TVA-3902234

TENNESSEE VALLEY AUTHORITY

Office of Natural Resources

TVA--3902234

DE83 902234

AN INVESTIGATION OF SAUGER SPAWNING IN THE VICINITY OF THE CLINCH RIVER BREEDER REACTOR PLANT

Prepared by

Charles F. Saylor
Edwin M. Scott, Jr.
Division of Natural Resource Operations

David A. Tomljanovich
Division of Air and Water Resources

February 11, 1983

TVA/ONR/WRF-83/1

AN INVESTIGATION OF SAUGER SPAWNING IN THE VICINITY OF THE CLINCH RIVER BREEDER REACTOR PLANT

Introduction

Objective

The purposes of this study were to: (1) identify where and when sauger (Stizostedion canadense) spawn in the Clinch River arm of Watts Bar Reservoir and (2) evaluate the potential for construction of instream facilities (intake, discharge, barge unloading dock) at the Clinch River Breeder Reactor Plant (CRBRP) site (Figure 1) to adversely impact sauger spawning in this portion of the reservoir.

Background

Each winter sauger migrate from the main body of Watts Bar Reservoir to the tailwaters of Fort Loudoun and Melton Hill Dams (Figure 1), where a fishery exists for several months each year. These dams block the saugers' upstream movement, compelling sexually mature individuals to spawn in the tailwater.

It has been assumed sauger spawn over riprap near the dam in these tailwaters; however, collection of very few larvae in these areas casts doubt on this assumption. Scott (1980) investigated the hypothesis sauger spawn several miles downstream from Melton Hill Dam. Scott's study concentrated on a three-mile reach of river adjacent to the CRBRP site and at Melton Hill Dam. While only one sauger egg was found, large numbers of males in spawning condition and several "flowing" or "spent" females were collected in the downstream study area. This area contains a submerged

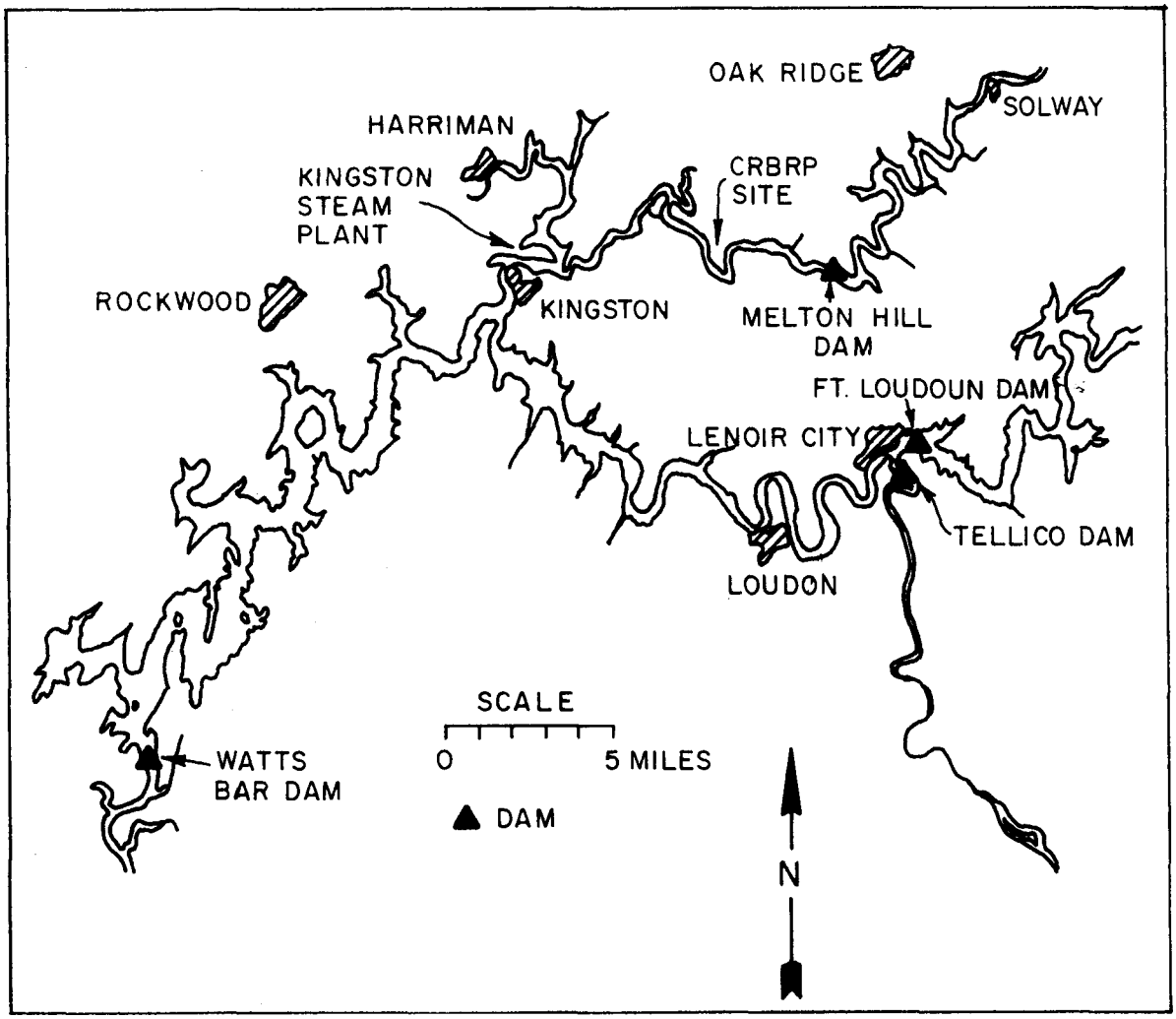

Figure 1. Watts Bar Reservoir showing upstream barriers (Ft. Loudoun and Melton Hill Dams) to sauger migration.

island, which appeared to be a major spawning ground based on numbers of adults collected. However, other data suggested spawning was not strictly localized in the area adjacent to the CRBRP site. During the time of Scott's study, biologists from Oak Ridge National Laboratory collected 36 mature males and one "flowing" female in a single net at CRM 19.7, nearly three miles upstream of the TVA study area. Scott collected large numbers of sauger at the lock wing walls; however, relatively more females in spawning condition were found downstream.

Although it is unlikely the CRBRP site is the only suitable spawning habitat in the Clinch River portion of Watts Bar Reservoir, Scott's study suggested significant spawning occurs in this area, especially between the proposed barge unloading facility and the discharge. Since other areas were not sampled, the extent of spawning throughout the remainder of the Clinch River was unknown. Results of Scott's study formed the basis for concern that construction of instream facilities might result in permanent destruction of a portion of important spawning habitat for those Watts Bar Reservoir sauger which migrate up the Clinch River. Long-term consequences would depend on extent of habitat modification and response of spawners to this modification. If the area were no longer suitable, they could conceivably select other habitat. In the event the CRBRP site were the only suitable habitat, spawning in less favorable habitat could result in reduced standing stocks. Prior to this study, knowledge of sauger reproduction in the Clinch River was insufficient to estimate potential construction-related impacts.

Materials and Methods

An initial assumption was that sauger spawn in one or more localized areas. Radio telemetry and gill netting were used to locate congregations of individuals and examine them for gonadal development (immature, gravid, flowing, or spent in the case of females and flowing or nonflowing in the case of males). The study was conducted from March 16 through May 12, 1982 between Clinch River Mile (CRM) 9.5 and Melton Hill Dam at CRM 23.1 (Figure 2). Once it was ascertained spawning had begun and the probable location(s) identified, sampling for eggs was initiated using an epibenthic sled specifically designed to collect sauger eggs adhering to the river bottom.

Radio Telemetry

Radio equipment consisted of ten transmitters, two loop antennas, an 8-element yagi antenna, headphones, and a programmable, scanning receiver, all purchased from Advanced Telemetry Systems, Bethel, Minnesota. External attachment of transmitters and operation of receiving equipment are described by Winter, et al (1978). Each transmitter had a unique frequency in the 49 to 50 MHz range. Transmitters weighed 25 g in air (10 g in water) and measured 70 mm in length and 17 mm in diameter. A 25 cm teflon-coated whip antenna extended posteriorly from the transmitter. Probable transmitter life was rated by the manufacturer at 60 to 73 days.

Tagging procedures were practiced in the laboratory on two captive sauger before any fish were tagged and released in the study area. Almost immediately after tags were attached to experimental fish, they were able to maintain equilibrium and swim normally.

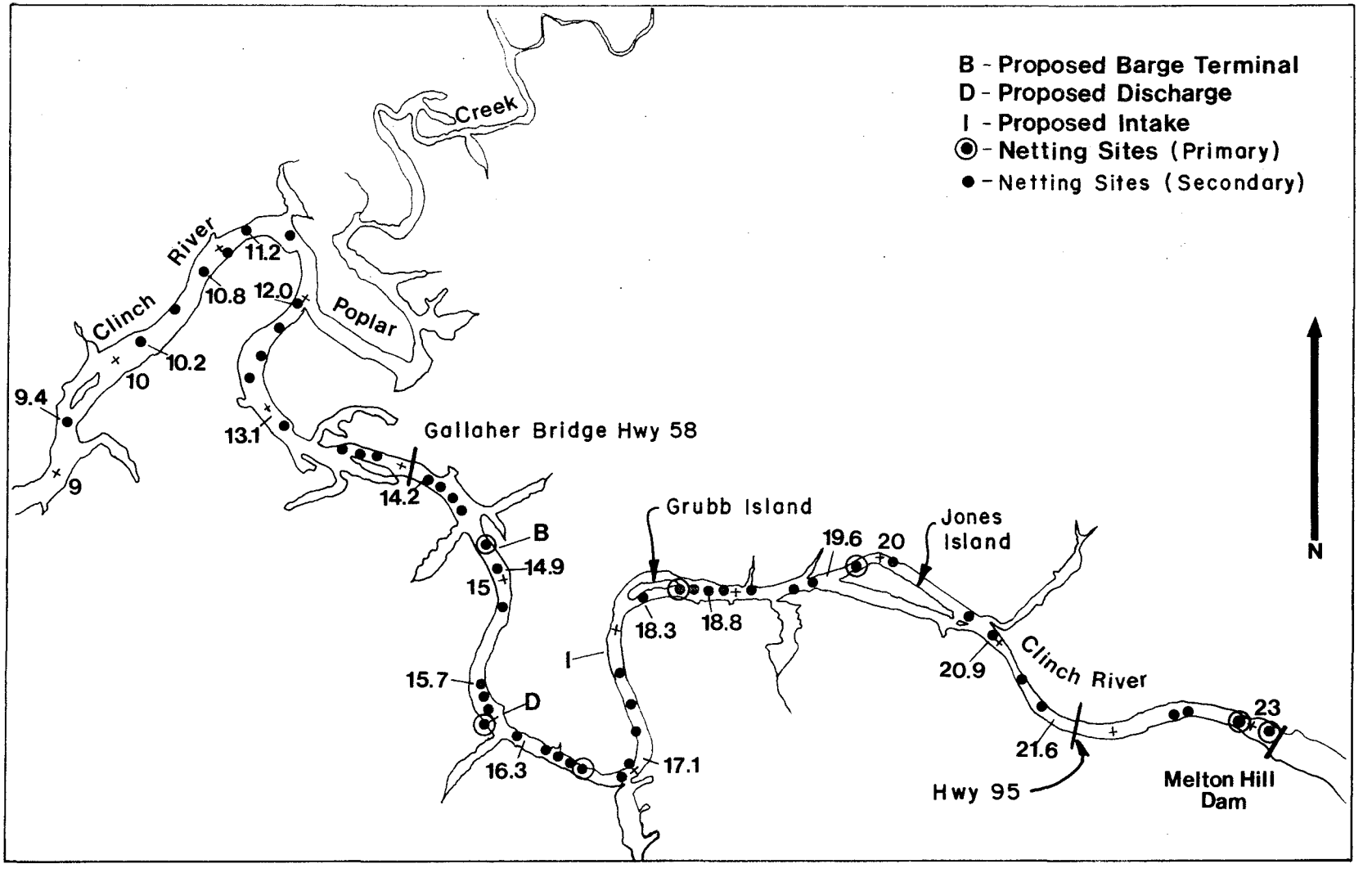

Figure 2. Sauger spawning study area in the Clinch River near the CRBRP site, March through May 1982. Dots denote gill net stations.

The largest (400 to 475 mm) sauger captured were selected for radio tagging. Nine fish (seven males and two gravid females) were tagged and released on March 29 and April 5. On April 19, one of the transmitters was transferred from a male that was injured during recapture to a gravid female. One transmitter was reserved for periodic testing of the receiving equipment. Most transmitters were placed on males since Nelson (1968) observed that male sauger congregate at spawning sites.

Searching was done from a moving boat using headphones to block out wind and motor noise. The yagi antenna, measuring 3.0 x 2.4 m and mounted perpendicular to the water surface, was used for long-range detection of radio signals (up to 400 m). At close range, a hand-held loop antenna was used.

Attempts were made to find transmitter-tagged fish at least twice each week from March 30 through May 12. With the scanning interval set at 4 to 6 seconds, the receiver was allowed to cycle through all transmitter frequencies until a signal was found. Each search included an upstream and downstream run of the Clinch River between Brashear Island (CRM 9.4) and Melton Hill Dam (CRM 23.1). Field data recorded for each siting included date, time, location to nearest tenth river mile, and approximate distance from shore.

Gill Netting

Gill nets were fished several times per week from March 16 through May 12. Fifty-five sites (Figure 2) included primary and secondary locations and places where two or more transmitter-tagged fish occurred relatively close together or where an individual transmitter-tagged fish frequented a particular area. Primary sites chosen for frequent sampling included the proposed barge terminal (CRM 14.7), the proposed discharge (CRM 16.0), and

several sites where initial gill netting was most successful (at Melton Hill Dam, CRM 23.1; the lower end of Jones Island, CRM 19.7; the head of Grubb Island, CRM 18.8; and CRM 16.7). Secondary sites were sampled less frequently.

Gill nets (2.4 m by 45.7 m and 3.8 cm mesh size) were anchored at both ends and set perpendicular to shore. Initial netting on reservoir overbank areas yielded few sauger. Subsequently, nets were set in the channel. Netting was primarily after sundown when sauger were most active. To obtain an adequate sample and minimize fish mortality, each net was fished a minimum of one hour and a maximum of five hours. Strong currents, which occurred during periods of power generation at Melton Hill Dam, rendered netting less effective. Therefore, most netting was done during periods of zero flow. Date, location, time set, and time lifted was recorded for each net set. A numbered Floy tag was injected under the soft dorsal fin of nearly all sauger collected alive in gill nets. Recaptures of Floy-tagged fish provided information on movement, abundance, and residence time in the study area. For each sauger captured, total length in mm, sex, spawning condition, and tag (Floy or radio transmitter) number were recorded. Daily water temperature readings of intake water at the Department of Energy's K-25 Plant (CRM 12.0) were provided by Union Carbide Corporation. Daily records of average hourly discharge from Melton Hill Dam were furnished by TVA's Reservoir Operations Branch.

Egg Sampling

Sauger eggs were sampled with an epibenthic sled beginning April 21 and ending May 14. Egg samples were taken at (1) netting sites where flowing female sauger had been captured, (2) netting sites with high catch rates, and (3) proposed construction sites for the CRBRP barge terminal and discharge.

Before egg sampling was started a laboratory study was conducted to examine adhesiveness of sauger eggs. This study provided valuable insight for interpreting field data and identifying sauger eggs. An important consideration in evaluating egg sampling data was whether eggs were actually spawned where collected or had drifted from upstream.

Standard techniques for collecting sauger eggs in the relatively deep Clinch River were not available. An epibenthic sled was developed during the study. The final design (Figure 3), which was first used on April 28, featured a steel frame with sled runners, a 0.5 m square tapered net of 500 μm openings, a towing harness, a brush of stiff fibers to loosen material from the substrate, and a water jet assembly to stir the substrate and force eggs out of pockets and crevices in course substrate. Surface water was forced through a 3.8 cm diameter hose to the water jet manifold by a two-cycle, gasoline powered pump. The net was raised about 10 cm above the runners to minimize entrapment of sand.

To evaluate the sled's performance and need for modification, and as a second method to determine presence of sauger eggs (i.e., direct observation), two SCUBA divers accompanied the sled (one on either side) as it was towed. Diver accompaniment was discontinued after the final modification (addition of water jets) was made and successful operation observed.

The first extensive sampling prior to addition of water jets consisted of diver-accompanied tows from right to left bank at six selected sites between CRM 19.7 and 16.0. This provided an opportunity to directly observe substrate types in the river. Thereafter, tows were made parallel to shore at each site. At each sample site a 100-yd (91.5-m) section of

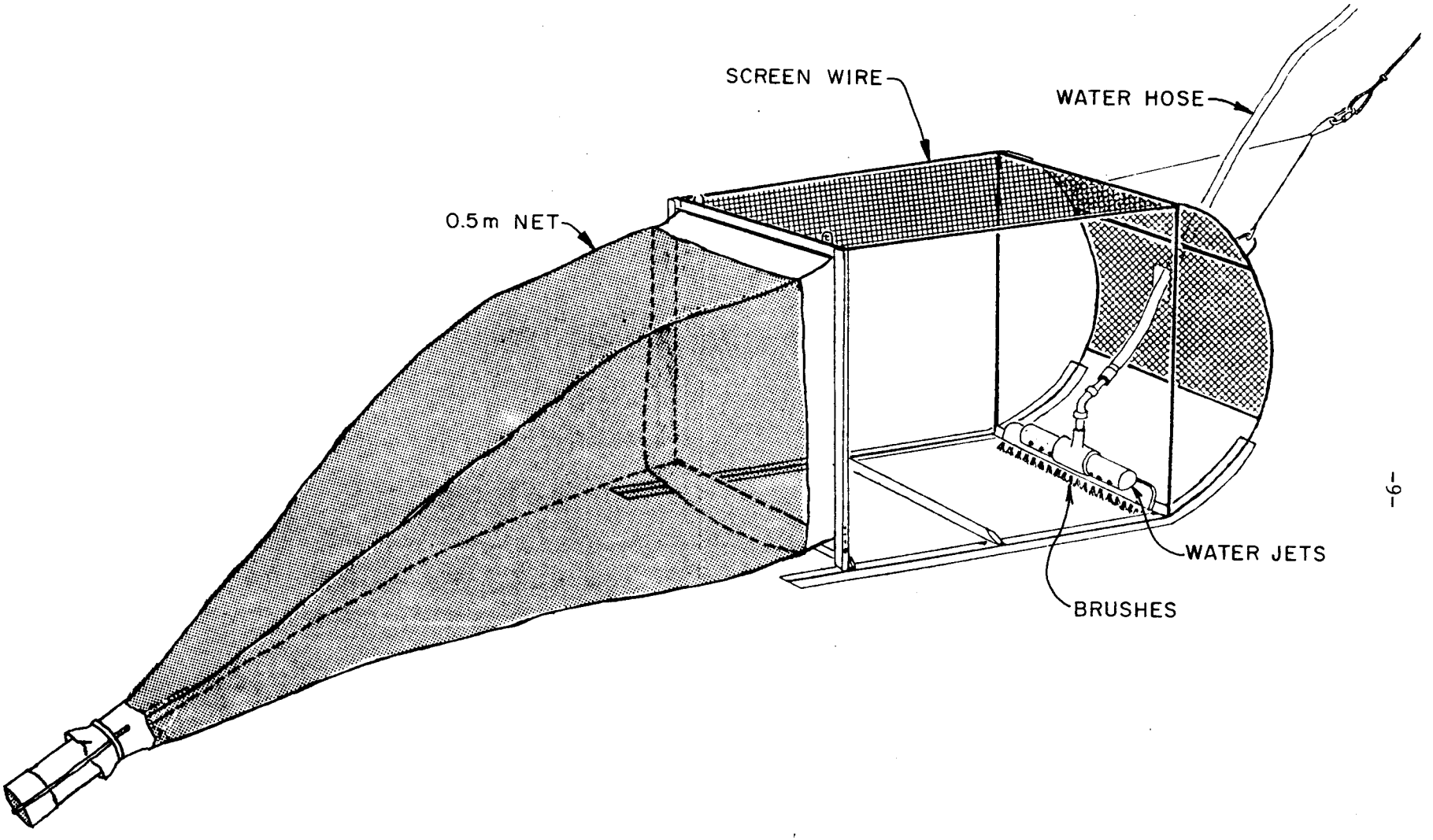

Figure 3. Epibenthic sled used to sample sauger eggs in the Clinch River, April and May 1982.

shoreline was measured and marked. Three parallel tows (left, middle, and right channel) were usually made between these markers. Each tow required about seven minutes and sampled approximately 46 m^2 of substrate. All samples were taken during periods of zero discharge through Melton Hill Dam. Net contents were removed, transferred to a labeled jar, preserved in 10 percent formalin, and later processed at the TVA fisheries laboratory.

Substrate in the study area was characterized during a TVA mussel survey conducted in May and June 1982 (Jenkinson 1982) after egg sampling was completed. Findings of that survey are presented with results of egg sampling.

Sauger Abundance

An attempt was made to estimate number of male and female sauger present in the study area using Floy-tag data. Although assumption of a closed system was violated in using the models, Schnabel and Petersen estimates (Ricker 1975) were made to provide a gross estimate of numbers of fish which may have used the area for spawning.

Determination of Sex, Spawning Condition, and Fecundity

Differentiation of sexes was made without sacrificing the fish by examining external spawning characteristics of adults. Milt could be observed by exerting pressure on the abdomen of males. If no milt appeared, the fish in question was presumed to be a female. Dissection of fish which died in the net revealed no immature males.

Female sauger were categorized as immature, unknown, gravid, flowing, or spent. A female was termed gravid when one or more eggs were visible when pressure was applied to the fish's abdomen. Females which readily released eggs with little or no pressure applied to the abdomen were

termed flowing and were considered to be at or very close to spawning. Spawning condition of females not extruding eggs could not be accurately assessed without dissecting the fish. If these fish were alive, they were termed females of unknown spawning condition and were released. Fish length or fullness of the body cavity was not a reliable indicator of sexual maturity. Dissection of questionable fish that were dead in the nets showed some sauger that appeared externally to be gravid were actually immature; fullness of the body cavity was caused by large amounts of visceral fat. Conversely, several females with less distended abdomens appeared to be immature but were gravid, having fully developed ovaries.

Sauger eggs were removed from three gravid females to estimate fecundity. Ovaries were preserved in 10 percent formalin and labeled with date, location of capture, and total length and weight of the individual. Total number of eggs per fish was estimated from subsamples using the following formula: $N = ST/C$

where,

N = the total number of eggs,

S = the number of eggs in the subsample,

T = the weight of N, and

C = the weight of S.

For each of these three fish, a subsample containing 200 or more eggs was taken from the middle of one ovary. The eggs were patted with an absorbent paper towel to remove excess water prior to weighing with a triple beam balance. Weight was measured to the nearest tenth of a gram.

Results

Of 14 sauger collected on March 16, the first sample date, six females were taken at the dam, and one female and seven males were collected near CRM 16. None of the females were flowing or spent. Milt from males was thick and flowed only by applying considerable pressure to the abdomen. Free-flowing males were first observed on April 5. Thus, at the beginning of the study there was no evidence spawning had already occurred.

Spatial Distribution of Adult Sauger

Data for the ten sauger tagged with radio transmitters is in Table 1. Transmitter-tagged fish moved frequently and in some instances traveled several miles in a few days or less (Figure 4a through 4c). Despite considerable movement, most transmitter-tagged fish remained in the study area. The majority were found between CRM 14.0 and 22.0. On some days, certain individuals could not be found, suggesting they temporarily left the study area. One male and one female apparently left the study area shortly after being tagged (Figures 4b and 4c) and never returned. Exits from the study area include the Clinch River downstream, Poplar Creek, Melton Hill Lock, and angler creel. Efforts to find transmitter-tagged fish downstream from the study area were hindered by deep water, 10.5 to 15.5 m, which reduces the range and/or blocks transmitter signals.

Although two or three fish were occasionally found in close proximity to each other, transmitter-tagged fish exhibited little tendency to congregate with each other. Thus, a single likely spawning area, as hypothesized, was not shown by movements of transmitter-tagged fish. Rather, these fish showed considerable upstream-downstream movement throughout the time they were in the area. After April 9 five males showed a tendency to

Table 1. Data for Radio Transmitter-Tagged Sauger, CRBRP Sauger Spawning Investigation, March through May 1982

Transmitter Frequency (MHz)	Date of Tagging	Release Location (CRM)	Sex	Total Length (mm)	Spawning Stage
49.068	3/29/82	19.7	M	453	Flowing
49.466	3/29/82	16.0	M	475	Flowing
49.188	3/29/82	14.7*	M	423	Flowing
	4/19/82	18.8	F	441	Gravid
49.126	3/29/82	23.1	M	465	Flowing
49.667	3/29/82	23.1	F	470	Gravid
49.366	4/ 5/82	16.5	M	432	Flowing
49.727	4/ 5/82	19.7	M	400	Flowing
49.527	4/ 5/82	23.1	M	454	Flowing
49.767	4/ 5/82	23.1	F	413	Gravid

*Tag transferred to this fish when the original recipient became stressed during recapture.

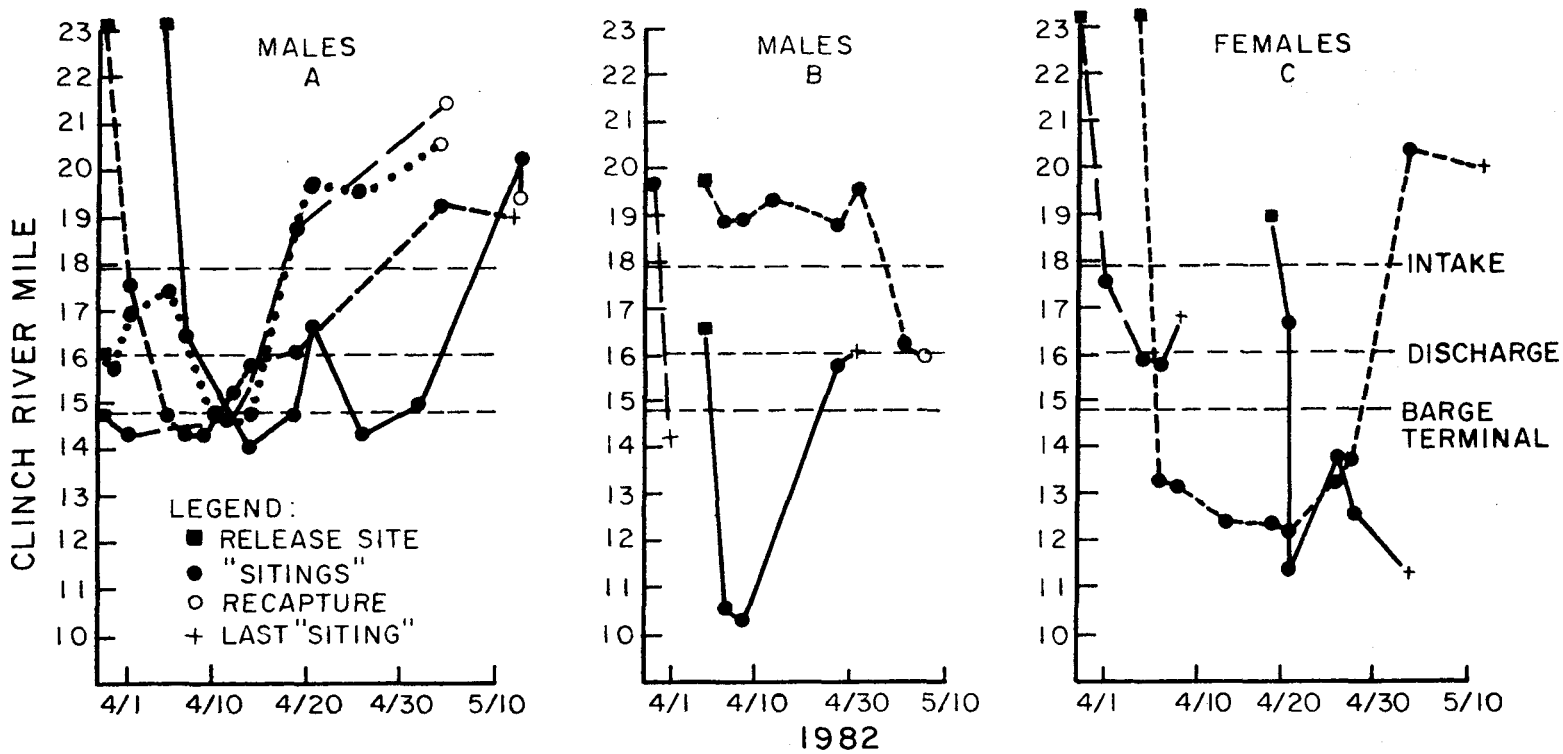

Figure 4. Movement of 10 adult sauger equipped with radio transmitters and released in the Clinch River near the CRBRP site, March through May 1982.

move mostly in an upstream direction (Figure 4a). However, one male (Figure 4b) and one female (Figure 4c) showed little movement for a period of several days. Overall, the telemetry data showed considerable independent movement of fish throughout the upper 12 miles of the Clinch River portion of Watts Bar Reservoir and, following considerable downstream movement immediately after tagging by seven of ten individuals, a gradual upstream advancement of five tagged fish beginning the second week of April.

A total of 622.4 gill netting hours yielded 742 sauger, for an average catch per unit effort (c/f) of 1.19 sauger per net hour. Netting at transmitter fish locations showed high sauger concentrations only at CRM 18.8 and 20.2. At CRM 18.8, where two transmitter-tagged fish were present on April 19, c/f was 11.2. At CRM 20.2 (Jones Island), where four transmitter fish were present on May 5, c/f was 4.4 sauger per net hour. These findings suggested these transmitter-tagged fish were part of an aggregation of sauger which eventually concentrated in the section of river from CRM 18.8 to 20.9. Netting at transmitter-tagged fish locations downstream from 18.8 did not yield catch rates as high as at upstream locations.

Netting at 55 sites between CRM 9.5 and 23.1 revealed sauger were most abundant in the upper 8.8 miles (CRM 14.3 to 23.1) of the study area (Figure 5). Of 150 total net sets throughout the study area, all sets resulting in c/f values $\geq$ three fish per net hour were in these upper 8.8 miles (Table 2). Highest c/f was at CRM 19.7 (Jones Island), at CRM 18.8 (between Jones and Grubb Islands), and at CRM 16.0 (CRBRP discharge location). This is consistent with findings from radio telemetry, which showed most transmitter-tagged fish frequented this upstream section of the study area.

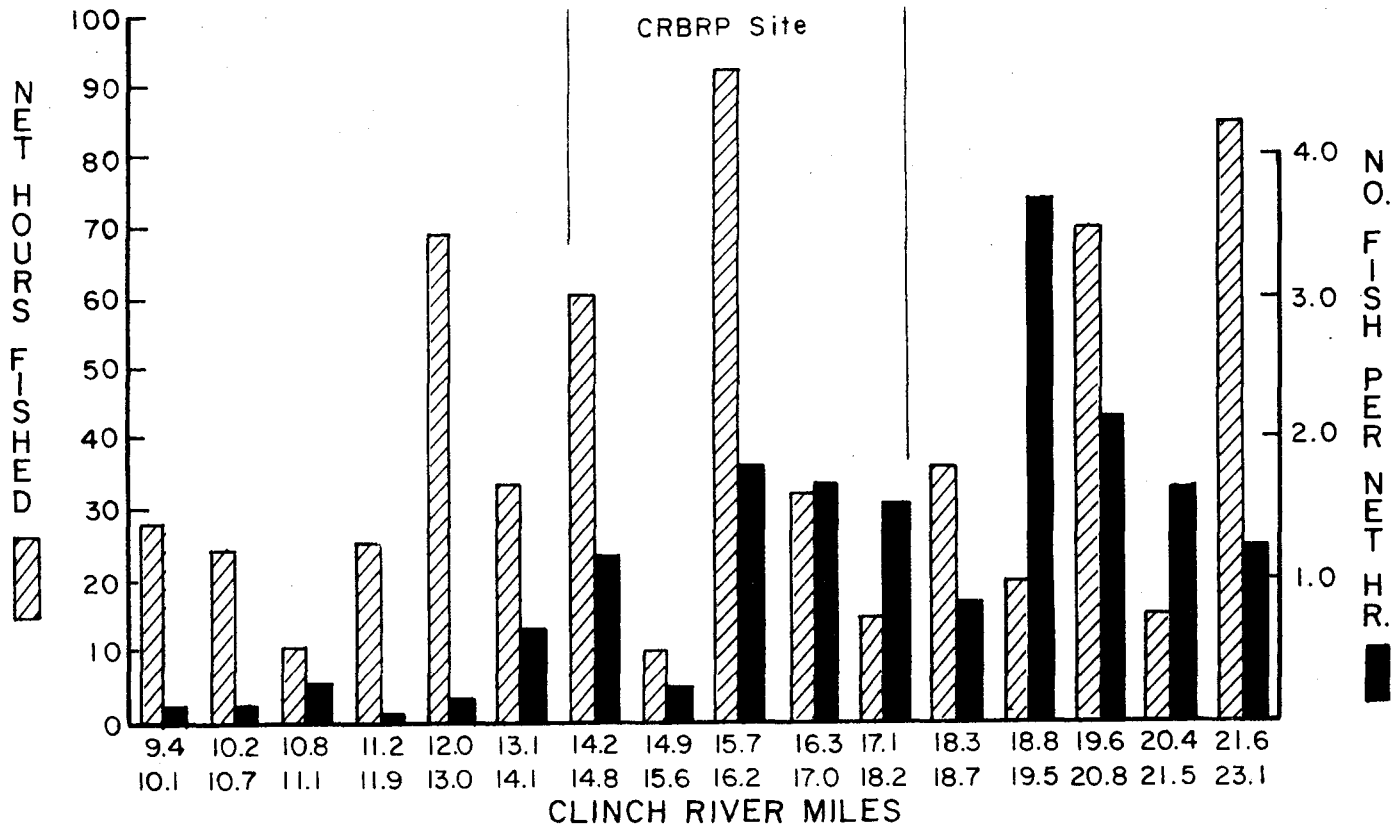

Figure 5. Gill netting effort and c/f of sauger during a spawning investigation near the CRBRP site, March through May 1982.

Table 2. Sites That Yielded Gill Net C/F Values ≥ Three Sauger Per Net Hour During the CRBRP Sauger Spawning Investigation, March through May 1982

Clinch River Mile	Location	Date	No. Fish per Net Hour
23.1	Melton Hill Dam	April 6	3.00
23.0	Melton Hill Dam	April 12	3.07
23.0	Melton Hill Dam	April 6	3.00
22.5	Melton Hill Dam	April 12	3.13
20.2	Jones Island	May 5	4.39
20.2	Jones Island	April 26	3.23
19.7	Jones Island	April 19	3.68
19.7	Jones Island	April 19	9.43
18.8	Upstream of Grubb Island	April 28	5.25
18.8	Upstream of Grubb Island	April 19	11.23
18.7	Upstream of Grubb Island	April 19	3.33
16.6	Upstream of CRBRP Discharge Site	April 5	4.59
16.1	CRBRP Discharge Site	April 19	8.16
16.0	CRBRP Discharge Site	April 28	7.50
16.0	CRBRP Discharge Site	April 5	9.95
16.0	CRBRP Discharge Site	March 31	4.40
16.0	CRBRP Discharge Site	March 29	3.79
14.7	CRBRP Barge Facility Site	April 24	3.82
14.5	CRBRP Barge Facility Site	April 24	5.33

Females were almost always more abundant than males near the dam, comprising 50 to 100 percent of the catch on individual sampling dates (Table 3). At downstream stations between CRM 21.5 and 9.4, females were much less abundant than males (3 to 46 percent of catch) throughout the study (Table 3). During the entire study, females comprised only 24 percent of total catch.

Individuals termed immature, unknown, gravid, flowing, or spent constituted 5, 45, 45, 2, and 3 percent, respectively of all females captured. Differences in proportion of gravid, flowing, and spent females likely reflects relative time fish in one of these conditions were in the study area and available for capture. Females were in the study area for up to several weeks in the gravid condition, but were probably flowing for only a short time. Length of time female sauger spawn is not in the literature, but a close relative, the walleye (Stizostedion vitreum vitreum) has been reported to complete spawning in a single night (Priegel 1969). Females probably left the study area soon after spawning (Nelson 1968, Scott and Crossman 1973).

Flowing female sauger were a strong indication of spawning at or near their location of capture. A flowing female was captured April 5 at CRM 16.6, April 19 at CRM 16.1, April 26 at CRM 23.1, and May 12 at CRM 19.5. The best example of spawning was at CRM 16.1 (April 19), when a female released eggs freely as the net was pulled into the boat. Several freely flowing males surrounded her in the net, further suggesting spawning at the time of capture. Fletcher (1977) reported two spawning clusters (flowing males in close proximity to a flowing female in a gill net) at CRM 14.7 in April 1976. Capture of these flowing females suggests sauger spawning is not restricted to one small area.

Table 3. Percentage Female Sauger Collected in Gill Nets Near Melton Hill Dam Vs Downstream Stations, CRBRP Sauger Investigation, March through May 1982

Date	Percentage Female of Total Catch	
	CRM 23.1 to 22.4	CRM 21.5 to 9.4
3/16	100	13
3/22	63	-
3/29	81	18
3/31	-*	15
4/5	-	8
4/6	50	-
4/7	-	17
4/12	71	19
4/14	-	46
4/19	80	16
4/21	-	21
4/24	-	21
4/26	75	3
4/28	-	18
5/5	57	6
5/12	-	12
Weighted Mean	78	16

*Denotes no netting effort.

Determination of Spawning Season

Average weekly c/f of males peaked during mid- to late April, increasing two-fold over earlier and later portions of the study (Figure 6). Highest c/f was on April 19, when c/f values ranged from 3.33 to 11.23 fish per net hour at five netting stations. This high c/f, coupled with presence of an obvious spawning cluster at CRM 16.1, suggested peak spawning was on or about 19 April.

Several near-flowing females (i.e., they readily extruded eggs with moderate pressure) were collected during the study. These observations do not positively identify specific spawning sites but help define length of spawning season and time of peak spawning activity. On March 29 a near-flowing female was collected at the dam and taken to the laboratory for use in the flume experiment. The following day she spawned her eggs in the holding tank. Other near-flowing females were collected on April 5 (1 fish), 7 (1 fish), 12 (2 fish), 19 (4 or 5 fish) and 23 (3 fish). Several of these fish were taken to the laboratory, and all were flowing within one or two days. Had they been left in the river, these fish likely would have been in flowing condition soon. In summary, although some spawning may have occurred during late March to early April, presence of flowing and near-flowing females and peak c/f of males strongly suggested peak spawning was in mid- to late April.

Movements of Floy-Tagged Sauger

A total of 411 sauger (90 females and 321 males) were marked with individually numbered Floy tags. Eleven females and 72 males were recaptured (including recaptured transmitter-tagged fish and double recaptures of Floy-

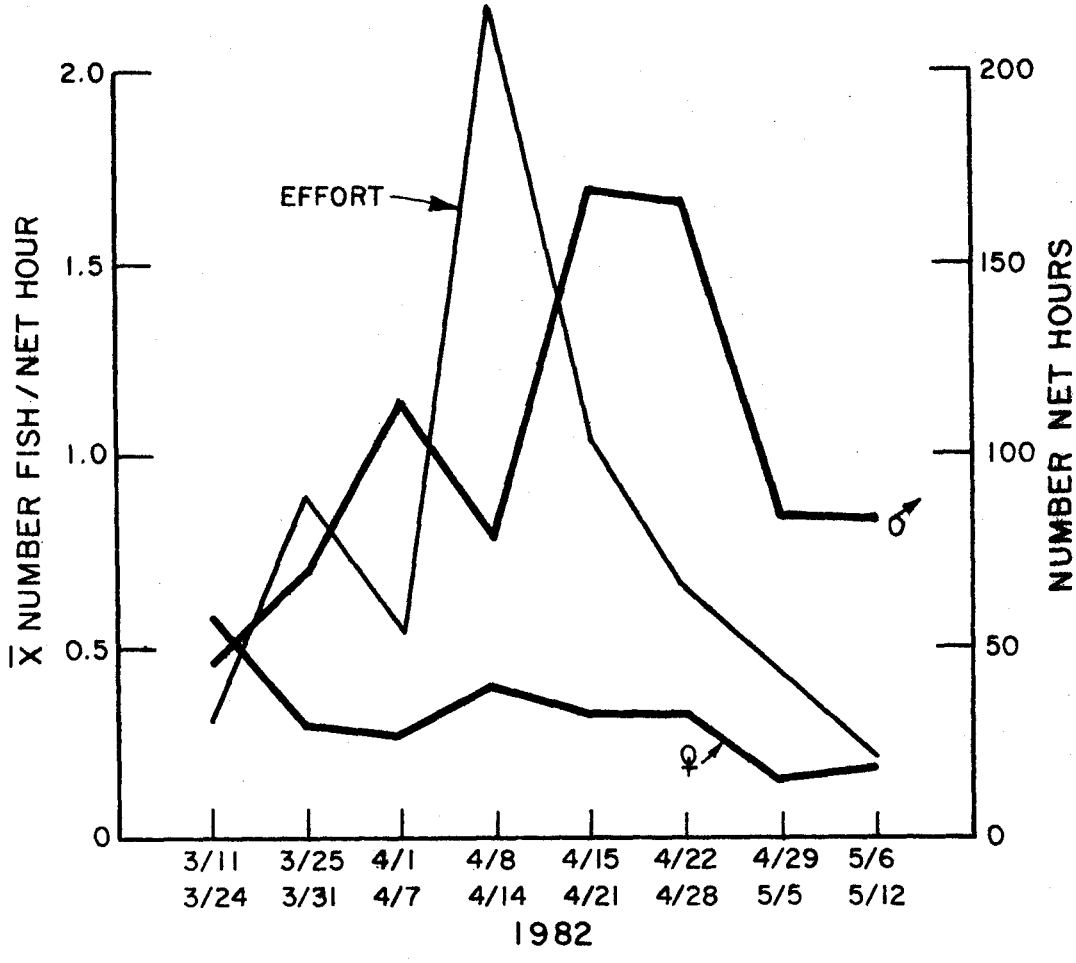

Figure 6. Gill net fishing effort and mean number of sauger per gill net hour near the CRBRP site, March through May 1982.

tagged fish). Recapture data, like the telemetry data, suggested individuals moved considerably throughout the study area rather than residing in localized areas throughout the spawning season (Figure 7).

Few recaptures at the dam after mid-April (Figure 7) suggested sauger do not return to the dam during the several weeks they are in the area. This pattern was also observed with the transmitter-tagged fish, which ranged throughout the area upstream of CRM 10.0, but were not found at the dam (Figure 4).

Movement of sauger from the Clinch to the Tennessee River of Watts Bar Reservoir during the spawning season was substantiated when a fisherman captured a Floy-tagged individual near Fort Loudoun Dam. This fish traveled a minimum of 44 miles in 18 days from its release site on the Clinch River on April 14.

Residence Time in the Study Area

Determining total residence time in the study area was not possible since it would have required capture of individual fish as they first entered and finally left the area. However, recaptures of several Floy-tagged sauger and monitoring of transmitter-tagged fish revealed minimum length of time these fish were in the study area. Many sauger were already present in the study area when sampling was initiated and may have been there for several weeks or even months. Some sauger are present near the dam by late December following the onset of cold weather.

Recapture data indicated males stayed in the study area longer than females. Median elapsed time between capture and recapture was 7 days for 11 Floy-tagged females and ranged from 5 to 20 days. Median elapsed time for 61 Floy-tagged males was 14 days and ranged from 1 to 44 days. Longer

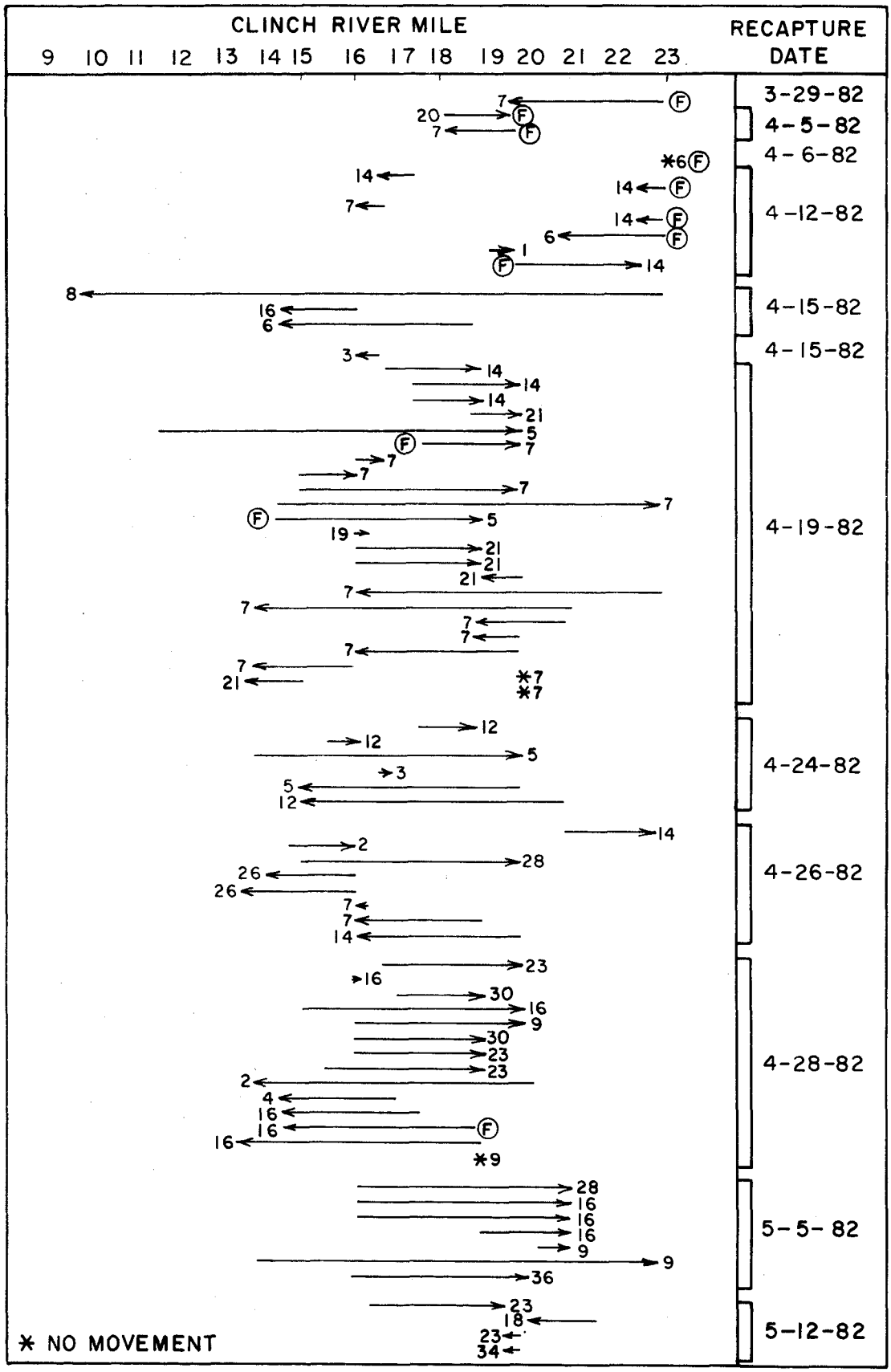

Figure 7. Movement of sauger and days at liberty from time of initial capture to recapture in gill nets set near the CRBRP site, March 16 through May 12 1982. Females denoted by circled F.

residence time for males is also suggested by the higher percentage of males recaptured (19.0 percent) compared to females (12.2). Telemetry data also indicated longer residence time in the study area for males (Figure 4). Elapsed time for males from release until last siting or recapture ranged from 4 to 45 days with a median of 37 days. Three transmitter-tagged females were tracked for 11, 15, and 37 days.

Sauger Abundance

Broad-boundary estimates of number of fish present during mid-to late April suggest less than 2,000 adult males and less than 1,000 adult females were present during the several week spawning season.

Fecundity

Estimates of egg production are in Table 4. Average estimated number of eggs per 453.6 grams (1 pound) of fish weight was 37,732, which is comparable to findings reported by others as cited by Priegel (1969).

Table 4. Fecundity Estimates for Three Female Sauger from the Clinch River Downstream from Melton Hill Dam, 1982

Total Fish Length (mm)	Fish Weight (gms)	Number of Eggs in Subsample	Estimated Total Number of Eggs
363	410	1,568	31,093
392	565	2,980	41,022
440	865	2,013	80,943

Available Spawning Substrate

Other investigators (Graham and Penkal 1978 and Priegel 1969) report sauger eggs are most abundant in gravel or gravel-cobble substrates and are less abundant in substrate containing sand or silt. Figure 8

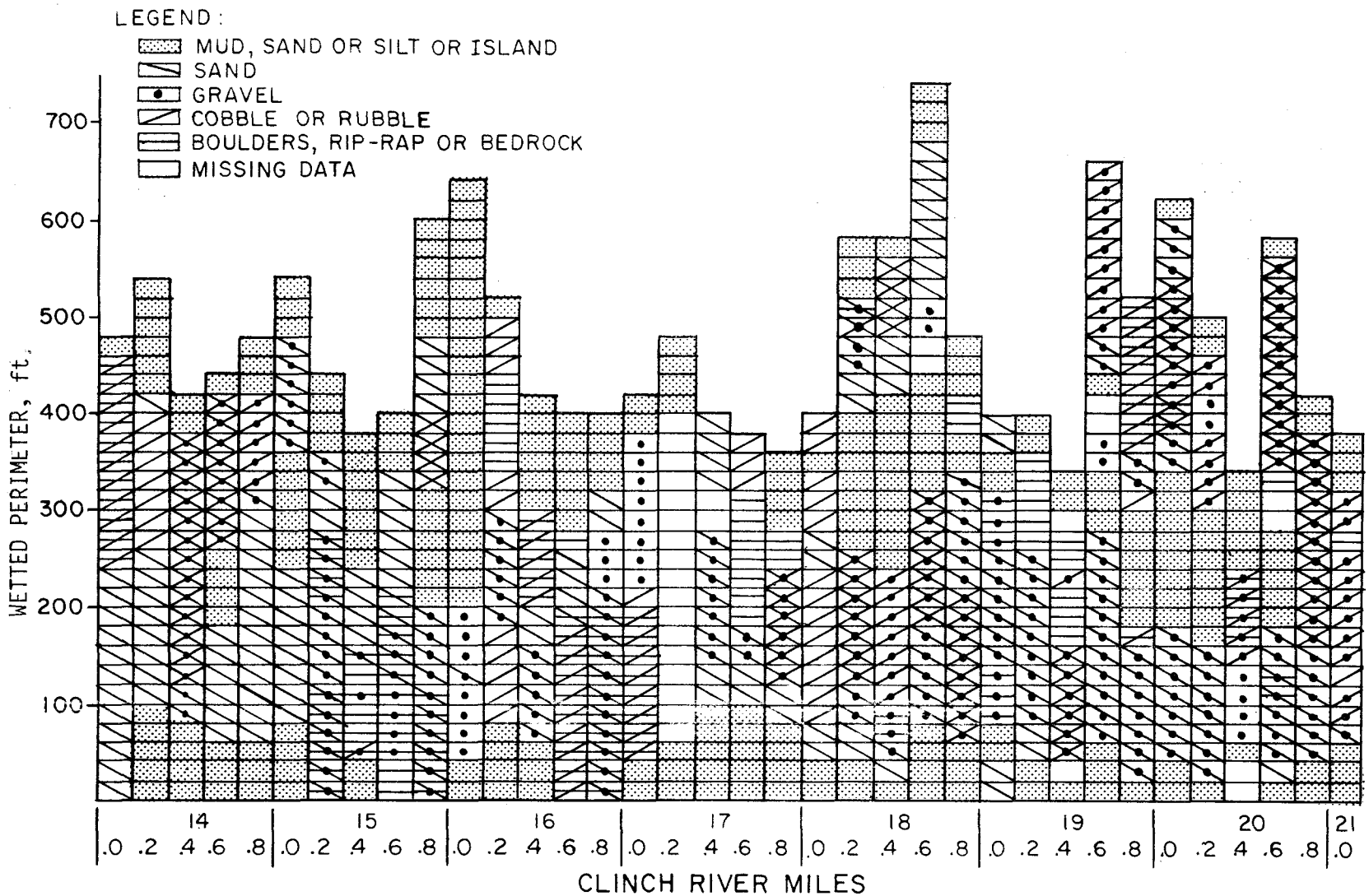

Figure 8. Diagrammatic representation of 20-ft. intervals examined for substrate type by scuba divers along each transect during a TVA mussel survey in May and June 1982 at Clinch River Miles 14.0 to 21.0. The left bank (facing downstream) is shown as a straight line at the bottom of the figure.

depicts Clinch River substrate types as described by SCUBA divers during the 1982 mussel survey. Differences in judgment among divers (primarily, whether to include sand in combination with other types of substrate) precluded a totally comparable description of actual substrate types. However, areas containing predominantly gravel, cobble, rubble, boulders, riprap, bedrock, or sand are probably fairly comparable. A fine layer of silt covered the entire area but was included in the descriptions only where it was the dominant substrate in the transect.

Potential sauger spawning sites, containing gravel and/or cobble, comprised 50 percent of all 20-foot intervals examined during the mussel survey (Figure 8). This type substrate was found in areas upstream and downstream of the plant site and in the area adjacent to the plant. Ideal spawning substrate (gravel and/or gravel-cobble with little or no sand present) is present in the main channel adjacent to Jones Island (CRM's 19.6, 20.2, 20.4) and Grubb Island (CRM 18.4); at CRM's 16.8 and 17.0; and near the barge unloading site at CRM 14.8 (Figure 8).

Egg Sampling

Flume experiments conducted before egg sampling was started showed both fertilized and unfertilized eggs were strongly adhesive and suggested eggs spawned on or near the substrate in the Clinch River would have settled and attached in the immediate spawning vicinity. Four days of initial experimental towing and 64 100-yd (91.4 m) tows on six subsequent days yielded 47 sauger eggs. Of 23 sample locations between CRM 14.7 and 23.1, sauger eggs were collected at only 8 (CRM's 14.7, 16.0, 18.5 18.9, 19.8,

20.1, 20.8, and 23.1; Figures 9 and 10 and Table 5). Eggs were present at depths ranging from 3 to 7.5 m. Egg abundance was greatest in the uppermost four miles of the study area.

Much of the substrate around CRM 14.8, the site of the CRBRP barge unloading facility, consists of combinations which include sand or fines. However, a 15.0 m wide zone of gravel-cobble substrate is present in the main channel adjacent to the right bank. Four sauger eggs were collected from this area. The most abundant substrate type at the proposed discharge site, CRM 16.0, is sand-gravel. Sampling over 739 m^2 at this location yielded only three eggs. Distinct zones of cobble were located near the left and right banks and at mid-channel immediately upstream at CRM 16.2 (Figure 8). These zones range from 6 to 15 m wide. Eggs were not sampled at the intake site since there was no indication from monitoring adult fish movement and concentration that sauger spawned in that area. The mussel survey did not reveal ideal spawning substrate in this immediate area.

Substrate from CRM 21.0 to 23.1 was not examined in the mussel survey, but immediately downstream from Melton Hill Dam, where 18 eggs were collected, very little sand was present in egg samples. Thus, the substrate survey indicated potential sauger spawning habitat is present throughout the study area, with ideal habitat at several localized areas.

Egg density (number of eggs/m^2 of substrate sampled) was only 0.013. This value multiplied by 1.03×10^6 m^2 of potential spawning area between CRM 14.0 and 23.1 is only 13,387 eggs, which is equivalent to a small fraction of eggs in a single gravid female. This low density probably does not reflect ineffectiveness of the sampler since 2,090 eggs of shad, minnows, suckers, darters, and temperate bass and 62 larvae of these families were collected. Further, from tests in the laboratory to examine adhesiveness of

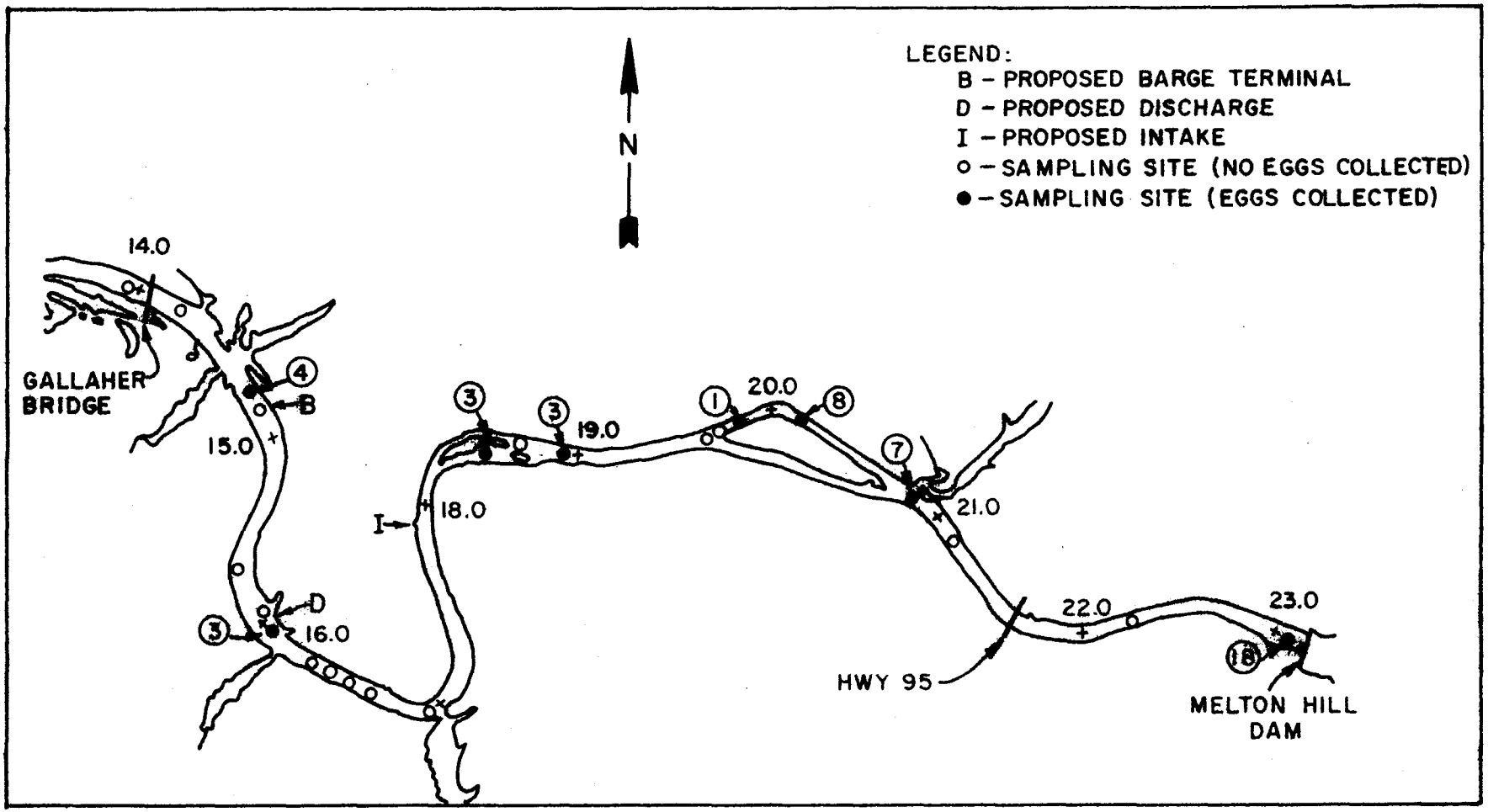

Figure 9 : Sample stations and number of sauger eggs (numeral circled) collected in the vicinity of the CRBRP site, April and May 1982.

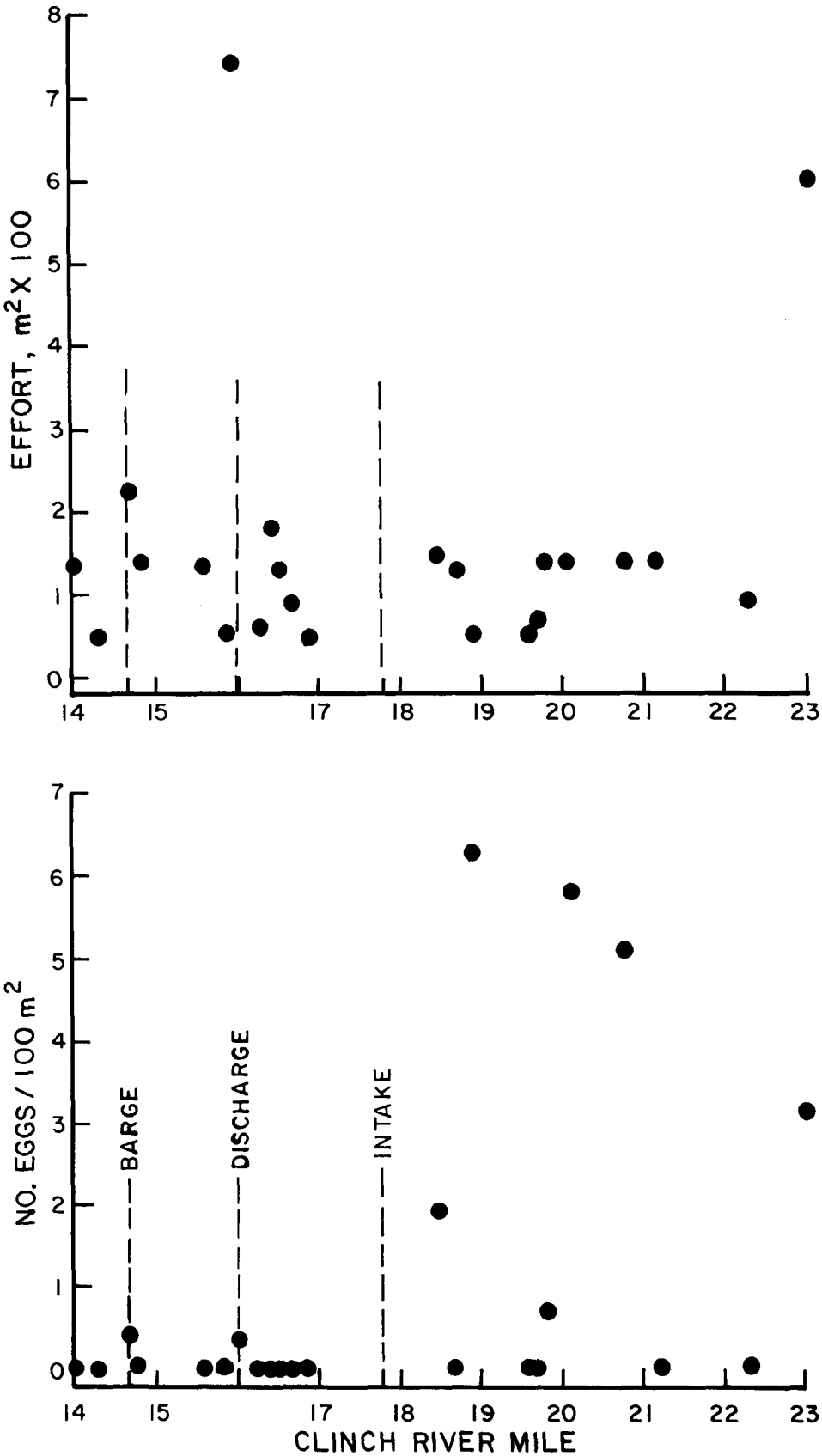

Figure 10. Sample effort and c/f of sauger eggs in the Clinch River near the CRBRP site, April and May 1982.

Table 5. Sampling Effort (Area of Substrate in M^2) and Number of Sauger Eggs Collected (in Parentheses) by Location and Date, CRBRP Sauger Investigation March through May 1982

Clinch River Mile	1982 April 21	April 23	April 26	April 27	April 28	April 29	May 4	May 7	May 11	May 14	Total
					Upstream of Plant Site						
23.1	-	-	-	-	138(10)	-	138(1)	138(4)	184(3)	-	598(18)
22.3	-	-	-	-	-	-	-	-	92(0)	-	92(0)
21.2	-	-	-	-	138(0)	-	-	-	-	-	138(0)
20.8	-	-	-	-	-	-	-	138(7)	-	-	138(7)
20.1	-	-	-	-	-	-	-	138(8)	-	-	138(8)
19.8	-	-	-	-	138(1)	-	-	-	-	-	138(1)
19.7	67(0)	-	-	-	-	-	-	-	-	-	67(0)
19.6	46(0)	-	-	-	-	-	-	-	-	-	46(0)
18.9	49(3)	-	-	-	-	-	-	-	-	-	49(3)
18.7	-	-	-	-	138(0)	-	-	-	-	-	138(0)
18.5	43(0)	-	-	-	-	-	-	-	-	106(3)	149(3)
											1691(40)
					Adjacent to Plant Site						
16.9	-	-	-	-	-	-	-	-	46(0)	-	46(0)
16.7	49(0)	-	-	-	46(0)	-	-	-	-	-	95(0)
16.5	-	-	-	-	-	138(0)	-	-	-	-	138(0)
16.4	-	-	-	-	-	-	138(0)	-	46(0)	-	184(0)
16.3	-	-	-	46(0)	-	-	-	-	-	-	46(0)
16.0	91(2)	259(1)	159(0)	46(0)	-	138(0)	-	-	46(0)	-	739(3)
15.9	-	-	-	-	-	-	-	-	46(0)	-	46(0)
15.6	-	-	-	-	-	-	-	-	138(0)	-	138(0)
14.8	-	-	-	-	-	-	-	-	138(0)	-	138(0)
14.7	-	-	-	-	-	138(4)	-	-	92(0)	-	230(4)
											1800(7)
					Downstream of Plant Site						
14.3	-	-	-	-	-	-	46(0)	-	-	-	46(0)
14.0	-	-	-	-	-	-	-	138(0)	-	-	138(0)
											184(0)
TOTALS	(5)	(1)	(0)	(0)	(11)	(4)	(1)	(19)			3675(47)

sauger eggs, it was apparent eggs were sufficiently large to see significant concentrations with the naked eye during SCUBA accompaniment of the sled. However, no eggs were observed on the river bottom during times divers accompanied the sled. Possible reasons for the low density observed in samples are discussed later in the report.

DISCUSSION

Sauger movement was more complex than the simple hypothesized pattern of fish migrating directly to Melton Hill Dam, retreating downstream and congregating in suitable spawning location(s), spawning, and returning to the main portion of Watts Bar Reservoir. Although this seems to be generally what occurs, much more upstream/downstream movement was observed than expected.

Watts Bar sauger face two conditions not encountered by those living in natural lakes and free-flowing streams. The most obvious is the dam, which blocks migration and requires fish to spawn in areas they probably would have bypassed had the dam not been present.

Secondly, fish present in the Clinch River downstream from Melton Hill Dam are subjected to on or off flows rather than less variable flows characteristic of unregulated streams. During the study, flow was either 10,000 cfs (one-unit generation), 20,000 cfs (two-unit generation), or zero cfs (no generation), neglecting very low upstream and downstream current oscillations caused by generation at Fort Loudoun and Watts Bar Dams. Generation at Melton Hill Dam usually did not exceed a few hours per day, and in some cases there was no generation in a 24-hour period. It is possible these two conditions significantly influence upstream/downstream movement patterns and sauger spawning activity.

Netting data alone would lead one to conclude the discharge area (CRM 16.0) as well as a few upstream locations, particularly between Grubb Island and the upstream end of Jones Island, are primary spawning locations. The best observation of sauger in the act of spawning was at CRM 16.1. However, results of radio telemetry, substrate analysis, and egg

sampling indicated the site adjacent to the discharge (CRM 16.0) may not be as important a spawning site as some other areas, even though large numbers of fish frequented this area.

The study was designed to first locate probable spawning sites by determining location of congregating adult sauger, followed by verification that they were at or near spawning condition, and finally, to confirm that spawning had occurred at those sites by collecting eggs. Thus, egg presence was to be the primary basis for spawning site determination. Despite the small number of eggs collected, egg samples showed sauger spawning was not limited to a localized area adjacent to the CRBRP site. However, collection of relatively few eggs did not permit a quantitative comparison among areas as to their relative importance as spawning locations. High catch per effort of adults in gill nets adjacent to Jones Island between CRM 19.6 and 20.8 corresponded to relatively greater numbers of eggs collected in that area. By contrast, at CRM 16.0 (the discharge location), where large numbers of adults were found and egg sampling effort was greatest, only three eggs were collected.

Egg distribution depends on where they are released in the water column, current velocity, and how far the female travels while releasing eggs. If sauger rush to the surface to spawn, as noted by Priegel (personal communication) in Lake Winnebago but not observed in this study, by the time the eggs sink 7.5 m they could be widely distributed. In the laboratory, eggs released from a female held over a 1.5-m column of water sank at a rate ranging from 0.8 to 1.5 m/min. Thus, if eggs are released much above the substrate during one- or two-unit generation they would be dispersed and carried considerable distances downstream before they settled and attached to the river bottom. In this study sauger (including flowing females) were

typically captured in the lower half of the gill nets in deep water. No evidence was obtained to suggest they spawn near the surface in the Clinch River. Release of eggs may occur near the surface in other water bodies where spawning occurs in shallow water, but this does not appear to happen in the Clinch River. Spawning depths of 0.6 to 3.7 m reported in other investigations (Scott and Crossman 1973) were much less than the 6.0 to 7.5 m depths from which most eggs were collected in this study.

Since a spawning female releases several thousand eggs, one would expect a very high initial density of eggs in the particular area where spawning occurred. Thus, if the sled sampled an area where spawning occurred, one would expect to collect a large number of eggs; yet the maximum number of eggs collected from an individual tow was eight.

One of several possibilities which could explain low egg densities observed is transfer of some eggs out of the study area by high current velocities during generation at Melton Hill Dam. During two-unit generation water velocities ranged from 3.5 fps 1.0 m from the water surface to 2.6 fps within 0.5 m of the bottom near CRM 14 (Goranflo, personal communication) and probably decreased significantly at the water/river-bottom interface. In the laboratory, eggs attached to rock substrate were subjected to velocities up to 1.1 fps (measured a few millimeters above the egg with laser velocimetry). Although results of the laboratory study showed sauger eggs strongly adhered to rock substrate during development, high flows during operation of Melton Hill Dam could likely cause some movement of eggs within the study area.

A second explanation for observed low egg densities is low probability of sampling the right place at the right time. There is approximately 1.03×10^6 m^2 of potential spawning habitat between CRM 14.0 and 23.1. Assuming a liberal estimate of 500 females, with spawning by

individuals confined to a relatively small area, a total sampling effort of 3,675 m^2 over several weeks could easily miss areas of high egg density. Considering the potential for high initial mortality of eggs has the effect of further decreasing the probability of sampling an area of high egg density.

The third and probable explanation for relatively low egg density observed is high mortality. On May 13 at approximately 2:00 a.m., an impromptu experiment was conducted. A small flowing female was captured at Jones Island and taken to CRM 18.5, where gravel substrate was present. A weighted buoy was placed next to the boat in approximately 5 m of water. The female was then spawned in a bucket of water. With constant swirling to minimize number of eggs settling and adhering to the bottom of the bucket, milt from two males was added to fertilize the eggs (several hundred eggs were returned to the laboratory where hatching six days later confirmed fertilization). Immediately after adding milt, the eggs (estimated at 20,000 to 30,000) were poured overboard next to the buoy. At the time the eggs were released there was no generation at the dam and no apparent flow in the river. The eggs were observed to slowly sink vertically from the release point.

Approximately 36 hours later, with visibility nearly 1 m, SCUBA divers searched the area and found no eggs. Immediately after searching the area, five parallel sled tows of approximately 30 to 45 m were made in the immediate area of the buoy. Only six sauger eggs were collected. These eggs were in an early stage of development and could have been among those artificially spawned. As there was no generation from Melton Hill Dam during the 36-hour experiment, disappearance of eggs was not a result of dispersal by current. The importance of predation in this area is unknown but must be considered a likely cause of egg disappearance. Fletcher (1977) listed 76

fish species collected in this area between 1960 and 1977. Many of these probably eat eggs. If heavy predation is typical, high densities of eggs would be present for only a relatively short period following spawning.

This explanation seems the most plausible since factors one and two were not present during the egg stocking experiment; i.e., there was no current to move these eggs from the area, and egg location was known exactly. Although explanations one and two may be real phenomena and contribute to low numbers of eggs found, a dramatic decrease in egg abundance obviously occurred in their absence.

Available data revealed adult sauger congregated at the discharge site, and some spawning evidently occurred at both this location and the barge terminal site. However, relative scarcity of eggs at these two locations compared to egg abundance at upstream sites suggests the discharge and barge terminal sites were relatively unimportant for sauger spawning. Relatively few eggs collected did not permit precise quantified comparisons of relative importance among areas for sauger reproduction.

CONCLUSION

Sauger spawning in the Clinch River arm of Watts Bar Reservoir appeared to be widely dispersed throughout nine miles of river downstream from Melton Hill Dam. Several locations within this nine-mile section (including the area adjacent to the CRBRP site) were utilized for spawning. Factors revealing spawning at particular sites included movement and abundance of adult sauger, presence of flowing females, and most importantly, presence of eggs. Spawning occurred between early April and mid-May with a peak from mid- to late April.

Based on results of combined facets of the study, construction of instream facilities will disrupt a very small portion of sauger spawning habitat in the Clinch River. Egg presence suggested several areas upstream of the CRBRP site were more important for sauger spawning than areas adjacent to the plant site. However, collection of low numbers of eggs relative to amount potentially available precludes making a quantitative comparison of relative importance among spawning locations. Except for this reservation it can be concluded that construction of instream facilities would probably have an insignificant effect on sauger spawning in the Clinch River arm of Watts Bar Reservoir.

LITERATURE CITED

Fletcher, J. W., 1977. Assessment of adult and larval fish populations of the lower Clinch River below Melton Hill Dam. Masters Thesis. Tenn. Tech. Univ. Cookeville, Tennessee. 90 p.

Graham, Patrick J., and R. F. Penkal, 1978. Aquatic environmental analysis in the lower Yellowstone River. Montana Department of Fish and Game, Ecology Service Division. 102 p.

Jenkinson, John J., 1982. Freshwater mussel and substrate survey of the lower Clinch River, Roane County, Tennessee. Tennessee Valley Authority, Division of Water Resources, Fisheries, and Aquatic Ecology Branch, 18 p.

Nelson, William R., 1968. Reproduction and early life history of sauger, Stizostedion canadense, in Lewis and Clark Lake. Tran. Amer. Fish. Soc. 97(2):159-166.

Priegel, Gordon R., 1969. The Lake Winnebago sauger: age, growth, reproduction, food habits and early life history. Tech. Bull. No. 43. Dept. of Natural Resources, Madison, Wisconsin. 63 p.

Ricker, W. E., 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Bd. Canada 191:328 p.

Scott, E. M., 1980. Clinch River Sauger Study. Unpublished Tennessee Valley Authority Report.

Scott, W. B. and E. J. Crossman, 1973. Freshwater fishes of Canada, Bulletin 184, Fisheries Research Board at Canada, Ottawa. pp. 762-766.

Winter, J. D., V. B. Kuachle, D. B. Siniff, and J. R. Tester, 1978. Equipment and methods for radio tracking freshwater fish. Misc. Report 152. Univ. Minn. Ag-Exp. Station 18 p.