Tennessee Valley Authority, Post Office Box 2000, Soddy-Daisy, Tennessee 37384-2000

June 10, 2004

State of Tennessee
Department of Environment and Conservation
Division of Water Pollution Control
Enforcement & Compliance Section
6th Floor, L & C Annex
401 Church Street
Nashville, Tennessee 37243-1534

Attention: Mr. Chip Hannah

Dear Mr. Hannah:

SEQUOYAH NUCLEAR PLANT - NONRADIOLOGICAL AQUATIC MONITORING PROGRAM
BIOLOGICAL MONITORING

Please find enclosed two copies of the report, "Biological Monitoring of the Tennessee River Near Sequoyah Nuclear Plant Discharge, 2003." This report is submitted in accordance with Part III, Section F of the TVA - Sequoyah Nuclear Plant NPDES Permit No. TN0026450.

Please contact me at (423) 843-6700 if you have any questions or comments.

Sincerely,

Stephanie A. Howard

Stephanie A. Howard
Principal Environmental Engineer
Signatory Authority for
J. Randy Douet
Site Vice President
Sequoyah Nuclear Plant

Enclosure
cc (Enclosure):

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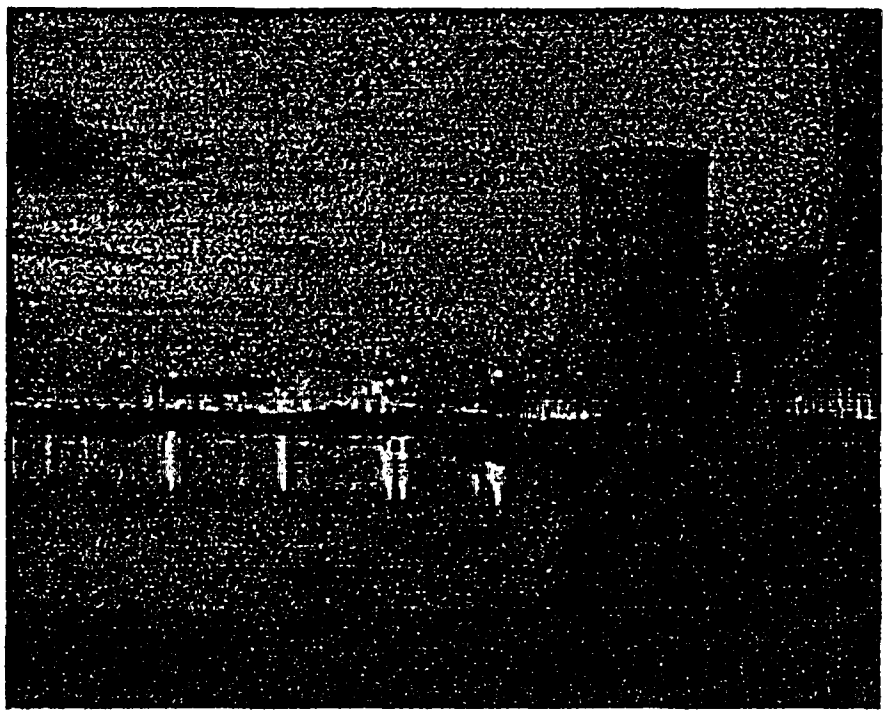
IE25

# Biological Monitoring of the Tennessee River Near Sequoyah Nuclear Plant Discharge 2003



by
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**June 2004**
**Final**

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Norris, Tennessee

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## Acronyms

| | |
|---|---|
| BI | Benthic Macroinvertebrate Index |
| BIP | Balanced Indigenous Population |
| NPDES | National Pollutant Discharge Elimination System |
| PSD | Proportional Stock Density |
| QA | Quality Assurance |
| RFAI | Reservoir Fish Assemblage Index |
| RSD | Relative Stock Density |
| RSDM | Relative Stock Density of Memorable-sized |
| RSDP | Relative Stock Density of Preferred-sized |
| RSDT | Relative Stock Density of Trophy-sized |
| SAHI | Shoreline Assessment Habitat Index |
| SFI | Sport Fishing Index |
| SQN | Sequoyah Nuclear Plant |
| SSS | Spring Sport Fish Survey |
| TRM | Tennessee River Mile |
| TVA | Tennessee Valley Authority |
| VS | Vital Signs |
| Wr | Relative Weight |

# Introduction

Section 316(a) of the Clean Water Act specifies that industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. Industries responsible for point-source dischargers of heated water can obtain a variance from state water quality standards if the industry can demonstrate compliance with thermal criteria by documenting the maintenance of Balanced Indigenous Populations (BIP) of aquatic life in the vicinity of its discharge. Sequoyah Nuclear Plant's (SQN) current National Pollutant Discharge Elimination System (NPDES) permit number TN0026450 states, "For Section 316(a), the permittee shall summarize previous data and indicate whether significant changes have occurred in plant operation, reservoir operations or in stream biology that would necessitate that significant changes to the permitted variance." The permittee shall use the Reservoir Fish Assemblage Index (RFAI) to assess Chickamauga Reservoir fish community health. Any apparent declines in the fish community health will be further investigated to discover whether the decline is a valid conclusion and if the decline is real to identify possible sources for the fish community decline. As part of the identification of potential sources for the decline, the instream effects of the discharges made under this permit will be investigated (TDEC 2000). In response to this requirement, Tennessee Valley Authority's (TVA's) Vital Signs (VS) monitoring program (Dycus and Meinert 1993) will be used to evaluate areas of Chickamauga Reservoir upstream and downstream of SQN discharge. The purpose of this document is to briefly summarize and provide Tennessee Department of Environment and Conservation the results of comparisons between current and historical monitoring data.

Prior to 1990, TVA focused on reservoir ecological assessments to meet specific needs as they arose. In 1990, TVA instituted a Valley-wide VS monitoring program which is a broad-based evaluation of the overall ecological conditions in major reservoirs. Data is evaluated with a multi-metric monitoring approach utilizing five environmental indicators: dissolved oxygen, chlorophyll, sediment quality, benthic macroinvertebrate community, and the fish community. When this program was initiated, specific evaluation techniques were developed for each indicator, and these techniques were fine-tuned to better represent ecological conditions. The outcome of this effort was development of multi-metric evaluation techniques for the fish assemblage (i.e., RFAI) and the benthic community, as described below. These multi-metric evaluation techniques have proven successful in TVA's monitoring efforts as well as other federal and state monitoring programs. Therefore, they will form the basis of evaluating these monitoring results. For consistency, only RFAI analyses between 1993 and 2003 will be utilized. The Benthic Macroinvertebrate Index (BI) is used primarily to support the RFAI analysis.

In the past, the Sport Fishing Index (SFI) was used in support of a thermal variance request at SQN (TVA 1996). The SFI was developed to quantify sport fishing quality for individual sport fish species. The SFI provides biologists with a reference point to measure the quality of a sport fishery. Comparison of the population sampling parameters and creel results for a particular sport fish species with expectations of these parameters from a high quality fishery (reference conditions) allows for the determination of fishing quality. Indices have been developed for

black bass (largemouth, smallmouth and spotted bass), sauger, striped bass, bluegill, and channel catfish. Each SFI relies on measurements of quantity and quality aspects of angler success and fish population characteristics.

In recent years, SFI information has been used to describe the quality of the resident fishery in conjunction with compliance monitoring, thermal variance requests, and other regulatory issues at TVA nuclear plants in Tennessee. Similar NPDES compliance monitoring programs using the methodologies described above are also being performed at Colbert and Widows Creek Fossil Plants in Alabama.

The TVA Spring Sport Fish Survey (SSS) is conducted to evaluate the sport fish population of TVA Reservoirs. The results of the survey are used by state agencies to protect, improve and assess the quality of sport fisheries. Predominant habitat types in the reservoir are surveyed to determine sport fish abundance. In addition to accommodating TVA and state databases, this surveying method aligns with TVA Watershed Team and TVA's Reservoir Operations Study objectives. Sample sites are selected using the shoreline habitat characteristics employed by the Watershed Teams. The survey predominantly targets three species of black bass; (largemouth, smallmouth, and spotted bass) and black and white crappie. These species are the predominant sport fish sought after by fisherman.

## Methods

### Fish Community

Reservoirs are typically divided into three zones for VS Monitoring – inflow, transition and forebay. The inflow zone is generally in the upper reaches of the reservoir and is riverine in nature; the transition zone or mid-reservoir is the area where water velocity decreases due to increased cross-sectional area, and the forebay is the lacustrine area near the dam. The Chickamauga Reservoir inflow zone is located at Tennessee River Mile (TRM) 529.0; the transition zone is located at TRM 490.5, and the forebay zone is located at TRM 472.3. The VS transition zone, which is located approximately 7.2 river miles upstream of the SQN discharge (TRM 483.3), will be used to provide upstream data for the 316(a) thermal variance studies performed in sample years between 1993 and 2003. An additional transition station was later added downstream of the SQN discharge to more closely monitor Chickamauga Reservoir aquatic communities in close proximity to the SQN thermal effluent. This station is located at TRM 482.0 and will be used for downstream comparisons of aquatic communities for the 1999 through 2003 sample seasons. The forebay zone, will serve as the downstream station for 1993 through 1995 and 1997 sample seasons.

Fish samples consisted of fifteen 300-meter electrofishing runs (approximately 10 minutes duration) and ten experimental gill net sets (five 6.1 meter panels with mesh sizes of 2.5, 5.1, 7.6, 10.2, and 12.7 cm) per station. Attained values for each of the 12 metrics were compared to reference conditions for transition zones of mainstream Tennessee River reservoirs and assigned scores based upon three categories hypothesized to represent relative degrees of degradation:

least degraded -5; intermediate -3; and most degraded -1. These categories are based on "expected" fish community characteristics in the absence of human-induced impacts other than impoundment. Individual metric scores for a station are summed to obtain the RFAI score.

Comparison of the attained RFAI score from the potential impact zone to a predetermined criterion has been suggested as a method useful in identifying presence of normal community structure and function and hence existence of a BIP. For multi-metric indices, two criteria have been suggested to ensure a conservative screening for a BIP. First, if an RFAI score reaches 70 percent of the highest attainable score (adjusted upward to include sample variability), and second, if fewer than half of RFAI metrics potentially influenced by thermal discharge receive a low (1) or moderate (3) score, then normal community structure and function would be present indicating that a BIP existed. Under these conditions, the heated discharge would meet screening criteria and no further evaluation would be needed.

The range of RFAI scores possible is from 12 to 60. As discussed in detail below, the average variance for RFAI scores in TVA reservoirs is 6 ($\pm$ 3). Therefore, any location that attains an RFAI score of 45 (42 + our sample variance of 3) or higher would be considered to demonstrate a BIP. It must be stressed that scores below this endpoint do not necessarily reflect an adversely impacted fish community. The endpoint is used to serve as a conservative screening level; for example, any fish community that meets these criteria is obviously not adversely impacted. RFAI scores below this level would require a more in-depth look to determine if a BIP exists. If a score below this criterion is obtained, an inspection of individual RFAI metric results would be an initial step to help identify if SQN operation is a contributing factor. This approach is appropriate if a validated multi-metric index is being used and scoring criteria applicable to the zone of study are available.

Upstream/downstream stations comparisons can be used to identify if SQN operation is adversely affecting the downstream fish community as well. A similar or higher RFAI score at the downstream station compared to the upstream (control) station is used as one basis for determining presence/absence of SQN operational impacts on the resident fish community. Definition of "similar" is integral to accepting the validity of these interpretations.

The Quality Assurance (QA) component of VS monitoring deals with how well the RFAI scores can be repeated and is accomplished by collecting a second set of samples at 15-20 percent of the stations each year. Experience to date with the QA component of VS shows that the comparison of RFAI index scores from 54 paired sample sets collected over a seven year period ranged from 0 to 18 points, the 75$^{th}$ percentile was 6, the 90$^{th}$ percentile was 12. The mean difference between these 54 paired scores is 4.6 points with 95 percent confidence limits of 3.4 and 5.8. Based on these results, a difference of 6 points or less is the value selected for defining "similar" scores between upstream and downstream fish communities. That is, if the downstream RFAI score is within 6 points of the upstream score, the communities will be considered similar. It is important to bear in mind that differences greater than 6 points can be expected simply due to method variation (25 percent of the QA paired sample sets exceeded that value). When this occurs, a metric-by-metric examination will be conducted to determine what caused the difference in scores and the potential for the difference to be thermally related.

## Benthic Macroinvertebrate Community

Ten benthic grab samples were collected at equally spaced points along the upstream and downstream transects. A Ponar sampler was used for most samples but a Peterson sampler was used when heavier substrate was encountered. Collection and processing techniques followed standard VS procedures. Bottom sediments were washed on a 533μ screen and organisms were then picked from the screen and remaining substrate and identified to Order or Family level in the field using no magnification. Benthic community results were evaluated using seven community characteristics or metrics. Results for each metric were assigned a rating of 1, 3, or 5 depending upon how they compared to reference conditions developed for VS sample sites. The ratings for the seven metrics were summed to produce a total benthic score for each sample site. Each reservoir section (inflow, transition, or forebay) differs in their maximum potential for benthic diversity; thus, the criteria for assigning metric ratings were adjusted accordingly such that the total benthic scores from sites on different reservoir sections are comparable. Potential scores ranged from 7 to 35. Ecological health ratings ("Poor," "Fair," or "Good") are then applied to scores. A similar or higher benthic index score at the downstream site compared to the upstream site is used as basis for determining if SQN's thermal discharge is having no effect on the Chickamauga Reservoir benthic community.

The QA component of VS monitoring shows that the comparison of benthic index scores from 49 paired sample sets collected over a seven year period ranged from 0 to 14 points, the $75^{th}$ percentile was 4, the $90^{th}$ percentile was 6. The mean difference between these 49 paired scores is 3.1 points with 95 percent confidence limits of 2.2 and 4.1. Based on these results, a difference of 4 points or less is the value selected for defining "similar" scores between upstream and downstream benthic communities. That is, if the downstream benthic score is within 4 points of the upstream score, the communities will be considered similar and it will be concluded that SQN has had no effect. Once again, it is important to bear in mind that differences greater than 4 points can be expected simply due to method variation (25 percent of the QA paired sample sets exceeded that value). When this occurs, a metric-by-metric examination will be conducted to determine what caused the difference in scores and the potential for the difference to be thermally related.

## Sport Fishing Index

Calculations described by Hickman (2000) were used to compare SFI values for selected quantity and quality parameters from creel and population samples to expected values that would occur in a good or high quality fishery. Quantity parameters include angler success and catch per unit effort from standard population samples (electrofishing, trap and experimental gill netting). Population quality is based on measurement of five aspects of each resident sport fish community. Four of these aspects address size structure (proportional number of fish in each length group) of the community, Proportional Stock Density (PSD), Relative Stock Density of Preferred-sized fish (RSDP), Relative Stock Density of Memorable-sized fish (RSDM), and Relative Stock Density of Trophy-sized fish (RSDT) (Figure 1). Relative weight (Wr), a measure of the average condition of individual fish makes up the fifth population quality aspect. As described by Hickman (2000), observed values were compared to reference ranges and assigned a corresponding numerical value. The SFI value is calculated by adding up the scores for quantity and quality from existing data and multiplying by two when only creel or population

data are available. Species received a low score when insufficient numbers of individuals were captured to reliably determine proportional densities or relative weights for particular parameters. SFI scores are typically compared to average Tennessee Valley reservoir scores; however, Valley-wide scores are unavailable from natural resource agencies. Therefore, Chickamauga Reservoir fish species scores will be compared to previous years.

**Spring Sport Fish Survey**

A SSS was conducted on Chickamauga Reservoir March 24-27, 2003. The summer pool level for Chickamauga is 682.5 msl and the level during the sample period was measured at 676.4 msl. Twelve sites at three locations including Harrison Bay, Ware Branch and Sale Creek were sampled using boat-mounted electrofishers. TVA Fisheries Biologists use electrofishing equipment to sample fish at selected locations. In that process an electric current is used to temporarily stun the fish so they float to the surface of the water. The fish are collected with nets, counted, weighed, measured, and released unharmed. Each run consisted of thirty minutes of continuous electrofishing, a total of eighteen hours, in the littoral zones of prominent habitat types represented in the reservoir.

Results of the SSS monitoring were calculated using Shoreline Assessment Habitat Index (SAHI), Relative Stock Density (RSD), PSD, and Wr.

Habitat type is evaluated using the SAHI metric and is a critical component incorporated into the spring sport fish survey. The resultant habitat designations (good, fair and poor) are correlated to black bass abundance (numbers/hour).

RSD is the number of fish greater than a minimum preferred length in a stock divided by the number of fish greater than or equal to a minimum stock size.

PSD is the number of fish greater than or equal to a minimum quality length in a sample divided by the number of fish greater than or equal to a minimum stock length.

Wr is an index that quantifies fish condition and the preferred range value is 90-105% for moderate density bass populations such as those found in the Tennessee Valley latitudes.

## Results and Discussion

**Fish Community**

In the autumn of 2003, the SQN downstream station scored 45 (Good) and the upstream station scored 42 (Good) using the RFAI analysis methodology (Tables 1 and 2). RFAI scores obtained from VS monitoring stations located upstream and downstream of the SQN discharge over the past several years have revealed consistently good fish community results (Table 3 and Figure 2). Regardless of which downstream station was used, the upstream station rating remained in the "Good" range and the downstream continued in the "Good" range, on average (Table 3 and Figure 2). As indicated in Table 3, between 1993 and 2003, the average RFAI score for the upstream station was 46 (76.6 percent of the maximum score). The two downstream stations (i.e., SQN transition and forebay) both averaged 46 (76.6 percent of the maximum score).

Electrofishing and gill netting catch rates for individual species from the downstream station are listed in Table 4 and 5. Based on the average upstream and downstream RFAI scores, 2003 macroinvertebrate community data, and the defining characteristics for a BIP, it can be concluded that SQN operation has had no impact on the Chickamauga Reservoir resident fish community, on average, for nine sampling seasons (Table 3).

**Benthic Macroinvertebrate Community**

Table 6 provides ratings for each metric as well as the overall benthic index score for both monitoring sites. Table 7 summarizes density by taxon at the upstream (TRM 490.5) and downstream (TRM 482) collection stations. In the 2003 sampling season, the upstream station benthic index scores were similar indicative of a BIP. The upstream and downstream comparisons produced benthic index scores of 31 (Good) and 29 (Good), respectively. Therefore, it appears that SQN has had no adverse effect on the benthic macroinvertebrate community immediately downstream from the plant. Table 8 provides benthic index scores from VS monitoring at the forebay (TRM 472.3) and transition zone stations from 1994 to 2003. The Chickamauga forebay zone sample station is of sufficient distance downstream (11 miles) that results would not be expected to reflect plant effects. The similar scores from TRM 472.3 and TRM 482 also indicate that SQN has had no effect on the macroinvertebrate community immediately downstream from the plant (Table 8).

**Sport Fishing Index**

In the autumn of 2003, Chickamauga Reservoir's sport fish population received similar SFI scores compared to the seven year average. Black bass, largemouth bass, smallmouth bass, spotted bass, crappie and white bass received higher scores than their seven year averages (Table 9 and Figure 3). Both sauger and striped bass received lower scores in 2003 compared to scores in 2002. The score for sauger was the lowest it has been since 1997 when this analysis technique was implemented by TVA. This quality assessment is not necessarily indicative of a trend. Historical data indicates that SFI scores typically vary across years. However if future scores would continue to decline, further investigation would be warranted. Channel catfish, crappie and white bass received their highest SFI scores to date. Crappie and white bass scores increased from 38 to 42 and 30 to 40, respectively (Table 9 and Figure 3). Tables 10 and 11 illustrate sport fish index scoring criteria for population metrics and creel quantity and quality.

Sauger, striped bass, and channel catfish are easily caught during their spring migration to preferred spawning habitats. Fishing creel surveys conducted in the spring would better describe and evaluate these species compared to only using autumn fisheries surveys.

**Spring Sport Fish Survey**

The sampling yielded 1,118 black bass; of these, 65.8% were harvestable size (10" or greater). Of the total black bass collected, 847 were largemouth, 239 were spotted and 32 were smallmouth bass. Overall catch rate (62.0 fish/hr.) was slightly higher than the 2002 survey (57.4/hour) (Table 12). The average weight of harvestable sized black bass was 1.3 pounds. The largest black bass collected were two 6.4 pound largemouth bass taken from Harrison Bay and

Sale Creek. Numbers of lunker bass increased substantially from last year's survey. A total of 23 bass over four pounds were collected and eight of these were over five pounds. In 2002, nine bass over four pounds were collected and four of them were five pounds plus.

Length frequency histograms illustrated a bimodal distribution with the dominant size classes being the 8-9 inch and 12-14 inch groups (Figure 4).

A positive correlation of habitat type-to-black bass abundance was evident on Chickamauga Reservoir during the 2003 survey. Among the three areas sampled, the correlations at Harrison Bay and Skull Island were positive but Sale Creek showed some variability among habitat types (Table 13). Overall catch rates for the reservoir were 78, 66 and 40 at the good, fair and poor habitats, respectively (Table 14).

The RSD and PSD value of 17 and 61 fell within the desirable or preferred ranges of 10-25 and 40-70, respectively (Figures 5 and 6).

The values shown in Figure 7 are designated by inch groups which reflect the classical categories, *i.e.*, 0-7 = substock, 8-11 = stock, 12-14 = quality, 15-19 = preferred, 20-24 = memorable and 25+ = trophy. All categories fell within the desired range, which reflects excellent condition of black bass in all size groups of the population. Field observations of large numbers of prey fish indicate an abundance of forage for all size classes of black bass.

A total of 288 crappie (249 black and 39 white crappie) were also collected during the survey. The crappies were collected predominantly from tree tops, stumps and other physical structures in shallow water.

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Table 1. Scoring Results for the Twelve Metrics and Overall Reservoir Fish Assemblage Index for Chickamauga Reservoir at the Sequoyah Downstream Sampling Station, 2003.

| | | Forebay TRM 472.3 | | Transition TRM 482.0 *Downstream Station* | |
|---|---|---|---|---|---|
| **Metric** | | **Obs** | **Score** | **Obs** | **Score** |
| **A. Species richness and composition** | | | | | |
| 1. Number of species | | 26 | 3 | 25 | 3 |
| 2. Number of centrachid species | | 8 | 5 | 6 | 5 |
| 3. Number of benthic invertivores | | 2 | 1 | 3 | 1 |
| 4. Number of intolerant species | | 5 | 5 | 5 | 5 |
| 5. Percent tolerant species | electrofishing | 55.6 | 1.5 | 54.7 | 1.5 |
| | gill netting | 27 | 1.5 | 26.4 | 1.5 |
| 6. Percent dominance by one species | electrofishing | 29.9 | 1.5 | 24.8 | 2.5 |
| | gill netting | 21.4 | 1.5 | 19.6 | 1.5 |
| 7. Number non-native species | electrofishing | 1.0 | 2.5 | 0.3 | 2.5 |
| | gill netting | 0.5 | 2.5 | 0.7 | 2.5 |
| 8. Number of top carnivore species | | 10 | 5 | 11 | 5 |
| **B. Trophic composition** | | | | | |
| 9. Percent top carnivores | electrofishing | 9.5 | 1.5 | 11.2 | 2.5 |
| | gill netting | 49.5 | 1.5 | 37.2 | 1.5 |
| 10. Percent omnivores | electrofishing | 11.2 | 2.5 | 20.4 | 2.5 |
| | gill netting | 35.2 | 0.5 | 39.2 | 0.5 |
| **C. Fish abundance and health** | | | | | |
| 11. Average number per run | electrofishing | 32.1 | 0.5 | 45.7 | 0.5 |
| | gill netting | 19.6 | 1.5 | 14.8 | 1.5 |
| 12. Percent anomalies | electrofishing | 0.8 | 2.5 | 0.3 | 2.5 |
| | gill netting | 0.5 | 2.5 | 0.7 | 2.5 |
| **RFAI** | | | **43 Good** | | **45 Good** |

Table 2. Scoring Results for the Twelve Metrics and Overall Reservoir Fish Assemblage Index for Chickamauga Reservoir at the Upstream Sampling Station, 2003.

| | | Transition TRM 490.5 *Upstream Station* | | Inflow TRM 529.0 | |
|---|---|---|---|---|---|
| **Metric** | | **Obs** | **Score** | **Obs** | **Score** |
| **A. Species richness and composition** | | | | | |
| 1. Number of species | | 29 | 3 | 30 | 5 |
| 2. Number of centrachid species | | 8 | 5 | 8 | 5 |
| 3. Number of benthic invertivores | | 3 | 1 | 5 | 3 |
| 4. Number of intolerant species | | 5 | 5 | 5 | 5 |
| 5. Percent tolerant species | electrofishing | 67.0 | 0.5 | 57.7 | 3 |
| | gill netting | 29.7 | 1.5 | 0 | 0 |
| 6. Percent dominance by one species | electrofishing | 31.2 | 1.5 | 34.2 | 3 |
| | gill netting | 28.1 | 0.5 | 0.0 | 0 |
| 7. Number non-native species | electrofishing | 1.1 | 2.5 | 0.6 | 5 |
| | gill netting | 0.8 | 2.5 | 0 | 0 |
| 8. Number of top carnivore species | | 10 | 5 | 10 | 5 |
| **B. Trophic composition** | | | | | |
| 9. Percent top carnivores | electrofishing | 11.8 | 2.5 | 10.2 | 1 |
| | gill netting | 31.3 | 1.5 | 0 | 0 |
| 10. Percent omnivores | electrofishing | 20.8 | 2.5 | 18.7 | 5 |
| | gill netting | 44.2 | 1.5 | 0 | 3 |
| **C. Fish abundance and health** | | | | | |
| 11. Average number per run | electrofishing | 41.3 | 0.5 | 69.1 | 3 |
| | gill netting | 24.9 | 2.5 | 0 | 0 |
| 12. Percent anomalies | electrofishing | 1.0 | 2.5 | 0.7 | 5 |
| | gill netting | 6.4 | 0.5 | 0 | 0 |
| **RFAI** | | | **42 Good** | | **48 Good** |

Table 3. Recent (1993-2003) RFAI Scores Collected as Part of the Vital Signs Monitoring Program Upstream and Downstream of Sequoyah Nuclear Plant.

| Station | Reservoir | Location | 1993 | 1994 | 1995 | 1997 | 1999 | 1993-1999 Average | 2000* | 2001 | 2002* | 2003 | 1993-2003 Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upstream | Chickamauga | TRM 490.5 | 49 | 40 | 46 | 39 | 45 | 44 (Good) | 46 | 45 | 51 | 42 | 46 (Good) |
| Sequoyah Transition | Chickamauga | TRM 482.0 | | | | | 41 | 41 (Good) | 48 | 46 | 43 | 45 | 46 (Good) |
| Forebay | Chickamauga | TRM 472.3 | 44 | 44 | 47 | 39 | 45 | 44 (Good) | 45 | 48 | 46 | 43 | 46 (Good) |

*The 2000, and 2002, sample years were not part of the VS monitoring program, however the same methodology was applied.

Table 4. Species Listing and Catch Per Unit Effort for the Embayment and Sequoyah Transects During the Fall Electrofishing and Gill Netting on Chickamauga Reservoir, 2003 (Electrofishing Effort = 300 Meters of Shoreline and Gill Netting Effort = Net-Nights).

| | Forebay TRM 472.3 | | | Transition TRM 482.0 | | |
|---|---|---|---|---|---|---|
| Common Name | Electrofishing Catch Rate Per Run | Electrofishing Catch Rate Per Hour | Gill Netting Catch Rate Per Net Night | Electrofishing Catch Rate Per Run | Electrofishing Catch Rate Per Hour | Gill Netting Catch Rate Per Net Night |
| Spotted gar | 0.27 | 1.43 | - | 0.20 | 1.08 | - |
| Longnose gar | - | - | - | - | - | 0.10 |
| Skipjack herring | - | - | 3.30 | - | - | 0.70 |
| Gizzard shad | 2.73 | 14.70 | 4.20 | 8.40 | 45.32 | 2.90 |
| Threadfin shad | 0.20 | 1.08 | 0.10 | - | - | - |
| Common carp | 0.33 | 1.79 | - | 0.13 | 0.72 | 0.10 |
| Golden shiner | 0.53 | 2.87 | 0.10 | 0.40 | 2.16 | 0.10 |
| Emerald shiner | 6.33 | 34.05 | - | 6.20 | 33.45 | - |
| Spotfin shiner | 0.13 | 0.72 | - | 1.33 | 7.19 | - |
| Spotted sucker | 0.20 | 1.08 | 0.60 | 0.27 | 1.44 | 0.50 |
| Blue catfish | - | - | 1.60 | - | - | 1.20 |
| Channel catfish | - | - | 1.00 | 0.40 | 2.16 | 1.50 |
| Flathead catfish | 0.33 | 1.79 | 0.20 | 0.13 | 0.72 | 0.30 |
| White bass | - | - | 0.10 | - | - | - |
| Yellow bass | 0.07 | 0.36 | 2.40 | 0.13 | 0.72 | 1.80 |
| Warmouth | 0.27 | 1.43 | - | - | - | - |
| Redbreast | 3.33 | 17.92 | - | 1.93 | 10.43 | - |
| Green sunfish | 0.27 | 1.43 | - | - | - | - |
| Bluegill | 9.60 | 51.61 | 0.70 | 11.33 | 61.15 | 0.40 |
| Longear sunfish | 0.40 | 2.15 | - | 1.93 | 10.43 | - |
| Redear sunfish | 3.67 | 19.71 | 1.00 | 6.40 | 34.53 | 1.60 |
| Hybrid sunfish | 0.07 | 0.36 | - | - | - | - |
| Smallmouth | 0.20 | 1.08 | 0.10 | 0.13 | 0.72 | 1.20 |
| Spotted bass | 1.27 | 6.81 | 2.50 | 2.80 | 15.11 | 0.80 |
| Largemouth | 0.93 | 5.02 | 0.20 | 1.47 | 7.91 | 0.20 |
| White crappie | - | - | 0.10 | - | - | 0.10 |
| Black crappie | - | - | 0.80 | 0.27 | 1.44 | 0.10 |
| Yellow perch | - | - | 0.10 | - | - | - |
| Logperch | - | - | - | 0.60 | 3.24 | - |
| Sauger | - | - | - | - | - | 0.20 |
| Freshwater | 0.27 | 1.43 | 0.50 | 0.33 | 1.80 | 1.00 |
| Brook silverside | 0.73 | 3.94 | - | - | - | - |
| **Total** | **32.13** | **172.76** | **19.6** | **45.71** | **246.76** | **14.8** |
| **Number** | **15** | | **10** | **15** | | **10** |
| **Number** | **482** | | **196** | **686** | | **148** |
| **Species** | **22** | | **19** | **20** | | **19** |

Table 5. Species Listing and Catch Per Unit Effort for the Transition and Inflow Transects During the Fall Electrofishing and Gill Netting on Chickamauga Reservoir, 2003 (Electrofishing Effort = 300 Meters of Shoreline and Gill Netting Effort = Net-Nights).

| | Transition TRM 490.5 | | | Inflow TRM 529.0 | |
|---|---|---|---|---|---|
| Common Name | Electrofishing Catch Rate Per Run | Electrofishing Catch Rate Per Hour | Gill Netting Catch Rate Per Net Night | Electrofishing Catch Rate Per Run | Electrofishing Catch Rate Per Hour |
| Longnose gar | - | - | - | 0.20 | 1.08 |
| Lake sturgeon | - | - | 0.10 | - | - |
| Spotted gar | 0.07 | 0.34 | - | - | - |
| Skipjack herring | - | - | 2.10 | - | - |
| Gizzard shad | 5.60 | 28.38 | 7.00 | 11.87 | 63.8 |
| Threadfin shad | 1.13 | 5.74 | 0.10 | 17.67 | 94.98 |
| Common carp | 0.4 | 2.03 | - | 0.40 | 2.15 |
| Golden shiner | 1.67 | 8.45 | - | 0.20 | 1.08 |
| Emerald shiner | 1.00 | 5.07 | - | 0.20 | 1.08 |
| Spotfin shiner | 1.27 | 6.42 | - | 0.73 | 3.94 |
| Steelcolor shiner | - | - | - | 0.27 | 1.43 |
| Bluntnose minnow | 0.80 | 4.05 | - | 0.13 | 0.72 |
| Spotted sucker | 0.40 | 2.03 | 0.30 | 0.27 | 1.43 |
| Black redhorse | - | - | - | 0.40 | 2.15 |
| Golden redhorse | - | - | - | 0.40 | 2.15 |
| Blue catfish | - | - | 2.60 | - | - |
| Channel catfish | 0.13 | 0.68 | 1.40 | 0.33 | 1.79 |
| Flathead catfish | 0.33 | 1.69 | 0.40 | 0.33 | 1.79 |
| White bass | - | - | - | 0.13 | 0.72 |
| Yellow bass | - | - | 3.30 | 1.13 | 6.09 |
| Warmouth | 0.93 | 4.73 | - | 0.07 | 0.36 |
| Redbreast sunfish | 3.87 | 19.59 | - | 0.47 | 2.51 |
| Green sunfish | 0.20 | 1.01 | - | 0.20 | 1.08 |
| Bluegill | 12.87 | 65.2 | - | 23.60 | 126.88 |
| Longear sunfish | 1.80 | 9.12 | - | 0.20 | 1.08 |
| Redear sunfish | 3.00 | 15.2 | 4.70 | 4.07 | 21.86 |
| Hybrid sunfish | - | - | - | 0.13 | 0.72 |
| Smallmouth bass | 0.80 | 4.05 | - | 0.67 | 3.58 |
| Spotted bass | 1.40 | 7.09 | 0.70 | 1.60 | 8.60 |
| Largemouth bass | 1.00 | 5.07 | 0.30 | 2.00 | 10.75 |
| White crappie | - | - | 0.10 | 0.07 | 0.36 |
| Black crappie | 1.27 | 6.42 | 0.80 | 0.87 | 4.66 |
| Yellow perch | 0.07 | 0.34 | 0.20 | - | - |

Table 5. (continued)

| Common Name | Transition TRM 490.5 Electrofishing Catch Rate Per Run | Transition TRM 490.5 Electrofishing Catch Rate Per Hour | Transition TRM 490.5 Gill Netting Catch Rate Per Net Night | Inflow TRM 529.0 Electrofishing Catch Rate Per Run | Inflow TRM 529.0 Electrofishing Catch Rate Per Hour |
|---|---|---|---|---|---|
| Logperch | 0.27 | 1.35 | - | 0.07 | 0.36 |
| Sauger | - | - | 0.10 | - | - |
| Walleye | - | - | - | 0.07 | 0.36 |
| Freshwater drum | 0.33 | 1.69 | 0.70 | 0.20 | 1.08 |
| Brook silverside | 0.67 | 3.38 | - | 0.13 | 0.72 |
| **Total** | **41.28** | **209.12** | **24.9** | **69.08** | **371.34** |
| **Number Samples** | **15** | | **10** | **15** | |
| **Number Collected** | **619** | | **249** | **1036** | |
| **Species Collected** | **25** | | **17** | **32** | |

Table 6. Individual Metric Ratings and the Overall Benthic Community Index Score for Upstream and Downstream Stations near Sequoyah Nuclear Plant, Chickamauga Reservoir, November 2003.

| Metric | TRM 490.5 Upstream | | TRM 482 Downstream | |
|---|---|---|---|---|
| | Obs | Rating | Obs | Rating |
| 1. Average number of taxa | 7.4 | 5 | 5.7 | 5 |
| 2. Proportion of samples with long-lived organisms | 90% | 5 | 60% | 3 |
| 3. Average number of EPT taxa | 0.7 | 3 | 0.3 | 1 |
| 4. Average proportion of oligochaete individuals | 10.7% | 5 | 9.4% | 5 |
| 5. Average proportion of total abundance comprised by the two most abundant taxa | 71.0% | 5 | 79.8% | 5 |
| 6. Average density excluding chironomids and oligochaetes | 341.7 | 3 | 580.0 | 5 |
| Zero-samples - proportion of samples containing no organisms | 0 | 5 | 0 | 5 |
| **Benthic Index Score** | | **31 Good** | | **29 Good** |

*Scored with transition criteria.

Table 7. Average Mean Density Per Square Meter of Benthic Taxa Collected at Upstream and Downstream Stations near Sequoyah Nuclear Plant, Chickamauga Reservoir, November 2003.

| Chickamauga Reservoir | | TRM 490.5 Upstream | |
|---|---|---|---|
| | Species | Mean Density | Occurrence per site |
| Phylum | Annelida | | |
| Subclass | Oligocheata | | |
| Family | Tubificidae | 120 | 8 |
| | *Branchiura sowerbyi* | 2 | 1 |
| | *Limnodrilus hoffmeisteri* | 30 | 6 |
| Class | Hirudinea | | |
| | Rhynchobdellida | | |
| Family | Glossiphoniidae | 5 | 1 |
| | *Helobdella stagnalis* | 18 | 4 |
| Phylum | Insecta | | |
| Order | Ephemeroptera | | |
| Family | Ephemeridae | | |
| | *Hexagenia limbata* <10mm | 17 | 6 |
| | *Hexagenia limbata* >10mm | 32 | 8 |
| Order | Trichoptera | | |
| Family | Polycentropodidae | | |
| | *Polycentropus sp.* | 2 | 1 |
| Family | Leptoceridae | | |
| | *Oecetis sp.* | 2 | 1 |
| Order | Diptera | | |
| Family | Chironomidae | | |
| | *Ablabesmyia annulata* | 8 | 3 |
| | *Chironomus sp.* | 10 | 5 |
| Phylum | Mollusca | | |
| Class | Gastropoda | | |
| Order | Mesogastropoda | | |
| Family | Viviparidae | | |
| | *Campeloma sp.* | 2 | 1 |
| | *Viviparus Georgianus* | 33 | 4 |
| | *Viviparus sp.* | 18 | 3 |
| Class | Bivalvia | | |
| | Veneroida | | |
| Family | Corbiculidae | | |
| | *Corbicula fluminea* <10mm | 38 | 7 |
| | *Corbicula fluminea* >10mm | 93 | 8 |

Table 7. (continued)

| Chickamauga Reservoir | | TRM 490.5 Upstream | |
|---|---|---|---|
| | Species | Mean Density | Occurrence per site |
| Family | Sphaeriidae | | |
| | *Musculium transversum* | 80 | 7 |
| | **Number of samples** | **10** | |
| | **Sum** | **862** | |
| | **Number of taxa** | **15** | |
| | **Number of EPT taxa** | **3** | |
| | **Sum of area sampled** | **0.6** | |

| Chickamauga Reservoir | | TRM 482 Downstream | |
|---|---|---|---|
| | Species | Mean Density | Occurrence per site |
| | Nematoda | | |
| | Turbellaria | | |
| | Tricladida | | |
| | Planariidae | | |
| | *Dugesia tigrina* | 2 | 1 |
| Phylum | Annelida | | |
| Subclass | Oligocheata | | |
| Family | Lumbricidae | 2 | 1 |
| Family | Tubificidae | 42 | 5 |
| | *Limnodrilus hoffmeisteri* | 13 | 5 |
| Class | Hirudinea | 2 | 1 |
| | Rhynchobdellida | | |
| Family | Glossiphoniidae | 2 | 1 |
| | *Helobdella stagnalis* | 20 | 5 |
| | Pharyngobdellida | | |
| Family | Erpobdellidae | 7 | 1 |
| | Crustacea | | |
| | Amphipoda | | |
| | Crangonyctidae | | |
| | *Crangonyx sp.* | 2 | 1 |
| Phylum | Insecta | | |
| Order | Ephemeroptera | | |
| Family | Ephemeridae | | |

Table 7. (continued)

| Chickamauga Reservoir | | TRM 482 Downstream | |
|---|---|---|---|
| | Species | Mean Density | Occurrence per site |
| | *Hexagenia limbata* <10mm | 5 | 2 |
| | *Hexagenia limbata* >10mm | 25 | 3 |
| Order | Trichoptera | | |
| Family | Polycentropodidae | | |
| | *Cyrnellus fraternus* | 8 | 3 |
| Order | Diptera | | |
| Family | Chironomidae | | |
| | *Ablabesmyia annulata* | 10 | 4 |
| | *Axarus sp.* | 2 | 1 |
| | *Chironomus sp.* | 7 | 3 |
| | *Coelotanypus sp.* | 127 | 8 |
| Phylum | Mollusca | | |
| Class | Gastropoda | | |
| | Lymnophila | | |
| Family | Physidae | | |
| | *Physella sp.* | 2 | 1 |
| Order | Mesogastropoda | | |
| Family | Viviparidae | | |
| | *Viviparus Georgianus* | 62 | 3 |
| Class | Bivalvia | | |
| | Veneroida | | |
| Family | Corbiculidae | | |
| | *Corbicula fluminea* <10mm | 195 | 9 |
| | *Corbicula fluminea* >10mm | 98 | 9 |
| Family | Sphaeriidae | | |
| | *Eupera cubensis* | 3 | 1 |
| | *Musculium transversum* | 200 | 10 |
| | **Number of samples** | **10** | |
| | **Sum** | **833** | |
| | **Number of taxa** | **18** | |
| | **Number of EPT taxa** | **2** | |
| | **Sum of area sampled** | **0.6** | |

Table 8. Recent (1994-2003) Benthic Index Scores Collected as Part of the Vital Signs Monitoring Program at Chickamauga Reservoir Transition (TRM 490.5 and TRM 482) and Forebay Zone (TRM 472.3) Stations.

| | | | Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Site** | **Reservoir** | **Location** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **Average** |
| Upstream | Chickamauga | TRM 490.5 | 33 | 29 | | 31 | | 31 | 23 | 25 | 23 | 31 | **28.3** |
| Downstream | Chickamauga | TRM 482 | | | | | | | 23 | 31 | 27 | 29 | **28.0** |
| Downstream | Chickamauga | TRM 472.3 | 31 | 27 | | 29 | | 25 | 27 | 27 | 23 | 27 | **27.0** |

Table 9. Sport Fishing Index Results for Chickamauga Reservoir, 2003

| | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Species** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **1997-2003 Average SFI Score** |
| Black bass | 35 | 41 | 25 | 35 | 31 | 34 | 34 | 34 |
| Smallmouth bass | 20 | 20 | 24 | 22 | 40 | 32 | 32 | 28 |
| Spotted bass | 20 | 37 | 24 | 40 | 26 | 32 | 32 | 30 |
| Largemouth bass | 34 | 37 | 34 | 32 | 28 | 36 | 36 | 34 |
| Bluegill | 30 | | 32 | 33 | 32 | 32 | 31 | 32 |
| Channel catfish | | | 32 | 29 | 30 | 25 | 33 | 35 |
| Crappie | 32 | | 31 | 31 | 32 | 38 | 42 | 35 |
| Sauger | 27 | 36 | 32 | 39 | 30 | 31 | 27 | 32 |
| Striped bass | 35 | | 30 | 30 | 40 | 34 | 31 | 33 |
| White bass | | | 31 | 30 | 30 | 30 | 40 | 32 |

Table 10. Sport Fishing Index Population Quantity and Creel Quantity and Quality Metrics and Scoring Criteria.

| Metrics | Scores | | |
|---|---|---|---|
| | 5 | 10 | 15 |
| **Black bass** | | | |
| Population (quantity) | | | |
| TVA electrofishing catch/hour | < 15 | 15-31 | > 31 |
| State electrofishing (catch/hour) | < 62 | 62-124 | > 124 |
| Creel (quantity)[a] | | | |
| Anglers (catch/hour) | < 0.3 | 0.3-0.6 | > 0.6 |
| BAIT and BITE data | < 1.1 | 1.1-2.3 | > 2.3 |
| Creel (quality) | | | |
| Pressure (hours/acre) | < 8 | 8-16 | > 16 |
| **Largemouth bass** | | | |
| Population (quantity)[b] | | | |
| TVA electrofishing catch/hour | < 13 | 13-25 | > 25 |
| State electrofishing (catch/hour) | < 53 | 53-106 | > 106 |
| Creel (quantity) | | | |
| Anglers (catch/hour) | < 0.29 | 0.29-0.58 | > 0.58 |
| Creel (quality) | | | |
| Pressure (hours/acre) | < 8 | 8-16 | > 16 |
| **Smallmouth bass** | | | |
| Population (quantity) | | | |
| TVA electrofishing catch/hour | < 4 | 4-8 | > 8 |
| State electrofishing (catch/hour) | < 8 | 8-15 | > 15 |
| Creel (quantity) | | | |
| Anglers (catch/hour) | < 0.1 | 0.1-0.3 | > 0.3 |
| Creel (quality) | | | |
| Pressure (hours/acre) | < 8 | 8-16 | > 16 |
| **Spotted bass** | | | |
| Population (quantity) | | | |
| TVA electrofishing catch/hour | < 5 | 5-11 | > 11 |
| State electrofishing (catch/hour) | < 14 | 14-27 | > 27 |
| Creel (quantity) | | | |
| Anglers (catch/hour) | < 0.07 | 0.07-0.13 | > 0.13 |
| Creel (quality) | | | |
| Pressure (hours/acre) | < 8 | 8-16 | > 16 |

Table 10. (continued)

| Metrics | Scores | | |
|---|---|---|---|
| | 5 | 10 | 15 |
| **Sauger** | | | |
| Population (quantity) | | | |
| Experimental gill net (catch/net night) | < 9 | 9-17 | > 17 |
| Creel (quantity) | | | |
| Anglers (catch/hour) | < 0.5 | 0.5-1 | > 1 |
| Creel (quality) | | | |
| Pressure (hours/acre) | < 5 | 5-10 | > 10 |
| **Channel catfish** | | | |
| Population (quantity) | | | |
| Experimental gill net (catch/net night) | < 2 | 2-4 | > 4 |
| Creel (quantity) | | | |
| Anglers (catch/hour) | < 0.3 | 0.3-0.7 | > 0.7 |
| Creel (quality) | | | |
| Pressure (hours/acre) | < 9 | 9-19 | > 19 |

[a]Each worth 2.5, 5.0, and 7.5 points if both data sets are available.
[b]TVA electrofishing only used when state agency electrofishing data is unavailable.

Table 11. Sport Fishing Index Population Quality Metrics and Scoring Criteria.

| | Scores | | |
|---|---|---|---|
| | 5 | 10 | 15 |
| **Metrics** | | | |
| Population (quality) | 1 | 2 | 3 |
| PSD | < 20 or > 80 | 20-39 or 61-80 | 40-60 |
| RSDP (preferred) | 0 or > 60 | 1-9 or 41-60 | 10-40 |
| RSDM (memorable) | 0 or > 25 | 1-4 or 11-25 | 5-10 |
| RSDT (trophy) | 0 | < 1 | ≥ 1 |
| $W_r$ (Stock-preferred size fish) | < 90 | > 110 | 90-110 |

Table 12. Electrofishing Catch Rate, Mean Weight, Percent Harvestable, Numbers of Black Bass Greater than Five Pounds, Numbers of Black Bass Greater than Four Pounds and Largest Black Bass Collected, Chickamauga Reservoir Black Bass Surveys, 1995-2003.

| Year | EF Catch Rate (no./hr.) | Mean Weight (lbs.) | % Harvestable | Bass >4 lbs. | Bass >5 lbs. | Largest bass (lbs.) |
|---|---|---|---|---|---|---|
| 2003 | 62.0 | 1.3 | 65.8 | 23 | 8 | 6.4 |
| 2002 | 57.4 | 1.1 | 59.4 | 9 | 4 | 6.6 |
| 2001 | 34.5 | 0.8 | 45.2 | 0 | 0 | 2.8 |
| 2000 | 34.4 | 1 | 51.2 | 3 | 0 | 4.8 |
| 1999 | 10.6 | 1.3 | 60.7 | 3 | 1 | 6.1 |
| 1998 | 37.2 | 1.1 | 44.5 | 9 | 2 | 6.6 |
| 1997 | 40.2 | 1 | 70.1 | 8 | 4 | 8.7 |
| 1996 | 51 | 1.2 | 42.6 | 13 | 9 | 7.9 |
| 1995 | 62 | 1.2 | 61.8 | 28 | 12 | 8.3 |

Table 13. Black Bass Catch Per Hour Compared to Habitat Types by Location.

| | Habitat Designation | | |
|---|---|---|---|
| **Reservoir and Site** | **Good** | **Fair** | **Poor** |
| **Chickamauga** | | | |
| Harrison Bay | 99(4) | 61(4) | 31(4) |
| Sale Creek | 67(4) | 76(4) | 36(4) |
| Skull Island | 69(4) | 63(5) | 58(3) |
| | | | |
| **Watts Bar** | | | |
| Blue Springs | 69(3) | 47(4) | 46(5) |
| Caney Creek | 78(3) | 61(5) | 49(4) |
| Kingston | 59(4) | 43(4) | 43(4) |
| Watts Bar Dam | 107(3) | 43(5) | 62(4) |
| | | | |

Catch per hour = number of fish collected per hour
( ) = number of transects sampled at each location

Table 14. Black Bass Catch Per Hour Compared to Habitat Types by Reservoir.

| | HABITAT DESIGNATION | | |
|---|---|---|---|
| | | | |
| **Reservoir** | **Good** | **Fair** | **Poor** |
| Chickamauga | 78 | 66 | 40 |
| Watts Bar | 77 | 49 | 50 |
| Wheeler | 57 | 54 | 56 |

Catch per hour = number of fish collected per hour

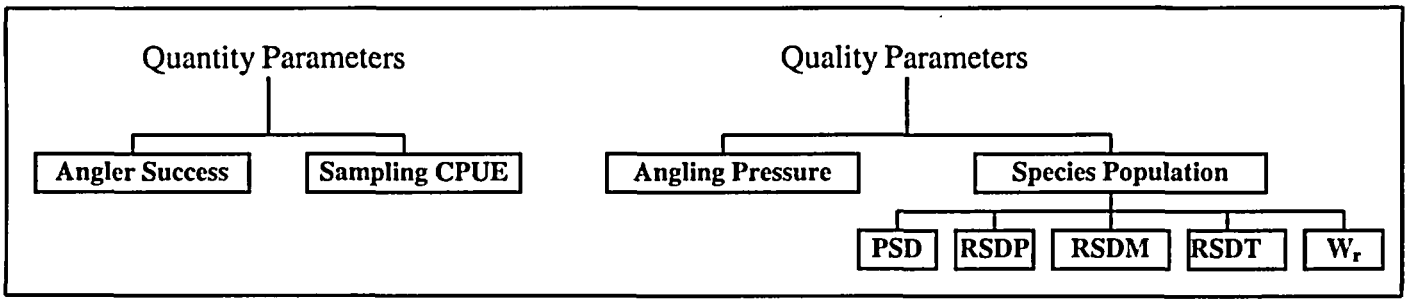


Figure 1. Parameters used to calculate the Sport Fishing Index (SFI).

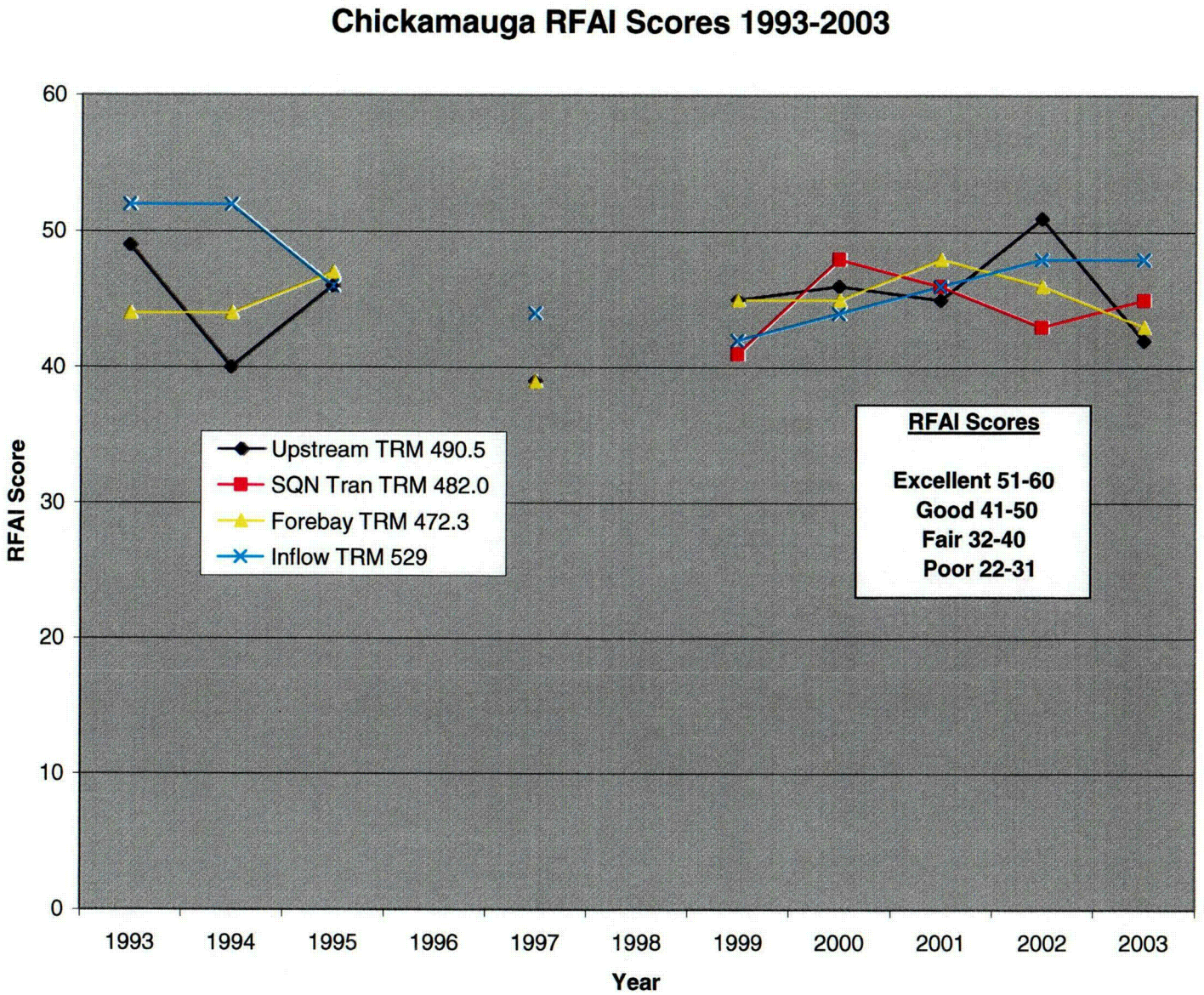


Figure 2. RFAI scores from sample years between 1993 and 2003.

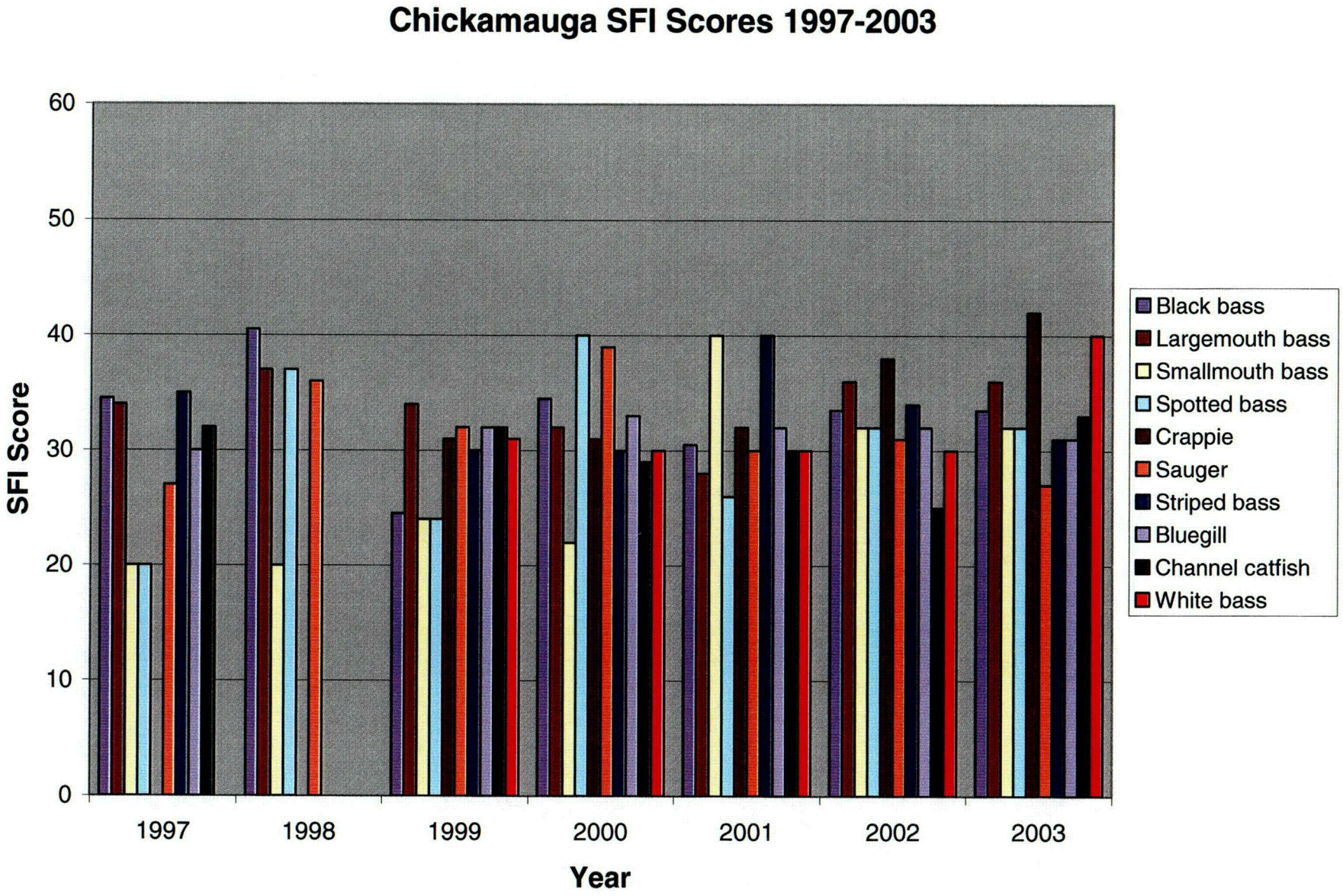


Figure 3. Sport Fishing Index results for Chickamauga Reservoir between 1997 and 2003.



C02

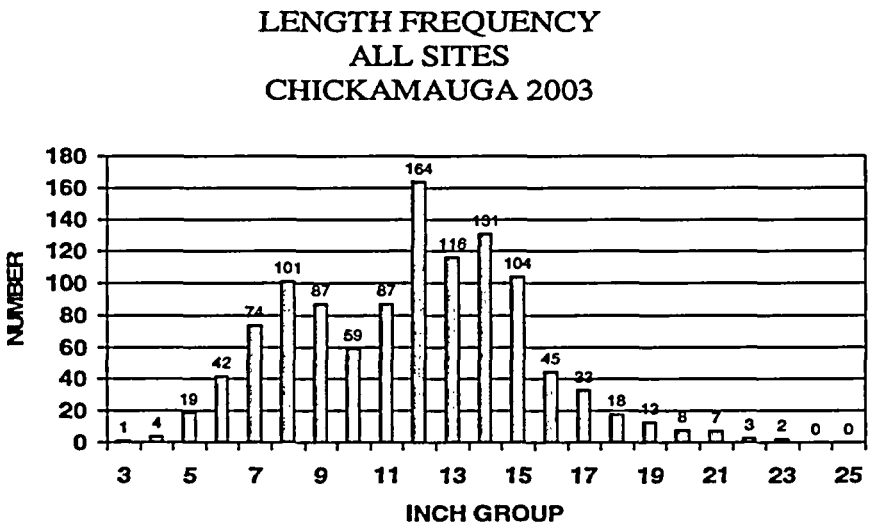


Figure 4. Chickamauga Reservoir length frequency histogram, (all sites) spring 2003.

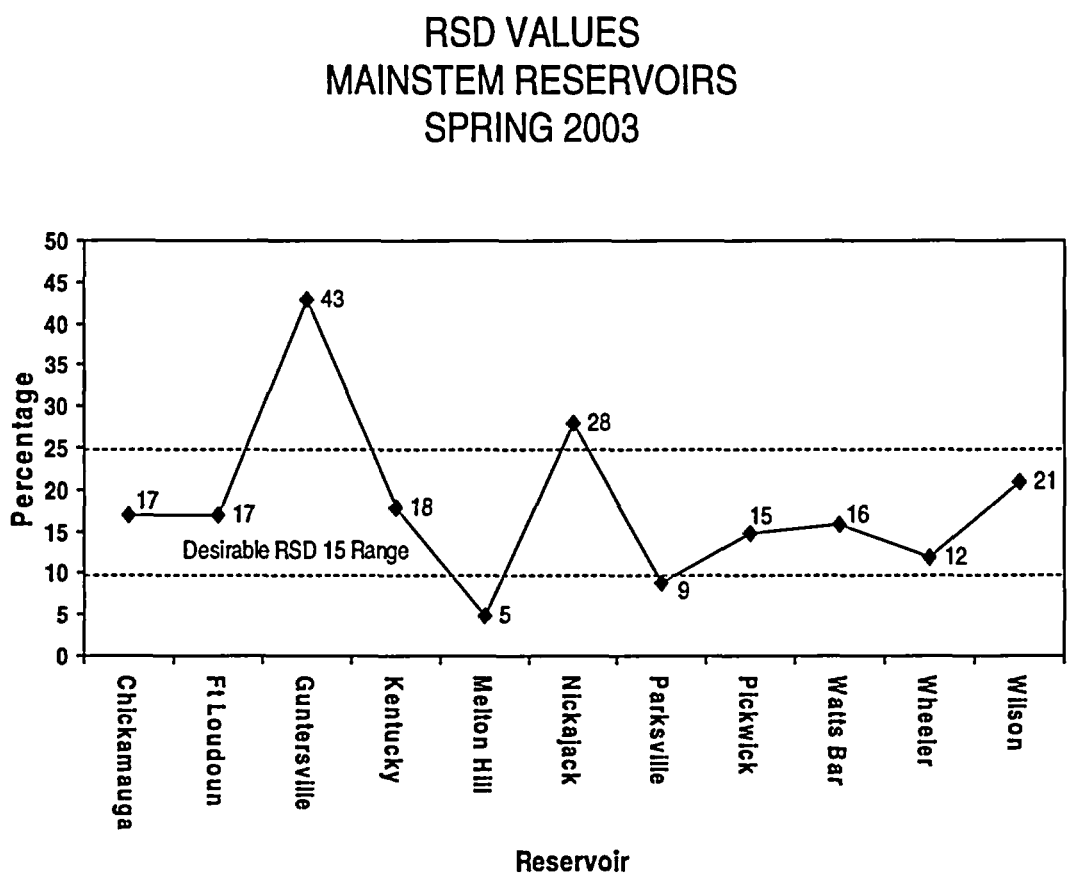


Figure 5. Relative stock density values for Tennessee River Reservoirs.

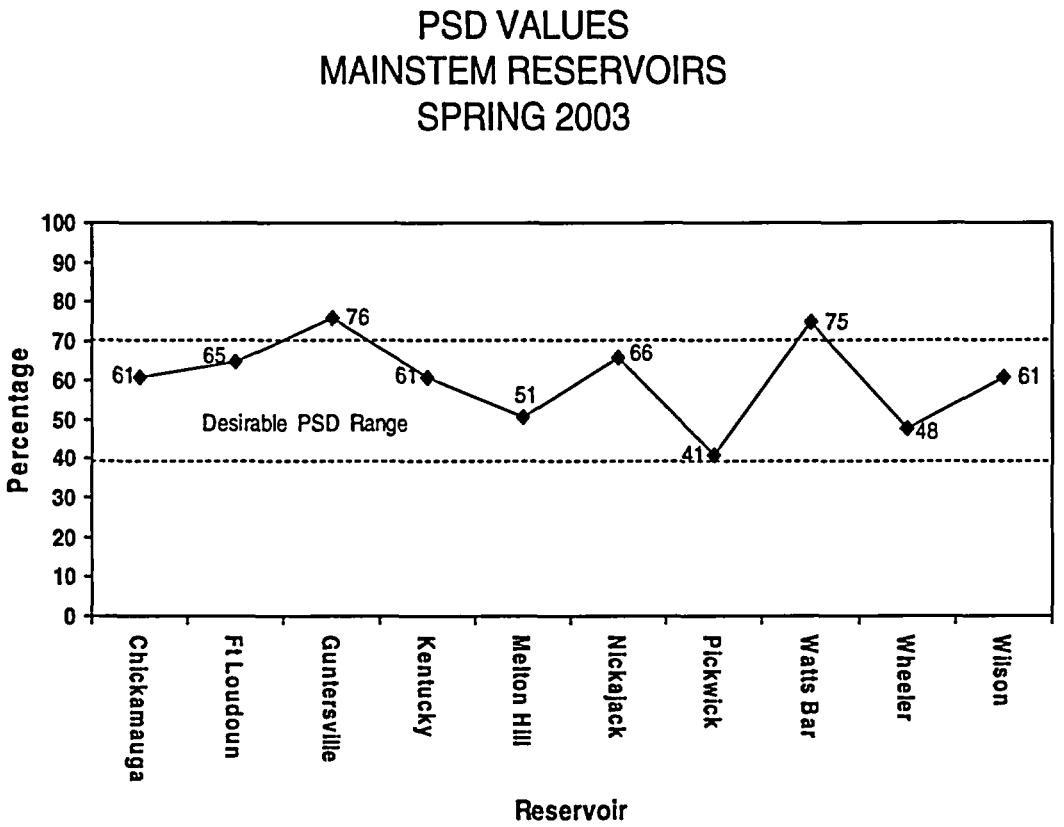


Figure 6. Proportional stock density values for Tennessee River Reservoirs.

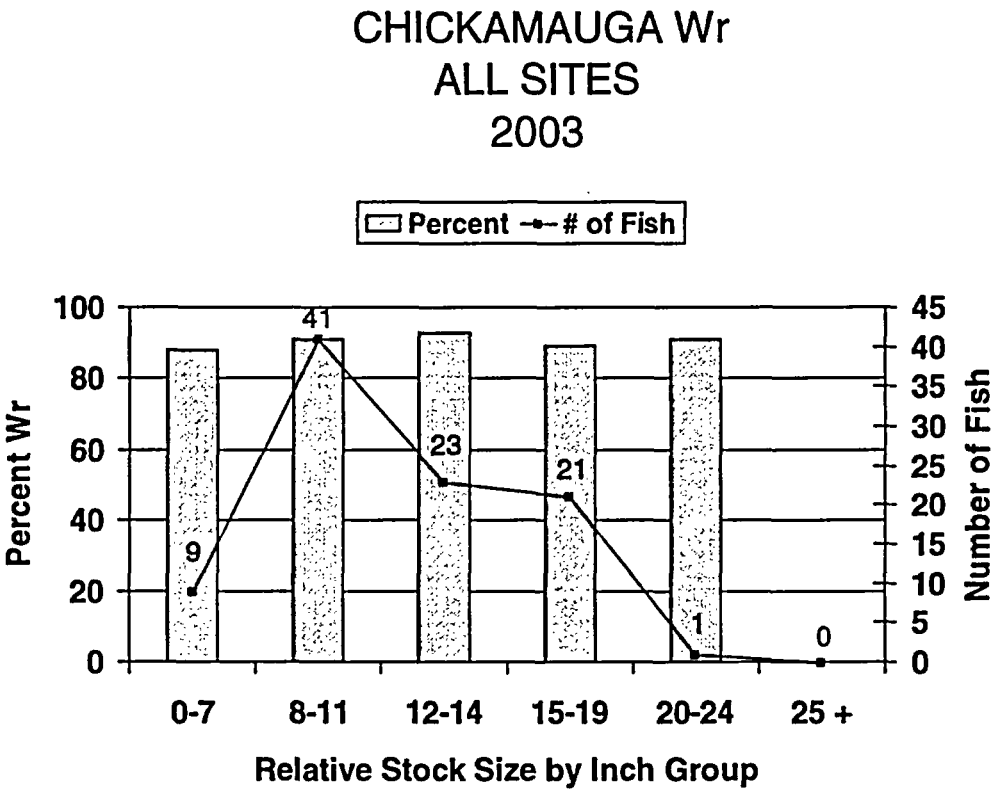


Figure 7. Chickamauga Reservoir mean relative weights (Wr) for largemouth bass broken out by RSD category and fish numbers.