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Using radio telemetry in sauger spawning studies in Douglas Reservoir, Tennessee

Christopher E. Skelton

To the Graduate Council:

I am submitting herewith a thesis written by Christopher E. Skelton entitled "Using radio telemetry in sauger spawning studies in Douglas Reservoir, Tennessee." 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:

David Etnier, Thomas Hill

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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C. W. Minkel

Associate Vice Chancellor
and Dean of the Graduate School

USING RADIO TELEMETRY IN SAUGER SPAWNING STUDIES IN DOUGLAS RESERVOIR, TENNESSEE

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Christopher E. Skelton

August 1992

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I want to send special thanks to Dr. Harvey Stirewalt. He holds much of the responsibility for my completing this program. His teaching will be missed.

ABSTRACT

Twenty-two sauger were tagged with externally-attached radio transmitters in December 1990 and February 1991 to determine spawning movements in Douglas Reservoir. The tagged fish began a concerted movement toward the headwaters of the reservoir in late February when water temperatures were 8-9 C. By March 30, five tagged male sauger were staging near the confluence of the Nolichucky and French Broad Rivers (FBRM 68.8). These fish moved upstream to an area just below Rankin Bridge (FBRM 71.2) on April 5, where they remained for approximately 10 days. Gill-netting and electro-fishing techniques were used to sample fish in the spawning area from April 5 to April 15. Several sauger and saugeye males in spawning condition and one gravid female sauger were caught, indicating that spawning was taking place. *Stizostedion* spp. eggs were collected from the area using an epibenthic egg sled, a larval drift net, and a larval kick seine. A 10-m wide strip approximately 300-m long stretching between the two Rankin Bridges was the only major spawning site found. The substrate in the spawning area consisted of a mix of cobble, pebble, gravel, coarse sand, and boulder. During the interval of spawning activities, current velocity near the substrate was 18-20 cm/sec and temperatures ranged from 14.0-17.2 C.

Cove rotenone data from the Tennessee Wildlife Resources Agency indicated that the sauger spawn for 1991 was not as successful as the spawn of 1990. In 1990, samples contained 8.1 young-of-year sauger per hectare while only a single young-of-year sauger was collected in 1991.

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CHAPTER 1

Introduction

Over the past decade, several studies on sauger (*Stizostedion canadense*) have been performed in the Tennessee River system. These studies were brought about as a result of decreasing sauger populations in several Tennessee Valley Authority (TVA) reservoirs. Watts Bar, Chickamauga, and Douglas reservoirs have all received some attention as a result of sauger declines. Research projects conducted on these reservoirs, and in some cases their tailwaters, have often employed radio telemetry as the method for tracking sauger movements and discovering spawning grounds.

Biotelemetry studies of aquatic animals began in the late 1950's (Trefethen 1956; Trefethen et al. 1957; Johnson 1960) with the advent of ultrasonic transmitters. Radio transmitters were first attached to freshwater fish in 1969 (Winter et al. 1973) and have since become a very popular method for monitoring fish movements. Sauger movements and spawning have been investigated with the use of radio telemetry in the Clinch River (Saylor et al. 1983), the Douglas Reservoir tailwater (Woodward et al. 1988), Chickamauga Reservoir (Hevel 1988; Hickman et al. 1989), and the Fort Loudoun tailwater (Medlin 1990; St. John 1990).

The sauger is a member of the perch family (Percidae) and is closely related to the walleye (*S. v. vitreum*). Percids are temperate mesotherms, preferring temperatures from 20-28 C. Gonadal development occurs during the fall and winter while temperatures are below 12 C. Spawning is initiated in the spring with gradually while temperatures are below 12 C. Spawning is initiated in the spring with gradually rising temperatures (Hokanson 1977).

Sauger are usually dispersed throughout Tennessee reservoirs during the summer and fall of the year (Hackney and Holbrook 1978). In late winter, however, they begin an upstream migration into riverine sections of reservoirs (Hevel 1988). The fish eventually reach the next upstream dam and are forced to spawn in the tailwater area (Saylor et al. 1983). After spawning is complete, the spent fish move back into the main body of the reservoir. In Tennessee, this upstream migration usually begins in late February, and spawning occurs from mid-March through mid-April (Hevel 1988; St. John 1990). Findings by Cobb (1960) in Pickwick Reservoir and Nelson (1968a and 1969) in Lewis and Clark Lake, SD, showed similar movement patterns.

Nelson (1968a), Hevel (1988), and Medlin (1990) found that sexually mature males reach the spawning area around mid-March and remain there approximately four weeks. Females do not arrive until they are ready to spawn. They stay at the spawning ground 1-2 days and then move back to the reservoir (Nelson 1968a; Scott and Crossman 1973). Sauger are simple spawners and do not build a nest or protect their young. Eggs are broadcast by females, fertilized by males as they fall to the bottom, and then abandoned (Collette et al. 1977). After sauger eggs are fertilized they become very adhesive. Priegel (1969) found that sauger eggs are adhesive only before water hardening. Nelson (1968a), Saylor et al. (1983), and Medlin (1990) found that sauger eggs continued to be adhesive after water hardening.

In areas where both sauger and walleye occur, it is possible for their spawning seasons to overlap. According to Collette et al. (1977), walleye spawn at 5.6-11.1 C, and sauger immediately after this. Sauger males are reported to become sexually ripe when water temperature reaches 11 C (Hickman et al. 1989). Because of their close phylogenetic relationship, and similar spawning habits, crosses of sauger and walleye (saugeye) are possible. Factors contributing to this hybridization might include limited spawning habitat or a low population of either of the two species (Hubbs 1955). Nelson and Walburg (1977) found that 10% of sauger and walleye caught in Lewis and Clark Lake resembled hybrids. Medlin (1990) found one *Stizostedion* in the Fort Loudoun tailwater that appeared to be a hybrid.

Tennessee sauger are reported to reach maturity at 2-3 years with males maturing slightly earlier than females (Hassler 1958). Hackney and Holbrook (1978) found that few southeastern sauger live past the age of three. Priegel (1969), working in Lake Winnebago, WI, found that most mortality occurred after age 4. Because sauger have such a short life, strong year classes are required to maintain a fishery.

Impoundments along the Missouri River showed increases in sauger populations after the first few years of their existence. Six to ten years after their completion, however, numbers of fish began to decline (Nelson and Walburg 1977). These decreases were characteristic of the decline noticed after the "boom" years of a new reservoir (Fitz and Holbrook 1978).

Douglas Reservoir had a popular sauger fishery in the 1950's and early 1960's. Fishermen would take advantage of the spring spawning run and catch many fish in the Douglas Reservoir headwater and dam tailwater. Sauger could also be caught in the reservoir during the summer months. Over the past twenty years, however, the population has declined (Hevel et al. 1985). TVA cove rotenone surveys indicated the population dropping steadily in the late 1960's and early 1970's until there were no young-of-year (y-o-y) sauger caught in the survey in 1983 (Schacher 1988). In an effort to boost the population, the Tennessee Wildlife Resources Agency (TWRA) stocked sauger fingerlings into Douglas in 1986 and 1987 (Schacher 1988). Approximately 275,000 sauger were stocked during these years. This stocking apparently provided a temporary solution to the declining sauger population. Cove rotenone data provided by TWRA indicated 8.1 y-o-y sauger per hectare in 1990, thus providing evidence that some spawning had occurred. The data from 1991, however, showed only 1 y-o-y sauger per hectare.

A study funded by TWRA was initiated in 1990 to collect data on Douglas Reservoir sauger. The project utilized radio telemetry to investigate movements and spawning. The objectives of the study were to:

1. locate and characterize critical pre-spawning staging areas and associated spawning habitats of sauger
2. evaluate spawning success
3. monitor seasonal movements of sauger using radio telemetry
4. perform an age and growth analysis of the reservoir population

The study was divided into two parts; this thesis primarily focuses on objectives 1 and 2.

CHAPTER 2

Description of the Study Area

Douglas Reservoir is located about 40 km east of Knoxville, Tennessee, and is situated between the cities of Newport, Dandridge, and Sevierville (Figure 1). The reservoir was formed in 1943 with the completion of Douglas Dam at French Broad River Mile (FBRM) 32.3. Douglas Reservoir extends 69 river kilometers upstream to the confluence of the Pigeon and French Broad Rivers.

Douglas Reservoir, a TVA storage reservoir, contains 12,300 surface hectares and drains a watershed of 1,427,383 hectares. The maximum height of Douglas Dam is 61.4 m, with a maximum pool elevation of 304 m msl and minimum pool of 285.76 m above sea level (Schacher 1988). Annual average retention time in the reservoir is 42 days (TVA 1985).

The two major tributaries of Douglas Reservoir are the Nolichucky River and the French Broad River (FBR). The FBR is formed by the confluence of the North, West, Middle, and East Forks of the river near Rosman, NC. The river enters Tennessee at the Cocke County line and flows north by northwest into Douglas Reservoir. The French Broad River averages approximately 16-m wide at the headwaters, while lower sections of the river average about 106-m wide. Concern over industrial and domestic pollution, siltation, and turbidity of the main FBR was expressed as early as 1965 (TVA 1965). Soil erosion and runoff due to tributary

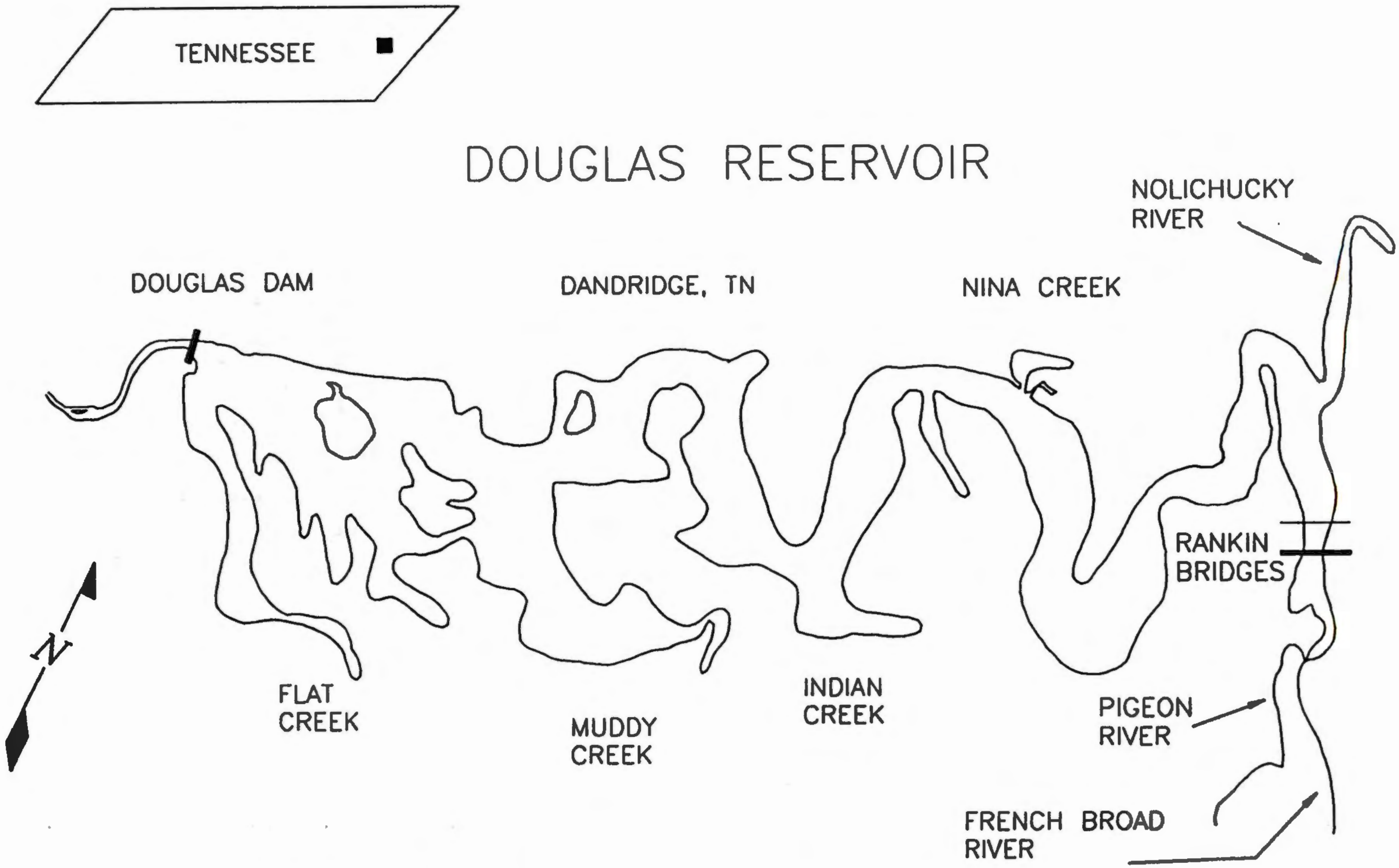

Figure 1. Map of Douglas Reservoir Study Area Indicating Major Embayments and Major Tributaries.

channelization have transformed much of the FBR into a big river habitat (Harned 1979). The Index of Biotic Integrity (IBI) (Karr et al. 1986) score for the FBR was 34 in 1991. This number falls within Karr's (1986) "poor" integrity class. The sampling took place at FBRM 78 (C. Saylor, TVA, pers. comm.).

The Nolichucky River originates in North Carolina and enters Tennessee at the Unicoi County line. From its origin at the confluence of the Cane and North Toe Rivers in western North Carolina, the Nolichucky flows 178 km to its confluence with the French Broad River at FBRM 68.8 (Schacher 1991).

Extensive erosion associated with abandoned mine sites in the North Carolina sections of Nolichucky River has severely degraded its overall water quality. The Tennessee portion of the watershed suffers from non-point pollution sources associated with agriculture. Although the Nolichucky River has problems, its 1991 IBI score was 46 (C. Saylor, pers. comm.), which is within Karr's (1986) "fair +" integrity class.

The Pigeon River is a tributary to the FBR at the upper reaches of Douglas Reservoir. This river has long been the subject of controversy surrounding the operation of the Champion Paper Mill in Canton, NC. Pollutants present in the Champion effluent include dissolved solids, suspended solids, chemical toxicants, tannin compounds, high organic enrichment, and high biochemical oxygen demand. Some effects of these pollutants are clogged substrate, darkened water which reduces available light, decreased dissolved oxygen, and stimulated growth of undesirable slime organisms (Schacher 1991). The 1991 IBI score for the Pigeon River falls within Karr's (1986) "poor" integrity class (C. Saylor, pers. comm.). The numerical score for the Pigeon River was 38 which is slightly higher than the score of 34 for the FBR.

CHAPTER 3

Methods

Netting and Tagging

Gill-netting for sauger was performed in two phases during the winter of 1990 and 1991. The objective of the first phase of netting was to tag fish so that their winter movements could be monitored. In order for the radio transmitter life to extend through the sauger spawning season, the second phase of tagging was performed in February. This tagging strategy allowed the sauger to be tracked to possible spawning areas in Douglas Reservoir. A third tagging phase was performed in June and July of 1991 so that summer movements could be monitored (Stodola 1992).

The first phase of netting lasted from November 24 to December 29, 1991, with radio tagging of 8 sauger being the objective. Several netting sites were used (Stodola 1992) but all sauger were caught at FBRM 34.5, just opposite Cowboy's Restaurant. The second phase of netting lasted from January 30 until February 13, 1991. Thirteen sauger were fitted with radio transmitters during this period. Three of these fish came from FBRM 34.5, while the remaining 10 were caught between FBRM 55 and FBRM 56 near Nina Creek. One additional sauger was tagged on March 4, 1991, at FBRM 34.5 (Table 1).

Several different net sizes were used. Four nets were of standard design. Two

Table 1. Summary of Radiotelemetry Data and Physical Characteristics of 22 Sauger in Douglas Reservoir, 1990 and 1991.

Tagging Date	Capture Site (FBRM)	Transmitter Frequency	Weight (g)	Length (mm)	Sex
12-16-90	34.5	48.700	1270	480	-
12-16-90	34.5	48.660	1130	460	-
12-16-90	34.5	48.830	1070	480	-
12-19-90	34.5	48.640	1290	500	-
12-19-90	34.5	48.720	1089	460	-
12-19-90	34.5	48.910	1018	480	-
12-29-90	34.5	48.950	998	460	-
12-29-90	34.5	48.960	1759	535	-
1-30-91	34.5	49.150	1120	480	-
2-1-91	56	48.930	1043	430	m
2-1-91	56	48.950	821	420	f
2-1-91	55	48.990	838	420	m
2-1-91	55	49.250	1357	490	f
2-1-91	55	49.200	1023	450	f
2-1-91	55	48.860	874	420	m
2-1-91	55	48.970	1169	470	f
2-4-91	34.5	48.840	998	440	m
2-4-91	34.5	48.820	1158	465	f
2-13-91	56	48.790	860	440	m
2-13-91	56	48.880	1260	480	f
2-13-91	56	48.810	1240	470	f
3-4-91	34.5	48.890	770	420	m

of these were provided by TWRA and had measurements of 80.6 m x 6 m x 76.2-mm bar mesh. The other two standard nets were provided by TVA and had measurements of 61 m x 2.4 m x 50.8-mm bar mesh. TVA also provided four experimental nets. Two were 30.4 m x 2.43 m, with five 6-m panels with mesh sizes of 76.2, 63.5, 50.8, 38.1, and 25.4 mm. Two others were 30.4 m x 2.43 m, with five 6-m panels with mesh sizes of 63.5, 50.8, 38.1, 25.4, and 19 mm. The TWRA nets were made of nylon monofilament and had exposed floats and weights on the float line and lead line, respectively. The TVA nets were made of monofilament and had core float lines and lead lines. All nets were held in place by weights at either end and marked with a float on at least one end.

Because sauger are more active at night (Cobb 1960; Kitchell et al. 1977), the gill-nets were set at about one-half hour before sunset and fished until approximately 2200 hours. The nets were typically set perpendicular to the shore with one end placed close to the bank. Nets were checked after 1-2 hours. The data recorded from captured sauger and saugeye consisted of weight (g), total length (mm), and general condition. An attempt was made to determine the sex of the fish caught during February netting. Slight pressure was placed along the belly of the sauger to try to exude eggs or milt. Another method used to sex fish was cannulation. A glass catheter with 2-mm diameter was inserted into the urogenital opening, thereby collecting eggs or milt. Other pertinent information recorded at netting times was water temperature (C), location, and depth.

The radio transmitters used in the study had an average weight of 15.35 g.

Each transmitter had a unique frequency between 48 and 50 megahertz. The transmitters were powered by lithium batteries and had a life expectancy of 4 months. According to Winter (1983), transmitters should not weigh over 2% of the fishes body weight. Therefore, only fish weighing over 770 g were used in the study. Captured sauger that appeared to be in good condition and weighed enough were tagged with radio transmitters following the methods in Winter (1983). The tagged fish were released at the capture site after an observation period of five minutes. A Challenger Model R2000 programmable scanning receiver fitted with a loop antenna was used to verify the existence of the transmitter signal at the time of tagging and on all tracking days. The transmitters and receiving equipment were purchased from Advanced Telemetry Systems, Isanti, MN.

Location of Staging and Spawning Areas

Radio Telemetry

Tracking of tagged sauger was performed approximately once a week by boat and twice a month by airplane from the end of December 1990 until August 1991. Boat tracking was usually in conjunction with netting days and generally lasted 2-4 hours. About one-half of the reservoir was covered during each tracking period. Tracking by airplane allowed coverage of the entire reservoir in less than two hours. All viable frequencies were programmed into the receiver and then removed as individuals were located. Fish locations were recorded as accurately as possible on a topographic map. During boat tracking, triangulation was used to obtain location information. When the fish were monitored from the airplane, the pilot circled until accurate location information could be determined.

Netting

The gill-nets described earlier were used in areas of sauger concentration (FBRM 68, 71, and 71.3) on March 26, and April 10 and 11, respectively. The nets were set parallel to the bank because of heavy flow. Captured sauger and saugeye were weighed (g) and total lengths (mm) were recorded. Since this netting occurred during the sauger spawning season, the sex of the fish was easily determined by putting light pressure on the belly of the fish, thereby exuding either eggs or milt. Scale samples were taken from sauger and saugeye for later use in age and growth analysis.

Electro-fishing

Electro-fishing from a boat fitted with two booms and a 230-V high cycle AC generator was used as an alternative to gill netting for fish collection. Electro-fishing was performed near the mouth of the Nolichucky River (FBRM 68.8) on April 4 and 5 and between FBRM 71 and 71.3 on April 5, 13, 15, 18 and 26. The boat was driven to the top of the transect to be sampled and the motor was put into neutral. The generator was then started and the area was shocked as the water flow pushed the boat backwards downstream. Stunned sauger and saugeye were scooped up with a dip net and placed in a cooler of water. After the transect was complete, total lengths (mm), weight (g), and sex were recorded.

Egg and larval fish collection

Fish eggs and larvae were sampled from March 31 to April 25 using a benthic egg sled (Figure 2), a larval drift net, and a larval kick seine. The benthic egg sled was provided by TVA and used as described by Saylor et al. (1983) and Medlin (1990) (Figure 3). The larval drift net (Figure 4), also provided by TVA, consisted of a metal frame fitted with a tapered 0.5-m plankton net with a removable collection cup at the end. This device was lowered to the bottom by the float line and allowed to remain stationary for approximately 10 minutes. After retrieval of the net, the sample was washed into the collection cup and then placed in a jar with 10% formalin. The larval seine was 81 x 91 cm with 0.5-m mesh and a removable collection cup attached in the middle. Two people were required to hold the net while a third person disturbed the substrate in front of the net. The sample was washed into the collection cup and then placed in a jar with 10% formalin for later analysis. Sauger eggs and larval fish were identified using a stereomicroscope. Because of the difficult nature of fish egg identification, some of the eggs could not be positively identified as sauger eggs. Questionable eggs were called probable sauger eggs (B. Wallus, TVA, pers. comm.).

Spawning Site Characterization

Substrate Analysis

Ten transects equally dividing the area between the two Rankin Bridges (FBRM 71.2-71.4) were surveyed using a transit and stadia rod. Visual assessment of the substrate was noted and points were marked at areas of transition. In the strip

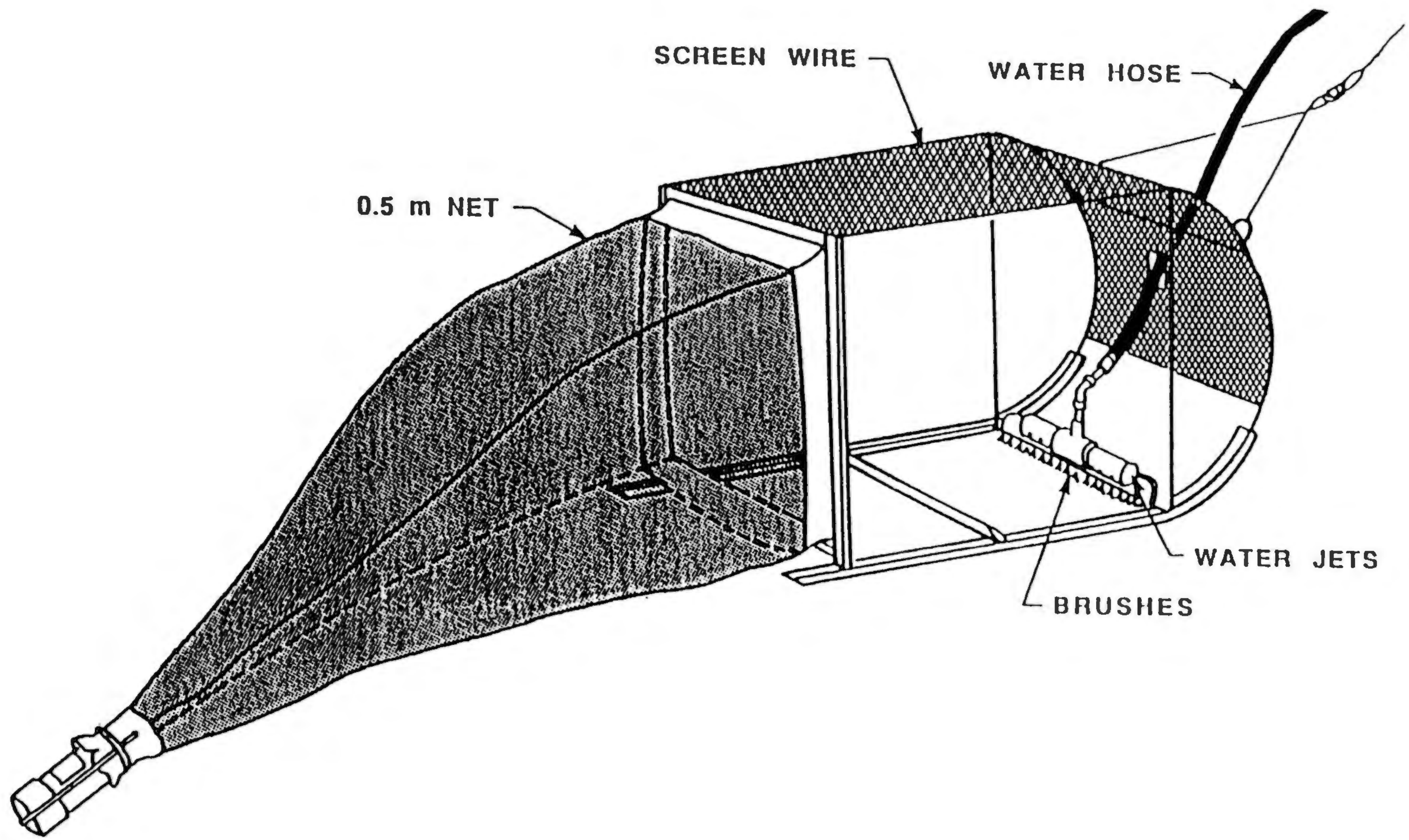

Figure 2. Epibenthic Egg Sampling Sled Used to Collect Sauger Eggs in the Douglas Reservoir Headwaters, 1991. (Source: Medlin 1990).

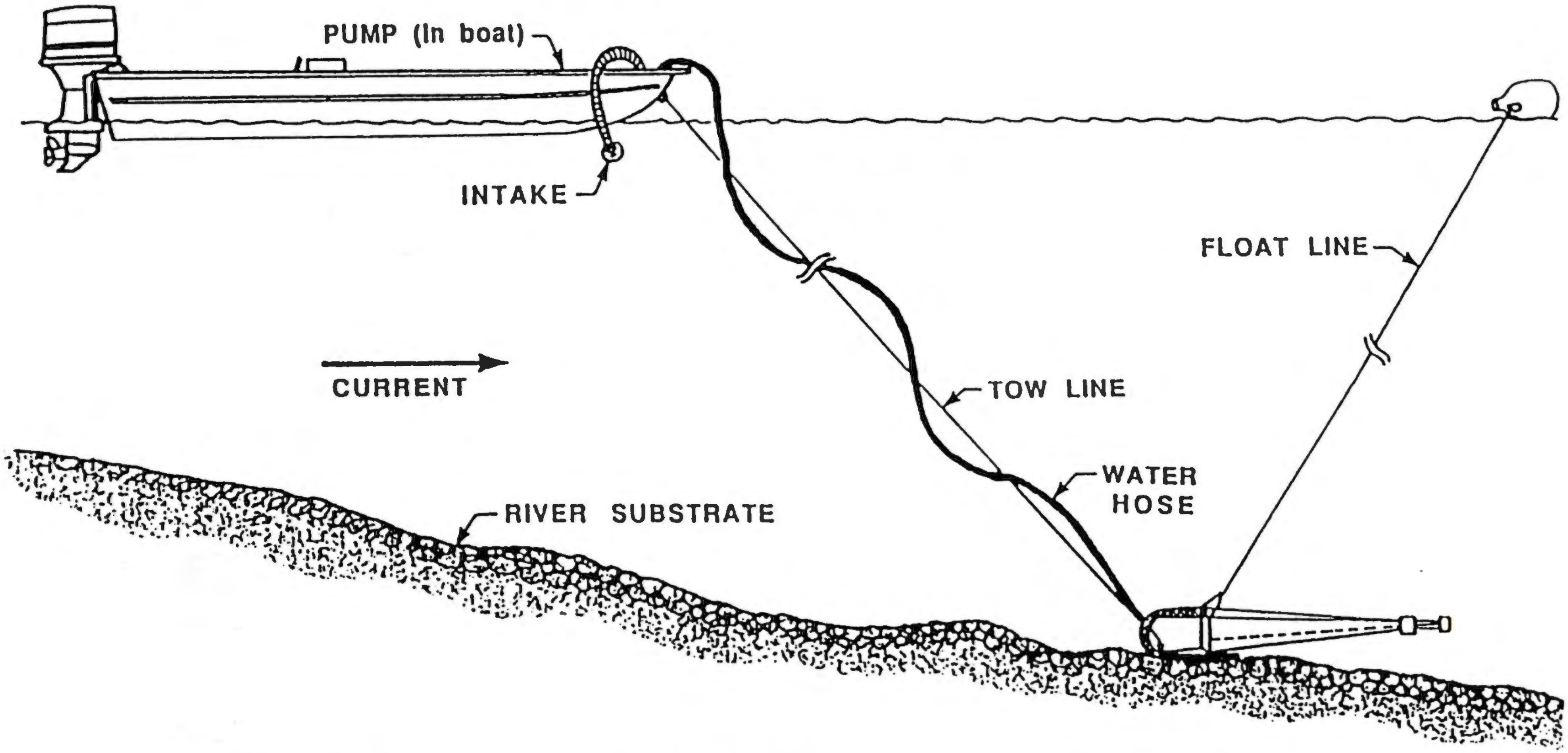

Figure 3. Schematic Drawing of the Epibenthic Egg Sampling Sled Illustrating Towing Procedure. (Source: Medlin 1990).

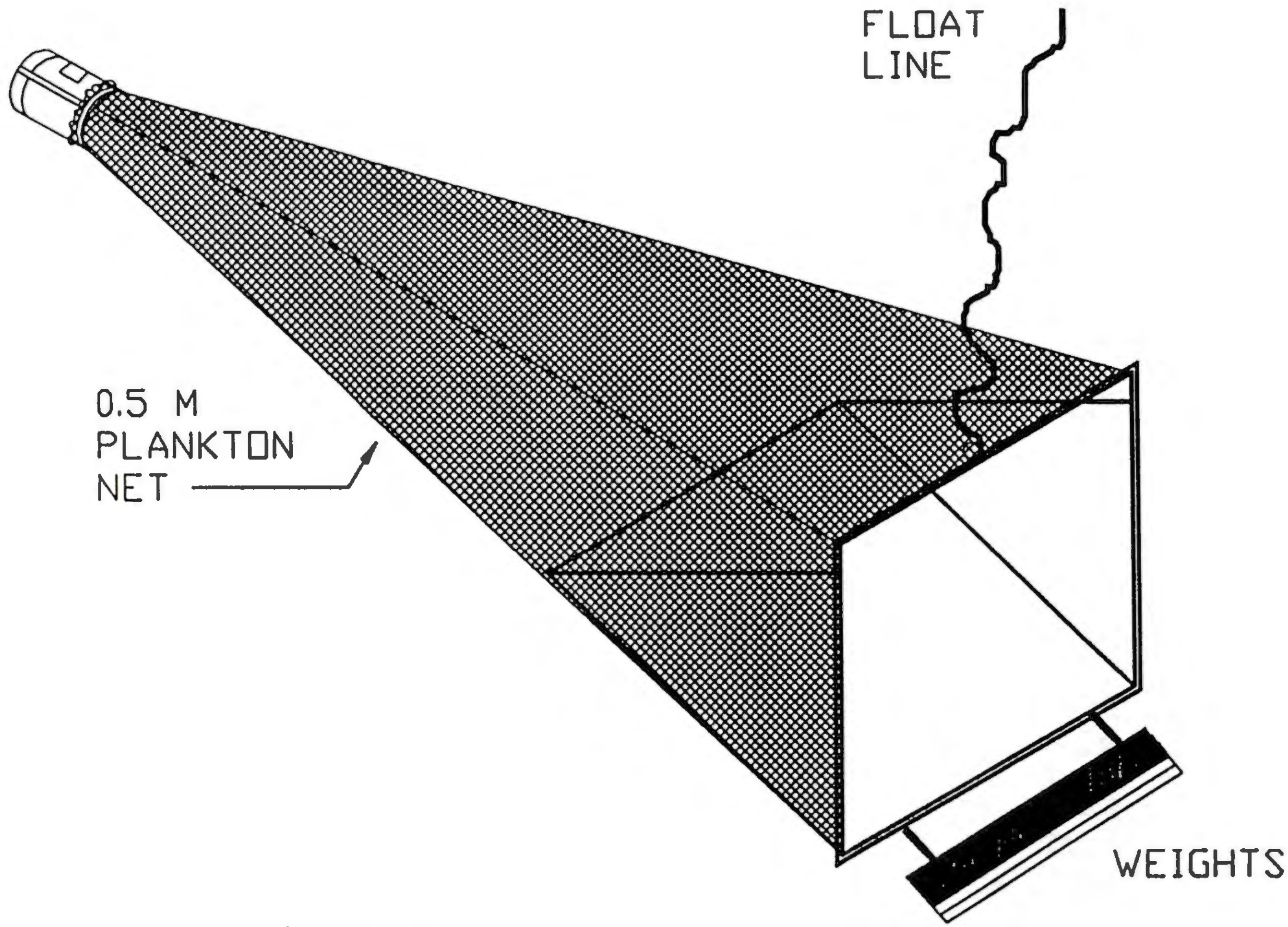

Figure 4. Larval Drift Net Used to Collect Sauger Eggs in the Douglas Reservoir Headwaters, 1991.

where spawning occurred, 1.0 m^2 form made of 2.5-cm PVC pipe was placed in ten randomly picked locations. All of the surface substrate was put into a bucket and then carried to the bank for measurement (Table 2). The percent of dominant particles was estimated at this time. In other areas between the Rankin Bridges the dominant size was mentioned first. Five transects were attempted below the old Rankin Bridge. Strong flow prevented any complete transects in this area, but particle sizes of areas surveyed were estimated.

Physical Parameters

Temperatures were recorded on all sampling nights during initial fish collection, tracking days, and spawning area studies. Temperatures were measured with Yellow Springs Instruments Models meters, 51B and 58.

Current measurements were recorded in the spawning area on two occasions using a large-vaned General Oceanics flow meter. The meter was attached to the larval drift net. Current was also recorded at FBRM 68.8 on two nights.

Water depth was measured with an Eagle Mach I depth finder. Water depths were recorded at netting sites, electrofishing sites, and egg collection areas.

Table 2. Modified Wentworth Substrate Particle Size Classification (Cummins 1962)

Classification	Particle Size Range (mm)
Boulder	> 256
Cobble (Rubble)	64 - 256
Pebble	32 - 64
Gravel	16 - 32
	8 - 16
	4 - 8
	2 - 4
Very Coarse Sand	1 - 2
Coarse Sand	0.5 - 1
Medium Sand	0.25 - 0.5
Fine Sand	0.125 - 0.25
Very Fine Sand	0.0625 - 0.125
Silt	0.0039 - 0.0625
Clay	< 0.0039

CHAPTER 4

Results and Discussion

Netting and Tagging

Netting at FBRM 34.5 during December 1990 yielded 10 sauger and 3 saugeye. *Stizostedion* sp. were caught primarily between 1800 and 2000 hours. All of the fish were caught in the lower part of the net, substantiating the findings of Nelson (1968a and 1969), Priegel (1969), and Medlin (1990). A knife was used to cut entangled netting so that the sauger could be placed in a cooler of water as quickly as possible. Sauger were tagged using the procedure described by Winter (1983). The fish were calm and did not have to be anesthetized. Transmitter attachment, weighing, and measuring took approximately 5 minutes. All but one fish left the tagging area after transmitter attachment. That fish was presumed to have died.

The second phase of netting was much more successful than the first phase. Gill-netting at FBRM 56, near the mouth of Nina Creek, revealed a much higher concentration of sauger than was present at FBRM 34.5. In five nights of netting, 40 sauger were caught. Ten sauger captured there were fitted with radio transmitters. The remaining 4 transmitters were attached to sauger captured at FBRM 34.5.

The presence of saugeye was discovered during the second phase of netting. On February 13, 1991, Wayne Schacher, a biologist for TWRA, noticed a

Stizostedion sp. that looked unusual. The fish was tentatively identified as a saugeye. The fish was taken to Eagle Bend fish hatchery and the saugeye identification was corroborated by hatchery Manager Mike Smith (TWRA, pers. comm.). Other specimens were identified by Dr. David Etnier (pers. comm.) at the University of Tennessee. When it became evident that saugeye might have been present throughout the netting periods, preserved specimens from December captures were reviewed. Three fish that had initially been called sauger were identified as saugeye. It seemed likely that a transmitter may have been put on a saugeye during tagging in December and February. After February 13, differentiation was made between saugeye and sauger.

Positive sexual identification was made on 5 male sauger and 1 female sauger during the February netting. Milt was exuded from the males after applying pressure to the abdomen. The female was identified using the cannulation technique. Photographs were taken of the collected sauger that did not exude either eggs or milt. Mike Smith (pers. comm.) made guesses as to what sex these fish were based on the appearance of the belly and the vent. Identifications using these photographs were not confirmed. In the past, sauger females have been identified on the basis of distended abdomens and swollen, reddish vents by Nelson et al. (1965).

Location of Staging and Spawning Areas

Radio telemetry and fish collections were used to determine where sauger were spawning in Douglas Reservoir. Tagged fish were tracked to areas of concentration. Sauger were captured by gill-netting and electro-fishing at these areas and were evaluated for their spawning condition. Radio-tagged sauger concentrated in two locations in the headwaters of Douglas. Sauger congregated initially at FBRM 68.8 and then moved to FBRM 71.2. Both were initially shoal areas, but rainfall within the watershed and a water depth increase at FBRM 68.8 near the end of March made that area more lakelike. Sauger in spawning condition were subsequently captured further upstream at FBRM 71.3 between the two Rankin Bridges from April 11 to April 15. *Stizostedion* sp. eggs were collected from this area. This segment of the FBR represents the only major spawning site located on Douglas Reservoir (Figure 5).

Fish Movements

Tagged sauger appeared to move randomly throughout the main body of the reservoir during January and the first part of February (Figure 6). Tracking data from February 24 (Figure 7) showed several sauger moving toward the headwaters of the reservoir. On March 30, five male sauger were located together near the mouth of the Nolichucky River (FBRM 68.8). By April 4, four of these fish had moved up the FBR to the area near the old Rankin Bridge (FBRM 71.2). Another fish joined them on April 5 (Figure 8). The sauger stayed clustered there until April 15, at which time they began to disperse downstream toward the main body of the reservoir.

These movement patterns are similar to patterns discovered in other Tennessee studies. Hevel (1988) and St. John (1990) reported that sauger stayed near spawning sites from mid-March through mid-April. After spawning was completed, sauger moved out of the spawning area, either upstream or downstream. All tagged fish had

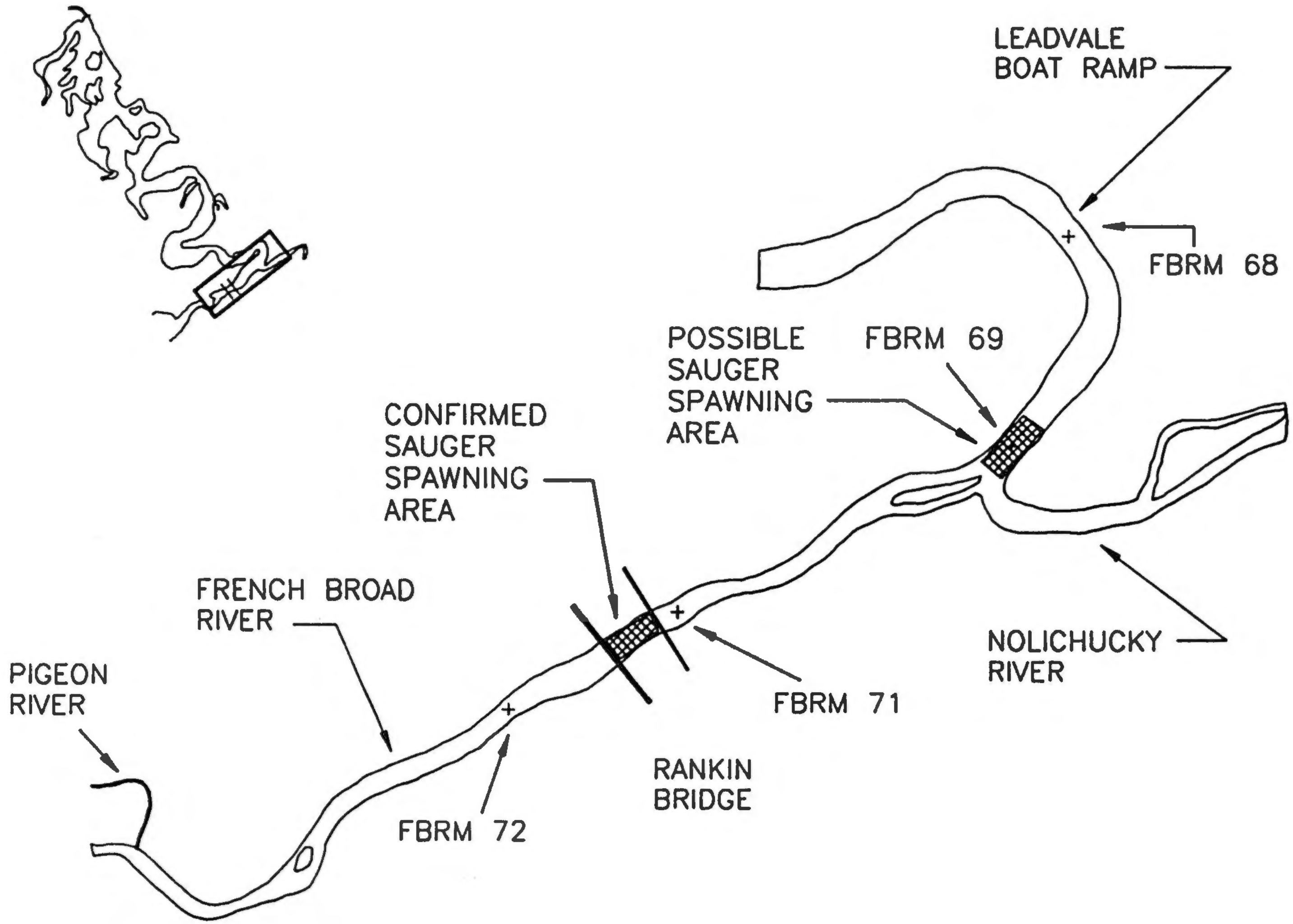

Figure 5. Map of the Douglas Reservoir Sauger Spawning Area.

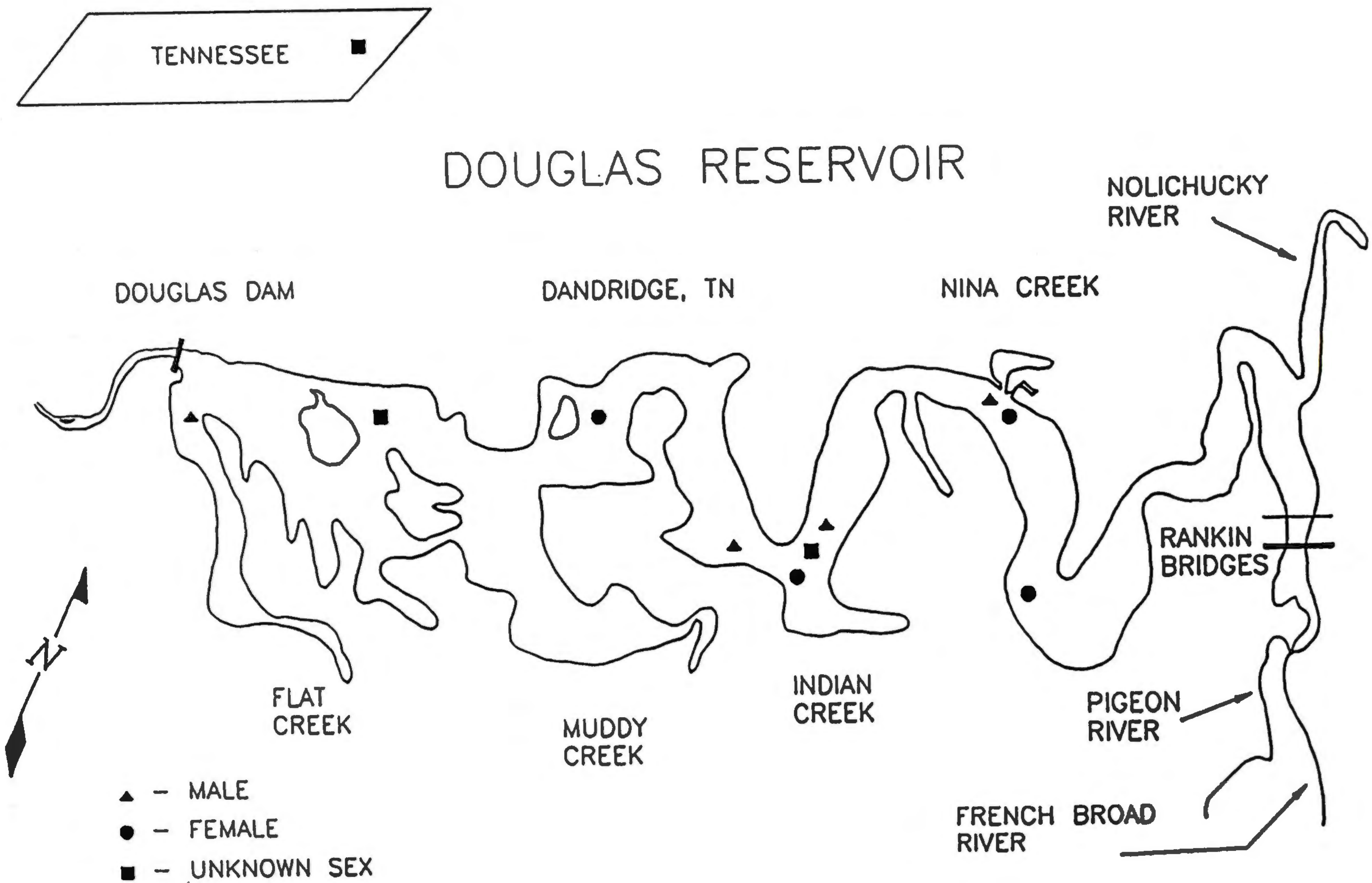

Figure 6. Locations of Radio-tagged Sauger in Douglas Reservoir on February 9, 1991.

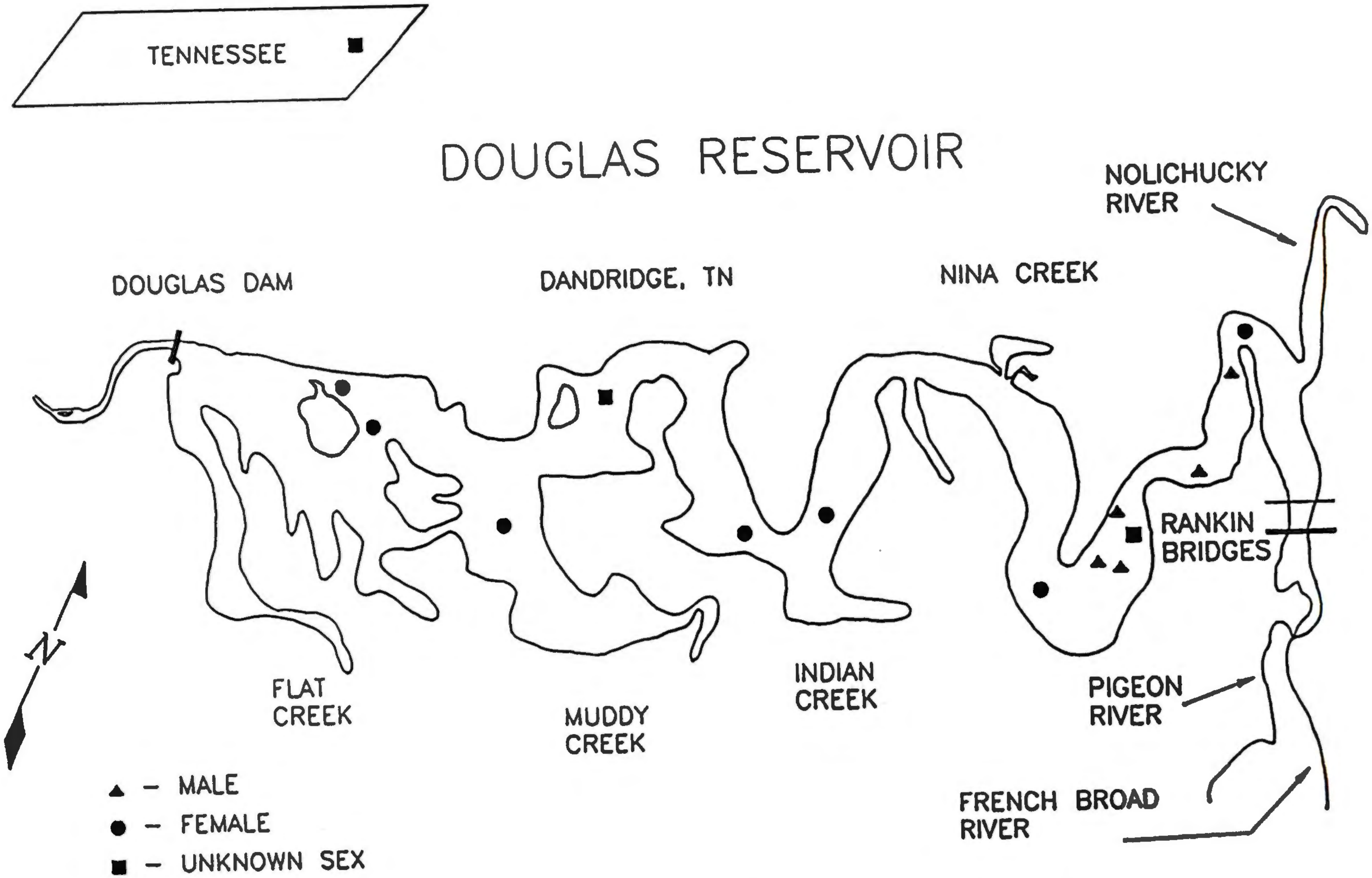

Figure 7. Locations of Radio-tagged Sauger in Douglas Reservoir on February 24, 1991.

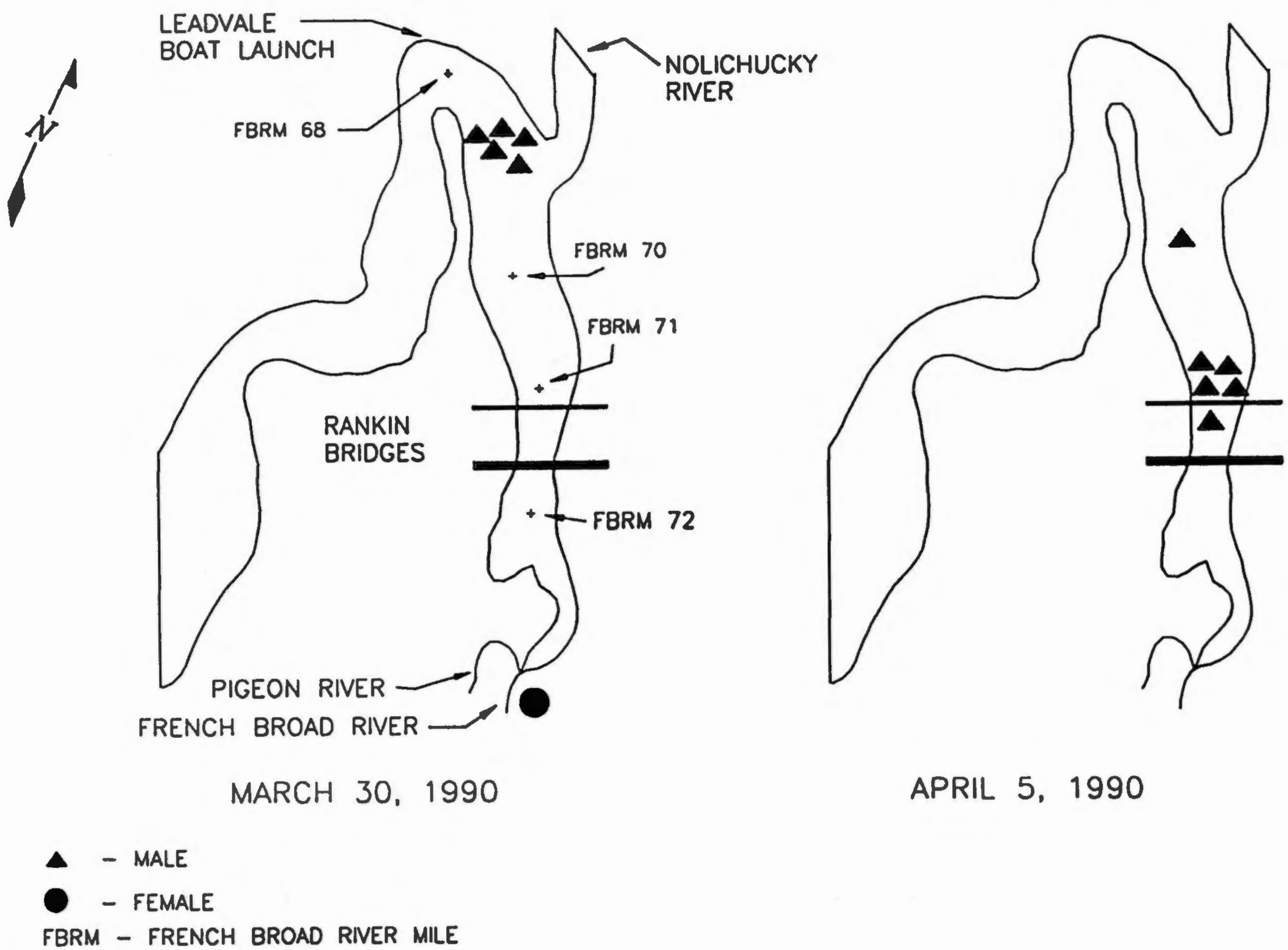

Figure 8. Map of Douglas Reservoir Headwaters Showing Movement of Sauger from March 30 to April 5, 1991.

moved out of the Douglas Reservoir headwaters by April 27 (Figure 9). Detailed movement patterns of these fish are described by Stodola (1992).

Netting and Electro-fishing

Because fish concentrated initially at FBRM 68.8, collection techniques were used in an attempt to catch sauger in spawning condition and verify that spawning was taking place. The use of gill-nets in this area of the river, characterized by large boulders and high flows, was difficult and unproductive. Thus the method was abandoned after one use on March 26. Electro-fishing was performed in the area on April 4 and 2 juvenile sauger were caught. As a result of the upstream movement of 4 tagged fish, electro-fishing was done at FBRM 71 on April 5. One flowing male saugeye was caught. Gill-nets were used again on April 10 at FBRM 71, but yielded no sauger. Netting was attempted at FBRM 71.3, between the two Rankin Bridges, on April 11. Six flowing male saugeye and 1 flowing male sauger were caught.

Electro-fishing was performed in this same area on April 13 and 15. Six male sauger and 8 male saugeye were caught during this period. All males were in spawning condition. One gravid female sauger was caught on April 13. Eggs from this female were exuded without even applying pressure to the abdomen. The presence of flowing males and a gravid female represents a strong indication that spawning was taking place. Some of the eggs from the female were artificially fertilized using a male sauger and kept for later comparison with collected egg samples.

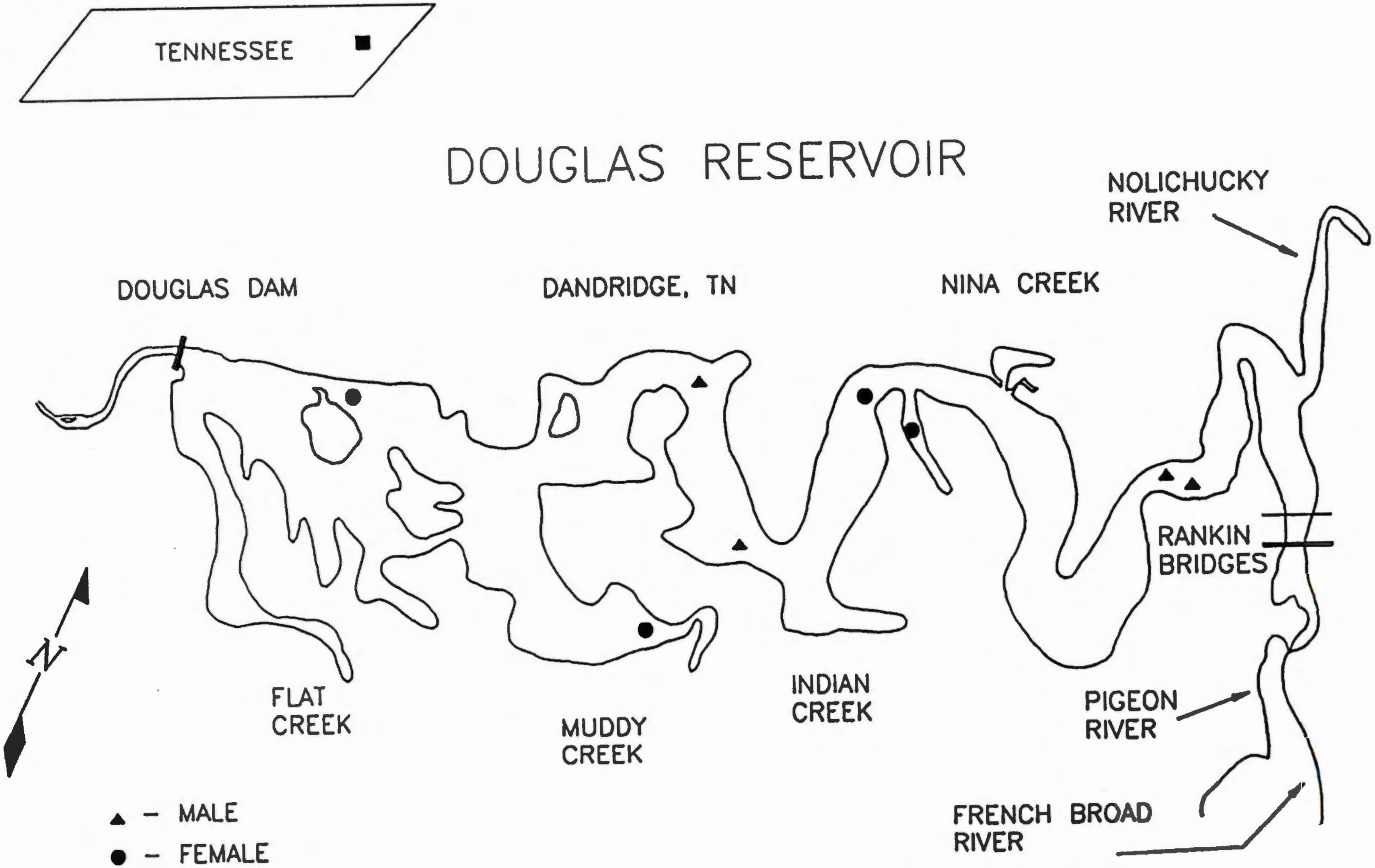

Figure 9. Locations of Radio-tagged Sauger in Douglas Reservoir on April 27, 1991.

Verification of the Spawning Area

Egg collections were attempted on Douglas Reservoir on 13 occasions between March 26 and April 26 (Table 3). Three egg sled tows and two drift net sets were executed at FBRM 68.8. One egg from this location was identified as a sauger egg. The benthic egg sled and the larval drift net were used again at FBRM 71. One walleye egg was trapped by the egg sled, and another egg identified as a sauger egg was caught in the drift net. *Stizostedion* eggs were collected at FBRM 71.3 from April 11 to April 16 using the egg sled, drift net, and larval kick seine. Thirteen sauger eggs, two *Stizostedion* sp. eggs, and one egg that was a sauger egg, were collected. All of the eggs were caught between the two Rankin Bridges, near right bank looking upstream. Eight of the eggs were collected with the benthic egg sled, four with the larval kick seine and, four with the drift net. Due to the adhesive nature of sauger eggs, it follows that most of the eggs collected were caught with the benthic egg sled and, larval kick seine. The number collected with the egg sled, however, was surprisingly high because of the difficulty encountered while operating the device in the fast moving current. Three egg sled tows on April 26 yielded no *Stizostedion* sp. eggs.

Several hundred additional eggs were collected in the sauger spawning area. Some were identified as being *Ictiobus* sp. and *Carpiodes* sp. but the majority were not identified.

According to Nelson (1968b), water hardened, fertilized, sauger eggs have a diameter range from 1.44-1.86 mm while walleye eggs range from 1.90-2.07 mm.

Table 3. Fish Egg Sampling in the Douglas Reservoir Headwaters, 1991.
FBRM = French Broad River Mile

1991 Date	Sampling Device	Location (FBRM)	Temp (C)	Type and Number of Eggs Collected	
3-26	Drift Net	68.8	14.0	sauger	1
3-27	Egg Sled	68.0	14.0	no eggs found	
3-31	Drift Net	68.0	10.2	no eggs found	
3-31	Egg Sled	68.8	10.2	Catostomidae	1
4-4	Egg Sled	68.8	13.5	sauger	1
4-5	Egg Sled	71.0	14.0	walleye	1
4-9	Drift Net	71.0	15.4	sauger	1
4-10	Drift Net	71.0	17.3	no eggs found	
4-10	Drift Net	71.0	17.3	no eggs found	
4-11	Drift Net	71.3	16.4	no eggs found	
4-11	Drift Net	71.3	16.4	sauger *Stizostedion* sp.	1 2
4-13	Egg Sled	71.3	14.9	sauger	8
4-15	Drift Net	71.3	16.4	sauger	1
4-16	Seine	71.3	17.2	sauger	4
4-26	Egg Sled	71.3	-	*Ictiobus* sp. *Carpiodes* sp.	

These measurements were the basis upon which the identified eggs were separated into species. The *Stizostedion* sp. designation resulted from eggs having an intermediate size of 1.86-1.90 mm.

Saylor et al. (1983), Hevel (1988), and Medlin (1990) used a benthic egg sled to collect sauger eggs. Spawning sites were positively identified by these researchers in the Fort Loudoun tailwater, the Watts Bar tailwater, and the Clinch River, respectively.

Fish larvae were caught on several occasions using egg sled, drift net, and larval seine. Ten larvae were caught with the larval seine, but they were so damaged that identification was impossible. Several larvae captured in the drift net were identified as being *Carpiodes* sp. and *Ictiobus* sp. There were no larvae identified as *Stizostedion* sp.

Habitat Analysis

Substrate Characterization

Analysis of the substrate between FBRM 71.2 and 71.4 indicated that an area 10-m wide and 300-m long between the two Rankin Bridges was suitable for sauger spawning (Figure 10). The stretch, along the right bank looking upstream, consisted of a mix of cobble, pebble, gravel, coarse sand, and boulder (Table 2). Priegel (1969) found sauger spawning over all types of substrate but mostly over cobble and rubble. Fifty-five percent of the substrate within the 10-m wide stretch was cobble-gravel. Nelson (1968a) and Hevel (1988) considered cobble-rubble to be ideal for sauger spawning. Crance (1987) also reported cobble-rubble (64-250 mm) substrates

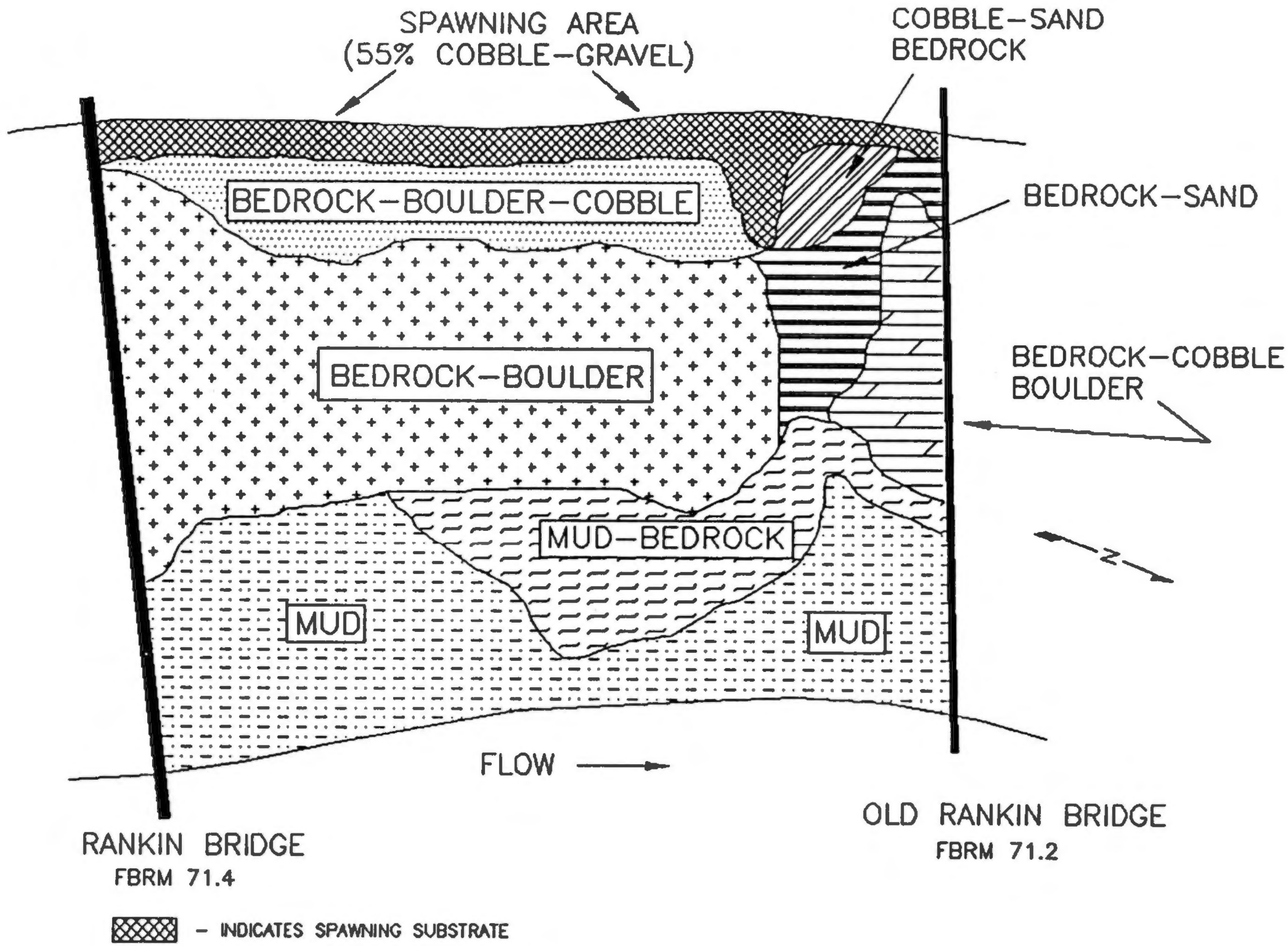

Figure 10. Map Showing Dominant Substrate Types at the Douglas Reservoir Spawning Site.

to be optimal for sauger spawning. Scott and Crossman (1973) and Robison and Buchanan (1988) found sauger spawning over cobble to gravel size substrate. Sauger were found spawning over cobble-pebble substrate in the Fort Loudoun tailwater (Medlin 1990).

Substrate adjacent to the Douglas Reservoir spawning site consisted of large amounts of bedrock, boulder, and sand. There were no eggs collected in this part of the river.

While conducting transects between FBRM 71.2 and 71.4, a factor that could affect sauger spawning was discovered. Approximately one-third of the area was covered with up to 1.0 m of black mud (Figure 10). In January, further inspection showed that the mud was gone, apparently scoured out as a result of heavy rains in December. It seems possible that a year without heavy rains would allow this mud to build up and cover the entire spawning area, thus forcing sauger to spawn over less desirable substrate.

Depth

The Douglas Reservoir spawning site, located between FBRM 71.2 and 71.4, showed little depth variation. Sauger eggs were collected in 1.0-1.5 m of water. Priegel (1969) collected sauger eggs in up to 1.3 m in Lake Winnebago, WI. Sauger eggs were collected in Lewis and Clark Lake, SD, in 0.6-3.7 m of water Nelson (1968a).

Recent studies by Hevel (1988) and Medlin (1990) found sauger spawning in transition areas between deep pools and shoal areas. Browder Shoals spawning area in the Fort Loudoun tailwater was characterized by a 19.2-m deep pool gently rising to a depth of 4.5 m. Eggs were collected at depths between 5.5 and 7.3 m. (Medlin 1990). The depth of the spawning area near Hunter Shoals in Watts Bar tailwater varied from 5-9 m. Sauger apparently used the deep pools to stage in during the day. The deep pool was needed because of the extremely light sensitive eyes of sauger.

There was not a deep pool adjacent to the spawning area at FBRM 71.3 for sauger to stage in during the day. Movement data indicated that the staging sauger may have used the shadow of the old Rankin Bridge as protection against sunlight during the day.

Current Velocity

Current velocity measurements taken near the substrate at FBRM 71.3 were 18-20 cm/sec. These measurements were taken on April 11 and 15. The optimal velocities for sauger spawning, incubation of eggs, and survival of larvae ranges from 9.1-61 cm/sec while zero velocities are thought to be unsatisfactory (Crance 1987). Current velocities near the bottom during zero discharge in the Watts Bar tailwater were 4.27 cm/sec in the pool to 6.83 cm/sec on the Hunter Shoals (Hevel 1988). Velocity measurements ranged from 0.6 cm/sec at zero generation, to 12.2 cm/sec during hydroelectric discharge at the Browder Shoals spawning area in the Fort Loudoun tailwater (Medlin 1990).

Low current velocity could be a factor limiting recruitment in the above mentioned studies. Heavy flow in the FBR should prevent any silting over and smothering of sauger eggs.

Temperature

Douglas Reservoir water temperatures taken in January and February ranged between 7 and 9 C (Table 4). By the end of February, when the sauger began moving upstream, temperatures were averaging 9 C. St. John (1990) found sauger had moved onto or near the Browder Shoals spawning site when water temperatures reached 10 C. A majority of the male sauger in the Watts Bar tailwater moved near the Hunter Shoals spawning area as the water temperature approached 11 C (Hickman et al. 1989). The sauger stayed near Hunter Shoals until late April when the water temperature reached 19 C.

Craig (1987) indicated that water temperature was the most important factor influencing the spawning habits of *Stizostedion* spp. Temperatures fluctuated greatly in the upper section of Douglas in March and April. From March 26 to April 16, the water temperature ranged from 10.0-17.2 C. During the period when spawning condition sauger were being caught, water temperature varied from 14.9-17.2 C. On the night that the only female sauger was captured, the temperature was 14.9 C.

Spawning Success

There was a strong indication that spawning took place at FBRM 71.3 during the spring of 1991. Flowing male sauger and saugeye and a gravid female sauger were captured. Sauger eggs were also collected in the area. None of the larvae captured, however, were identified as being sauger.

There appeared to be limited recruitment of sauger in 1991. Although spawning occurred in Douglas Reservoir in 1991, only 1 y-o-y sauger was collected

Table 4. Water Temperatures and Lake Levels for Douglas Reservoir from 2-1-91 to 4-16-91.

Date	Location FBRM	Water Temperature (C)	Lake Level (ft)
2-1-91	56.0	5.5	947.84
2-10-91	50.6	8.0	947.61
2-13-91	56.0	8.0	947.91
2-23-91	40.9	8.0	964.24
2-25-91	42.7	9.0	963.17
3-2-91	42.5	10.0	960.36
3-10-91	44.0	10.0	962.74
3-23-91	42.0	15.0	965.88
3-26-91	68.8	14.0	968.08
3-31-91	68.8	10.2	981.28
4-4-91	68.8	13.5	981.58
4-5-91	71.0	14.0	981.58
4-9-91	71.0	15.4	982.23
4-10-91	71.0	17.3	982.21
4-11-91	71.3	16.4	982.22
4-13-91	71.3	14.9	982.20
4-15-91	71.3	16.4	982.96
4-16-91	71.3	17.2	983.34

in the 1991 cove rotenone sampling that took place in August. Further evidence of limited sauger recruitment was recorded by TVA crews conducting their annual fall assessment. Only 1 y-o-y sauger was collected during sampling in October (TVA 1991).

Saugeye

During the course of this study, it was discovered that a population of *Stizostedion canadense* x *S. vitreum* hybrids (saugeye) was present in Douglas Reservoir. This was somewhat unusual because sauger-walleye hybrids have never been stocked into Douglas Reservoir (M. Smith, pers. comm.). After discovery of saugeye on February 13, 1991, the ratio of sauger to saugeye collected was found to be approximately 1:1 (Stodola 1992). Fifteen saugeye and 8 sauger were captured at the Douglas Reservoir spawning site (FBRM 71.3). This ratio is much higher than the 10:1 ratio that Thompson (1935) suggested as being the upper frequency level of parental to hybrid fish.

Natural interspecific hybridization is more common among fishes, especially fresh water, than in any other class of vertebrates. Altered environment is the most important, but by no means the only factor influencing the production of hybrids. A positive correlation exists between success in hybridization and closeness of relationship, such that greater survival of hybrids occurs when the parental species are more intimately related (Lagler et al. 1962). Another situation conducive to hybrid production is the cohabitation of a few individuals with a multitude of a related species (Hubbs 1955).

On April 10, 1981, a total of 625,000 walleye fry was released into the Nolichucky River above Douglas Reservoir in an attempt to reestablish the population. In 1982, another 16,500 walleye fingerlings (25-38 mm) were released in portions of the upper Nolichucky River in Tennessee and North Carolina (M. Smith, pers. comm.). It appears that these stockings were not successful in establishing a self-sustaining population because only 3 walleye were caught in gill netting between November 24, 1990 and July 7, 1991 (Stodola 1992). Only 1 walleye was reported in the Douglas Reservoir creel survey for 1990 (Peterson 1990).

The small Douglas Reservoir walleye population combined with a small sauger population could result in production of hybrids. It is not known whether the saugeye have viable gametes or not, but it was apparent that the saugeye were engaged in spawning activity. If all, or a portion, of the saugeye were non-viable the competition with sauger for access to spawning females could lead to a decreased number of fertilized eggs. A single spawning season with saugeye competing with sauger could be a major factor contributing to a poor sauger spawn. Research is currently underway at the TWRA Eagle Bend fish hatchery to evaluate the viability of gametes from sauger-walleye crosses and backcrosses.

Other Spawning Areas

Radio-tagged sauger congregated at one additional location in the Douglas Reservoir headwaters. The fish gathered at FBRM 68.8 near the mouth of the Nolichucky River. The area was characterized by a shoal with a deep pool just upstream. Suitable spawning substrate appears to be present in the area (Saylor

1986). According to Kerry Hevel (TVA, pers. comm.), a deep pool directly upstream from a shoal is the optimum habitat for sauger spawning.

On March 26, a TVA electro-fishing crew captured sauger and walleye in spawning condition at the mouth of the Nolichucky River. TVA collected the area again on March 31, but captured only juvenile (D. Harris, TVA, pers. comm.). Stodola (1992) reported catching 2 juvenile sauger on March 31. Gill-netting and electro-fishing at FBRM 68.8 on subsequent nights produced no adult sauger. One sauger egg was collected in this area on March 26. It seemed likely that spawning could have occurred but little proof was obtained.

A 4-m rise in the lake level from March 26 to March 31 made the area around FBRM 68.8 more lakelike (Table 4). Current velocity decreased from 40-18 cm/sec during this time. Water temperature similarly dropped from 14.1-10.2 C during the same period. Radio-tagged sauger moved upstream after March 31. It seems likely that the fish moved in response to one or more of these environmental changes. There were not any other significant congregations of sauger in Douglas Reservoir during March and April of 1991.

Saylor (1986) reported that availability of suitable spawning substrate does not appear to be a limiting factor for Douglas Reservoir sauger. He found gravel-rubble and rubble-gravel areas at FBRM 66, 68.5, 70.9, 73, and 74.5. He also characterized areas in the Nolichucky River below Enka Dam that were suitable for sauger spawning.

Since there appears to be adequate spawning substrate in the FBR and the

Nolichucky River, it seems possible that limited staging areas could be a factor inhibiting sauger spawning success. Data collected by Hevel (1988) and Medlin (1990) indicated that sauger utilized deep pools for daytime staging. Since there were no pools adjacent to the Rankin Bridge spawning site, sauger in the FBR may have used the shadow of the old Rankin Bridge as refuge from sunlight during the day.

CHAPTER 5

Summary

Twenty-two sauger were tagged with externally attached radio transmitters in December 1990 and February 1991. The tagged fish appeared to move randomly during January and the first three weeks in February. On February 24, tracking data indicated that the sauger were moving toward the headwaters of the reservoir. The water temperature averaged 9 C at that time. The fish continued to move upstream until there was a congregation of 5 tagged male fish at FBRM 68.8 on March 30 and 31. Following changes in current velocity and water depth, four of these fish moved up to FBRM 71.2 by April 4. Sixteen male sauger and saugeye in spawning condition and one gravid female sauger were captured near FBRM 71.3 between April 11 and April 15. Radio tracking on April 16 showed that tagged sauger had begun to disperse downstream, indicating that spawning was near completion. The area between the two Rankin Bridges was the only major spawning site discovered on Douglas Reservoir.

The spawning area is a 10 by 300-m strip, along the right bank looking upstream, between the two Rankin Bridges (FBRM 71.2-71.4). The substrate was a mix of cobble, pebble, gravel, coarse sand, and boulder. Cobble-gravel substrate made up 55% of the mixture. Current velocity near the substrate was 18-20 cm/sec. Water temperatures ranged from 14.0-17.3 C from April 5 to April 15.

Sauger eggs were collected in 1-1.5 m of depth between the Rankin Bridges from April 11 to April 16. Eggs were collected with a benthic egg sled, larval drift net, and larval kick seine. The egg collections provided proof that sauger spawning had occurred.

An additional potential spawning site on Douglas Reservoir was FBRM 68.8 near the mouth of the Nolichucky River. Sauger congregated there from mid-to late-March. A TVA electro-fishing crew collected sauger and walleye in the area on March 26. One egg identified as being sauger was captured there. Saylor (1986) reported finding suitable spawning substrate in the area.

The presence of saugeye in Douglas Reservoir was documented by Stodola (1992). After discovery of the hybrid, the capture ratio of sauger to saugeye was found to be 1:1. Presence of a hybrid in such a large percentage indicated limited spawning grounds and depressed populations. It seemed likely that the large population of *Stizostedion* hybrids could inhibit sauger reproduction by competing with more viable parental fish.

CHAPTER 6

Recommendations

It appears that stocking of sauger will likely be required to maintain the sauger population at this point. Only 1 y-o-y sauger was found in the TWRA cove rotenone study conducted in August of 1991. That represented a decrease from 8.1 sauger per hectare captured in 1990. Results from the 1992 cove rotenone sampling study will provide further insight into the status of sauger recruitment. In addition to cove rotenone work, efforts to ascertain year class strength should be made, including the use of light traps and towed plankton nets for collection of pelagic larval fish. These techniques should be used during the months of April and early May in the main body of Douglas Reservoir.

Careful consideration should be exercised before any physical alterations are made on or near the spawning area at FBRM 71.3. The spawning area is very limited and the disruption of a small portion of it could be serious. Poor water quality could be a limiting factor affecting the early life history of sauger in Douglas Reservoir. Further work should be done to reduce the levels of pollutants introduced into Douglas Reservoir from the Pigeon River, and to identify and remediate the sources of pollution in the French Broad River.

It would be helpful if research could be continued to further define the spawning strategy of Douglas Reservoir sauger. The literature is very limited regarding spawning of sauger in headwater reservoirs. One spawning site was found, but it is possible that there are more. It is important that all of these areas be identified and protected.

Additional research might provide proof that the absence of staging areas is a limiting factor affecting sauger spawning. Evaluation is needed to ascertain the presence or loss of pool staging habitats near potential spawning shoals on each major tributary river. Investigation into the feasibility of construction of suitable pools to restore these staging habitats would be a beneficial management endeavor.

Results of the movement data from this study indicated that none of the tagged sauger moved into the Nolichucky River. Attempts to reintroduce a spawning population of sauger in the Nolichucky River could be initiated by either stocking sauger fry or implanting fertilized eggs in the river. Future studies in the Nolichucky could reveal the presence or absence of a homing ability in sauger.

An investigation of gamete viability of saugeye and their backcrosses would provide insight for further stocking regimes. It appears that the sauger and walleye populations might be unable to exist together in Douglas Reservoir under the conditions that are currently available. Perhaps one of the two species could sustain a breeding population if the other is absent.

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