Tennessee Valley Authority, Post Office Box 2000, Spring City, Tennessee 37381-2000

June 11, 2012

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U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555-0001

Watts Bar Nuclear Plant Unit 2
Docket No. 50-391

Subject: **Estimates of Entrainment of Fish Eggs and Larvae at Watts Bar Nuclear Plant at Tennessee River Mile 528 from March 2010 through March 2011 (TAC No. MD8203)**

Reference: TVA letter dated April 9, 2010, "Watts Bar Nuclear Plant (WBN) Unit 2 - Response to U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information Regarding Environmental Review (TAC No. MD8203)"

The purpose of this letter is to provide a report entitled, "Estimates of Entrainment of Fish Eggs and Larvae at Watts Bar Nuclear Plant at Tennessee River Mile 528 from March 2010 through March 2011," dated May 2012. As discussed in Reference 1 Question AE-7, TVA planned to perform additional aquatic monitoring during 2010-2011 in the Watts Bar and Chickamauga Reservoirs in the vicinity of Watts Bar Nuclear Plant. The enclosed report presents the results of the ichthyoplankton monitoring conducted during 2010-2011 to describe taxonomic composition, abundance, and temporal and spatial distribution in the vicinity of WBN and to estimate entrainment of fish eggs and larvae at the WBN Intake Pumping Station (IPS) and Supplemental Condenser Cooling Water (SCCW) intake due to the proposed operation of Unit 2 at the plant site. The monitoring began March 2010 and updates and verifies historical monitoring conducted in 1996 and 1997. As stated in Reference 1, additional monitoring will be undertaken after Unit 2 begins operation.

There are no new commitments made in this letter. If you have any questions, please contact Gordon Arent at (423) 365-2004.

D030
NRR

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 11th day of June, 2012.

Respectfully,

R.A. Hruby, Jr.

Raymond A. Hruby, Jr.
General Manager, Technical Services
Watts Bar Unit 2

Enclosure:

Estimates of Entrainment of Fish Eggs and Larvae at Watts Bar Nuclear Plant at Tennessee River Mile 528 from March 2010 through March 2011

cc (Enclosure):

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ENCLOSURE

Estimates of Entrainment of Fish Eggs and Larvae at Watts Bar Nuclear Plant at Tennessee River Mile 528 from March 2010 through March 2011

Estimates of Entrainment of Fish Eggs and Larvae at Watts Bar Nuclear Plant at Tennessee River Mile 528 from March 2010 through March 2011

TENNESSEE VALLEY AUTHORITY

Engineering, Environment & Support Services

MAY 2012

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Abbreviations and Acronyms

cfs	cubic feet per second
fps	feet per second
IPS	Intake Pumping Station
msl	mean sea level
SCCW	Supplemental Condenser Cooling Water
TRM	Tennessee River Mile
TVA	Tennessee Valley Authority
WBH	Watts Bar Hydroelectric Dam
WBN	Watts Bar Nuclear Plant

Introduction

Tennessee Valley Authority (TVA) conducted ichthyoplankton monitoring during 2010-2011 to describe taxonomic composition, abundance, and temporal and spatial distribution in the vicinity of Watts Bar Nuclear Plant (WBN) and to estimate entrainment of fish eggs and larvae at the WBN Intake Pumping Station (IPS) and Supplemental Condenser Cooling Water (SCCW) intake due to the proposed operation of an additional nuclear reactor (Unit 2) at the Plant site. This monitoring began March 2010 and updates and verifies historical monitoring conducted in 1996 and 1997. This report presents taxonomic composition, temporal and spatial distribution, densities and estimated entrainment during March 2010 through March 2011, comparison of these data with data collected during 1996 and 1997, and entrainment estimates with the addition of Unit 2.

Location and General Site Characteristics

WBN is located on the right descending (west) bank of upper Chickamauga Reservoir at Tennessee River Mile (TRM) 528 approximately 1.9 miles downstream of Watts Bar Hydroelectric Dam (WBH; TRM 529.9) and one mile downstream of the decommissioned Watts Bar Fossil Plant (Figure 1). At the plant site, Chickamauga Reservoir is 335.5 meters (m) wide with mid-channel depths ranging from 5.5 m to 7.9 m. Flow and water levels at the site are regulated by the operation of TVA's Watts Bar and Chickamauga dams. The running long-term daily average river flow past WBN from 1942 to present, as measured from Watts Bar Hydroelectric Dam (WBH) discharge, is 27,047 cubic feet per second (cfs). During the period from March 2010 through March 2011, daily average river flow past WBN was 19,308 cfs.

Plant Description

WBN Unit 1 went into commercial operation on May 27, 1996 and is designed for a net electrical output of 1,160 megawatts (gross electrical output of 1,218 megawatts). Unit 2, of similar size, is under construction on the same site.

Intake Pumping Station

Cooling water flows from Chickamauga Reservoir through the plant intake channel to the IPS located approximately 1.9 miles downstream of WBH at TRM 528 (Figure 1). WBN Unit 1 and proposed Unit 2 use closed-cycle cooling such that the cooling water withdrawn at the intake pumping station is to make up for evaporation and for cooling tower blowdown. The intake channel leading to the pumping station has a cross-sectional area of approximately 1,650 ft^2 at Chickamauga Reservoir winter pool elevation of 677 ft mean sea level (msl), and 3,159 ft^2 at summer pool elevation of 681 ft msl. The IPS includes four gated openings containing a combined gross flow area of approximately 360 ft^2, producing a maximum average velocity at the entrance of IPS of 0.17 fps at summer pool and 0.18 fps at winter pool. The maximum average approach velocity entering the IPS wet well for the traveling water screens at summer and winter pools is 0.40 and 0.37 fps, respectively. At the traveling water screens, the combined unobstructed through-screen area of the flow corresponding to the gated openings is reduced to approximately 140 ft^2, producing a maximum average through-screen velocity of 0.62 fps at summer pool and 0.67 fps at winter pool (Table 1).

The maximum average flow rate at the IPS for WBN Unit 1 only is approximately 73 cfs at summer pool and 68 cfs at winter pool. Hydraulic entrainment for Unit 1 at summer and winter pools is 0.3% of the long-term average river flow past the plant (27,047 cfs). With the operation of both Unit 1 and proposed Unit 2, the maximum average flow rate at the IPS at summer pool is expected to be 134 cfs, or 0.5% of the long-term average river flow past the plant. At winter pool, the average flow rate with operation of both Unit 1 and proposed Unit 2 is expected to be 113 cfs, or 0.4% of the long term average river flow (Table 1). Even at 0.5%, the percent hydraulic entrainment under dual unit operation is still ten times smaller than EPA's performance standard of 5%, which EPA established in its 2001 rulemaking implementing section 316(b) of the Clean Water Act for new facilities that use water from rivers, streams, lakes, and reservoirs for cooling purposes (EPA, 2001).

Maximum average velocities at the entrance to the IPS and at through-screen are inversely related to reservoir elevation of Chickamauga Reservoir (i.e., higher at winter pool); maximum average approach velocity entering the IPS wet well for the traveling water screens is directly related to water surface elevation (i.e., higher at summer pool) (Table 1). The reason for this difference is that during both summer and winter pools, the openings at which the maximum average approach velocity entering the IPS wet well for the traveling water screens is measured are submerged. Because openings are submerged for summer and winter pools, the cross-sectional area of the flow through these openings is the same for both summer and winter pools. Therefore, since the normal maximum IPS flow is higher at summer pool than winter, the maximum average approach velocity entering wet well for traveling water screens, in like manner, will be higher at summer pool. In contrast, the openings at which the maximum average velocities at the entrance to the IPS and at through-screen are measured are not submerged at both reservoir elevations; thus, the cross-sectional areas depend on the surface water elevation. As a result, maximum average velocities at the entrance to the IPS and at through-screen are higher at winter pool.

Table 1 also illustrates that under dual unit operation maximum intake velocities will not increase, but average flow rates will increase. This is because the IPS contains additional intake openings to accommodate supplementary intake demand that will result under dual unit operation.

Supplemental Condenser Cooling Water Intake System

The WBN SCCW intake system, designed to augment the makeup water supply system for WBN, became operational in 1999. The SCCW is designed to provide between 115,000 and 135,000 gallons of water per minute (gpm) by gravity flow from Watts Bar Reservoir to WBN to supplement the cooling capacity of the Unit 1 cooling tower. Since the SCCW system is operated by gravity flow, the amount of water entering and exiting the system depends on the elevation of the water surface behind Watts Bar Dam. Water from the reservoir flows by gravity through an intake screen house that is adjacent to the west upstream side of WBH. The water enters the screen house through six intake sluice gates with bottoms at elevation 710 ft msl and traveling water screens. The gates act as water skimmers since normal summer headwater is at elevation 740.5 ft msl. The SCCW is conveyed through the Unit 2 tower basin to the Unit 1 tower discharge flume. Here it mixes with the warmer water from the Unit 1 tower prior to being pumped to the inlet of the Unit 1 main condenser.

SCCW flow conditions during dual unit operation will be less than those during Unit 1 operation only. Reasons for this are twofold: (1) no changes are being made in the capacity of the SCCW intake and discharge conduits, and (2) the water level in the Unit 2 cooling tower basin, which receives the SCCW inflow, will be higher (i.e., reduced head for driving the flow). In like manner, the velocities also will be less. However, following the completion of Unit 2, SCCW velocities can still be as high as those for the current Unit 1 operation during periods when the Unit 2 condenser cooling water system is out of service (e.g., Unit 2 outage). Therefore, to properly describe the full range of possible flow conditions, values for current operation (Unit 1 only) and when Unit 1 and Unit 2 are both in operation are presented in Table 1.

Maximum average velocity at the entrance to the SCCW screen house is 0.44 fps during summer pool (741 ft msl) and 0.38 fps during winter pool (737 ft msl). At summer and winter pools, maximum average approach velocity entering the wet well for traveling water screens is 2.18 and 1.65 fps, respectively. The maximum average through-screen velocity is 1.15 and 1.00 fps at summer and winter pools, respectively. At summer pool, the maximum average flow rate is 313 cfs or 1.1% of the long-term average river flow past WBN (27,047 cfs); the maximum average flow rate at winter pool is 238 cfs or 0.9% of long-term average river flow past WBN (Table 1). Even at 1.1%, the SCCW hydraulic entrainment is approximately five times less than EPA's performance standard of 5% (EPA, 2001).

Materials and Methods

Data Collection

Ichthyoplankton samples during 2010-2011 monitoring were collected weekly from March 2010 through August, then monthly from September through March 2011 on a diel schedule (day and night). Samples were collected at five stations along a transect located in Chickamauga Reservoir at TRM 528.5, which was perpendicular to river flow just upstream of the IPS water intake channel. Four samples were collected within the IPS channel located at TRM 528.0. In Watts Bar Reservoir two samples were collected (and combined) in front of the SCCW intake (TRM 529.9) and at five stations along a transect located at TRM 530.2 (Figure 1). Samples were taken with a beam net (0.5 m square, 1.8 m long, with 505 micron "nitex" mesh netting) towed into the current at a speed of 1.0 m/s for ten minutes. The volume of water filtered through the net was measured with a large-vaned General Oceanics Inc.® flowmeter. At both reservoir transects, eight samples (four each day and night) were collected at three stations: a full stratum sample on both left and right over banks and two mid-channel samples (full-stratum and a bottom tow). Detailed ichthyoplankton sampling procedures used during 2010-2011 monitoring are outlined in S&F OPS-FO-BR-23.5 (TVA, 2010a).

The SCCW intake and reservoir transect in Watts Bar Reservoir were not sampled in 1996 and 1997 because the SCCW system was not operational at this time; therefore, only ichthyoplankton data collected during April through June 2010 at the IPS channel and the Chickamauga Reservoir transect were compared to that of 1996 and 1997.

Laboratory Analysis

Laboratory analyses followed the same procedures in 2010 and 2011 as in 1996 and 1997. Fish eggs and larvae were removed from the samples, identified to the lowest possible taxon, counted and measured (larvae) to the nearest millimeter total length following procedures outlined in S&F OPS-FO-BR-24.1 (TVA, 2010b). Taxonomic decisions were based on TVA's "Preliminary Guide to the Identification of Larval Fishes in the Tennessee River," (Hogue et al., 1976) and other pertinent literature (Wallus et al., 1990; Kay et al., 1994; Simon and Wallus, 2003; Simon and Wallus, 2006; Wallus and Simon, 2006; and Wallus and Simon, 2008).

Some specimens could not be identified to species. The term "unidentifiable larvae" applies to specimens too damaged or mutilated to identify, while "unspecifiable" before a taxon implies a level of taxonomic resolution (i.e., "unspecifiable catostomids" designates larvae within the family Catostomidae that currently cannot be identified to a lower taxon). The category "unidentifiable eggs" applies to specimens that cannot be identified due to damage or lack of taxonomic knowledge. Taxonomic refinement is a function of specimen size and developmental stage. Throughout historical reports, the designation "unspecifiable clupeids" refers to clupeids less than 20 mm in total length and could include *Dorosoma cepedianum* (gizzard shad), *D.*

petenense (threadfin shad), and/or *Alosa chrysochloris* (skipjack herring) (Table 3). Any clupeid specimen identified to species level represents a juvenile 20 mm or longer in total length.

Developmental stage of moronids also determines level of taxonomic resolution. *Morone saxatilis* (striped bass) hatch at a larger size than either *M. chrysops* (white bass) or *M. mississippiensis* (yellow bass). Although it is currently impossible to distinguish between larvae of the latter two species, *M. saxatilis* can be eliminated as a possibility based on developmental characteristics of specimens 5 mm or less in total length (hence, the taxonomic designation "*Morone* not *saxatilis*"). Specimens identified as "*Morone* sp." are those greater than 5 mm total length that could be any of the three species.

Data Analysis

Temporal occurrence and relative abundance of eggs and larvae by taxon are presented and discussed for samples collected during 2010-2011 monitoring periods. Densities of fish eggs and larvae are expressed as numbers per 1,000 m^3 and were calculated using the equation:

$$D = \frac{1{,}000(\mathit{Number\ fish\ eggs\ or\ larvae\ collected})}{\mathit{Sample\ volume}}$$

Estimated entrainment of fish eggs and larvae was calculated by the following equation:

$$Ent = \frac{\sum DQ}{1000}$$

where *Ent* is estimated entrainment of fish eggs or larvae, *D* is the mean density (number/1,000 m^3) of fish eggs or larvae and *Q* is the flow (m^3/d). To estimate densities of fish eggs and larvae transported past WBN (from reservoir samples), densities of fish eggs and larvae from all stations along the reservoir transect were multiplied by the corresponding 24-hour river flow past the plant. Entrainment estimates for intake samples were calculated using the same method, except densities of fish eggs and larvae from the intake samples and plant intake water were used.

Percentage of transported ichthyofauna entrained at WBN IPS and SCCW intakes was estimated using the formula:

$$E = \frac{100 D_i Q_i}{D_r Q_r},$$

where D_i is the mean density (number/1,000 m^3) of fish eggs or larvae in intake samples; D_r is the mean density (number/1,000 m^3) of fish eggs or larvae in the reservoir transect; Q_i is the plant intake water flow (m^3/d); and Q_r is the river flow past WBN (m^3/d).

Results and Discussion

During thirty-three sample periods in 2010-2011 (weekly March-August 2010 then monthly September-March 2011), the average volume of water filtered was 603 m^3 for IPS samples, 773 m^3 for Chickamauga Reservoir transect samples, 299 m^3 for SCCW samples, and 782 m^3 for Watts Bar Reservoir transect samples (Table 2). Only one weekly sample was collected during March 2011 due to extremely high flows during the first three weeks of that month. A list of families of fish eggs and larvae collected from March 2010 through March 2011 including the lowest level of taxonomic resolution is presented in Table 3.

Chickamauga Reservoir transect and WBN Intake Pumping Station

Fish Eggs

A total of 4,035 fish eggs was collected from the Chickamauga Reservoir transect and the WBN IPS during March 2010 through March 2011. Total fish eggs were comprised of freshwater drum at 98.4%, moronids (not striped bass) 1.1%, clupeids 0.5%, and catostomids (trace) (Table 4). Densities of eggs peaked twice in reservoir samples, first on June 1 (1,356/1,000 m^3) and again on July 11 at 2,039/1,000 m^3 (Table 5, Figure 2). The second peak in July is not typical. Peaks in freshwater drum spawning typically occur May through June (Wrenn, 1968); however, spawning can continue into later summer months. Highest density recorded in intake samples was 327/1,000 m^3 also on July 11. All eggs collected on those dates were sciaenid (freshwater drum) eggs. Period of occurrence for sciaenid eggs in samples was from May 2 through August

22, 2010 (Table 5). Freshwater drum are pelagic (open water) reservoir spawners as opposed to some species (e.g., sauger, white bass) which spawn in flowing waters such as streams and tailwaters (Etnier and Starnes, 1993). Therefore, the semi-buoyant freshwater drum eggs occurring in these samples were spawned above the dam and subsequently subjected to turbine passage from WBH.

A comparison of freshwater drum egg densities collected during both day and night and by station across the reservoir transect and by day and night in intake samples is presented in Table 6. Night densities were significantly greater than during daytime. Night density along the left descending bank was greater than at the other four stations. One possible explanation for higher densities at night could be a result of lower turbine generation at night and a "pooling effect" on the pelagic, semi-buoyant eggs. Another possibility is the diel timing of drum spawning above the dam to cause eggs to arrive in the tailwater when night samples were collected.

All other fish eggs were collected in lower densities in reservoir samples during March (catostomids), April (moronids), and May (clupeids) (Table 5).

Fish Larvae

Weekly sampling at the Chickamauga Reservoir transect and the WBN IPS from March 2010 through August 2010 and monthly from September through March 2011 collected a total of 6,156 larval fish. Relative abundance for all taxa of larval fish collected during the thirty-three sample periods (intake and reservoir combined) was dominated by clupeids (71.2%), centrarchids (14.8%), moronids (10.9%) and sciaenids (2.0%) (Table 4). Larval moronids, percids (darters and sauger), and clupeids were the earliest taxa (April 11, 2010) to be collected in both reservoir and intake samples (Table 5). Densities of total fish larvae peaked on May 17 in both intake (728/1,000 m^3) and reservoir (905/1,000 m^3) samples (Table 7, Figure 4). Clupeid larvae were the dominant taxon represented in both peaks (Table 5). It should be noted that peak density of fish larvae on May 17 was coincidentally the date that there was no turbine flow through WBH to accommodate a hydrothermal survey of the WBN's Supplemental Condenser Cooling Water (SCCW) thermal plume under no-flow condition (TVA, 2011a).

Larval densities declined weekly after the May 17 peak at approximately the same rate they increased beginning in mid-April (Table 7, Figure 4). Densities essentially bottomed-out by late June, but increased slightly again during July as a result of collection of later-spawned centrarchid larvae (Table 5).

Clupeidae

Clupeid larvae were first collected on April 18 in both intake and reservoir samples. Peak densities occurred on May 17, also in both sample locations. Larval clupeids were no longer collected in reservoir samples after August 1 in reservoir samples and August 22 in intake samples (Table 5, Figure 6). Occasional specimens collected after August 1 and August 22 were juveniles.

Centrarchidae

Larval centrarchids were collected from April 25 through August 29 in both intake and reservoir samples (Table 5). Peak densities occurred on June 7 and June 14 in reservoir and intake samples, respectively (Table 5, Figure 8). Higher densities of centrarchid larvae collected in intake samples reflect the tendency for sunfish species to build nests and spawn in more protected environments such as the intake channel. Higher densities were collected at night in intake samples and from samples collected along the left descending bank station at the reservoir transect (Table 6). Densities declined abruptly by the end of June, but during July and August, significant numbers of centrarchid larvae were collected again in intake samples only (Table 5, Figure 8). This is considered the result of late-spawning by centrarchids residing in the intake channel.

Moronidae

Larval moronids (white bass and yellow bass) made up 10.9% of the total larvae collected in 2010-2011 (Table 4). The first moronid larvae were collected on April 11, which was also the date of highest Moronidae densities for both intake (276/1,000 m^3) and reservoir (262/1,000 m^3) samples (Table 5, Figure 10). A smaller (75/1,000 m^3) secondary peak occurred on June 7 in intake samples. Spatial distribution was similar across stations at the reservoir transect and between day and night samples. Sample densities in intake samples were noticeably higher at night (Table 6). Moronid larvae were collected until June 7 and June 14 in reservoir and intake samples, respectively (Table 5, Figure 10).

Sciaenidae

Larval sciaenids (freshwater drum) composed 1.2% and 2.7% of larvae collected in intake and reservoir samples, respectively (Table 4). Larvae were first collected on May 2 in reservoir and May 17 in intake samples (Table 5). Peak densities were recorded on June 7 in both reservoir (37/1,000 m^3) and intake (26/1,000 m^3) samples (Table 5, Figure 12). Sciaenid larvae were collected until June 21 in both intake and reservoir samples, although four juvenile specimens were collected in August intake samples (Table 5, Figure 12). Spatial distribution was similar across stations and between day and night at the reservoir transect and slightly higher in night intake samples (Table 6).

Incidental Families Collected

Larvae (or juveniles) representing five additional families were collected, all comprising less than one percent of the total. Numbers collected in both intake and reservoir samples by lowest taxonomic level identifiable are shown in Table 4.

- **Cyprinidae** – Twenty-eight cyprinids were collected, with 26 identified to the genus *Pimephales*. Distribution between intake and reservoir samples was similar (Table 4).
- **Atherinopsidae** – Family containing brook and Mississippi silverside. Twenty-three of 27 collected were identifiable only to family (Table 4).
- **Percidae** – Family containing yellow perch, logperch, darters and sauger. Thirteen larvae were collected, most noteworthy was one larval sauger collected in a reservoir sample on April 11 (Tables 4 and 5). This indicates some degree of spawning by sauger in the tailwater even though the primary spawning area for sauger is several miles downstream on Hunter Shoals (Hickman et al., 1990).
- **Catostomidae** – Two buffalo larvae (*Ictobinae*) were collected in reservoir samples (Table 4).
- **Ictaluridae** – One channel catfish larva was collected in a reservoir sample (Table 4).

Estimated Entrainment at the WBN IPS

IPS entrainment estimates for fish eggs and larvae by sample period during March 2010 through March 2011 and weekly, monthly, and annual percent entrainment for the period sampled are presented in Table 7. During this period, total annual entrainment of ichthyoplankton passing WBN was estimated to be 0.11% for fish eggs and 0.43% for fish larvae. There were some anomalously higher percentages, however, for individual weekly samples. During the May 17 and August 22 sample periods, densities of fish eggs in intake samples (117 and 27/1,000 m^3, respectively) were significantly higher than in reservoir samples (13 and 1/1,000 m^3, respectively) and resulted in higher entrainment estimates (4.1% and 6.5%, respectively) for those periods. However, monthly entrainment estimates for the months in which these two anomalous events occurred, May and August, were 0.26% and 1.81%, respectively. Similarly for fish larvae, during sample periods 13, 15–19, 21, 22, and 24, densities were considerably higher in intake samples and entrainment estimates ranged from 1.07% (June 28) to 10.34% (July 25) (Table 7). The higher intake densities during these sample periods were due to higher numbers of centrarchid larvae (Table 5; Figure 8). This is probably a result of the intake channel shoreline serving as spawning and nursery habitat.

The EPA's recommended maximum water withdrawal of 5% or less of mean annual river flow is based on the assumption that 5% of the river's organisms would be entrained as well and that water withdrawal rates of 5% or less have a low tendency to cause significant entrainment impacts (EPA, 2001). Total entrainment values of 0.11% for fish eggs and 0.43% for fish larvae are well below this recommended value.

Watts Bar Reservoir transect and SCCW Intake

Fish Eggs

Ichthyoplankton monitoring conducted at the SCCW intake structure and the Watts Bar Reservoir transect (TRM 530.2) above WBD during the period March 7, 2010 and March 25 2011 filtered 9,851 m^3 and 25,795 m^3 of water, respectively (Table 2). At the SCCW intake, a total of 23 fish eggs (18 sciaenid and 5 clupeid) were collected and nine sciaenid eggs were collected at the upstream transect (Table 4, Figure 3). These numbers of fish eggs collected were lower than those observed at the downstream transect. Higher densities of drifting, semi-buoyant freshwater drum eggs would be expected at the upstream transect. One explanation for the low densities could be dilution in the large, open forebay area where sampling was conducted upstream compared to the more concentrated tailwater area downstream.

Fish Larvae

Total numbers collected and percent composition for each taxon are presented in Table 4. A total of 2,498 fish larvae was collected at the SCCW intake dominated by 89.3% clupeids and 9.0% centrarchids. All other families made up less than one percent of the total. At the upstream reservoir transect, 5,056 larvae were collected. Families constituting over one percent of the total were Clupeidae (3,937; 77.9%), Centrarchidae (788; 15.6%), Sciaenidae (128; 2.5%), and Moronidae (82; 1.6%) (Table 4). A graph of weekly densities of total fish larvae collected at the upstream transect and the SCCW intake is presented in Figure 5.

Clupeidae

Larval clupeids were first collected on April 18 at both reservoir and intake and were present in samples through August 29, 2010 at the reservoir transect and August 8 at the SCCW intake. Specimens collected during July and August were juveniles (Table 5). Densities of clupeids peaked on May 9, 2010 at both the upstream transect and the SCCW intake (Table 5). The highest density (4,104/1,000 m^3) was recorded at the SCCW intake, compared to 1,294/1,000 m^3 at the upstream transect (Table 5, Figure 7). The higher densities at the SCCW intake during the same sampling period can be explained by fluvial dynamics created by generation from WBH, which result in an eddying effect in Watts Bar forebay. Ichthyoplankton spawned in the forebay drift toward the SCCW intake where they are pooled and become available for entrainment. A few juvenile and adult clupeids were collected in November and December, 2010 and January and February, 2011 (Table 5). Diel and spatial distribution of clupeids at the upstream reservoir transect showed mostly higher densities at night and near both shorelines. Densities at the SCCW intake were also higher at night (Table 6).

Centrarchidae

Centrarchid larvae were collected at the upstream transect from March 28 through August 29, 2010, and at the SCCW intake from April 25 through August 29, 2010 (Table 5). Peak densities of 240/1,000 m^3 and 228/1,000 m^3 occurred at the upstream transect on June 14, 2010 and at the SCCW intake on June 1, 2010, respectively. A secondary spawn by centrarchids was indicated by densities of 47/1,000 m^3 at the upstream transect and 57/1,000 m^3 at the SCCW intake on August 15, 2010 (Table 5, Figure 9). Diel and spatial distribution of centrarchids at the upstream reservoir transect showed mostly higher densities at night and near both shorelines. Densities at the SCCW intake were also higher at night (Table 6).

Moronidae

Larval moronids occurred in samples from April 18 through June 14, 2010 at the upstream transect and from April 25 through May 23, 2010 at the SCCW intake (Table 5, Figure 11). Spatial distribution across the upstream transect was even during day samples, but higher densities were recorded near the left descending bank at night (Table 6).

Sciaenidae

Sciaenid larvae were collected during May and June at both the upstream transect and the SCCW intake. Peak densities occurred at both locations on June 14, 2010 (Figure 13). Spatial distribution of sciaenid larvae was basically even across stations at the upstream transect and densities were somewhat higher at night at both the upstream transect and the SCCW intake (Table 6).

Incidental Families Collected

Larvae of families representing less than one percent of the total collected from the upstream transect and the SCCW intake during 2010-2011 totaled 136 specimens (Table 4).

- **Atherinopsidae** – Thirty-four of 57 collected were identifiable only to family; seventeen were Mississippi silversides and 6 were brook silversides. All but one individual were collected in reservoir samples (Table 4).
- **Cyprinidae** – Forty-seven cyprinids were collected, with 46 identified to the genus *Pimephales*. Most *Pimephales* spp. were collected in reservoir samples (Table 4).
- **Ictaluridae** – Fifteen channel catfish larvae and 5 blue catfish larvae were collected (Table 4).
- **Percidae** – Family containing yellow perch, logperch, darters and sauger. Eight of the 11 larvae collected were yellow perch (Table 4).
- **Catostomidae** – One buffalo larva (*Ictobinae*) was collected in reservoir samples (Table 4).

Estimated Entrainment at WBN SCCW

Estimated entrainment of fish eggs at the SCCW intake on May 17 was 14.6% and 3.9% on June 1. On June 21 and July 18, 2010 densities of 3/1,000 m^3 and 13/1,000 m^3 fish eggs, respectively, were estimated for the SCCW intake, while no eggs were collected at the reservoir transect (Table 7) making an entrainment estimate for these two periods impossible. Given this fact and the low numbers of fish eggs collected at these two sites (23), overall entrainment of fish eggs for the 2010 through 2011 period was estimated to be 2.23%.

Estimated entrainment for fish larvae by sample period at the WBN SCCW intake during 2010 through 2011 is presented in Table 7. Total percent entrainment for fish larvae passing the SCCW intake for the period sampled was estimated to be 1.98%. Weekly entrainment percentages were higher than the annual estimate for six of the 33 sample periods (Table 7). As noted for entrainment at the WBN IPS downstream, densities of larvae at the SCCW intake are occasionally estimated to be higher or similar to densities recorded for the reservoir transect resulting in higher estimated entrainment for those sample periods.

The entrainment estimate of 2.23% for fish eggs and 1.98% for fish larvae at the WBN SCCW is, as noted for the WBN IPS downstream, well below EPA's guideline of recommended maximum water withdrawal of 5% or less to have a low tendency to cause significant entrainment impacts (EPA, 2001).

Comparison with Historical Data (1996 and 1997)

The most recent monitoring of ichthyoplankton at WBN (prior to current monitoring) was conducted during April through June 1996 and the same period in 1997 (TVA, 1998). Results of that monitoring (densities and entrainment estimates by sample period), along with those of the same period (April through June) in 2010, are presented in Table 8. This section will compare results from ichthyoplankton data collected during April through June 1996, 1997, and 2010.

At the reservoir transect downstream of the dam, average seasonal densities of fish eggs in 1996, 1997, and 2010 were 340/1,000 m^3, 160/1,000 m^3, and 134/1,000 m^3, respectively. In the IPS channel, average fish egg densities were similar among the three years at 32/1,000 m^3 in 1996, 27/1,000 m^3 in 1997, and 22/1,000 m^3 in 2010. Average larval fish densities in the reservoir samples were 443/1,000 m^3 in 1996, 908/1,000 m^3 in 1997, and 305/1,000 m^3 in 2010. Among the three years, larval fish densities in the IPS channel were 1,595/1,000 m^3 (1996), 1,150/1,000 m^3 (1997), and 352/1,000 m^3 (2010) (Table 8).

The timing of peak densities of fish eggs at the reservoir transect differed among the three years: April 22 in 1996, March 21 in 1997, and June 1 in 2010. Peak densities of fish eggs in reservoir samples were similar among years at 1,528/1,000 m^3 in 1996, 1,070/1,000 m^3 in 1997, and 1,356/1,000 m^3 in 2010. The highest densities of fish larvae during the three years were observed during the week of June 3, 1996 in the intake samples (5,575/1,000 m^3), June 23, 1997, in the intake samples (2,646/1,000 m^3), and May 17, 2010, in the reservoir samples (905/1,000 m^3) (Table 8).

Among the three years, highest seasonal entrainment recorded for fish eggs was 0.12% of those in the reservoir in 2010 and for larvae 0.88% in 1996. Seasonal entrainment for fish eggs was lowest in 1996 (0.02%) and 1997 (0.02%) and lowest for fish larvae in 2010 (0.40%). As stated in the previous section, one sample period (May 17) in 2010 exhibited an entrainment estimate of for fish eggs (4.08%) that was higher than any in 1996 or 1997 and was due to a considerably higher density of fish eggs in intake samples (117/1,000 m^3) than in reservoir samples (13/1,000 m^3). Similarly for fish larvae in 2010, during sample dates on June 1, June 14, and June 21 densities were higher in intake samples than reservoir samples and entrainment estimates ranged from 2.32% to 8.65% (Table 8).

Although the entrainment percentages were similar for the monitoring periods in 1996 and 1997 and for 2010, the fish egg and larvae densities were lower at the Chickamauga Reservoir transect in 2010. This is likely to be the result of normal fluctuations in fish spawning success.

Estimated Entrainment with WBN Unit 2

Proposed operation of Unit 2, given that both units would only withdraw water through the IPS to provide make-up for evaporation and cooling tower blowdown, would increase average flow rates and percent hydraulic entrainment to values shown in Table 1. Numbers of entrained fish eggs and larvae could increase proportionally to average flow rates, which would expand numbers entrained by the ratio of 73 to 134 cfs at summer pool or 68 to 113 cfs at winter pool (Table 1). Based on these expansion ratios, the addition of Unit 2 would increase estimated entrainment of fish eggs to 0.20% at summer pool and 0.18% at winter pool and entrainment of fish larvae to 0.79% and 0.71% at summer and winter pools, respectively. However, considering the highly variable spawning success of fish communities and variability in ichthyoplankton densities among years, numbers of fish eggs and larvae entrained with dual unit operation would be driven by spawning success of fish and numbers of eggs and larvae transported past WBN via WBH turbine passage rather than the projected increase in flow volume.

As discussed earlier, SCCW intake flows and velocities will decrease under normal dual unit operation. Therefore, entrainment estimates for the SCCW intake could be expected to decrease proportionately to average flow rates.

Even with the addition of Unit 2, estimated total entrainment values for summer and winter pools at the IPS and SCCW intakes are well below the EPA recommended maximum water withdrawal of 5% of mean annual river flow.

Conclusions

Total entrainment percentages for both fish eggs and larvae for WBN Unit 1 during April through June 2010 were similar to those estimated for previous operational monitoring during the same period in 1996 and 1997. It was concluded in the previous report (TVA, 1998) that the low entrainment levels would not be detrimental to the ichthyoplankton population of Chickamauga Reservoir. Therefore, the April through June 2010 ichthyoplankton population in upper Chickamauga Reservoir should not have been adversely affected due to entrainment by WBN Unit 1. The year-long study in 2010-2011 confirmed that the March-June period was an appropriate time frame for analyzing ichthyoplankton entrainment. Nonetheless, the 2010-2011 monitoring extended the sampling to year-round to eliminate the possibility of spawning occurring beyond the normal range.

Addition of WBN Unit 2 should increase entrainment by the IPS and decrease entrainment by the SCCW, both in proportion to water withdrawal, assuming all water is taken from the respective IPS and SCCW. Since entrainment by the IPS with Unit 1 was generally below 1% of reservoir ichthyoplankton except for specific periods of significant spawning in the intake channel, the expected increase of water withdrawal should not increase entrainment above the EPA-recommended 5% of mean annual river flow. The addition of Unit 2 will decrease SCCW entrainment from levels already below the EPA's recommendation of 5% of mean annual flow.

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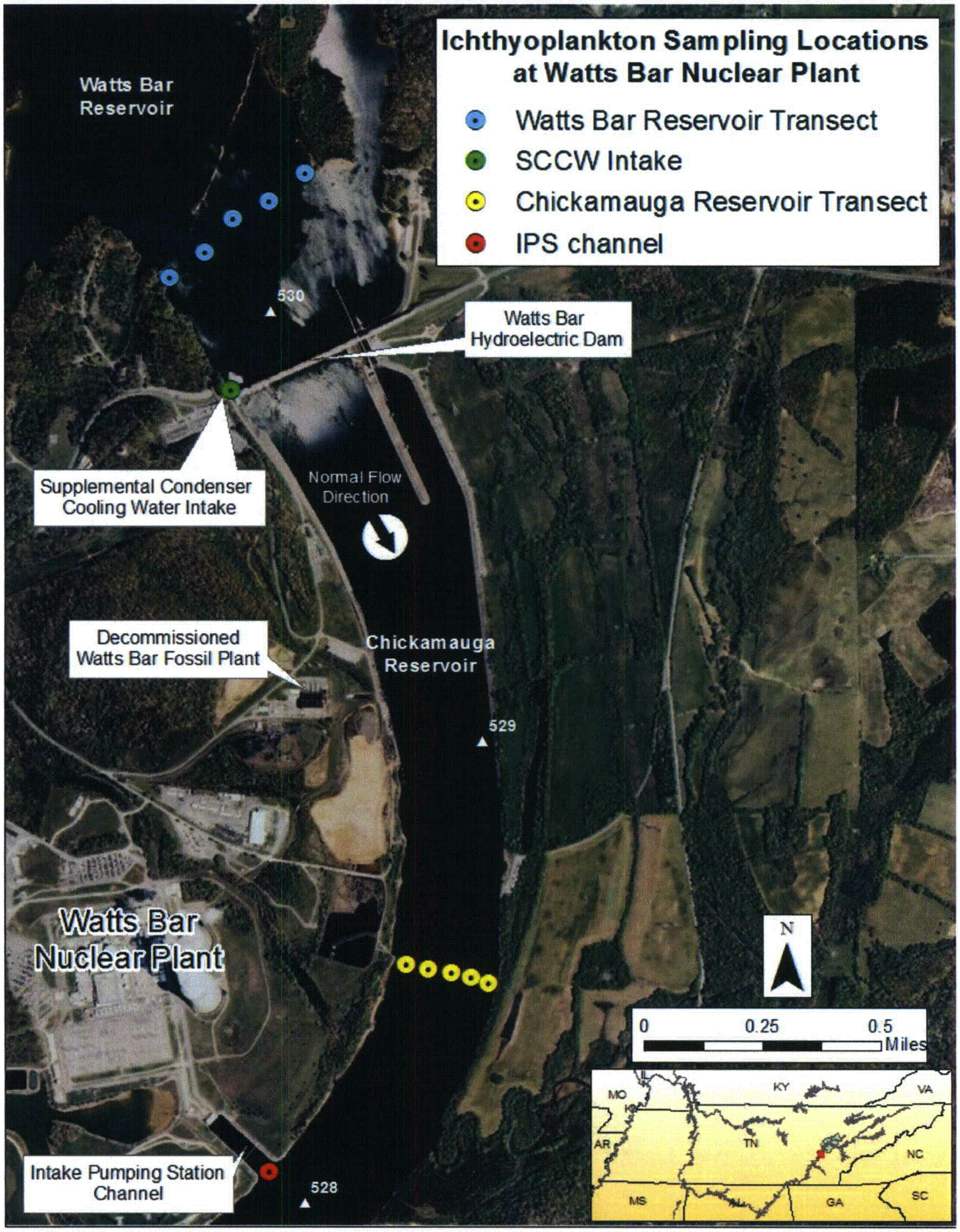

Figure 1. Locations of sampling stations at the WBN Intake Pumping Station channel (TRM 528), Supplemental Condenser Cooling Water intake (TRM 529.9), and reservoir transects in Chickamauga Reservoir (TRM 528.5) and Watts Bar Reservoir (TRM 530.2) used to collect ichthyoplankton (fish eggs and larvae) from March 2010 through March 2011 in the vicinity of Watts Bar Nuclear Plant, Rhea County, TN.

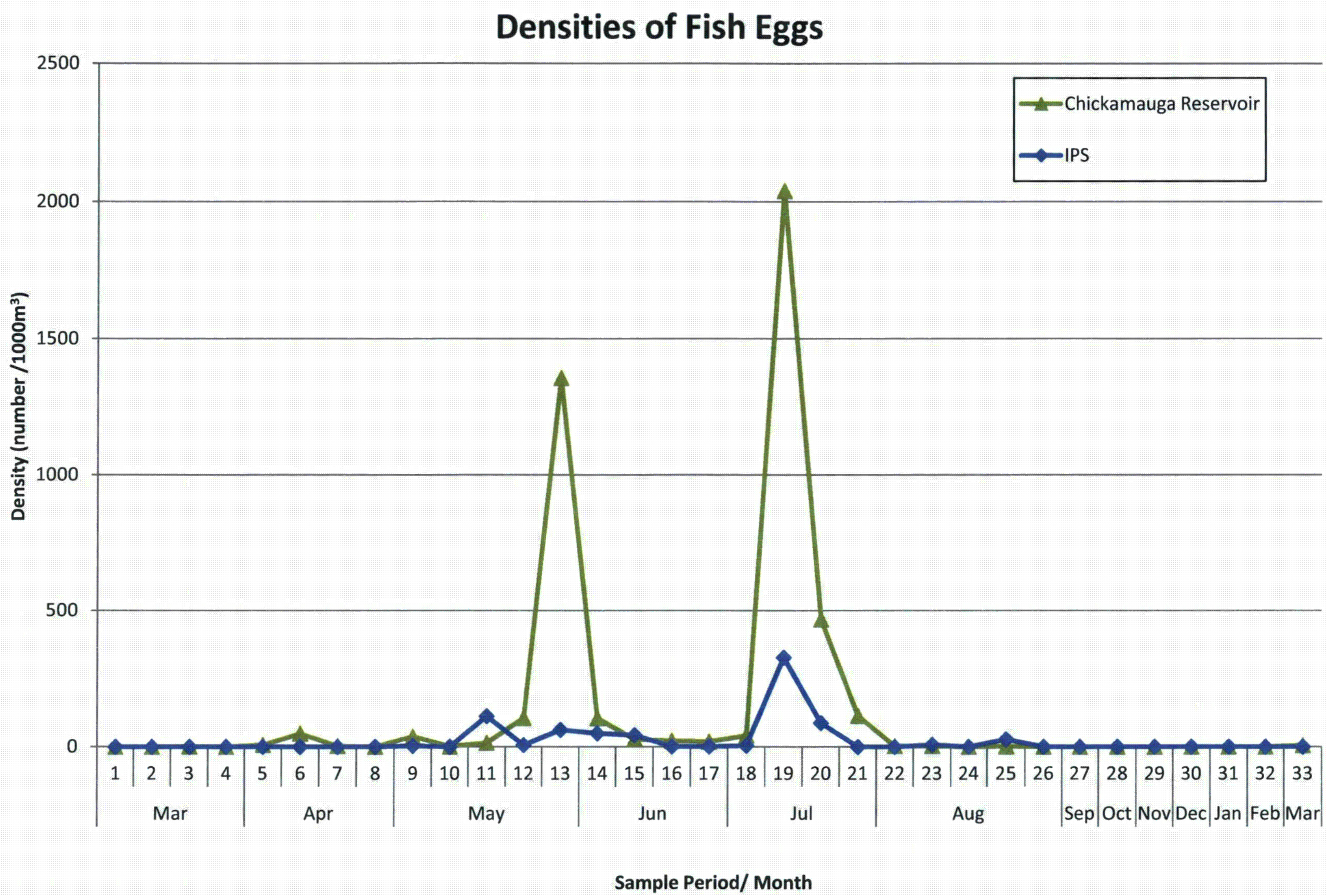

Figure 2. Densities of fish eggs collected at the Intake Pumping Station (IPS) channel and the Chickamauga Reservoir transect downstream of Watts Bar dam in the vicinity of Watts Bar Nuclear Plant, Rhea County, TN, from March 2010 through March 2011.

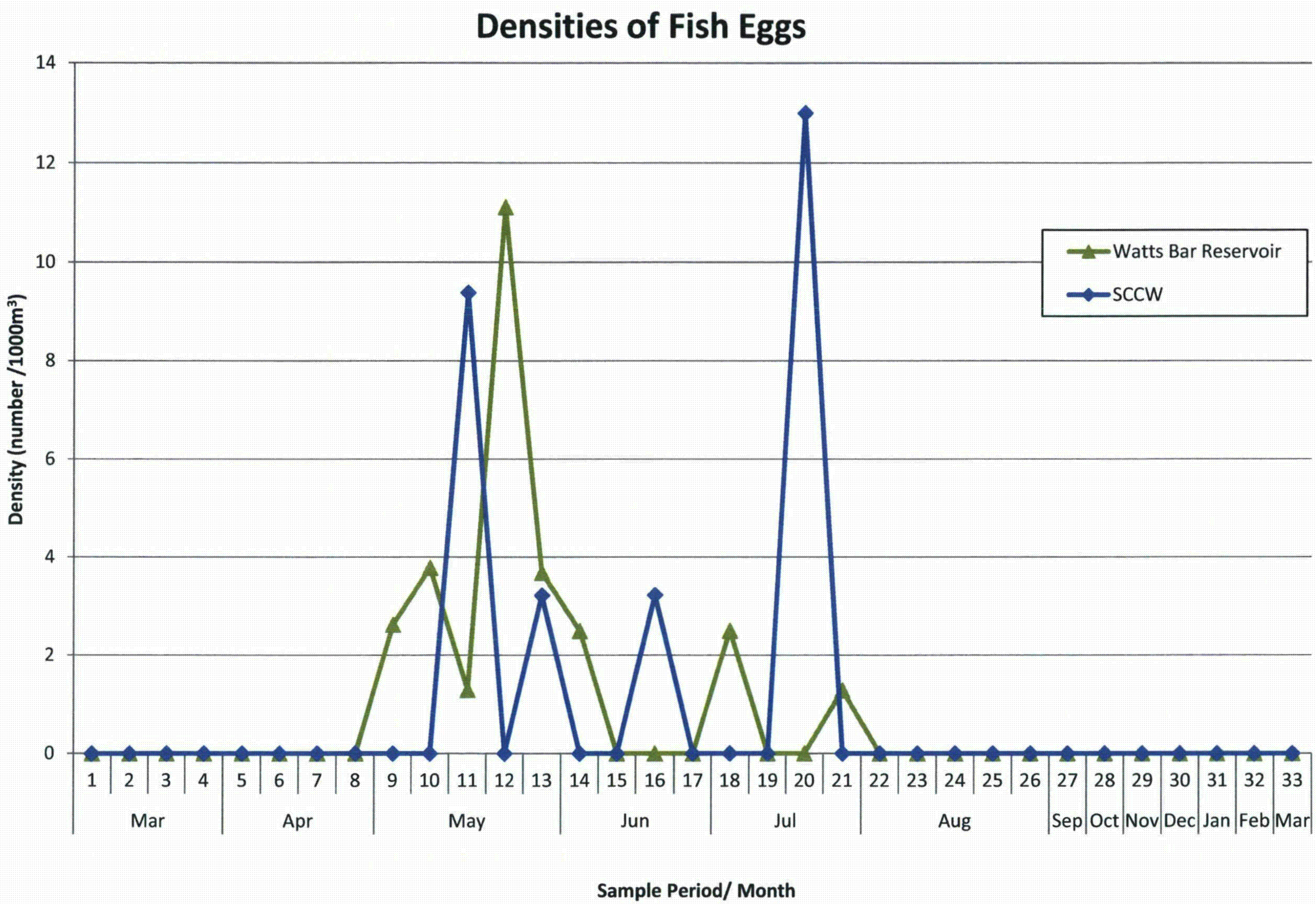

Figure 3. Densities of fish eggs collected at the Supplemental Condenser Cooling Water (SCCW) intake and the Watts Bar Reservoir transect upstream of Watts Bar dam in the vicinity of Watts Bar Nuclear Plant, Rhea County, TN, from March 2010 through March 2011.

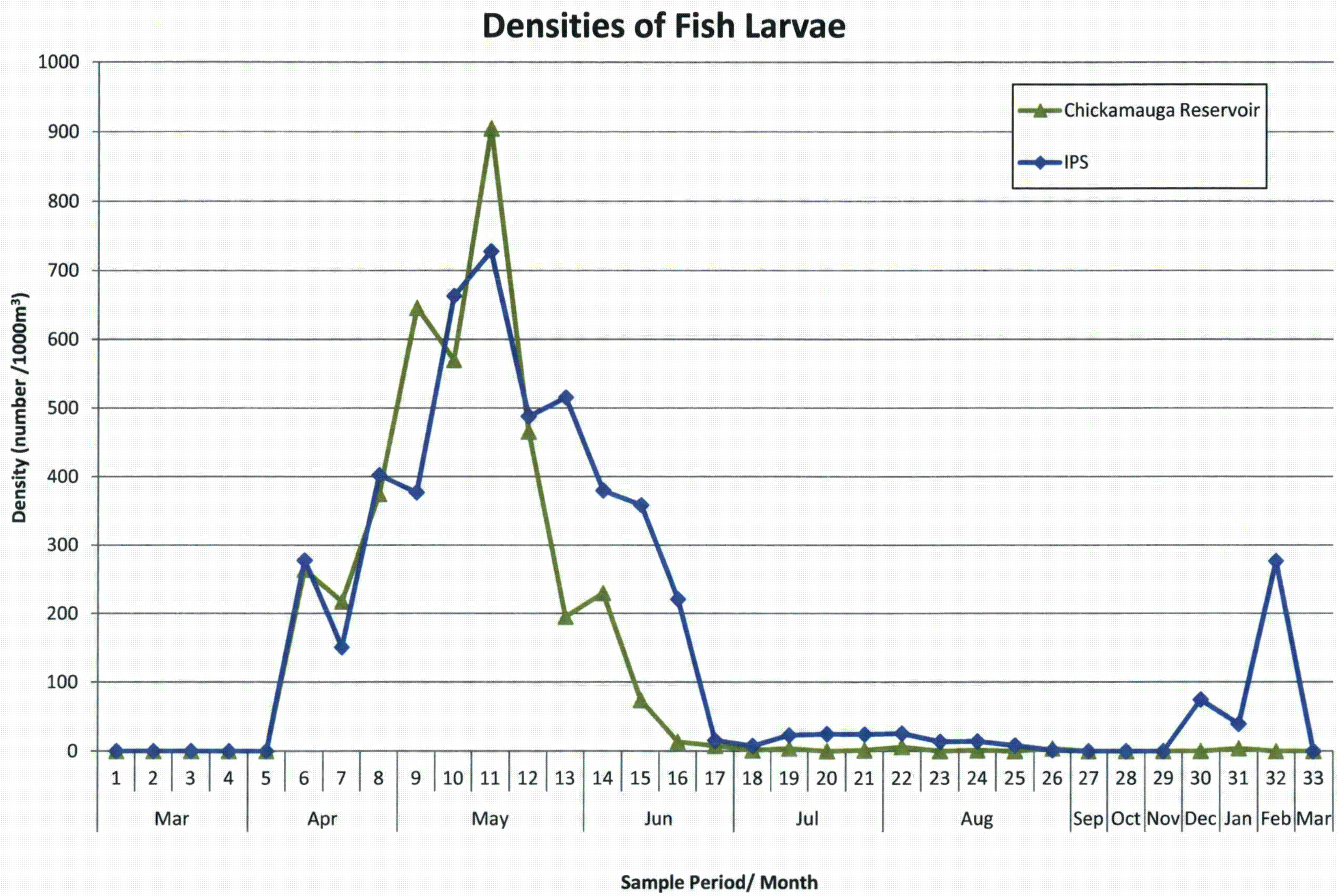

Figure 4. Densities of fish larvae collected at the Intake Pumping Station (IPS) channel and the Chickamauga Reservoir transect downstream of Watts Bar dam in the vicinity of Watts Bar Nuclear Plant, Rhea County, TN, from March 2010 through March 2011.

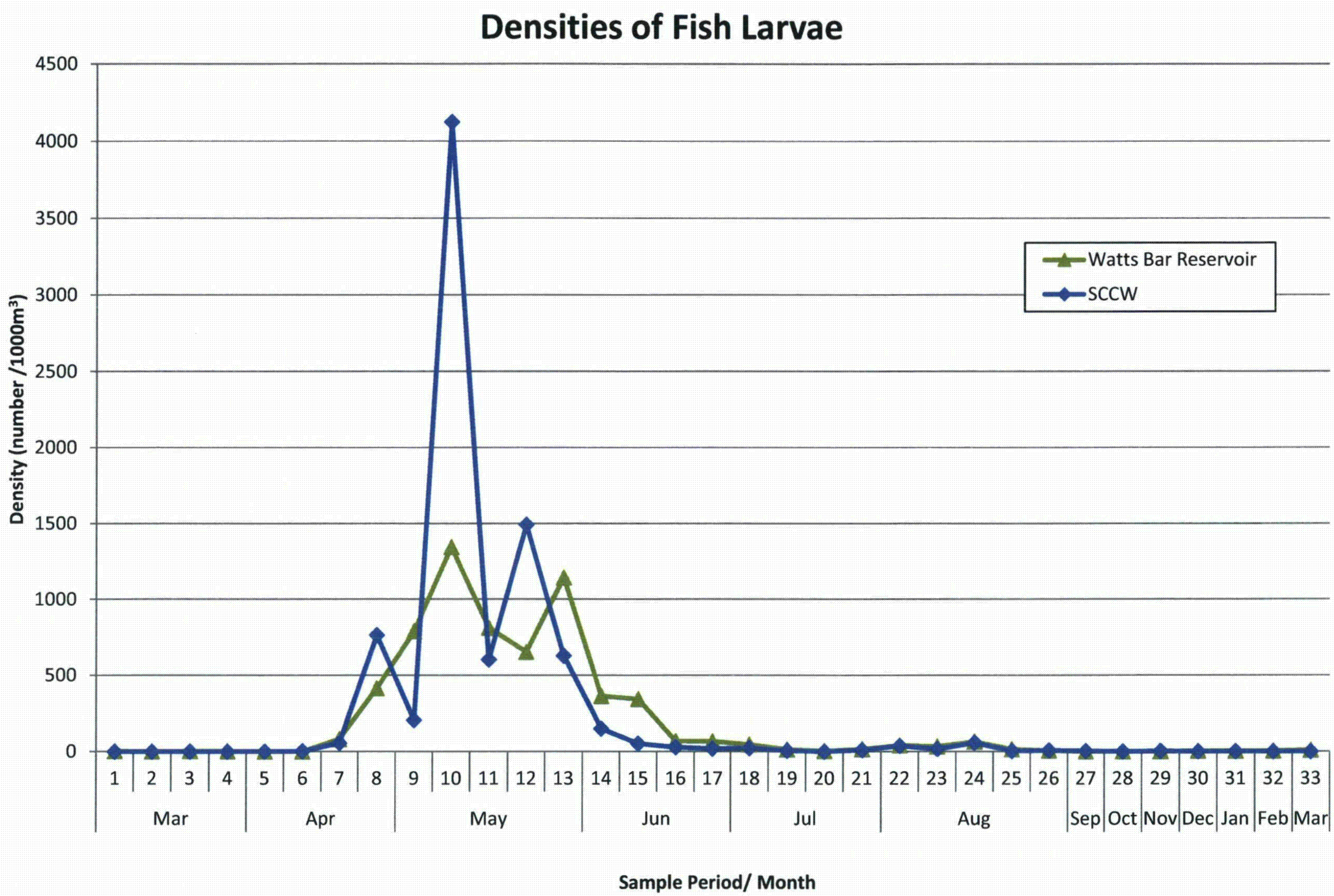

Figure 5. Densities of fish larvae collected at the Supplemental Condenser Cooling Water (SCCW) intake and the Watts Bar Reservoir transect upstream of Watts Bar dam in the vicinity of Watts Bar Nuclear Plant, Rhea County, TN, from March 2010 through March 2011.

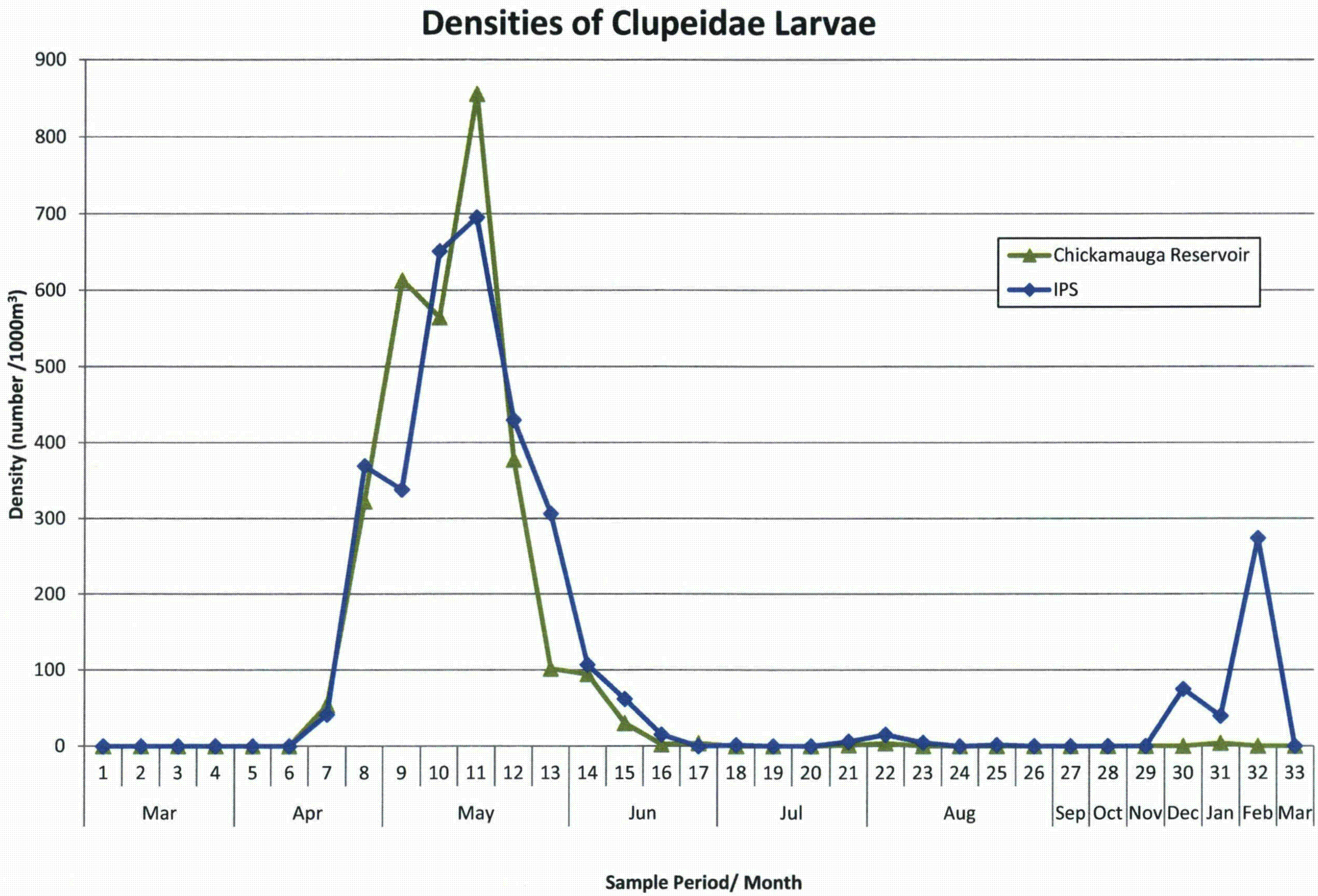

Figure 6. Densities of Clupeidae larvae collected at the Intake Pumping Station (IPS) channel and the Chickamauga Reservoir transect downstream of Watts Bar dam in the vicinity of Watts Bar Nuclear Plant, Rhea County, TN, from March 2010 through March 2011.

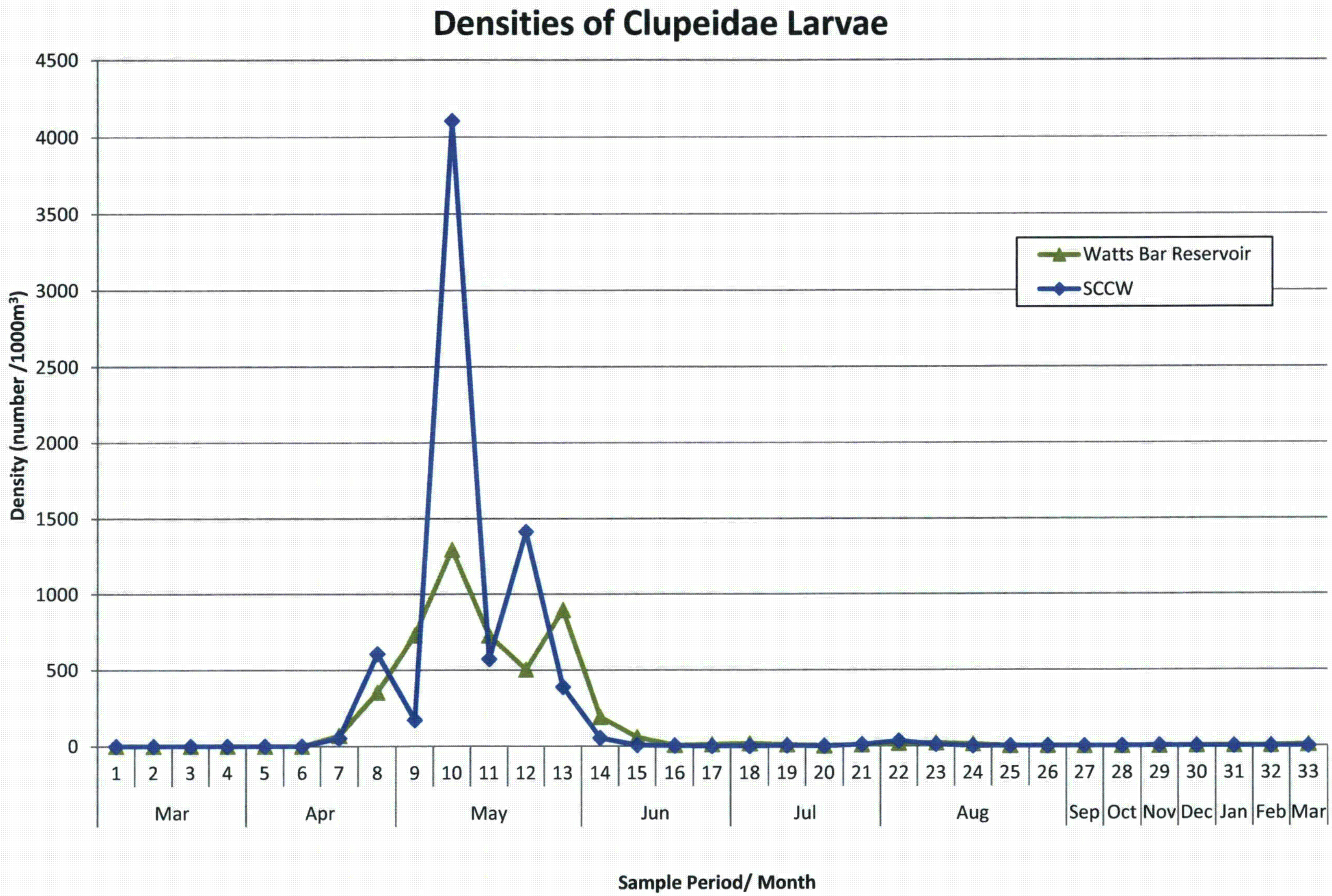

Figure 7. Densities of Clupeidae larvae collected at the Supplemental Condenser Cooling Water (SCCW) intake and the Watts Bar Reservoir transect upstream of Watts Bar dam in the vicinity of Watts Bar Nuclear Plant, Rhea County, TN, from March 2010 through March 2011.

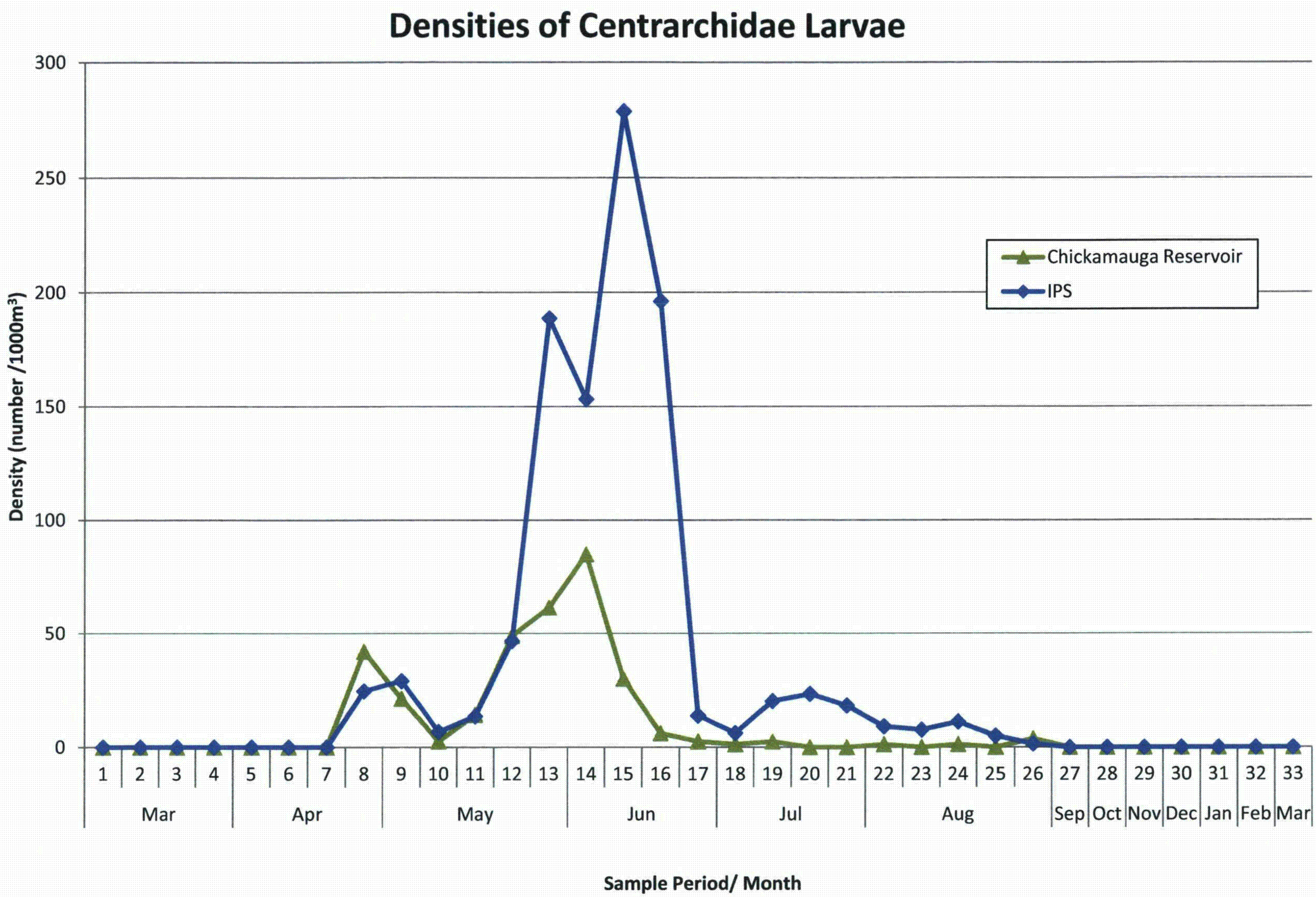

Figure 8. Densities of Centrarchidae larvae collected at the Intake Pumping Station (IPS) channel and the Chickamauga Reservoir transect downstream of Watts Bar dam in the vicinity of Watts Bar Nuclear Plant, Rhea County, TN, from March 2010 through March 2011.

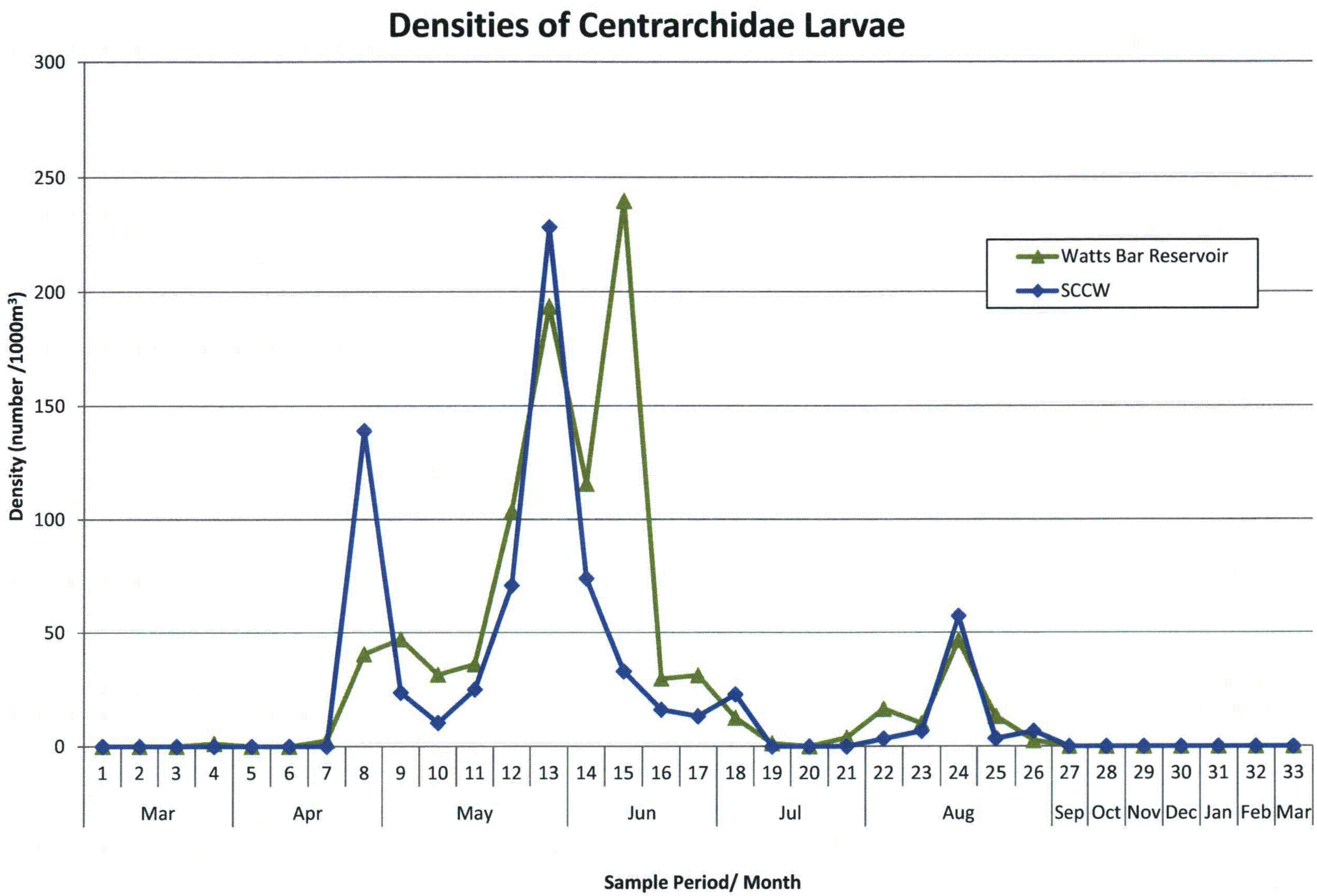

Figure 9. Densities of Centrarchidae larvae collected at the Supplemental Condenser Cooling Water (SCCW) intake and the Watts Bar Reservoir transect upstream of Watts Bar dam in the vicinity of Watts Bar Nuclear Plant, Rhea County, TN, from March 2010 through March 2011.

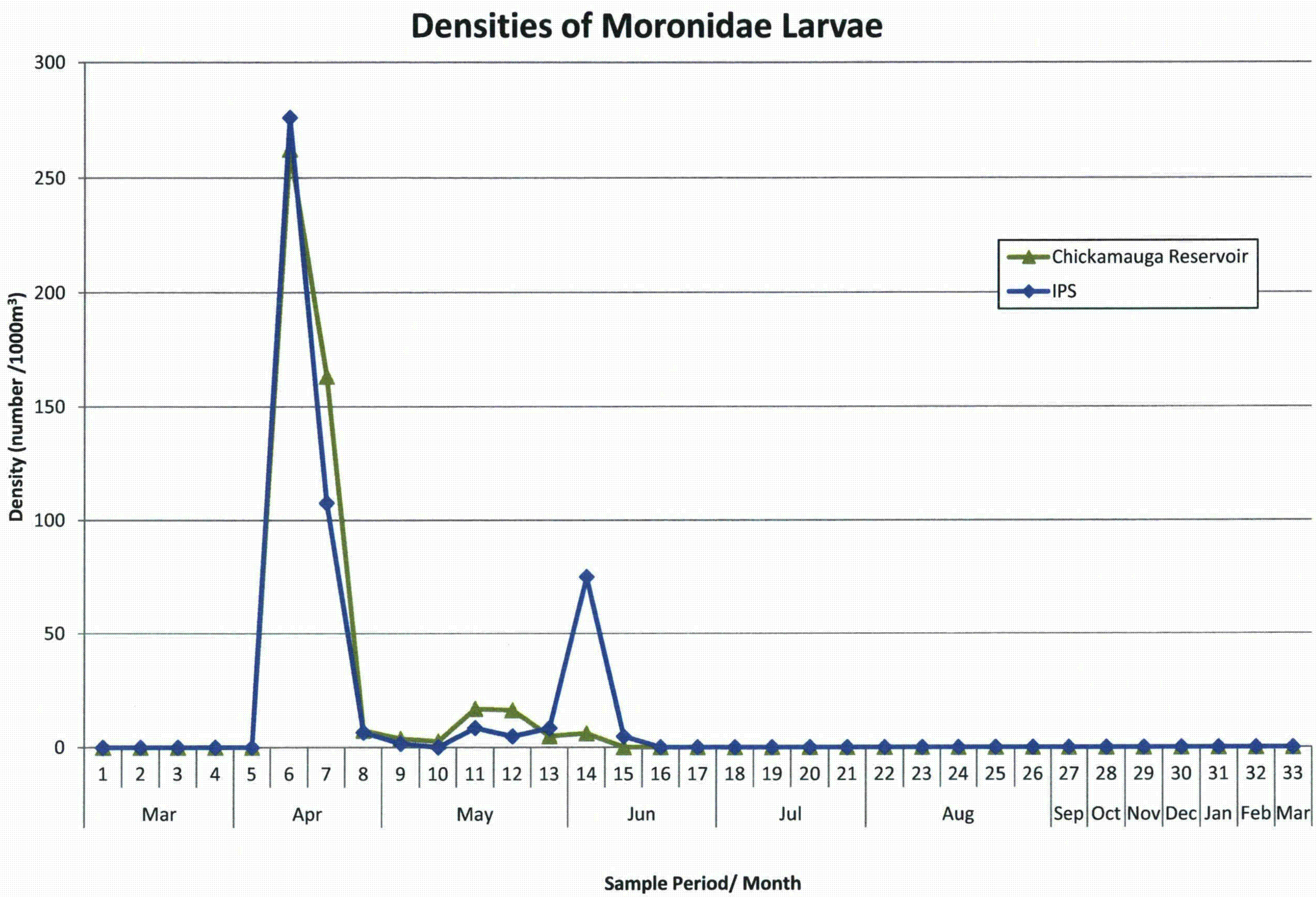

Figure 10. Densities of Moronidae larvae collected at the Intake Pumping Station (IPS) channel and the Chickamauga Reservoir transect downstream of Watts Bar dam in the vicinity of Watts Bar Nuclear Plant, Rhea County, TN, from March 2010 through March 2011.

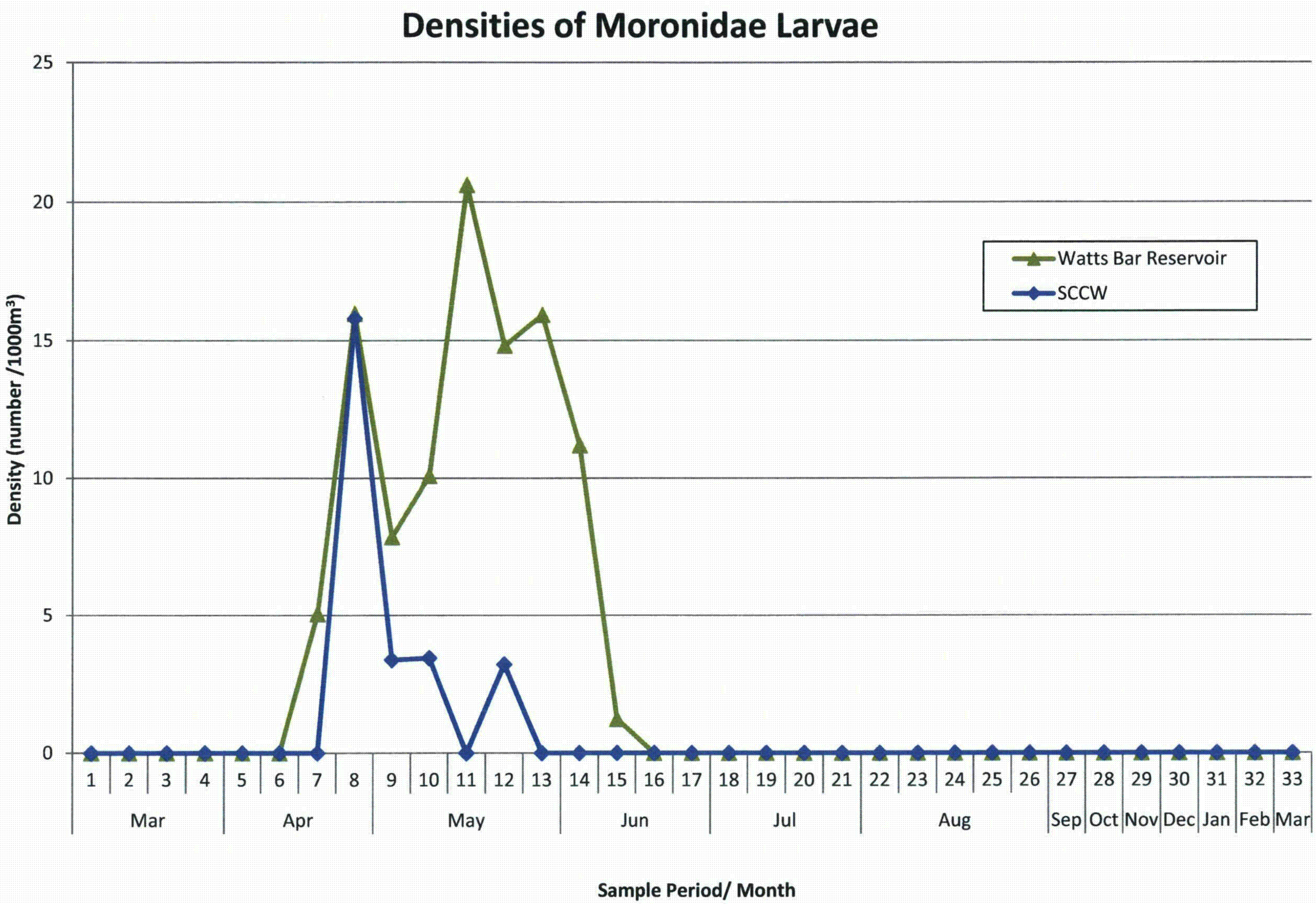

Figure 11. Densities of Moronidae larvae collected at the Supplemental Condenser Cooling Water (SCCW) intake and the Watts Bar Reservoir transect upstream of Watts Bar dam in the vicinity of Watts Bar Nuclear Plant, Rhea County, TN, from March 2010 through March 2011.

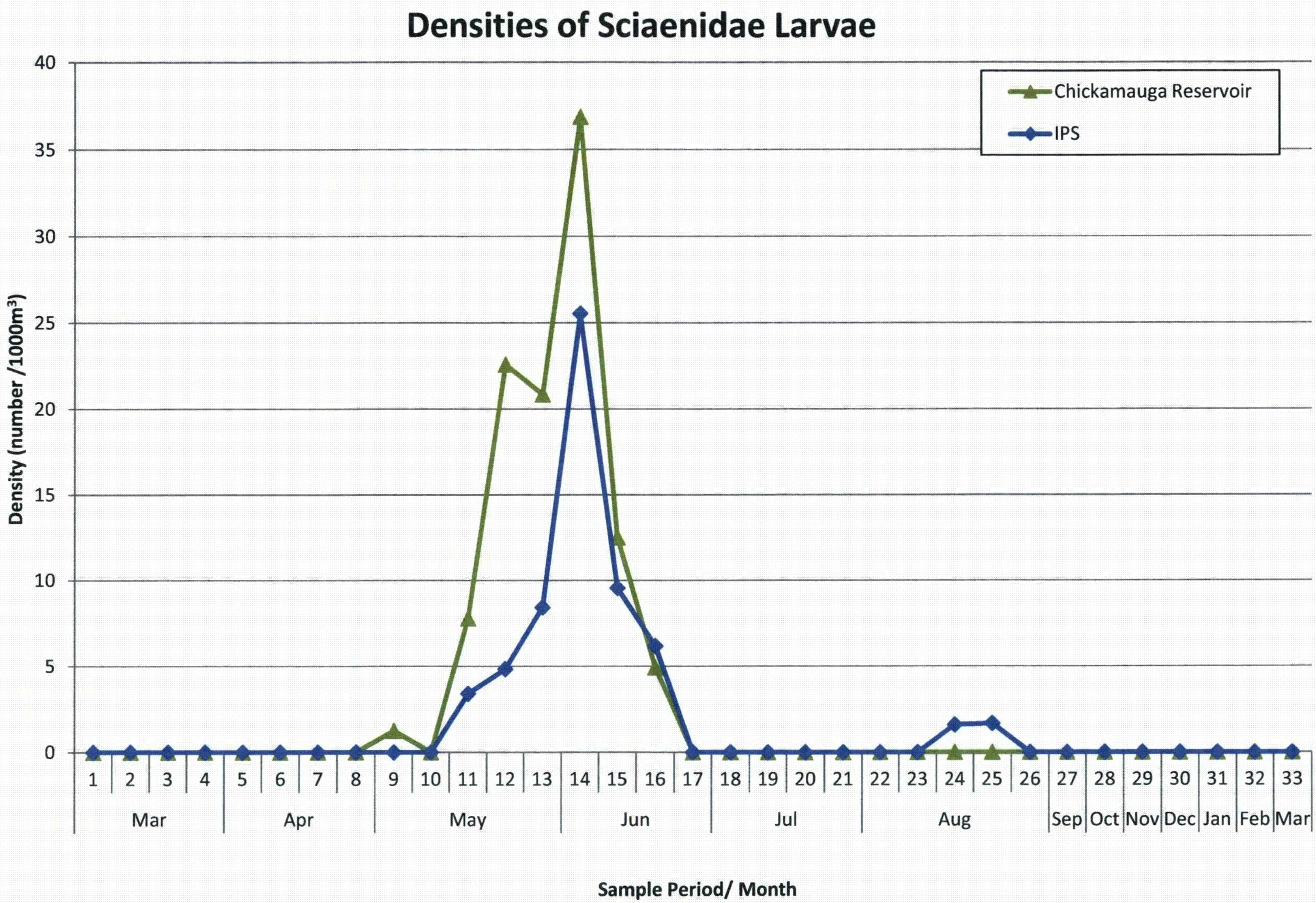

Figure 12. Densities of Sciaenidae larvae collected at the Intake Pumping Station (IPS) channel and the Chickamauga Reservoir transect downstream of Watts Bar dam in the vicinity of Watts Bar Nuclear Plant, Rhea County, TN, from March 2010 through March 2011.

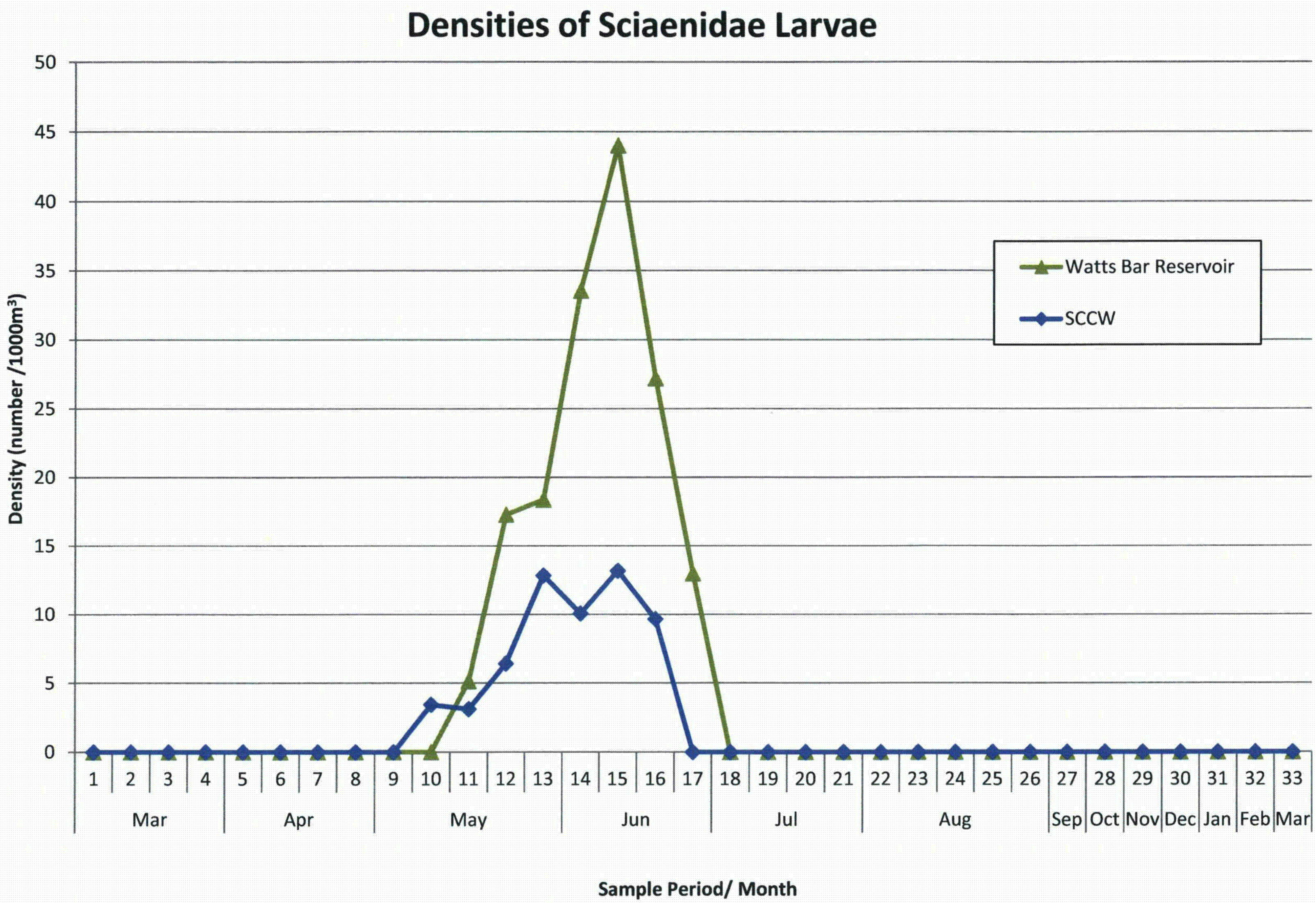

Figure 13. Densities of Sciaenidae larvae collected at the Supplemental Condenser Cooling Water (SCCW) intake and the Watts Bar Reservoir transect upstream of Watts Bar dam in the vicinity of Watts Bar Nuclear Plant, Rhea County, TN, from March 2010 through March 2011.

Table 1. Comparison of maximum average velocity at entrance of intake pumping system, approach velocity entering wet well for traveling water screens, through-screen velocity, and flow rate and percent hydraulic entrainment (percent of river flow) past the Watts Bar Nuclear intake pumping station (IPS) and Supplemental Condenser Cooling Water (SCCW) intake at summer and winter pool elevations and during operation of Unit 1 only and expected values during operation of Units 1 and 2 combined. SCCW values represent those for Unit 1 only and Units 1 and 2 combined. Calculations presented in TVA, 2011b. (msl = mean sea level)

IPS	Summer Pool (681 ft msl)		Winter Pool (677 ft msl)	
	Unit 1 Only	Units 1 and 2 Combined	Unit 1 Only	Units 1 and 2 Combined
Maximum Average Velocity at Entrance of IPS	0.17 fps	0.17 fps	0.18 fps	0.18 fps
Maximum Average Approach Velocity Entering Wet Well for Traveling Water Screens	0.40 fps	0.40 fps	0.37 fps	0.37 fps
Maximum Average Through-Screen Velocity	0.62 fps	0.62 fps	0.67 fps	0.67 fps
Maximum Average Flow Rate	73 cfs	134 cfs	68 cfs	113 cfs
Percent Hydraulic Entrainment *	0.3%	0.5%	0.3%	0.4%
SCCW **	**Summer Pool (741 ft msl)**		**Winter Pool (737 ft msl)**	
Maximum Average Velocity at Entrance to SCCW Screen House (Face of Trash Racks)	0.44 fps		0.38 fps	
Maximum Average Approach Velocity Entering Wet Well for Traveling Water Screens	2.18 fps		1.65 fps	
Maximum Average Through-Screen Velocity	1.15 fps		1.00 fps	
Approximate Maximum Average Flow Rate	313 cfs		238 cfs	
Percent Hydraulic Entrainment *	1.1%		0.9%	

* Percent hydraulic entrainment is based on a long-term average river flow past WBN of 27,047 cfs.
** Values presented for SCCW bound the full range of flow conditions observed during operation of Unit 1 only and Units 1 and 2 combined (see text for explanation).

Table 2. Total volume of water filtered by sample period from March 2010 through March 2011 at the Intake Pumping Station (IPS) channel (TRM 528), Chickamauga Reservoir transect (TRM 528.5), Supplemental Condenser Cooling Water (SCCW) Intake (TRM 529.9), and Watts Bar Reservoir transect (TRM 530.2) near Watts Bar Nuclear Plant to estimate densities and entrainment of fish eggs and larvae.

Sample Period	Sample Date	IPS (m^3)	Chickamauga Reservoir transect (m^3)	SCCW (m^3)	Watts Bar Reservoir transect (m^3)
1	7-Mar-10	598	796	153	750
2	14-Mar-10	585	773	300	758
3	21-Mar-10	577	729	295	753
4	28-Mar-10	588	744	304	779
5	4-Apr-10	595	744	288	782
6	11-Apr-10	612	751	326	796
7	18-Apr-10	623	760	319	793
8	25-Apr-10	609	809	316	814
9	2-May-10	618	801	296	765
10	9-May-10	588	774	290	794
11	17-May-10	588	771	320	776
12	23-May-10	621	798	311	810
13	1-Jun-10	594	816	311	816
14	7-Jun-10	587	814	298	804
15	14-Jun-10	628	799	303	818
16	21-Jun-10	647	813	310	809
17	28-Jun-10	647	787	303	770
18	4-Jul-10	642	802	306	802
19	11-Jul-10	642	816	301	756
20	18-Jul-10	641	785	308	791
21	25-Jul-10	491	805	297	780
22	1-Aug-10	656	824	298	791
23	8-Aug-10	650	811	296	793
24	15-Aug-10	625	788	297	794
25	22-Aug-10	595	760	287	761
26	29-Aug-10	644	802	297	779
27	20-Sep-10	612	748	300	773
28	13-Oct-10	597	783	303	777
29	16-Nov-10	613	792	312	793
30	22-Dec-10	601	752	306	756
31	19-Jan-11	609	775	301	729
32	14-Feb-11	361	734	295	745
33	25-Mar-11	604	440	305	787
Total		**19,888**	**25,495**	**9,851**	**25,795**
Average		**603**	**773**	**299**	**782**

Table 3. List by family of fish eggs and larvae collected at the Intake Pumping Station (IPS) channel (TRM 528), Chickamauga Reservoir transect (TRM 528.5), Supplemental Condenser Cooling Water (SCCW) Intake (TRM 529.9), and Watts Bar Reservoir transect (TRM 530.2) near Watts Bar Nuclear Plant from March 2010 through March 2011, and lowest level of taxonomic resolution for each family.

	Scientific Name	Common Name	Lowest Level of Taxonomic Identification
Eggs			
	Catostomidae	**Suckers**	**Family** - Catostomid spp.
	Clupeidae	**Shad**	**Family** - Clupeid spp. (not skipjack herring)
	Moronidae	**Temperate Basses**	**Genus** - *Morone* spp. (not striped bass)
	Sciaenidae	**Drums**	**Species** - Freshwater drum
Larvae			
	Atherinopsidae	**Silversides**	**Family** - Atherinid spp. **Species** - Brook and Mississippi silverside
	Catostomidae	**Suckers**	**Subfamily** - Ictiobines (buffalo and carpsucker)
	Centrarchidae	**Sunfishes**	**Genus** - Crappie, lepomids (sunfishes), and black bass **Species** - Larger individuals to largemouth bass, white crappie, and bluegill
	Clupeidae	**Shad**	**Family** - All larvae <20 mm TL **Species** - Larger individuals to alewife, skipjack, and gizzard and threadfin shad
	Cyprinidae	**Minnows and Carps**	**Family** - Cyprinid spp. **Genus** - *Pimephales* spp. and *Cyprinella* spp. **Species** - Common carp
	Ictaluridae	**Catfishes**	**Species** - Blue and channel catfish
	Moronidae	**Temperate Basses**	**Genus** - *Morone* and *Morone* type (but not *saxatilis*) **Species** - White bass and yellow bass
	Percidae	**Darters**	**Genus** - *Percina* (*P. caprodes* type, not *P. caprodes*) type **Species** - Sauger and yellow perch
	Sciaenidae	**Drums**	**Species** - Freshwater drum

Table 4. Actual numbers and percent composition of fish eggs and larvae collected in entrainment samples at the Intake Pumping Station (IPS) channel (TRM 528), Chickamauga Reservoir transect (TRM 528.5), Supplemental Condenser Cooling Water (SCCW) Intake (TRM 529.9), and Watts Bar Reservoir transect (TRM 530.2) from March 2010 through March 2011 in the vicinity of Watts Bar Nuclear Plant.

Taxon	IPS Channel		Chickamauga Reservoir transect (TRM 528.5)		Total	
	Total Numbers Collected	Percent Comp.	Total Numbers Collected	Percent Comp.	Total Numbers Collected	Percent Comp.
FISH EGGS						
Sciaenidae						
Aplodinotus grunniens (freshwater drum) eggs	455	98.9%	3,514	98.3%	3,969	98.4%
Moronidae						
Unspecifiable moronids (not *M. saxatilis*)			43	1.2%	43	1.1%
Clupeidae						
Clupeid eggs	5	1.1%	15	0.4%	20	0.5%
Percidae						
Percid eggs			2	0.1%	2	T
Catostomidae						
Catostomid eggs			1	T	1	T
Total	**460**	**100%**	**3,575**	**100%**	**4,035**	**100%**
LARVAE						
Clupeidae	**1,998**	**66.0%**	**2,387**	**76.3%**	**4,385**	**71.2%**
Unspecifiable Clupeids	1,741	57.5%	2,270	72.5%	4,011	65.2%
Dorosoma cepedianum (gizzard shad)	91	3.0%	111	3.5%	202	3.3%
Dorosoma petenense (threadfin shad)	166	5.5%	5	0.2%	171	2.8%
Alosa chrysochloris (skipjack herring)			1	T	1	T
Centrarchidae	**650**	**21.5%**	**261**	**8.3%**	**911**	**14.8%**
Lepomis spp.	515	17.0%	132	4.2%	647	10.5%
Lepomis macrochirus (bluegill)	7	0.2%			7	0.1%
Micropterus spp (not *M. dolomieu*)	2	0.1%	2	0.1%	4	0.1%
Pomoxis spp.	125	4.1%	125	4.0%	250	4.1%
Pomoxis annularis (white crappie)	1	T	2	0.1%	3	T
Moronidae	**301**	**9.9%**	**367**	**11.7%**	**668**	**10.9%**
Unspecifiable Moronid	16	0.5%	35	1.1%	51	0.8%
Unspecifiable Moronid (not *M. saxatilis*)	236	7.8%	324	10.4%	560	9.1%
Morone chrysops (white bass)	49	1.6%	8	0.3%	57	0.9%
Sciaenidae	**37**	**1.2%**	**84**	**2.7%**	**121**	**2.0%**
Aplodinotus grunniens (freshwater drum)	37	1.2%	84	2.7%	121	2.0%
Cyprinidae	**15**	**0.5%**	**13**	**0.4%**	**28**	**0.5%**
Unspecifiable Cyprinid	1	T			1	T
Pimephales spp	14	0.5%	12	0.4%	26	0.4%
Cyprinella spp.			1	T	1	T
Atherinopsidae	**17**	**0.6%**	**10**	**0.3%**	**27**	**0.4%**
Unspecifiable Atherinopsid	14	0.5%	9	0.3%	23	0.4%
Menidia audens (Mississippi silverside)	2	0.1%	1	T	3	T
Labidesthes sicculus (brook silverside)	1	T			1	T
Percidae	**9**	**0.3%**	**4**	**0.1%**	**13**	**0.2%**
Sander canadensis (sauger)			1	T	1	T
Perca flavescens (yellow perch)	4	0.1%	3	0.1%	7	0.1%
Percina spp. (not *P. caprodes*)	1	T			1	T
Percina spp. (*P. caprodes* type)	4	0.1%			4	0.1%
Catostomidae			**2**	**0.1%**	**2**	**T**
Ictiobinae			2	0.1%	2	T
Ictaluridae			**1**	**T**	**1**	**T**
Ictalurus punctatus (channel catfish)			1	T	1	T
Total	**3,027**	**100%**	**3,129**	**100%**	**6,156**	**100%**

Table 4 (continued).

Taxon	SCCW Intake		Watts Bar Reservoir transect (TRM 530.2)		Total	
	Total Numbers Collected	Percent Comp.	Total Numbers Collected	Percent Comp.	Total Numbers Collected	Percent Comp.
FISH EGGS						
Sciaenidae						
Aplodinotus grunniens (freshwater drum) eggs	18	78.3%	9	100%	27	84.4%
Clupeidae						
Unspecifiable Clupeid (not skipjack herring) eggs	5	21.7%			5	15.6%
Total	**23**	**100%**	**9**	**100%**	**32**	**100%**
LARVAE						
Clupeidae	**2,231**	**89.3%**	**3,937**	**77.9%**	**6,168**	**81.7%**
Unspecifiable Clupeid	2,215	88.7%	3,469	68.6%	5,648	75.2%
Dorosoma cepedianum (gizzard shad)	16	0.6%	458	9.1%	474	6.3%
Dorosoma petenense (threadfin shad)			4	0.1%	4	0.1%
Alosa chrysochloris (skipjack herring)			2	T	2	T
Alosa pseudoharengus (alewife)			4	0.1%	4	0.1%
Centrarchidae	**226**	**9.0%**	**788**	**15.6%**	**1,014**	**13.4%**
Lepomis spp.	123	4.9%	576	3.1%	699	9.3%
Lepomis macrochirus (bluegill)			7	0.1%	7	0.1%
Micropterus spp (not *M. dolomieu*)			3	0.1%	3	T
Micropterus salmoides (largemouth bass)			1	T	1	T
Pomoxis spp.	102	4.1%	196	3.9%	298	3.9%
Pomoxis annularis (white crappie)	1	T	5	0.1%	6	0.1%
Moronidae	**8**	**0.3%**	**82**	**1.6%**	**90**	**1.2%**
Unspecifiable Moronid	8	0.3%	59	1.2%	67	0.9%
Moronid (not *M. saxatilis*)			4	0.1%	4	0.1%
Morone chrysops (white bass)			19	0.4%	19	0.3%
Sciaenidae	**18**	**0.7%**	**128**	**2.5%**	**146**	**1.9%**
Aplodinotus grunniens (freshwater drum)	18	0.7%	128	2.5%	146	1.9%
Cyprinidae	**6**	**0.2%**	**41**	**0.8%**	**47**	**0.6%**
Cyprinus carpio (common carp)			1	T	1	T
Pimephales spp	6	0.2%	40	0.8%	46	0.6%
Atherinopsidae	**1**	**T**	**56**	**1.1%**	**57**	**0.8%**
Unspecifiable Atherinopsid	1	T	33	0.7%	34	0.5%
Menidia audens (Mississippi silverside)			17	0.3%	17	0.2%
Labidesthes sicculus (brook silverside)			6	0.1%	6	0.1%
Percidae	**5**	**0.2%**	**6**	**0.1%**	**11**	**0.1%**
Perca flavescens (yellow perch)	4	0.2%	4	0.1%	8	0.1%
Percina spp. (not *P. caprodes*)	1	T	1	T	2	T
Percina spp. (*P. caprodes* type)			1	T	1	T
Catostomidae			**1**	**T**	**1**	**T**
Ictiobinae			1	T	1	T
Ictaluridae	**3**	**0.1%**	**17**	**0.3%**	**20**	**0.3%**
Ictalurus punctatus (channel catfish)	3	0.1%	12	0.2%	15	0.2%
Ictalurus furcatus (blue catfish)			5	0.1%	5	0.1%
Total	**2,498**	**100%**	**5,056**	**100%**	**7,554**	**100%**

Table 5. Average densities (number/1,000 m^3) by sample period and family of fish eggs and larvae collected at the Intake Pumping Station (IPS) channel (TRM 528), Chickamauga Reservoir transect (TRM 528.5), Supplemental Condenser Cooling Water (SCCW) Intake (TRM 529.9), and Watts Bar Reservoir transect (TRM 530.2) from March 2010 through March 2011 at Watts Bar Nuclear Plant.

		Fish Eggs							Fish Larvae															
		Chickamauga Reservoir transect					IPS Channel		Chickamauga Reservoir transect									IPS Channel						
Sample Period	Sample Date	Sciaenidae	Clupeidae	Moronidae	Catostomidae	Percidae	Sciaenidae	Clupeidae	Clupeidae	Centrarchidae	Moronidae	Sciaenidae	Cyprinidae	Atherinopsidae	Percidae	Catostomidae	Ictaluridae	Clupeidae	Centrarchidae	Moronidae	Sciaenidae	Cyprinidae	Atherinopsidae	Percidae
1	07-Mar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	14-Mar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	21-Mar	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	28-Mar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	04-Apr	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	11-Apr	-	-	48	-	-	-	-	-	-	262	-	-	-	1	-	-	-	-	276	-	-	-	2
7	18-Apr	-	-	3	-	-	-	-	54	-	163	-	-	-	-	-	-	42	-	108	-	-	-	2
8	25-Apr	-	-	-	-	-	-	-	322	42	7	-	-	-	-	2	-	369	25	7	-	-	-	2
9	02-May	20	17	-	-	-	-	3	613	21	4	1	4	-	2	-	-	338	29	2	-	2	-	6
10	09-May	-	1	-	-	-	-	-	565	3	3	-	-	-	-	-	-	651	7	-	-	2	3	-
11	17-May	13	-	-	-	-	116	2	856	14	17	8	3	6	1	-	-	695	14	9	3	2	3	2
12	23-May	105	-	-	-	-	3	3	377	49	16	23	-	-	-	-	-	430	47	5	5	-	2	-
13	01-Jun	1,356	-	-	-	-	62	-	102	61	5	21	5	1	-	-	-	307	189	8	8	2	2	-
14	07-Jun	104	-	-	-	-	49	-	95	85	6	37	4	4	-	-	-	107	153	75	26	5	12	2
15	14-Jun	28	-	-	-	-	43	-	30	30	-	13	-	-	-	-	1	62	279	5	10	2	2	-
16	21-Jun	22	-	-	-	-	2	-	2	6	-	5	-	-	-	-	-	15	196	-	6	2	2	-
17	28-Jun	19	-	-	-	-	2	-	4	3	-	-	-	-	-	-	-	-	14	-	-	2	-	-
18	04-Jul	41	-	-	-	-	5	-	-	1	-	-	-	-	-	-	-	2	6	-	-	-	-	-
19	11-Jul	2,039	-	-	-	-	327	-	-	2	-	-	-	1	-	-	-	-	20	-	-	2	2	-
20	18-Jul	466	-	-	-	-	87	-	-	-	-	-	-	-	-	-	-	-	23	-	-	2	-	-
21	25-Jul	113	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	6	18	-	-	-	-	-
22	01-Aug	2	-	-	-	-	-	-	4	1	-	-	7	-	-	-	-	15	9	-	-	2	-	-
23	08-Aug	2	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	5	8	-	-	2	-	-
24	15-Aug	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	11	-	2	2	-	-
25	22-Aug	1	-	-	-	-	27	-	-	-	-	-	-	-	-	-	-	2	5	-	2	-	-	-
26	29-Aug	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	2	-	-	-	-	-
27	20-Sep	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	13-Oct	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	16-Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	22-Dec	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	75	-	-	-	-	-	-
31	19-Jan	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	39	-	-	-	-	-	-
32	14-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	274	-	-	-	-	3	-
33	25-Mar	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5 (continued).

		Fish Eggs			Fish Larvae																	
		Watts Bar Reservoir transect		SCCW Intake	Watts Bar Reservoir transect									SCCW Intake								
Sample Period	Sample Date	Sciaenidae	Clupeidae	Sciaenidae	Clupeidae	Centrarchidae	Sciaenidae	Moronidae	Atherinopsidae	Cyprinidae	Ictaluridae	Percidae	Catostomidae	Clupeidae	Centrarchidae	Sciaenidae	Moronidae	Cyprinidae	Percidae	Ictaluridae	Atherinopsidae
1	07-Mar	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
2	14-Mar	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
3	21-Mar	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-
4	28-Mar	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
5	04-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	11-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-
7	18-Apr	-	-	-	69	3	-	5	-	-	1	4	-	53	-	-	-	-	3	-	-
8	25-Apr	-	-	-	353	41	-	16	-	1	-	2	1	607	139	-	16	-	3	-	-
9	02-May	1	1	-	730	47	-	8	1	3	1	-	-	172	24	-	3	3	3	-	-
10	09-May	-	4	-	1,294	31	-	10	1	5	-	1	-	4,104	10	3	3	-	3	-	-
11	17-May	1	-	9	728	36	5	21	14	8	-	-	-	572	25	3	-	3	-	-	-
12	23-May	11	-	-	503	104	17	15	7	6	-	-	-	1,412	71	6	3	-	-	-	-
13	01-Jun	2	1	3	895	194	18	16	17	2	1	-	-	389	228	13	-	-	-	-	-
14	07-Jun	2	-	-	191	116	34	11	9	1	2	-	-	54	74	10	-	3	-	7	3
15	14-Jun	-	-	-	59	240	44	1	-	-	-	-	-	7	33	13	-	-	-	-	-
16	21-Jun	-	-	3	6	30	27	-	2	1	2	-	-	3	16	10	-	-	-	-	-
17	28-Jun	-	-	-	12	31	13	-	1	6	4	-	-	-	13	-	-	7	-	-	-
18	04-Jul	2	-	-	17	12	-	-	5	11	-	-	-	-	23	-	-	-	-	-	-
19	11-Jul	-	-	-	9	1	-	-	3	-	-	-	-	3	-	-	-	-	-	3	-
20	18-Jul	-	-	13	3	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
21	25-Jul	1	-	-	9	4	-	-	1	-	1	-	-	10	-	-	-	-	-	-	-
22	01-Aug	-	-	-	18	16	-	-	6	-	-	-	-	34	3	-	-	-	-	-	-
23	08-Aug	-	-	-	20	10	-	-	-	1	1	-	-	10	7	-	-	-	-	-	-
24	15-Aug	-	-	-	13	47	-	-	1	4	-	-	-	-	57	-	-	-	-	-	-
25	22-Aug	-	-	-	1	13	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-
26	29-Aug	-	-	-	3	3	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-
27	20-Sep	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
28	13-Oct	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	16-Nov	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-
30	22-Dec	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	19-Jan	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	14-Feb	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	25-Mar	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 6. Densities (number/1,000 m3) by family of fish eggs and larvae during day and night collected at the Intake Pumping Station (IPS) channel (TRM 528), Chickamauga Reservoir transect (TRM 528.5), Supplemental Condenser Cooling Water (SCCW) Intake (TRM 529.9), and Watts Bar Reservoir transect (TRM 530.2) from March 2010 through March 2011 at Watts Bar Nuclear Plant. *Intake densities are averages of four samples.

Fish Eggs	Chickamauga Reservoir transect										IPS Channel*	
	Day					Night					Day	Night
Family	RDB	40% from RDB	Midchannel (Bottom Tow)	60% from RDB	LDB	RDB	40% from RDB	Midchannel (Bottom Tow)	60% from RDB	LDB		
Sciaenidae	1.5	4.3	0.8	2.0	2.8	200.8	211.0	279.5	267.8	393.8	8.2	38.1
Moronidae	0.8	1.2	0.4	-	-	1.9	3.0	8.4	0.8	0.4	-	-
Clupeidae	-	1.6	-	0.4	0.4	0.4	1.9	0.8	0.4	-	0.2	0.3
Percidae	-	-	0.4	-	-	-	-	0.4	-	-	-	-
Catostomidae	0.4	-	-	-	-	-	-	-	-	-	-	-
Total:	**2.7**	**7.0**	**1.6**	**2.4**	**3.2**	**203.1**	**215.9**	**289.1**	**269.0**	**394.2**	**8.2**	**38.1**
Diel Avg:			**3.4**					**274.2**			**8.2**	**38.1**
24-hr Avg:						**138.8**					**23.1**	

Fish Larvae	Chickamauga Reservoir transect										IPS Channel*	
	Day					Night					Day	Night
Family	RDB	40% from RDB	Midchannel (Bottom Tow)	60% from RDB	LDB	RDB	40% from RDB	Midchannel (Bottom Tow)	60% from RDB	LDB		
Clupeidae	55.2	48.8	42.0	54.2	53.1	174.7	104.9	64.1	112.6	218.3	60.2	142.0
Centrarchidae	9.6	6.2	10.3	6.4	5.2	15.9	4.9	9.2	3.9	30.3	15.7	50.2
Moronidae	20.1	9.8	12.8	4.0	10.0	16.3	16.3	7.2	20.3	26.4	4.8	25.7
Sciaenidae	1.2	1.6	5.8	1.2	1.2	3.8	4.5	5.6	5.5	3.5	0.2	3.6
Cyprinidae	-	-	0.8	-	0.4	0.8	-	0.8	0.8	1.6	0.1	1.4
Atherinopsidae	1.2	-	-	0.4	0.4	0.4	0.4	-	0.4	0.8	1.1	0.6
Percidae	0.4	-	-	0.4	-	-	0.4	-	0.4	-	0.2	0.7
Catostomidae	-	-	-	-	-	0.4	-	-	-	0.4	-	-
Ictaluridae	-	-	-	-	-	-	0.4	-	-	-	-	-
Total:	**87.6**	**66.4**	**71.6**	**66.6**	**70.2**	**212.1**	**131.4**	**86.9**	**143.9**	**281.2**	**82.3**	**224.2**
Diel Avg:			**72.5**					**171.1**			**82.3**	**224.2**
24-hr Avg:						**121.8**					**153.3**	

***IPS densities are averages of four samples.**

Table 6 (continued).

Fish Eggs	Watts Bar Reservoir transect										SCCW Intake**	
	Day					Night					Day	Night
Family	RDB	40% from RDB	Midchannel (Bottom Tow)	60% from RDB	LDB	RDB	40% from RDB	Midchannel (Bottom Tow)	60% from RDB	LDB		
Sciaenidae	-	-	2.0	0.8	0.4	2.7	0.4	0.4	0.4	-	0.2	1.6
Clupeidae	0.4	-	-	-	1.2	-	-	-	0.4	-	-	-
Total:	**0.4**	**0.0**	**2.0**	**0.8**	**1.6**	**2.7**	**0.4**	**0.4**	**0.8**	**0.0**	**0.2**	**1.6**
Diel Avg:			**0.9**					**0.8**			**0.2**	**1.6**
24-hr Avg:						**0.9**					**0.9**	

Fish Larvae	Watts Bar Reservoir transect										SCCW Intake**	
	Day					Night					Day	Night
Family	RDB	40% from RDB	Midchannel (Bottom Tow)	60% from RDB	LDB	RDB	40% from RDB	Midchannel (Bottom Tow)	60% from RDB	LDB		
Clupeidae	61.5	26.1	2.0	47.6	415.3	317.3	164.8	7.1	232.1	251.6	51.6	399.1
Centrarchidae	33.7	8.0	-	8.5	29.9	109.1	12.9	-	22.8	79.7	16.1	29.6
Sciaenidae	0.8	2.3	0.8	1.2	0.4	7.7	6.0	4.0	13.1	13.2	0.8	2.8
Moronidae	0.4	0.8	-	1.5	1.6	3.5	1.1	-	4.2	18.6	0.6	1.0
Atherinopsidae	0.4	0.8	-	2.7	0.8	10.0	2.3	-	1.9	2.7	-	0.2
Cyprinidae	-	0.4	1.2	0.4	-	8.1	1.9	0.4	0.4	3.1	0.2	1.0
Ictaluridae	-	-	-	-	-	1.2	0.4	2.8	2.3	-	-	0.6
Percidae	-	-	-	-	-	0.4	0.4	-	0.8	0.8	0.2	0.8
Catostomidae	-	-	-	-	-	-	-	-	0.4	-	-	-
Total:	**96.8**	**38.3**	**3.9**	**62.0**	**448.0**	**457.3**	**189.8**	**14.2**	**278.0**	**369.7**	**69.6**	**435.2**
Diel Avg:			**129.8**					**261.8**			**69.6**	**435.2**
24-hr Avg:						**195.8**					**252.4**	

****SCCW densities are averages of two samples.**

Table 7. Estimated entrainment by sample period of fish eggs and larvae collected at the Intake Pumping Station (IPS) channel (TRM 528), Chickamauga Reservoir transect (TRM 528.5), Supplemental Condenser Cooling Water (SCCW) Intake (TRM 529.9), and Watts Bar Reservoir transect (TRM 530.2) from March 2010 through March 2011 at Watts Bar Nuclear Plant including intake and reservoir flow and average densities.

Fish Eggs									
		Chickamauga Reservoir transect			IPS Channel				
Sample Period	Sample Date	Density (no./1000m³)	River Flow (10^4 m³/day)	Estimated Number Transported	Density (no./1000m³)	Water Demand (10^4 m³/ day)	Estimated Number Entrained	Weekly Percent Entrainment	Monthly Percent Entrainment
1	7-Mar	0	5,999	0	0	9	0	0%	0%
2	14-Mar	0	7,735	0	0	9	0	0%	
3	21-Mar	1	4,364	5.99 X 10^4	0	9	0	0%	
4	28-Mar	0	2,697	0	0	10	0	0%	
5	4-Apr	7	2,144	1.44 X 10^5	0	10	0	0%	0%
6	11-Apr	48	1,739	8.34 X 10^5	0	10	0	0%	
7	18-Apr	3	1,477	3.89 X 10^4	0	9	0	0%	
8	25-Apr	0	2,550	0	0	10	0	0%	
9	2-May	37	11,925	4.47 X 10^6	3	16	5.05 X 10^2	0.01%	0.26%
10	9-May	1	3,083	3.98 X 10^4	0	16	0	0%	
11	17-May	13	3,645	4.73 X 10^5	117	16	1.93 X 10^4	4.08%	
12	23-May	105	2,877	3.03 X 10^6	6	16	1.06 X 10^3	0.03%	
13	1-Jun	1,356	1,851	2.51 X 10^7	62	16	1.01 X 10^4	0.04%	0.08%
14	7-Jun	104	3,463	3.62 X 10^6	49	17	8.13 X 10^3	0.22%	
15	14-Jun	28	3,036	8.36 X 10^5	43	17	7.12 X 10^3	0.85%	
16	21-Jun	22	3,142	6.96 X 10^5	2	17	2.57 X 10^2	0.04%	
17	28-Jun	19	3,113	5.94 X 10^5	2	17	2.55 X 10^2	0.04%	
18	4-Jul	41	3,099	1.28 X 10^6	5	17	7.75 X 10^2	0.06%	0.09%
19	11-Jul	2,039	3,026	6.17 X 10^7	327	17	5.56 X 10^4	0.09%	
20	18-Jul	466	2,118	9.88 X 10^6	87	17	1.48 X 10^4	0.15%	
21	25-Jul	113	3,246	3.67 X 10^6	0	17	0	0%	
22	1-Aug	2	5,475	1.33 X 10^5	0	17	0	0%	1.81%
23	8-Aug	2	5,301	1.31 X 10^5	8	18	1.38 X 10^3	1.06%	
24	15-Aug	0	5,645	0	0	18	0	0%	
25	22-Aug	1	5,477	7.21 X 10^4	27	18	4.70 X 10^3	6.53%	
26	29-Aug	0	5,694	0	0	17	0	0%	
27	20-Sep	0	4,265	0	0	17	0	0%	0%
28	13-Oct	0	3,778	0	0	17	0	0%	0%
29	16-Nov	0	7,098	0	0	14	0	0%	0%
30	22-Dec	0	9,388	0	0	16	0	0%	0%
31	19-Jan	0	4,997	0	0	9	0	0%	0%
32	14-Feb	0	2,915	0	0	9	0	0%	0%
33	25-Mar	5	11,413	5.71 X 10^5	0	9	0	0%	0%
			Total:	**1.17 X 10^8**		**Total:**	**1.24 X 10^5**	**Annual Percent Entrained 0.11%**	

Table 7 (continued).

Fish Larvae										
		Chickamauga Reservoir transect			IPS Channel					
Sample Period	Sample Date	Density (no./1000m³)	River Flow (10^4 m³/ day)	Estimated Number Transported	Density (no./1000m³)	Water Demand (10^4 m³/ day)	Estimated Number Entrained	Weekly Percent Entrained	Monthly Percent Entrained
1	7-Mar	0	5,999	0	0	9	0	0%	0%
2	14-Mar	0	7,735	0	0	9	0	0%	
3	21-Mar	0	4,364	0	0	9	0	0%	
4	28-Mar	0	2,697	0	0	10	0	0%	
5	4-Apr	0	2,144	0	0	10	0	0%	0.47%
6	11-Apr	264	1,739	4.58×10^6	278	10	2.69×10^4	0.59%	
7	18-Apr	217	1,477	3.21×10^6	151	9	1.35×10^4	0.42%	
8	25-Apr	374	2,550	9.55×10^6	402	10	4.06×10^4	0.43%	
9	2-May	646	11,925	7.70×10^7	377	16	5.89×10^4	0.08%	0.26%
10	9-May	570	3,083	1.76×10^7	663	16	1.05×10^5	0.60%	
11	17-May	905	3,645	3.30×10^7	728	16	1.20×10^5	0.36%	
12	23-May	465	2,877	1.34×10^7	488	16	8.00×10^4	0.60%	
13	1-Jun	195	1,851	3.61×10^6	516	17	8.37×10^4	2.32%	2.25%
14	7-Jun	230	3,463	7.96×10^6	380	17	6.25×10^4	0.78%	
15	14-Jun	74	3,036	2.24×10^6	358	17	5.93×10^4	2.65%	
16	21-Jun	14	3,142	4.25×10^5	221	17	3.68×10^4	8.65%	
17	28-Jun	8	3,113	2.37×10^5	15	17	2.55×10^3	1.07%	
18	4-Jul	1	3,099	3.86×10^4	8	17	1.29×10^3	3.34%	7.18%
19	11-Jul	4	3,026	1.11×10^5	23	17	3.97×10^3	3.57%	
20	18-Jul	0	2,118	0	25	17	4.23×10^3	*	
21	25-Jul	1	3,246	4.03×10^4	24	18	4.17×10^3	10.34%	
22	1-Aug	6	5,475	3.32×10^5	26	18	4.44×10^3	1.34%	1.83%
23	8-Aug	0	5,301	0	14	18	2.49×10^3	*	
24	15-Aug	1	5,645	7.16×10^4	14	17	2.59×10^3	3.61%	
25	22-Aug	0	5,477	0	8	17	1.47×10^3	*	
26	29-Aug	4	5,694	2.13×10^5	2	17	2.70×10^2	0.13%	
27	20-Sep	0	4,265	0	0	14	0	0%	0%
28	13-Oct	0	3,778	0	0	16	0	0%	0%
29	16-Nov	0	7,098	0	0	9	0	0%	0%
30	22-Dec	0	9,388	0	75	9	1.16×10^4	*	*
31	19-Jan	4	4,997	1.93×10^5	39	9	3.33×10^3	1.72%	1.72%
32	14-Feb	0	2,915	0	277	9	2.46×10^4	*	*
33	25-Mar	0	11,413	0	0	9	0	0%	0%
			Total:	**1.74×10^8**		**Total:**	**7.54×10^5**	**Annual Percent Entrained 0.43%**	

Table 7 (continued).

Fish Eggs									
		Watts Bar Reservoir transect			SCCW Intake				
Sample Period	Sample Date	Density (no./1000m³)	River Flow (10^4 m³/day)	Estimated Number Transported	Density (no./1000m³)	Water Demand (10^4 m³/ day)	Estimated Number Entrained	Weekly Percent Entrained	Monthly Percent Entrained
1	7-Mar	0	5,881	0	0	45	0	0%	0%
2	14-Mar	0	7,622	0	0	39	0	0%	
3	21-Mar	0	4,239	0	0	51	0	0%	
4	28-Mar	0	2,570	0	0	54	0	0%	
5	4-Apr	0	2,016	0	0	58	0	0%	0%
6	11-Apr	0	2,044	0	0	57	0	0%	
7	18-Apr	0	1,347	0	0	57	0	0%	
8	25-Apr	0	2,404	0	0	73	0	0%	
9	2-May	3	11,806	3.09×10^5	0	46	0	0%	0.88%
10	9-May	4	2,980	1.13×10^5	0	44	0	0%	
11	17-May	1	3,616	4.66×10^4	9	73	6.81×10^3	14.63%	
12	23-May	11	2,733	3.04×10^5	0	78	0	0%	
13	1-Jun	4	1,701	6.25×10^4	3	76	2.44×10^3	3.91%	3.71%
14	7-Jun	2	3,374	8.39×10^4	0	81	0	0%	
15	14-Jun	0	2,925	0	0	76	0	0%	
16	21-Jun	0	2,977	0	3	93	2.98×10^3	*	
17	28-Jun	0	2,950	0	0	92	0	0%	
18	4-Jul	2	2,910	7.26×10^4	0	115	0	0%	9.57%
19	11-Jul	0	2,631	0	0	322	0	0%	
20	18-Jul	0	1,962	0	13	83	1.07×10^4	*	
21	25-Jul	1	3,096	3.97×10^4	0	76	0	0%	
22	1-Aug	0	5,324	0	0	78	0	0%	0%
23	8-Aug	0	5,158	0	0	70	0	0%	
24	15-Aug	0	5,500	0	0	71	0	0%	
25	22-Aug	0	5,329	0	0	74	0	0%	
26	29-Aug	0	5,545	0	0	75	0	0%	
27	20-Sep	0	4,118	0	0	73	0	0%	0%
28	13-Oct	0	3,634	0	0	71	0	0%	0%
29	16-Nov	0	6,961	0	0	64	0	0%	0%
30	22-Dec	0	9,258	0	0	57	0	0%	0%
31	19-Jan	0	4,864	0	0	60	0	0%	0%
32	14-Feb	0	2,819	0	0	22	0	0%	0%
33	25-Mar	0	11,339	0	0	0.02	0	0%	0%
			Total:	**1.03×10^6**		**Total:**	**2.30×10^4**	**Annual Percent Entrained 2.23%**	

Table 7 (continued).

Fish Larvae									
		Watts Bar Reservoir transect			SCCW Intake				
Sample Period	Sample Date	Density (no./1000m³)	River Flow (10^4 m³/day)	Estimated Number Transported	Density (no./1000m³)	Water Demand (10^4 m³/ day)	Estimated Number Entrained	Weekly Percent Entrained	Monthly Percent Entrained
1	7-Mar	3	5,881	1.57×10^5	0	45	0	0%	
2	14-Mar	1	7,622	1.01×10^5	0	39	0	0%	0%
3	21-Mar	3	4,239	1.13×10^5	0	51	0	0%	
4	28-Mar	3	2,570	6.60×10^4	0	54	0	0%	
5	4-Apr	0	2,016	0	0	58	0	0%	
6	11-Apr	0	2,044	0	3	57	1.76×10^3	*	5.33%
7	18-Apr	82	1,347	1.10×10^6	56	57	3.21×10^4	2.91%	
8	25-Apr	414	2,404	9.95×10^6	765	73	5.56×10^5	5.58%	
9	2-May	790	11,806	9.33×10^7	206	46	9.48×10^4	0.10%	
10	9-May	1,343	2,980	4.00×10^7	4,125	44	1.80×10^6	4.49%	1.94%
11	17-May	811	3,616	2.93×10^7	604	73	4.38×10^5	1.49%	
12	23-May	653	2,733	1.78×10^7	1,493	78	1.17×10^6	6.53%	
13	1-Jun	1,144	1,701	1.65×10^7	630	76	4.79×10^5	2.46%	
14	7-Jun	364	3,374	1.23×10^7	151	81	1.22×10^5	0.99%	
15	14-Jun	344	2,925	1.01×10^7	53	76	4.03×10^4	0.40%	1.50%
16	21-Jun	69	2,977	2.06×10^6	29	93	2.68×10^4	1.30%	
17	28-Jun	67	2,950	1.99×10^6	20	92	1.83×10^4	0.92%	
18	4-Jul	46	2,910	1.34×10^6	23	115	2.63×10^4	1.96%	
19	11-Jul	13	2,631	3.48×10^5	7	322	2.14×10^4	6.15%	2.47%
20	18-Jul	4	1,962	7.44×10^4	0	83	0	0%	
21	25-Jul	15	3,096	4.76×10^5	10	76	7.71×10^3	1.62%	
22	1-Aug	40	5,324	2.15×10^6	37	78	2.86×10^4	1.33%	
23	8-Aug	33	5,158	1.69×10^6	17	70	1.19×10^4	0.70%	
24	15-Aug	64	5,500	3.53×10^6	57	71	4.09×10^4	1.16%	1.06%
25	22-Aug	14	5,329	7.70×10^5	3	74	2.58×10^3	0.34%	
26	29-Aug	5	5,545	2.85×10^5	7	75	5.08×10^3	1.78%	
27	20-Sep	0	4,118	0	3	73	2.44×10^3	*	*
28	13-Oct	0	3,634	0	0	71	0	0%	0%
29	16-Nov	0	6,961	0	3	64	2.06×10^3	*	*
30	22-Dec	4	9,258	3.67×10^5	0	57	0	0%	0%
31	19-Jan	3	4,864	1.34×10^5	0	60	0	0%	0%
32	14-Feb	4	2,819	1.14×10^5	0	22	0	0%	0%
33	25-Mar	9	11,339	1.02×10^6	0	0.02	0	0%	0%
			Total:	**2.49×10^8**		**Total:**	**4.92×10^6**	**Annual Percent Entrained 1.98%**	

*** For this sample period, fish larvae were collected in intake samples, but not in reservoir samples. Calculating entrainment for these sample periods was mathematically impossible.**

Table 8. Estimated entrainment of fish eggs and larvae during April through June 1996, 1997, and 2010 at Watts Bar Nuclear Plant including Intake Pumping Station (IPS) and Chickamauga Reservoir flow, sample periods and dates, and average densities.

1996 – Fish Eggs

		Chickamauga Reservoir transect			IPS Channel			
Sample Period	Sample Date	Density (no./1000m^3)	River Flow (10^4 m^3/ day)	Estimated Number Transported	Density (no./1000m^3)	Water Demand (10^4 m^3/ day)	Estimated Number Entrained	Percent Entrained
1	8-Apr	382	2,040	7.80 X 10^{6}	17	12.7	2.18 X 10^{3}	0.03%
2	22-Apr	1,528	6,290	9.61 X 10^{7}	109	7.1	7.73 X 10^{3}	0.01%
3	6-May	26	2,410	6.17 X 10^{5}	59	16.2	9.54 X 10^{3}	1.55%
4	20-May	84	4,360	3.64 X 10^{6}	0	15.4	0	0%
5	3-Jun	10	8,200	7.80 X 10^{5}	9	11.7	1.03 X 10^{3}	0.13%
6	17-Jun	7	6,940	4.84 X 10^{5}	0	22.6	0	0%
		Avg Dens: 340	**Total:**	**1.09 X 10^{8}**	**Avg Dens: 32**	**Total:**	**2.05 X 10^{4}**	**0.02%***

1996 – Larvae

		Chickamauga Reservoir transect			IPS Channel			
Sample Period	Sample Date	Density (no./1000m^3)	River Flow (10^4 m^3/ day)	Estimated Number Transported	Density (no./1000m^3)	Water Demand (10^4 m^3/ day)	Estimated Number Entrained	Percent Entrained
1	8-Apr	1	2,040	2.93 X 10^{4}	0	12.7	0	0%
2	22-Apr	22	6,290	1.39 X 10^{6}	0	7.1	0	0%
3	6-May	426	2,410	1.03 X 10^{7}	294	16.2	4.77 X 10^{4}	0.47%
4	20-May	594	4,360	2.59 X 10^{7}	1,348	15.4	2.08 X 10^{5}	0.80%
5	3-Jun	1,065	8,200	8.73 X 10^{7}	5,575	11.7	6.51 X 10^{5}	0.75%
6	17-Jun	551	6,940	3.82 X 10^{7}	2,354	22.6	5.32 X 10^{5}	1.39%
		Avg Dens: 443	**Total:**	**1.63 X 10^{8}**	**Avg Dens: 1,595**	**Total:**	**1.44 X 10^{6}**	**0.88%***

1997 – Fish Eggs

		Chickamauga Reservoir transect			IPS Channel			
Sample Period	Sample Date	Density (no./1000m^3)	River Flow (10^4 m^3/ day)	Estimated Number Transported	Density (no./1000m^3)	Water Demand (10^4 m^3/ day)	Estimated Number Entrained	Percent Entrained
1	21-Mar	1,070	10,900	1.17 X 10^{8}	177	10.3	1.82 X 10^{4}	0.02%
2	14-Apr	16	2,380	3.80 X 10^{5}	0	12.4	0	0%
3	28-Apr	11	5,430	5.72 X 10^{5}	0	10.1	0	0%
4	15-May	1	4,960	3.35 X 10^{4}	0	10.4	0	0%
5	27-May	3	4,630	1.25 X 10^{5}	0	11.0	0	0%
6	9-Jun	0	7,490	0	0	11.9	0	0%
7	23-Jun	18	9,990	1.81 X 10^{6}	9	12.3	1.12 X 10^{3}	0.06%
		Avg Dens: 160	**Total:**	**1.20 X 10^{8}**	**Avg Dens: 27**	**Total:**	**1.94 X 10^{4}**	**0.02%***

1997 – Larvae

		Chickamauga Reservoir transect			IPS Channel			
Sample Period	Sample Date	Density (no./1000m^3)	River Flow (10^4 m^3/ day)	Estimated Number Transported	Density (no./1000m^3)	Water Demand (10^4 m^3/ day)	Estimated Number Entrained	Percent Entrained
1	21-Mar	52	10,900	5.70 X 10^{6}	35	10.3	3.65 X 10^{3}	0.06%
2	14-Apr	319	2,380	7.59 X 10^{6}	232	12.4	2.89 X 10^{4}	0.38%
3	28-Apr	1,115	5,430	6.05 X 10^{7}	427	10.1	4.30 X 10^{4}	0.07%
4	15-May	1,689	4,960	8.37 X 10^{7}	1,822	10.4	1.89 X 10^{5}	0.23%
5	27-May	550	4,630	2.55 X 10^{7}	625	11.0	6.88 X 10^{4}	0.27%
6	9-Jun	1,032	7,490	7.74 X 10^{7}	2,260	11.9	2.70 X 10^{5}	0.35%
7	23-Jun	1,600	9,990	1.60 X 10^{8}	2,646	12.3	3.25 X 10^{5}	0.20%
		Avg Dens: 908	**Total:**	**4.20 X 10^{8}**	**Avg Dens: 1,150**	**Total:**	**9.28 X 10^{5}**	**0.22%***

Table 8 (continued).

2010 – Fish Eggs								
		Chickamauga Reservoir transect			IPS Channel			
Sample Period	Sample Date	Density (no./1000m³)	River Flow (10^4 m³/ day)	Estimated Number Transported	Density (no./1000m³)	Water Demand (10^4 m³/ day)	Estimated Number Entrained	Percent Entrained
1	4-Apr	7	2,140	1.44×10^5	0	9.8	0	0%
2	11-Apr	48	1,740	8.34×10^5	0	9.7	0	0%
3	18-Apr	3	1,480	3.89×10^4	0	9.0	0	0%
4	25-Apr	0	2,550	0	0	10.1	0	0%
5	2-May	38	11,900	4.47×10^6	3	15.6	5.05×10^2	0.01%
6	9-May	1	3,080	3.98×10^4	0	15.9	0	0%
7	17-May	13	3,650	4.73×10^5	117	16.4	1.93×10^4	4.08%
8	23-May	105	2,880	3.03×10^6	6	16.4	1.06×10^3	0.03%
9	1-Jun	1,356	1,850	2.51×10^7	62	16.2	1.01×10^4	0.04%
10	7-Jun	105	3,460	3.62×10^6	49	16.5	8.13×10^3	0.22%
11	14-Jun	28	3,040	8.36×10^5	43	16.6	7.12×10^3	0.85%
12	21-Jun	22	3,140	6.96×10^5	2	16.6	2.57×10^2	0.04%
13	28-Jun	19	3,110	5.94×10^5	2	16.5	2.55×10^2	0.04%
		Avg Dens: 134	**Total:**	**3.99×10^7**	**Avg Dens: 22**	**Total:**	**4.67×10^4**	**0.12%**

2010 – Larvae								
		Chickamauga Reservoir transect			IPS Channel			
Sample Period	Sample Date	Density (no./1000m³)	River Flow (10^4 m³/ day)	Estimated Number Transported	Density (no./1000m³)	Water Demand (10^4 m³/ day)	Estimated Number Entrained	Percent Entrained
1	4-Apr	0	2,140	0	0	9.8	0	0%
2	11-Apr	264	1,740	4.58×10^6	278	9.7	2.69×10^4	0.59%
3	18-Apr	217	1,480	3.21×10^6	151	9.0	1.35×10^4	0.42%
4	25-Apr	374	2,550	9.55×10^6	402	10.1	4.06×10^4	0.43%
5	2-May	646	11,900	7.70×10^7	377	15.6	5.89×10^4	0.08%
6	9-May	570	3,080	1.76×10^7	663	15.9	1.05×10^5	0.60%
7	17-May	905	3,650	3.30×10^7	728	16.4	1.20×10^5	0.36%
8	23-May	465	2,880	1.34×10^7	488	16.4	8.00×10^4	0.60%
9	1-Jun	195	1,850	3.61×10^6	516	16.2	8.37×10^4	2.32%
10	7-Jun	230	3,460	7.96×10^6	380	16.5	6.25×10^4	0.78%
11	14-Jun	74	3,040	2.24×10^6	358	16.6	5.93×10^4	2.65%
12	21-Jun	14	3,140	4.25×10^5	221	16.6	3.68×10^4	8.65%
13	28-Jun	8	3,110	2.37×10^5	16	16.5	2.55×10^3	1.08%
		Avg Dens: 305	**Total:**	**1.73×10^8**	**Avg Dens: 352**	**Total:**	**6.90×10^5**	**0.40%**

*** Denoted values will not match those in TVA, 1998 and are quotients of total estimated number entrained and total estimated number transported. The corresponding values in TVA, 1998 were calculated by averaging weekly percent entrained values.**