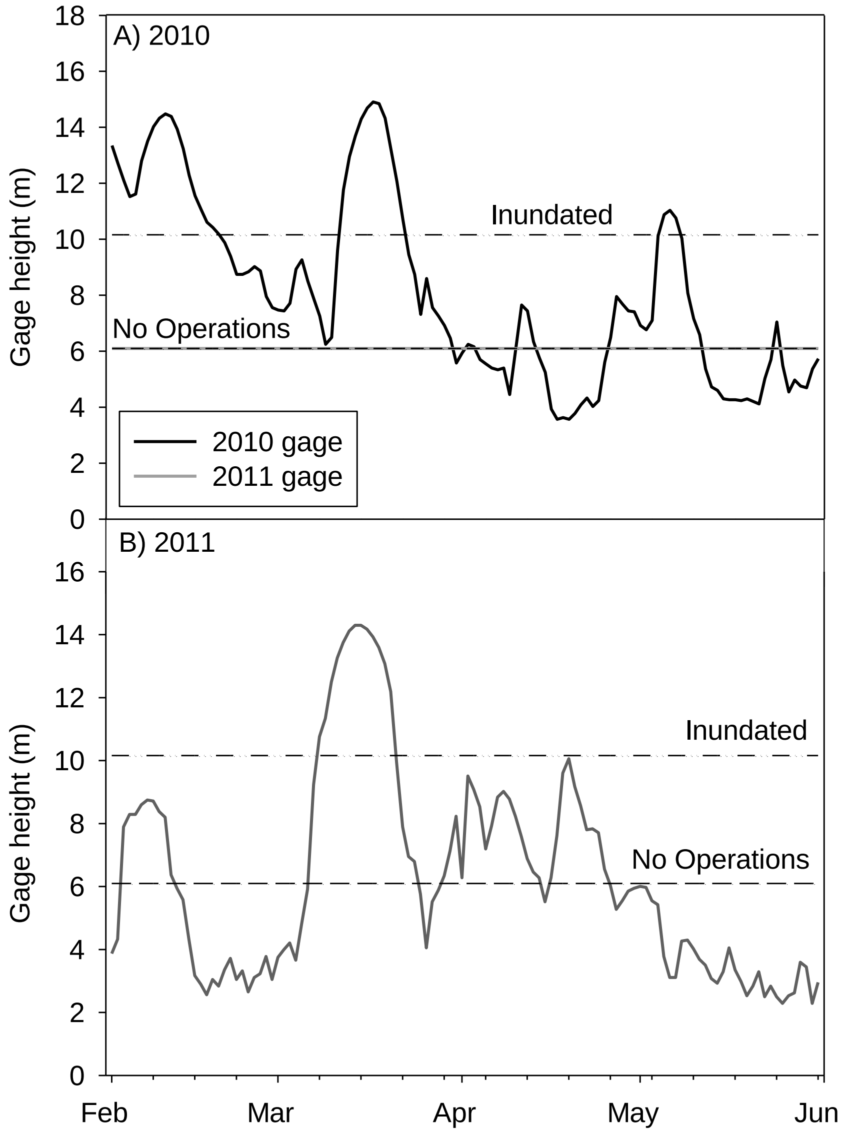

Figure 14. Gage heights at Claiborne Lock and Dam in 2010 (A) and 2011 (B) from 1 February to 31 May. Area above "no operations" and below "inundated" represents time when no fish passage opportunities are available.

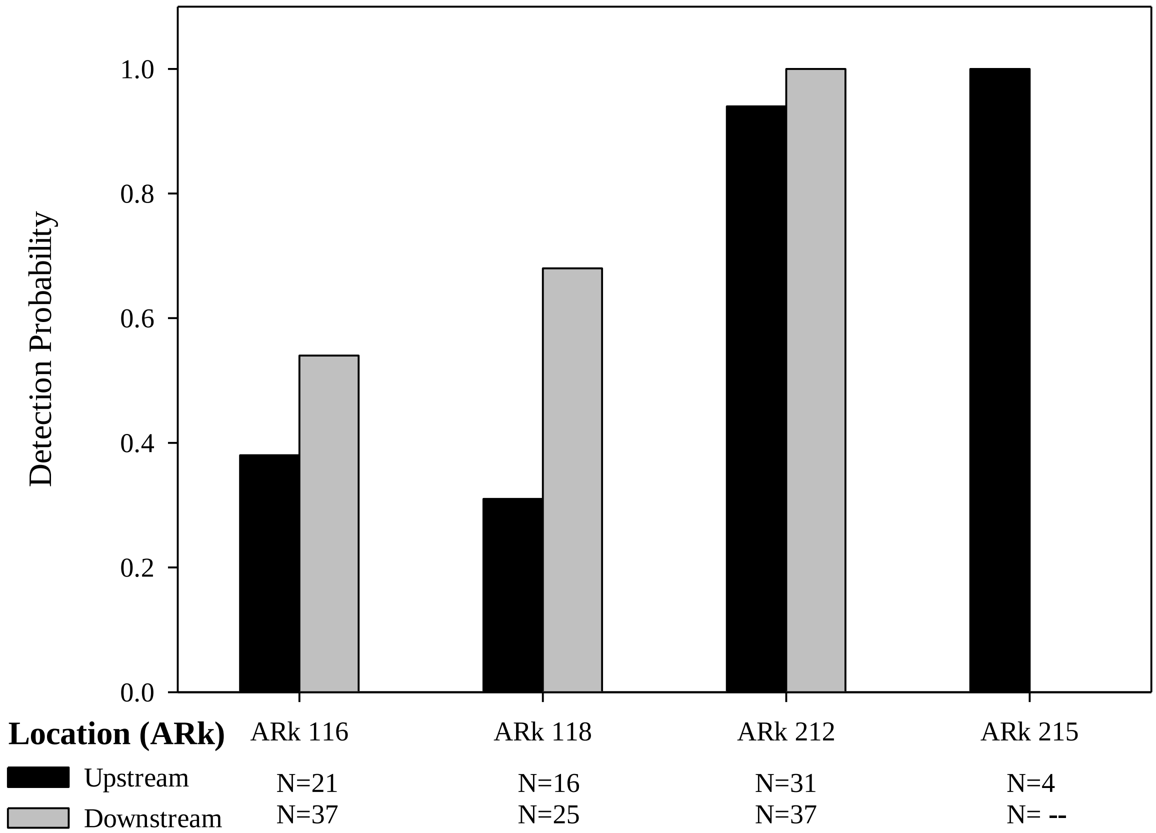

Figure 15. Detection probabilities for submersible ultrasonic receivers for paddlefish movement in 2010 and 2011 on the Alabama River, AL. N= number of fish used in calculation.

APPENDIX I

TAGGING SPREADSHEET, 2010 AND 2011

Appendix I

Tagging spreadsheet. Site is expressed as: CL (Claiborne) MF (Millers Ferry). Tagged is expressed as: F (Anchor Tag), S (Sonic Tag), and R (Radio Tag).

Date	Species	Location	TL (mm)	EFL (mm)	Weight (Kg)	Sex	ID	Tagged
30-Mar-10	Paddlefish	CL	-	850	7.6	F	1000	F/S
30-Mar-10	Paddlefish	CL	-	740	5.2	-	1001	F/S
30-Mar-10	Paddlefish	CL	-	725	4.8	-	1002	F/S
30-Mar-10	Paddlefish	CL	-	1055	15.6	F	1003	F/S
30-Mar-10	Paddlefish	CL	-	860	7.0	F	1004	F/S
30-Mar-10	Paddlefish	CL	-	888	11.2	F	1005	F/S
30-Mar-10	Paddlefish	CL	-	938	12.8	F	1007	F/S
30-Mar-10	Paddlefish	CL	-	850	7.6	F	1008	F/S
30-Mar-10	Paddlefish	CL	-	603	2.4	-	1009	F/S
30-Mar-10	Paddlefish	CL	-	590	3.0	-	1010	F/S
30-Mar-10	Paddlefish	CL	-	840	7.6	-	1011	F/S
30-Mar-10	Paddlefish	CL	-	660	3.2	-	1012	F/S
30-Mar-10	Paddlefish	CL	-	915	8.8	-	1013	F/S
30-Mar-10	Striped Bass	CL	680	-	4.2	-	1006	F/S
31-Mar-10	Alabama bass	CL	431	-	0.9	-	1018	F/S
31-Mar-10	Largemouth bass	CL	520	-	-	-	1027	F/S
31-Mar-10	Paddlefish	CL	-	695	3.6	-	1015	F/S
31-Mar-10	Paddlefish	CL	-	815	7.4	F	1016	F/S
31-Mar-10	Paddlefish	CL	-	720	4.2	-	1017	F/S
31-Mar-10	Paddlefish	CL	-	695	3.8	-	1019	F/S
31-Mar-10	Paddlefish	CL	-	830	6.6	-	1020	F/S
31-Mar-10	Paddlefish	CL	-	990	13.0	F	1021	F/S
31-Mar-10	Paddlefish	CL	-	755	5.6	-	1022	F/S
31-Mar-10	Paddlefish	CL	-	850	7.6	-	1023	F/S
31-Mar-10	Paddlefish	CL	-	584	2.4	-	1024	F/S
31-Mar-10	Paddlefish	CL	-	880	8.6	-	1025	F/S
31-Mar-10	Paddlefish	CL	-	875	6.6	-	1026	F/S
31-Mar-10	Paddlefish	CL	-	790	5.2	-	1028	F/S
31-Mar-10	Paddlefish	CL	-	970	10.8	F	1029	F/S
31-Mar-10	Paddlefish	CL	-	720	4.4	-	1030	F/S
31-Mar-10	Paddlefish	CL	-	600	2.6	-	1031	F/S
31-Mar-10	Striped Bass	CL	510	-	2.2	-	1014	F/S
31-Mar-10	Striped Bass	CL	818	-	7.8	-	1032	F/S

Date	Species	Location	TL (mm)	EFL (mm)	Weight (Kg)	Sex	ID	Tagged
6-Apr-10	Alabama bass	MF	-	-	-	-	1046	F
6-Apr-10	Channel Cat	MF	-	-	-	-	1053	F
6-Apr-10	Flathead	MF	-	-	-	-	1052	F
6-Apr-10	Freshwater drum	CL	420	-	-	-	41	F/S
6-Apr-10	Freshwater drum	MF	-	-	-	-	1038	F
6-Apr-10	Largemouth bass	MF	-	-	-	-	1043	F
6-Apr-10	Largemouth bass	MF	-	-	-	-	1045	F
6-Apr-10	Largemouth bass	MF	490	-	1.6	-	1047	F/S
6-Apr-10	Largemouth bass	MF	-	-	-	-	1051	F
6-Apr-10	Paddlefish	MF	-	890	10.5	F	1033	F/S
6-Apr-10	Paddlefish	MF	-	840	6.4	-	1034	F/S
6-Apr-10	Paddlefish	MF	-	890	8.5	-	1035	F/S
6-Apr-10	Paddlefish	MF	-	780	5	-	1049	F/S
6-Apr-10	Paddlefish	MF	-	949	11.9	F	1057	F/S
6-Apr-10	SE bluesucker	CL	595	-	-	-	45	F/S
6-Apr-10	SE bluesucker	CL	555	-	-	-	46	F/S
6-Apr-10	S. buffalo	CL	280	-	-		40	F/S
6-Apr-10	S. buffalo	CL	390	-	-	-	42	F/S
6-Apr-10	S. buffalo	CL	395	-	-	-	43	F/S
6-Apr-10	S. buffalo	CL	415	-	-	-	44	F/S
6-Apr-10	S. buffalo	MF	540	-	2	-	1040	F/S
6-Apr-10	S. buffalo	MF	-	-	-	-	1036	F
6-Apr-10	S. buffalo	MF	-	-	-	-	1039	F
6-Apr-10	S. buffalo	MF	-	-	-	-	1042	F
6-Apr-10	S. buffalo	MF	-	-	-	-	1044	F
6-Apr-10	S. buffalo	MF	-	-	-	-	1050	F
6-Apr-10	S. buffalo	MF	-	-	-	-	1054	F
6-Apr-10	S. buffalo	MF	-	-	-	-	1055	F
6-Apr-10	S. buffalo	MF	-	-	-	-	1056	F
6-Apr-10	Striped mullet	MF	-	-	-	-	1037	F
6-Apr-10	Striped Bass	MF	710	-	4.6	M	1048	F/S
7-Apr-10	Alabama bass	MF	464	-	-	-	1069	F
7-Apr-10	Alabama bass	MF	383	-	-	-	1082	F
7-Apr-10	Alabama bass	MF	426	-	-	-	1083	F
7-Apr-10	Alabama bass	MF	420	-	-	-	1084	F
7-Apr-10	Alabama bass	MF	455	-	-	-	1085	F
7-Apr-10	Freshwater drum	MF	464	-	-	-	1080	F
7-Apr-10	Freshwater drum	MF	340	-	-	-	1086	F
7-Apr-10	Highfin carpsucker	MF	380	-	-	-	1068	F

Date	Species	Location	TL (mm)	EFL (mm)	Weight (Kg)	Sex	ID	Tagged
7-Apr-10	Paddlefish	MF	-	920	13.0	F	1058	F/S/R
7-Apr-10	Paddlefish	MF	-	950	10.8	-	1059	F/S
7-Apr-10	Paddlefish	MF	-	855	6.6	-	1060	F/S
7-Apr-10	Paddlefish	MF	-	790	5.8	-	1064	F/S
7-Apr-10	Paddlefish	MF	-	900	8.4	-	1065	F/S/R
7-Apr-10	Paddlefish	MF	-	843	6.6	-	1066	F/S/R
7-Apr-10	Paddlefish	MF	-	880	6.4	-	1072	F/S/R
7-Apr-10	Paddlefish	MF	-	960	12.1	F	1088	F/S
7-Apr-10	Paddlefish	MF	-	790	5.5	-	1089	F/S
7-Apr-10	Paddlefish	MF	-	812	7.1	-	1090	F/S
7-Apr-10	SE bluesucker	MF	565	-	-	-	1061	F/S
7-Apr-10	SE bluesucker	MF	540	-	-	F	1062	F/S
7-Apr-10	SE bluesucker	MF	581	-	-	-	1071	F/S
7-Apr-10	SE bluesucker	MF	576	-	-	F	1073	F/S
7-Apr-10	SE bluesucker	MF	571	-	-	-	1074	F/S
7-Apr-10	SE bluesucker	MF	590	-	-	F	1078	F/S
7-Apr-10	S. buffalo	MF	420	-	-	-	1070	F
7-Apr-10	S. buffalo	MF	425	-	-	-	1075	F
7-Apr-10	S. buffalo	MF	490	-	-	-	1076	F
7-Apr-10	S. buffalo	MF	500	-	-	-	1077	F
7-Apr-10	S. buffalo	MF	505	-	-	-	1079	F
7-Apr-10	S. buffalo	MF	535	-	-	-	1091	F
7-Apr-10	Striped mullet	MF	490	-	-	-	1067	F
7-Apr-10	Striped Bass	MF	860	-	-	M	1087	F/S
7-Apr-10	White bass	MF	397	-	-	-	1063	F/S
7-Apr-10	White bass	MF	427	-	-	F	1081	F
13-Apr-10	Paddlefish	CL	-	660	3.8	-	1092	F
13-Apr-10	Paddlefish	CL	-	591	3	-	1093	F
13-Apr-10	Paddlefish	CL	-	825	7.9	-	1094	F/S/R
13-Apr-10	Paddlefish	CL	-	710	5.1	F	1095	F/R
13-Apr-10	Paddlefish	CL	-	855	7.5	-	1097	F
13-Apr-10	Paddlefish	CL	-	780	5.5	-	1098	F
13-Apr-10	Paddlefish	CL	-	914	13	F	1099	F/R
13-Apr-10	Paddlefish	CL	-	770	6.3	-	1096	F/R
13-Apr-10	Paddlefish	CL	-	920	11.4	F	1100	F/R
22-Oct-10	Alabama bass	CL	410	-	1.05	-	1102	F
22-Oct-10	Alabama bass	CL	389	-	1	-	1103	F
22-Oct-10	Alabama bass	CL	401	-	1	-	1104	F
22-Oct-10	Alabama bass	CL	432	-	1.2	-	1105	F

Date	Species	Location	TL (mm)	EFL (mm)	Weight (Kg)	Sex	ID	Tagged
22-Oct-10	Alabama bass	CL	385	-	0.8	-	1106	F
22-Oct-10	Alabama bass	CL	444	-	1.4	-	1107	F
22-Oct-10	Freshwater drum	CL	510	-	3.1	-	1108	F/S
22-Oct-10	Striped mullet	CL	-	-	-	-	1109	F
22-Oct-10	Striped mullet	CL	-	-	-	-	1110	F
5-Nov-10	Paddlefish	CL	-	795	5.7	-	1111	F/S
22-Nov-10	Alabama bass	CL	487	-	1.9	-	1112	F
22-Nov-10	Alabama bass	CL	385	-	0.9	-	1114	F
22-Nov-10	Alabama bass	CL	370	-	0.7	-	1117	F
22-Nov-10	Alabama bass	CL	363	-	0.7	-	1118	F
22-Nov-10	Blacktail redhorse	CL	-	-	-	-	1123	F
22-Nov-10	Blacktail redhorse	CL	-	-	-	-	1124	F
22-Nov-10	Blacktail redhorse	CL	-	-	-	-	1125	F
22-Nov-10	Largemouth bass	CL	431	-	1.1	-	1113	F
22-Nov-10	Largemouth bass	CL	406	-	0.9	-	1115	F
22-Nov-10	Largemouth bass	CL	384	-	0.8	-	1116	F
22-Nov-10	Paddlefish	CL	-	855	9	-	1126	F/S
22-Nov-10	Paddlefish	CL	-	915	10	-	1127	F/S
22-Nov-10	Paddlefish	CL	-	950	13	-	1128	F/S
22-Nov-10	Paddlefish	CL	-	863	7.4	-	1129	F/S
22-Nov-10	Paddlefish	CL	-	863	7.4	-	1130	F/S
22-Nov-10	Striped mullet	CL	-	-	-	-	1119	F
22-Nov-10	Striped mullet	CL	-	-	-	-	1120	F
22-Nov-10	Striped mullet	CL	-	-	-	-	1121	F
22-Nov-10	Striped mullet	CL	-	-	-	-	1122	F
14-Dec-10	Paddlefish	CL	-	915	9.5	-	1131	F/S
14-Dec-10	Paddlefish	CL	-	854	7.9	-	1132	F/S
14-Dec-10	Paddlefish	CL	-	866	7.3	-	1133	F/S
14-Dec-10	Paddlefish	CL	-	635	3.1	-	1134	F/S
14-Dec-10	Paddlefish	CL	-	910	8	-	1135	F/S/R
14-Dec-10	Paddlefish	CL	-	814	7.9	-	1136	F/S
14-Dec-10	Paddlefish	CL	-	910	7.9	-	1149	F/S/R
14-Dec-10	Paddlefish	CL	-	864	9	-	1148	F/S/R
20-Dec-10	Alabama bass	MF	506	-	-	-	1138	F
13-Jan-11	Paddlefish	CL	-	940	13	-	1139	F/S
13-Jan-11	S. buffalo	CL	623	-	3.8	-	1140	F/S
13-Jan-11	S. buffalo	CL	555	-	2.7	-	1141	F/S
13-Jan-11	S. buffalo	CL	492	-	1.6	-	1142	F
13-Jan-11	S. buffalo	CL	549	-	2.4	-	1143	F

Date	Species	Location	TL (mm)	EFL (mm)	Weight (Kg)	Sex	ID	Tagged
14-Jan-11	Alabama bass	MF	-	-	-	-	1144	F
14-Jan-11	Alabama bass	MF	-	-	-	-	1145	F
14-Jan-11	Alabama bass	MF	470	-	1.6	-	1146	F/S
15-Feb-11	Alabama bass	MF	-	-	-	-	1154	F
15-Feb-11	Blue catfish	MF	-	-	-	-	1150	F
15-Feb-11	Blue catfish	MF	-	-	-	-	1151	F
15-Feb-11	Blue catfish	MF	-	-	-	-	1152	F
15-Feb-11	Blue catfish	MF	-	-	-	-	1153	F
15-Feb-11	Largemouth bass	MF	495	-	1.8	-	1157	F
15-Feb-11	Paddlefish	MF	-	840	9.8	-	1155	F/S
15-Feb-11	SE bluesucker	MF	498	-	-	-	1156	F/S
22-Feb-11	Paddlefish	CL	-	930	10.3	-	1158	F/S
22-Feb-11	Paddlefish	CL	-	898	8.9	M	1159	F/S
22-Feb-11	Paddlefish	CL	-	732	5.5	M	1161	F/S
22-Feb-11	Paddlefish	CL	-	994	12.5	F	1162	F/S/R
22-Feb-11	Paddlefish	CL	-	750	5	-	1163	F/S
1-Mar-11	Blue catfish	MF	-	-	-	-	1164	F
1-Mar-11	Blue catfish	MF	-	-	-	-	1166	F
1-Mar-11	Channel Catfish	MF	-	-	-	-	1167	F
1-Mar-11	Hybrid Striped bass	MF	-	-	-	-	1168	F
1-Mar-11	Paddlefish	MF	-	910	9.6	-	1160	F/S
1-Mar-11	Paddlefish	MF	-	915	11	-	1165	F/S
1-Mar-11	Paddlefish	MF	-	795	6.8	M	1169	F/S
1-Mar-11	Paddlefish	MF	-	1030	16.8	F	1171	F/S
24-Mar-11	Paddlefish	MF	-	926	13	F	1172	F/S/R
24-Mar-11	Paddlefish	MF	-	870	7.8	-	1173	F/S/R
24-Mar-11	Paddlefish	MF	-	825	7.2	-	1174	F/S
24-Mar-11	Paddlefish	MF	-	625	2.9	-	1175	F/S
24-Mar-11	Paddlefish	MF	-	665	4.4	-	1176	F/S
24-Mar-11	Paddlefish	MF	-	805	6.7	M	1178	F/S/R
24-Mar-11	Paddlefish	MF	-	805	5.5	-	1179	F/S
24-Mar-11	Paddlefish	MF	-	670	4.3	-	1180	F/S
24-Mar-11	Paddlefish	MF	-	965	10.1	M	1183	F/S/R
24-Mar-11	Paddlefish	MF	-	780	6.5	-	1184	F/S
24-Mar-11	Paddlefish	MF	-	615	2.9	-	1185	F/S
24-Mar-11	Paddlefish	MF	-	753	5.4	-	1186	F/S
24-Mar-11	Paddlefish	MF	-	855	7.9	-	1188	F/S
24-Mar-11	Paddlefish	MF	-	822	7.9	-	1189	F/S
24-Mar-11	Paddlefish	MF	-	832	7	-	1190	F/S

Date	Species	Location	TL (mm)	EFL (mm)	Weight (Kg)	Sex	ID	Tagged
24-Mar-11	Paddlefish	MF	-	705	4.1	-	1191	F/S
24-Mar-11	S. buffalo	MF	414	-	1	-	1177	F/S
24-Mar-11	S. buffalo	MF	562	-	3	F	1181	F/S
24-Mar-11	S. buffalo	MF	430	-	1.2	F	1182	F/S
24-Mar-11	S. buffalo	MF	395	-	0.8	-	1187	F/S
24-Mar-11	S. buffalo	MF	425	-	1	-	1192	F/S
24-Mar-11	S. buffalo	MF	435	-	1.2	-	1193	F/S
25-Mar-11	Hybrid Striped bass	MF	730	-	5.3	-	1206	F
25-Mar-11	Paddlefish	MF	-	1060	17.3	F	1194	F/S
25-Mar-11	Paddlefish	MF	-	815	6.1	M	1195	F/S
25-Mar-11	Paddlefish	MF	-	672	3.9	-	1197	F/S
25-Mar-11	Paddlefish	MF	-	1008	12	-	1202	F/S
25-Mar-11	Paddlefish	MF	-	885	9.1	-	1203	F/S
25-Mar-11	Paddlefish	MF	-	905	8.5	-	1204	F/S
25-Mar-11	Paddlefish	MF	-	815	7.2	-	1205	F/S
25-Mar-11	S. buffalo	MF	400	-	0.8	-	1198	F/S
25-Mar-11	S. buffalo	MF	366	-	0.6	-	1199	F/S
25-Mar-11	S. buffalo	MF	430	-	1.1	-	1200	F/S
25-Mar-11	S. buffalo	MF	440	-	1	-	1201	F/S
12-Apr-11	Alabama bass	CL	417	-	-	-	1207	F
12-Apr-11	Alabama bass	CL	427	-	-	-	1208	F
12-Apr-11	Alabama bass	CL	389	-	-	-	1209	F
12-Apr-11	Alabama bass	CL	388	-	-	-	1210	F
12-Apr-11	Quillback	CL	371	-	-	-	1216	F/S
12-Apr-11	Quillback	CL	439	-	-	-	1218	F/S
12-Apr-11	S. buffalo	CL	492	-	2	-	1211	F/S
12-Apr-11	S. buffalo	CL	515	-	2.3	M	1212	F/S
12-Apr-11	S. buffalo	CL	480	-	2	M	1213	F/S
12-Apr-11	S. buffalo	CL	486	-	2	-	1214	F/S
12-Apr-11	S. buffalo	CL	462	-	2	M	1215	F/S
12-Apr-11	S. buffalo	CL	590	-	3	-	1217	F/S
14-Apr-11	Quillback	MF	342	-	-	-	1224	F/S
14-Apr-11	S. buffalo	MF	435	-	-	-	1220	F/S
14-Apr-11	S. buffalo	MF	471	-	2	-	1221	F/S
14-Apr-11	S. buffalo	MF	448	-	-	-	1222	F/S
14-Apr-11	Striped bass	MF	464	-	1.6	M	1219	F/S
14-Apr-11	White bass	MF	381	-	-	-	1223	F/S
28-Apr-11	Quillback	CL	330	-	-	-	1228	F/S
28-Apr-11	SE bluesucker	CL	560	-	-	-	1225	F/S

Date	Species	Location	TL (mm)	EFL (mm)	Weight (Kg)	Sex	ID	Tagged
28-Apr-11	Striped bass	CL	470	-	-	M	1226	F/S
28-Apr-11	Striped bass	CL	472	-	-	M	1227	F/S
2-May-11	Highfin carpsucker	CL	328	-	-	M	1233	F/S
2-May-11	Highfin carpsucker	CL	335	-	-	M	1234	F/S
2-May-11	Highfin carpsucker	CL	310	-	-	-	1235	F/S
2-May-11	Highfin carpsucker	CL	320	-	-	M	1236	F/S
2-May-11	Quillback	CL	355	-	-	-	1230	F/S
2-May-11	SE bluesucker	CL	470	-	-	-	1231	F/S
2-May-11	Striped bass	CL	440	-	-	M	1229	F/S
3-May-11	Highfin carpsucker	CL	300	-	-	-	1237	F/S
3-May-11	Highfin carpsucker	CL	323	-	-	-	1238	F/S
3-May-11	Highfin carpsucker	CL	312	-	-	M	1239	F/S
3-May-11	SE bluesucker	CL	610	-	-	-	1232	F/S
9-May-11	Blacktail redhorse	MF	380	-	-	-	1245	F/S
9-May-11	Highfin carpsucker	MF	360	-	0.68	-	1240	F/S
9-May-11	Highfin carpsucker	MF	340	-	0.58	-	1241	F/S
9-May-11	Highfin carpsucker	MF	335	-	0.45	-	1242	F/S
9-May-11	Highfin carpsucker	MF	362	-	0.74	-	1243	F/S
9-May-11	Highfin carpsucker	MF	330	-	0.5	-	1246	F/S
9-May-11	Highfin carpsucker	MF	330	-	0.57	-	1247	F/S
9-May-11	Highfin carpsucker	MF	350	-	0.55	-	1248	F/S
10-May-11	Highfin carpsucker	CL	282	-	0.38	-	1249	F/S
10-May-11	Highfin carpsucker	CL	325	-	0.52	-	1250	F/S
10-May-11	Quillback	CL	350	-	-	-	1251	F/S
10-May-11	Quillback	CL	384	-	0.63	M	1252	F/S

APPENDIX II

DETAILED MOVEMENT DATA, CLAIBORNE AND MILLERS FERRY TAGGED FISHES
2010 AND 2011

APPENDIX II

Detailed information regarding the movements of fish tracked below Claiborne and Millers Ferry Locks and Dams in 2010 and 2011.

Of the 29 paddlefish, seventeen (59%) were detected moving upstream of the release site before moving downstream, and twelve (41%) initially moved downstream after release. Fourteen paddlefish moved upstream and were detected on the SUR located at Claiborne dam inside the navigational lock chamber, but never made it upstream of the dam. Three paddlefish that moved upstream continued moving upstream past the Claiborne Dam. Two of these paddlefish were detected by a receiver located ARk 120, just 3 km above Claiborne dam. The third paddlefish continued moving 95 river km up to the tailrace area below the Millers Ferry powerhouse at ARk 212 where it remained for nearly a month, before moving back downstream over Claiborne dam to ARk 104. Twenty-one (72%) of the twenty-nine tagged paddlefish were detected moving downstream past the lowest SUR on the Alabama River at ARk 104. Eleven of those fish continued moving downstream and were detected by manual tracking efforts from ARk 103 to ARk 8. The paddlefish located at ARk 8 was located during a radio-tracking flight in an oxbow near a site known locally as “Spoonbill sandbar”. The furthest downstream detection of a paddlefish tagged at Claiborne in 2010 was in Mobile Bay just south of the Interstate-10 Bridge on 3 December. With the addition of 8 SURs and continued manual tracking in 2011, I was able to continue monitoring the movements of 7 of the paddlefish tagged at Claiborne in 2010. Two of the fish that were released in 2010, returned to Claiborne before moving upstream of the dam in March during high flows that inundated the spillway. One of the paddlefish that passed upstream of Claiborne in 2010 returned in 2011 and was last detected above the dam at ARk 120. The other continued moving upstream to Millers Ferry dam, where it was detected for 3 days before moving back downstream over Claiborne dam and returned to ARk 87, where 2 other paddlefish tagged in 2010 at Claiborne were also detected in 2011. The other 2 paddlefish remained in the reaches of the Alabama River between ARk 103 and 110, and 1 paddlefish was last detected on the Tombigbee River near the Alabama River cutoff.

The movements of 6 other species tagged below Claiborne dam were monitored in 2010. A freshwater drum tagged below the dam was detected moving downstream to ARk 104 initially after release, before moving back upstream to Claiborne dam where it was detected entering the lock chamber before proceeding back downstream to ARk 104. A sonic tagged Alabama bass (Tag # 1018) was tracked moving below Claiborne dam in 2010 where it was last detected at ARk 100 , 17 km downstream below Claiborne Dam. In 2011, 396 days after last detection, Alabama bass 1018 were caught by an angler at the base of the Millers Ferry dam, 111 river km upstream of its last known location, unfortunately the sonic tag had already expired so mode of passage could not be assessed. One largemouth bass, 1 bluesucker, 2 Sm. buffalo and 2 striped bass were last detected below the dam. One Sm. buffalo however, was detected moving downstream to ARk 67 near Eureka landing in 2010 and detected again moving back upstream to Claiborne dam at ARk 117 in February of 2011 where it remained for a month before moving back downstream over 100 km to ARk 15. Additionally, a striped bass was detected moving downstream and was last detected at ARk 104.

The movements of a total of 15 paddlefish, 6 Southeastern bluesuckers, 2 largemouth bass, 2 striped bass, 1 white bass, and 1 Sm. buffalo tagged in 2010 below Millers Ferry lock and dam were also monitored. Four of the five fish that moved upstream (33%), were manually located in the area directly below the dam, however only one paddlefish moved upstream of the Millers Ferry dam, where it was last detected in 2010 on a receiver deployed at ARk 220. In the winter of 2011, this fish was detected back at ARk 220, then proceeded to move upstream where it was last detected on a receiver located at ARk 303, near the Cahaba River. Six other individual paddlefish tagged in 2010 were also detected in 2011. Five of those paddlefish (83%) were detected moving back upstream to Millers Ferry dam between late January and early March. One paddlefish continued moving past Millers Ferry on March 14th and was detected moving up to ARk 303 near the Cahaba River, before moving back downstream where it was last detected at ARk 252. The remaining fish that returned to the tailrace area of Millers Ferry proceeded back downstream and were last detected above Claiborne dam, and 1 continued moving downstream past Claiborne and was last detected at ARk 87. Five moved downstream and remained in the vicinity of the tailrace area below Millers Ferry dam between ARk 188 and 209. Nine continued moving downstream and were detected above Claiborne dam. Four moved downstream past Claiborne dam and were detected in the reaches of the lower Alabama River between ARk 87 to 104.

Only 1 other individual was detected moving upstream past Millers Ferry dam in 2010. A largemouth bass anchor tagged below Millers Ferry was caught by an angler 0.75 km upstream of the lock chamber. The other largemouth bass was last detected at Millers Ferry dam, along with a Sm. buffalo. Two striped bass were tracked moving downstream over Claiborne dam where they were last detected at ARk 104. All six Southeastern bluesuckers moved downstream from Millers Ferry to Claiborne dam in the spring of 2010. Four (67%) continued moving downstream over Claiborne and were detected the area directly below the dam down to ARk 104. One bluesucker was detected the following sampling season further downstream at ARk 67.

In 2011, monitored the movements of 17 paddlefish, 9 highfin carpsuckers, 7 Sm. buffalo, 6 quillbacks, 4 Alabama bass, 3 Southeastern bluesuckers, 3 striped bass, and 1 anchor tagged striped mullet released below Claiborne Dam. Paddlefish on average moved upstream 41 km after release (Figure 7). Only 6 paddlefish (35%) were unsuccessful in moving upstream beyond Claiborne dam. Four paddlefish were detected moving upstream of Claiborne dam at ARk 120, seven fish continued moving upstream to the tailrace area below Millers Ferry dam and remained in the area from March 12th – April 19th before moving back downstream to Claiborne. Most paddlefish moved downstream on average 28 km (Figure 8) and were last detected at ARk 104, two remained in the tailrace area below Claiborne dam, and 4 were detected further downstream. One paddlefish remained at ARk 87, 3 continued moving downstream to the reaches of the lower Alabama River near ARk 16, with 1 detected moving up the Tombigbee River in June.

The other species tracked below Claiborne dam in 2011 also showed the ability to make long distance movements on the Alabama River. Seven highfin carpsuckers were tracked from the vicinity of Claiborne dam down to ARk 16. Three fish remained in the tailrace area directly below the dam; three continued moving downstream and were last detected at ARk 104. Two highfin carpsuckers continued moving downstream, where one was last detected at ARk 67 and one on the lowest receiver at ARk 16. Sm. buffalo displayed similar movement patterns, however 2 moved upstream of Claiborne dam during high flows. Most Sm. buffalo moved downstream and were last detected at ARk 104 or in the tailrace area directly below the dam. One fish continued moving downstream and was last detected at ARk 87. The two fish that passed upstream of Claiborne were detected at Millers Ferry for nearly a month, from March 16th to April 12th, before moving back downstream over Claiborne dam where they remained in the tailrace area between ARk 109 to 117. Only one quillback released below the dam remained in the tailrace area, most moved downstream to ARk 104. One quillback continued moving downstream and was detected near Eureka landing at ARk 67. Four Alabama bass anchor tagged below Claiborne were caught from 24 to 237 days after release within 8 km of where they were released. One anchor tagged striped mullet was detected moving downstream, where it was caught by an angler 101 km downstream in the Alabama River cutoff. Two striped bass and 1 southeastern bluesucker were never detected leaving the area directly below Claiborne dam. One striped bass continued to move downstream to occupy an area near ARk 87, where several other individuals representing multiple species have been detected. Two Southeastern bluesuckers moved downstream and were detected at ARk 97 and ARk 67.

A total of 28 paddlefish, 13 Sm. buffalo, 7 highfin carpsuckers, 1 quillback, 1 Southeastern bluesucker, 1 blacktail redhorse, 1 striped bass, 1 Alabama bass, and an anchor tagged blue catfish released below Millers Ferry dam in 2011 were tracked through the remainder of the study. Similar to 2010, the upstream movements of most fish were restricted by Millers Ferry Dam. Paddlefish on average moved only 3.76 km upstream from release site (Figure 9). Of the 28 paddlefish tracked, 26 (93%) were never detected beyond Millers Ferry dam. Only 2 (7%) fish continued moving upstream into Bill Dannelly Reservoir; one was manually tracked at ARk 220, 6 km upstream of the dam, and the other was detected on a receiver deployed on the Alabama River near the Cahaba River. Most fish (61%) at Millers Ferry moved downstream in the spring, shortly after release to occupy the reach between Claiborne and Millers Ferry dams. Ten fish continued moving downstream past Claiborne and were detected in the tailrace area, ARk 104, and the lower reaches of the Alabama River near ARk 16. The furthest distance moved for any paddlefish tagged at Millers Ferry were by 2 fish detected moving approximately 245 km downstream, past Claiborne dam to the Mobile River, and up the Tombigbee. On average, paddlefish moved 85 km downstream of the dam (Figure 10).

One blacktail redhorse, one Alabama bass, and a blue catfish all were last detected directly below the powerhouse. Additionally, 4 Sm. buffalo were last detected in the vicinity of Millers Ferry Dam. Five continued moving downstream to occupy the river, somewhere between Claiborne and Millers Ferry dam. Four Sm. buffalo made it down to Claiborne Dam. However, only 1 actually continued moving downstream past the dam, where it was last detected at on a receiver deployed at ARk 104. A quillback and striped bass were last detected moving downstream at ARk 209. The only Southeastern bluesucker tracked was detected moving downstream to the area directly above Claiborne dam in the spring, before moving back up to Millers Ferry where it remained for a month and a half before being detected back down near Claiborne in the fall.

APPENDIX III

LOCK OPERATION SPREADSHEET, CLAIBORNE AND MILLERS FERRY LOCKS AND DAMS

FEBRUARY – MAY, 2010 AND 2011

Appendix III

Claiborne Lock operation spreadsheet 2010. LGO Times indicate times lower lock gates were opened. UGO Times indicate times upper lock gates were opened. Lock Times indicate timing/number of normal lock operations at dam.

Date	L G O Times	Lock Times	U G O Times	Lock Times	L G O Times	Lock Times	U G O Times	Lock Times
2/1/2010	-	-	-	-	-	-	-	-
2/2/2010	-	-	-	-	-	-	-	-
2/3/2010	-	-	-	-	-	-	-	-
2/4/2010	-	-	-	-	-	-	-	-
2/5/2010	-	-	-	-	-	-	-	-
2/6/2010	-	-	-	-	-	-	-	-
2/7/2010	-	-	-	-	-	-	-	-
2/8/2010	-	-	-	-	-	-	-	-
2/9/2010	-	-	-	-	-	-	-	-
2/10/2010	-	-	-	-	-	-	-	-
2/11/2010	-	-	-	-	-	-	-	-
2/12/2010	-	-	-	-	-	-	-	-
2/13/2010	-	-	-	-	-	-	-	-
2/14/2010	-	-	-	-	-	-	-	-
2/15/2010	-	-	-	-	-	-	-	-
2/16/2010	-	-	-	-	-	-	-	-
2/17/2010	-	-	-	-	-	-	-	-
2/18/2010	-	-	-	-	-	-	-	-
2/19/2010	-	-	-	-	-	-	-	-
2/20/2010	-	-	-	-	-	-	-	-
2/21/2010	-	-	-	-	-	-	-	-
2/22/2010	-	-	-	-	-	-	-	-
2/23/2010	-	-	-	-	-	-	-	-
2/24/2010	-	-	-	-	-	-	-	-
2/25/2010	-	-	-	-	-	-	-	-
2/26/2010	-	-	-	-	-	-	-	-
2/27/2010	-	-	-	-	-	-	-	-
2/28/2010	-	-	-	-	-	-	-	-
3/1/2010	-	-	-	-	-	-	-	-
3/2/2010	-	-	-	-	-	-	-	-
3/3/2010	-	-	-	-	-	-	-	-

Date	L G O Times	Lock Times	U G O Times	Lock Times	L G O Times	Lock Times	U G O Times	Lock Times
3/4/2010	-	-	-	-	-	-	-	-
3/5/2010	-	-	-	-	-	-	-	-
3/6/2010	-	-	-	-	-	-	-	-
3/7/2010	-	-	-	-	-	-	-	-
3/8/2010	-	-	-	-	-	-	-	-
3/9/2010	-	-	-	-	-	-	-	-
3/10/210	-	-	-	-	-	-	-	-
3/11/210	-	-	-	-	-	-	-	-
3/12/210	-	-	-	-	-	-	-	-
3/13/210	-	-	-	-	-	-	-	-
3/14/210	-	-	-	-	-	-	-	-
3/15/2010	-	-	-	-	-	-	-	-
3/16/2010	-	-	-	-	-	-	-	-
3/17/2010	-	-	-	-	-	-	-	-
3/18/2010	-	-	-	-	-	-	-	-
3/19/2010	-	-	-	-	-	-	-	-
3/20/2010	-	-	-	-	-	-	-	-
3/21/2010	-	-	-	-	-	-	-	-
3/22/2010	-	-	-	-	-	-	-	-
3/23/2010	-	-	-	-	-	-	-	-
3/24/2010	-	-	-	-	-	-	-	-
3/25/2010	-	-	-	-	-	-	-	-
3/26/2010	-	-	-	-	-	-	-	-
3/27/2010	-	-	-	-	-	-	-	-
3/28/2010	-	-	-	-	-	-	-	-
3/29/2010	-	-	-	-	-	-	-	-
3/30/2010	-	-	-	-	-	-	-	-
3/31/2010	400	-	1000	5	1600	1	2200	1
4/1/2010	400	1	1000	1	1600	-	2200	-
4/2/2010	400	-		1		-		-
4/3/2010	400	-	1000		1600	-	2200	-
4/4/2010	400	-	1000		1600	-	2200	-
4/5/2010	400	-	-	-	-	-	-	-
4/6/2010	-	-	-	-	-	-	-	-
4/7/2010	-	-	-	-	-	-	-	-
4/8/2010	400	-	-	-	-	-	-	-
4/9/2010	400	-	1000		1600	-	2200	-
4/10/201	400	-	-	-	-	-	-	-

Date	L G O Times	Lock Times	U G O Times	Lock Times	L G O Times	Lock Times	U G O Times	Lock Times
4/11/201	-	-	-	-	-	-	-	-
4/12/2010	-	-	-	-	-	-	-	-
4/13/2010	-	-	-	-	-	-	-	-
4/14/2010	-	-	-	4	1600	-	2200	-
4/15/2010	400	-	1000	3	1600	1	2200	-
4/16/2010	400	-	1000	-	1600		2200	-
4/17/2010	400	-	1000	-	1600	2	2200	-
4/18/2010	400	-	1000	-	1600	-	2200	-
4/19/2010	400	-	1000	1	1600	-	2200	-
4/20/2010	400	-	1000	-	1600	-	2200	-
4/21/2010	400	-	1000	-	1600	-	2200	-
4/22/2010	400	-	1000	-	1600	-	2200	-
4/23/2010	400	-	1000	-	1600	-	2200	-
4/24/2010	400	-	1000	-	1600	-	2200	-
4/25/2010	400	-	1000	-	1600	-	2200	-
4/26/2010	-	-	-	-	-	-	-	-
4/27/2010	-	-	-	-	-	-	-	-
4/28/2010	-	-	-	-	-	-	-	-
4/29/2010	-	-	-	-	-	-	-	-
4/30/2010	-	-	-	-	-	-	-	-
5/1/2010	-	-	-	-	-	-	-	-
5/2/2010	-	-	-	-	-	-	-	-
5/3/2010	-	-	-	-	-	-	-	-
5/4/2010	-	-	-	-	-	-	-	-
5/5/2010	-	-	-	-	-	-	-	-
5/6/2010	-	-	-	-	-	-	-	-
5/7/2010	-	-	-	-	-	-	-	-
5/8/2010	-	-	-	-	-	-	-	-
5/9/2010	-	-	-	-	-	-	-	-
5/10/2010	-	-	-	-	-	-	-	-
5/11/2010	-	-	-	-	-	-	-	-
5/12/2010	400	-	1000	-	1600	-	2000	-
5/13/2010	400	-	1000	-	1600	-	2000	-
5/14/2010	400	-	1000	-	1600	-	2000	-
5/15/2010	400	-	1000	1	1600	1	2000	-
5/16/2010	400	-	1000	-	1600	-	2000	-
5/17/2010	400	-	1000	-	1600	-	2000	-
5/18/2010	400	-	1000	-	1600	-	2000	-

Date	L G O Times	Lock Times	U G O Times	Lock Times	L G O Times	Lock Times	U G O Times	Lock Times
5/19/2010	-	-	-	-	-	-	-	-
5/20/2010	-	-	-	-	-	-	-	-
5/21/2010	400	-	1000	-	1600	-	2000	-
5/22/2010	400	-	1000	-	1600	2	2000	-
5/23/20`0	400	-	-	-	-	-	-	-
5/24/2010	-	-	-	-	-	-	-	-
5/25/2010	-	-	-	-	-	-	-	-
5/26/2010	-	-	-	-	-	-	-	-
5/27/2010	-	-	-	-	-	-	-	-
5/28/2010	400	-	1000	-	1600	-	2000	-
5/29/2010	400	-	1000	1	1600	-	2000	1
5/30/2010	400	-	1000	-	1600	-	2000	-
5/31/2010	400	-	1000	-	1600	-	2000	-

Appendix III

Millers Ferry Lock operation spreadsheet 2010. LGO Times indicate times lower lock gates were opened. UGO Times indicate times upper lock gates were opened. Lock Times indicate timing/number of normal lock operations at dam.

Date	L G O Times	Lock Times	U G O Times	Lock Times	L G O Times	Lock Times	U G O Times	Lock Times
2/1/10	600	-	1000	-	1800	-	2200	-
2/2/10	600	-	1000	-	1800	-	2200	-
2/3/10	600	-	1000	-	1800	-	2200	-
2/4/10	600	-	1000	-	1800	-	2200	-
2/5/10	600	-	1000	-	1800	-	2200	-
2/6/10	600	700	830	1000	1800	1045	2200	-
2/7/10	600	-	1000	-	1800	-	2200	-
2/8/10	600	-	1000	-	1800	-	2200	-
2/9/10	600	-	1000	-	1800	-	2200	-
2/10/10	600	-	1000	-	1800	-	2200	-
2/11/10	600	-	1000	-	1800	-	2200	-
2/12/10	600	-	1000	-	1800	-	2200	-
2/13/10	600	-	1000	-	1800	-	2200	-
2/14/10	600	-	1000	-	1800	-	2200	-
2/15/10	600	-	1000	-	1800	-	2200	-
2/16/10	600	-	1000	-	1800	-	2200	-
2/17/10	600	-	1000	-	1800	-	2200	-
2/18/10	600	-	1000	-	1800	-	2200	-
2/19/10	600	740	1000	1145	1800	-	2200	-
2/20/10	600	655	1000	745	1800	840	2200	1015
2/21/10	600	-	1000	-	1800	-	2200	-
2/22/10	600	-	1000	-	1800	-	2200	-
2/23/10	600	-	1000	-	1800	-	2200	-
2/24/10	600	-	1000	-	1800	-	2200	-
2/25/10	600	-	1000	-	1800	-	2200	-
2/26/10	600	-	1000	-	1800	-	2200	-
2/27/10	600	700	1000	1300	1800	-	2200	-
2/28/10	600	-	1000	-	1800	-	2200	-
3/1/10	600	-	1000	-	1800	-	2200	-
3/2/10	600	-	1000	-	1800	-	2200	-
3/3/10	600	-	1000	-	1800	-	2200	-

Date	L G O Times	Lock Times	U G O Times	Lock Times	L G O Times	Lock Times	U G O Times	Lock Times
3/4/10	600	-	1000	-	1800	-	2200	-
3/5/10	600	-	1000	-	1800	-	2200	-
3/6/10	600	-	830	-	1800	-	2200	-
3/7/10	600	-	1000	-	1800	-	2200	-
3/8/10	600	-	1000	-	1800	-	2200	-
3/9/10	600	-	1000	-	1800	-	2200	-
3/10/10	600	-	1000	-	1800	-	2200	-
3/11/10	600	-	1000	-	1800	-	2200	-
3/12/10	600	-	1000	-	1800	-	2200	-
3/13/10	600	-	1000	-	1800	-	2200	-
3/14/10	600	-	1000	-	1800	-	2200	-
3/15/10	600	-	1000	-	1800	-	2200	-
3/16/10	600	-	1000	-	1800	-	2200	-
3/17/10	600	-	1000	-	1800	-	2200	-
3/18/10	600	-	1000	-	1800	-	2200	-
3/19/10	600	-	1000	-	1800	-	2200	-
3/20/10	600	725	1000	-	1800	-	2200	-
3/21/10	600	-	1000	-	1800	-	2200	-
3/22/10	600	-	1000	-	1800	-	2200	-
3/23/10	600	-	1000	-	1800	-	2200	-
3/24/10	600	700	1000	1230	1800	-	2200	-
3/25/10	600	-	1000	-	1800	-	2200	-
3/26/10	600	1410	1000	-	1800	-	2200	-
3/27/10	600	740	1000	810	1800	845	2200	1230
3/28/10	600	-	1000	-	1800	-	2200	-
03/29/10	600	-	1000	-	1800	-	2200	-
3/30/10	600	1230	1630	-	1800	-	2200	-
3/31/10	700	-	1630	-	1800	-	2200	-
4/1/10	645	-	330	-	1800	-	2200	-
4/2/10	630	-	1150	-	1800	-	2200	-
4/3/10	600	-	1000	-	1800	-	2200	-
4/4/10	600	-	1000	-	1800	-	2200	-
4/5/10	710	-	1600	-	1800	-	2200	-
4/6/10	650	-	1600	-	1800	-	2200	-
4/7/10	710	-	1200	-	1800	-	2200	-
4/8/10	600	-	1000	-	1800	-	2200	-
4/9/10	600	-	1000	-	1800	-	2200	-
4/10/10	600	-	1000	-	1800	-	2200	-

Date	L G O Times	Lock Times	U G O Times	Lock Times	L G O Times	Lock Times	U G O Times	Lock Times
4/11/10	600	-	1000	-	1800	-	2200	-
4/12/10	600	-	1000	-	1800	-	2200	-
4/13/10	600	-	1000	-	1800	-	2200	-
4/14/10	600	-	1000	1530	1800	-	2200	-
4/15/10	600	-	1000	1035	1800	1145	2200	-
4/16/10	600	-	1000	-	1800	-	2200	-
4/17/10	600	-	1000	-	1800	-	2200	-
4/18/10	600	-	1000	-	1800	-	2200	-
4/19/10	600	825	1000	930	1800	1645	2200	-
4/20/10	600	705	1000	1010	1800	1320	2200	1435
4/21/10	600	805	1000	1715	1800	-	2200	-
4/22/10	600	1345	1000	1450	1800	1530	2200	1730
4/23/10	600	730	1000	1000	1800	1030	2200	1340
4/24/10	600	750	1000	1700	1800	-	2200	-
4/25/10	600	710	1000	1700	1800	-	2200	-
4/26/10	600	1000		1200	1800	1500	2200	1700
4/27/10	600	1030	1000	1255	1800	-	2200	-
4/28/10	600	1300	1000	1530	1800	-	2200	-
04/29/10	600	-	1000	-	1800	-	2200	-
4/30/10	600	-	1630	-	1800	-	2200	-
5/1/10	-	-	-	-	-	-	-	-
5/2/10	-	-	-	-	-	-	-	-
5/3/10	-	-	-	-	-	-	-	-
5/4/10	-	-	-	-	-	-	-	-
5/5/10	-	-	-	-	-	-	-	-
5/6/10	-	-	-	-	-	-	-	-
5/7/10	-	-	-	-	-	-	-	-
5/8/10	-	-	-	-	-	-	-	-
5/9/10	-	-	-	-	-	-	-	-
5/10/10	-	-	-	-	-	-	-	-
5/11/10	-	-	-	-	-	-	-	-
5/12/10	-	-	-	-	-	-	-	-
5/13/10	-	-	-	-	-	-	-	-
5/14/10	-	-	-	-	-	-	-	-
5/15/10	-	-	-	-	-	-	-	-
5/16/10	-	-	-	-	-	-	-	-
5/17/10	-	-	-	-	-	-	-	-
5/18/10	-	-	-	-	-	-	-	-

Date	L G O Times	Lock Times	U G O Times	Lock Times	L G O Times	Lock Times	U G O Times	Lock Times
5/19/10	-	-	-	-	-	-	-	-
5/20/10	-	-	-	-	-	-	-	-
5/21/10	-	-	-	-	-	-	-	-
5/22/10	-	-	-	-	-	-	-	-
5/23/10	-	-	-	-	-	-	-	-
5/24/10	-	-	-	-	-	-	-	-
5/25/10	-	-	-	-	-	-	-	-
5/26/10	-	-	-	-	-	-	-	-
5/27/10	-	-	-	-	-	-	-	-
5/28/10	-	-	-	-	-	-	-	-
5/29/10	-	-	-	-	-	-	-	-
5/30/10	-	-	-	-	-	-	-	-
5/31/10	-	-	-	-	-	-	-	-

Appendix III

Claiborne Lock operation spreadsheet 2011. LGO Times indicate times lower lock gates were opened. UGO Times indicate times upper lock gates were opened. Lock Times indicate timing/number of normal lock operations at dam.

Date	L G O Times	Lock Times	U G O Times	Lock Times	L G O Times	Lock Times	U G O Times	Lock Times
2/1/2011	1000	-	1600	-	2200	-	0400	-
2/2/2011	-	-	-	-	-	-	-	-
2/3/2011	-	-	-	-	-	-	-	-
2/4/2011	-	-	-	-	-	-	-	-
2/5/2011	-	-	-	-	-	-	-	-
2/6/2011	-	-	-	-	-	-	-	-
2/7/2011	-	-	-	-	-	-	-	-
2/8/2011	-	-	-	-	-	-	-	-
2/9/2011	-	-	-	-	-	-	-	-
2/10/2011	-	-	-	-	-	-	-	-
2/11/2011	-	2	-	-	-	-	-	-
2/12/2011	-	-	-	-	-	-	-	-
2/13/2011	-	-	-	-	-	-	-	-
2/14/2011	1000	-	1600	-	2200	-	0400	-
2/15/2011	1000	-	1600	-	2200	-	0400	-
2/16/2011	1000	-	1600	-	2200	-	0400	-
2/17/2011	1000	-	1600	-	2200	-	0400	-
2/18/2011	1000	-	1600	-	2200	-	0400	-
2/19/2011	1000	-	1600	-	2200	-	0400	-
2/20/2011	1000	1	1600	-	2200	-	0400	-
2/21/2011	1000	-	1600	-	2200	-	0400	-
2/22/2011	1000	-	1600	-	2200	-	0400	-
2/23/2011	1000	-	1600	-	2200	-	0400	-
2/24/2011	1000	1	1600	-	2200	-	0400	-
2/25/2011	1000	-	1600	-	2200	-	0400	-
2/26/2011	1000	-	1600	-	2200	-	0400	-
2/27/2011	1000	-	1600	-	2200	-	0400	-
2/28/2011	1000	-	1600	-	2200	-	0400	-
3/1/2011	1000	-	1600	-	2200	-	0400	0800
3/2/2011	1000	-	1600	-	2200	-	0400	-
3/3/2011	1000	-	-	-	-	-	-	-

Date	L G O Times	Lock Times	U G O Times	Lock Times	L G O Times	Lock Times	U G O Times	Lock Times
3/4/2011	-	-	-	-	-	-	-	-
3/5/2011	-	-	-	-	-	-	-	-
3/6/2011	-	-	-	-	-	-	-	-
3/7/2011	-	-	-	-	-	-	-	-
3/8/2011	-	-	-	-	-	-	-	-
3/9/2011	-	-	-	-	-	-	-	-
3/10/2011	-	-	-	-	-	-	-	-
3/11/2011	-	-	-	-	-	-	-	-
3/12/2011	-	-	-	-	-	-	-	-
3/13/2011	-	-	-	-	-	-	-	-
3/14/2011	-	-	-	-	-	-	-	-
3/15/2011	-	-	-	-	-	-	-	-
3/16/2011	-	-	-	-	-	-	-	-
3/17/2011	-	-	-	-	-	-	-	-
3/18/2011	-	-	-	-	-	-	-	-
3/19/2011	-	-	-	-	-	-	-	-
3/20/2011	1000	-	1600	-	2200	-	0400	-
3/21/2011	1000	-	1600	-	2200	-	0400	-
3/22/2011	1000	-	1600	-	2200	-	0400	-
3/23/2011	1000	-	1600	-	2200	-	0400	-
3/24/2011	1000	-	1600	-	2200	-	0400	-
3/25/2011	1000	-	1600	1700	2200	-	0400	-
3/26/2011	1000	-	1600	1400	2200	-	0400	0800
3/27/2011	1000	-	1600	-	2200	-	0400	-
3/28/2011	1000	-	1600	-	2200	-	0400	-
3/29/2011	1000	-	1600	-	2200	-	0400	-
3/30/2011	1000	-	1600	-	2200	-	0400	-
3/31/2011	1000	-	1600	-	2200	-	0400	-
4/1/2011	1000	-	1600	-	2200	-	-	0400
4/2/2011	-	-	-	-	-	-	-	-
4/3/2011	-	-	-	-	-	-	-	-
4/4/2011	-	-	-	-	-	-	-	-
4/5/2011	-	-	-	-	-	-	-	-
4/6/2011	-	-	-	-	-	-	-	-
4/7/2011	-	-	-	-	-	-	-	-
4/8/2011	-	-	-	-	-	-	-	-
4/9/2011	-	-	-	-	-	-	-	-
4/10/2011	-	-	-	-	-	-	-	-

Date	L G O Times	Lock Times	U G O Times	Lock Times	L G O Times	Lock Times	U G O Times	Lock Times
4/11/2011	-	-	-	-	-	-	-	-
4/12/2011	-	-	-	-	-	-	-	-
4/13/2011	-	-	-	-	-	-	-	-
4/14/2011	-	-	-	-	-	-	-	-
4/15/2011	-	-	-	-	-	-	-	-
4/16/2011	-	-	-	-	-	-	-	-
4/17/2011	-	-	-	-	-	-	-	-
4/17/2011	-	-	-	-	-	-	-	-
4/18/2011	-	-	-	-	-	-	-	-
4/19/2011	-	-	-	-	-	-	-	-
4/20/2011	-	-	-	-	-	-	-	-
4/21/2011	-	-	-	-	-	-	-	-
4/22/2011	-	-	-	-	-	-	-	-
4/23/2011	-	-	-	-	-	-	-	-
4/24/2011	-	-	-	-	-	-	-	-
4/25/2011	-	-	-	-	-	-	-	-
4/26/2011	-	-	-	-	-	-	-	-
4/27/2011	1000	-	1600	2000	2200	-	-	0400
4/28/2011	1000	-	1600	-	2200	-	-	0400
4/29/2011	1000	1415	1600	-	2200	-	-	0400
4/30/2011	1000	1000	1600	1600	2200	-	-	0400
5/1/2011	1000	-	1600	-	2200	-	0400	-
5/2/2011	-	-	-	-	-	-	-	-
5/3/2011	-	-	-	-	-	-	-	-
5/4/2011	-	-	-	-	-	-	-	-
5/5/2011	1000	-	1600	-	2200	-	0400	-
5/6/2011	1000	-	1600	-	2200	-	0400	-
5/7/2011	1000	-	1600	-	2200	-	0400	-
5/8/2011	1000	-	1600	-	2200	-	0400	-
5/9/2011	1000	-	1600	-	2200	-	0400	-
5/10/2011	1000	-	1600	-	2200	-	0400	-
5/11/2011	-	-	-	-	-	-	-	-
5/12/2011	-	-	-	-	-	-	-	-
5/13/2011	-	-	-	-	-	-	-	-
5/14/2011	-	-	-	-	-	-	-	-
5/15/2011	-	-	-	-	-	-	-	-
5/16/2011	-	-	-	-	-	-	-	-
5/17/2011	-	-	-	-	-	-	-	-

Date	L G O Times	Lock Times	U G O Times	Lock Times	L G O Times	Lock Times	U G O Times	Lock Times
5/18/2011	-	-	-	-	-	-	-	-
5/19/2011	-	-	-	-	-	-	-	-
5/20/2011	-	-	-	-	-	-	-	-
5/21/2011	-	-	-	-	-	-	-	-
5/22/2011	-	-	-	-	-	-	-	-
5/23/2011	-	-	-	-	-	-	-	-
5/24/2011	-	-	-	-	-	-	-	-
5/25/2011	-	-	-	-	-	-	-	-
5/26/2011	-	-	-	-	-	-	-	-
5/27/2011	-	-	-	-	-	-	-	-
5/28/2011	-	-	-	-	-	-	-	-
5/29/2011	-	-	-	-	-	-	-	-
5/30/2011	-	-	-	-	-	-	-	-
5/31/2011	-	-	-	-	-	-	-	-

Appendix III

Millers Ferry Lock operation spreadsheet 2011. LGO Times indicate times lower lock gates were opened. UGO Times indicate times upper lock gates were opened. Lock Times indicate timing/number of normal lock operations at dam.

Date	L G O Times	Lock Times	U G O Times	Lock Times	L G O Times	Lock Times	U G O Times	Lock Times
2/1/11	-	-	-	-	-	-	-	-
2/2/11	-	-	-	-	-	-	-	-
2/3/11	-	-	-	-	-	-	-	-
2/4/11	-	-	-	-	-	-	-	-
2/5/11	-	-	-	-	-	-	-	-
2/6/11	-	-	-	-	-	-	-	-
2/7/11	-	-	-	-	-	-	-	-
2/8/11	-	-	-	-	-	-	-	-
2/9/11	-	-	-	-	-	-	-	-
2/10/11	1500	650	1000	720	-	1230	-	1300
2/11/11	1500	-	1000	-	-	-	-	-
2/12/11	1500	-	1000	-	-	-	-	-
2/13/11	1500	-	1000	-	-	-	-	-
2/14/11	1500	-	1000	-	-	-	-	-
2/15/11	1500	-	1000	-	-	-	-	-
2/16/11	1500	700	1000	930	-	-	-	-
2/17/11	1500	800	1000	1145	-	-	-	-
2/18/11	1500	1045	1000	1205	-	1300	-	1500
2/19/11	1500	600	1000	630	-	700	-	1300
2/20/11	1500	1430	1000	-	-	-	-	-
2/21/11	1500	-	1000	-	-	-	-	-
2/22/11	1500	755	1000	815	-	1300	-	-
2/23/11	1500	1030	1000	1330	-	-	-	-
2/24/11	1500	600	1000	600	-	-	-	-
2/25/11	1500	-	1000	-	-	-	-	-
2/26/11	1500	-	1000	-	-	-	-	-
2/27/11	1500	-	1000	-	-	-	-	-
2/28/11	1500	-	1000	-	-	-	-	-
3/1/11	1500	-	1000	-	-	-	-	-
3/2/11	1500	-	1000	-	-	-	-	-
3/3/11	1500	-	1000	-	-	-	-	-

Date	L G O Times	Lock Times	U G O Times	Lock Times	L G O Times	Lock Times	U G O Times	Lock Times
3/4/11	1500	-	1000	-	-	-	-	-
3/5/11	1500	-	1000	-	-	-	-	-
3/6/11	1500	-	100	-	-	-	-	-
3/7/11	1500	-	1000	-	-	-	-	-
3/8/11	1500	-	1000	-	-	-	-	-
3/9/11	1500	-	1000	-	-	-	-	-
3/10/11	1500	-	1000	-	-	-	-	-
3/11/11	1500	-	1000	-	-	-	-	-
3/12/11	1500	-	1000	-	-	-	-	-
3/13/11	1500	-	1000	-	-	-	-	-
3/14/11	1500	-	1000	-	-	-	-	-
3/15/11	-	-	-	-	-	-	-	-
3/16/11	-	-	-	-	-	-	-	-
3/17/11	-	-	-	-	-	-	-	-
3/18/11	-	-	-	-	-	-	-	-
3/19/11	-	-	-	-	-	-	-	-
3/20/11	-	-	-	-	-	-	-	-
3/21/11	-	-	-	-	-	-	-	-
3/22/11	-	-	-	-	-	-	-	-
3/23/11	-	-	-	-	-	-	-	-
3/24/11	-	-	-	-	-	-	-	-
3/25/11	1500	800	1000	1030	-	1200	-	1420
3/26/11	1500	-	1000	-	-	-	-	-
3/27/11	1500	-	1000	-	-	-	-	-
3/28/11	-	-	-	-	-	-	-	-
03/29/11	-	-	-	-	-	-	-	-
3/30/11	-	-	-	-	-	-	-	-
3/31/11	-	-	-	-	-	-	-	-
4/1/11	-	-	-	-	-	-	-	-
4/2/11	-	-	-	-	-	-	-	-
4/3/11	1500	-	1000	-	-	-	-	-
4/4/11	1500	-	1000	-	-	-	-	-
4/5/11	1500	745	1000	815	-	-	-	-
4/6/11	-	-	-	-	-	-	-	-
4/7/11	-	-	-	-	-	-	-	-
4/8/11	-	-	-	-	-	-	-	-
4/9/11	1500	-	1000	-	-	-	-	-
4/10/11	1500	-	1000	-	-	-	-	-

Date	L G O Times	Lock Times	U G O Times	Lock Times	L G O Times	Lock Times	U G O Times	Lock Times
4/11/11	-	-	-	-	-	-	-	-
4/12/11	-	-	-	-	-	-	-	-
4/13/11	-	-	-	-	-	-	-	-
4/14/11	-	-	-	-	-	-	-	-
4/15/11	-	-	-	-	-	-	-	-
4/16/11	1500	-	1000	-	-	-	-	-
4/17/11	1500	-	1000	-	-	-	-	-
4/18/11	-	-	-	-	-	-	-	-
4/19/11	-	-	-	-	-	-	-	-
4/20/11	-	-	-	-	-	-	-	-
4/21/11	-	-	-	-	-	-	-	-
4/22/11	-	-	-	-	-	-	-	-
4/23/11	1500	-	1000	-	-	-	-	-
4/24/11	1500	800	1000	810	-	-	-	-
4/25/11	-	-	-	-	-	-	-	-
4/26/11	-	-	-	-	-	-	-	-
4/27/11	1500	-	1000	-	-	-	-	-
4/28/11	1500	-	1000	-	-	-	-	-
04/29/11	1500	-	1000	-	-	-	-	-
4/30/11	1500	-	1000	-	-	-	-	-
5/1/2011	1500	-	1000	-	-	-	-	-
5/2/2011	1500	-	1000	-	-	-	-	-
5/3/2011	1500	-	1000	-	-	-	-	-
5/4/2011	1500	-	1000	-	-	-	-	-
5/5/2011	1500	-	1000	-	-	-	-	-
5/6/2011	1500	-	1000	-	-	-	-	-
5/7/2011	1500	-	1000	-	-	-	-	-
5/8/2011	1500	-	1000	-	-	-	-	-
5/9/2011	1500	-	1000	-	-	-	-	-
05/10/11	1500	-	1000	-	-	-	-	-
5/11/11	1500	-	1000	-	-	-	-	-
5/12/11	1500	-	1000	-	-	-	-	-
5/13/11	1500	-	1000	-	-	-	-	-
5/14/11	1500	-	1000	-	-	-	-	-
5/15/11	1500	-	1000	-	-	-	-	-
5/16/11	1500	-	1000	-	-	-	-	-
5/17/11	1500	-	1000	-	-	-	-	-
5/18/11	1500	-	1000	-	-	-	-	-

Date	L G O Times	Lock Times	U G O Times	Lock Times	L G O Times	Lock Times	U G O Times	Lock Times
5/19/11	1500	-	1000	-	-	-	-	-
5/20/11	1500	900	1000	930	-	-	-	-
5/21/11	1500	600	1000	645	-	945	-	1000
5/22/11	1500	-	1000	-	-	-	-	-
5/23/11	1500	-	1000	-	-	-	-	-
5/24/11	1500	-	1000	-	-	-	-	-
5/25/11	1500	-	1000	-	-	-	-	-
5/26/11	1500	-	1000	-	-	-	-	-
5/27/11	1500	-	1000	-	-	-	-	-
5/28/11	1500	-	1000	-	-	-	-	-
5/29/11	1500	-	1000	-	-	-	-	-
5/30/11	1500	-	1000	-	-	-	-	-
5/31/11	1500	-	1000	-	-	-	-	-