Blue Sucker Movement and Habitat Use in the Lower Sabine River, Texas

FINAL REPORT

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Table of Contents

List of Figures

List of Tables

Appendices

Executive Summary

The Texas Instream Flow Program identified the Lower Sabine River as a priority sub-basin for conducting instream flow studies and during the study design process Blue Sucker was identified as a key or focal species due to its threatened status as well as flow dependent life history.

In 2010, The Texas Water Development Board (TWDB) contracted with Texas Parks and Wildlife Department (TPWD) to execute a study to characterize seasonal movements and habitat use in the lower Sabine River, Texas. As part of the contract, TPWD solicited Requests for Qualifications in March 2012 and managed the selection process. In July 2012, a subcontract with BIO-WEST, Inc. was executed to perform all project objectives including study design, equipment acquisition, and project execution. BIO-WEST submitted a draft report in June 2013 which documents the methods and results of tracking in 2012-2013. Based on the findings of that report, TPWD continued telemetry efforts through the 2014 Blue Sucker spawning season in attempts to document a spawning migration and habitat conditions for spawning adults. This report provides a summary of results from those efforts as well as the BIO-WEST final report (Appendix B).

In October 2012, TPWD and BIO-WEST began field efforts by collecting and tagging 60 fishes in the lower Sabine River. Fifty-six Blue Sucker, three Blacktail Redhorse, and one Spotted Sucker were implanted with a Combined Acoustic / Radio Transmitter (CART) or a smaller radio-only tag in order to facilitate tracking by telemetry. This resulted in 33 male Blue Sucker, 22 female, two juvenile, and two of unknown sex being tagged and released at their capture locations in the Sabine River.

Telemetry was conducted using both active and passive tracking techniques. Active tracking was accomplished using a receiver and Yagi-antenna, operated from either a boat or small fixed-wing aircraft. Upon discovery of a tagged fish, a GPS point, time, and general habitat characteristics were recorded for each fish. The Sabine River was actively tracked by BIO-WEST (2012-2013) and TPWD (2013-2014). Passive tracking involved the strategic placement of up to eight stationary Submersible Underwater Receivers (SURs) in the main channel of the river.

Although tracking indicated the importance of several areas in the Sabine River and its tributaries, no spawning migrations or aggregations were confirmed or observed in 2013 or 2014. Two juvenile Blue Sucker were collected during the tagging effort in October 2012. Based on their 266 mm total length they were estimated to be age-2 suggesting that recruitment occurred in the months following the 2010 spawning season. This study also documented that Blue Sucker associate with large woody debris, an abundant habitat feature in the lower Sabine River. Bayou Anacoco, a major tributary of the Sabine River, also served as habitat for adult Blue Sucker.

Funding for this project was provided through a grant from the Texas Water Development Board (TWDB Contract No. 1004831019).

Introduction

In 2001, the Texas Legislature addressed the importance of balancing human and environmental water needs. Senate Bill 2 directed the Texas Parks and Wildlife Department (TPWD), the Texas Commission on Environmental Quality (TCEQ) and the Texas Water Development Board (TWDB), in cooperation with other appropriate agencies, to "…jointly establish and continuously maintain an instream flow data collection and evaluation program…" In addition, the agencies were directed to "…conduct studies and analyses to determine appropriate methodologies for determining flow conditions in the state rivers and streams necessary to support a sound ecological environment." The Texas Instream Flow Program identified the Lower Sabine River as a priority sub-basin for conducting instream flow studies (TIFP 2002) and during the study design process for the lower Sabine River Blue Sucker was identified as a key or focal species due to its threatened status as well as its flow dependent life history.

In brief, Blue Sucker *Cycleptus elongatus* is a long-lived member of the Catostomid family of fishes, native to the Mississippi and Gulf Coast drainages of North America. Modifications to many large river systems throughout their range have altered habitat and blocked migration routes, resulting in a decline in the overall abundance and distribution of this species (Cross 1967; Williams 1989; Edwards et al. 2004). Blue Sucker is listed as threatened by the Texas Parks and Wildlife Department (TPWD). It inhabits large rivers but may utilize tributaries and other habitats for different life stages and activities. Blue Sucker is typically found in deep (1-2 m), fast riffles or rapids, where they feed on benthic invertebrates (Moss et al. 1983; Morey and Berry 2003; BIO-WEST 2006). Cobble, boulder, and bedrock substrates are commonly utilized. Spawning occurs when water temperatures are 12-18 °C, typically from February to April (Rupprecht and Jahn 1980; BIO-WEST 2006). Larval and juvenile Blue Sucker are rarely encountered and little information exists regarding their habitat requirements.

In Texas, Blue Sucker has been collected from the Sabine, Neches, Red, and Colorado river basins. An undescribed *Cycleptus* (Rio Grande Blue Sucker) occurs in the Rio Grande River (Buth and Mayden 2001; Bessert 2006).

Blue Sucker occurs in the Sabine River both upstream and downstream of Toledo Bend Reservoir. While recent fish community sampling conducted on the lower Sabine River documented the presence of Blue Sucker (SRA-TX et al. 2007; BIO-WEST 2011), very little is known of the population structure, distribution, or life history requirements in this river system.

In 2010, The Texas Water Development Board (TWDB) contracted with TPWD to execute a study to characterize seasonal movements and habitat use in the lower Sabine River (Appendix A: Scope of Work). As part of the contract, TPWD solicited Requests for Qualifications in March 2012 and managed the selection process. In July 2012, a subcontract with BIO-WEST, Inc. was executed to perform all project objectives including study design, equipment acquisition, and project execution. BIO-WEST submitted a draft report in June 2013 (final report included as Appendix B) which documents the methods and results of tracking in 2012-2013; revisions were made in 2015. Based on the findings of that report and discussions among study partners, TPWD continued telemetry efforts through the 2014 Blue Sucker spawning season in attempts to document habitat conditions for spawning adults. This report provides a summary of those efforts as well as the BIO-WEST report in Appendix B.

Methods

Study Area

A detailed description of the Study Area is found in Appendix B. In brief, the Sabine River Basin is nearly 10,000 square miles, and covers three ecoregions (Blackland Prairie, East Texas Timberlands, and Coastal Prairie). Its headwaters are in northwestern Hunt County, Texas, and it empties into Sabine Lake in Orange County, Texas. At river mile (RM) 148 is the southern end of Toledo Bend Reservoir, an 181,619 acre impoundment created by Toledo Bend Dam which was completed in 1969. The reservoir

and dam are used for hydropower, and regularly releases water for hydropeaking typically during the summer months. When generation is required, river flows quickly increase to 14,000 cubic feet per second (cfs) from base flow releases of about 144 cfs. Downstream of Toledo Bend Dam is the lower Sabine River (RM 148 – RM 0), which forms the border of Texas and Louisiana.

Fish Collections

Electrofishing was used in order to capture fishes for tag implantation using a Smith-Root 5.0 GPP electrofisher mounted to a 16-foot aluminum jon boat with adjustable boom. This method was deemed least stressful and result in high survival rates post-surgery. Other methods (trammel and/or hoop nets) are less successful in a riverine environment, and during a recent study performed by BIO-WEST (2011) no Blue Sucker was captured using hoop nets in the Sabine River. Upon capture, fishes were temporarily retained in a livewell on the electrofishing boat, but were quickly moved to a flow-through holding tank placed in the river prior to surgery.

Tagging

Fishes were tagged at 9 different tagging locations from RM 34 to RM 145 (though there were more "capture" locations due to surgery setup constraints). Two types of tags were used for these fishes: Combined acoustic-radio transmitters (CART) and radio-tags. CART tags emit both an acoustic and radio signal, and are thus able to be tracked both with submerged hydrophones and with radio antennas from above the water. Eight stationary Submersible Ultrasonic Receivers (SURs) were deployed throughout the river to passively track (via acoustic signal) any tagged fishes that pass or get near the SUR. Models and brands of telemetry equipment are reported in Appendix B. Combined acoustic/radio transmitter tags are larger in size, and therefore, were only put into adult fish. Radio-only tags are smaller and were initially saved for any juvenile Blue Sucker or other smaller species. However, only two juvenile Blue Sucker (Total Length [TL] = 266 mm for both), three Blacktail Redhorse *Moxostoma poecilurum*, and one Spotted Sucker *Minytrema melanops* were tagged with the radio-only tags. Therefore, the remaining radio-only tags were implanted into adult Blue Sucker. Both types of tags are uniquely coded for each fish, and thus allow for tracking of the 60 target fishes. Appendix B provides details and photographs of the implantation surgery.

Tracking

Details of active and passive tracking methods are included in Appendix B. In summary, eight tracking events were conducted by BIO-WEST in 2012and 2013. Although most tracking was conducted by boat, tracking was also conducted by plane during two events in 2013. Beginning in May 2013, TPWD with the assistance of BIO-WEST led active tracking including efforts in August 2013, February 2014, and April 2014 (two) in attempts to observe spawning movements or aggregations. Passive acoustic-tracking was accomplished by the deployment of Submersible Ultrasonic Receivers (SURs) at eight different locations in the Sabine River. SURs were deployed in October 2012 and all that could be relocated were removed by the end of April 2014. SUR 132 near Burkeville was stolen sometime before July 2013 and was replaced at an upstream location (near RM 133). Two SURs could not be relocated by the end of field efforts: SUR 36 near Deweyville due to continuous high flow conditions and SUR 64 downstream of Big Cow Creek due to a fallen tree and high flow conditions. However, these two SURs recorded few to zero contacts with tagged fishes during 2012-2013 (see Table 3 in Appendix B).

Spawning Site Characterization

One goal of this study was to locate spawning aggregations and thus determine where and when Blue Sucker reproduce in the Sabine River. Along with monitoring water temperatures, large upstream movements and identification of frequently used areas were used to help better define a spawning

window. Another method of determining spawning timing was to capture adult Blue Sucker and assess spawning condition. This was based on presence/absence of tubercles, and presence/absence of freely running milt or eggs. Assessment of spawning condition was performed by BIO-WEST in spring 2013 (March 27 and April 8) and by TPWD and staff from Texas Cooperative Fish and Wildlife Research Unit at Texas Tech University in spring 2014.

Sub-adult Habitat Use

Boat electrofishing and fish seines were utilized in habitats suspected of being rearing areas. Habitat conditions such as current velocity, depth, instream cover and substrate would be characterized if sub-adult (larval or juvenile stages) Blue Sucker were located. TPWD and BIO-WEST sampled Sabine River and Bayou Anacoco habitats in May 2013; TPWD and the Texas Cooperative Fish and Wildlife Research Unit at Texas Tech University sampled the lower Sabine River in September 2014 to collect sub-adult Blue Sucker that may have been spawned earlier in 2014.

Results

Tagging

The week of October 14, 2012 resulted in 60 fishes tagged and released over nine tagging locations (see Figures 2 and 3 in Appendix B). Flows on the river ranged from 272 to 999 cfs at Burkeville (RM 132) during this week. Of the 56 Blue Sucker tagged, 22 were female, 30 male, and four of undetermined sex. Of these, 45 were implanted with CART tags, and 11 with radio tags (see Table 2 in Appendix B). The remaining four radio tags were implanted in three Blacktail Redhorse and one Spotted Sucker.

Blue Sucker total length ranged from 266 to 620 mm, with weights of 120 to 2,290 g describing a tight length to weight relationship (r^2 = .936, see Figure 11 in Appendix B). Two sub-adult Blue Sucker (both tagged near RM 35 and 266 mm TL each) indicate relatively recent recruitment (i.e., February-April 2010). Age-length data (T. Grabowski, USGS, unpublished data) from both the Colorado and Sabine rivers was used to estimate the two juvenile Blue Sucker (both 266 mm TL) from the Sabine River at age 2 (Figure 1). Additionally, one other sub-adult Blue Sucker was observed during electrofishing near RM 36, but not captured.

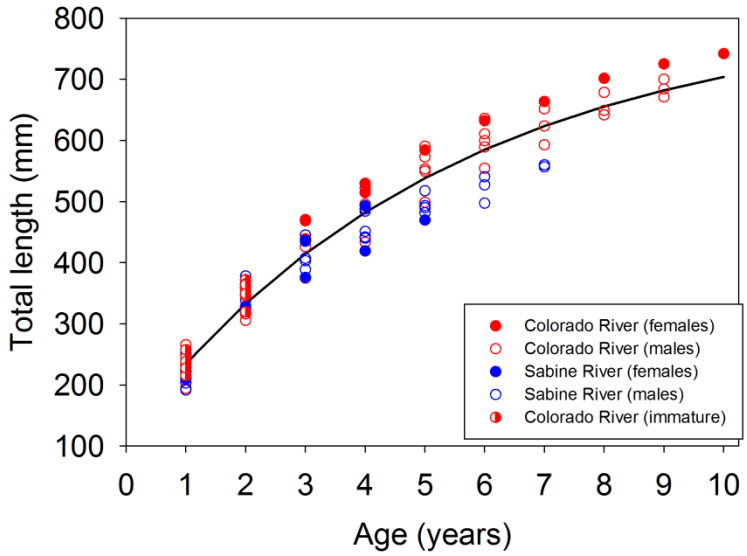

FIGURE 2.—Estimated age and total length of Sabine and Colorado River Blue Sucker.

Movement

Radio tracking by TPWD focused on areas of the Sabine River between Burkeville (RM 132) and Toledo Bend (RM 146) and occurred in August 2013, February 2014, and on two events in April 2014 (Table 1) because of the likelihood of detecting spawning aggregations near a large riffle complex downstream of the confluence of the tailrace and spillway channels at RM 140, where we suspected spawning was taking place (see Figure 2 in Appendix B). Indeed, most of the radio tag detections occurred at the riffle, but no spawning or signs of spawning were documented.

TABLE 1.—Locations (river mile (RM)) of Blue Sucker on specific dates using active radio telemetry.

Tag No.	Gender	8/1/2013	2/27/2014	4/8/2014	4/22/2015	4/24/2014
4	M	RM140.5		RM140.5	RM140.5	
5	M	RM140	RM140	RM140	RM140	
6	F	Spillway				
7	F	RM140	RM140		RM140	
8	M		RM137			
9	F	RM140	RM140	Tailrace	RM140	
10	M	RM140				
12	M	RM140	RM140	RM140	RM140	
14	M		RM137			
15	M		RM140	Tailrace		
16	M		RM138			
17	F	RM140	RM140		RM140	
19	M		RM137			
20	M	RM140				
22	F		RM136			
23	M		RM136			
25	F		RM138			
30	M		RM132			RM132
31	F		RM132			RM132
32	M	RM140	RM137			
42	F	RM140.5				

Of these tracked fishes only fish 32, a male Blue Sucker, and fish 42, a female Blue Sucker, were found substantial distances from their tagging locations. Fish 32 was tagged at RM91 and tracked at RM 140, 49 miles upstream; this fish was also located near the Toledo Bend Reservoir spillway SUR in June 2013, and largely stayed within 2 miles of the riffle complex located downstream of the confluence of the tailrace and spillway channels at RM 140 through the end of the study. Fish 42, tagged at RM34, was found 106.5 miles upstream near the confluence of the spillway and tailrace channels at RM 140.5, but was not detected by any of the SURs as it moved upstream of RM 91 (February 2013). Fishes 30 and 31 were consistently found at RM 132 at a bend in the river in a concrete block pile upstream of the Highway 63 bridge near Burkeville, TX.

A total of 120,874 contacts (262 active, 120,612 passive) were recorded from October 2012 through May 2013 (Appendix B: Table 3 and Table 4) by BIO-WEST. SURs at RM 140 (just upstream of large riffle complex) and 132 (near Burkeville) recorded the highest number of passive contacts due to the high

number of tagged fishes that remained in these locations over the duration of the study. SURs at RM 36 and RM 24 recorded no data over the study period. Only fish 50 (Spotted Sucker) was never successfully found after tagging. However, every tagged Blue Sucker was found at least twice during the study period. Only one Blue Sucker (33, female) was not actively tracked during the study; however, it did record 1,858 contacts on the SUR at RM 132. It is believed that the radio-transmitting part of the CART tag was malfunctioning because the RM 132 SUR recorded a contact eight minutes prior to this location being actively tracked by boat.

Net movement (upstream RM minus downstream RM as determined from each previously tracked location thus a positive value is net movement upstream) peaked in early February 2013 (+58.8 mi.), in the third week of February (+98.3 mi.) 2013, and again in May (+118.8 mi.) 2013. The peak in May is a result of one Blue Sucker male (fish 29) traveling 59.9 miles back upstream to its tagging location, and one Blue Sucker of undetermined sex traveling 58.9 miles upstream to its original tagging location. The only net downstream movement occurred during November (-5.0 mi.) and December 2012 (-2.2 mi.).

While both male and female Blue Sucker made long-distance movements, males traveled farther over the course of the study (Appendix B: Figure 12). The timing of movement also differed between male and female Blue Sucker. While females moved a combined 177.6 miles in early February, males only moved 134.1 miles. Near the end of February 2013, males moved almost five times as far as females (389.7 and 79.8 miles, respectively). Movement for both sexes began on the ascending limb of the hydrograph. In May, females displayed no movement from their previous position, while one male moved almost 60 miles upstream. Females were much more likely to move in relation to higher flows than males (Appendix B: Figure 13). While male Blue Sucker also moved at higher flows, the relationship (lower R^2 values) was not as strong as for females. Further, male and female adult Blue Sucker were tracked to Bayou Anacoco, a major tributary to the lower Sabine River entering from the Louisiana side near RM 105 indicating use of the stream as adult habitat.

Spawning Site Characterization

One objective of the study was to discover spawning sites in the Sabine River. Although telemetry indicated upstream movement (both on the river and in one tributary) by Blue Sucker during late winter and early spring, no spawning aggregations (a large number of fish congregated in one area) were observed neither in 2013 nor in 2014. In 2013, BIO-WEST used electrofishing to assess spawning condition of Blue Sucker at the RM 140 riffle. On March 27, 2013 two collected males expressed milt while females did not express eggs. On April 8, 2013, seven adults were collected but none expressed milt nor eggs. In 2014, TPWD assessed river conditions and spawning conditions of collected Blue Sucker. On February 25, 2014, water temperature in the spillway channel was 8.64° C, 11.6° C at the powerhouse intake (Mel Swoboda, Sabine River Authority, pers. comm.), and 12.74° C at the RM 140 riffle (which is downstream of the confluence of the tailrace and spillway channels). These temperatures are generally below (or at the low end of) those expected to be optimal for cueing spawning (Adams et al. 2006; BIO-WEST 2006). On April 8 2014, water temperature in the tailrace was 15.53° C, but recent rainfall triggered operation of one turbine generating 7000 cfs. Water temperature at the RM 140 riffle (completely submerged at 7000 cfs) was 15.64° C reflecting the tailrace temperatures. Sampling was deemed unsafe and inefficient at that high flow. Water temperature at Bon Weir was 18.47 ° C. On April 21, 2014, water temperature at the spillway channel was 18.15° C and 21.03° C at the RM 140 riffle. These temperatures reflect conditions exceeding the optimal range for spawning (12-18 C). At RM 140, six specimens were collected for gonad examination. Three males expressed milt with pressure and the three females did not express eggs and were flaccid. Upon dissection of females, no eggs were seen and there was no indication that ovaries had been spent indicating the lack of eggs for the 2014 spawning season.

Habitat measurements were taken in the RM 140 riffle at the location of Blue Sucker collections. One collection was 0.67 m deep, 0.97 m/s current velocity over bedrock with large woody debris while the second collection was 1.01 m deep and 0.79 m/s current velocity over bedrock with large woody debris. While Blue Sucker were present in this habitat, we saw no spawning activity.

Sub-adult Habitat Use

In May 2013, five seine hauls at the mouth of Bayou Anacoco resulted in no sub-adult Blue Sucker. This area was of particular interest because of substantial backwater habitats. Backwater areas are suspected to be rearing areas for young Blue Sucker (Fisher and Willis 2000; Adams et al. 2006). Eight seine hauls in the Sabine River in habitat where previous juvenile Blue Sucker were collected (SRA-TX et al. 2007) resulted in no Blue Sucker. On September 23, 2014, the Sabine River at Hwy 63 (RM 132) was sampled with a 15' purse seine. Six seine hauls resulted in no Blue Sucker. On September 24, 2014, Bayou Anacoco was sampled with boat electrofisher. No Blue Sucker was collected during 1200 seconds of effort. No Blue Sucker was collected from 16 seine hauls covering 360 feet of Sabine River shoreline upstream and downstream of the confluence with Bayou Anacoco. In addition, 325 seconds of boat electrofishing effort in the main Sabine River channel resulted in no sub-adult Blue Sucker.

Discussion

Data collected in this tagging study has expanded the knowledge of the movement and spawning related behavior of Blue Sucker. Results of radio tracking (passive and active) in this study further support the contention that Blue Sucker will migrate long distances in winter and spring as seen in the Colorado River (BIO-WEST 2006). It appears that a rising hydrograph during this time period is a cue that initiates movement. While males seem to move farther, females also make long migrations to (presumably) spawn. Movement data collected from this study also indicated Blue Sucker have a relatively small home range outside of their spring/winter movements we presume is related to spawning. Of the Blue Sucker that made long distance movements in 2012-2013, seven (Fish 2, 9, 11, 17, 29, 35, and 37) returned to their original tagging location.

Passive tracking addresses the problem of limited funds (and time) that are often a part of radio tracking studies. Because active tracking involves a lot of time and manpower, SURs fill the need for more frequent monitoring. Through their use, it was easier to document movement and target specific reaches than with manual tracking. Most critically, the SUR at RM 104 provided information on the timing of fish entering and leaving Anacoco Bayou. This provided a closer evaluation and understanding of how streamflow may have influenced Blue Sucker utilization of this major tributary. The SURs at RM 24 and RM 36 provided no data over the course of the study (through at least July 31, 2013).

SUR placement is critical for not only detecting moving fish, a, but for avoiding theft. The Burkeville SUR at RM 132 was stolen sometime before August 2013. It was quickly replaced upstream in a less accessible location, but several months of detection data were lost.

Blue Sucker spawning was observed in shallow, rocky shoals of the Colorado River, Texas, (Mosier and Ray 1999; BIO-WEST 2006) and we were hopeful to observe spawning in similar habitats of the Sabine River. However, telemetry data from the Sabine suggests adult Blue Sucker may have spawned in other areas where spawning could not be visually observed. Although spawning was not actually witnessed, tracking revealed congregations of adult Blue Sucker at several key areas (RM 140, RM 128-130, RM 83, and Anacoco Bayou) but spawning was not confirmed. However, the timing and degree of movements of tagged Blue Sucker in the Sabine River suggest that spawning potentially occurred at several sites possibly representing a wide spectrum of habitats (bedrock riffle, sandy run, woody debris, etc.). These types of macrohabitats could be more closely monitored in the future to confirm their potential as Blue Sucker spawning locations.

Although no spawning aggregations were observed in 2013, it is likely that Blue Sucker spawned during the first week of April. Water temperature data from late March at several sites on the river ranged from 15 to 16 °C where adult Blue Sucker were captured. In the Colorado River (BIO-WEST 2006), Blue Sucker spawning occurred from 12 to 16 °C, putting the Sabine River water temperatures in late March within the range when spawning is known to occur in Texas (BIO-WEST 2006). While efforts again in 2014 were made to locate spawning fish in late February, early April, and late April, no spawning was observed. In late February water temperatures were 8.64° C in the spillway channel and near 12° C in the tailrace and river downstream, water temperatures less than or on the low end of the spawning range. On April 8 2014, releases (7,000 cfs) from Toledo Bend precluded effective observations or safe/effective sampling conditions. Male Blue Sucker collected later in April expressed milt but only when squeezed. Females were flaccid yet ovaries appeared to be unspent when dissected.

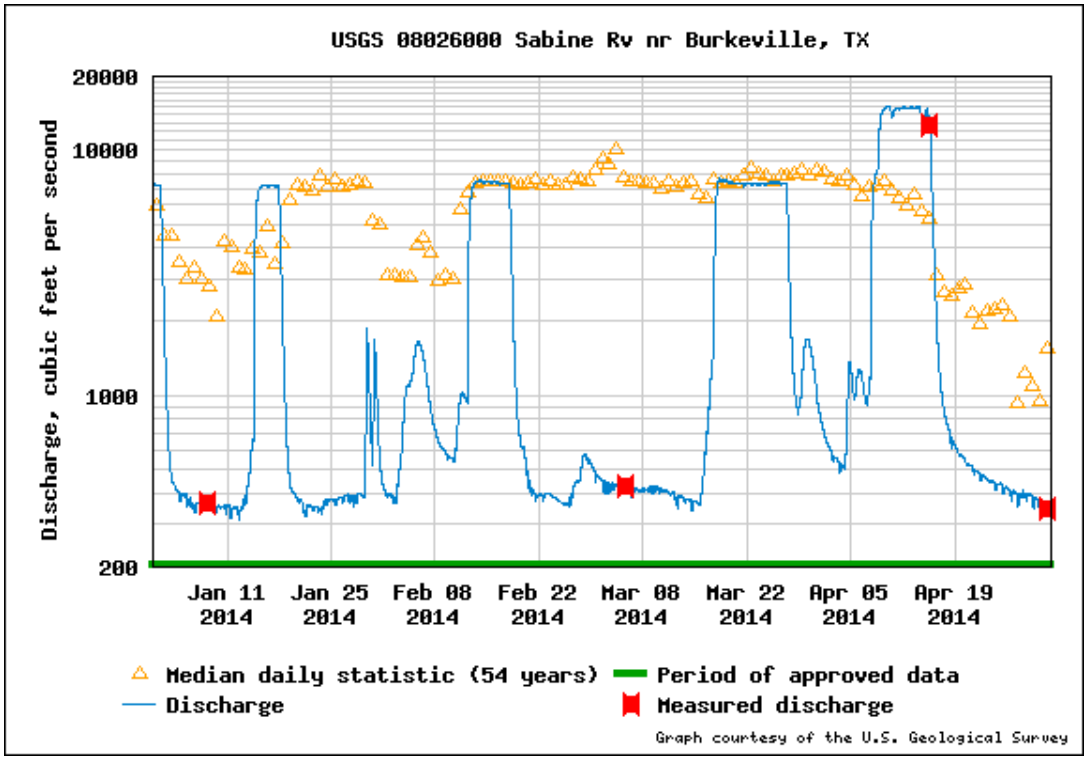

FIGURE 2.—Discharge (cfs) from U.S. Geological Survey streamflow gage 08026000 Sabine River near Burkeville, TX from Jan 1 to May 1 2014.

Blue Sucker reproductive development could have been interrupted due to fluctuations in water temperatures (and sources of such) and large changes in streamflow concomitant with hydropower releases at Toledo Bend during the months leading up to the 2014 spawning season (Figure 1).

Probably the largest life history data gap is the lack of understanding of larval and juvenile (age-0 to age-2) Blue Sucker recruitment. The capture of two juvenile Blue Sucker (54 and 64) during this study is extremely important. These two juveniles were both 266 mm TL (Appendix B: Figure 35) and likely were age-2 (Figure 1). Both were caught between RM 34 and RM 36 in deep runs near large woody debris in the lower portion of the river basin. While fish 64 moved 15.4 miles downstream, fish 54 did not move from its capture location for the entire study. Both habitats were similar to their capture locations (deep run with large woody debris), but neither appeared to make any movements associated with spawning. The capture of these two individuals implies that at this age they are already associating with adult Blue Sucker in the same type of habitat. This pattern was also recently found in the lower Colorado River when

seven juvenile Blue Sucker were collected largely in the lower part (near Altair, Texas) of that river (M. Acre, Texas Tech University, personal communication). It may be that rearing habitats are more plentiful in these parts of the basin due to an increased number of backwaters and connections to off-channel backwater habitats during higher flows. If these two juveniles were indeed hatched in 2010 when flows were high during the winter and spring months it is suggesting that Blue Sucker require higher flow during spawning months to ensure successful reproduction. In addition, the lower flows in May of 2010 may have allowed larvae to successfully navigate into nursery areas. Adams et al. (2006) demonstrated that survival of larval Blue Sucker was unrelated to flow due to their abundance during a high and low flow year (during spawning months), but the study concluded that access to nursery habitats regardless of flow was likely more important to larval survival. Further sampling for larvae and juveniles in Sabine River backwater habitats could lead to a better understanding of this elusive stage in Blue Sucker life history.

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APPENDIX A: SCOPE OF WORK

Exhibit A

Scope of Work

Radio tracking of blue sucker in lower Sabine River sub-basin

1. Introduction

Water planning in Texas will be greatly aided by determining instream flow strategies to maintain healthy riverine ecosystems. Knowing the impact of various flow strategies on key species will be valuable in choosing between alternatives. Key species are defined as those that are particularly flow sensitive or are related to aspects of the riverine ecosystem of concern to stakeholders. Blue sucker, *Cycleptus elongatus,* has been identified as a key species for an instream study of the Sabine River below Toledo Bend Reservoir. Although blue sucker has been listed by the State of Texas as a threatened species, its habitat and migration requirements within the lower Sabine River sub-basins are not well known. Other key species may also be targeted for tracking.

This study will characterize seasonal movements and habitat use of the blue sucker in the Sabine River downstream of Toledo Bend Reservoir using radio telemetry. The primary objectives are to determine spawning locations by locating sexually mature adults, track movements during different seasons, and determine differential habitat use among varying life stages. Results will be used to develop an improved understanding of the species' life history and environmental requirements. Information from this study will be of benefit when assessing alternative flow regimes and identifying conservation strategies in the lower Sabine River as well as other river basins where long-lived, flow-sensitive species, such as the blue sucker, occur.

Other target species can also be tagged and tracked with little additional effort since they can be tracked using the same equipment and generally within the same stream reach. This would allow for an economy of scale since the crews would already be deployed in the field for the collection and tracking of blue sucker.

2. Study Location, Plan, and Schedule

This study will be focused on the lower Sabine River downstream of Toledo Bend Reservoir. Field crews will sample all blue sucker life stages. Approximately 30 adults will be tagged and tracked using radio telemetry. Areas of adult habitat use including spawning habitat will be identified and measured for variables such as velocity, depth, substrate, and cover. At the same time, sampling will be conducted to identify habitat use of other live stages of blue sucker, including juvenile, young of the year, and larval stages, as possible.

3. Deliverables

TPWD, in consultation with subcontractors, will provide a final report summarizing study methods and results, including insights gained regarding blue sucker habitat use (adult, juvenile, and larval), spawning habitat use, and migratory behavior.

4. Task and Expense Category Budget

Funding for this project will be provided from the US Army Corps of Engineers' Planning Assistance to States Fund ($150,000) and TWDB's Research and Planning Fund ($75,000).

APPENDIX B: BIO-WEST REPORT

Blue Sucker Tracking Study

Sabine River, Texas

2012 – 2013

June 2013 (revised October 2015)

BIO-WEST, Inc.

Table of Contents

List of Figures

List of Figures ctd.

List of Tables

Appendices

Executive Summary

The blue sucker (*Cycleptus elongatus*) is a large-river catostomid fish native to the Mississippi River Basin and Western Gulf Slope drainages of Texas and Louisiana. Modifications to many large river systems throughout their range have altered habitat and blocked migration routes, resulting in a decline in the overall abundance and distribution of this species. Due to such concerns, and the disjunct distribution of the species within the state, blue suckers are listed as threatened by the Texas Parks and Wildlife Department (TPWD). Recent fish community sampling conducted on the lower Sabine River documented the presence of blue suckers throughout the reaches sampled (River mile [RM] 64 – RM 146), with a relatively abundant population compared to other Texas river systems (BIO-WEST 2011). Therefore, to learn more about this unique population, a blue sucker tracking study was initiated on the lower Sabine River in October 2012. The goal of the study was to track adult blue sucker movements, and locate spawning aggregations in the lower Sabine River in order to better understand the life history of this rare species. Habitat in the lower Sabine River (RM 148 – RM 0) is characterized by scattered bedrock outcrops immediately below Toledo Bend Dam, followed by sandy runs filled with large, woody debris in the upper and middle reaches, and then transitions to deep braided channels with large sand bars and scattered woody debris in the lower reaches. It is a managed river with variable flows due to hydropower generation at Toledo Bend Dam (RM 148).

To accomplish the aforementioned goals, 60 fishes were tagged at 9 different tagging locations from RM 145 to RM 34. Fifty-six blue suckers, 3 blacktail redhorse (*Moxostoma poecilurum*), and 1 spotted sucker (*Minytrema melanops*) were implanted with either a Combined Acoustic / Radio Transmitter (CART) or a smaller radio-only tag in order to facilitate tracking by telemetry. This resulted in 33 males, 22 females, 2 immatures, and 2 fishes of unknown sex being tagged and released at their capture locations in the Sabine River.

Telemetry was conducted using both active and passive tracking techniques. Active tracking was accomplished using a receiver and Yagi-antenna, operated from either a boat or small fixed-wing aircraft. Upon discovery of a tagged fish, a GPS point, time, and general habitat characteristics were recorded for each fish. About 565 miles of the Sabine River were actively tracked over 8 events in 2012-2013. Passive tracking involved the strategic placement of 8 stationary Submersible Underwater Receivers (SURs) in the main channel of the river. These receivers record the time and date when a CART-tagged fish is detected by them.

A total of 120,874 contacts (262 active, 120,612 passive) were recorded over the study period in 2012 – 2013. SURs in the upper reaches of the river provided the most contacts because more blue suckers were tagged there, and more of them remained in this section of the Sabine River. SURs at RM 36 and RM 24 did not record any contacts over the study period. Every tagged blue sucker was found at least two times during the study period, while fish 50 (spotted sucker) was never found (possibly due to tag malfunction). Fish 30 and 31 (blue suckers) had the largest number of contacts of all tagged fishes. Net movement was highest in May, but it also peaked in January and February 2013. Male blue suckers traveled farther and later in the year than females with much of the movement taking place on the ascending limb of the hydrograph. This may indicate that males travel more in relation to spawning than females.

Fish 29 (male blue sucker) traveled farther (216.6 miles) in the Sabine River than any other fish. It traveled to the Old River (Louisiana) before returning to the reach (RM 132) where it was tagged in October. Five blue suckers were located in Anacoco Bayou (a major tributary) during early 2013. Although none were found together it reinforces the importance of tributaries to blue suckers; however, it was unclear if any blue sucker spawning occurred in Anacoco bayou during the study period. As in the Sabine River, discharge was high in Anacoco Bayou during the time the blue suckers were detected in it.

Although tracking indicated the importance of several areas in the Sabine River and its tributaries, no spawning aggregations were observed in 2013. Electrofishing in March and April 2013, provided information on the condition of blue suckers. Water temperatures during this time period ranged from 15 ° Celsius (C) to 19 ° C, which is in the range of temperatures at known spawning aggregations (in other rivers). Spawning condition of female blue suckers in March revealed that they still had eggs inside them, while some males had running milt and tubercles over their entire body. By April 8, 2013 females appeared spent, while males did not express milt when squeezed. This indicated that spawning likely occurred during the first week of April. Only two juvenile blue suckers were caught during the tagging effort, and underscored the need for understanding the early life stages. The presence of these juveniles proves that spawning can be successful in blue suckers. However, what conditions are necessary to facilitate recruitment to adult size remains poorly understood. This data gap in blue sucker life history is acknowledged throughout the literature, and continued tracking could help narrow this down by knowing where and when spawning is taking place in the Sabine River. The findings in this study underscore the importance of identifying and protecting critical habitats during all life stages of the State Threatened blue sucker.

Introduction

The blue sucker (*Cycleptus elongatus*) is a long-lived member of the Catostomidae family that is native to the Mississippi and Gulf Coast drainages of North America. In Texas, its range extends from the Red River to the Rio Grande River (Thomas et al. 2007) with an undescribed *Cycleptus* species occupying the Rio Grande River (Bessert 2006, Buth and Mayden 2001). Blue suckers inhabit deep (1 -2 meters [m]), fast riffles typically over gravel and bedrock substrate, where they feed on benthic invertebrates (BIOWEST 2006, Morey and Berry 2003, Moss et al. 1983). Although once considered abundant throughout its range, population declines due to overfishing and habitat fragmentation (dams) have resulted in blue suckers being considered a species of special concern throughout most of their range (Jelks et al. 2008). While blue suckers have a large range throughout North America, they are considered rare where they are found, and as a result large data gaps remain in describing the life history of this large sucker.

In Texas, the blue sucker is a State Threatened Fish (Hubbs et al. 1991). Like in other parts of the country its life history in Texas is poorly understood, but some studies have shed light on the aspects of its movement. In the Colorado River, blue suckers exhibit large movements likely associated with spawning (BIOWEST 2006). These fish moved up to 115 miles during a high water year to spawn at the base of Longhorn Dam in Austin (the farthest upstream barrier to movement, BIOWEST 2006). This particular spawning aggregation had not been observed before and included blue suckers tagged from three different tagging sites in the Colorado River. Spawning occurs when water temperatures are 12 – 18° Celsius (C) typically from February to April (Adams et al. 2006, BIOWEST 2006). However, spawning migrations seem to be tied to hydrologic conditions, as BIOWEST (2006) also found that in subsequent years when flows were lower prior to and during the spawning period blue suckers did not undertake any large scale migrations. Although spawning doesn't occur until the spring months, egg development (females) and tubercles (males and females) have been observed as early as October (BIOWEST 2006). Blue suckers produce small (2 – 3 millimeter [mm]), white eggs that cling to the substrate after the female releases them (Moss et al. 1983, BIOWEST 2006). Hatch times are variable, but can be as short as 6 days after spawning (Semmens 1985). It is at this point in a blue suckers' life history that large data gaps are found. Throughout their range age–0 to age-2 blue suckers are extremely rare, and little is known about their habitat use. Larvae have been found in typical larval fish habitat like backwaters and margins of the main channel (Adams et al. 2006, Fisher and Willis 2000). Juvenile blue suckers are rarely found, but in the Rio Grande River they were observed in shallow riffles over gravel substrate (T. Bonner person. comm. 2006). BIOWEST (2006) spent considerable amounts of time in all habitats in the Colorado River, but were unable to locate a single larval or juvenile blue sucker. These data gaps are typical throughout other river systems where blue suckers are found.

It is this lack of knowledge that initiated the blue sucker study on the Sabine River in 2012. The goal of the study was to track adult blue sucker movements and locate spawning aggregations in the lower Sabine River in order to better understand the life history of this State Threatened species.

Study Area

The Sabine River Basin is nearly 10,000 square miles, and covers 3 ecoregions (Blackland Prairie, East Texas Timberlands, and Coastal Prairie). Its headwaters are in northwestern Hunt County, Texas, and it empties into Sabine Lake in Orange County, Texas. At river mile (RM) 148 is the southern end of Toledo Bend Reservoir, an 181,619 acre impoundment created by Toledo Bend Dam which was completed in 1969. The dam is used for hydropower, and regularly releases water for hydropeaking typically during the summer months. This can result in river flows increasing to 14,000 cubic feet per second (cfs) from base flows (200-300 cfs) when generation is required. Downstream of Toledo Bend Dam is the lower Sabine River (RM 148 – RM 0), which forms the border of Texas and Louisiana (Figures 1, 2 and 3). RM 148 to RM 138 is characterized by pools, riffles, and runs with extensive areas of bedrock and boulder substrate (most notably forming a large riffle at ~ RM 140). From RM 147 to RM 141 is the spillway channel that contains two large bedrock riffles. This channel typically has lower flows (water is only released from the gates during flooding events), but when generation is occurring backflow from the tailrace can back up the spillway channel inundating both riffles. From RM 138 to RM 0, the river is sinuous with sandy substrates and large woody debris the most common instream structure. Near RM 30 the river splits into two major channels with most of the flow going into the "Old River" on the Louisiana side. These separate channels merge together at ~ RM18. This section of the river is highly braided, and the main channel is typical of large, coastal plain rivers.

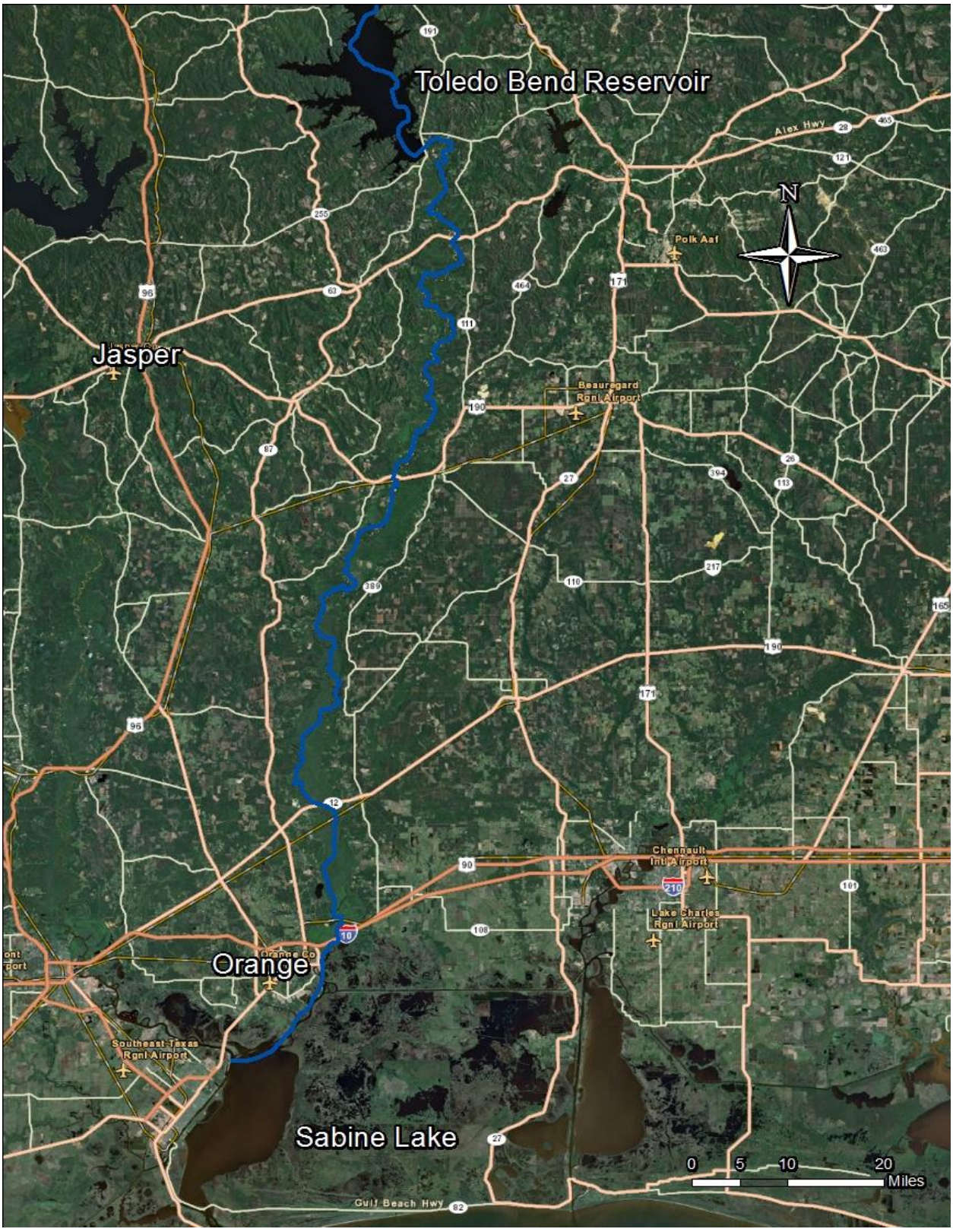

Figure 1. The lower Sabine River from Toledo Bend Reservoir (RM 148) to Sabine Lake (RM 0).

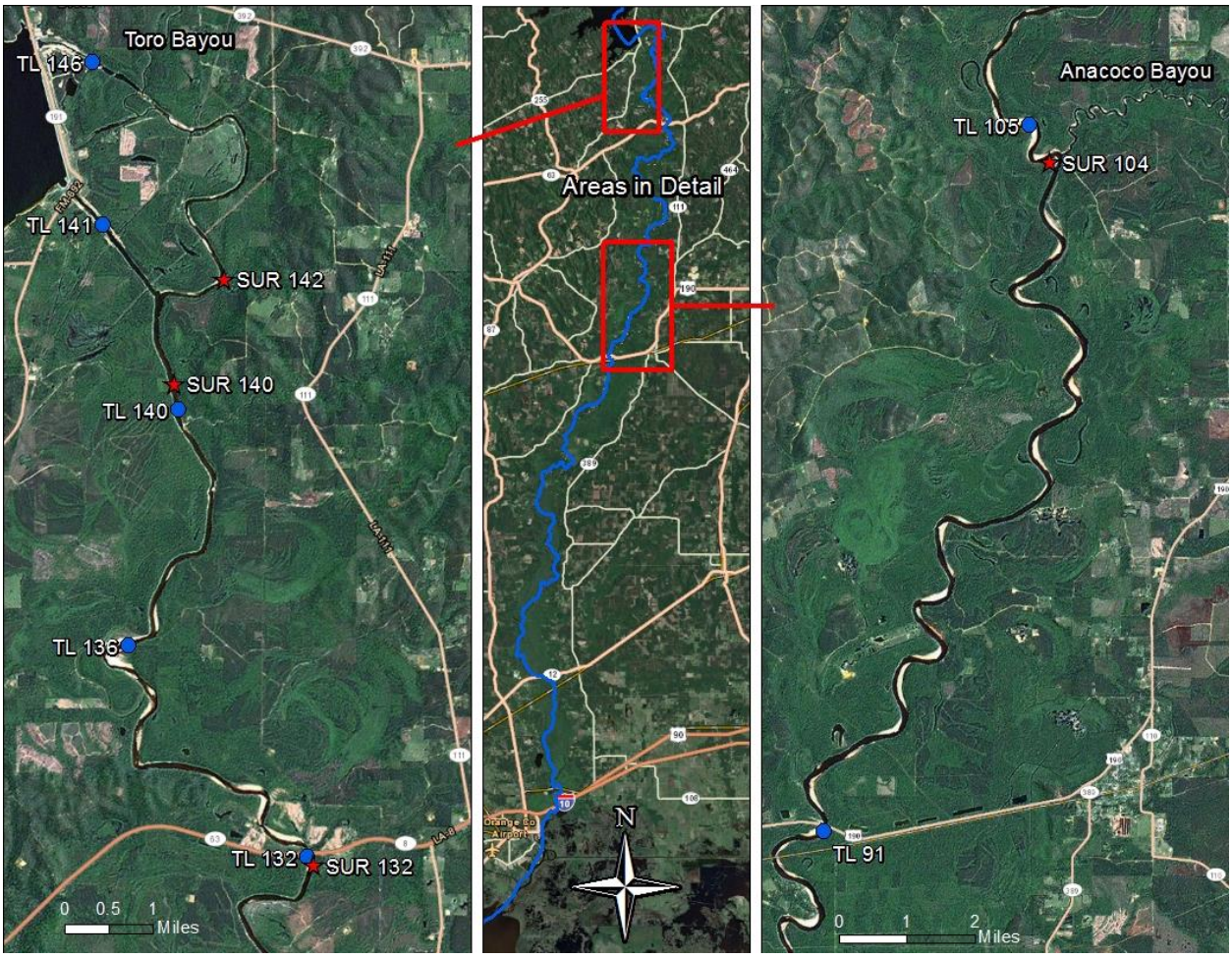

Figure 2. Tagging (TL) and Submersible Ultrasonic Receiver (SUR) locations with associated river mile of the upper portions of the lower Sabine River.

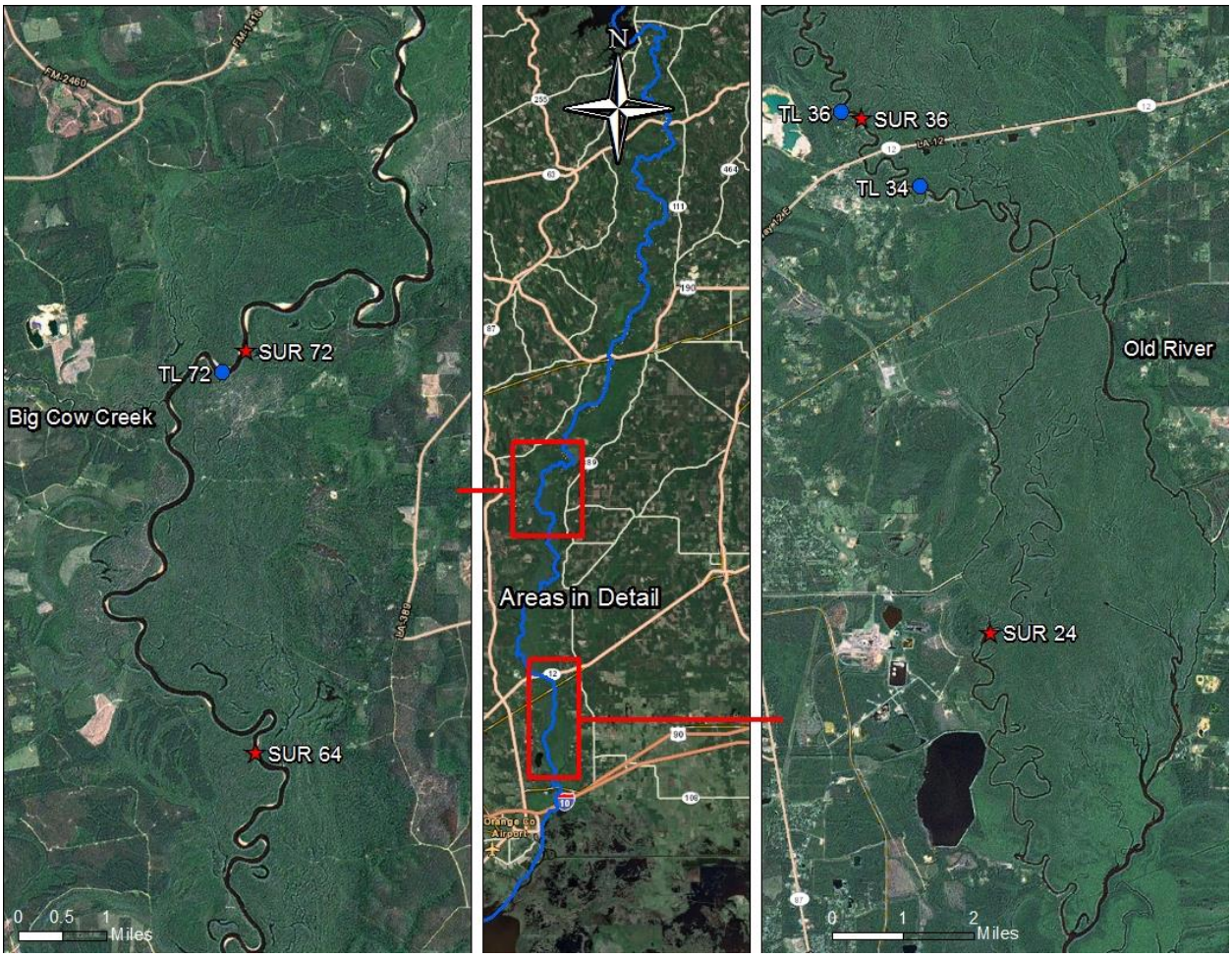

Figure 3. Tagging (TL) and Submersible Ultrasonic Receiver (SUR) locations with associated river mile of the lower portions of the lower Sabine River.

Methods

Capture

Electrofishing was used in order to capture fishes for tag implantation (Figure 4). A Smith-Root 5.0 GPP electrofisher mounted to a 16-foot aluminum johnboat with adjustable boom were used to capture all suckers. This method was deemed least stressful for the fishes, which would result in high survival rates post-surgery. Other methods (trammel and/or hoop nets) are less successful in a riverine environment, and during a recent study performed by BIOWEST (2011) no blue suckers were captured using hoop nets in the Sabine River. Upon capture, fishes were temporarily retained in a livewell on the electrofishing boat, but were quickly moved to a flow-through holding tank placed in the river prior to surgery.

Tagging

Fishes were tagged at 9 different tagging locations from RM 34 to RM 145 (though there were more "capture" locations due to surgery setup constraints). Two types of tags were used for these fishes: Combined Acoustic / Radio Transmitters (CART, 45 tags, Figure 5) and radio-tags (15 tags, Figure 6).

Figure 4. Electrofishing for blue suckers on the Sabine River, Texas, during October 2012.

CART tags emit both an acoustic and radio signal, and are thus able to be tracked both with submerged hydrophones and with radio antennas from above the water. Eight stationary Submersible Ultrasonic Receivers (SURs) were deployed throughout the river to passively track (via acoustic signal) any tagged fishes that pass or get near the SUR (see section below). CART tags (Lotek MM-MC-11-45, 5-second burst rate) are larger in size (12 mm diameter, 78 mm length, 16 grams [g] dry weight), and therefore, were only put into adult fish. Radio-only tags are smaller (10 mm diameter, 35 mm length, 5g dry weight) and were initially saved for any juvenile blue suckers or other smaller species. However, only 2 juvenile blue suckers (Total Length [TL] = 266 for both), 3 blacktail redhorse, and one spotted sucker were tagged with the radio-only tags. Therefore, the remaining radio-only tags were implanted into adult blue suckers. Both types of tags are uniquely coded for each fish, and thus allow for efficient tracking of the 60 target fishes.

Figure 5. A Combined Acoustic / Radio Transmitters (CART) tag prior to implantation.

Figure 6. A radio tag prior to implantation.

Surgery for tag implementation was performed by Dr. Chris Bunt of Biotactic, with Kevin Mayes of TPWD performing surgery on one blacktail redhorse. At each collection site, a surgery setup was laid out central to likely capture locations so fishes were moved as little as possible prior to and following tag implementation. Two flow-through holding tanks were placed within the current of the river for holding fishes prior to and after surgery (Figure 7). Prior to incision each fish was moved from the holding tank, weighed (g), measured (TL mm), and placed into the surgery tub which contained a mixture of clove oil and river water. When the fish lost equilibrium and breathing slowed, an incision was made on the ventral side of the fish posterior to the pectoral fins (Figure 8a and b). At this time a determination of the sex of the fish was made based on visual examination of the gonads. Then a tag (CART or radio) was inserted into the fish (Figure 8c and d) along with a Passive Integrated Transponder (PIT) tag (each with a unique alpha-numeric code). PIT tags may be beneficial in the event of recapture coincident with transmitter loss. At this time, a small fin clip was taken from a subset of tagged blue suckers (36 fish) and put in alcohol for later genetic analysis (to be completed by TPWD). After tag insertion, one or two sutures (using silk or polypropylene thread) were used to close the incision along with one or two drops of Vetbond ™ (Figure 8e and f). Post-surgery fishes were immediately placed back in the river in the flow-through recovery tank. Fishes were judged ready to be released after they regained equilibrium and were breathing and swimming normally. Although recovery often occurred minutes after surgery, all fishes were held for at least 30 minutes prior to release. All fishes were released at their original capture location. Figure 9 shows a fully recovered tagged fish.

Figure 7. Surgery setup with recovery tub in foreground at RM 140 riffle.

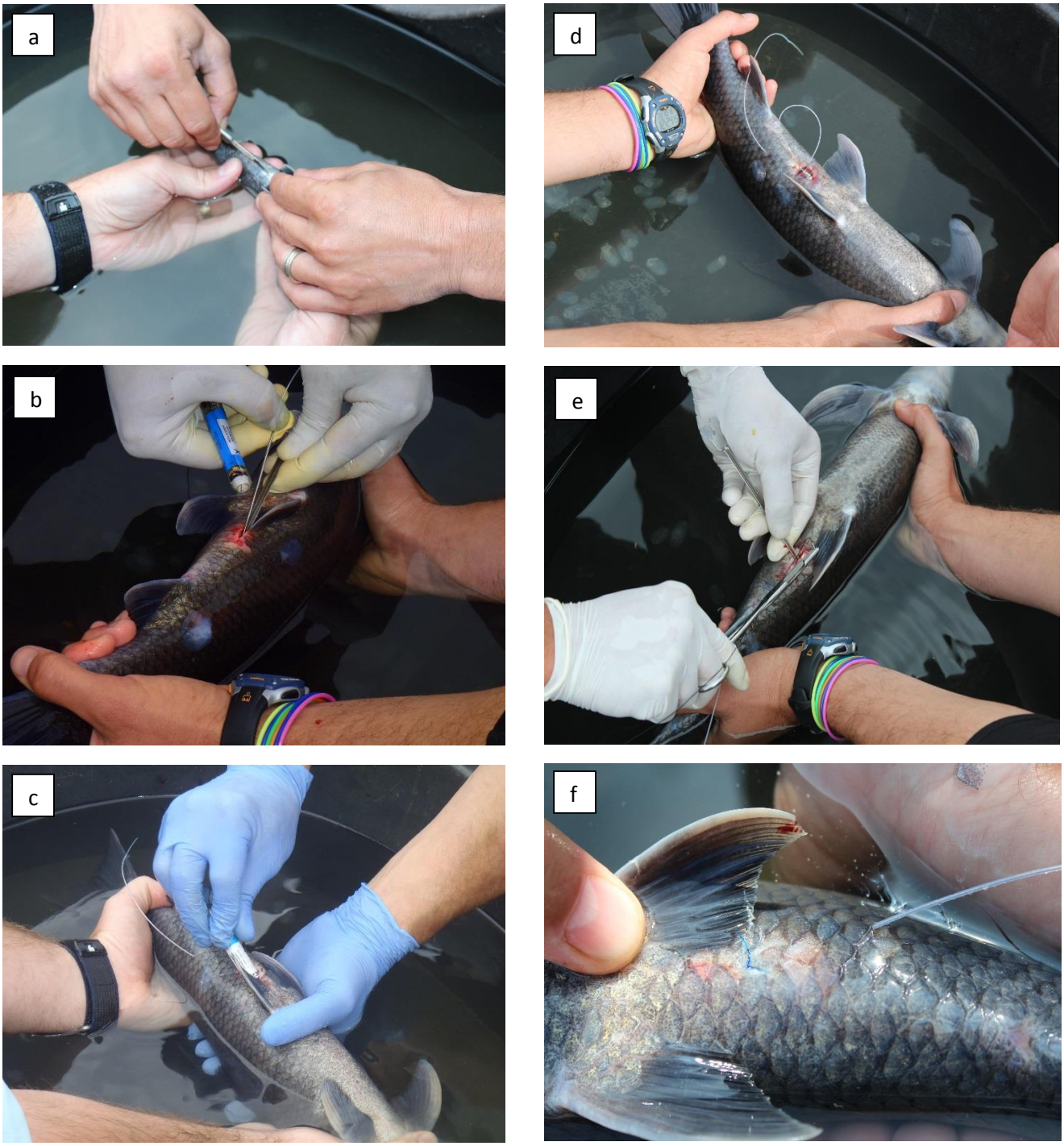

Figure 8. Tagging surgery on blue sucker, October 2012. a) Incision is made b) Antenna is threaded through the body cavity c) CART tag is implanted d) Antenna is pulled taut e) Incision is sewn f) Completed surgery.

Figure 9. Tagged and fully recovered blue sucker (fish 45, male) at RM 34 surgery site on the Sabine River, Texas, October 18, 2012.

Tracking

Active

Manual radio-tracking was accomplished using a SRX_400 Telemetry Receiver (Lotek Wireless, Inc.) programmed with all 60 tags. When a tag was heard, the receiver displayed a code unique to each tag. The receiver was connected to a Yagi-antenna that was mounted high on the boat (or wing when tracking by air) in order to maximize the likelihood of hearing a tagged fish in all river conditions. Each time a code was displayed, tracking continued until a strong signal was heard at a low gain (0 – 20). A GPS point, time, and general habitat characteristics (mesohabitat, presence/absence of instream structure) were recorded for each fish. This allowed calculations of movement between subsequent tracking efforts. Eight tracking events were conducted in 2012 – 2013, though not all reaches of the river were tracked the same number of times due to time/river condition constraints (Table 1). Although most tracking was conducted by boat, tracking was also conducted by plane during two events in 2013.

Table 1. Active blue sucker radio-tracking effort for 2012-2013 in the Sabine River.

Type	Miles Tracked	Date
Boat	35	11/5/12 - 11/9/12
Boat	37	12/10/12 - 12/14/12
Boat	6	1/14/13 - 1/15/13
Boat, Plane	158[1]	2/4/13 - 2/7/13
Boat, Plane	284[1]	2/19/13 - 2/26/13
Boat	23	3/25/13 - 3/28/13
Boat	4	4/8/2013
Boat	18	5/13/13 - 5/15/13
Total	**565**	**33[2]**

[1] Some sections of the river were tracked twice during the same week.
[2] Total numbers of days tracked.

Passive

Passive acoustic-tracking was accomplished by the deployment of Submersible Ultrasonic Receivers (SURs) at 8 different locations in the Sabine River (Figures 2 and 3). These receivers constantly monitor for acoustic signals of CART tags, and log the date and time when a particular frequency is heard. These were spaced longitudinally throughout the river, but also placed at strategic points where any migrations of fishes were likely to occur. These receivers were downloaded at least once a month to determine if any tagged fishes had passed by the SUR. This provided a larger data collection effort without the necessity of constant tracking efforts (thereby reducing project costs). These SURs were attached to large posts driven into the riverbed near one bank so that the hydrophone was directed towards the river allowing for a large "listening zone" (Figure 10). The posts stick up above (or at) the waterline allowing for ease of downloading while being hidden to reduce tampering. After downloading, SURsoft Software was used to determine if any tagged fishes passed by the SUR.

Figure 10. Submersible Ultrasonic Receiver (SUR) a) Getting locked into metal sleeve b) Hydrophone (yellow) rotated to point towards middle of Sabine River, October 2012.

Spawning Site Characterization

One goal of this study was to locate spawning aggregations and thus determine where and when blue suckers spawn in the Sabine River. Along with monitoring water temperatures, large upstream movements and identification of frequently used areas of blue suckers were used to help narrow down a spawning window. Another method of determining spawning timing was to capture adult blue suckers and assess body condition based on presence/absence of tubercles, and presence/absence of freely running milt or eggs. Assessment of spawning condition was performed twice in spring 2013 (March 27 and April 8) using electrofishing (described above) to capture adult blue suckers.

Results

Tagging

The week of October 14, 2012 resulted in 60 fishes tagged in the Sabine River spread over 9 tagging locations (Figures 2 and 3). Flows on the river ranged from 272 to 999 cfs at Burkeville (RM 132) during this week. Of the 56 blue suckers tagged, 22 were female, 30 male, and 4 of undetermined sex. Of these, 45 were implanted with CART tags, and 11 with radio tags (Table 2). The remaining four radio tags were implanted in 3 blacktail redhorse and 1 spotted sucker (TL 296 – 311 mm, TW 300 – 320 g).

Table 2. Tagging information on individual fishes for the Sabine River, TX for the week of October 14, 2012. Unk. – Unable to determine sex.

Tag Number	Species	Location	Date	Length (mm)	Weight (g)	Sex	Genetics (Y/N - # sample)
1	Blue Sucker	RM - 146	10/15/2012	605	2,290	F	N
2	Blue Sucker	RM - 146	10/15/2012	590	1,820	Unk.	N
3	Blue Sucker	RM - 141	10/15/2012	496	1,040	F	N
4	Blue Sucker	RM - 140	10/16/2012	540	1,250	M	Y-1
5	Blue Sucker	RM - 140	10/16/2012	589	1,770	F	Y-2
6	Blue Sucker	RM - 140	10/16/2012	565	1,570	F	Y-3
7	Blue Sucker	RM - 140	10/16/2012	595	1,860	F	Y-4
8	Blue Sucker	RM - 140	10/16/2012	515	910	M	Y-5
9	Blue Sucker	RM - 140	10/16/2012	585	1,860	F	Y-6
10	Blue Sucker	RM - 140	10/16/2012	563	1,560	M	Y-7
11	Blue Sucker	RM - 140	10/16/2012	510	1,200	M	Y-8
12	Blue Sucker	RM - 140	10/16/2012	509	1,290	M	Y-9
13	Blue Sucker	RM - 140	10/16/2012	494	1,060	Unk.	Y-10
14	Blue Sucker	RM - 140	10/16/2012	495	1,120	M	Y-11
15	Blue Sucker	RM - 140	10/16/2012	605	1,800	M	Y-12
16	Blue Sucker	RM - 140	10/16/2012	509	1,130	M	Y-13
17	Blue Sucker	RM - 140	10/16/2012	511	1,070	F	Y-14
18	Blue Sucker	RM - 140	10/16/2012	488	1,070	M	Y-15
19	Blue Sucker	RM - 140	10/16/2012	525	1,340	M	Y-16
20	Blue Sucker	RM - 140	10/16/2012	482	890	M	Y-17
21	Blue Sucker	RM - 140	10/16/2012	543	1,400	F	Y-18
22	Blue Sucker	RM - 136	10/16/2012	502	1,070	F	N
23	Blue Sucker	RM - 136	10/16/2012	582	1,660	M	N
24	Blue Sucker	RM - 136	10/16/2012	500	1,040	M	N
25	Blue Sucker	RM - 136	10/16/2012	504	980	F	N
26	Blue Sucker	RM - 136	10/16/2012	528	1,180	F	N
27	Blue Sucker	RM - 136	10/16/2012	539	1,240	F	N
28	Blue Sucker	RM-132	10/16/2012	503	1,060	F	N
29	Blue Sucker	RM-132	10/16/2012	596	1,380	M	N
30	Blue Sucker	RM-132	10/16/2012	508	1,070	M	N
31	Blue Sucker	RM-132	10/16/2012	615	1,700	F	N
32	Blue Sucker	RM-91	10/17/2012	492	1,090	M	Y-32
33	Blue Sucker	RM-132	10/16/2012	480	810	F	N
34	Blue Sucker	RM-91	10/17/2012	492	960	M	Y-33
35	Blue Sucker	RM-91	10/17/2012	489	1,610	F	Y-34

Table 2 ctd. Tagging information on individual fishes for the Sabine River, TX for the week of October 14, 2012.

Number	Species	Location	Date	Length (mm)	Weight (g)	Sex	Genetics (Y/N - # sample)
36	Blue Sucker	RM-91	10/17/2012	505	1,080	M	Y-35
37	Blue Sucker	RM-91	10/17/2012	560	1,450	M	Y-36
38	Blue Sucker	RM-72	10/17/2012	507	1,220	M	N
39	Blue Sucker	RM-72	10/17/2012	613	2,200	F	N
40	Blue Sucker	RM-72	10/17/2012	620	2,240	F	N
41	Blue Sucker	RM-72	10/17/2012	498	1,370	M	N
42	Blue Sucker	RM-34	10/18/2012	526	1,450	F	Y-42
43	Blue Sucker	RM-34	10/18/2012	516	1,390	F	Y-43
44	Blue Sucker	RM-34	10/18/2012	480	1,100	M	Y-44
45	Blue Sucker	RM-34	10/18/2012	480	1,110	M	Y-45
50	Spotted Sucker	RM - 140	10/16/2012	296	300	M	N
51	Blacktail Redhorse	RM - 140	10/16/2012	311	320	F	N
52	Blacktail Redhorse	RM - 140	10/16/2012	308	320	M	N
53	Blacktail Redhorse	RM-72	10/17/2012	306	320	M	N
54	Blue Sucker	RM-34	10/18/2012	266	130	Immature	N
55	Blue Sucker	RM-34	10/18/2012	474	1,070	M	Y-46
56	Blue Sucker	RM-34	10/18/2012	510	1,200	M	Y-47
57	Blue Sucker	RM-34	10/18/2012	522	1,230	M	Y-48
58	Blue Sucker	RM-34	10/18/2012	537	1,470	F	Y-37
59	Blue Sucker	RM-34	10/18/2012	506	1,290	M	Y-38
60	Blue Sucker	RM-36	10/18/2012	487	1,070	M	Y-39
61	Blue Sucker	RM-36	10/18/2012	266	120	Immature	Y-40
62	Blue Sucker	RM-36	10/18/2012	482	1,050	M	Y-41
63	Blue Sucker	RM-36	10/18/2012	504	1,180	F	Y-42
64	Blue Sucker	RM-105	10/19/2012	486	930	M	N

Total length of blue suckers ranged from 266 to 620 mm, with weights of 120 to 2,290 g describing a tight length to weight relationship (r^2 = .936, Figure 11). The two immature blue suckers may have been age-2 fish based on their size (266 mm TL for each), but it was impossible to be certain without ageing the fish. However, it does indicate that there has been some relatively recent recruitment of this species in the Sabine River. Additionally, one other immature blue sucker was observed during electrofishing near RM 36, but not captured.

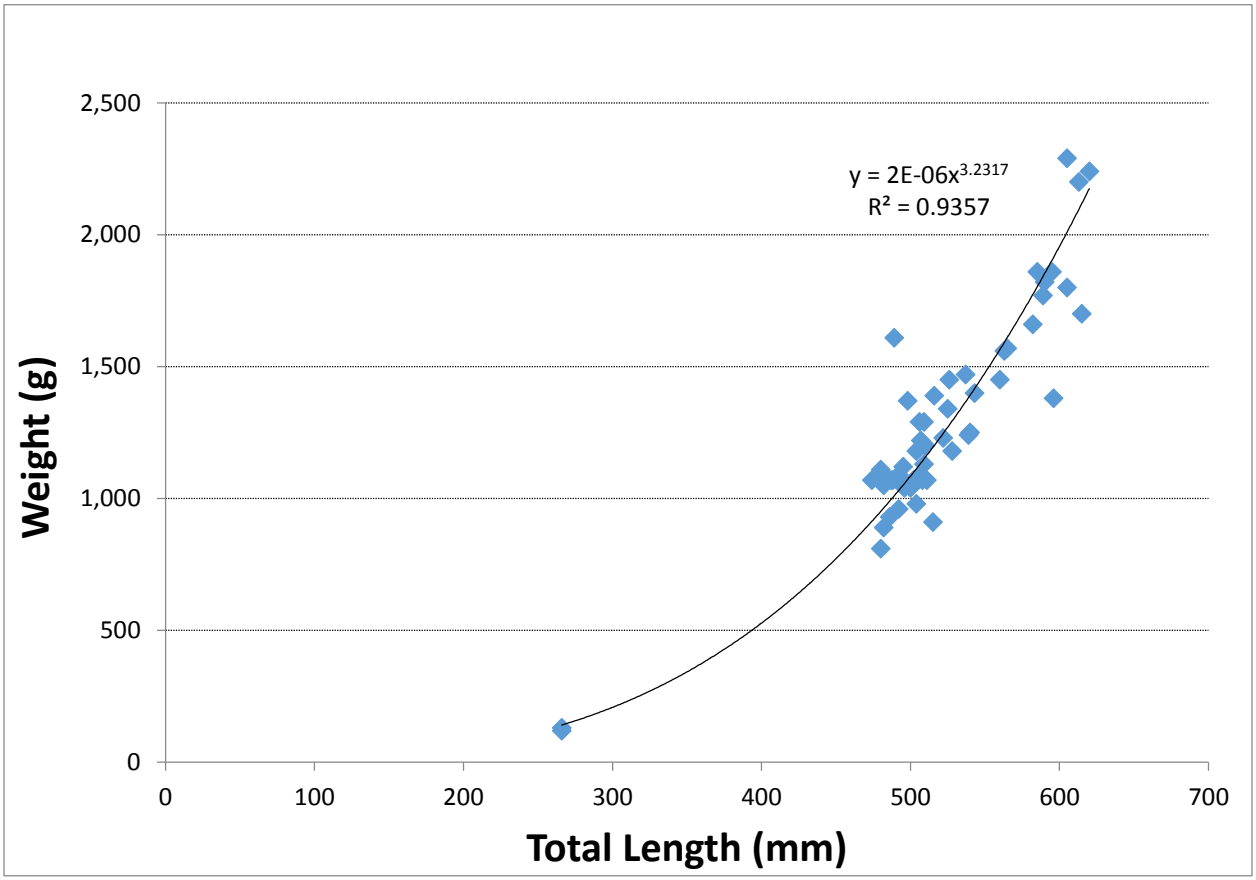

Figure 11. Total length and weight of 56 tagged blue suckers in the Sabine River during October 2012.

Tracking

A total of 120,874 contacts (262 active, 120,612 passive) were recorded over the study period in 2012 – 2013 (Table 3 and Table 4). SURs at RM 140 and 132 recorded the highest number of passive contacts (46,108 and 56,513, respectively) due to the high number of tagged fishes that remained in these locations over the duration of the study. SURs at RM 36 and RM 24 recorded no data over the study period. Only fish 50 (spotted sucker) was never successfully found after tagging. It is possible that this radio-tag was programmed incorrectly because a "false" contact (duplicate code on the wrong frequency) was heard several times in the same place in the vicinity of where this fish was tagged. However, every tagged blue sucker was found at least twice during the study period. Fish 30 and 31 (tagged at RM 132) recorded the highest number of passive and active contacts combined (23,183 and 31,113 hits, respectively) due to their static positions near the RM 132 SUR during the course of the study. Only one blue sucker (33, female) was not actively tracked during the study; however, it did record 1,858 contacts on the SUR at RM 132. It is believed that the radio-transmitting part of the CART tag was malfunctioning because the RM 132 SUR recorded a contact 8 minutes prior to this location being actively tracked by boat.

Table 3. Submersible Ultrasonic Receiver (SUR) locations and number of times a tagged fish neared the SUR (contacts) during 2012-2013.

SUR Location (River Mile)	# of Contacts
142	3,573
140	46,108
132	56,513
104	600
72	13,815
64	3
36	0
24	0
Total	**120,612**

Table 4. Number of active (manual tracking) and passive (SUR) contacts, tagging locations, final locations and dates of tagged fish during 2012-2013. BS – blue sucker, BT – blacktail redhorse, SS – spotted sucker.

Fish	Species	Tagging Location (River Mile)	Active	Passive (SUR)	Final Location (River Mile)	Date
1	BS	146	6	3492	142	4/2/2013
2	BS	146	4	381	146	5/14/2013
3	BS	141	3	124	132	4/4/2013
4	BS	140	4	2802	140	4/16/2013
5	BS	140	8	17085	140	5/5/2013
6	BS	140	7	520	140	4/18/2013
7	BS	140	7	3017	140	4/25/2013
8	BS	140	6	1237	138	5/14/2013
9	BS	140	8	2099	140	5/14/2013
10	BS	140	4	6441	140	5/3/2013
11	BS	140	4	228	132	3/2/2013
12	BS	140	7	876	140	5/14/2013
13	BS	140	4	310	139	5/14/2013
14	BS	140	6	27	138	5/14/2013
15	BS	140	8	1009	140	5/14/2013
16	BS	140	6	255	139	5/14/2013
17	BS	140	5	641	140	5/14/2013
18	BS	140	5	109	135	5/14/2013
19	BS	140	6	0	138	5/14/2013
20	BS	140	7	8328	140	5/14/2013
21	BS	140	2	0	130	2/20/2013
22	BS	136	2	0	136	12/11/2012
23	BS	136	5	0	136	5/14/2013
24	BS	136	6	738	134	5/14/2013
25	BS	136	5	207	137	5/14/2013
26	BS	136	5	0	136	5/14/2013
27	BS	136	2	98	122	2/22/2013
28	BS	132	3	3	127	2/22/2013
29	BS	132	5	125	132	5/14/2013
30	BS	132	8	23175	132	5/14/2013
31	BS	132	8	31105	132	5/14/2013
32	BS	91	4	53	140	4/13/2013
33	BS	132	0	1858	132	5/14/2013
34	BS	91	4	0	90	2/26/2013
35	BS	91	6	165	104	4/14/2013
36	BS	91	2	0	90	2/26/2013
37	BS	91	4	12	91	5/15/2013

Table 4 ctd. Number of active (manual tracking) and passive (SUR) contacts, tagging locations, final locations and dates of tagged fish during 2012-2013. BS – blue sucker, BT – blacktail redhorse, SS – spotted sucker.

Fish	Species	Tagging Location (River Mile)	Active	Passive (SUR)	Final Location (River Mile)	Date
38	BS	72	5	13521	72	1/31/2013
39	BS	72	4	0	74	3/27/2013
40	BS	72	4	301	72	3/27/2013
41	BS	72	4	151	104	4/14/2013
42	BS	34	3	109	91	2/26/2013
43	BS	34	4	0	34	2/23/2013
44	BS	34	3	0	83	2/26/2013
45	BS	34	4	10	91	2/26/2013
50	SS	140	0	0	n/a	n/a
51	BR	140	6	0	140	5/14/2013
52	BR	140	5	0	140	5/14/2013
53	BR	72	3	0	72	2/26/2013
54	BS	34	4	0	32	3/26/2013
55	BS	34	2	0	32	12/13/2012
56	BS	34	4	0	74	2/26/2013
57	BS	34	2	0	32	12/13/2012
58	BS	34	2	0	34	12/13/2012
59	BS	34	3	0	47	2/26/2013
60	BS	36	4	0	36	5/15/2013
61	BS	36	2	0	23 (old river)	5/15/2013
62	BS	36	3	0	83	2/26/2013
63	BS	36	3	0	61	2/26/2013
64	BS	105	2	0	Anacoco Bayou	2/22/2013
		Total	**262**	**120,612**		

Net movement (upstream – downstream from each previously tracked location) peaked in early February (+58.8 mi.), in the third week of February (+98.3 mi.) 2013, and again in May (+118.8 mi.) 2013. The peak in May is a result of 1 blue sucker male (fish 29) traveling 59.9 miles back upstream to its tagging location, and one blue sucker of undetermined sex traveling 58.9 miles upstream to its original tagging location. The only net downstream movement occurred during November (-5.0 mi.) and December 2012 (-2.2 mi.).

While both male and female blue suckers made long-distance movements, males traveled farther over the course of the study (Figure 12). Data were normalized to take into account both tracking trips (days) and days between tracking trips; however, net movement trends were the same so non-normalized data are presented for clarity. The timing of movement also differed between male and female blue suckers. While females moved a combined 177.6 miles in early February, males only moved 134.1 miles. Near the end of February, males moved almost 5 times as far as females (389.7 and 79.8 miles, respectively). Mean movements for females during this period was 14.1 miles (N=6), while males moved 25.0 miles

(N=16). Movement for both sexes began on the ascending limb of the hydrograph. In May, females displayed no movement from their previous position, while one male moved almost 60 miles upstream.

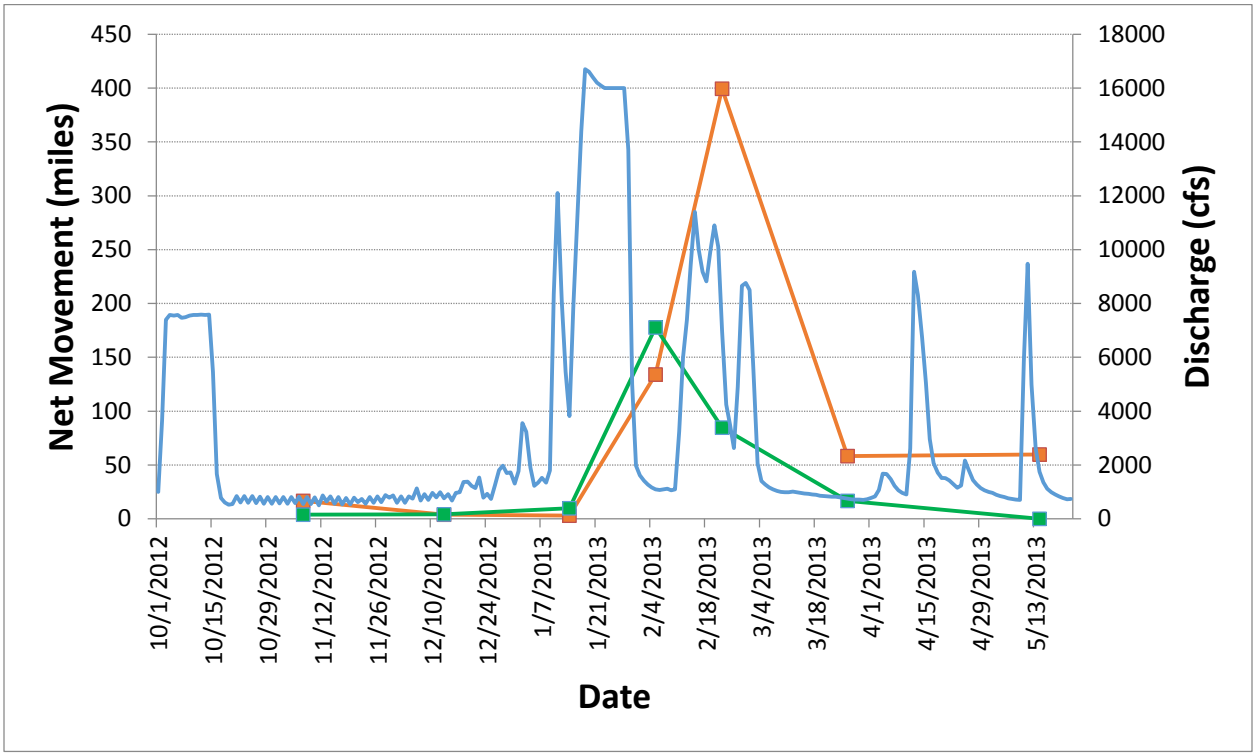

Figure 12. Net movement of male (red line) and female (green line) blue suckers for 2012-2013 from active tracking. Hydrograph from USGS station 08028500, Bon Weir (RM 91).

Females were much more likely to move in relation to higher flows than males (Figure 13). Male blue suckers also moved at higher flows, but the magnitude of the movement was not as strong as females. Attenuation of discharge in the lower reaches of the Sabine River may also have contributed to increased movement by males even though flows had dropped nearer to base flow in the upper reaches of the Sabine River.

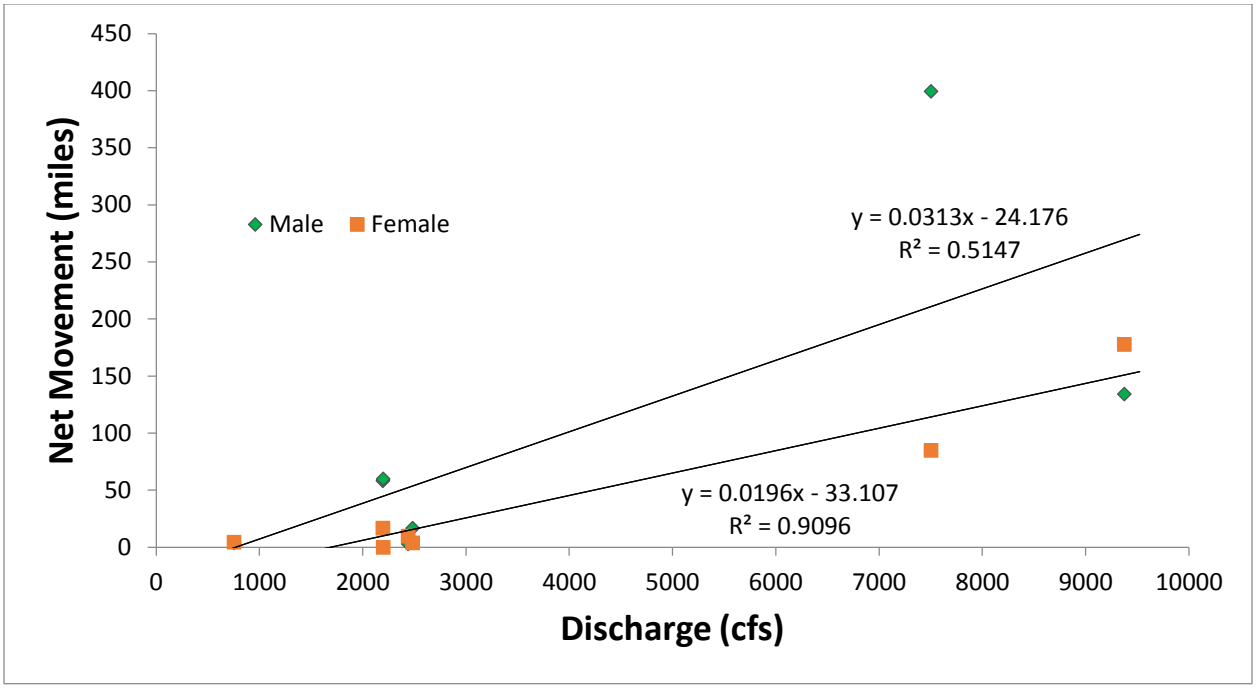

Figure 13. Relationship between net movement and discharge (one month rolling average) for male (green, top line) and female (orange, bottom line) blue suckers. Discharge from USGS station 08028500, Bon Weir (RM 91).

Fish 29, a male blue sucker (tagging location RM 132), moved 216.6 miles (net movement of 0 miles) during the course of the study (Figures 14-16). It stayed at its tagging location until late January when it began to move downstream on the descending limb of the hydrograph. Its farthest downstream location was in the Old River (Louisiana side of the Sabine River after it splits) at RM 23 on February 23, 2013. At this time flows were higher than normal and little could be determined about the habitat this fish was occupying. It was located at RM 64 on March 25, 2013 when it passed by a SUR indicating that it had started moving back upstream. This movement may have occurred on the descending limb of the hydrograph again, but it is unclear when it left its most downstream position. By May 14, 2013 it was back to its original tagging location completing the nearly 217 mile journey.

Figure 14. Fish 29, a male blue sucker tagged at RM 132.

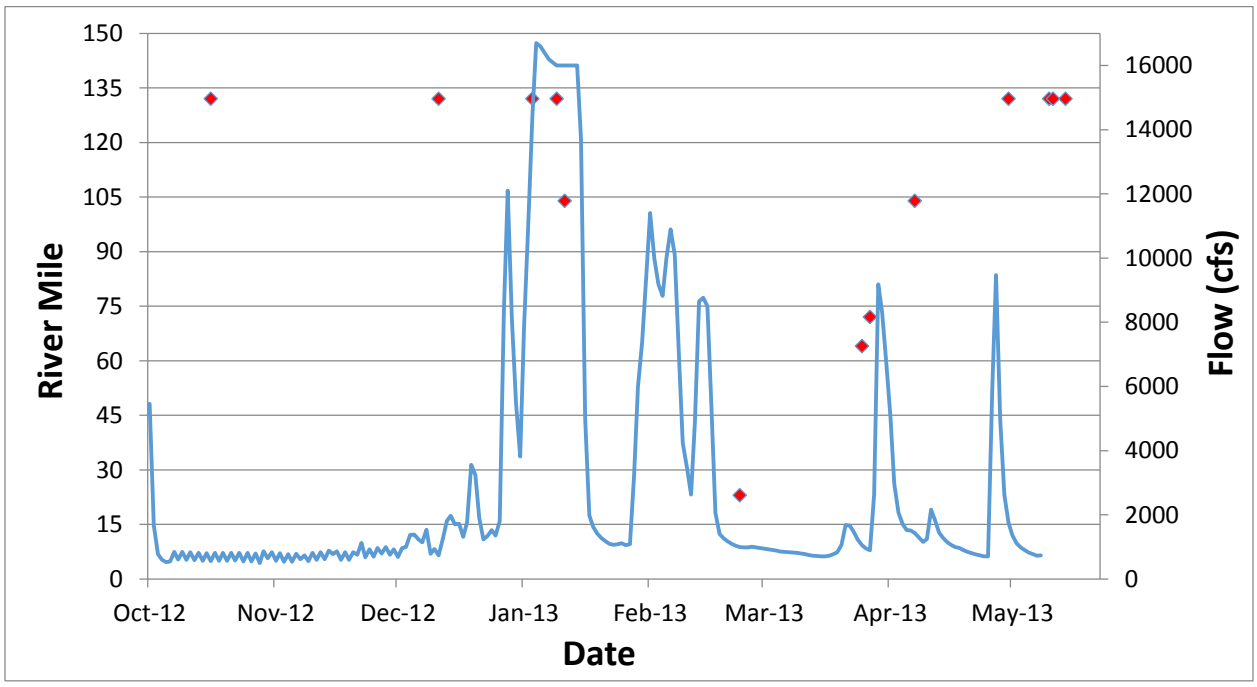

Figure 15. Fish 29's (blue sucker male) movement in 2012-2013. Each point represents a contact by passive or active tracking. Hydrograph from USGS station 08028500, Bon Weir (RM 91).

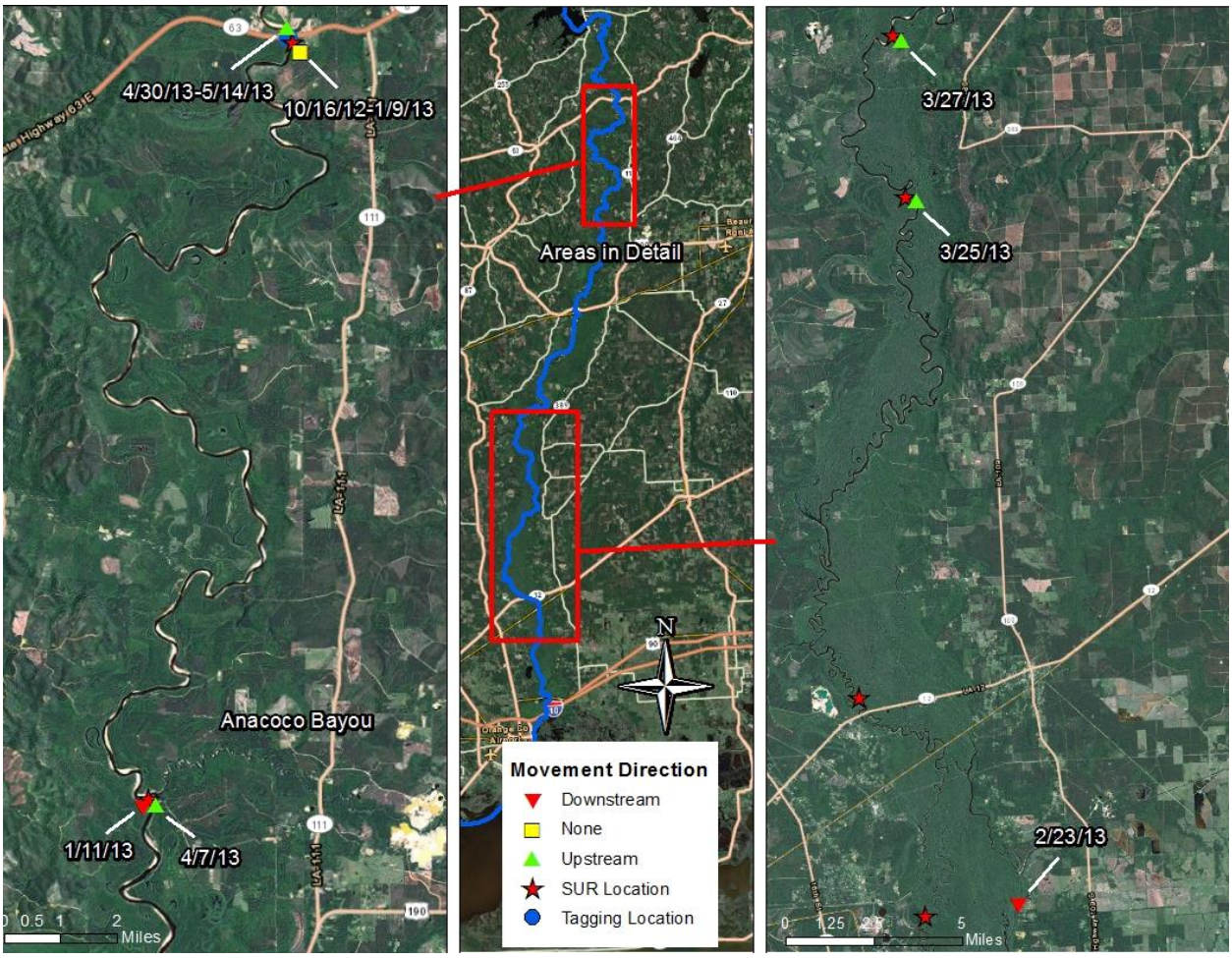

Figure 16. Fish 29's (blue sucker male) movement in 2012-2013. Each point represents a contact by passive or active tracking.

Another male blue sucker, fish 10, also exhibited a large downstream movement in early 2013, but it was found in a major tributary of the lower Sabine River, Anacoco Bayou (Figures 17-19). In early 2013, fish 10 moved 36 miles downstream from its tagging location (RM 140) to Anacoco Bayou. This fish was located 17.4 miles up Anacoco Bayou on February 7, 2013. The habitat associated with this location was a run with large woody debris present, but the precise location was not known because this fish was tracked by airplane. It appeared that fish 10 moved downstream during the descending limb of the hydrograph, but there are too few contacts during this time to know precisely. Fish 10 was detected by a SUR upstream of the mouth of Anacoco Bayou (~RM 104) on February 21, and one day later by manual tracking at RM 107. By April 9, 2013 this fish was located back at its tagging location.

Figure 17. Fish 10, a male blue sucker tagged at RM 140.

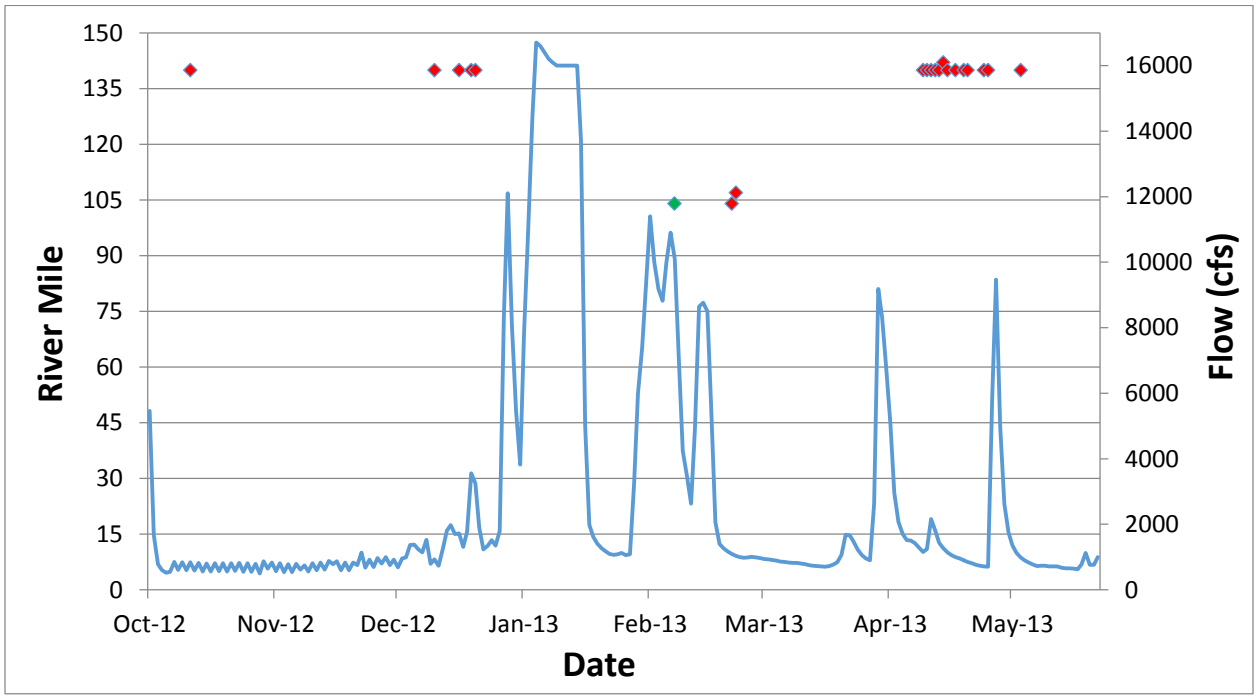

Figure 18. Fish 10's (blue sucker male) movement in 2012-2013. Each point represents a contact by passive or active tracking. Green data points reflect locations in Anacoco Bayou. Hydrograph from USGS station 08028500, Bon Weir (RM 91).

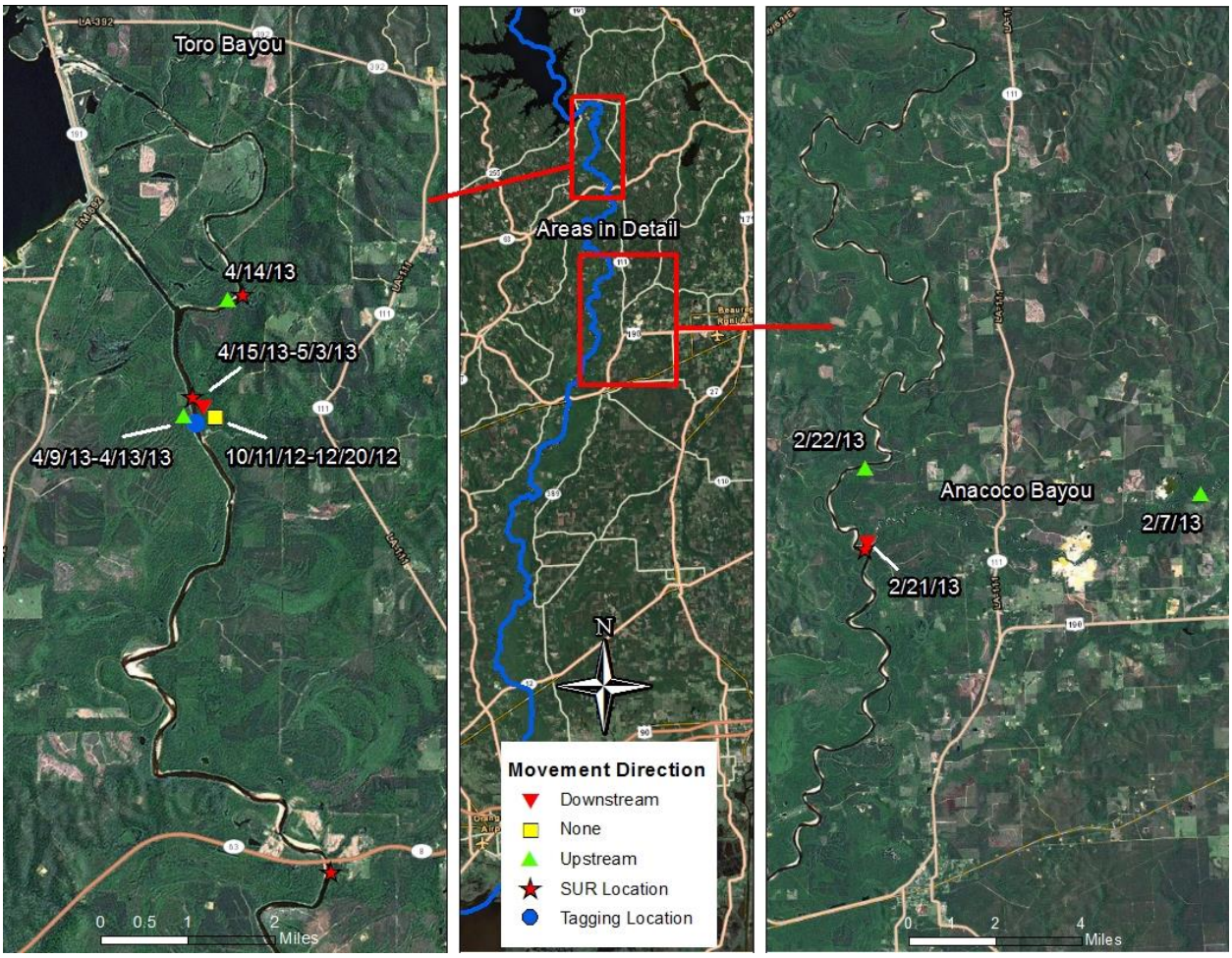

Figure 19. Fish 10's (blue sucker male) movement in 2012-2013. Each point represents a contact by passive or active tracking.

Male blue suckers were not the only ones to inhabit Anacoco Bayou in 2013. Fish 35, a female tagged at RM 91 was also located in this tributary (Figures 20-22). This fish was first located 18 miles up Anacoco Bayou on February 7, 2013 completing a 31 mile upstream journey. This was the farthest upstream any fish was found in this tributary. Like fish 10 it appeared to be amongst large woody debris in a run, but this fish was also tracked by air making it difficult to pinpoint its habitat. It was also unclear if this fish moved upstream as flows were increasing or decreasing. Two weeks later (February 21, 2013) it had moved 12.7 miles downstream, and 4 days later moved 3.7 miles downstream, but was still in Anacoco Bayou. Like other blue suckers it returned to its tagging location (March 26, 2013); however, it again moved upstream (13 miles), and was in the vicinity of a SUR (~RM 104) in early April.

Figure 20. Fish 35, a female blue sucker tagged at RM 91.

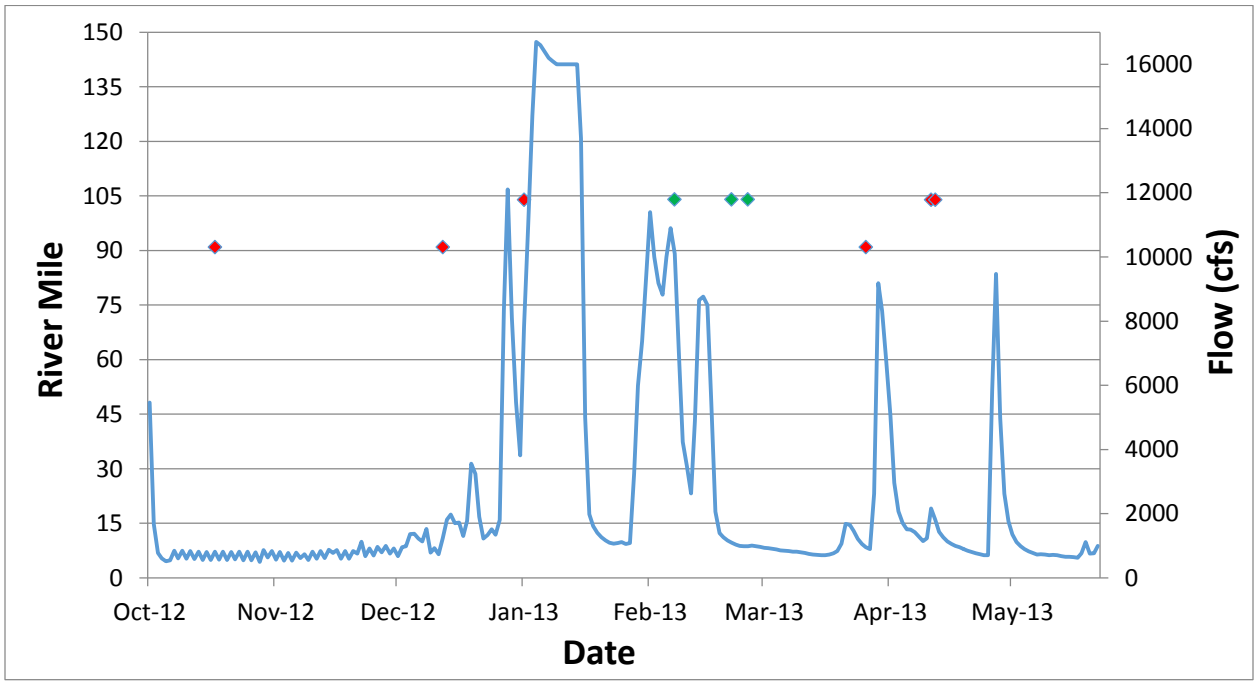

Figure 21. Fish 35's (blue sucker female) movement in 2012-2013. Each point represents a contact by passive or active tracking. Green data points reflect locations in Anacoco Bayou. Hydrograph from USGS station 08028500, Bon Weir (RM 91).

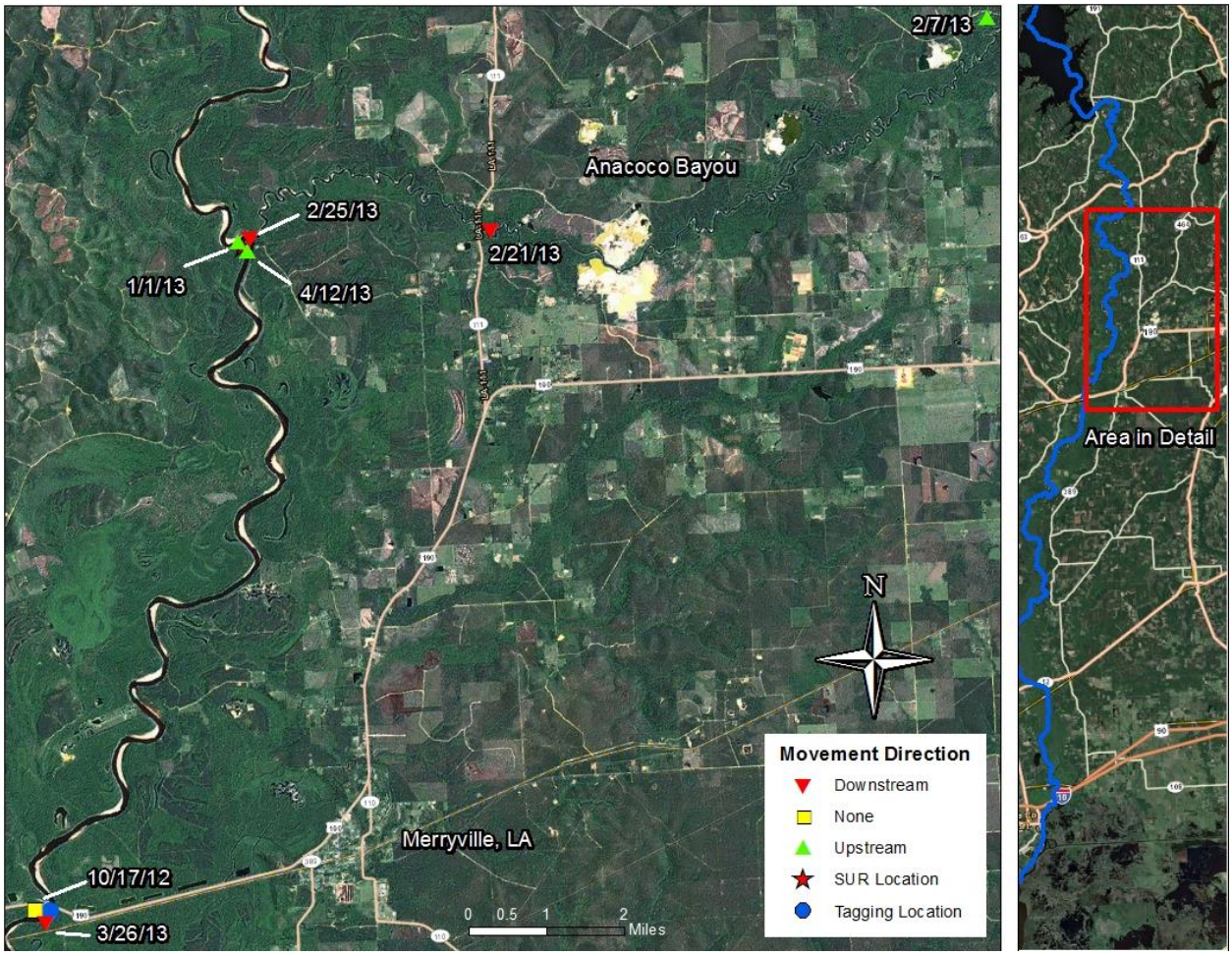

Figure 22. Fish 35's (blue sucker female) movement in 2012-2013. Each point represents a contact by passive or active tracking.

Fish 3, a male blue sucker, moved the farthest (41 miles) of all blue suckers that were found in Anacoco Bayou (Figures 23-25). It was originally tagged in the tailrace (RM 141) of Toledo Bend Dam, and on February 7, 2013 it was located at the LA 111 bridge crossing of Anacoco Bayou. The bayou is sinuous and sandy here with large woody debris present throughout its course. This fish appeared to begin its downstream movement on the ascending limb of the hydrograph. It was subsequently heard on the nearest SUR (RM 104) over two days in late February, and its last contact was on the RM 132 SUR on April 4, 2013, only 9 miles downstream of its tagging location reflecting its upstream migration.

Figure 23. Fish 3, a male blue sucker tagged at RM 141.

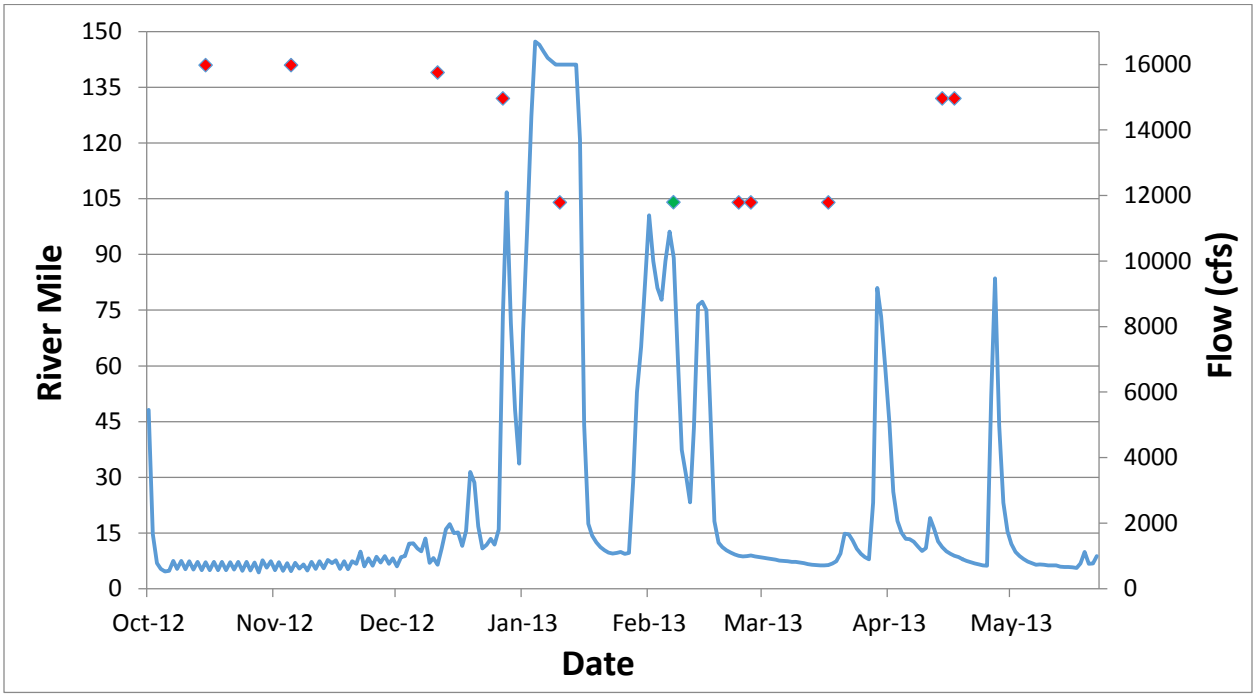

Figure 24. Fish 3's (blue sucker male) movement in 2012-2013. Each point represents a contact by passive or active tracking. Green data points reflect locations in Anacoco Bayou. Hydrograph from USGS station 08028500, Bon Weir (RM 91).

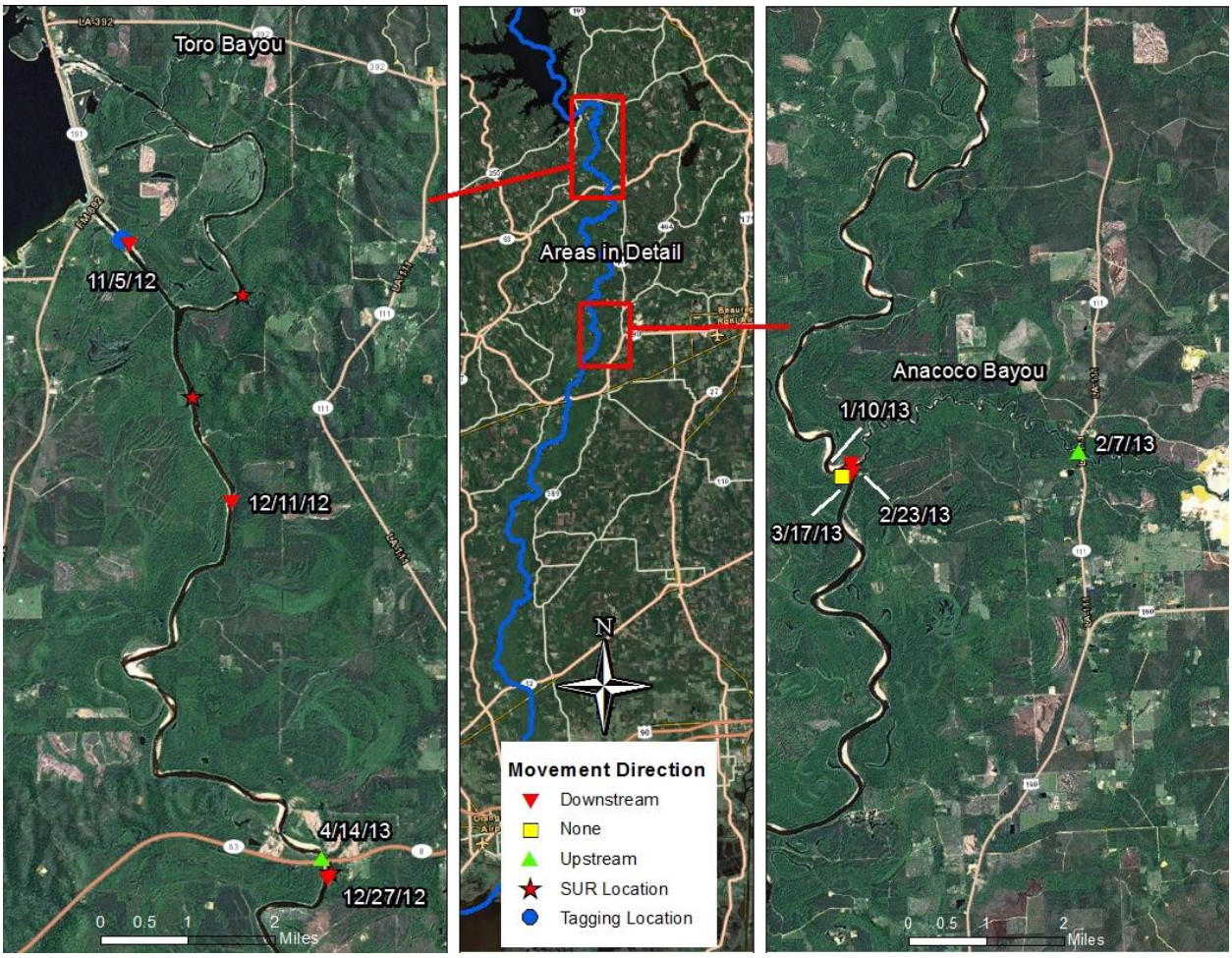

Figure 25. Fish 3's (blue sucker male) movement in 2012-2013. Each point represents a contact by passive or active tracking.

Additionally, fish 37 (male blue sucker) was located 13.2 miles up Anacoco Bayou on February 7, 2013. One other male blue sucker (fish 64) used Anacoco Bayou when it was found 6.1 miles upstream on February 22, 2013. It is important to note that none of the blue suckers that were located in Anacoco Bayou were located within the same river mile on the same date.

A female blue sucker, fish 42 (tagged at RM 34) traveled the longest distance of all females in this study (Figures 26-28). It traveled 68.9 miles upstream to ~RM 104 on February 2, 2013, which is just downstream of the mouth of Anacoco Bayou. However, this fish was never tracked within the bayou itself. It was found among large woody debris in the thalweg of the Sabine River. This movement coincided with a period where flows were higher in the system. It was last located at RM 91 on February 26, 2013 in large woody debris where blue suckers have been captured (and tagged) before.

Figure 26. Fish 42, blue sucker female tagged at RM 34.

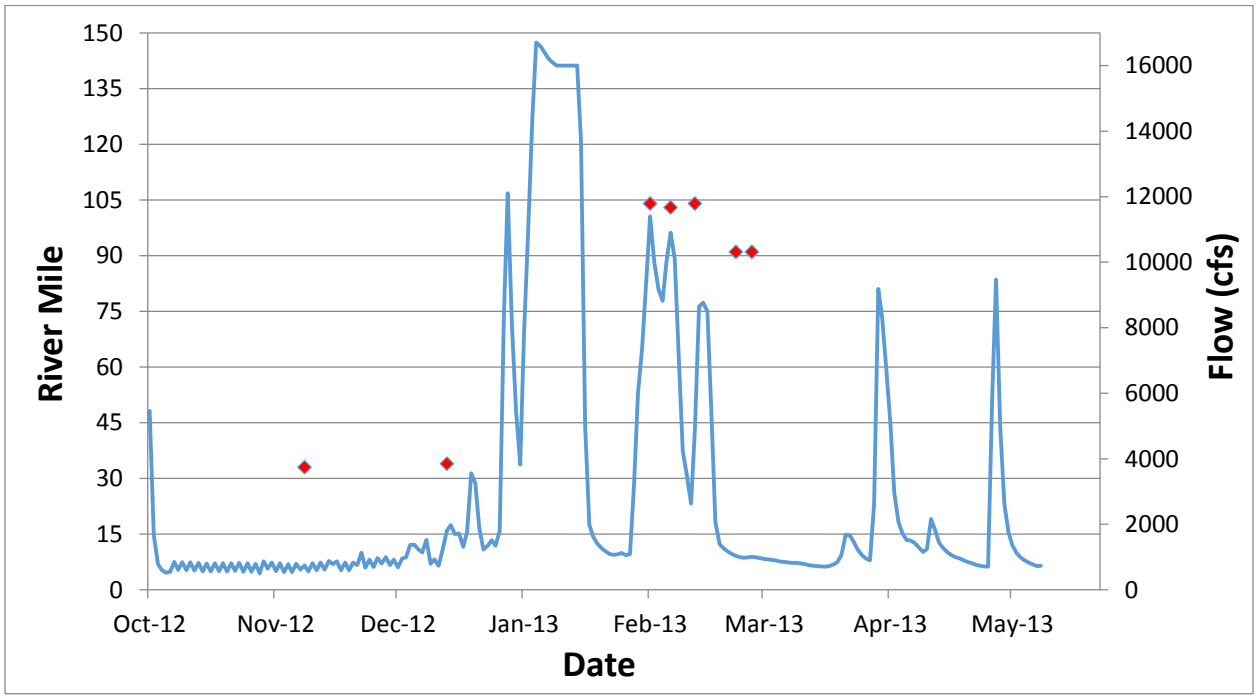

Figure 27. Fish 42's (blue sucker female) movement in 2012-2013. Each point represents a contact by passive or active tracking. Hydrograph from USGS station 08028500, Bon Weir (RM 91).

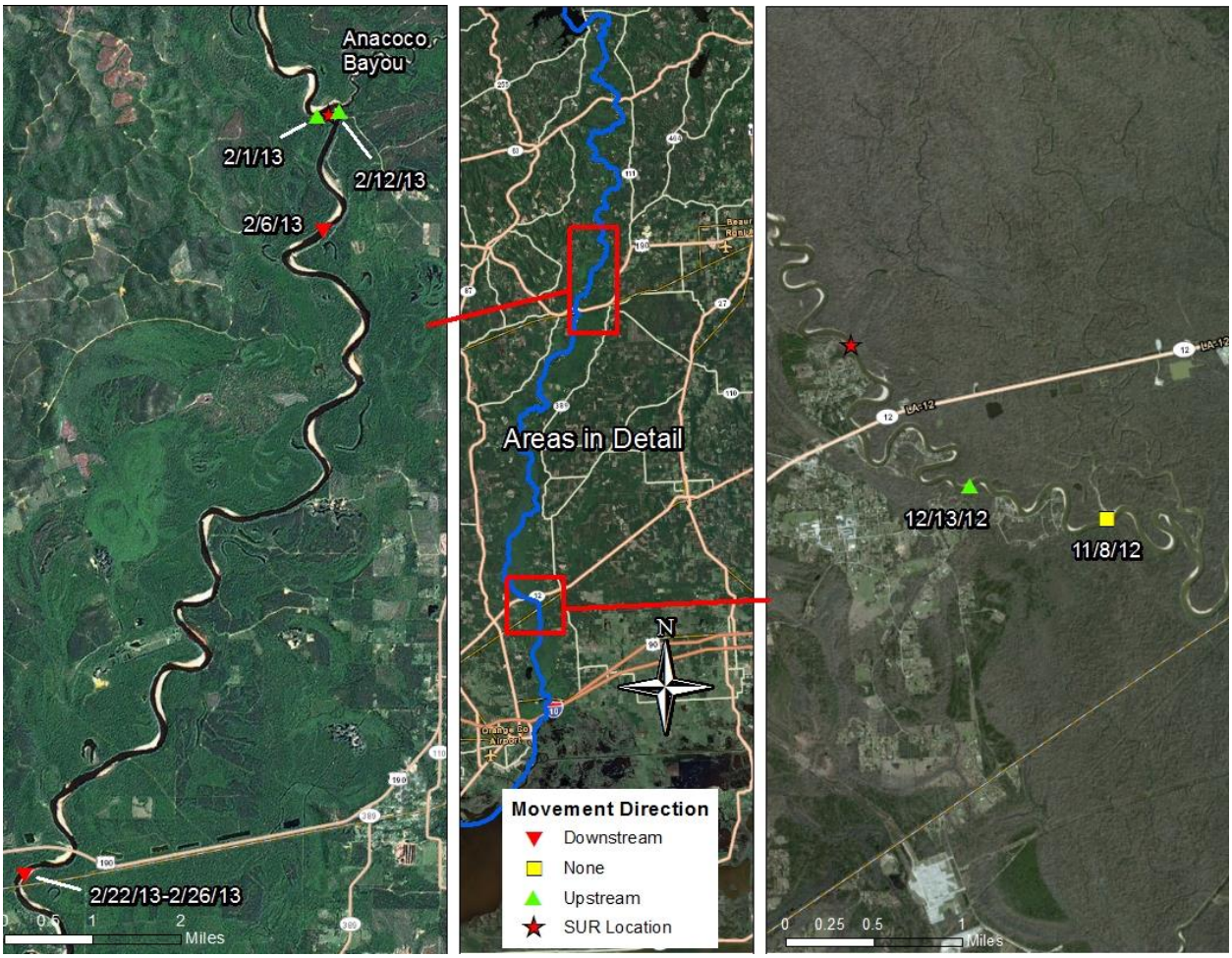

Figure 28. Fish 42's (blue sucker female) movement in 2012-2013. Each point represents a contact by passive or active tracking.

Spawning Site Characterization

One goal of the study was to use tagged fish in order to discover spawning sites in the Sabine River. Although telemetry indicated a lot of upstream movement (both on the river and in one tributary) by blue suckers during late winter and early spring, no spawning aggregations were observed in 2013. Therefore, it was decided to electrofish for blue suckers where aggregations are known to be in order to assess spawning condition on March 27, 2013. At a large bedrock riffle at RM 140, 5 adult blue suckers were collected. Two expressed milt (Figure 29), while two showed no signs of spawning readiness. One appeared to be female with a belly that felt full, but no eggs were expressed. In addition, two blacktail redhorse were caught with one freely expressing milt, and the other freely expressing eggs (Figure 30). All males (blue sucker and blacktail redhorse) had tubercles on their heads and bodies. Observations at the riffle itself did not show any blue suckers in the shallow areas engaging in spawning behavior as has been seen in the Colorado River in Texas (BIOWEST 2006). In other blue sucker populations engaged in spawning behavior milt and eggs were freely expressed with little pressure (BIOWEST 2006, Vokoun et

al. 2003). Water temperature on this date was 15.8° C, which is within recorded spawning temperatures (13 – 17 ° C) in other rivers (Rupprecht and Jahn 1980, Petersen et al. 1999, BIOWEST 2006).

Figure 29. Blue sucker male with running milt at RM 140 on March 27, 2013.

Figure 30. Blacktail redhorse female with eggs at RM 140 on March 27, 2013.

Electrofishing continued at the RM 72 tagging site on March 27, 2013. Only two blue suckers were captured here, with one believed to be female and the other a confirmed male (recaptured tagged fish #38). The male had tubercles over its entire body (Figure 31), while the female also appeared to have an extended abdomen full of eggs. Water temperature at this location was 17.7° C.

Figure 31. A male blue sucker (fish 38) captured at RM 72 displaying tubercles on March 27, 2013.

Blue suckers were again collected on April 8, 2013 at the 140 riffle to assess spawning condition. Seven adults were caught, with none expressing milt or eggs. Two females had flat (apparently spent) abdomens, while 3 males did not express milt. Only two of the males and none of the other blue suckers had prominent tubercles on their head or body (Figure 32). One more female was caught at RM 146, and also had a flaccid belly. Water temperature at RM 140 was 19.4°C, above the presumed optimal spawning temperature range.

Figure 32. Blue sucker captured during spawning condition effort. No eggs or tubercles were observed on this fish.

At this time an effort was made using kick nets to dislodge any eggs that may be clinging to the bedrock at the RM 140 riffle (a further indication of spawning). After an hour of sampling in areas where blue suckers were known to be (based on telemetry), no eggs were recovered and the effort was abandoned. Based on the condition of the fish collected, spawning at the RM 140 riffle may have occurred during the first week of April 2013, but without more data it is difficult to pinpoint the exact spawning period. However, given variations in water temperature and flow throughout the system, timing in other areas may have varied.

Discussion

Data collected in the blue sucker tagging study has expanded the knowledge of the movement and spawning related behavior of this State Threatened species. Tracking (passive and active) proved that these large fish will migrate long distances in winter and spring if flows are increasing. Additionally, while males seem to move farther, females also make these long migrations to (presumably) spawn. Telemetry also indicated that blue suckers have a small home range that they keep to outside of their spawning movements. Of the blue suckers that made long distance movements in 2012-2013, 7 (fish 2, 9, 11, 17, 29, 35, and 37) returned to their original tagging location. For example, fish 2 moved 63 miles downstream during the spring of 2013 to RM 83. At this time (February 22, 2013) this male was among two other tagged blue suckers. Fish 38, another male had migrated 11.5 miles upstream from its tagging location to reach RM 83, while fish 44 (male) migrated 50.3 miles upstream to get here. Four days later, fish 62 (male) was located at this same bend (RM 83) in the river after traveling 51.3 miles upstream. At this time, the only tagged fish left was fish 44, but it is reasonable to assume that all 4

tagged males occupied this habitat at the same time during the typical blue sucker spawning season. When these fish were located the river was high because of recent rainfall, so it was difficult to assess habitat, but they appeared to be in the thalweg in a large bend in the river at RM 83. Although substrate on the bottom could not be confirmed, there was rip-rap lining the bank in this area because of homes located nearby. Additionally, there was some large woody debris located in the bend. Unfortunately, we could not capture these fish to assess their condition, and to see if a large group of suckers were located here. However, it is reasonable to assume that this is an important location likely related to spawning. This information could only be determined by tracking tagged fish, and in the future could lead to more precise data regarding this location. Of the blue suckers at RM 83, only fish 2 had returned (63 miles back upstream) to its original tagging location as of the end of this study.

A similar grouping of blue suckers was discovered by aerial tracking at RM 128 to RM 130 on February 7, 2013. Although these blue suckers were spread over a wider area in the river (~2 river miles), 4 tagged fish from 3 tagging locations were located here. Fish 11 (male) and fish 21 (female) were originally tagged at the RM 140 site, while fish 28 (female) was tagged at RM 132, and fish 41 (male) was tagged at RM 72. Unlike the previous aggregation, this one included two females. Fish 28 and 41 were found in the same section of the river on February 7, 2013. Fish 28 traveled 4 miles downstream to this location, while fish 41 traveled 43.7 miles upstream to a section of river that is a run with large woody debris present. Since this location was found by air the substrate is unknown, but there is bedrock present on the banks which may indicate an outcrop in the river. Such bedrock outcrops have been known to harbor spawning aggregations of blue suckers in the Colorado River, Texas (BIOWEST 2006). Fish 11 and 21 were found in the same half-mile stretch of river (RM 130) on the same date. Similarly, they were found in a run with large woody debris present, but the substrate could not be determined by air. On February 20, 2013, fish 21 and 28 were found in the same stretch of river (RM 130) that fish 21 and 11 had been occupying two weeks previous. Fish 11 was the only one of these four to make it back to its tagging location by the end of the study. As in the RM 83 aggregation spawning condition could not be assessed, but it does display that these suckers are making large movements (both upstream and down) from different tagging locations to the same stretch of river indicating the importance of these specific habitats.

Another significant grouping of tagged blue suckers occurred in Anacoco Bayou (a major tributary of the lower Sabine River, Figure 2) in early February. Unlike the groupings in the Sabine River, these fish were spread out in the bayou, and not found to be occupying the same location at the same time. What was similar among these 5 tagged blue suckers was their timing into and out of Anacoco Bayou. The 5 blue suckers that occupied this tributary were fish 3 (female, RM 141 tagging location), fish 10 (male, RM 140 tagging location, fish 35 (female, RM 91 tagging location), fish 37 (male, RM 91 tagging location), and fish 64 (male, RM 105 tagging location). According to SUR data, fish 3, 35, and 37 likely entered Anacoco Bayou in early January (1/1/13 – 1/10/13) on the ascending limb of the hydrograph (Figure 33). Fish 35 was located farthest up the bayou in February, but like the other tagged fish it is unclear what their destination was in this tributary. Like the Sabine River, the tributary is sinuous with sand as the dominant substrate, and large woody debris spread throughout its channel. The only area with bedrock and boulders (that could be observed from the air) is located at the dam that creates Anacoco Lake, Louisiana, which is 51 miles upstream of the mouth at the Sabine River, and is a barrier to upstream movement (Figure 34). This site looks like optimal habitat for a spawning site, but of the two times this

location was tracked, no tagged fish were found there. Therefore, it is likely that if they were using the

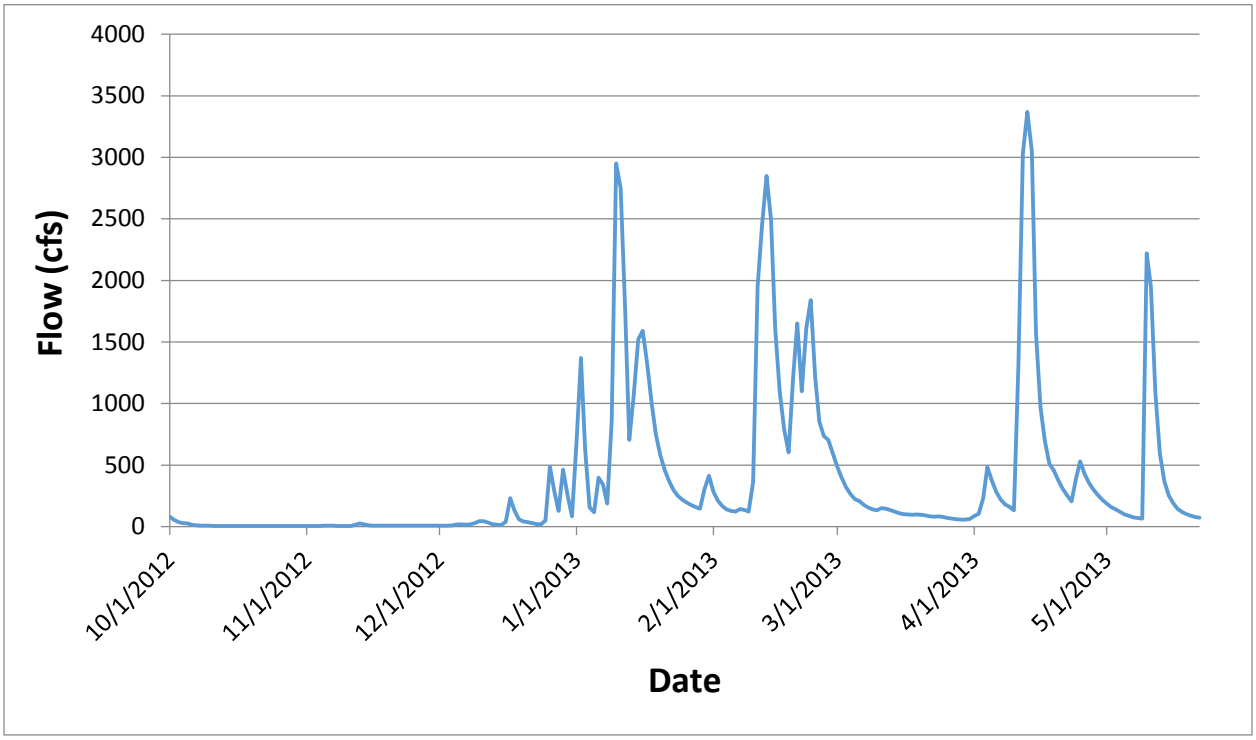

Figure 33. Hydrograph of Anacoco Bayou at LA 111 (USGS gage 08028000) from 2012-2013.

tributary to spawn it may have occurred somewhere else. During the times the tagged fish occupied Anacoco Bayou, flows ranged from 116 to 2,950 cfs (USGS gage 08028000, 2013). Fish 3, 10, and 35 moved out of Anacoco Bayou (according to SUR data) on 2/21/2013 (fish 10, 35) and 2/23/2013 (fish 3). This downstream movement also occurred on the ascending limb of the hydrograph (flow range: 1,100 – 1,840 cfs). This timing indicates that blue suckers are using increases in flow to aid in their movement into and out of the bayou. During this time, water temperature was 13.5° C both at Anacoco Dam and the road crossing at LA 111, within the range (13 – 17° C) of other blue sucker spawning aggregations (Rupprecht and Jahn 1980, Petersen et al. 1999, BIOWEST 2006).

Figure 34. Anacoco Dam, an upstream barrier to migration on Anacoco Bayou, LA.

Telemetry data suggest that male blue suckers move farther and later in the spring than females. While one spawning season is not enough to suggest this as a trend it does raise an important question in the life history of blue suckers. Peterson et al. (2000) found that male southeastern blue suckers (*Cycleptus meridionalis*) moved towards spawning areas earlier in the spring than females, but little is known if this trend varies by basin. In the Sabine River it appears that female movement is more closely linked to discharge (r^2 = 0.9096) than male blue sucker movement (r^2 = .5147) (Figure 13). One-third of the net movement for males in February is due to fish 29 being located 109 miles downstream of its previous location. If this fish is excluded, movement of male blue suckers is very closely linked to discharge (r^2=.9307). This male had not been located since December 2012, which indicates that the fish likely was moving much earlier, possibly on the ascending limb of the hydrograph. It may also be true that males will move each year to spawn regardless of flow (dependent on upstream barriers), while females may stay in their home range unless flows are sufficient to trigger spawning movement. Considering both males and females made long-distance movements in the Sabine River it does not appear as though males are the only ones to move in order to spawn. By May, no females had moved from their previous position, while one male had made the long journey back to its original tagging location (fish 29). Several seasons of movement data could lend credence to the hypothesis that males move farther and later than females, and that female blue sucker spawning movement may be more closely tied to flow.

Passive tracking addresses the problem of limited funds (and time) that are often a part of tracking studies. Because active tracking involves a lot of time and manpower, these SURs fill the need of more

frequent monitoring. Through their use, it was easier to track down fish and target specific reaches with manual tracking. In the case of this study, some of this targeting was done by airplane. Most critically, the SUR at RM 104 provided the timing of when several tagged fish were entering and leaving Anacoco Bayou. This allowed a closer evaluation and understanding of how discharge affected when the blue suckers utilized this major tributary. After 8 months of study, it is evident where the placement of SURs was most effective. The SURs at RM 24 and RM 36 provided no data over the course of the study. While no contacts were provided from the SUR at RM 24, it does tell us that this section of the Sabine River is not utilized by tagged blue suckers frequently. Electrofishing in this area further supports that conclusion.

Although no spawning aggregations were observed in 2013, it is speculated that blue suckers spawned during the first week of April, but further data collection was needed to support this conclusion. Water temperature data from late March at several sites on the river ranged from 15° C to 16 ° C where adult blue suckers were captured. In the Colorado River (Texas), spawning occurred from 12° C to 16° C, putting the Sabine River temperatures in late March within the range when spawning is known to occur (Rupprecht and Jahn 1980, Petersen et al. 1999, BIOWEST 2006).

BIO-WEST biologists have previously observed blue suckers spawning in shallow areas of the Colorado River, Texas, and were hopeful to observe spawning in the Sabine River. However, telemetry data suggests that tagged adult blue suckers may have spawned in deeper pockets where spawning could not be visually observed. Although spawning was not actually witnessed, tracking revealed congregations of adult blue suckers at several key areas during spring 2013 (RM 140, RM 128-130, RM 83, and Anacoco Bayou). The timing and degree of movements of tagged blue suckers in the Sabine River suggest that spawning occurred at several sites possibly representing a wide spectrum of habitats (bedrock riffle, sandy run, woody debris, etc.). These key areas should be monitored in the future to confirm their potential as blue sucker spawning locations.

Probably the largest data gap is the lack of understanding of larval and juvenile (age-0 to age-2) blue sucker life history. The capture of two juveniles during this study is extremely important. These two juveniles were both 266 mm TL (Figure 35), and according to published data this would make them age-2 fish (Hand and Jackson 2003, Morey and Berry 2003, Moss et al. 1983, Rupprecht and Jahn 1980). Both were caught between RM 34 and RM 36 in deep runs near large woody debris in the lower portion of the river basin. While fish 64 moved 15.4 miles downstream, fish 54 did not move from its capture location for the entire study. Both habitats were similar to their capture locations (deep run with large woody debris), but neither appeared to make any movements associated with spawning. The capture of these two individuals implies that at this age they are already associating with adult blue suckers in the same type of habitat. A question that might be asked is why were juveniles only observed in the lower reaches of the Sabine River? It may be that rearing habitats are more plentiful due to an increased number of backwaters and (during higher flows) connections to off-channel habitat. It is not well understood at what age blue suckers are sexually mature, but Peterson et al. (1999) found fully developed gonads in age-4 males; however, gonad assessment would have required killing these fish and was not a part of this study. Additionally, flow data from the nearest gage suggests that these two juveniles possibly hatched in 2010 (Figure 36). Flows were high during the winter and spring months in 2010 enabling spawning movements for adult blue suckers. This may imply that blue suckers require certain higher flow periods in winter and/or during the spawning months to ensure successful

reproduction. In addition, the lower flows in May of 2010 may have allowed larvae to successfully navigate the river without being washed into poor habitat; however more data are required to assess blue sucker recruitment. Adams et al. (2006) demonstrated that survival of larval blue suckers were unrelated to flow due to their abundance during a high and low flow year (during spawning months), but the study concluded that access to nursery habitats regardless of flow was likely more important to larval survival. Further sampling for larvae and juveniles in the Sabine River could lead to a better understanding of this elusive stage in blue sucker life history.

Figure 35. A juvenile blue sucker (Fish 54) caught at RM 34 in October, 2012.

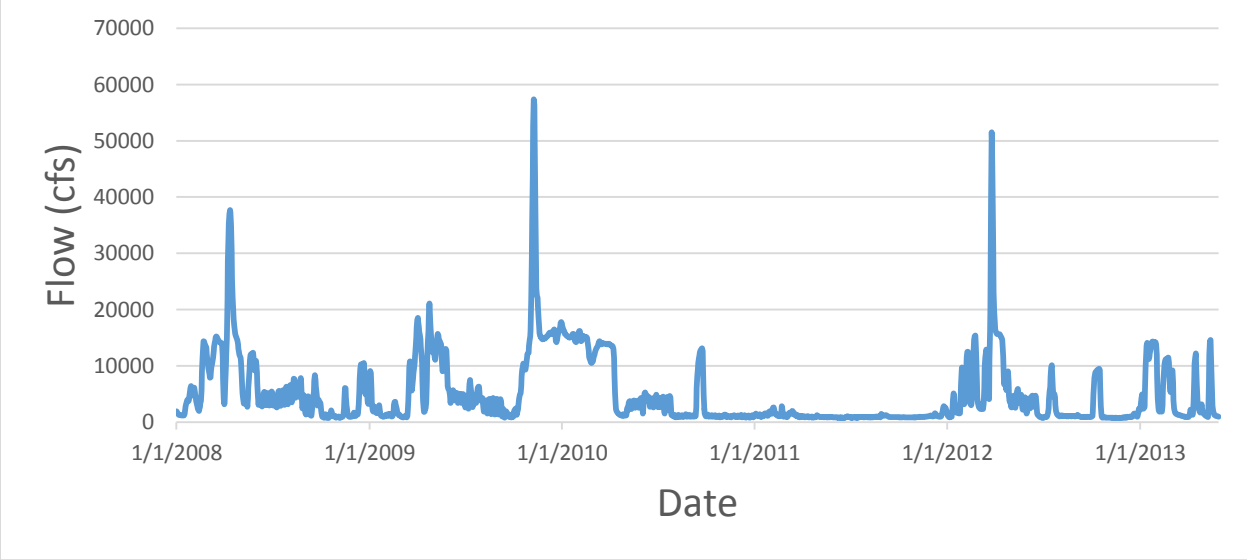

Figure 36. Hydrograph from Ruliff gage (08030500) on the Sabine River, 2008-2013.

Conclusions

Data collected from the blue sucker tracking study on the Sabine River in 2012-2013 confirms behavior that has been observed in other basins where this rare fish is found. With ample flow these large riverine fish will travel long distances (both upstream and downstream) in order to spawn. In the Sabine River, blue suckers were found to use a major tributary during the spring spawning period, but didn't appear to use this tributary after spawning was presumed to be complete. While the use of tributaries during spawning months is not unknown in this species (BIOWEST 2006), it does provide a more complete picture of how this species utilizes large river basins. These findings also underscore the importance of protecting critical habitats however diverse they may be. In the case of the blue sucker in the Sabine River, critical main channel habitats likely include bedrock riffles and runs, and instream structure including large, woody debris; however further study of specific habitat requirements is needed. These large fish also require higher velocity habitats (BIOWEST 2006) that are found in the Sabine River even when total discharge is very low. Of course in a study that only spans 8 months, there are data gaps that need to be addressed. Another year of tracking would help to understand the types of habitats and movements these fish participate in that are not related to spawning. Tracking the spawning movements in 2014 could lead to unknown spawning aggregations, the importance of other tributaries, and how and when blue suckers move if flows are different from 2013. Knowing their movements in differing discharges is critical to properly managing blue suckers.

Future studies should focus on sampling the larval and juvenile stages of blue suckers. Questions regarding these life stages such as, "Why after extensive sampling on the lower Colorado River, were no juvenile blue suckers found (BIO-WEST 2006)" or "Why, if juveniles on the Sabine River are found in the same habitats as adults, were they only collected in the lower river" continue to elude researchers. This remains the most important data gap to address because it will allow management to focus on the needs of these critical life stages in a blue sucker's development. While dams have caused habitat fragmentation, and in several river systems subsequent declines in populations of blue suckers, they can be advantageous because through proper management they can provide flows for critical life stages exactly when they are needed. If larval fish were found to be using nutrient rich backwaters and side channels, then dam releases could be timed to provide connections to these critical habitats. If higher flows are needed to contribute to oxygenating eggs immediately after spawning, then these flows could also be provided likely without detrimental effects to other uses (electricity generation). While this study expands our knowledge of blue sucker life history, its most important aspect is continuing to highlight the data gaps that need addressing in order to sustain a future for this species in managed waterways like the Sabine River.

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Attachment 1
TWDB Comments on Blue Sucker Movement and
Habitat Use in the Lower Sabine River, Texas
TWDB Contract No. 1004831019

Blue Sucker Movement and Habitat Use in the Lower Sabine River, Texas
Draft-final report to the Texas Water Development Board

Draft Final Report Comments:

Overall, the draft final report is well written and clearly documents the project and associated results. There are a few minor typos and opportunities to clarify some portions of the project.

REQUIRED CHANGES

1. Please correct the following typos:
    a. Page 1, 5th paragraph, 3rd sentence ending "2010 spawning season; hydrology during the" doesn't make sense. Please rewrite to insure meaning is clear.
    b. Page 3, 2nd paragraph, 2nd sentence, "with adjustable boom were used" should be "with adjustable boom was used."
    c. Page 4, 4th paragraph, 2nd sentence, "TPWD and BIOWEST Sabine River" should be "TPWD and BIOWEST sampled Sabine River."

SUGGESTED CHANGES

2. On page 2, 2nd paragraph, 5th sentence, Blue Sucker habitat is described in metric units ("1-2 m"). In the rest of the document, standard units are provided. For example, on page 7, 2nd paragraph, 2nd sentence, Blue Sucker habitat is described as "2.2 ft. deep, 3.18 fps velocity." For consistency, please consider providing standard units throughout the document.
3. On page 4, 3rd paragraph, 4th sentence mentions work performed by "Texas Tech." It is unclear who this refers to. Perhaps this is the same entity referred to as "USGS Cooperative Unit at Texas Tech University" in the 4th paragraph on page 4. Please consider adding some wording to the Introduction (possibly the 5th paragraph on page 2) to clarify the identity of this entity and their relationship to the study.

All changes were made as requested although metric units were used consistently throughout the document.