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Dispersal, persistence, and areas of core use of re-introduced juvenile lake sturgeon in the Upper Tennessee River System

Misty Dawn Huddleston

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To the Graduate Council:

I am submitting herewith a thesis written by Misty Dawn Huddleston entitled "Dispersal, persistence, and areas of core use of re-introduced juvenile lake sturgeon in the Upper Tennessee River System." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

J. Larry Wilson, Major Professor

We have read this thesis and recommend its acceptance:

Paul D. Ayers, Edwin M. Scott

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Anne Mayhew

Vice Chancellor and
Dean of Graduate Studies

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DISPERSAL, PERSISTENCE, AND AREAS OF CORE USE OF RE-INTRODUCED JUVENILE LAKE STURGEON IN THE UPPER TENNESSEE RIVER SYSTEM

A Thesis

Presented for the

Master of Science

Degree

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Misty Dawn Huddleston

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ABSTRACT

The lake sturgeon (*Acipenser fulvescens*) historically occurred throughout the Tennessee River system but was extirpated by the 1960's due to over-consumption, and habitat destruction and alteration from pollution, and dam construction. In response to improvements in water quality and other improvements made by the Tennessee Valley Authority (TVA), a multi-agency partnership was formed to reintroduce lake sturgeon in the Upper Tennessee River system. The initial re-introduction occurred in 2000, and to date over 45,000 fish from multiple age classes have been released.

Little is known about the behavior of the hatchery-reared juvenile lake sturgeon in this system. A biotelemetry study of hatchery-reared juvenile lake sturgeon released into the French Broad River was conducted to determine if patterns exist in their dispersal, persistence, and use of the upper Tennessee River system. Radio transmitters were surgically implanted into 20 juvenile lake sturgeon that were released into the French Broad River in the fall of 2004.

Persistence within the system was 50% for the 90-day battery life of the transmitters. The mean dispersal from the release site was 10.6 river miles (sd=7.9). The mean linear range was 7.3 river miles and ranged from 1.0-20.3 total river miles. Directional movement was correlated with changes in flow; distances traveled, dispersal distances, and depth selection exhibited slight linear relationships to daily temperatures and mean daily discharges from an upstream hydroelectric dam. Juvenile lake sturgeon exhibited aggregation and used core areas in the French Broad River, a tributary to the Tennessee River. Areas of aggregation and core use were located within the bend of the river, with sand substrate, and corresponding mean depth of approximately 6 meters.

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CHAPTER I

INTRODUCTION

The lake sturgeon (*Acipenser fulvescens*) is considered to be a threatened species by the American Fisheries Society Endangered Species Committee, and is listed as endangered in the state of Tennessee (Williams et al. 1989). The lake sturgeon historically occupied waters from Canada to Alabama (Hesse and Carreiro 1997); including the Tennessee River system. Historical sightings indicate that lake sturgeon were once widespread throughout the larger tributaries of the Tennessee River (Hatcher 2000), with documented occurrences dating back to 1854. Post-impoundment sightings and collection of specimens have been reported in Watts Bar, Tellico, Fort Loudoun, and Douglas Reservoirs, and the French Broad River (Kuhne 1939; Brimley 1946; Etnier et al. 1979; Etnier and Starnes 1993). These sightings are limited and this species is presently believed extirpated from this area. Factors that contributed to the decrease in populations of this species include over-harvesting, barriers to movement from construction of hydroelectric dams, and habitat destruction or degradation from channelization and other anthropogenic impacts (Harkness and Dymond 1961; Priegel and Wirth 1971; Etnier and Starnes 1993; Slade and Auer 1997; Smith and Clugston 1997; Thomas and Haas 2002).

Dams alter the natural flow regimes of rivers directly modifying the physical habitat (Bain et al. 1988), as well as creating barriers to movement and migration of lake sturgeon (Payne 1987; Thuemler 1988; Curtis et al. 1997; Smith and Clugston 1997; McKinley et al. 1998). In contrast, spawning areas may be created in the tailwaters below dams. Impounded areas created by dams (i.e., Fort Loudoun Reservoir on the Tennessee

River) may also provide low current velocity and soft substrates, which may provide feeding and resting habitat for lake sturgeon (Knights et al. 2002). Cherokee Dam and Douglas Dam, constructed by the Tennessee Valley Authority (TVA) and completed 1941 and 1943, respectively, serve as barriers to further upstream movement on the upper Tennessee River System. The construction of these dams also resulted in habitat alteration by altering the natural flow regimes of the French Broad River and Holston River and negatively impacting dissolved oxygen levels in the tailwater areas below these dams.

Prior to the creation of the Clean Water Act (CWA) of 1973 habitat degradation from point source and non-point source pollution continued to impact river systems throughout the nation. Enactment of the CWA created more rigorous regulations involving point source pollution, which resulted in gradually improving water quality throughout the nation. However, the improvement in the upper Tennessee River system was gradual until the TVA initiated changes in the operation of tributary dams on the Tennessee River System.

In 1991, TVA initiated the Reservoir Releases Improvement/Lake Improvement Plan (RRI/LIP); this management program, coupled with pollution abatement from creation of the CWA, resulted in improved water quality and sustained minimum flows in the Holston River, French Broad River, and the upper Tennessee River (Scott et al. 1996). Low dissolved oxygen issues were alleviated by the installation of surface water pumps and an oxygen injection system at Douglas Dam in 1993 and at Cherokee Dam in 1995. The addition of turbine venting in 1995 further increased dissolved oxygen in the tailwaters at both dams. The RRI mandated that certain TVA tributary dams maintain

minimum downstream flows by turbine pulsing (Scott et al. 1996). Minimum flows of 585 cfs (cubic feet per second) and 325 cfs were provided below Douglas Dam and Cherokee Dam, respectively, by periodic turbine pulsing beginning in 1987.

The fish and benthic macroinvertebrate communities of the French Broad River, below Douglas Dam, and the Holston River, below Cherokee Dam recovered rapidly after the implementation of the CWA and the improvements made by TVA. The rapid recovery that occurred over the following years led biologists to believe that the lake sturgeon could be reintroduced to the upper Tennessee River System (Scott et al. 1996). Biologists also believed that suitable lake sturgeon spawning habitat existed in the tailwaters below Cherokee and Douglas dams. The shorelines below both dams were rip-rapped with large rocks, which provide large interstitial spaces needed for spawning, and other areas of both rivers contained additional presumed spawning habitat in the form of wing-dams that were built to aid in riverboat navigability. In addition, other migratory fish species, i.e., sauger (*Sander canadense*) and white bass (*Morone chrysops*) have been successful in inhabiting and reproducing in this system, post-impoundment. The improvements in water quality and the recovering aquatic fauna, coupled with the presence of potential spawning habitat and known spawning occurrences by other migratory fish species, resulted in the formation of the Tennessee River Lake Sturgeon Working Group (TRLSWG) in 1995 (TRLSWG 2005).

The Lake Sturgeon Re-introduction Program (LSRP) was initiated by the TRLSWG in 1998 and is a multi-agency partnership between the Tennessee Wildlife Resources Agency (TWRA), University of Tennessee (UT), Tennessee Valley Authority (TVA), Wisconsin Department of Natural Resources (WIDNR), World Wildlife Fund

(WWF), U.S. Fish and Wildlife Service (USFWS), U.S. Geological Survey, Tennessee Aquarium Research Institute (TNARI), Tennessee Cooperative Fishery Research Unit (TNCFRU), Tennessee Clean Water Network, and Conservation Fisheries, Incorporated. The goals of the LSRP are to restore a self-sustaining population of lake sturgeon in the Tennessee River Basin to a level that would allow the lake sturgeon to be removed from the endangered species list of the State of Tennessee and to use the best available science to manage this program in a way that ensures a future recreational fishery and long-term population viability (TRLSWG Management Plan 2005).

In 2000, the TRLSWG initiated an experimental stocking plan to test their beliefs that this species could be successfully reintroduced into the upper Tennessee River system (TRLSWG 2005). Forty-one lake sturgeon from a 1998 year-class were obtained from spawning of wild Wisconsin (Wolf River) stocks, and were surgically implanted with radio telemetry transmitters and released into the French Broad River. The stocking occurred at two sites and over three seasons (Spring, Summer, Fall) in 2000, to determine if movement and persistence were related to season and location of stocking. Results from this research indicated that the lake sturgeon dispersed widely throughout the upper Tennessee River system and that they appeared to be thriving in this system (Martin and Layzer 2001). As a result of this research, production was initiated at three National Fish Hatcheries (NFHs) operated by the USFWS (Warm Springs, PVT John Allen, Mammoth Spring) and at the TNARI using eggs provided by the WIDNR, and obtained from the Wolf, Yellow, and Wisconsin rivers, Wisconsin (TRLSWG 2005).

The initial lake sturgeon re-introduction occurred in 2000, and over 45,000-lake sturgeon from multiple age classes have been released to date. The re-introduction

program appears to be going well with reported sightings and incidental captures by fishermen throughout the upper Tennessee River system (Appendix C.1). However, attempts to monitor survival of stocked fish within the upper Tennessee River system by the TVA and TWRA have been marginally successful (Appendix C.2). This could be attributed to the fact that the lake sturgeon is highly migratory or that sampling locations were chosen without sufficient knowledge of habitat preferences. It has been found that lake sturgeon tend to use core areas (McKinley et al. 1998; Borkholder et al. 2002; Knights et al. 2002; Thomas and Haas 2002). According to Smith and King (2005), core areas of activity may be more important in lotic environments than in lentic environments. The restoration program in the upper Tennessee River System could benefit by determining persistence and dispersal within this system and by determining if sturgeons utilize specific areas, i.e., core areas. The presence of core areas of use would provide sampling locations to determine the success of the stocking program, as well as areas that may require further protection. The objectives of this study were to: (1) determine dispersal and persistence of hatchery-reared, juvenile lake sturgeons released into the French Broad River; (2) determine if patterns of movement exist, either spatially or temporally, and (3) determine the presence, if any, of core use areas or areas of aggregation, and their associated habitat characteristics.

CHAPTER II

LITERATURE REVIEW

Sturgeons are regarded as one of the most primitive surviving bony fishes in the world and their lineage can be traced back 350 million years to the Devonian Period (Etnier and Starnes 1993). The lake sturgeon (*Acipenser fulvescens*) is one of 27 species of sturgeons that are recognized worldwide, although most are considered extinct, endangered, or threatened. The genus *Acipenser* is holarctic with about 11 species in Eurasia and five species occurring in North America (Bemis and Kynard 1997). The lake sturgeon is the only strictly freshwater species occurring in North America. This species has a unique combination of life history characteristics that have helped ensure their survival over the last 100 million years; however, according to Boreman (1997), it is this unique combination of morphological, habitat, and life history characteristics, which also cause them to be highly susceptible to anthropogenic activities. Throughout its range, the lake sturgeon has been severely impacted from over-fishing, destruction or modification of habitat, and loss of range through dam construction, which has led to the threatened status of this species (Williams et at. 1989). Lake sturgeon once occurred throughout the Upper Tennessee River system (Kuhne 1939); however, they are believed extirpated from this portion of their range with the last reported sighting in the 1960's (Etnier and Starnes 1993). The lake sturgeon is currently listed as an endangered species in the state of Tennessee (Williams et al. 1989).

Re-introduction

A re-introduction is a planned release of a native species into an area that is within its historical range for the purpose of re-establishing that population (Griffith et al.

1989). Species become extirpated due to certain conditions such as habitat loss or degradation, loss of range, or excessive harvest. When these conditions no longer exist, re-introductions become a viable option. The lake sturgeon is considered to have been extirpated from the Upper Tennessee River system by the mid-1900's due to extreme sensitivity to over-fishing, dependence on large, often polluted urban river systems for spawning, and the construction of hydroelectric dams that block migration routes to historical spawning sites (Etnier and Starnes 1993; Birstein et al. 1997). For species, like the lake sturgeon, that cannot physically return to their historical range, re-introductions are necessary to re-build populations (Poly 2002). Therefore, re-introductions are becoming increasingly important as a conservation tool (Griffith et al. 1989). There are at present several lake sturgeon re-introduction and rehabilitation programs being conducted throughout its historical range (i.e., Michigan, New York) (Holey et al. 2000, Hughes 2002).

Morphology

The lake sturgeon was originally described in 1817 (Rafinesque 1820). Etnier and Starnes (1993) gave the following as determining characters for this species: 9-17 dorsal plates, 29-42 lateral plates, 35-40 dorsal fin rays, and 25-30 anal fin rays. Body color ranges from yellowish brown to gray, with juveniles often exhibiting small dark blotches that fade away as they mature. The lake sturgeon has a protruding mouth with fleshy lips that they use for 'vacuuming' prey from the substrate. The prominent shovel-like snout has four barbels, which are located about halfway between the mouth and the snout tip. Juveniles have five rows of sharp, bony scutes along the body that eventually become smooth as the fish matures (Wallus 1990) (Figure 1).

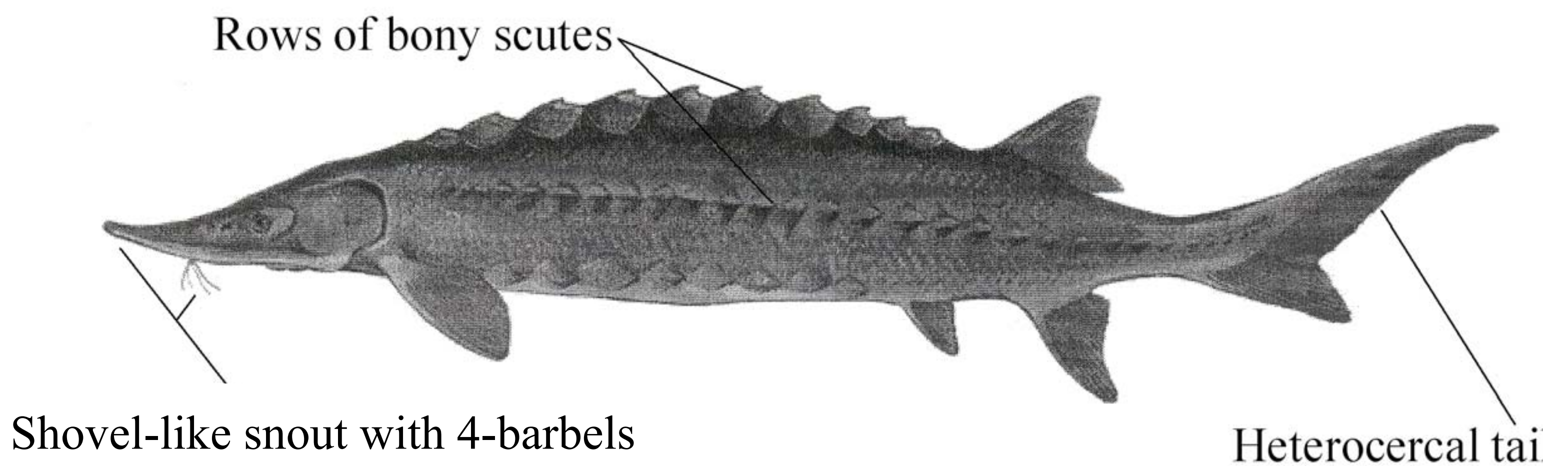

Figure 1. Major characteristics of the lake sturgeon (Courtesy of TVA and TWRA).

Biology

Life history information for lake sturgeon exists primarily for northern populations, with limited information known about life history characteristics of southern populations. This is primarily due to the fact that the lake sturgeon is believed extirpated from its southern range. Information available for northern populations indicates a preference for large lake and river habitats. Knights et al. (2002) found that lake sturgeon showed a preference for areas where bottom current velocities were no more than 40 centimeters per second at depths ranging from 1 to 3 meters. They also found that lake sturgeon showed a strong preference for silt-containing substrates. It is believed that these characteristics would be preferable, as they would serve as optimal feeding sites. Lake sturgeon are considered generalists, feeding primarily on benthic organisms such as insect larvae, mollusks, and crayfishes which are prey organisms that would be abundant in such areas [with those types of substrate] (Buckley and Kynard 1985; Auer 1996; Kempinger 1996).

Lake sturgeons grow and mature slowly with the first spawn of males occurring between 12-20 years of age or when they reach 85-114 cm in total length (TL). Females grow and mature even more slowly, with their first spawn occurring between 14-25 years of age or when they reach 90-140 cm TL (Scott and Crossman 1973). Females tend to live longer and grow larger than the males. The maximum life span of the lake sturgeon is 70-100 years (Peterson et al. 2003) and records indicate that specimens have been found as large as 2.4 m in total length (TL) and 141 kg in weight (Becker 1983). However, most mature lake sturgeon average between 1.0-1.5 meters TL and weigh an average 4.5-36.2 kg (Scott and Crossman 1973). The mating system of the lake sturgeon is both polyandrous

and polygynous, which allows maximum opportunities to mate with numerous individuals and, in doing so, maximizing genetic diversity of offspring (Bruch and Binkowski 2002; Peterson et al. 2003). The reproductive strategy of this species once helped ensure healthy populations, however, due to human influences and other factors, this reproductive strategy is now a limiting factor in rehabilitation and re-introduction attempts throughout this species' historic range. The lake sturgeon is slow to reach reproductive maturity and coupled with that, females reproduce every 4-9 years, while males are capable of spawning every other year (Kempinger 1996). However, Etnier and Starnes (1993) reported that southern populations could potentially mature sooner reproductively and likely spawn more often due to warmer temperatures.

The lake sturgeon is a highly fecund species with females capable of producing 1100 eggs per kg of total body weight and males capable of producing 2 billion sperm per cc of ejaculate (Harkness and Dymond 1961). Spawning is triggered by water temperature increases that signal the fish to begin migrating to the spawning site, usually occurring from April through June. Males arrive first and cluster in shallow water where they await the arrival of the females. Once the optimum temperature is reached (12-18^{o}C), females begin to join the male groups. One to five males will flank a female and spawning will initiate. Eggs are extruded in 5-second bursts and then fertilized by released male sperm; the eggs are then broadcast over the underlying substrate. Females spawn over a period of 5-24 hours and then return to their home range. Males remain at the spawning site often for the duration of spawning activity and then return to their home range (Etnier and Starnes 1993; Bruch and Binkowksi 2002).

Preferred substrates for spawning in the Great Lakes were found to be cobble

beds 10-40 cm in diameter and smaller beds of coarse gravel ranging from 2-8 cm in diameter. Water quality at spawning sites in the Great Lakes was found to have the following characteristics: Secchi disk transparency range of 2.5-6.5 m, current velocity of 0.35-0.98 m/sec (Manny and Kennedy 2002). Other key characteristics of spawning sites included extensive spawning substrate (natural or man-made), clean substrate with extensive clean interstitial spaces, and closeness in proximity to deep over-wintering pools (Bruch and Binkowski 2002). The egg source used for the LSRP initiated by the TRLSWG, came from the Wolf River, Wisconsin, below Shawano Dam, where the lake sturgeon spawns along rip-rapped shorelines similar to those found in the tailwaters of the Cherokee and Douglas dams on the upper Tennessee River system (TRLSWG 2005).

Movements

Several studies have examined the movement patterns of adult lake sturgeon in various river systems (Fortin et al. 1993; Rusak and Mosindy 1997; McKinley et al. 1998; Auer 1999; Borkholder et al. 2002; Knights et al. 2002). However, few studies have been conducted to determine movement patterns of juvenile, hatchery-reared lake sturgeon (Benson et al. 2005). Results from those studies that have been conducted involving juveniles and adults, including radio-telemetry tracking studies and those involving trawl-net captures, have failed to pinpoint any significant pattern in lake sturgeon movements. Knights et al. (2002) attributed this occurrence to the use of fish from multiple age classes and both sexes. According to reports from Knights et al. (2002) and Auer (1996), lake sturgeons exhibit different movement and feeding patterns at different life stages. With multiple fish being tracked during different life stages, it seems logical that data would not indicate a clear pattern of movement. The lake sturgeon has

been shown to exhibit highly migratory behavior traveling as much as 200 km within a river system (Knights et al. 2002). However, this species has also been shown to use core areas within a system and to exhibit site fidelity to re-introduction locations and tagging locations (Auer 1996; Borkholder et al. 2002; Knights et al. 2002; Thomas and Haas 2002). In a study conducted on the Kettle River, Minnesota, this species was shown to exhibit movement patterns that were correlated with changes in discharge, i.e., fish were positively rheotactic, moving upstream against the current during periods of increasing discharge and moving downstream with the current during periods of decreasing discharge (Borkholder et al. 2002).

Movements can also be related to changes in water temperature. In a study conducted in Ontario, Canada, McKinley et al. (1998) found that lake sturgeon moved downstream as temperatures approached 13^{0}C. Habitat preferences and movement patterns of lake sturgeon may also differ between northern and southern populations or between sub-stocks of the species. Most of the available literature has indicated a further need to study movements using single age classes (yearlings, juveniles, sub-adults, adults) to determine if movement patterns exist, either spatially, temporally, or otherwise.

CHAPTER III

DESCRIPTION OF STUDY AREA

The Upper Tennessee River System includes the Holston River from Cherokee Dam (HRM 52.2) downstream to its confluence with the French Broad River (TNRM 652), 32.3 miles of the French Broad River from Douglas Dam downstream to its confluence with the Holston River, and 50 miles of the Tennessee River upstream of Fort Loudoun Dam (TNRM 602), known as Fort Loudoun Reservoir (Figure 2). The Upper Tennessee River System includes a total of 174 miles (280 km) of both riverine and lacustrine habitat. The author will use river "miles" (instead of "kilometers") in the discussion of this research since all maps used in the study are noted in river miles (RM).

Fort Loudoun Reservoir has a surface area of 6,273 hectares with a navigation channel depth of 3.4 m (Voigtlander and Poppe 1989; Etnier and Starnes 1993, Hampson et al. 2000). Fort Loudoun Reservoir has a maximum depth of 26.1 m, an average depth of 6.8 m, and an average width of 0.6 km. The average annual water retention time is 9.8 days (Voigtlander and Poppe 1989).

The French Broad River watershed drains 13,271 km^2 (Hampson et al. 2000). The gradients of the French Broad River are low to moderate and the water is hard and relatively high in productivity. The stream substrate in the French Broad River is mostly limestone bedrock, fine chert gravel, and silty sand (Starnes and Etnier 1986; Hampson et al. 2000). The French Broad River below Douglas Dam has depths that range from less than 1.0 m in shoal areas to 15 m deep in some of the larger pools; however, water levels vary up to 3 m depending on discharges from Douglas Dam.

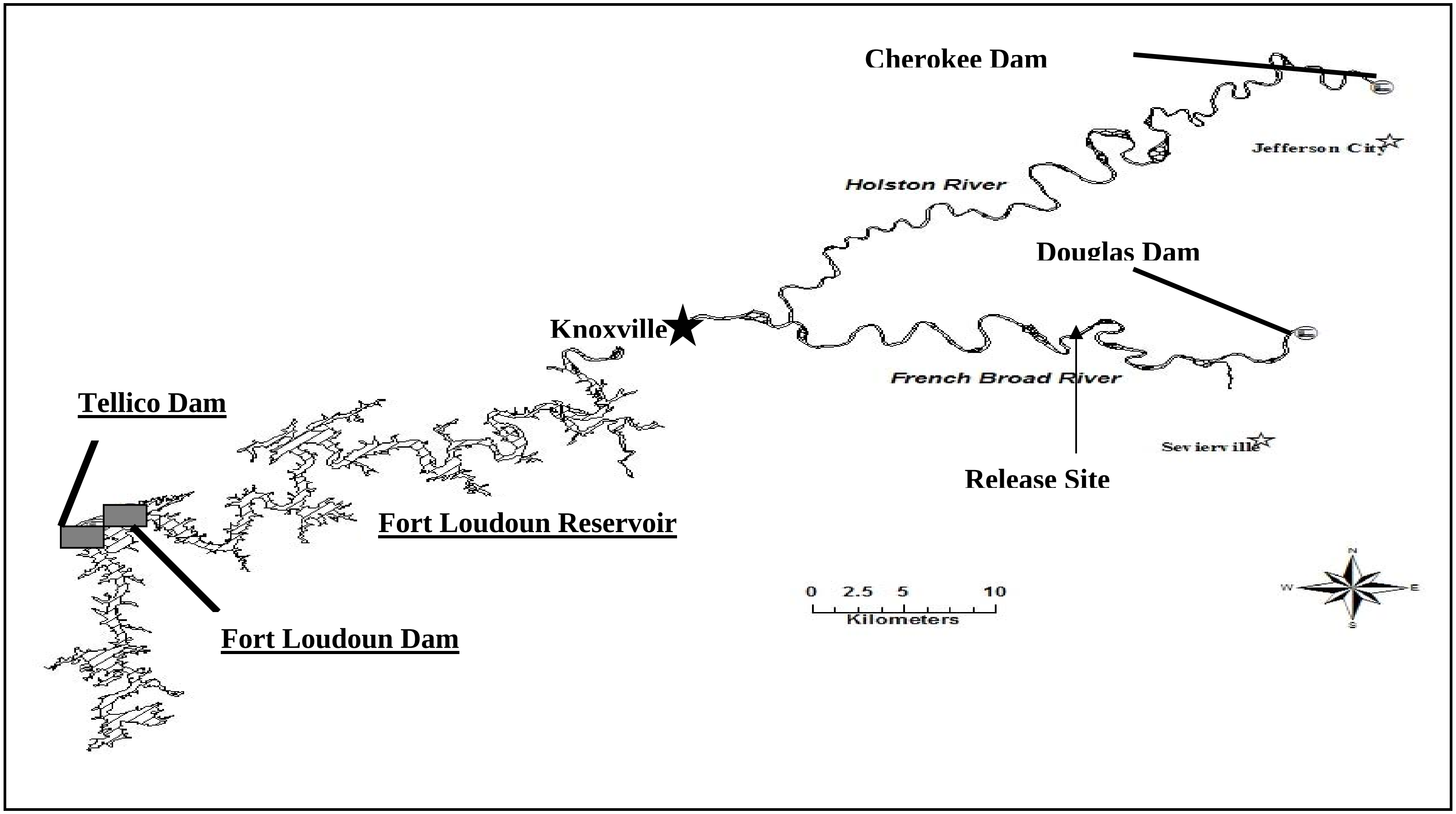

Figure 2. Map of the upper Tennessee River system showing lake sturgeon release site location at Seven Islands Wildlife Refuge 29 October and 4 November 2004.

CHAPTER IV

METHODS

Transmitter Implantation

Twenty juvenile lake sturgeon (1+ age class) reared at Cohutta Fish Hatchery, Cohutta, Georgia, were used in the study. These fish were hatched from eggs collected from adult lake sturgeon from the Wolf River, Wisconsin, in 2003 (Carlos Echevarria, Warm Springs NFH, personal communication). Fish were certified as disease free by Warm Springs National Fish Hatchery prior to use in this study. The twenty juvenile lake sturgeon had a mean weight of 560 g and ranged from 460-755 g, and had a mean length of 516 mm and ranged from 480-565 mm. Radio transmitters [Advanced Telemetry Systems (ATS), Inc., Isanti, Minnesota] with unique frequencies were surgically implanted into lake sturgeon. Transmitters weighed 3.6 g, had a nominal battery life of ≥ 100 days, a pulse width of 20 milliseconds and a pulse rate of 55 pulses per minute. Transmitter weights did not exceed the maximum recommended 2% body weight of the fish (Winter 1996).

Transmitters were implanted following procedures modified from Thuemler (1988) and Moser and Ross (1995). All surgical instruments were sterilized in a 70% ethyl alcohol bath. Fish were anaesthetized using a 100-mg/L solution of tricaine methanesulfonate (MS-222); this solution was also used to irrigate the gills in order to ensure sedation throughout the procedure (Figure 3). A hose was placed in the mouth to allow fresh water to irrigate the gills and support respiration during the procedure, which took approximately 10 minutes to complete.

Betadine was initially used to disinfect the ventral area anterior to the pelvic fins

Figure 3. Gill irrigation with MS-222 during surgical procedure.

prior to the incision, then after the incision was made, and again once the suture process was completed. A 25-mm incision was made just off and parallel to the mid-line in the abdominal wall, and anterior to the vent beginning at the third scute above the pelvic fin. The transmitter was inserted at a 45^0 angle through the incision and into the body cavity allowing the antenna to trail out the posterior end of the incision. The incision was then closed using a single synthetic, non-absorbable, ETHICON (Ethibond Extra Green Braided, 4.0 Metric) suture inserted in a criss-crossing pattern and closed using a double-knot.

Immediately following the transmitter implant, each fish was weighed to the nearest 0.1 kg (OHAUS-Ranger scale) and a total length measurement was taken to the

nearest millimeter. Radio-tagged fish were held in tanks at the Cohutta Fish Hatchery for a period of 10 days to allow fish to heal from the implant surgery and to ensure that fish were healthy and free of infection prior to release. Due to infection with *Saprolegnia*, four of the fish had to be held an additional six days to allow for treatment and recovery. Fish were treated with malachite green and held until recovered. A single mortality occurred from *Saprolegnia* infection (tag 48.190); the tag was recovered and implanted into a new fish. At the completion of the recovery period, fish were delivered to the release site in two oxygenated haul tanks; tanks were salted to minimize stress during the 1.5-hour trip from the hatchery to the release location. During the transport process, periodic stops were made to monitor water temperature and dissolved oxygen.

Upon arrival at the release site, the haul tank water was slowly acclimated to the ambient river temperature. Each fish was inspected for general health, incisions were checked, and sutures removed (Figure 4). Radio signals from each transmitter were verified prior to the implantation process and again prior to release into the French Broad River. Due to the issues with infection, only 16 of the 20 fish were released on 29 October 2004 at the Seven Islands Wildlife Refuge (SIWR) on the French Broad River (FBRM 18) (Figure 2). The remaining four fish were released on 4 November 2004 at the same location and following the same procedures.

Biotelemetry

Radio-telemetry tracking by boat was conducted on the French Broad River for the duration of the battery life of the transmitters. Tracking was conducted 1-6 days per week, weather and water levels permitting. An attempt was made to cover the entire study area at least once per week; however, due to weather conditions and extremely low

Figure 4. Suture site, 2-weeks post-surgical implant of transmitter.

water levels, the Holston River, below Cherokee Dam, was not covered once per week (Table 1). Therefore, the majority of the tracking effort was concentrated within the French Broad River and the Tennessee River.

A hand-held loop antenna, a boat-mounted loop antenna, and two ATS receivers (Model R4000) were used to track fish. Fish were relocated searching from the upstream end of the study area (Douglas or Cherokee Dam) and continuously moving in a downstream direction (maintaining boat speed at approximately 3 miles per hour) until all fish were located or until the study area had been covered, when water levels permitted. On field days where water levels were sufficiently low enough to alter the search pattern;

Table 1. Summary of tracking dates and searching locations on the upper Tennessee River system.

	River				Section		
Date	TN	FB	H	Tributary	U	M	L
29-Oct-04		X				X	
30-Oct-04		X				X	
31-Oct-04		X				X	
01-Nov-04		X			X		
04-Nov-04		X			X		
05-Nov-04		X			X		
08-Nov-04		X	X				X
09-Nov-04	X				X		
10-Nov-04			X				X
12-Nov-04	X						X
13-Nov-04	X				X	X	
15-Nov-04		X					X
17-Nov-04			X		X	X	
19-Nov-04		X				X	
22-Nov-04		X					X
26-Nov-04		X	X				X
29-Nov-05			X			X	X
03-Dec-04	X					X	
04-Dec-04		X			X		
08-Dec-04		X			X	X	X
10-Dec-04	X				X	X	
12-Dec-04	X						X
14-Dec-04		X			X		
16-Dec-04		X			X	X	X
17-Dec-04			X				X
21-Dec-04		X			X		
22-Dec-04	X				X	X	
27-Dec-04		X			X		
29-Dec-04		X			X	X	X
04-Jan-05	X						X
05-Jan-05		X			X		

Table 1. Continued.

Date	River			Tributary	Section		
	TN	FB	H		U	M	L
07-Jan-05	X				X		
10-Jan-05			X				X
13-Jan-05	X			X		X	X
17-Jan-05	X						X
21-Jan-05		X					X
23-Jan-05			X				X
25-Jan-05		X			X		
27-Jan-05		X			X	X	X
01-Feb-05		X					X
03-Feb-05	X				X	X	
06-Feb-05	X			X			
08-Feb-05		X				X	
15-Feb-05		X					X
18-Feb-05			X		X	X	X
22-Feb-05		X		X			
26-Feb-05	X				X		
01-Mar-05	X					X	
07-Mar-05	X						X
15-Mar-05		X	X			X	X
21-Mar-05		X	X			X	X
30-Mar-05		X	X				X
02-Apr-05	X						X
05-Apr-05		X			X	X	
08-Apr-05		X					X
15-Apr-05		X			X	X	

TN= Tennessee River
FB= French Broad River
H= Holston River
U= Upper Section
M= Middle Section
L= Lower Section

the area was then divided in half and searched over two days instead of one. Once an individual fish was located, decreasing the sensitivity of the receiver and determining the location of greatest signal strength determined the exact location. The mean error in transmitter location using this method was reported to be 10 m (Knights et al. 2002).

When individual fish were identified a waypoint location was assigned using a GPS III PLUS (Garmin International, Olathe, Kansas). Waypoints marked the fish location by assigning a Northing and Easting value in Universal Transverse Mercator (UTM) coordinates. The water column depth (m) was also recorded at each fish location by taking a reading from a boat-mounted sonar (Eagle FishMark™ 320 Sonar, Eagle Electronics, Catoosa, Oklahoma). A description of the area surrounding the location was also recorded for each fish waypoint location.

Data Analyses

Data collected were summarized in the Microsoft Excel ™ (Microsoft Office 2003, Microsoft Corporation) program and then imported and analyzed using ArcGIS 9.1™ software (Environmental Systems Research Institute, 2005). All statistical comparisons were made using the Statistical Analysis Software Version 9.1 (SAS Institute Inc., Cary, NC) and assuming $\alpha=0.05$, unless stated otherwise. These programs allowed the data for each fish to be analyzed both individually and collectively. Data analysis was performed on 140 data points from 17 of the 20 radio-tagged juvenile lake sturgeon; one fish was never found and two fish were considered mortalities.

Dispersal was calculated as the net distance moved by individual fish from the stocking location (SIWR, FBRM 17.5) for each successive observation, and by the number of days it took a fish to emigrate from the French Broad River (Martin and

Layzer 2001). The fate (survival) of each fish was determined by documenting whether a fish was: (1) found alive beyond 90 days or until the termination of the study on 15 April 2005 (persistence), (2) determined to have died, or (3) missing from the study area (emigrated). Missing fish were presumed to have emigrated from the French Broad River because the study area was searched weekly and tag failure was reported to occur at less than 5% (Advanced Telemetry Systems, Isanti, Minnesota). Persistence of tagged fish was defined as the number of days a tagged fish remained alive and in the French Broad River.

Individual maps were created for each fish (except fish 48.090 and 48.170) (Appendix A) and used to determine movement and dispersal data. Distances moved (movements) between successive locations were determined for each tagged fish by using the measuring tool in the ArcGIS program. Linear ranges for each fish were determined as the distance between farthest upstream and downstream contact locations (Curtis et al. 1997; Daugherty and Sutton 2005). A chi-square goodness-of-fit test was performed to compare directional movement (upstream, downstream, no change) to changes in flow (increasing, decreasing, no change). One-way analysis of variance (ANOVA) was used to compare distances traveled (movements) and dispersal distances with temperature and discharge data obtained from TVA. ANOVA was also used to determine if depth selections of juvenile lake sturgeon were related to temperature and discharges from Douglas dam.

Grid Analyses

A 0.5-min x 0.5-min grid design modified from (Smith and King 2005) was used to determine areas of core use by overlaying the grid on the map of the upper Tennessee

River System (Appendix B.1-B.4). Habitat use was determined as the total number of grids used at least once divided by the total number of grids available. Core areas were determined as any grid with five or more waypoint locations taken over the course of the study. Areas of aggregation were determined as any grid with more than one fish present on the same day.

Underwater Video Mapping

Underwater video mapping was conducted along four transects established in the lower section of the French Broad River (RM 2-5) on 12 August 2005 (Appendix B.1). Students from the Department of Biosystems Engineering and Soil Science, University of Tennessee, conducted the video mapping procedure and subsequent data analysis (Swinson et al. 2005) based on locations provided by the radio-telemetry results. Transects 1, 2, and 3 were located in sections of the lower French Broad River determined to be core use areas or areas of aggregation. A control transect was established in an adjacent section that was visually similar on the surface to transects 1-3.

A canoe, propelled by trolling motor, was equipped with a Splashcam Deep Blue underwater video camera (Ocean Systems Inc., Everett, Washington) attached to a video camcorder by 60 meters of cable. The Splashcam was positioned in the rear of the canoe and operated by a pulley system, allowing the operator to visually monitor and adjust the camera position along the river bottom to provide the clearest picture. Starting and stopping points were determined from radio-telemetry data and were located in areas with the highest clustering of waypoints. The procedure for conducting transects was to work across the river in a zigzag pattern at 45^0 angles, at an approximate speed of two miles per hour (Swinson et al. 2005). All video footage was analyzed and substrate was

classified into nine different types: bedrock, cliffs, debris, grass, gravel, rock, sand, shells, and trash (Swinson et al. 2005). Definitions of substrate classifications used are included in Table 2.

Table 2. Substrate classification and descriptions used for analysis of video footage collected on the French Broad River, 12 August 2005, (Swinson et al. 2005).

Habitat Type	Description
Bedrock	Solid lake bottom
Cliffs	River bottom characterized by large drop off and steep inclines
Debris	Branches, trees, large man-made remnants (tires, farm machinery…)
Grass	Underwater patches of grass
Gravel	Sandy loose rock, mainly small
Rock	Large rocks, boulders
Sand	Large patches of sand
Shells	Large areas of broken mussel shells
Trash	Trash consisting of cans, wrappers, and other small remains

CHAPTER V

RESULTS AND DISCUSSION

Biotelemetry

Radio-telemetry tracking resulted in the collection of 161 waypoint locations taken for 19 of the 20 juvenile lake sturgeon stocked in the French Broad River; one fish was not found during the study period and was excluded from data analysis. Two other fish were also excluded from data analysis, as they were believed to be mortalities or to have dropped their transmitters (resulting in 143 waypoint locations for data analyses). The mean number of observations per fish was 8.2 and ranged from 3-15 (sd=3.8), and the mean number of days a fish was tracked was 98 d and ranged from 13-169 d (Appendix A). Temperature and daily discharge data for Douglas Dam for the study period were provided by TVA and indicated a mean temperature of 10.4 ^{0}C (sd=4.2) and ranged from 5.1-19.8 ^{0}C. The mean daily discharge for the duration of the study was 342 cms (sd=182.6) and ranged from 170-957.1 cms (data provided by TVA).

Persistence was 50% for the 90-day battery life of the transmitters (Table 3). Persistence of lake sturgeons stocked into the French Broad River in this study was higher than the persistence (33%) determined for a fall cohort stocked in the French Broad River, September 2000 (Martin and Layzer 2001). Thuemler (1988) also documented low persistence of lake sturgeons stocked in the fall in the Menominee River, Wisconsin, with the majority of tagged fish moving 39 km downstream and out of the target section of river. Smith and Clugston (1997) also documented downstream dispersal in the fall by Atlantic sturgeon (*Acipenser oxyrhynchus*); they found that fish

Table 3. Radio-telemetry data of stocked juvenile lake sturgeon, 29 October 2004 through 15 April 2005.

Transmitter ID	Number Days Tracked	Days In French Broad River	Fate	Last Location	Last Location (RM)	Notes
48.011	91	91	P	UFBR	32.1	
48.031			M			Never Located
48.051	103	103	P	LFBR	3.5	*
48.071	169	169	P	UFBR	22.5	*
48.090	169	159	D	UFBR	25.9	
48.110	32	6	M	HR	10.3	
48.130	50	41	M	HR	13.3	
48.151	138	138	P	LFBR	5.2	
48.170	159	159	D	UFBR	23.7	
48.190	69	69	M	UFBR	32.3	
48.210	144	91	P	UTNR	648.9	*, **
48.230	32	12	M	HR	25.8	
48.250	19	19	M	LFBR	1.5	
48.270	85	71	M	UTNR	651.5	*
48.290	13	10	M	UTNR	651.8	
48.310	153	41	P	LFBR	10.5	
48.331	91	91	P	UFBR	19.7	
48.351	110	17	P	LFBR	2.6	
48.371	138	138	P	LFBR	1.8	
48.391	91	91	P	UFBR	29	

* Fish held an additional week due to *Saprolegnia* infection.

** Fish held an additional week due to *Saprolegnia* infection. Treatment failed, tag recovered and implanted into new fish and then released same day.

LFBR= Lower French Broad River

UFBR= Upper French Broad River

HR= Holston River

UTNR= Upper Tennessee River

M= Missing from system, emigrated, or transmitter failure

P= Persisted

D= Suspected mortality or dropped transmitter

began to move downstream as the water temperature cools to 20 ^{0}C. Research conducted on lake sturgeons in Ontario, Canada, documented rapid downstream dispersal in the fall months as temperature decreased to 13 ^{0}C (McKinley et al. 1998). .

Mean weekly dispersal from the release site was highly variable and ranged from 0.1 to 25.0 RM (Table 4). The greatest known dispersal distance from the release site was 43.25 RM (in 31 days) for fish 48.230 (Appendix A.11). The most rapid dispersal was fish 48.110, traveling 32.3 RM in 12 days (Appendix A.5). The mean total dispersal distance from the release site was 10.6 RM (sd=7.9). The mean linear range was 7.3 RM (sd=7.1) and ranged from 1.0-20.3 total river miles (Table 5).

Movements by fish during this study were highly variable. Some fish moved upstream from the release site and remained in the upper portion of the French Broad River (RM 17.5 to RM 32.25) for the duration of tracking. Lake sturgeon 48.011, 48.071, 48.190, 48.210, and 48.391 all moved upstream to Douglas Dam at FBRM 32.25 and were found there on subsequent tracking occasions, for a period of 16-38 days (Appendix A).

Some fish moved downstream from the release site and remained in the lower portion of the French Broad River from (RM 0 to RM 5) for the duration of the study. Lake sturgeon 48.051, 48.151, 48.351, and 48.371 moved downstream to the lower five miles of the French Broad River and were found in this section on each pass through, for the duration of the study. The mean time taken by these fish to reach this section was 8.5 d (SE=1.8, 95% C.I.= ±5.9). The mean time they remained in this section was 80.5 d (SE=8.9, 95% C.I.= ±28.3).

Table 4. Mean weekly dispersal in river miles (RM) for juvenile lake sturgeon tracked from 29 October 2004 to 15 February 2005.

Week #	Mean Weekly Dispersal (RM)
1	0.33
2	3.66
3	15.39
4	11.60
5	14.10
6	24.96
7	11.41
8	14.03
9	11.90
10	12.08
11	11.18
12	15.72
13	15.60
14	10.07
15	12.07
16	*
17	15.02

* Only one fish located this week

Table 5. Linear range information for fish that persisted in the French Broad River, 29 October 2004 through 27 January 2005.

Fish Number	Linear Range (River Miles)	Observations
48.011	1.0	5
48.051	2.4	10
48.071	13.8	11
48.151	1.5	7
48.210	20.3	11
48.310	17.0	8
48.331	3.4	10
48.351	2.7	15
48.371	3.6	13
48.391	7.8	6

Lake sturgeon 48.110, 48.230, 48.270, 48.290, and 48.310 all moved rapidly downstream, mean of 9.6 d (SE=1.0, 95% C.I.= ±2.7), and out of the French Broad River into the Holston River or the Tennessee River. Lake sturgeon 48.110 and 48.230 both moved into the Holston River and were last seen on 29 November 2004, which was 31 d post-stocking. Lake sturgeon 48.250 moved widely upstream and downstream within the French Broad River before emigrating and was last observed on 26 November 2004. Lake sturgeon 48.331 exhibited minimal movement both upstream and downstream within a confined section of the French Broad River (RM 17.3 to 20.7) near the release site.

Research conducted on the Mississippi River determined that shovelnose sturgeon (*Scaphirhynchus platorynchus*) exhibited similar patterns: some fish demonstrated restricted ranges of <50 m, while others exhibited extended ranges >1 km (Curtis et al. 1997). Another study conducted in Alberta, Canada, found that lake sturgeon also exhibited signs of similar movement patterns to those found within the French Broad River, with some fish remaining sedentary while others were widely distributed (McLeod et al. 1999).

Data Analyses

The highly variable movement patterns exhibited by lake sturgeon could be attributed to several factors: innate behaviors, responses to changes in temperature, river discharges, or habitat and reproduction requirements. Movements of several sturgeon species, including the lake sturgeon, have been correlated with river velocity or river discharge from upstream dams (McLeod et al. 1999; Peake 1999; Borkholder et al. 2002; Erickson et al. 2002; Knights et al. 2002; Benson et al. 2005; Young and Scarnecchia

2005) and with temperature changes in relation to season of the year (Smith and Clugston 1997; McKinley et al. 1998; Knights et al. 2002; Benson et al. 2005; Kynard et al. 2005). Movements of juvenile lake sturgeon within the French Broad River were also correlated to temperatures and river discharges from Douglas Dam. Directionality of movements of juvenile lake sturgeon in the French Broad River were highly correlated with changes in mean daily discharge from Douglas Dam; fish moved upstream during periods of increasing flow and downstream during periods of decreasing flow (χ^2=11.9, $\underline{P}$=0.0025). Distances moved (or movement) by fish between successive locations were slightly positively correlated to changes in temperature (ANOVA, R^2=0.11, $\underline{P}$=0.0004) and discharge (ANOVA, R^2=0.05, $\underline{P}$=0.0196) (Tables 6 and 7). Dispersal (net distance from the release site on successive locations) was positively correlated with changes in temperature (ANOVA, R^2=0.1, $\underline{P}$=0.0009) and discharge (ANOVA, R^2=0.05, $\underline{P}$=0.0188) from Douglas Dam (Tables 8 and 9).

Depths selected by juvenile lake sturgeon in the French Broad River were also correlated to temperature (ANOVA, R^2=0.1, $\underline{P}$=0.0118) and discharges (ANOVA, R^2=0.084, $\underline{P}$=0.0203) from Douglas Dam (Tables 10 and 11). Depth selection was positively correlated to mean daily discharge from Douglas dam and negatively correlated to mean daily temperature. Fish moved to deeper areas with increasing river discharges and with decreasing temperatures. The mean depth at fish locations was 5.85 m (sd=2.8), and ranged from 1.5-13.7 m (Figure 5). Several sturgeon species, including the lake sturgeon, have been found to prefer depths >5 m (Moser and Ross 1995; Curtis et al. 1997; McKinley et al. 1998; McLeod et al. 1999; Erickson et al. 2002; Hatin et al. 2002; Kynard et al. 2005; Young and Scarnecchia 2005).

Table 6. ANOVA comparing distances traveled to daily temperatures from Douglas Dam, 29 October 2004 through 15 April 2005.

Analysis of Variance						
Source	DF	Sum of Squares	Mean Square	R-Square	F Value	Pr > F
Model	1	261.64214	261.64214	0.1098	13.45	0.0004
Error	109	2121.01263	19.45883			
Corrected Total	110	2382.65477				

Table 7. ANOVA comparing distances traveled to mean daily discharges from Douglas Dam, 29 October 2004 through 15 April 2005.

Analysis of Variance						
Source	DF	Sum of Squares	Mean Square	R-Square	F Value	Pr > F
Model	1	116.71128	116.71128	0.049	5.61	0.0196
Error	109	2265.94349	20.78847			
Corrected Total	110	2382.65477				

Table 8. ANOVA comparing dispersal distance to daily temperatures from Douglas Dam, 29 October 2004 through 15 April 2005.

Analysis of Variance						
Source	DF	Sum of Squares	Mean Square	R-Square	F Value	Pr > F
Model	1	385.50204	385.50204	0.0966	11.66	0.0009
Error	109	3604.07983	33.06495			
Corrected Total	110	3989.58187				

Table 9. ANOVA comparing dispersal distance to mean daily discharges from Douglas Dam, 29 October 2004 through 15 April 2005.

Analysis of Variance						
Source	DF	Sum of Squares	Mean Square	R-Square	F Value	Pr > F
Model	1	198.04872	198.04872	0.0188	5.69	0.0188
Error	109	3791.53315	34.78471			
Corrected Total	110	3989.58187				

Table 10. ANOVA comparing depth selection to daily temperatures from Douglas Dam, 29 October 2004 through 15 April 2005.

Analysis of Variance						
Source	DF	Sum of Squares	Mean Square	R-Square	F Value	Pr > F
Model	1	48.40282	48.40282	0.0979	6.73	0.0118
Error	109	446.07828	7.19481			
Corrected Total	110	494.48109				

Table 11. ANOVA comparing depth selection to mean daily discharges from Douglas Dam, 29 October 2004 through 15 April 2005.

Analysis of Variance						
Source	DF	Sum of Squares	Mean Square	R-Square	F Value	Pr > F
Model	1	41.44538	41.44538	0.0203	5.67	0.0203
Error	109	453.03572	7.30703			
Corrected Total	110	494.48109				

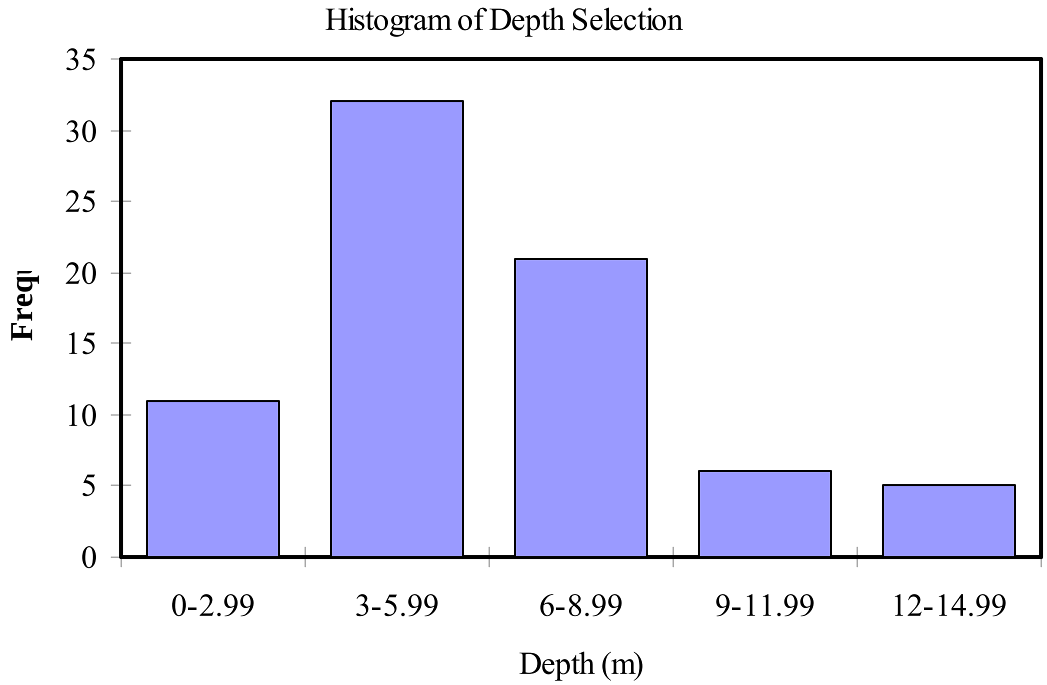

Figure 5. Histogram of depth selection of juvenile lake sturgeon,
16 December 2004 to 15 February 2005.

Grid Analysis

Habitat use by several sturgeon species has been evaluated in both riverine and lacustrine systems utilizing many different methods to characterize the habitat both qualitatively and quantitatively. In this study a 0.5-min x 0.5-min grid overlay was inserted on the map created in the ArcMap program; there were a total of 80 squares from the grid overlay that contained portions of the French Broad River. Grids were not used in relation to their availability; 42.5% of grids were used by at least one fish on one occasion, while only 8.8% of grids had five or more waypoint locations (core use areas) (Table 12) and only 6.3% of grids indicating aggregation (Table 13). The grid analysis of

Table 12. Summary of core use areas from grid analysis of the French Broad River, Tennessee.

Grid Name	Total Observed Waypoint Locations	Percentage of Total Observed Waypoint Locations	River Area in Grid (Hectares)	Waypoints per Hectare
DD Grid 1	15	18.80%	12.6	1.19
SIWR Grid 1	11	13.80%	6.9	1.59
PRB Grid 2	11	13.80%	12.8	0.85
PRB Grid 3	9	11.30%	10.7	0.84
SR Grid 1	8	10.00%	9.6	0.83
SR Grid 2	6	7.50%	10.6	0.56
SR Grid 4	5	6.30%	15.2	0.32

DD= Douglas Dam (FBRM 32.3)
SIWR= Seven Islands Wildlife Refuge (release site, FBRM 17.5)
PRB= Paint Rock Bluff (FBRM 3.5-5.5)
SR= Sea Ray (FBRM 1.5-3.0)

Table 13. Summary of aggregation data from grid analysis of the French Broad River, Tennessee.

Grid Name	Number Fish in Grid	Date	Tag Numbers
DD Grid 1	5	21-Dec-04	48.011, 48.071, 48.190, 48.210, 48.391
DD Grid 1	4	27-Dec-04	48.011, 48.071, 48.190, 48.391
DD Grid 1	4	05-Jan-05	48.011, 48.071, 48.190, 48.391
PRB Grid 2	3	08-Dec-04	48.051, 48.151, 48.371
PRB Grid 2	3	16-Dec-04	48.151, 48.351, 48.371
PRB Grid 3	2	10-Jan-05	48.351, 48.371
SR Grid 1	2	22-Nov-04	48.051, 48.351
SR Grid 4	2	22-Nov-04	48.250, 48.371
SR Grid 4	2	26-Nov-04	48.250, 48.371

the French Broad River indicated that there were seven grids that were core use areas (Table 12), with five of the grids occurring in the lower five miles of the river near the confluence with the Holston River (Appendix B). Within the core use areas the density of waypoint observations ranged from 0.33 to 1.59 per hectare (Table 12). Recurring features of core use areas were: a mean depth of 6 m (range of 1.5-13.7), located in the bend of the river, and with an associated rock bluff. Areas of aggregation also occurred during the study period on nine different days in five of the same grids that were core use areas, with the number of fish aggregating in a grid ranging from two to five (Table 13). Smith and Clugston (1997) also found that juvenile Atlantic sturgeon (*Acipenser oxyrhynchus*) remain in or in close proximity to the river mouth during winter and spring. Green sturgeon (*Acipenser medirostris*) in Canada, were found to prefer specific holding sites during summer and fall months and they exhibited restricted home ranges within holding sites.

The holding sites were primarily located in the bend of the river and typically (> 5 m) deep (Erickson et al. 2002). McKinley et al. (1998) also described lake sturgeon using core areas or holding sites in the lower portion of the river. Lake sturgeon tracked on the Mississippi River exhibited high use in the bends of the river, tailwaters, and confluences of tributaries (Knights et al. 2002). Lake sturgeon in the French Broad River followed a similar trend, with the exception of the confluence of the Holston and French Broad Rivers, which did not qualify as an area of core use. Waypoint locations were recorded there at least once during the study. Additional reports of core use and aggregation by lake sturgeon were also documented in Alberta, Canada (McLeod et al. 1999), and the Kettle River, Minnesota (Borkholder et al. 2002). Smith and King

(2005)conducted a study on Black Lake, Michigan, to determine if areas of core use exist in lentic systems. They concluded that lake sturgeon did not exhibit areas of core use in Black Lake, and proposed that core areas of activity are likely more important in lotic systems, i.e., the French Broad River. Based on the results from the grid analysis, the Paint Rock Bluff (FBRM 3.5-5.5) and Sea Ray (FBRM 1.5-3.0) grids were selected for further analysis using the underwater video mapping.

Underwater Video Analysis

In transect 1 the primary substrate types found were bedrock, gravel, and sand; the area also had a small proportion of shells, aquatic vegetation, trash and debris. The majority of this transect was flat bottomed and covered in sand with interspersed areas of gravel or visible bedrock covered in various amounts of sand. A few fish were observed in this area, including largemouth bass (*Micropterus salmoides*) and buffalo (*Ictiobus* spp.); no lake sturgeons were observed (Swinson et al. 2005).

In transect 2 the primary substrate types found were bedrock, gravel, sand and debris. The beginning of this transect was primarily gravel, with a large portion of the middle section consisting of sandy bedrock, and the lower section consisting of smooth sandy areas interspersed with a few large rocks. Small areas of debris were also found in various portions of this transect. Two fish were observed in this transect, one buffalo (*Ictiobus* spp.), and one small lake sturgeon, probably less than one year of age (Swinson et at. 2005).

In transect 3 the primary substrate types found were bedrock, gravel, sand and debris. The majority of this transect consisted of moderately sized areas of gravel and sandy bedrock with a few large areas of woody debris. A few fish were observed in this

transect, including two buffalo (*Ictiobus* spp.) and one juvenile lake sturgeon (Appendix B.7.) (Swinson et al. 2005).

The primary substrate types found in the control transect were rock, gravel, debris, bedrock, sand, and cliffs. This area was characterized by large slabs of bedrock, pushed up from the bottom, creating large cliffs, and also contained a considerable amount of rock and gravel. There were a few small areas of grass and scattered mussel shells and a very small amount of sandy areas scattered through the transect area.

Underwater video mapping of the core use areas and aggregation areas on the French Broad River indicated similarities in substrate type, i.e., flat bottom areas with minimal gravel or rock and substantial sand deposition. Dominant substrate types for transects 1-3 were the same, bedrock, gravel, and sand; the only differences were the in quantity found within each transect (visual assessment). Dominant substrate types for the control transect, however, were different than the types found in transects 1-3, and consisted primarily of cliffs, rough bedrock, debris, and a minimal amount of sand. Although variations among substrate types in all transects were small, one distinctive feature was found in the control site that was not found in the other transects, the presence of more rocky and rough surfaces. Transects 1, 2, and 3 all had moderately sized areas of the river bottom that were characterized as sand or smooth bedrock, while the control transect did not have any moderate sized areas of similar substrate. In addition, the image of a juvenile lake sturgeon captured in the video footage clearly showed the fish swimming over a smooth sandy area; this provides evidence that this is their preferred substrate/habitat type. Although these data are preliminary (underwater mapping was only conducted in two of the core use grids) the results seem to indicate a

preference for sand-type substrates, and areas where these types of substrate would naturally occur (i.e., where the current slows and sand deposits).

Substrate preferences characterized with the underwater video mapping of the river bottom are in-line with other research conducted on lake sturgeon and other species of sturgeon. In a study conducted on hatchery-reared juvenile lake sturgeon, data indicated a strong preference for smooth and sandy substrates in a test-tank experiment (Peake 1999). Shovelnose sturgeons (*Scaphirhynchus platorynchus*) were frequently located in areas of current over sand bottoms, sand bars, or bedrock (Keenlyne 1997). Juvenile lake sturgeon in Wisconsin were also collected over sand substrates (Benson et al. 2005). McKinley et al. (1998) also found lake sturgeon preferred sand or silt substrates. This preference for sand has also been reported for other sturgeon species in various river systems (Kempinger 1996; Curtis et al. 1997; Knights et al. 2002; Bennett et al. 2005; Kynard et al. 2005; Smith and King 2005; Young and Scarnecchia 2005).

Chapter VI

Summary and Recommendation

A multi-agency partnership was formed to re-introduce lake sturgeon (*Acipenser fulvescens*) in the Upper Tennessee River system. The initial re-introduction occurred in 2000, and to date over 45,000 lake sturgeon from multiple age classes have been released. Re-introductions of the lake sturgeon were in response to improvements in water quality and other improvements made by the Tennessee Valley Authority (TVA). A biotelemetry study of hatchery-reared juvenile lake sturgeon released into the French Broad River was conducted to determine if patterns exist in their dispersal, persistence, and use of the upper Tennessee River system. Results of the study are as follows:

1. Persistence of lake sturgeon after release into the French Broad River was 50%, with less than half of the fish emigrating out of the river into other portions of the Upper Tennessee River system. This level of persistence could be due to the fact that this species is highly mobile and can travel long distances.
2. The mean dispersal from the release site was 10.6 RM (sd=7.9), primarily downstream from the release site. This finding corroborates other research studies on juvenile sturgeon species in various systems, which documents that juveniles tend to use the lower portions of tributary rivers and confluences of tributary rivers for over-wintering habitat.
3. The mean linear range was 7.3 RM (sd=7.1) and ranged from 1.0-20.3 total river miles. Juveniles rapidly dispersed to over-wintering locations and then exhibited minimal movements within their linear range.

4. Direction of movement was correlated with changes in river discharge (χ^2=14.46, $\underline{P}$=0.0007). Movement distance (ANOVA, $\underline{P}$<0.05), dispersal distance (ANOVA, $\underline{P}$<0.05), and depth selection (ANOVA, $\underline{P}$<0.05), were correlated with temperature and river discharges from an upstream hydroelectric dam.
5. Juvenile lake sturgeon exhibited aggregation and used core areas in the French Broad River, a tributary to the Tennessee River. Areas of aggregation and core use were located within the bend of the river, with sand substrate, and mean depth of approximately 6 m (1.5-13.7 m).

It is recommended that further research be conducted on the entire Upper Tennessee River System to determine the quantity of areas that are suitable juvenile habitat, i.e., areas > 5 m, in the bend of the river, with associated rock bluff and corresponding sandy or bedrock substrates. A study to determine the quantity of available habitat would be useful in determining other areas within this system where core use and aggregation are likely to occur. It is also recommended that the underwater video analysis should be a component of such a study.

A long-term (>one year) radio-telemetry tracking study should also be conducted on other age classes and across seasons to determine if use of the Upper Tennessee River system differs between age classes or between seasons. This information would be useful for determining management strategies by age class.

An additional study should be conducted to determine the most effective sampling methods for capturing lake sturgeon of various age-classes in the upper Tennessee River system. Specific areas where sampling efforts should be concentrated included: Fort

Loudoun Reservoir and downstream of Fort Loudoun Dam, the lower five river miles of the French Broad and Holston Rivers, immediately below Douglas and Cherokee Dam, and any other area of the upper Tennessee River system that has similar habitat characteristics as the core use areas and areas of aggregation found in this study.

Additional consideration should be given to determining ways to further protect the areas determined to be core use areas. The core use areas on the lower French Broad River and at Douglas Dam on the upper French Broad River experience high angling pressure (personal observation). Additional steps should be taken to ensure that sport-anglers are knowledgeable of this species and its protected status within the state of Tennessee.

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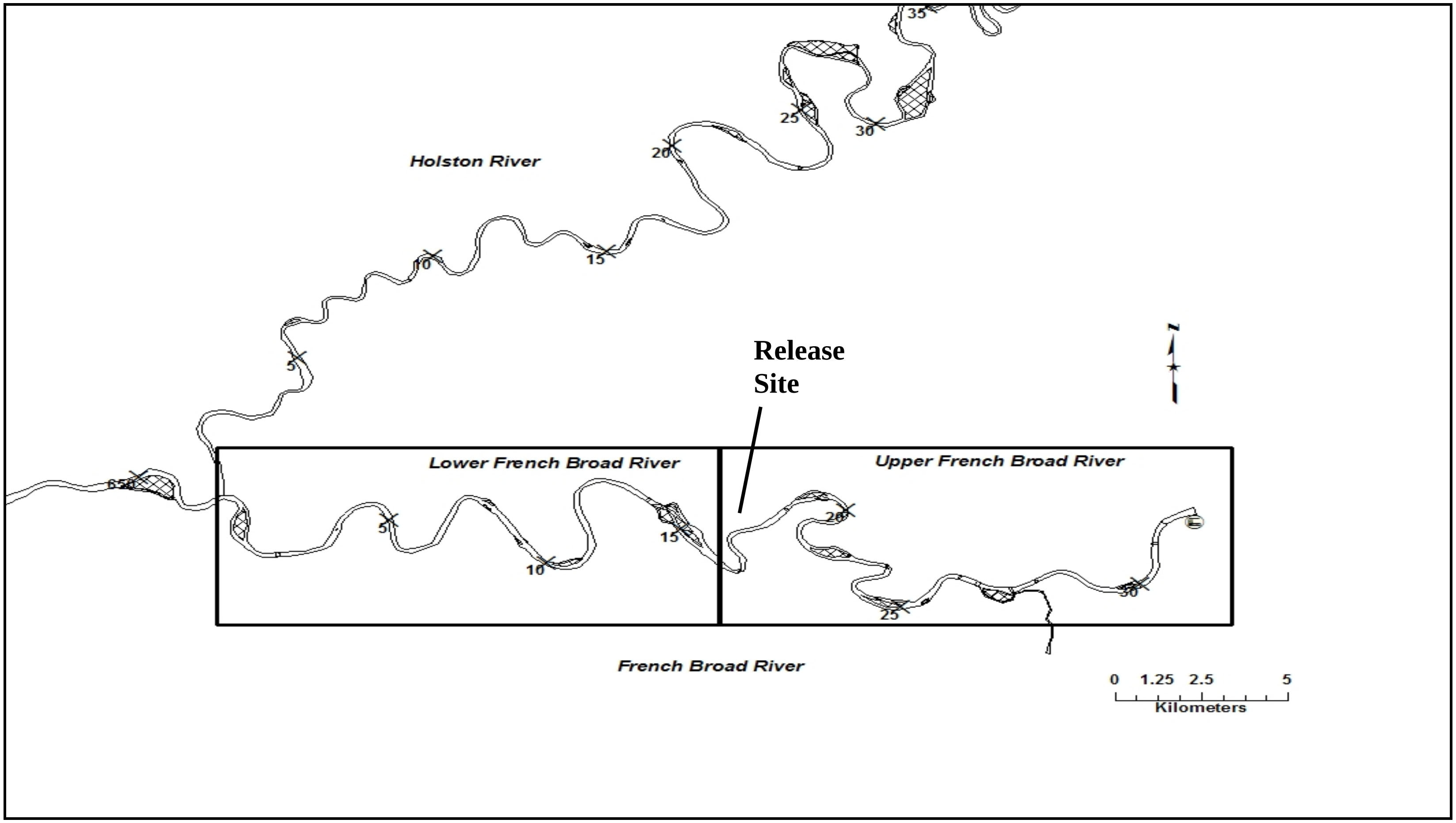
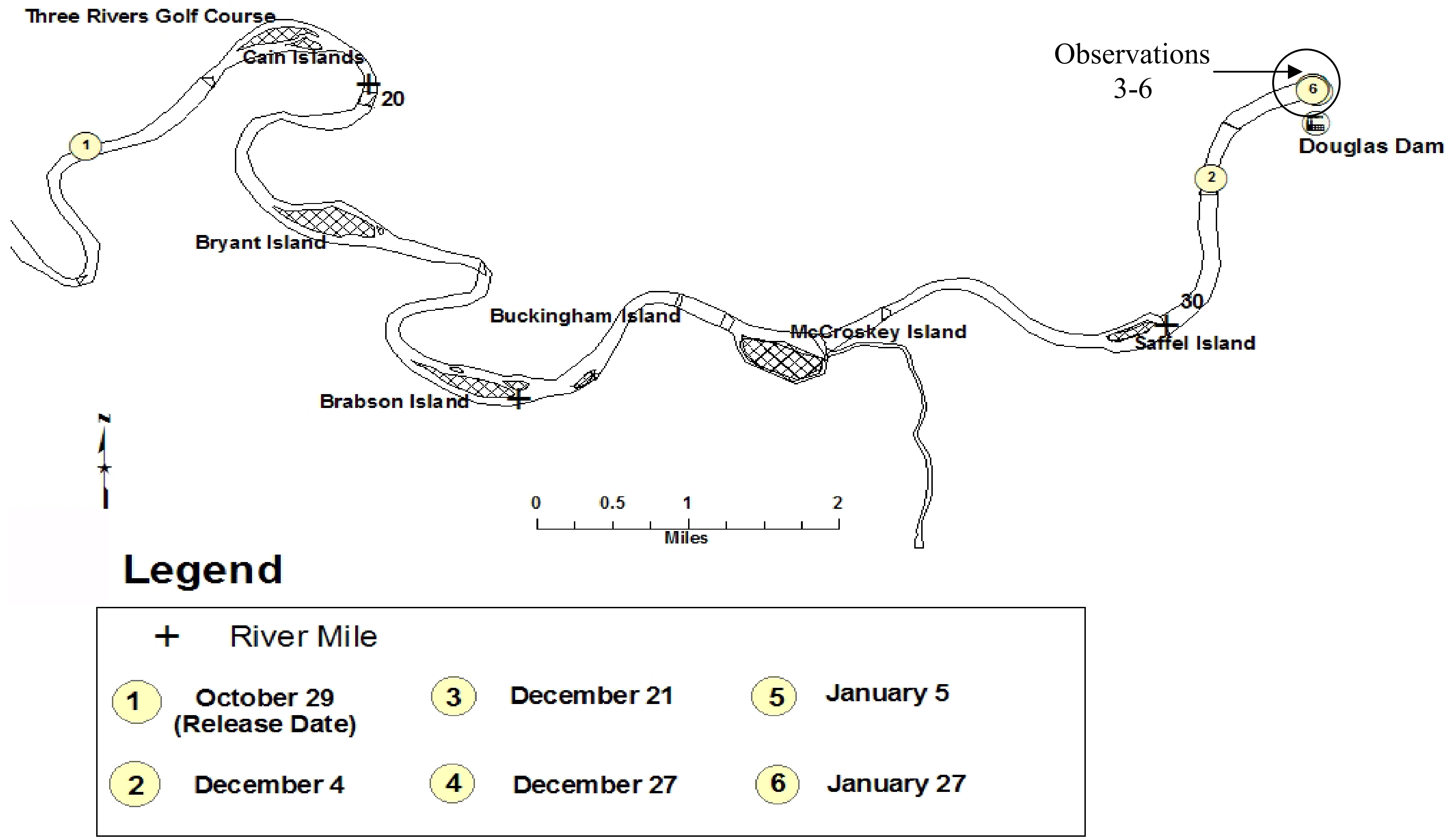
APPENDICES



Appendix A.1. Map of the French Broad River indicating separate sections: the upper French Broad River and the lower French Broad River.

Upper French Broad River



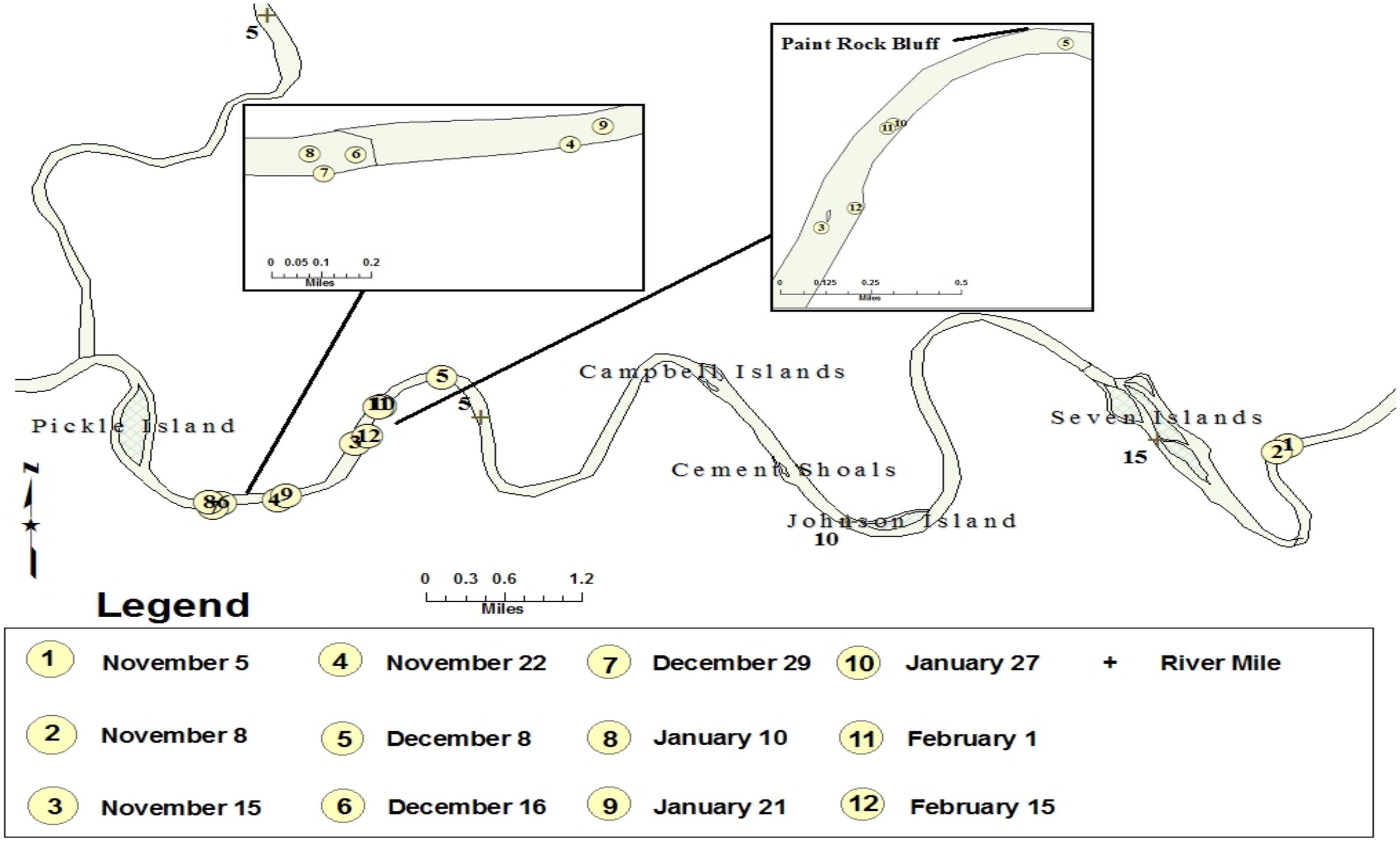
Appendix A.2. Movement of lake sturgeon # 48.011 from 29 October 2004 to 27 January 2005. Circled numbers represent observed locations in chronological order.

Appendix A.2. Summary of data for lake sturgeon # 48.011

Transmitter Frequency:	48.011	Tracking Duration (dates):	29 October 2004-27 January 2005
Total Length (mm):	480	Tracking Duration:	91 days
Weight (g):	490	Number of Observations:	6
		Total River Miles (RM) Traveled:	14.7

Date	Distance Traveled (RM)	Depth (m)	River Temperature ^{0}C	Location
29-Oct-04	0.0			17.5
4-Dec-04	13.6			31.2
21-Dec-04	1.1	5.5	8.6	32.3
27-Dec-04	0.0	9.1	7.1	32.2
5-Jan-05	0.0	12.2	4.7	32.2
27-Jan-05	0.0	1.5	6.6	32.1

Lower French Broad River



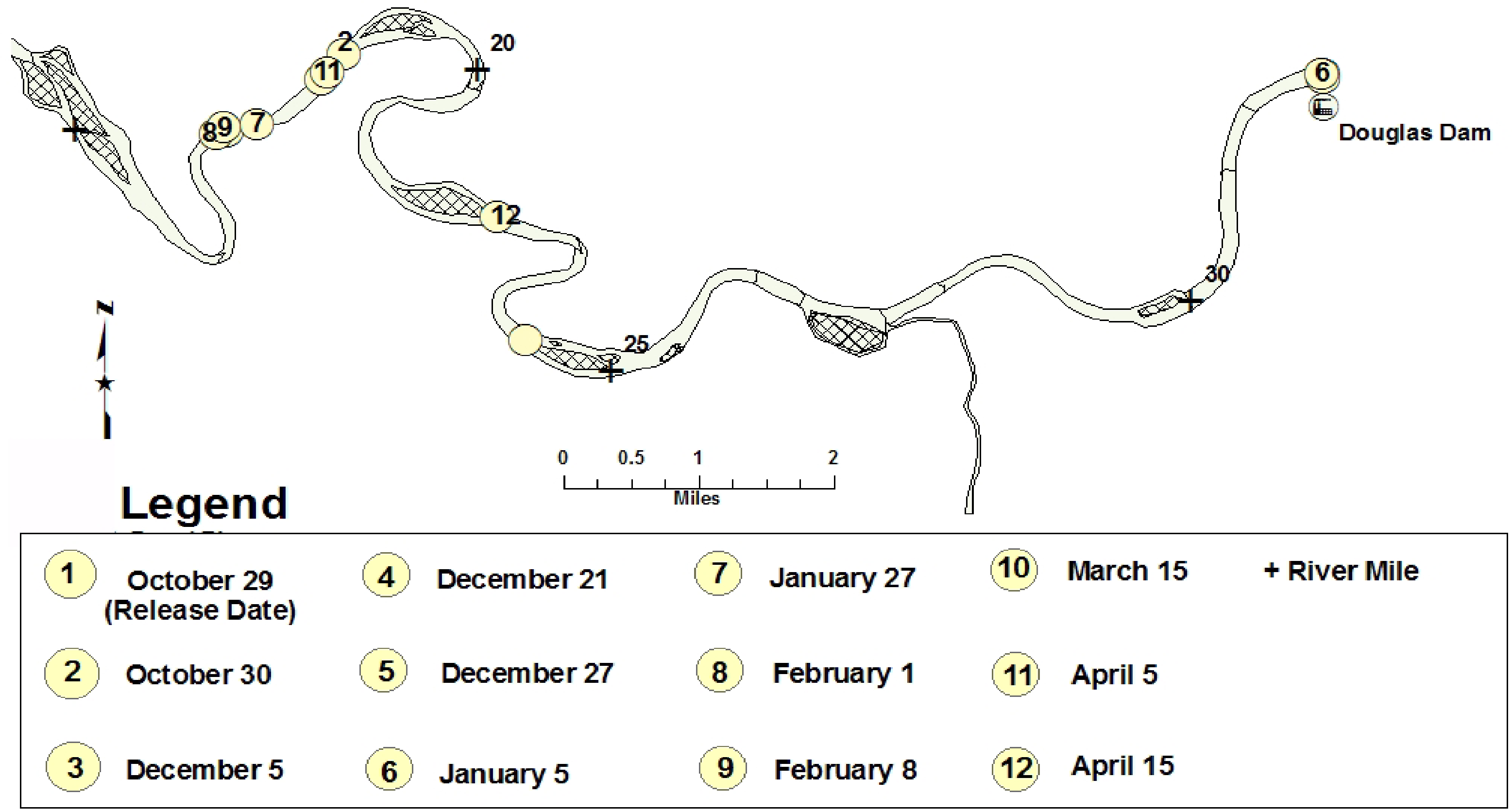
Appendix A.3. Movement of lake sturgeon # 48.051 from 5 November 2004 to 15 February 2005. Circled numbers represent observed locations in chronological order.

Appendix A.3. Summary of data for lake sturgeon # 48.051.

Transmitter Frequency:	48.051	Tracking Duration (dates):	5 November 2004-15 February 2005
Total Length (mm):	480	Tracking Duration:	103 days
Weight (g):	525	Number of Observations:	12
		Total River Miles (RM) Traveled:	21.7

Date	Distance Traveled (RM)	Depth (m)	River Temperature ^{0}C	Location
5-Nov-04	0.0			17.5
8-Nov-04	0.1			17.5
15-Nov-04	14.0			3.4
22-Nov-04	0.9			2.5
8-Dec-04	1.9			4.5
16-Dec-04	2.4	4.7	12.4	2.2
29-Dec-04	0.1	3.7	6.3	2.2
10-Jan-05	0.1	4.5	7.5	2.1
21-Jan-05	0.6	2.2	4.4	2.5
27-Jan-05	1.2	6.1	7.1	3.8
1-Feb-05	0.0	7.3	6.7	3.7
15-Feb-05	0.3	1.5	6.6	3.5

Upper French Broad River

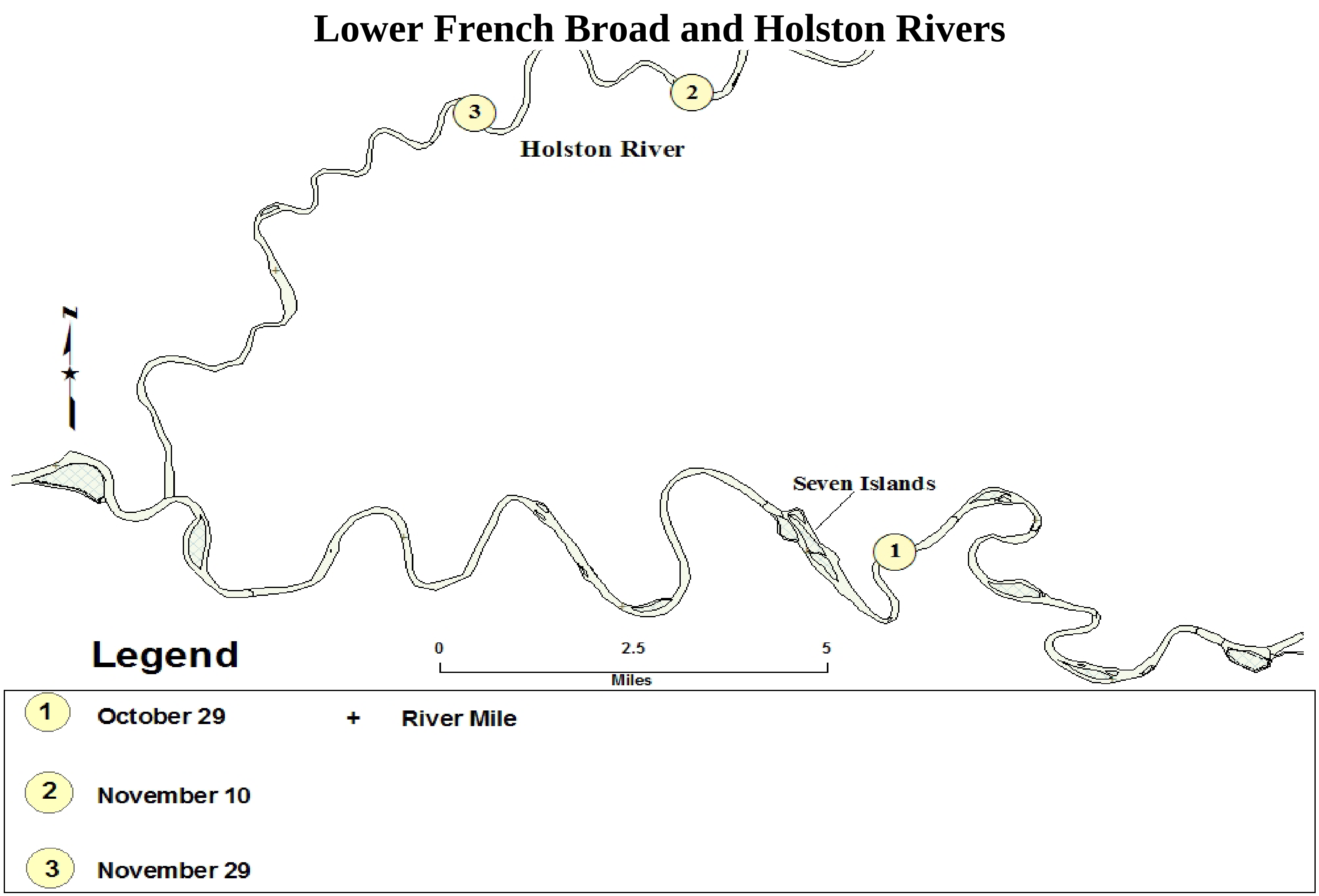


Appendix A.4. Movement of lake sturgeon #48.071 from 29 October 2004 to 15 April 2005. Circled numbers represent observed locations in chronological order.

Appendix A.4. Summary of data for lake sturgeon # 48.071.

Transmitter Frequency:	48.071	Tracking Duration (dates):	29 October 2004-15 April 2005
Total Length (mm):	505	Tracking Duration:	169 days
Weight (g):	505	Number of Observations:	12
		Total River Miles (RM) Traveled:	34.5

Date	Distance Traveled (RM)	Depth (m)	River Temperature ^{0}C	Location
29-Oct-04	0.0			17.5
30-Oct-04	1.1			18.7
5-Nov-04	5.6			24.4
21-Dec-04	7.9	13.7	8.6	32.3
27-Dec-04	0.0	6.4	7.0	32.3
5-Jan-05	0.0	9.1	4.7	32.3
27-Jan-05	14.3	5.0	6.7	17.8
1-Feb-05	0.3	6.2	7.4	17.5
8-Feb-05	0.1	4.6	10.0	17.5
15-Mar-05	0.9	3.4	8.2	18.4
5-Apr-05	0.1	3.5	12.2	18.5
15-Apr-05	5.0	2.8	12.4	22.5

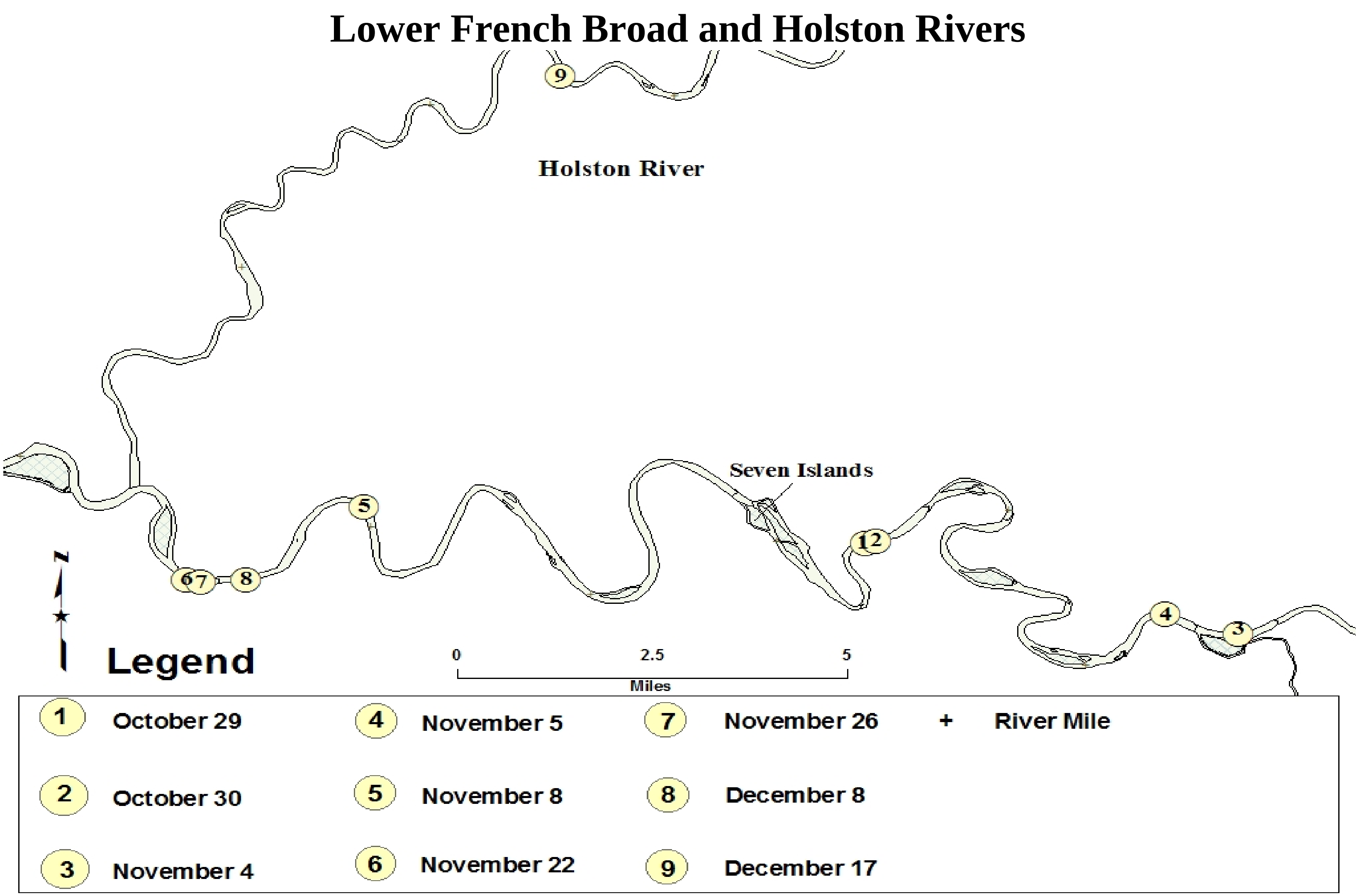


Appendix A.5. Movement of lake sturgeon # 48.110 from 29 October 2004 to 29 November 2004. Circled numbers represent observed locations in chronological order.

Appendix A.5. Summary of data for lake sturgeon # 48.110.

Transmitter Frequency:	48.110	Tracking Duration (dates):	29 October 2004-29 November 2004
Total Length (mm):	530	Tracking Duration:	32 days
Weight (g):	630	Number of Observations:	3
		Total River Miles (RM) Traveled:	36.9

Date	Distance Traveled (RM)	Depth (m)	River Temperature ^0C	Location	
29-Oct-04	0.0			17.5	
10-Nov-04	32.3			-14.9	Holston River
29-Nov-05	4.6			-10.3	Holston River



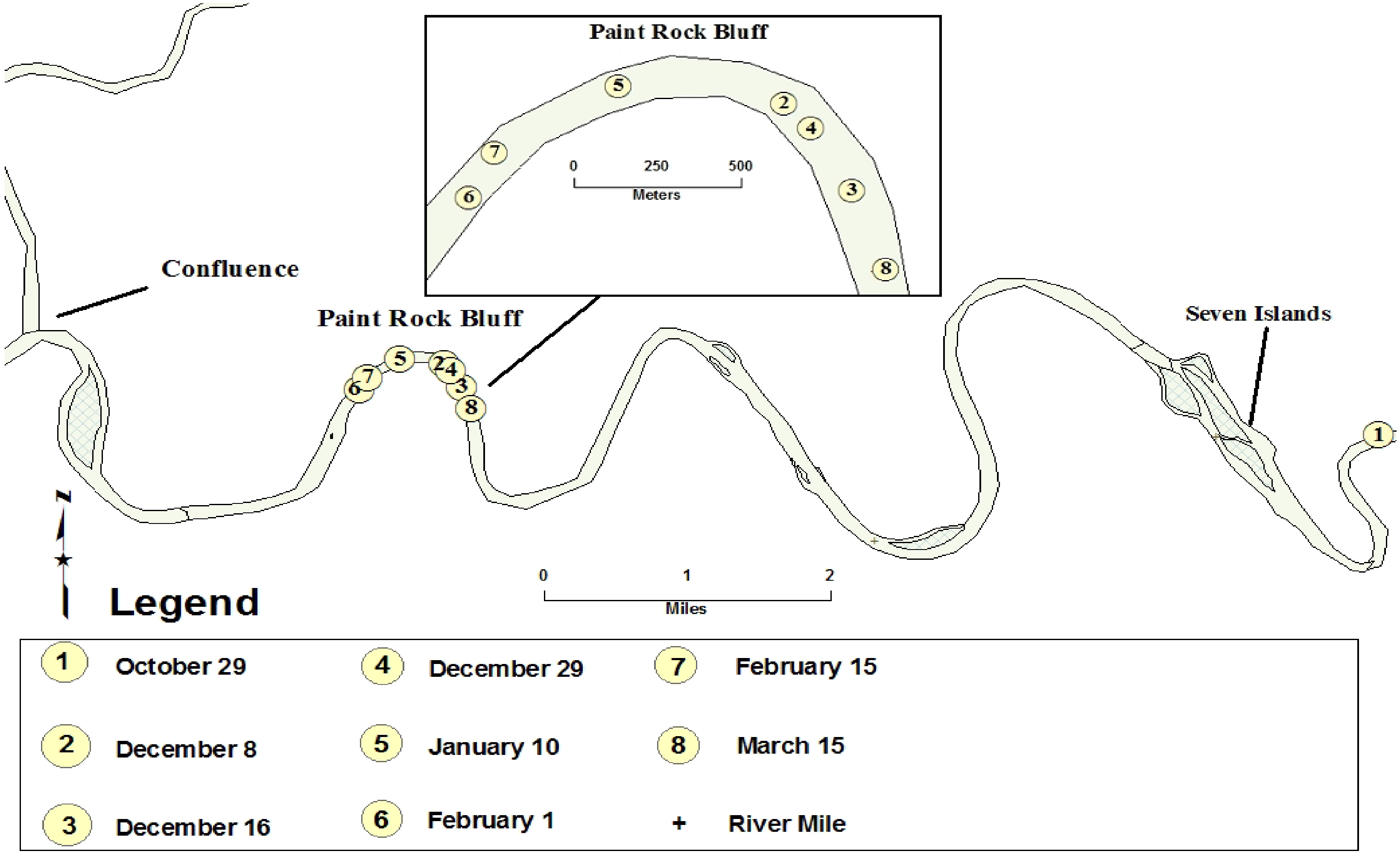
Appendix A.6. Movement of lake sturgeon # 48.130 from 29 October 2004 to 17 December 2004. Circled numbers represent observed locations in chronological order.

Appendix A.6. Summary of data for lake sturgeon # 48.130.

Transmitter Frequency:	48.130	Tracking Duration (dates):	29 October 2004-17 December 2004
Total Length (mm):	520	Tracking Duration:	91 days
Weight (g):	560	Number of Observations:	6
		Total River Miles (RM) Traveled:	14.7

Date	Distance Traveled (RM)	Depth (m)	River Temperature ^0C	Location	
29-Oct-04	0.0			17.5	
30-Oct-04	0.2			17.7	
4-Nov-04	9.5			27.3	
5-Nov-04	1.0			26.3	
8-Nov-04	21.7			4.8	
22-Nov-04	3.0			1.8	
26-Nov-04	0.2			2.0	
8-Dec-04	0.6			2.5	
17-Dec-04	15.8	4.2	12.2	-13.3	Holston River

Lower French Broad River



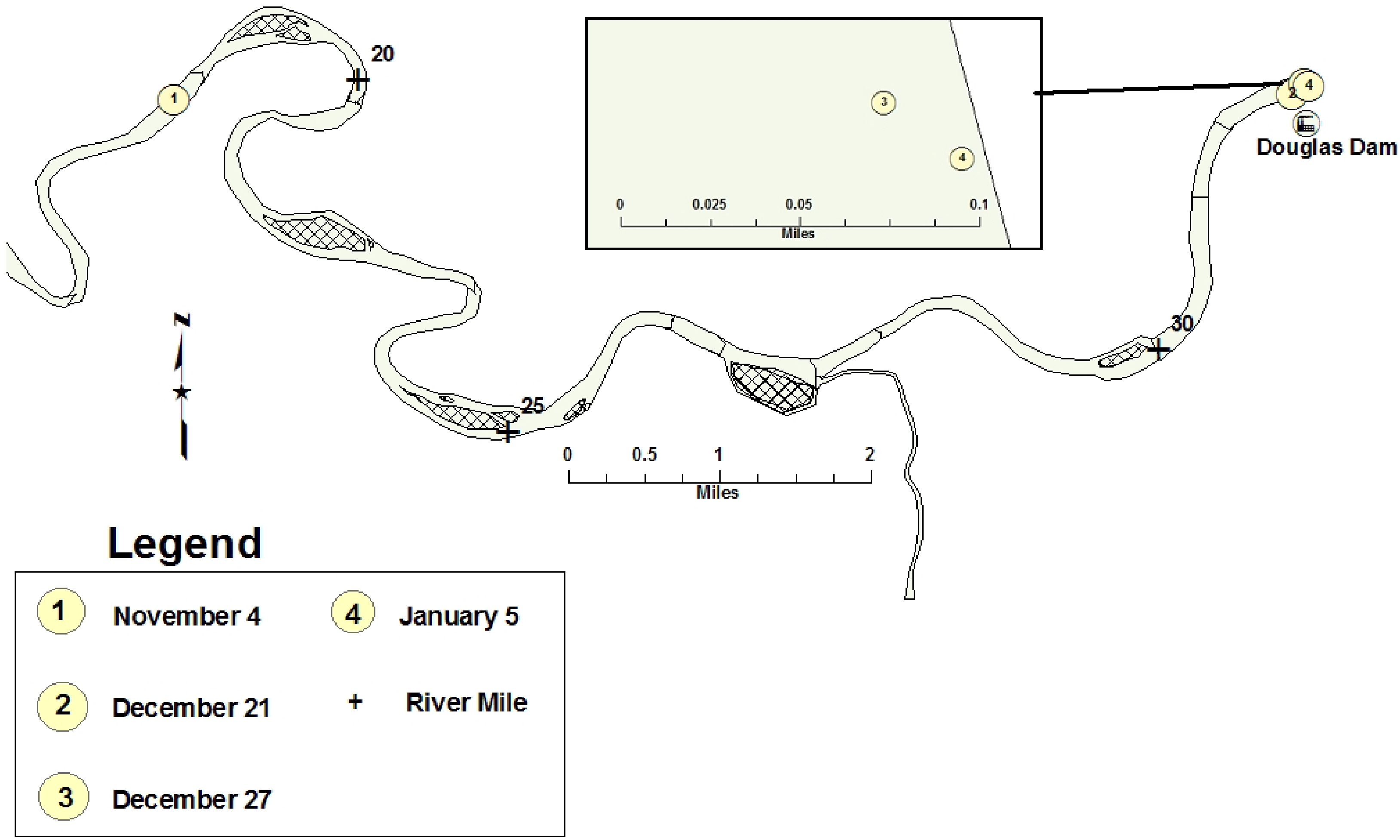
Appendix A.7. Movement of lake sturgeon # 48.151 from 29 October 2004 to 15 March 2005. Circled numbers represent observed locations in chronological order.

Appendix A.7. Summary of data for lake sturgeon # 48.151.

Transmitter Frequency:	48.151	Tracking Duration (dates):	29 October 2004-15 March 2005
Total Length (mm):	545	Tracking Duration:	138 days
Weight (g):	640	Number of Observations:	8
		Total River Miles (RM) Traveled:	15.4

Date	Distance Traveled (RM)	Depth (m)	River Temperature ^{0}C	Location
29-Oct-04	0.0			17.5
8-Dec-04	13.1			4.6
16-Dec-04	0.2	2.7	11.2	5.0
29-Dec-04	0.1	4.1	6.3	4.7
10-Jan-05	0.4	6.2	7.3	4.3
1-Feb-05	0.4	7.6	6.8	3.9
15-Feb-05	0.1	7.1	6.7	4.0
15-Mar-05	1.0	2.9	8.6	5.2

Upper French Broad River



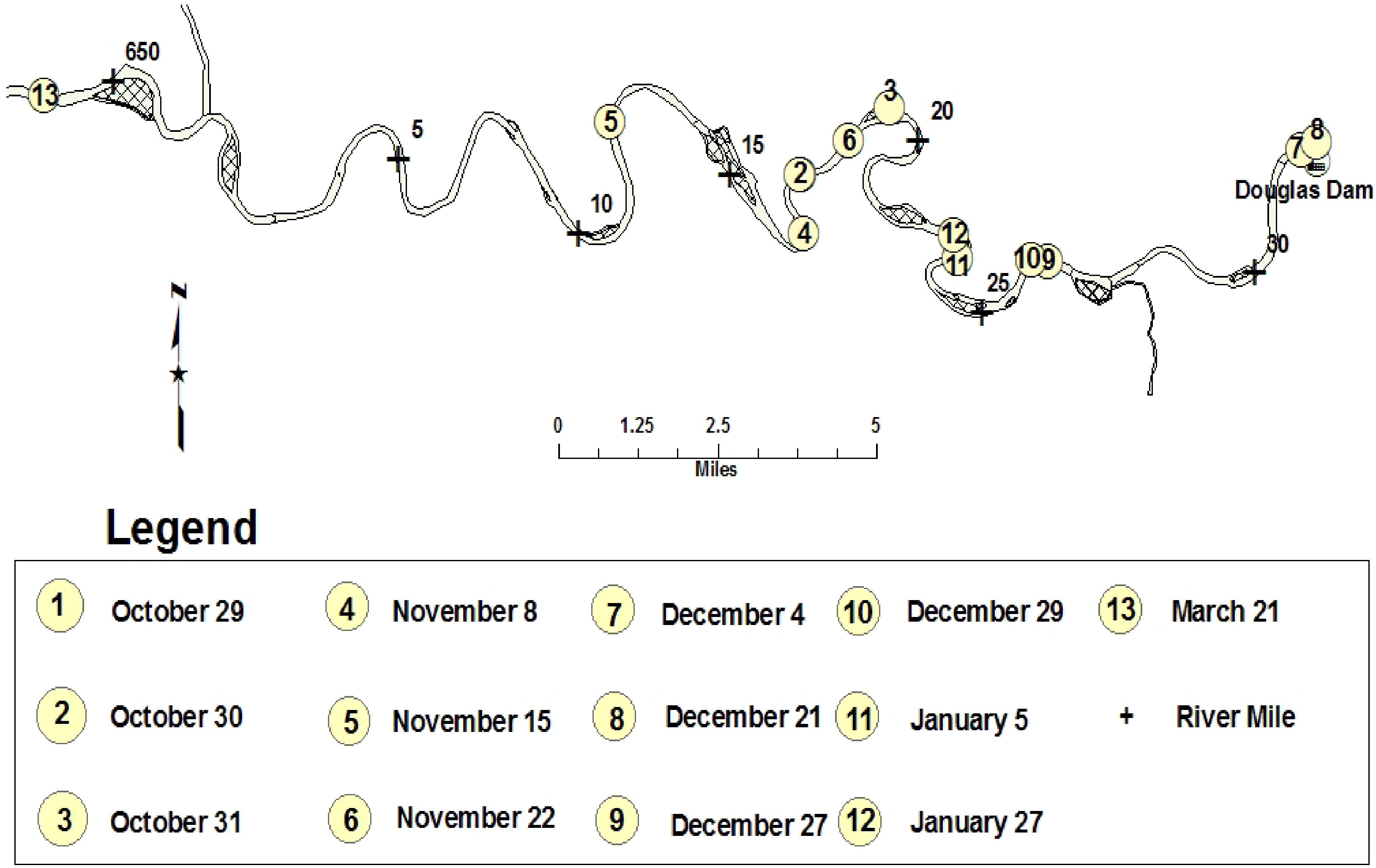
Appendix A.8. Movement of lake sturgeon # 48.190 from 4 November 2004 to 5 January 2005. Circled numbers represent observed locations in chronological order.

Appendix A.8. Summary of data for lake sturgeon # 48.190.

Transmitter Frequency:	48.190		Tracking Duration (dates):	4 November 2004- 5 January 2005
Total Length (mm):	520		Tracking Duration:	69 days
Weight (g):	570		Number of Observations:	4
			Total River Miles (RM) Traveled:	16.1

Date	Distance Traveled (RM)	Depth (m)	River Temperature ^0C	Location
5-Nov-04	0.0			18.3
21-Dec-04	16.0	2.7	8.6	32.1
27-Dec-04	0.1	9.1	7.1	32.3
5-Jan-05	0.0	12.2	4.7	32.3

French Broad River

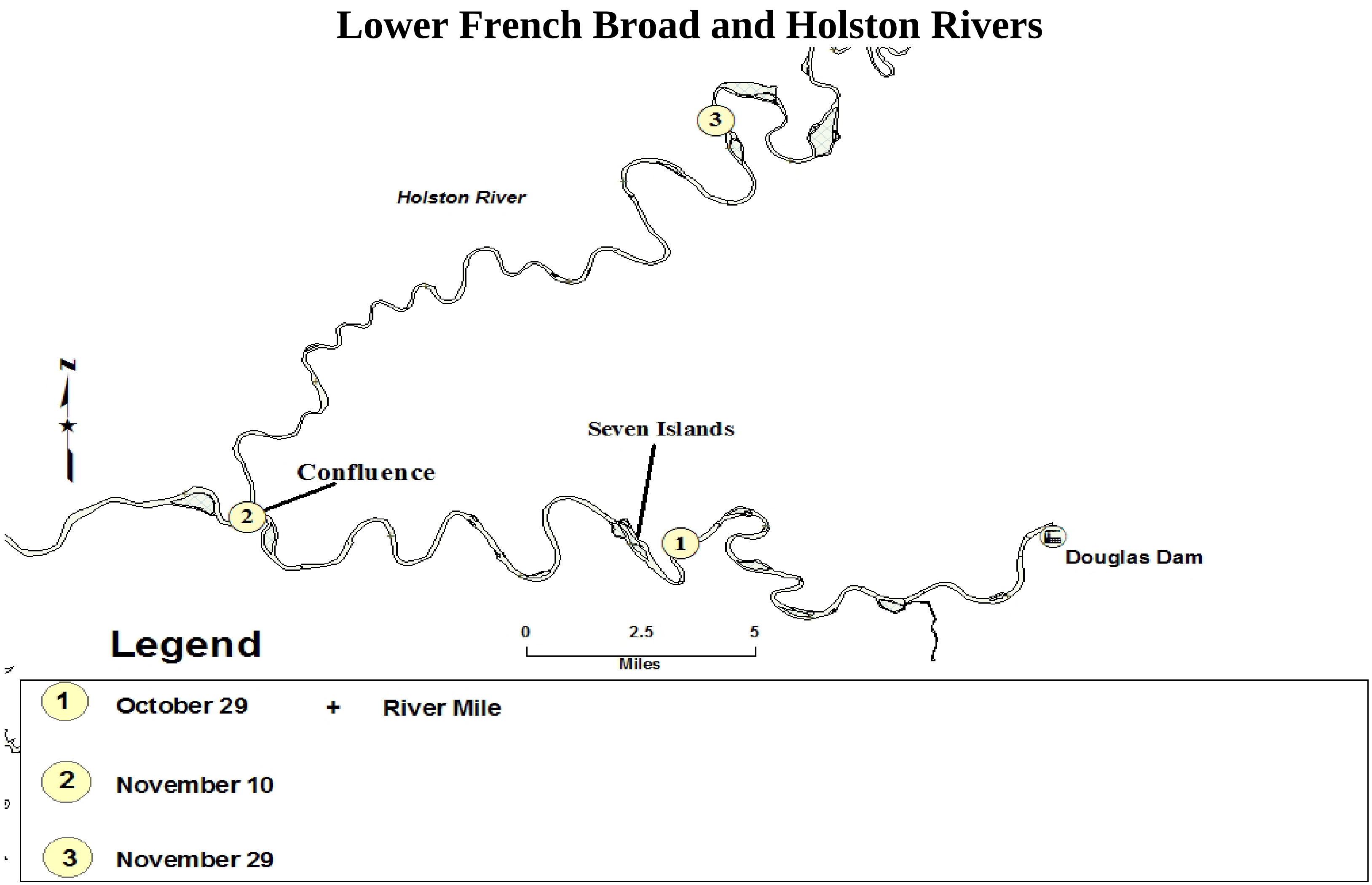


Appendix A.9. Movement of lake sturgeon # 48.210 from 29 October 2004 to 21 March 2005. Circled numbers represent observed locations in chronological order.

Appendix A.9. Summary of data for lake sturgeon # 48.210.

Transmitter Frequency:	48.210		Tracking Duration (dates):	29 October 2004-21 March 2005
Total Length (mm):	485		Tracking Duration:	144 days
Weight (g):	505		Number of Observations:	13
			Total River Miles (RM) Traveled:	65.7

Date	Distance Traveled (RM)	Depth (m)	River Temperature ^0C	Location	
29-Oct-04	0.0			17.5	
30-Oct-04	0.0			17.5	
31-Oct-04	1.8			19.3	
8-Nov-04	2.8			16.7	
15-Nov-04	4.5			12.0	
22-Nov-04	6.4			18.5	
4-Dec-04	14.4			32.0	
21-Dec-04	0.2	7.0	8.8	32.3	
27-Dec-04	5.9	4.6	7.0	26.3	
29-Dec-04	0.3	5.9	6.3	26.0	
5-Jan-05	2.7	8.4	4.9	23.5	
27-Jan-05	0.6	6.0	6.7	23.0	
21-Mar-05	26.1	5.8	9.7	-3.1	Tennessee River



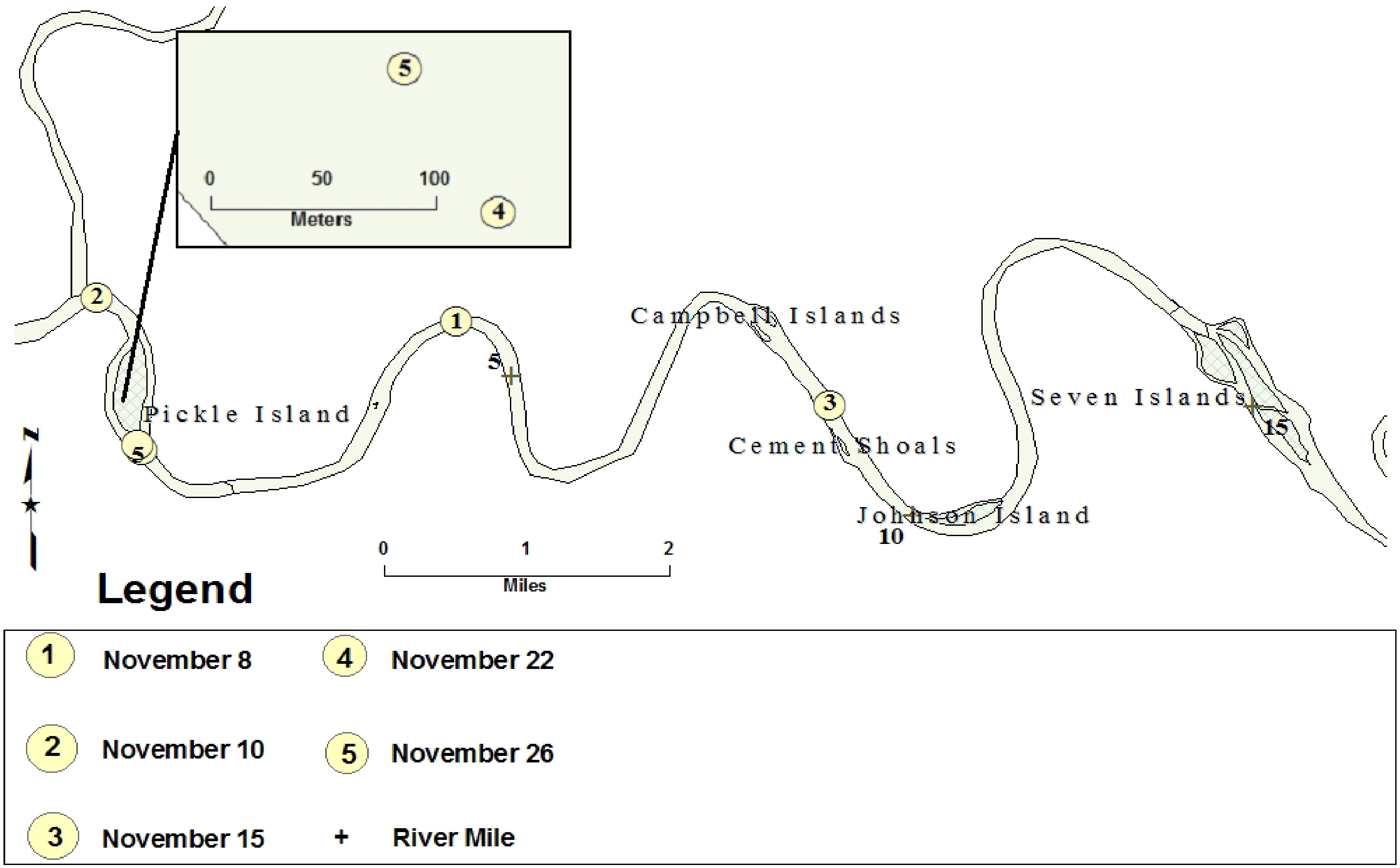
Appendix A.10. Movement of lake sturgeon # 48.230 from 29 October 2004 to 29 November 2004. Circled numbers represent observed locations in chronological order.

Appendix A.10. Summary of data for lake sturgeon # 48.230.

Transmitter Frequency:	48.230	Tracking Duration (dates):	29 October 2004-29 November 2005
Total Length (mm):	510	Tracking Duration:	32 days
Weight (g):	550	Number of Observations:	3
		Total River Miles (RM) Traveled:	43.3

Date	Distance Traveled (RM)	Depth (m)	River Temperature ^{0}C	Location	
29-Oct-04	0.0			17.5	
10-Nov-04	17.5			-0.3	Tennessee River
29-Nov-05	25.8			-25.8	Holston River

Lower French Broad River



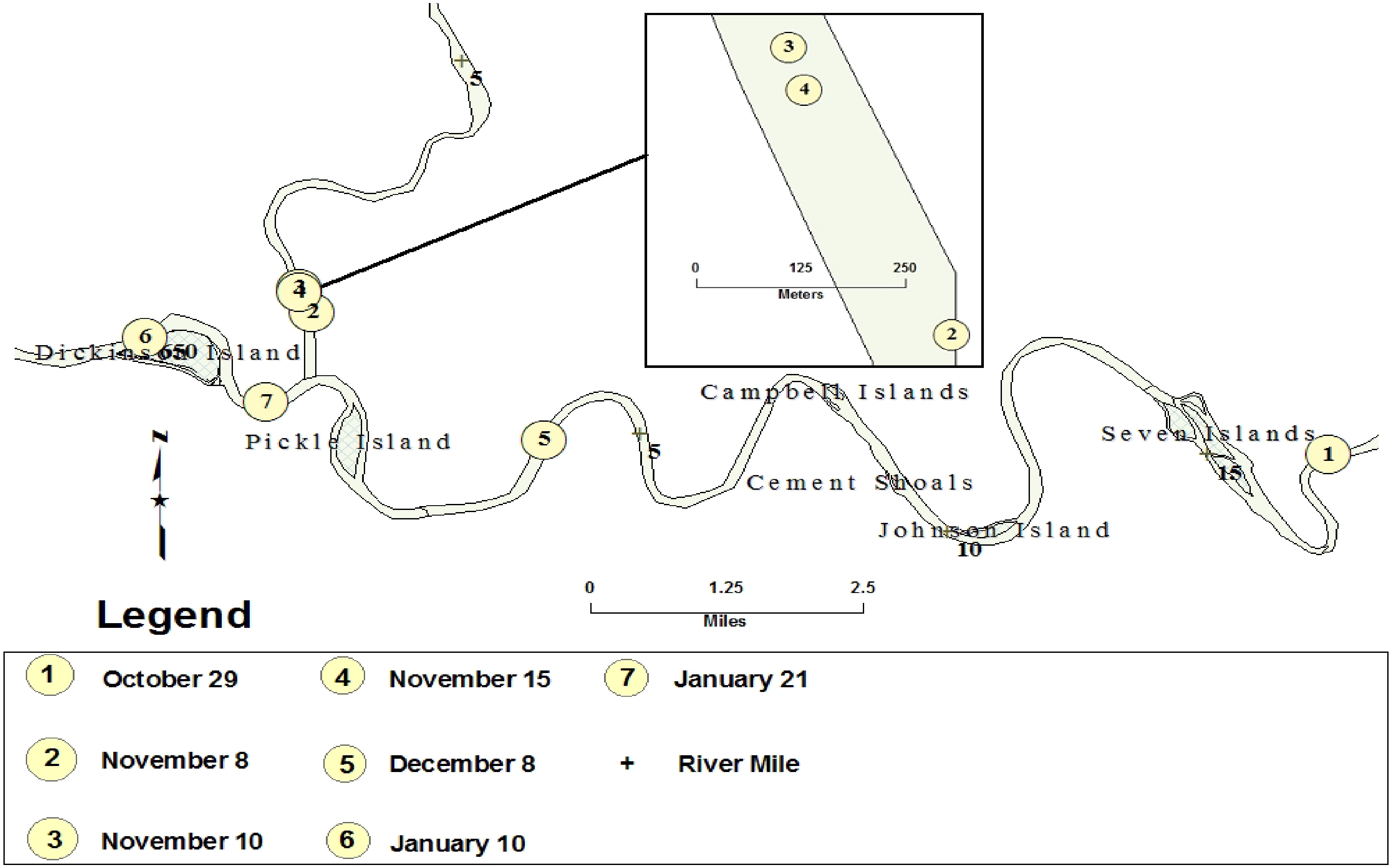
Appendix A.11. Movement of lake sturgeon # 48.250 from 8 November 2004 to 26 November 2004. Circled numbers represent observed locations in chronological order.

Appendix A.11. Summary of data for lake sturgeon # 48.250.

Transmitter Frequency:	48.250	Tracking Duration (dates):	8 November 2004-26 November 2004
Total Length (mm):	565	Tracking Duration:	19 days
Weight (g):	755	Number of Observations:	5
		Total River Miles (RM) Traveled:	34

Date	Distance Traveled (RM)	Depth (m)	River Temperature ^{0}C	Location
8-Nov-04	13.5			4.4
10-Nov-04	4.4			0.0
15-Nov-04	8.9			9.0
22-Nov-04	7.5			1.5
26-Nov-04	0.1			1.5

Confluence of Lower French Broad and Lower Holston Rivers

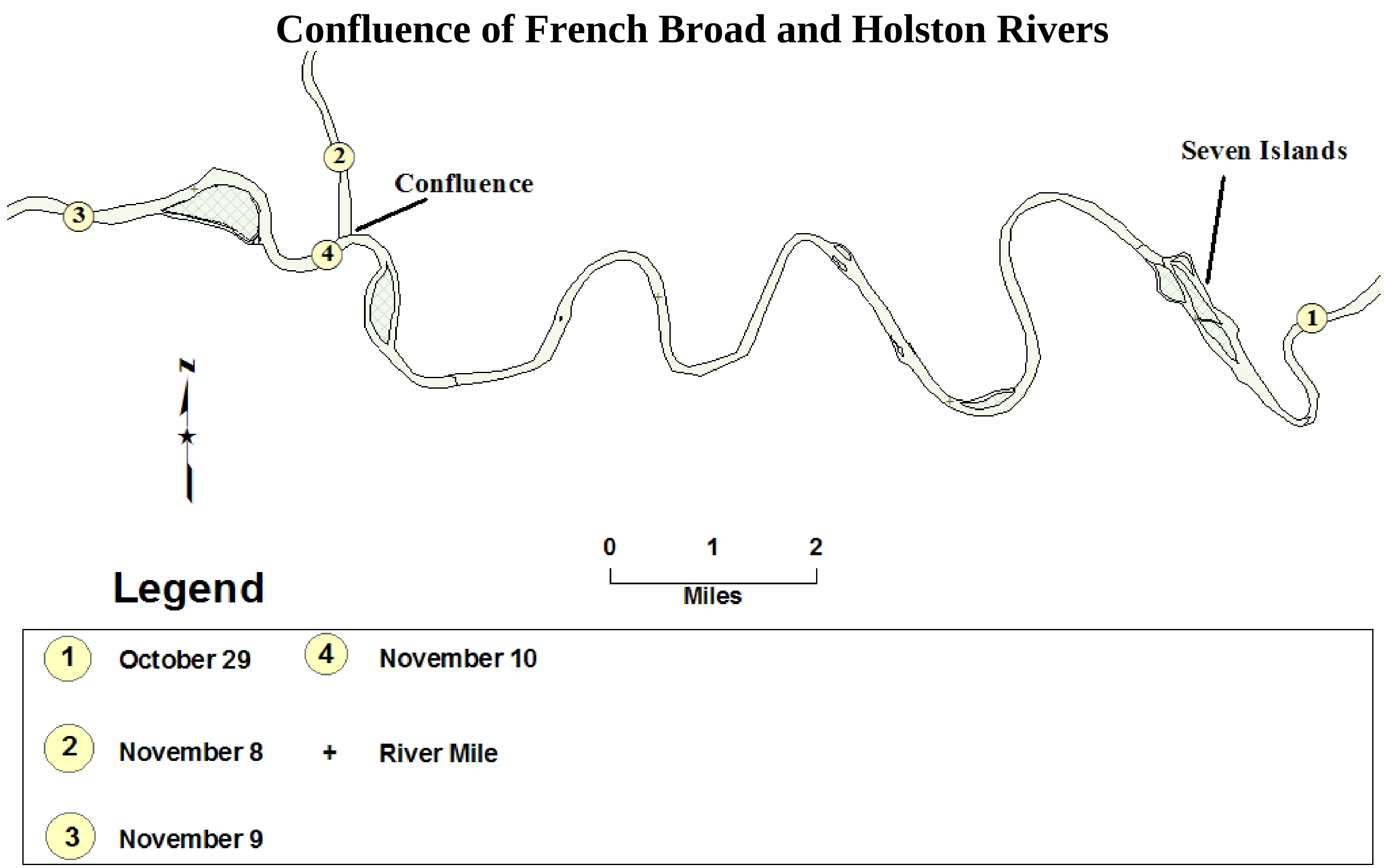


Appendix A.12. Movements of lake sturgeon # 48.270 from 29 October 2004 to 21 January 2005. Circled numbers represent observed locations in chronological order.

Appendix A.12. Summary of data for lake sturgeon #48.270.

Transmitter Frequency:	48.270	Tracking Duration (dates):	29 October 2004-21 January 2005
Total Length (mm):	500	Tracking Duration:	85 days
Weight (g):	485	Number of Observations:	7
		Total River Miles (RM) Traveled:	30.9

Date	Distance Traveled (RM)	Depth (m)	River Temperature ^{0}C	Location	
29-Oct-04	0.0			17.5	
8-Nov-04	18.2			-0.6	Holston River
10-Nov-04	0.3			-0.9	Holston River
15-Nov-04	0.0			-0.9	Holston River
8-Dec-04	4.7			3.5	
10-Jan-05	6.0	7.8	6.9	-2.1	Tennessee River
21-Jan-05	1.7	4.5	7.8	-0.5	Tennessee River

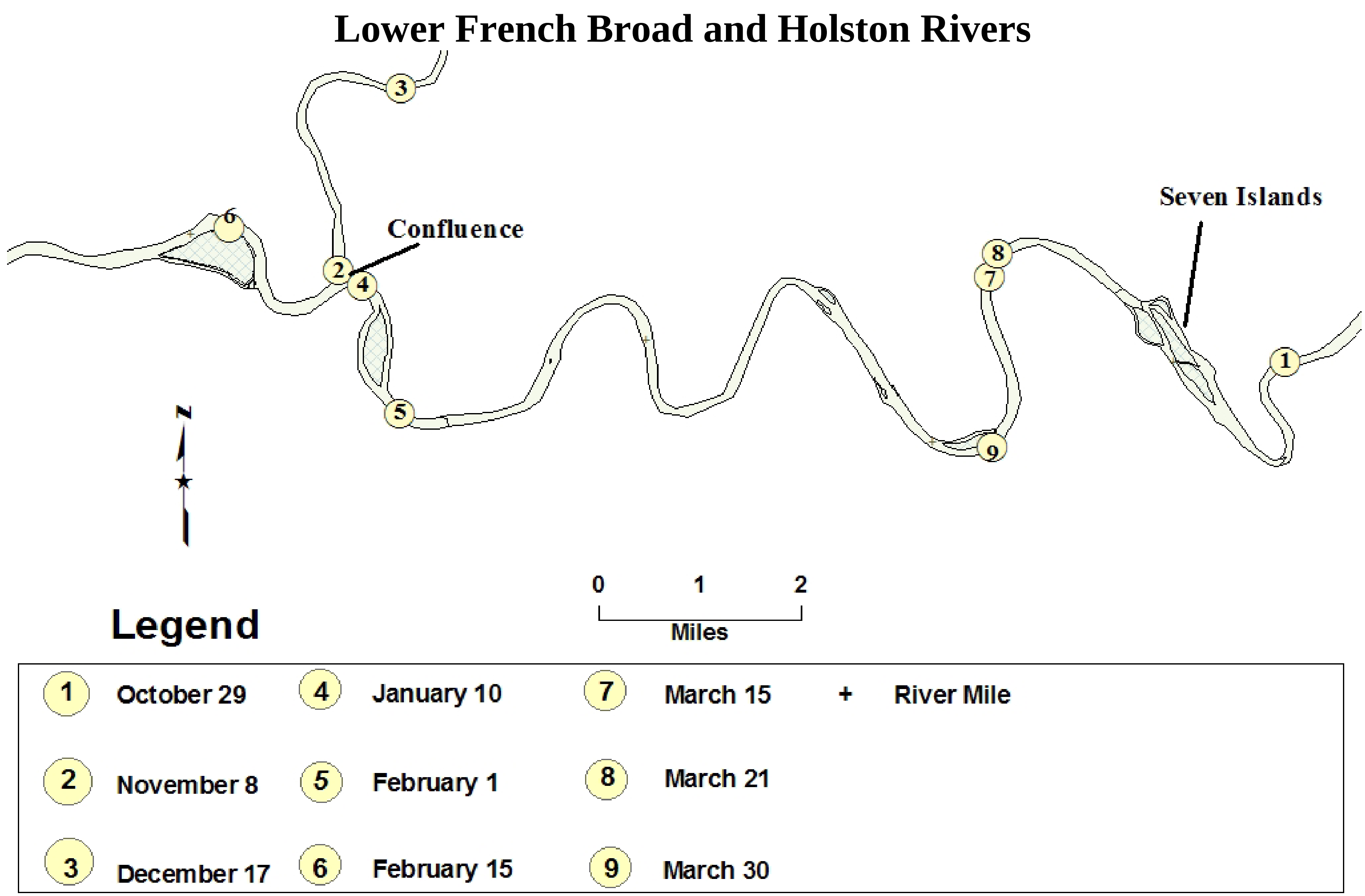


Appendix A.13. Movements of lake sturgeon # 48.290 from 29 October 2004 to 10 November 2004. Circled numbers represent observed locations in chronological order.

Appendix A.13. Summary of data for lake sturgeon # 48.290.

Transmitter Frequency:	48.290	Tracking Duration (dates):	29 October 2004-10 November 2004
Total Length (mm):	510	Tracking Duration:	13 days
Weight (g):	535	Number of Observations:	4
		Total River Miles (RM) Traveled:	25

Date	Distance Traveled (RM)	Depth (m)	River Temperature ^{0}C	Location	
29-Oct-04	0.0			17.5	
8-Nov-04	18.0			-0.8	Holston River
9-Nov-04	4.0			-3.1	Tennessee River
10-Nov-04	3.0			-0.3	Tennessee River



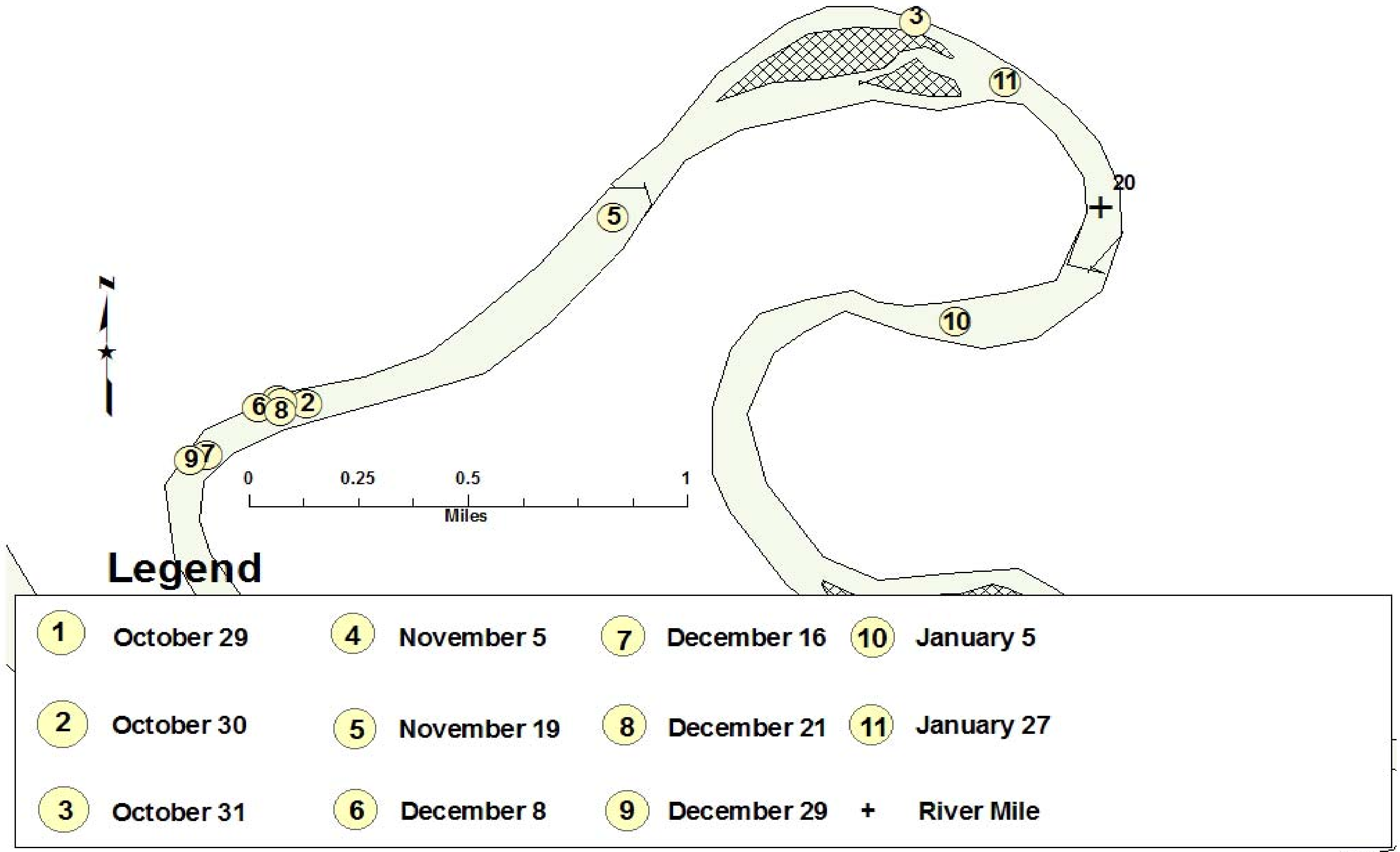
Appendix A.14. Movement of lake sturgeon # 48.310 from 29 October 2004 to 30 March 2005. Circled numbers represent observed locations in chronological order.

Appendix A.14. Summary of data for lake sturgeon # 48.310.

Transmitter Frequency:	48.310	Tracking Duration (dates):	29 October 2004-30 March 2005
Total Length (mm):	525	Tracking Duration:	153 days
Weight (g):	555	Number of Observations:	9
		Total River Miles (RM) Traveled:	45.3

Date	Distance Traveled (RM)	Depth (m)	River Temperature ^0C	Location	
29-Oct-04	0.0			17.5	
4-Nov-04	17.6			0.0	
17-Dec-04	2.9	2.3	11.7	-3.0	Holston River
10-Jan-05	3.2	5.5	7.3	0.4	
1-Feb-05	1.5	6.7	6.7	1.8	
15-Feb-05	3.5	6.1	7.9	-1.6	Tennessee River
15-Mar-05	14.2	4.8	8.3	12.3	
21-Mar-05	0.3	1.8	8.9	12.5	
30-Mar-05	2.1	0.5	13.9	10.5	

Upper French Broad River



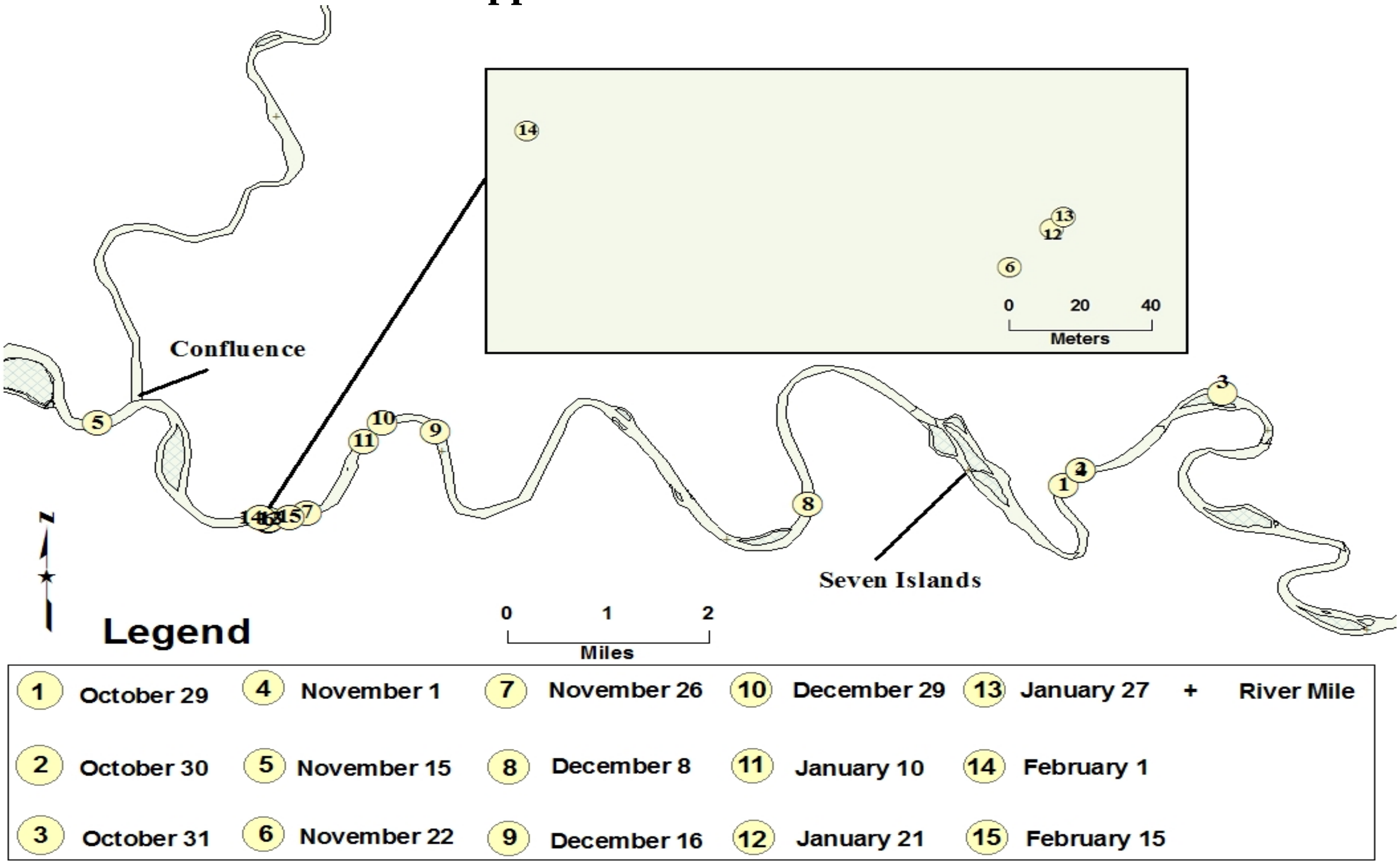
Appendix A.15. Movements of lake sturgeon # 48.331 from 29 October 2004 to 27 January 2005. Circled numbers represent observed locations in chronological order.

Appendix A.15. Summary of data for lake sturgeon # 48.331.

Transmitter Frequency:	48.331	Tracking Duration (dates):	29 October 2004-27 January 2005
Total Length (mm):	515	Tracking Duration:	91 days
Weight (g):	575	Number of Observations:	11
		Total River Miles (RM) Traveled:	10.4

Date	Distance Traveled (RM)	Depth (m)	River Temperature ^0C	Location
29-Oct-04	0.0			17.5
30-Oct-04	0.1			17.6
31-Oct-04	1.8			19.4
5-Nov-04	1.8			17.5
19-Nov-04	0.9			18.5
8-Dec-04	1.0			17.5
16-Dec-04	0.2	4.5	10.6	17.4
21-Dec-04	0.2	6.2	8.7	17.5
29-Dec-04	0.2	10.1	6.3	17.3
5-Jan-05	3.2	7.3	4.9	20.6
27-Jan-05	0.9	5.7	6.8	19.7

Upper French Broad River

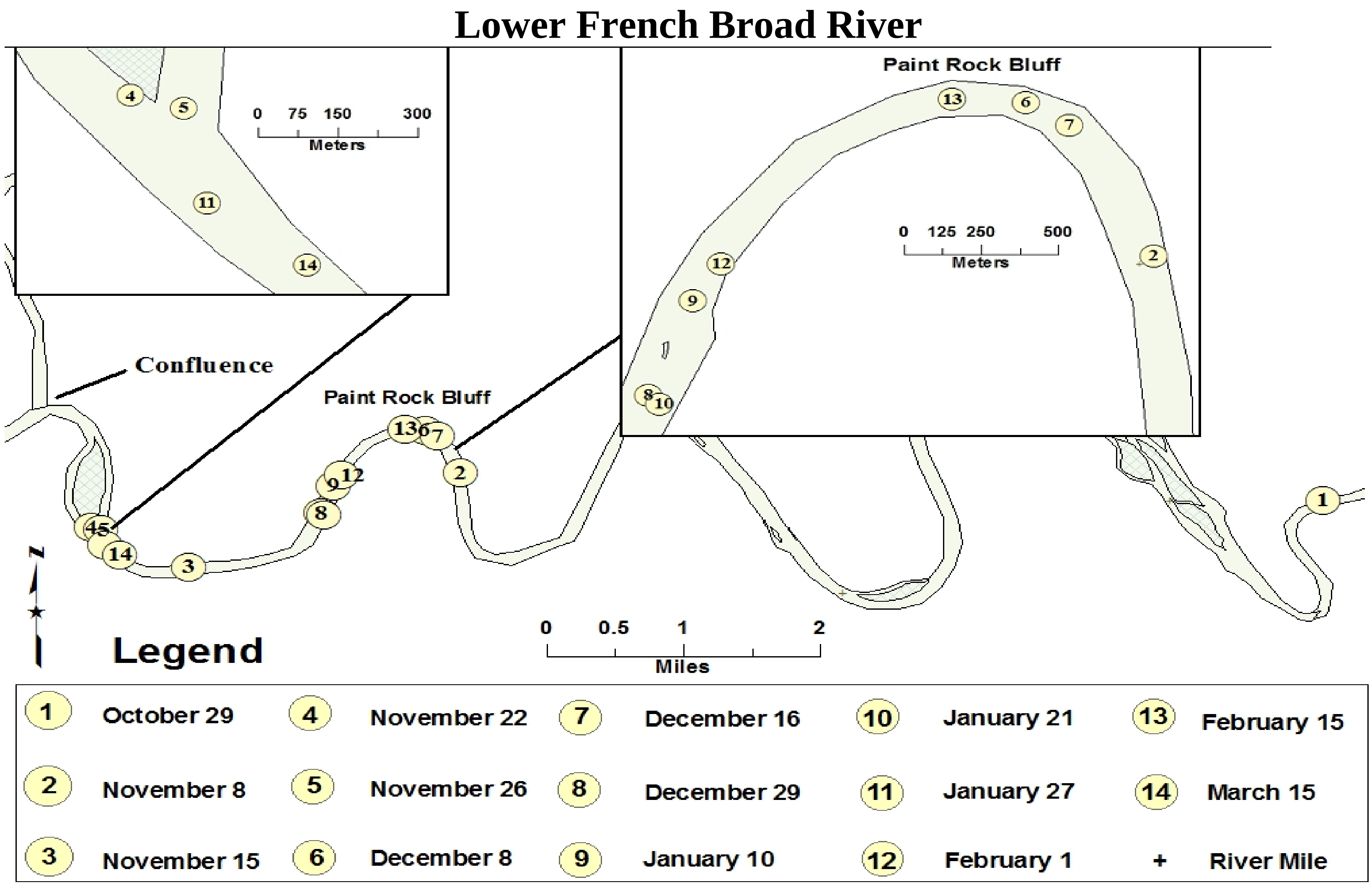


Appendix A.16. Movement of lake sturgeon # 48.351 from 29 October 2004 to 15 February 2005. Circled numbers represent observed locations in chronological order.

Appendix A.16. Summary of data for lake sturgeon # 48.351.

Transmitter Frequency:	48.351	Tracking Duration (dates):	29 October 2004-15 February 2005
Total Length (mm):	495	Tracking Duration:	110 days
Weight (g):	525	Number of Observations:	15
		Total River Miles (RM) Traveled:	43

Date	Distance Traveled (RM)	Depth (m)	River Temperature ^0C	Location	
29-Oct-04	0.0			17.3	
30-Oct-04	2.1			17.6	
31-Oct-04	1.8			19.3	
1-Nov-04	0.1			17.5	
15-Nov-04	18.4			-0.5	Tennessee River
22-Nov-04	3.0			2.5	
26-Nov-04	0.4			2.8	
8-Dec-04	8.3			11.0	
16-Dec-04	6.3	3.0	11.4	4.8	
29-Dec-04	0.6	5.7	6.2	4.2	
10-Jan-05	0.3	8.3	7.4	3.8	
21-Jan-05	1.5	4.6	6.9	-2.4	
27-Jan-05	0.0	4.8	7.1	2.4	
1-Feb-05	0.1	3.5	6.6	2.3	
15-Feb-05	0.3	4.1	6.7	2.6	

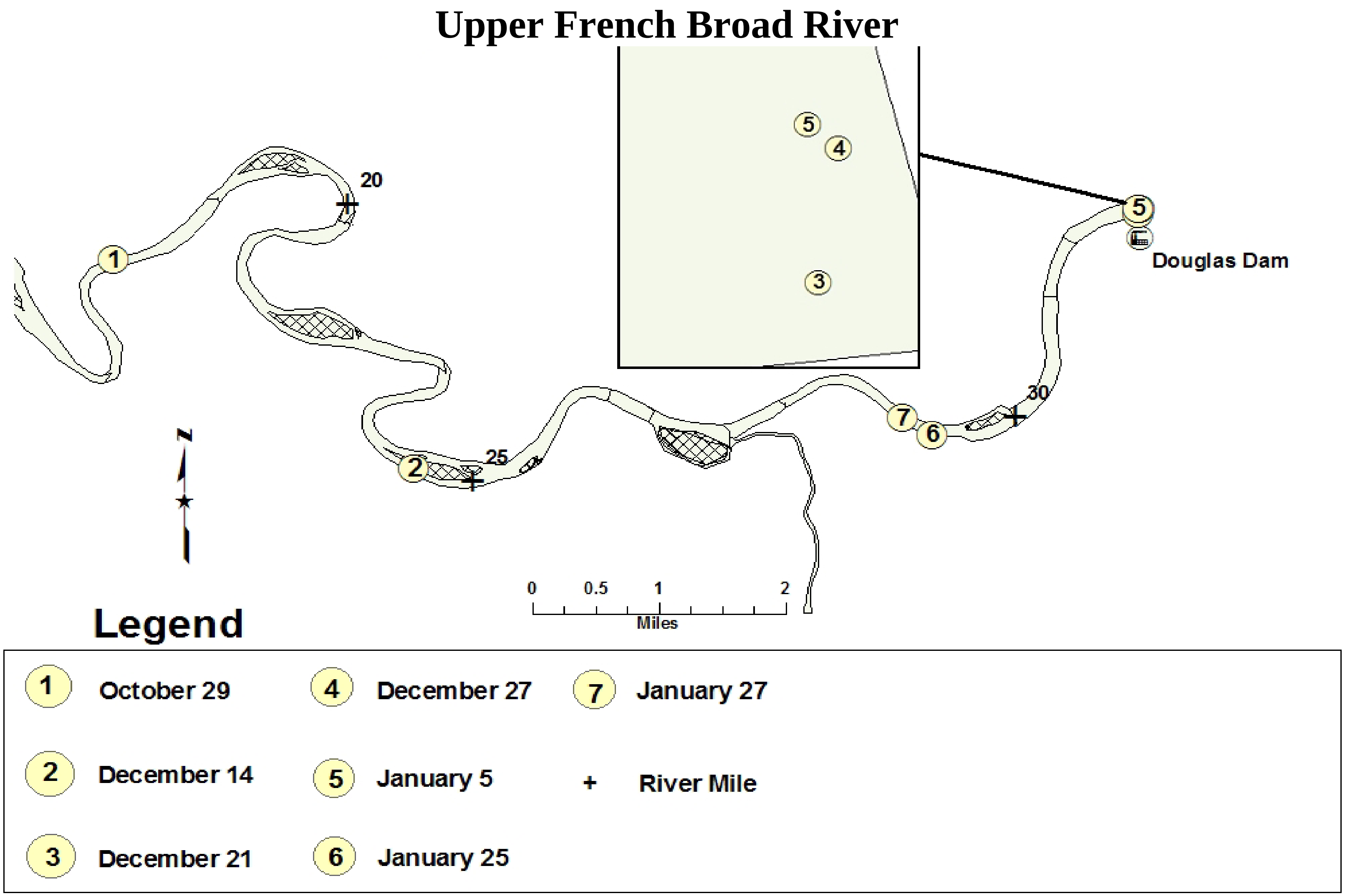


Appendix A.17. Movement of lake sturgeon # 48.371 from 29 October 2004 to 15 March 2005. Circled numbers represent observed locations in chronological order.

Appendix A.17. Summary of data for lake sturgeon # 48.371.

Transmitter Frequency:	48.371	Tracking Duration (dates):	29 October 2004-15 March 2005
Total Length (mm):	520	Tracking Duration:	138 days
Weight (g):	460	Number of Observations:	14
		Total River Miles (RM) Traveled:	27.4

Date	Distance Traveled (RM)	Depth (m)	River Temperature ^{0}C	Location
29-Oct-04	0.0			17.5
8-Nov-04	12.5			5.2
15-Nov-04	2.8			2.3
22-Nov-04	0.9			1.5
26-Nov-04	0.1			1.6
8-Dec-04	3.2			4.5
16-Dec-04	0.1	3.7	12.2	4.7
29-Dec-04	1.3	3.8	6.1	3.3
10-Jan-05	0.3	2.5	7.4	3.5
21-Jan-05	0.3	3.8	6.8	3.3
27-Jan-05	1.9	4.7	7.2	1.7
1-Feb-05	0.6	6.2	6.7	3.8
15-Feb-05	0.6	4.4	6.7	4.4
15-Mar-05	2.8	6.4	9.1	1.8

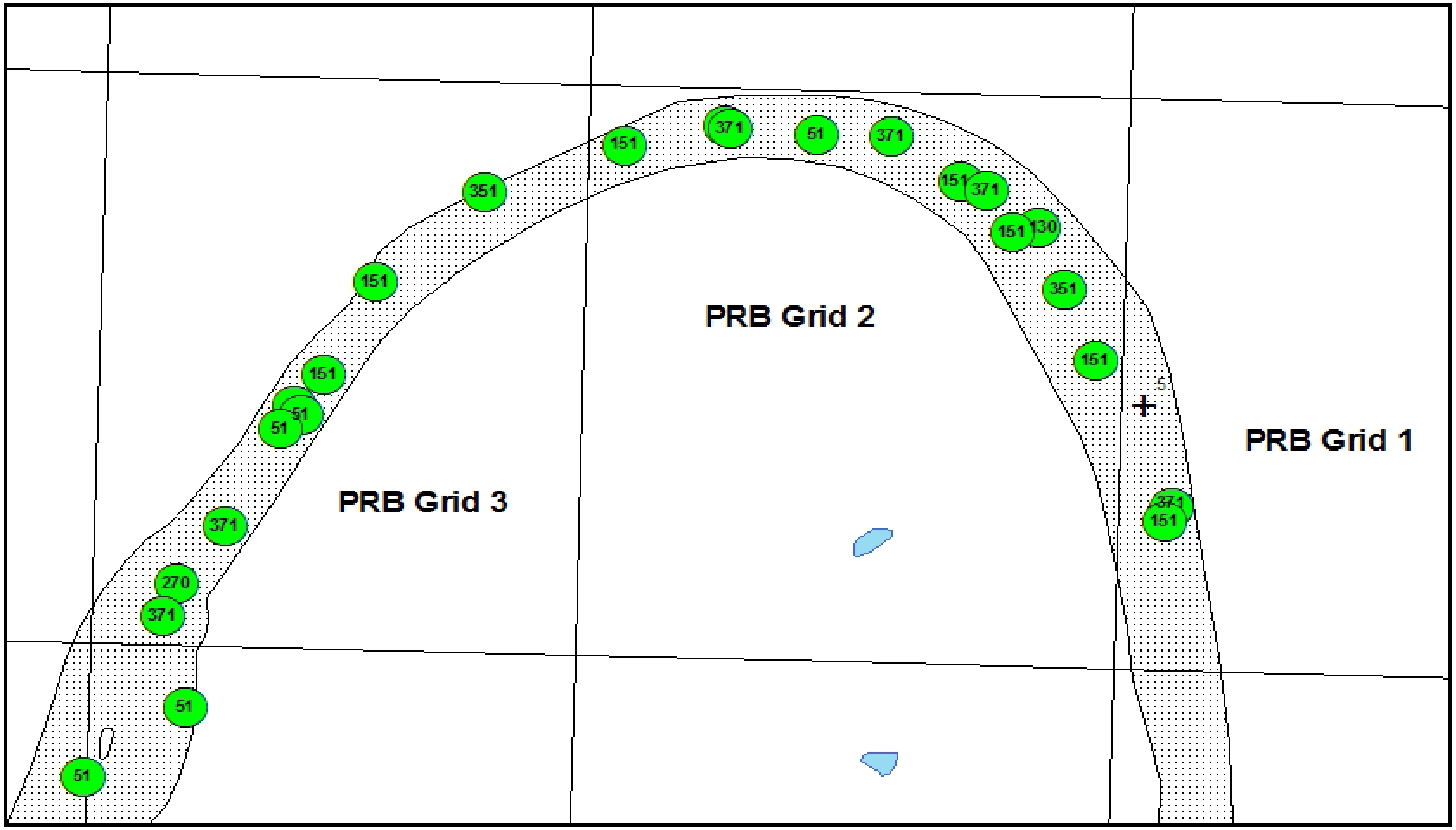


Appendix A.18. Movement of lake sturgeon # 48.391 from 29 October 2004 to 27 January 2005. Circled numbers represent observed locations in chronological order.

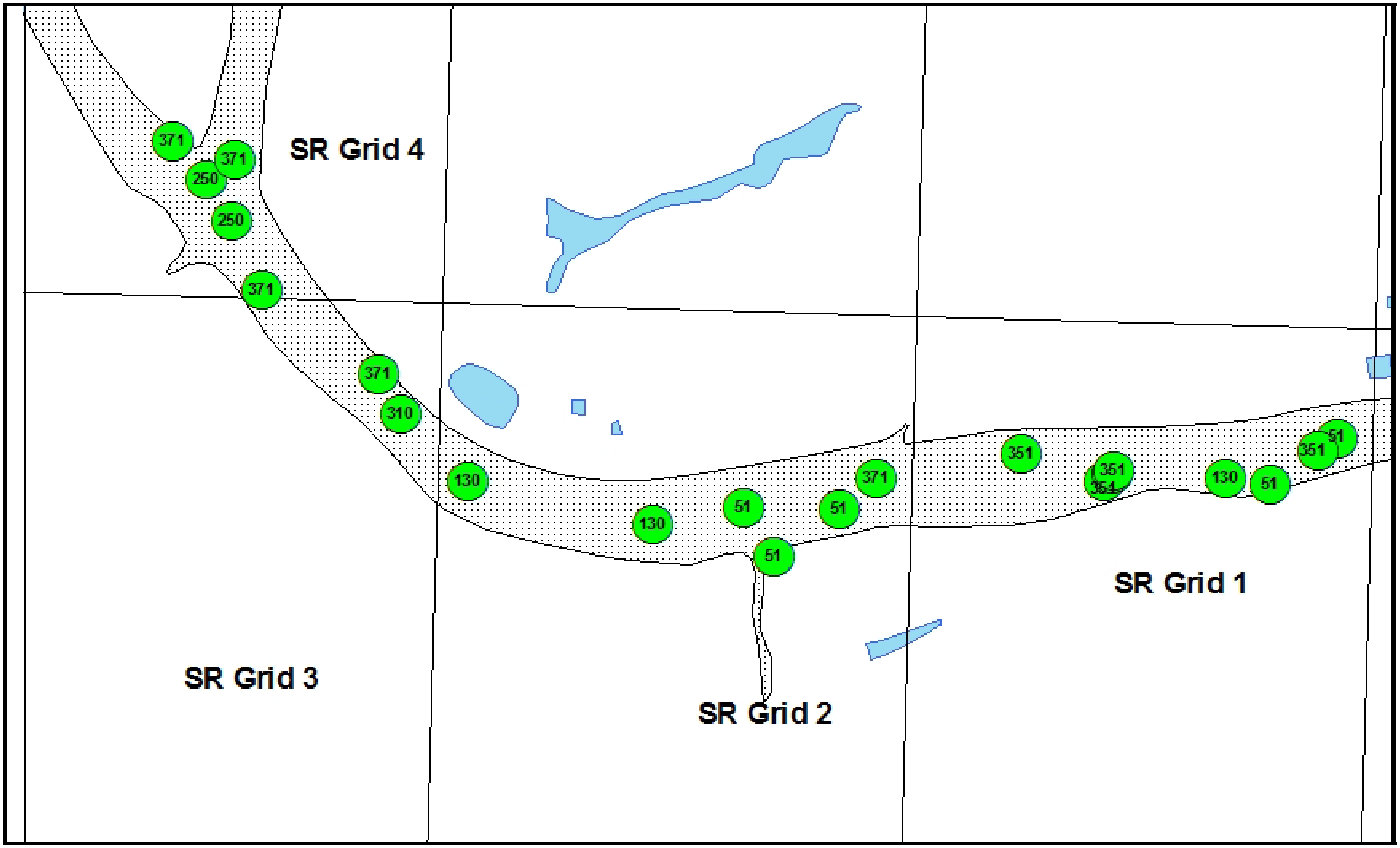
Appendix A.18. Summary of data for lake sturgeon # 48.391.

Transmitter Frequency:	48.391	Tracking Duration (dates):	29 October 2004-27 Jauary 2005
Total Length (mm):	540	Tracking Duration:	91 days
Weight (g):	585	Number of Observations:	7
		Total River Miles (RM) Traveled:	7.8

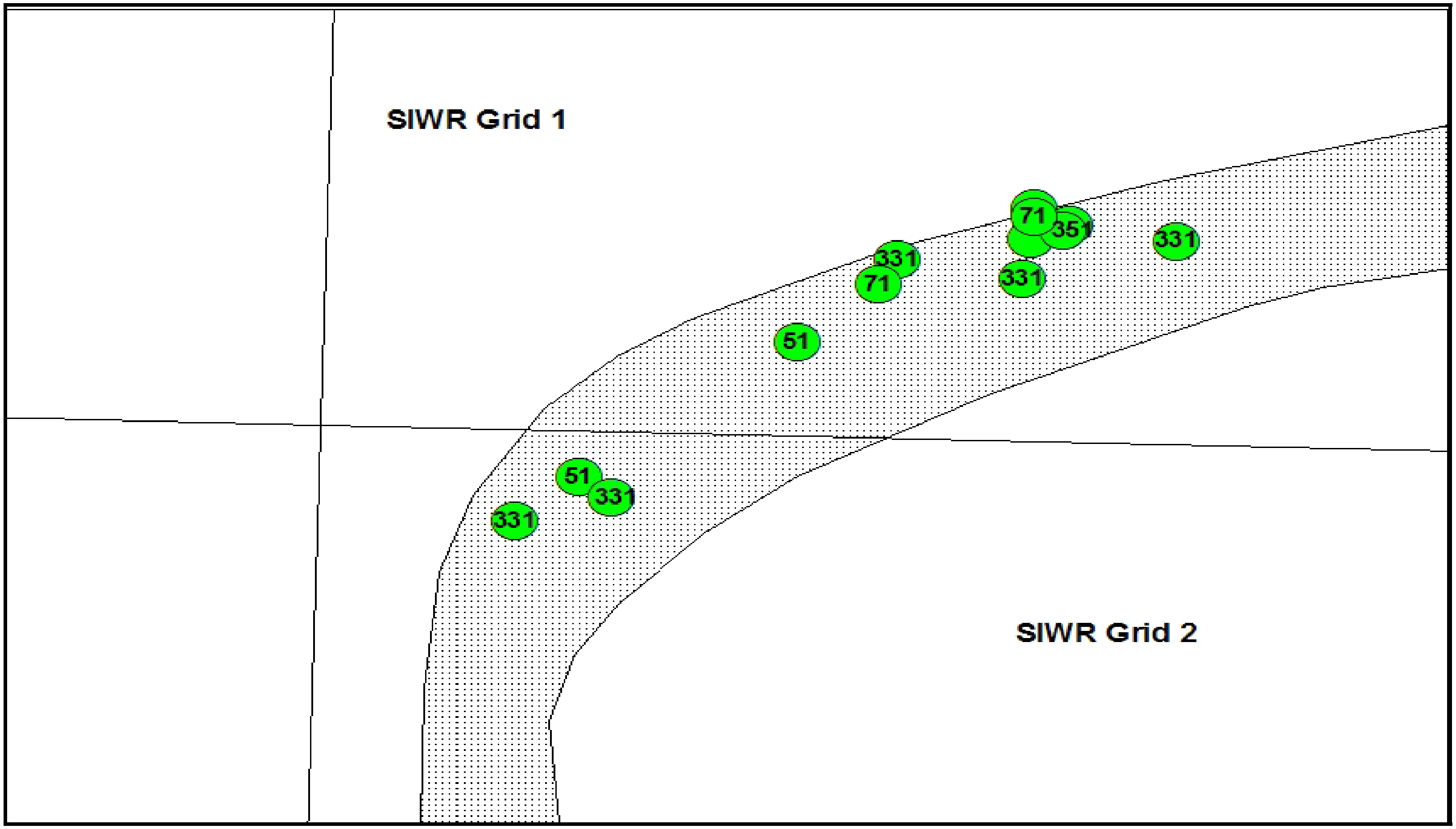
Date	Distance Traveled (RM)	Depth (m)	River Temperature ^0C	Location
29-Oct-04	0.0			17.5
14-Dec-04	6.8			24.6
21-Dec-04	7.8	4.7	8.4	32.0
27-Dec-04	0.0	9.3	6.9	32.0
5-Jan-05	0.0	12.2	4.7	32.0
25-Jan-05	3.0	1.7	7.1	29.3
27-Jan-05	0.3	4.1	6.7	29.0



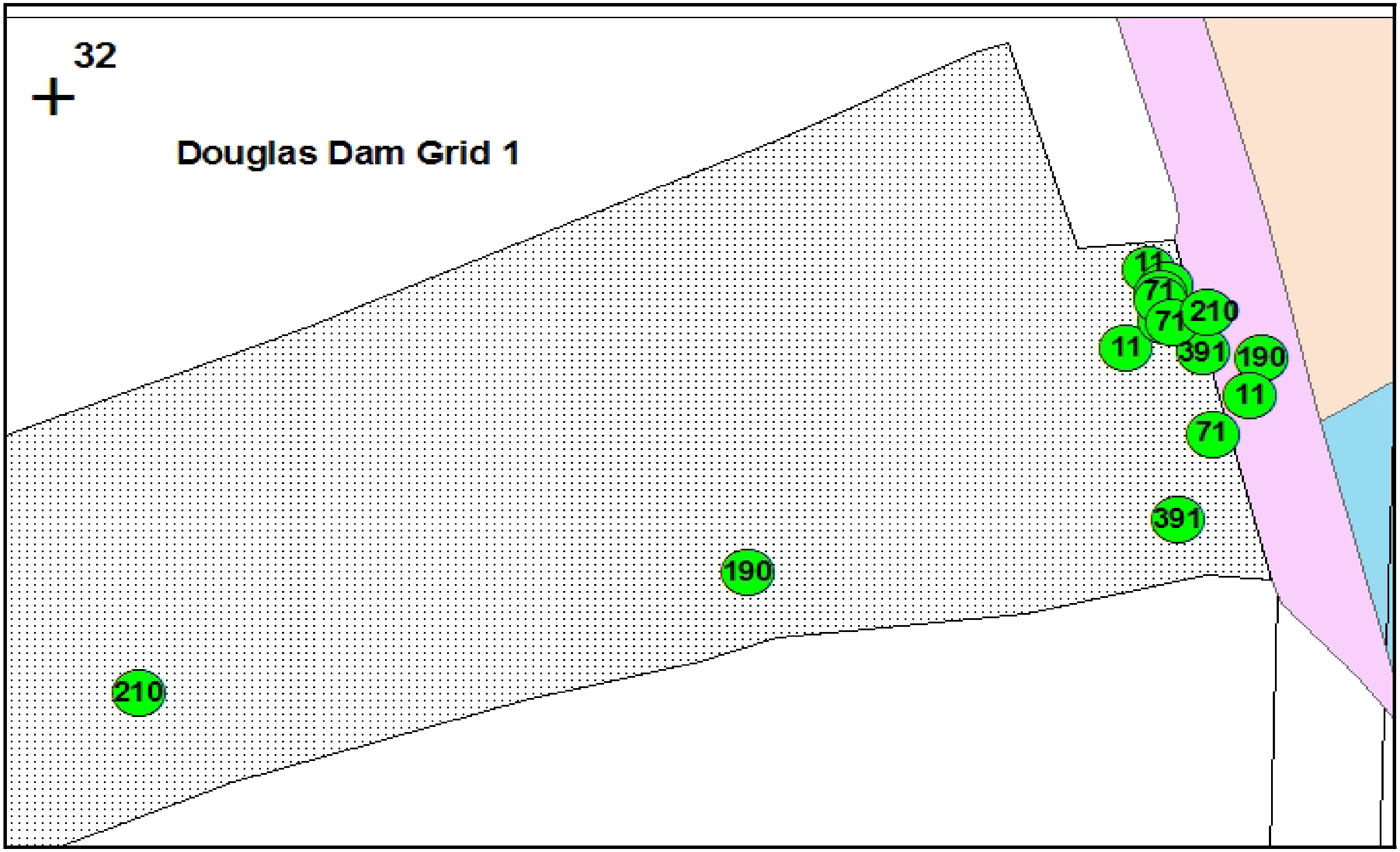
Appendix B.1. Map illustrating grids and areas of core use at Paint Rock Bluff bend (FBRM 2.5-5.5).



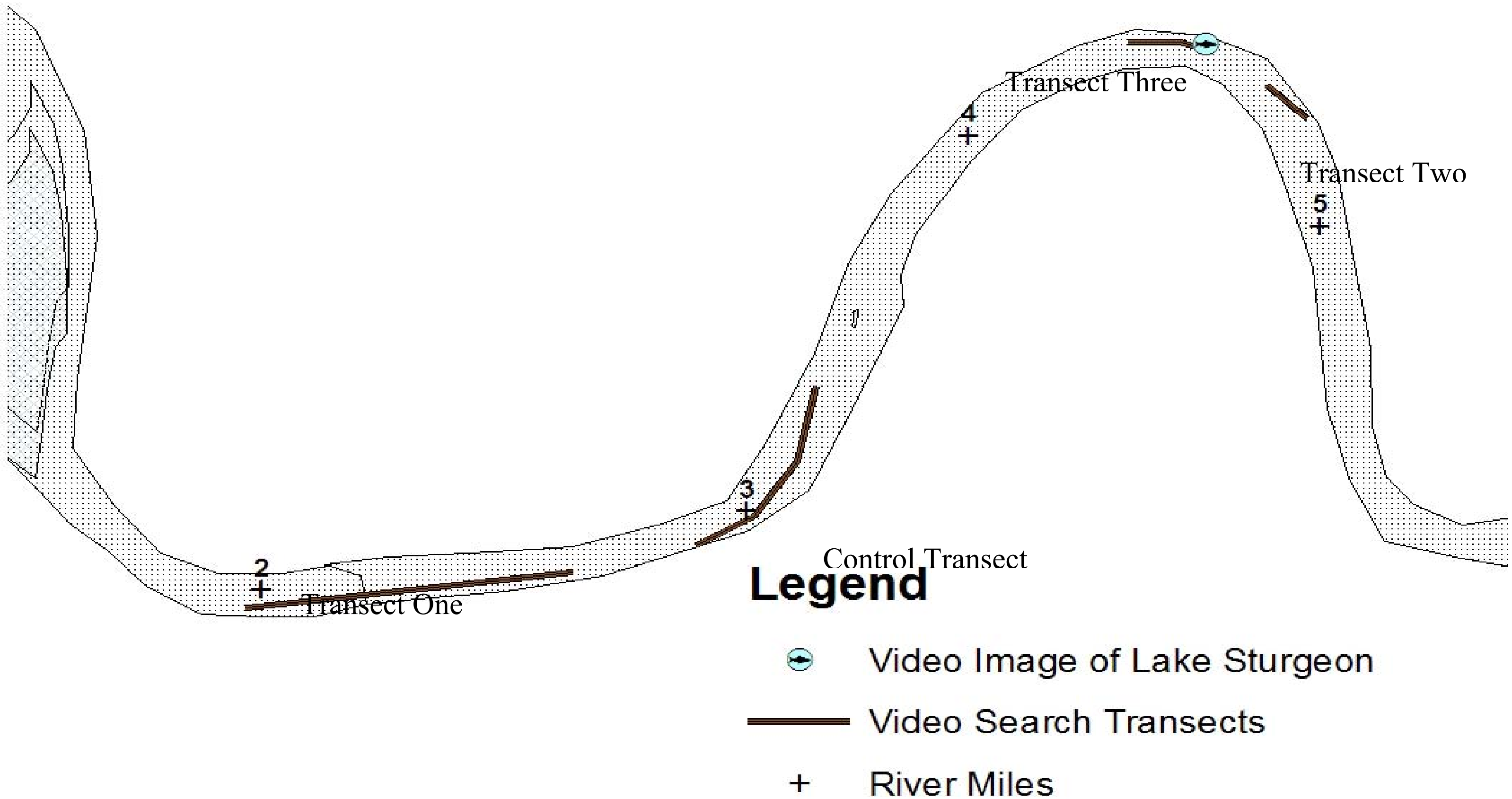
Appendix B.2. Map illustrating grids and areas of core use at Sea Ray bend (FBRM 1.5-3.0).



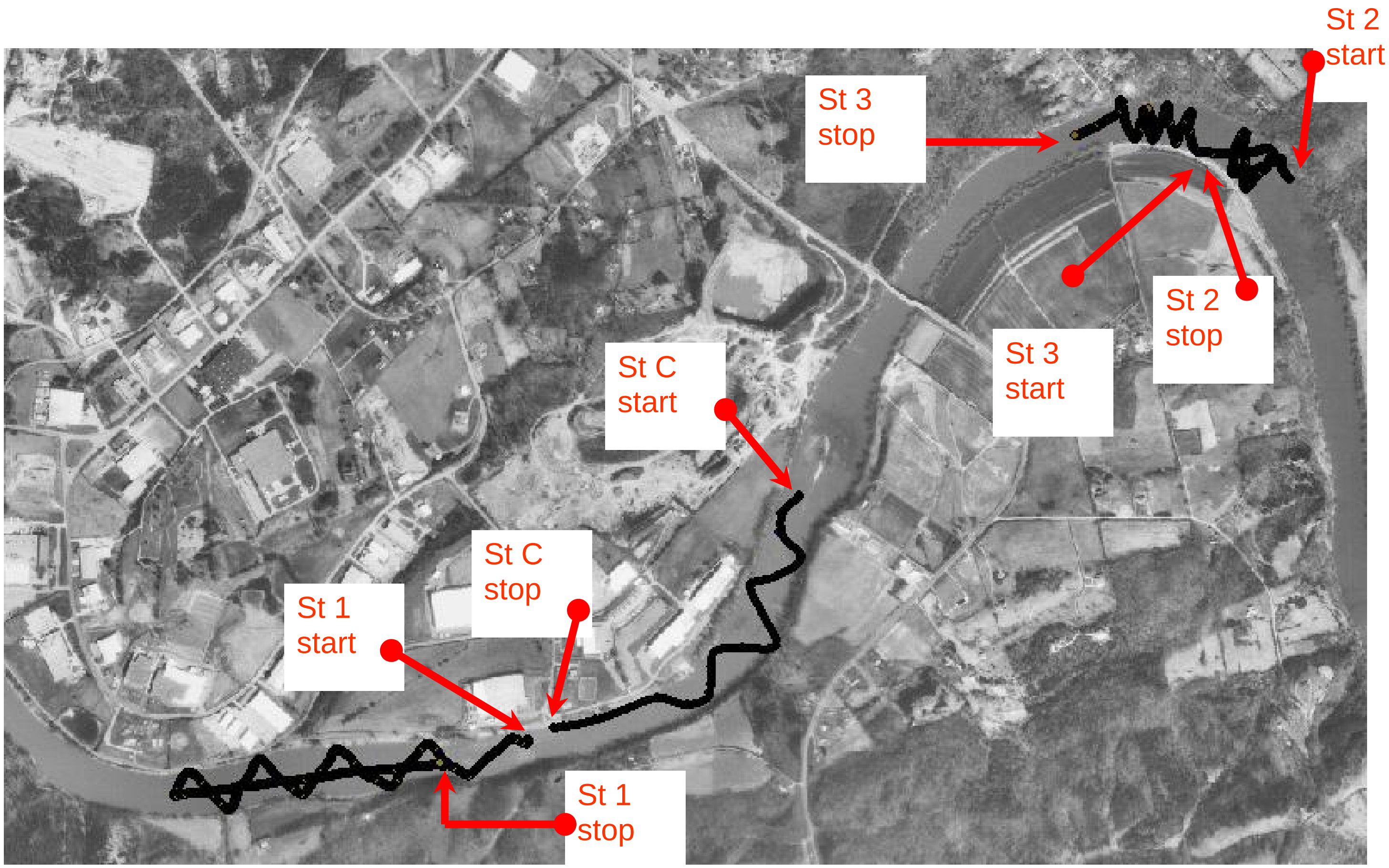
Appendix B.3. Map illustrating grids and areas of core use at Seven Islands Wildlife Refuge (SIWR) (FBRM 17.5).



Appendix B.4. Map illustrating grids and areas of core use at Douglas Dam (FBRM 32.25).



Appendix B.5. Map illustrating transect locations. Fish symbol indicates location of lake sturgeon captured with video footage.



Appendix B.6. Satellite image illustrating search transects and patterns used for video mapping (Swinson et al. 2005).

Appendix B.7. Video image of a juvenile lake sturgeon observed in transect three of the video analysis on the lower French Broad River, 12 August 2005.

Year	Date	Size	Location	Notes
2002	Feb-02	24 inch	Clinch River, Bull Run Steam Plant	
	Feb-02	24 inch	French Broad River	Forks of the River, (lower five river miles)
	Jul-02	24 inch	Holston River	Approximately river mile 17
	Jul-02	18 inch	French Broad River	Near Paint Rock Bluff
2003	8-Jun-03	21-22 inch	Holston River	
	9-Jun-03		Little Pigeon River, West Prong	
	29-Jul-03	22 inch	Holston River below Cherokee Dam	
	31-Jul-03	22-24 inch	French Broad River (approx. River Mile 10)	Johnson Island
	30-Sep-03		Little Pigeon River, West Prong	Caught 15-20 in one day
	3-Dec-03		Douglas Dam	
	8-Dec-03	14 inch	Ft. Loudoun Dam	
2004	9-Jun-04	< 30 inches	Little Pigeon River, West Prong	Several caught
	No Date	24 inch	Fort Loudoun Reservoir	Fisherman reported sighting of dead lake sturgeon
	7-Aug-04	>36 inches	Holston River	Nances Ferry
	13-Aug-04		No location given	
2005	14-Apr-05	20 inch	Fort Loudoun Dam tailwater	TWRA electroshocking
	19-Apr-05	16 inch	Fort Loudoun Dam tailwater	TWRA gillnet
	9-Aug-05	34 inch	Little Pigeon River, Middle Prong	Richardson Cove
	13-Oct-05		French Broad River, Seven Islands	Fisherman report two caught in the summer

Appendix C.1. Tennessee Lake Sturgeon Restoration Program, angler reports for 2003-2005. (Provided by TVA)

Year	Date	Size	Location	Notes
2002	Jun-02	7 inch	French Broad River	TVA backpack shocking
	May-02		French Broad River	Seven Islands area, one small, one large
2003	May-03		French Broad River	Campbell Island, backpack seine sample
	Jun-03	22 inch	French Broad River	Cain Islands, TWRA boat shocking
	Fall	17 inch	Chickamauga Reservoir	
2004	May-04		French broad River, Holston River	Six visually observed, two captured
2005				No sturgeon captured

Appendix C.2. Tennessee Lake Sturgeon Restoration Program, monitoring efforts 2003-2005. (Provided by TVA)

VITA

Misty Dawn Huddleston was born on November 25, 1975, in Lake City, Tennessee. She attended public school in Clinton, Tennessee, and graduated with honors from Clinton High School in 1994. After a brief stint in the U.S. Army, she returned to Knoxville, Tennessee, and enrolled at Pellissippi State Technical Community College. After transferring to the University of Tennessee, she received her Bachelor of Science degree in Wildlife and Fisheries Science from the University of Tennessee in 2004. In May 2006, Misty received her Master of Science degree in Wildlife and Fisheries Sciences from the University of Tennessee, Knoxville.