Tennessee Valley Authority, Post Office Box 2000, Soddy-Daisy, Tennessee 37379-2000

May 15, 2007

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

Dear Mr. Hannah:

SEQUOYAH NUCLEAR PLANT - 2006 BIOLOGICAL MONITORING REPORT

Enclosed is the "Biological Monitoring of the Tennessee River Near Sequoyah Nuclear Plant Discharge 2006" Report. 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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Biological Monitoring of the Tennessee River Near Sequoyah Nuclear Plant Discharge 2006

by

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May 2007

Tennessee Valley Authority
Aquatic Monitoring and Management
Knoxville, 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 thermal discharges go directly to surface waters. Industries responsible for point-source discharges 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 analyze previous and new data to determine whether significant changes have occurred in the plant operation, reservoir operation, or in stream biology that would necessitate the need for changes in the thermal 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 results of the Calendar Year 2006 monitoring and analyses to the Tennessee Department of Environment and Conservation and compare these results with historical monitoring data.

Prior to 1990, TVA conducted 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 are evaluated with a multi-metric monitoring approach utilizing five environmental indicators: dissolved oxygen, chlorophyll, sediment quality, the 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 (i.e., Benthic Macroinvertebrate Index [BI]). These multi-metric evaluation techniques have proven successful in TVA's monitoring efforts as well as for other federal and state monitoring programs. For consistency, only RFAI analyses between 1993 and 2006 will be utilized. The 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 relies on measurements of quantity and quality aspects of angler success and fish population characteristics. This 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), crappie, sauger, striped bass, bluegill, channel catfish, and white bass.

In recent years, SFI information has been used to describe the quality of the resident sport 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 Browns Ferry Nuclear Plant, Colbert and Widows Creek Fossil Plants in Alabama.

The TVA Spring Sport Fish Survey (SSS) is conducted to evaluate sport fish populations in 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 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 sample site is located at Tennessee River Mile (TRM) 529.0, the transition zone sampling site is located at TRM 490.5, and the forebay zone sampling sites are located at TRM 482.0 and 472.3. The transition zone sampling site, which is located approximately 7.2 river miles upstream of the SQN discharge, is used as a control site to provide upstream data for 316(a) thermal variance studies conducted during sample years from 1993 to 2006. The downstream station is located at TRM 482.0 and has been sampled each year from 1999 to 2006 to monitor Chickamauga Reservoir aquatic communities in close proximity to the SQN thermal effluent. Previously, the downstream station was located at TRM 472.3 during sample years from 1993 to 1997.

Sampling effort consisted of fifteen 300-meter electrofishing runs (approximately 10 minute 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 site. Attained values for each of the 12 metrics were compared to reference conditions for transition zones of lower 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 site 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.

Potential RFAI scores range from 12 to 60. Ecological health ratings ("Very Poor" 12-21, "Poor" 22-31, "Fair" 32-40, "Good" 41-50, or "Excellent" 51-60) are then applied to scores. 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. Additionally, upstream/downstream site comparisons can be used to identify if SQN operation is adversely affecting the downstream fish community. 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 75th percentile was 6, the 90th 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 a transect extending from the right descending bank to the left descending bank at each site. A Ponar sampler was used for most samples but a Peterson sampler was used when larger substrate was encountered. Collection and processing techniques followed standard VS procedures. Bottom sediments were washed on a 533μ screen; 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 at different reservoir sections are comparable. Potential scores ranged from 7 to 35. Ecological

health ratings ("Very Poor" 7-12, "Poor" 13-18, "Fair" 19-23, "Good" 24-29, or "Excellent" 30-35) 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 absence of impact on the Chickamauga Reservoir benthic macroinvertebrate community related to SQN's thermal discharge.

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 75th percentile was 4 and the 90th 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 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. The 2006 Tennessee Wildlife Resources Agency gill netting and creel data were not available for analyses before this report was submitted; therefore 2005 SFI data were used. Additionally, 2005 SFI values were only calculated for black bass species in Chickamauga Reservoir due to insufficient data for other sport fish species.

Spring Sport Fish Survey

A Spring Sport Fish Survey was conducted on Chickamauga Reservoir March 21-23, 2006. During the sampling period, water levels on Chickamauga Reservoir were 676.8 to 677.3 msl (summer pool level is 682.5 msl). Sampling was conducted using a boat mounted electrofishing unit at a total of twelve sites at Harrison Bay, Ware Branch, and Sale Creek. Sampling effort at each site consisted of thirty minutes of continuous electrofishing in the littoral zones of

prominent habitat types present. After being stunned, fish were collected with dip nets, counted, weighed, measured, and then released unharmed.

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 SSS. 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

RFAI fish data collected during autumn 2006 from TRM 490.5 upstream from SQN resulted in a RFAI score of 47 ("Good"), while the downstream site at TRM 482 scored 37 ("Fair") (Table 1). Although the downstream site scored "Fair", this site has averaged "Good" over all sample years with a average score of 43 (72 percent of the maximum score) (Table 2). Because the downstream site scored ten points lower than the upstream site, individual RFAI metrics were examined to evaluate this difference and to determine if this score was indicative of thermal effects (refer to Table 3 for scoring criteria for the twelve RFAI metrics).

Species richness and composition metrics constituted seven points of the ten point score difference (Table 1). The total number of species at the upstream site was 31, compared to 27 at the downstream site, which resulted in a two point scoring difference for the metric "Number of species". During 2006, six species were collected at the upstream site that were not found at the downstream site (smallmouth bass, warmouth, northern hog sucker, sauger, white bass, and chestnut lamprey) and two species were collected at the downstream site that were not encountered at the upstream site (western mosquitofish and longnose gar) (Tables 4 and 5). Although more species were collected at the upstream site, four of the six species found only at the upstream site were collected in low numbers (1 sauger, 1 northern hog sucker, 1 chestnut lamprey, and 8 white bass). The single northern hog sucker collected at the upstream site resulted in this site scoring a total of four points higher than the downstream site for two metrics, "Number of benthic invertivores" and "Number of intolerant species", and influenced the higher score for the metric "Number of species". Three benthic invertivore species were collected at the downstream site while four species, including the northern hog sucker, were found at the upstream site, resulting in a two point score difference (Table 1). Three species considered intolerant were collected at the downstream site while 5 species were found at the upstream site, including smallmouth bass and the single northern hog sucker, resulting in a two point difference. Although no smallmouth bass were collected at TRM 482 downstream from SQN, only 18 individuals were collected at the upstream site during 2006 RFAI sampling. Additionally, of the 708 black bass collected during the 2006 SSS in Chickamauga Reservoir, only 22 were smallmouth bass; two of the three SSS sample sites were located above SQN. The lack of smallmouth bass in the RFAI sample at TRM 482 is most likely related to the scarcity of physical habitat preferred by smallmouth bass rather than to thermal effects.

The downstream site (TRM 482) scored one point lower than the upstream site (TRM 490.5) for each of the metrics "Percent tolerant individuals", "Percent omnivores", and "Average number per run" because of a lower catch rate in gill net samples at the downstream site (Table 1). The electrofishing catch rate at the downstream site was higher than the upstream site, and overall, more fish were actually collected at the downstream site than at the upstream site (Tables 4 and 5). Higher numbers of tolerant individuals and omnivores were collected in gill nets at the upstream site, but since the gill net catch rate was higher, the percentage of tolerant individuals and omnivores in the sample was lower than the downstream site, giving it a higher score.

As discussed above, primary factors influencing the higher upstream score were: the collection of a single northern hog sucker (which greatly influenced three metrics); the collection of a few additional species (each primarily consisting of one individual); and a higher gill net catch rate. Examination of the factors influencing individual metrics indicates that the fish community composition is not considerably different between the upstream and downstream sites even though the scores are significantly different. Furthermore, six of the eight sample years have scored "Good" at the downstream site (Figure 2). If the score at the downstream site continues to decline in subsequent samples, further investigation may be required.

It is important to note that the upstream site is scored with transition criteria and the downstream site is scored using forebay criteria (Table 3). More accurate comparisons can be made between sites that are located in the same reservoir zone (i.e., transition to transition). Due to the location of SQN, it is not possible to have an upstream and downstream site within the same reservoir zone. SQN is located at the downstream end of the transition zone on Chickamauga Reservoir; therefore the downstream site is located in the upstream section of the forebay. The physical and chemical composition of a forebay is different than that of a transition; consequently, inherent differences exist among the aquatic communities (e.g. species diversity is often higher in a transition than a forebay zone).

RFAI scores (Table 1, Figure 2) and electrofishing and gill netting catch rates (Tables 4 and 5) are presented for Chickamauga Reservoir inflow and forebay sites (TRM 529 and 472.3) to provide an overview of ecological health throughout the reservoir; however, aquatic communities at these sites are not affected by SQN temperature effects and are not used to determine BIP in relation to SQN. Both of these sites scored "Good" during 2006.

Benthic Macroinvertebrate Community

Benthic macroinvertebrate data collected during autumn 2006 from TRM 490.5 upstream from SQN resulted in a BI score of 27 ("Good"), while the downstream site at TRM 482 scored 31 ("Excellent") (Table 6). Table 7 provides density by taxon from the 2006 samples at these sites.

With the exception of the 2000 sample, the BI scores have remained in the "Good" to "Excellent" ecological health range for all sampling seasons at both sites (Table 8). These data indicate that a healthy benthic macroinvertebrate community exists in both the upstream and downstream vicinity of SQN and that the plant is not adversely impacting this fauna.

Data collected in Chickamauga Reservoir forebay (TRM 472.3) resulted in a BI score of 29 "Good". This site is located 11 river miles downstream of SQN and sampling results should not reflect temperature effects from the plant. This site is included to provide additional data on the downstream health of the benthic macroinvertebrate community (Table 8).

To ensure data integrity, samples collected and identified in the field at the SQN monitoring sites (TRM 490.5 and TRM 482) were also identified in the laboratory by an independent consultant. The average Benthic Index scores during years when a sample was both field and lab processed were similar for both sites (Table 9). These results indicate that scores based on field-processed samples provide an acceptable representation of scores based on lab-processed samples. Therefore, during future monitoring, samples will be lab processed one out of every five years in a permit cycle instead of every year.

Sport Fishing Index

SFI scores for Chickamauga Reservoir during 2005 were only calculated for black bass species (largemouth, smallmouth, and spotted) due to insufficient data to accurately calculate SFI scores for other sport fish species. Largemouth and spotted bass scored higher than the nine year average during 2005, while smallmouth bass scored 2 points lower than the nine year average (Table 10, Figure 3). Overall, the nine year average score for black bass was the same as the 2005 score (Table 10).

Tables 11 and 12 illustrate SFI scoring criteria for population metrics and creel quantity and quality.

Spring Sport Fish Survey

A total of 18 hours of electrofishing resulted in collection of 608 largemouth bass, 78 spotted bass, and 22 smallmouth bass; of these, 72 percent were harvestable size ($\geq$ 10 inches). Overall catch rate (39.4 fish/hour) was substantially less than the 2005 survey (72.6 fish/hour), but was similar to the average catch rate from all twelve sample years (Table 13). The largest black bass collected was a 7.1 pound largemouth bass taken from Sale Creek. Large bass were well represented with 39 bass greater than three pounds, 14 greater than four pounds, and 7 over five pounds. The three-pound category showed an increase of 50 percent over 2005 results, while the four and five-pound categories remained constant. Almost half of the largemouth bass collected were in the 10-13 inch size class (Figure 4). Fish >14 inches comprised 19 percent of the overall sample. All size classes up to 21 inches were represented in the population.

Habitat type is derived from the Shoreline Assessment Habitat Index (SAHI) which was developed by TVA's Resource Stewardship Program. The resultant habitat designations (good, fair, and poor) are correlated to black bass abundance (numbers/hour). Among the three areas sampled during 2006, the correlations of habitat type to black bass abundance at Harrison Bay were positive while bass collected at Sale Creek and Skull Island showed some variability among habitat types, *i.e.*, the catch rates (abundance) did not align with the habitat designation types (Table 14).

The following results describe the quality and condition of black bass collected in Chickamauga Reservoir during spring 2006: The RSD value (22) fell within the desirable range (10-25) (Figure 5). The PSD value (57) was also within the preferred range (40-70) (Figure 6). Wr 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.

Only 32 crappie (29 black crappie and 3 white crappie) were collected during the survey. Crappie were collected predominantly from tree tops, stumps, and other physical structures in shallow water. Optimum water temperatures for crappie spawning occurred earlier in the spring of 2006 which may have been a factor affecting the catch rate.

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Table 1. Scoring Results for the Twelve Metrics and Overall Scores for all RFAI sites sampled in Chickamauga Reservoir, 2006.

		Forebay TRM 472.3		Forebay TRM 482.0 *Downstream Site*		Transition TRM 490.5 *Upstream Site*		Inflow TRM 529.0	
Metric		**Obs**	**Score**	**Obs**	**Score**	**Obs**	**Score**	**Obs**	**Score**
A. Species richness and composition									
1. Number of species		25	3	27	3	31	5	27	3
2. Number of centrarchid species		8	5	6	5	7	5	6	5
3. Number of benthic invertivores		2	1	3	1	4	3	5	3
4. Number of intolerant species		5	5	3	3	5	5	6	5
5. Percent tolerant individuals	electrofishing	74.6	0.5	72.4	0.5	70.1	0.5	65.3	1
	gill netting	28.6	0.5	29.6	0.5	30	1.5	-	-
6. Percent dominance by one species	electrofishing	37.4	1.5	33.6	1.5	35.3	1.5	29.1	3
	gill netting	24.4	1.5	22.5	1.5	25.2	1.5	-	-
7. Number non-native species	electrofishing	0.5	2.5	0	2.5	0	2.5	0.1	5
	gill netting	0.4	2.5	0	2.5	0	2.5	-	-
8. Number of top carnivore species		8	5	8	5	10	5	9	5
B. Trophic composition									
9. Percent top carnivores	electrofishing	5.9	1.5	6.5	1.5	8.3	1.5	9	1
	gill netting	62.8	2.5	40.8	1.5	51.2	1.5	-	-
10. Percent omnivores	electrofishing	8.3	2.5	24.6	1.5	37.2	1.5	31.5	3
	gill netting	30.8	1.5	47.9	0.5	27.2	1.5	-	-

Table 1. (continued)

Metric		Forebay TRM 472.3 Obs	Forebay TRM 472.3 Score	Forebay TRM 482.0 *Downstream Site* Obs	Forebay TRM 482.0 *Downstream Site* Score	Transition TRM 490.5 *Upstream Site* Obs	Transition TRM 490.5 *Upstream Site* Score	Inflow TRM 529.0 Obs	Inflow TRM 529.0 Score
C. Fish abundance and health									
11. Average number per run	electrofishing	55.1	0.5	60.9	0.5	49.1	0.5	61.7	3
	gill netting	26.6	2.5	14.2	1.5	25	2.5	-	-
12. Percent anomalies	electrofishing	0.7	2.5	0.4	2.5	0.3	2.5	1.5	5
	gill netting	1.9	2.5	3.5	1.5	0.4	2.5	-	-
RFAI		**44**		**37**		**47**		**42**	
		Good		**Fair**		**Good**		**Good**	

*TRM 472.3 and 482 scored with forebay criteria, TRM 490.5 scored with transition criteria, and TRM 529 scored with inflow criteria (Refer to Table 3). RFAI Scores: Very Poor 12-21, Poor 22-31, Fair 32-40, Good 41-50, Excellent 51-60.

Table 2. RFAI Scores Developed Using the RFAI Metrics from Samples Collected during 1993 to 2006, Upstream and Downstream of Sequoyah Nuclear Plant.

Station	Reservoir	Location	1993	1994	1995	1997	1999	2000*	2001	2002*	2003	2004*	2005	2006*	1993-2006 Average
Upstream	Chickamauga	TRM 490.5	49	40	46	39	45	46	45	51	42	49	48	47	46 (Good)
Downstream	Chickamauga	TRM 482.0					41	48	46	43	45	41	39	37	43 (Good)
Downstream	Chickamauga	TRM 472.3	44	44	47	39	45	45	48	46	43	43	46	44	45 (Good)

*The 2000, 2002, 2004, and 2006 sample years were not part of the VS monitoring program, however the same methodology was applied.

Table 3. Scoring Criteria for Forebay, Transition, and Inflow Sections of Upper Mainstem Reservoirs in the Tennessee River System. Upper Mainstem Reservoirs include Chickamauga, Fort Loudoun, Melton Hill, Nickajack, Tellico, and Watts Bar.

		Scoring Criteria								
		Forebay			Transition			Inflow		
Metric	Gear	1	3	5	1	3	5	1	3	5
A. Species richness and composition										
1. Total species	Combined	<14	14-27	>27	<15	15-29	>29	<14	14-27	>27
2. Total Centrarchid species	Combined	<2	2-4	>4	<2	2-4	>4	<3	3-4	>4
3. Total benthic invertivores	Combined	<4	4-7	>7	<4	4-7	>7	<3	3-6	>6
4. Total intolerant species	Combined	<2	2-4	>4	<2	2-4	>4	<2	2-4	>4
5. Percent tolerant individuals	Electrofishing	>62%	31-62%	<31%	>62%	31-62%	<31%	>58%	29-58%	<29%
	Gill netting	>28%	14-28%	<14%	>32%	16-32%	<16%			
6. Percent dominance by 1 species	Electrofishing	>50%	25-50%	<25%	>40%	20-40%	<20%	>46%	23-46%	<23%
	Gill netting	>29%	15-29%	<15%	>28%	14-28%	<14%			
7. Percent non-native species	Electrofishing	>4%	2-4%	<2%	>6%	3-6%	<3%	>17%	8-17%	<8%
	Gill netting	>16%	8-16%	<8%	>9%	5-9%	<5%			
8. Total top carnivore species	Combined	<4	4-7	>7	<4	4-7	>7	<3	3-6	>6
B. Trophic composition										
9. Percent top carnivores	Electrofishing	<5%	5-10%	>10%	<6%	6-11%	>11%	<11%	11-22%	>22%
	Gill netting	<25%	25-50%	>50%	<26%	26-52%	>52%			
10. Percent omnivores	Electrofishing	>49%	24-49%	<24%	>44%	22-44%	<22%	>55%	27-55%	<27%
	Gill netting	>34%	17-34%	<17%	>46%	23-46%	<23%			
C. Fish abundance and health										
11. Average number per run	Electrofishing	<121	121-241	>241	<105	105-210	>210	<51	51-102	>102
	Gill netting	<12	12-24	>24	<12	12-24	>24			
12. Percent anomalies	Electrofishing	>5%	2-5%	<2%	>5%	2-5%	<2%	>5%	2-5%	<2%
	Gill netting	>5%	2-5%	<2%	>5%	2-5%	<2%			

Table 4. Species Listing and Catch Per Unit Effort for Forebay Transects on Chickamauga Reservoir during Fall Electrofishing and Gill Netting, 2006. (Electrofishing Effort = 300 Meters of Shoreline, Gill Netting Effort = 10 Net-Nights)

	Forebay TRM 472.3			Forebay 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	-	-	-	0.13	0.58	-
Longnose gar	-	-	-	-	-	0.20
Skipjack herring	-	-	3.90	-	-	2.10
Gizzard shad	3.47	14.53	6.50	12.53	54.65	3.20
Threadfin shad	5.53	23.18	-	0.33	1.45	-
Hybrid shad	-	-	0.40	-	-	0.50
Common carp	0.27	1.12	0.10	-	-	-
Golden shiner	0.53	2.23	0.50	0.27	1.16	0.20
Emerald shiner	0.67	2.79	-	1.73	7.56	-
Spotfin shiner	0.47	1.96	-	2.53	11.05	-
Bluntnose minnow	-	-	-	2.00	8.72	-
Bullhead minnow	-	-	-	0.13	0.58	-
Spotted sucker	0.20	0.84	0.20	0.13	0.58	0.10
Blue catfish	-	-	0.50	-	-	1.50
Channel catfish	0.33	1.40	0.20	0.20	0.87	1.40
Flathead catfish	0.07	0.28	0.40	0.13	0.58	0.30
Western mosquitofish	-	-	-	0.07	0.29	-
Yellow bass	-	-	3.20	-	-	0.90
Warmouth	0.27	1.12	-	-	-	-
Redbreast sunfish	14.33	60.06	-	4.67	20.35	-
Green sunfish	0.47	1.96	-	0.07	0.29	-
Bluegill	20.60	86.31	0.10	20.47	89.24	0.50
Longear sunfish	0.67	2.79	-	0.73	3.20	-
Redear sunfish	2.20	9.22	0.90	7.47	32.56	0.70
Hybrid sunfish	0.07	0.28	-	-	-	-
Smallmouth bass	1.00	4.19	-	-	-	-
Spotted bass	1.13	4.75	4.10	2.00	8.72	0.90
Largemouth bass	1.00	4.19	0.30	1.53	6.69	0.10
White crappie	-	-	0.10	-	-	-
Black crappie	-	-	-	0.13	0.58	1.30
Logperch	-	-	-	1.00	4.36	-
Freshwater drum	0.40	1.68	0.50	0.13	0.58	0.30
Brook silverside	0.20	0.84	-	-	-	-
Inland silverside	1.20	5.03	-	2.53	11.05	-
Total	**55.15**	**231.03**	**26.60**	**60.91**	**265.69**	**14.20**
Number Samples	**15**		**10**	**15**		**10**
Number Collected	**827**		**266**	**914.00**		**142**
Species Collected	**23**		**17**	**23**		**16**

Table 5. Species Listing and Catch Per Unit Effort for the Transition and Inflow Transects on Chickamauga Reservoir during Fall Electrofishing and Gill Netting, 2006. (Electrofishing Effort = 300 Meters of Shoreline, Gill Netting Effort = 10 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	-	-	-	0.13	0.58
Spotted gar	0.07	0.32	-	0.13	0.58
Skipjack herring	-	-	3.10	-	-
Gizzard shad	17.33	84.14	6.30	17.93	77.52
Threadfin shad	3.87	18.77	0.10	0.07	0.29
Common carp	-	-	-	0.07	0.29
Golden shiner	0.60	2.91	-	-	-
Emerald shiner	1.53	7.44	-	1.27	5.48
Spotfin shiner	0.40	1.94	-	2.93	12.68
Bluntnose minnow	0.07	0.32	-	-	-
Bullhead minnow	0.07	0.32	-	-	-
Smallmouth buffalo	-	-	-	-	-
Black buffalo	-	-	-	-	-
Northern hog sucker	0.07	0.32	-	-	-
Spotted sucker	0.33	1.62	0.10	0.20	0.86
Black redhorse	-	-	-	0.40	1.73
Golden redhorse	-	-	-	0.80	3.46
Blue catfish	-	-	0.10	0.07	0.29
Channel catfish	0.27	1.29	0.40	1.33	5.76
Flathead catfish	0.20	0.97	-	0.47	2.02
White bass	-	-	0.80	-	-
Yellow bass	-	-	5.50	0.53	2.31
Striped bass	-	-	-	-	-
Rock bass	-	-	-	0.07	0.29
Warmouth	0.07	0.32	-	-	-
Redbreast sunfish	4.33	21.04	-	1.27	5.48
Green sunfish	0.07	0.32	-	0.20	0.86
Bluegill	11.40	55.34	-	16.67	72.05
Longear sunfish	1.00	4.85	-	1.67	7.20
Redear sunfish	2.80	13.59	-	5.53	23.92
Smallmouth bass	1.13	5.50	0.10	0.67	2.88
Spotted bass	1.60	7.77	1.00	2.13	9.22
Largemouth bass	0.27	1.29	0.40	1.07	4.61
White crappie	-	-	-	-	-
Black crappie	0.80	3.88	1.80	0.33	1.44

Table 5. (continued)

	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**
Yellow perch	-	-	-	-	-
Logperch	0.27	1.29	-	1.47	6.34
Sauger	-	-	0.10	-	-
Freshwater drum	0.20	0.97	0.60	1.27	5.48
Brook silverside	-	-	-	1.00	4.32
Inland silverside	0.40	1.94	-	2.00	8.65
Chestnut lamprey	-	-	0.10	-	-
Total	**49.15**	**238.46**	**25**	**61.68**	**266.59**
Number Samples	**15**		**10**	**15**	
Number Collected	**737**		**250**	**925**	
Species Collected	**25**		**17**	**28**	

Table 6. Individual Metric Ratings and the Overall Benthic Index Field Scores for Upstream (TRM 490.5) and Downstream (TRM 482) Sampling Sites Near Sequoyah Nuclear Plant, Chickamauga Reservoir, 2006.

	TRM 490.5 Upstream		TRM 482 Downstream	
Metric	**Obs**	**Rating**	**Obs**	**Rating**
1. Average number of taxa	5.4	5	5	5
2. Proportion of samples with long-lived organisms	0.8	5	0.9	5
3. Average number of EPT taxa	0.5	3	0.7	3
4. Average proportion of oligochaete individuals	2.5	5	17.3	3
5. Average proportion of total abundance comprised by the two most abundant taxa	83.1	3	77.2	5
6. Average density excluding chironomids and oligochaetes	223.3	1	266.7	5
7. Zero-samples - proportion of samples containing no organisms	0	5	0	5
Benthic Index Score		**27 Good**		**31 Excellent**

*TRM 490.5 scored with transition criteria, TRM 482 scored with forebay criteria.

Benthic Index Scores: Very Poor 7-12, Poor 13-18, Fair 19-23, Good 24-29, Excellent 30-35

Table 7. Average Mean Density Per Square Meter of Benthic Taxa Collected at Upstream (TRM 490.5) and Downstream (TRM 482) Sampling Sites Near Sequoyah Nuclear Plant, Chickamauga Reservoir, 2006.

Chickamauga Reservoir Species	TRM 490.5 Upstream Mean Density	TRM 482 Downstream Mean Density
Tubellaria		
Tricladida		
Planariidae		3
Oligocheata		
Oligochaetes	15	85
Hirudinea	15	67
Crustacea		
Amphipoda		15
Isopoda		
Insecta		
Ephemeroptera		
Mayflies		2
Ephemeridae		
Hexagenia (≤10 mm)	3	2
Hexagenia (>10 mm)	15	22
Megaloptera		
Sialidae		
Sialis sp.	2	
Odonata		
Anisoptera		
Zygoptera		
Trichoptera		
Caddisflies		5
Plecotera		
Stoneflies		
Coeleoptera		
Diptera		
Ceratopogonidae		
Chironomidae		
Chironomids	322	113
Gastropoda		
Snails	10	20
Basommatophora		
Ancylidae		
Ferrissia sp.		
Bivalvia		
Unionidae		
Mussels		

Table 7. (continued)

Chickamauga Reservoir Species	TRM 490.5 Upstream Mean Density	TRM 482 Downstream Mean Density
Veneroida		
Corbiculidae		
Corbicula (≤10mm)	28	57
Corbicula (>10mm)	17	57
Sphaeriidae		
Fingernail clams	133	17
Dreissenidae		
Dreissena polymorpha		
Number of samples	**10**	**10**
Total Mean Density/SQ Meter	**560**	**465**
Total area sampled (SQ Meters)	**0.6**	**0.6**

Table 8. Benthic Index Field Scores from Data Collected during 1994-2006 at Chickamauga Reservoir Transition (TRM 490.5) and Forebay (TRM 482.0 and TRM 472.3) Sites.

Site	Reservoir	Location	1994	1995	1997	1999	2000	2001	2002	2003	2004	2005	2006	Average
Upstream	Chickamauga	TRM 490.5	33	29	31	31	23	25	25	31	31	31	27	29
Downstream	Chickamauga	TRM 482.0					23	31	29	29	33	31	31	30
Downstream	Chickamauga	TRM 472.3	31	27	29	25	27	27	21	27	29	27	29	27

Benthic Index Scores: Very Poor 7-12, Poor 13-18, Fair 19-23, Good 24-29, Excellent 30-35
Note: No data were collected for 1996 and 1998.

Table 9. A Comparison of Benthic Index Scores from Field and Lab Processed Samples at the Upstream (TRM 490.5) and Downstream (TRM 482) Sites from Sequoyah Nuclear Plant. Scores are only Presented for Years when Field Samples were Lab Processed.

Site	TRM	Score	2000	2001	2002	2003	2004	2005	2006	Average
Upstream	490.5	Field	23	25	25	31	31	31	27	28
		Lab	21	19	23	27	29	31	23	25
Downstream	482	Field	23	31	29	29	33	31	31	30
		Lab	27	29	27	33	35	33	33	31

Table 10. Sport Fishing Index Scores for Chickamauga Reservoir, 1997-2005.

Species	1997	1998	1999	2000	2001	2002	2003	2004	2005	1997-2005 Average SFI Score
Black bass	35	41	25	35	31	34	34	31	33	33
Smallmouth bass	20	20	24	22	40	32	32	32	26	28
Spotted bass	20	37	24	40	26	32	32	32	36	31
Largemouth bass	34	37	34	32	28	36	36	38	36	35
Bluegill	30	-	32	33	32	32	31	34	-	32
Channel catfish	-	-	32	29	30	25	33	38	-	31
Crappie	32	-	31	31	32	38	42	40	-	35
Sauger	27	36	32	39	30	31	27	26	-	31
Striped bass	35	-	30	30	40	34	31	-	-	33
White bass	-	-	31	30	30	30	40	-	-	32

Table 11. Sport Fishing Index Population Quantity, Creel Quantity, 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
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

Table 11. (continued)

Metrics	Scores 5	10	15
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 are unavailable.

Table 12. Sport Fishing Index Population Quality Metrics and Scoring Criteria.

Metrics	Scores 5	10	15
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 13. Electrofishing Catch Rates and Population Characteristics of Black Bass Collected during Spring Sport Fish Surveys on Chickamauga Reservoir, 1995-2006.

Year	EF Catch Rate (no./hr.)	Mean Weight (lbs.)	% Harvestable	Bass >4 lbs.	Bass >5 lbs.	Largest bass (lbs.)
2006	39.4	1.3	71.7	14	7	7.1
2005	72.6	1.3	36.9	15	9	6.2
2004	40.9	1.3	60.2	13	6	6.6
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
Average	**45.2**	**1.2**	**55.8**	**11.5**	**5.2**	**6.5**

Table 14. Black Bass Catch Per Hour Compared to Habitat Types by Location during Spring Sport Fish Surveys on Chickamauga Reservoir, 2006.

Reservoir and Site	Habitat Designation		
	Good	Fair	Poor
Chickamauga			
Harrison Bay	58(4)	36(4)	41(4)
Sale Creek	27(4)	45(4)	15(4)
Skull Island	79(2)	42(8)	17(2)

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

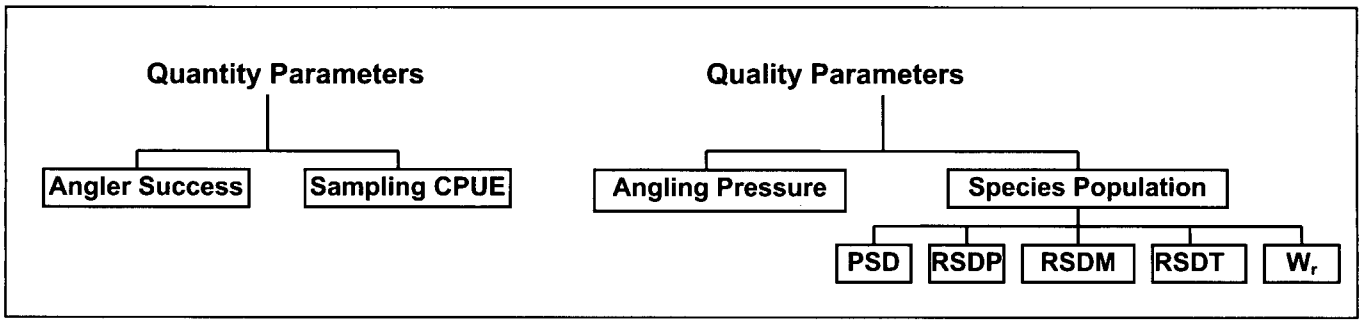

Figure 1. Parameters used to calculate the Sport Fishing Index (SFI).

Figure 2. Annual Chickamauga Reservoir RFAI scores for sample years between 1993 and 2006.

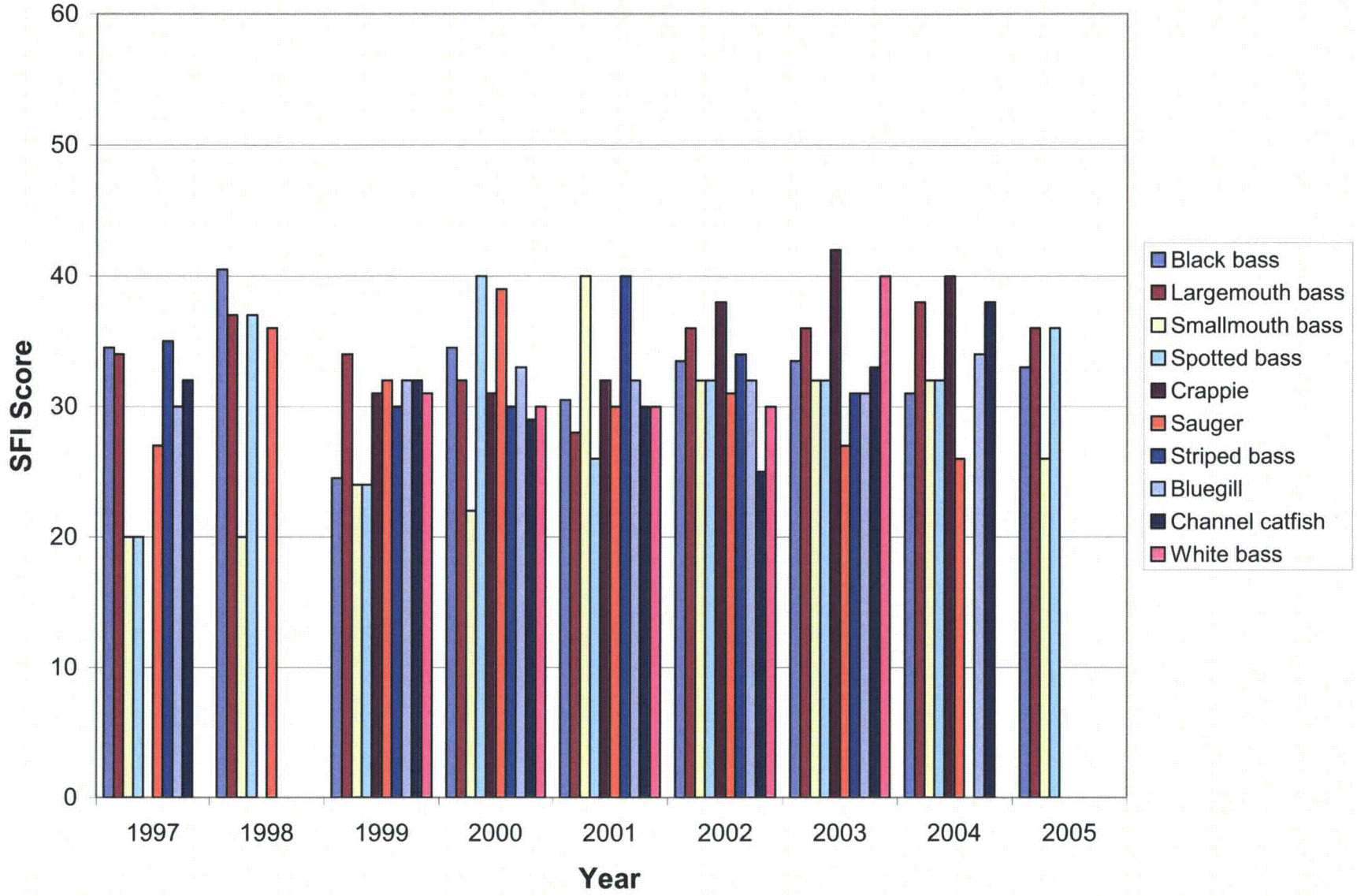

Figure 3. Sport Fishing Index results for Chickamauga Reservoir between 1997 and 2005.

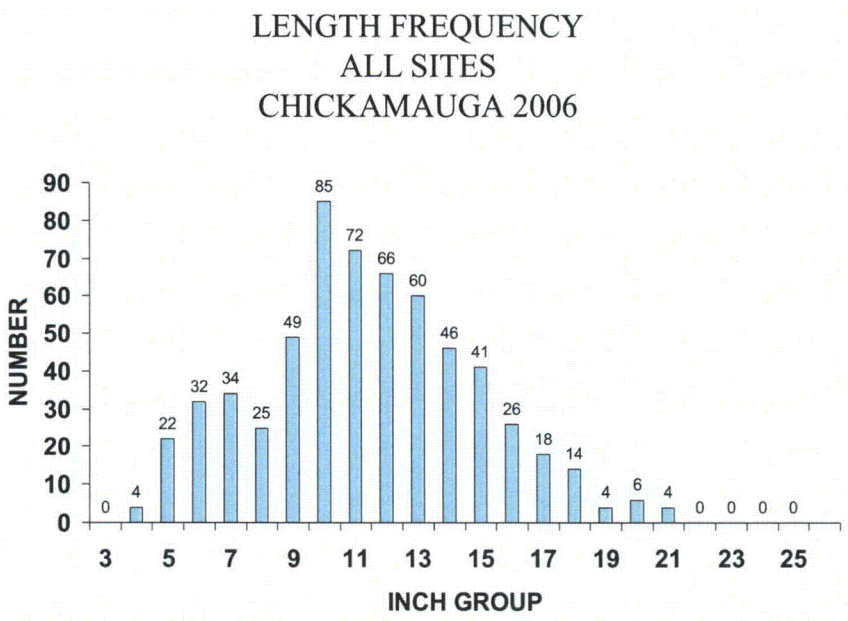

Figure 4. Length frequency distribution for largemouth bass collected from Chickamauga Reservoir (all sites) during the Spring Sport Fish Survey, 2006.

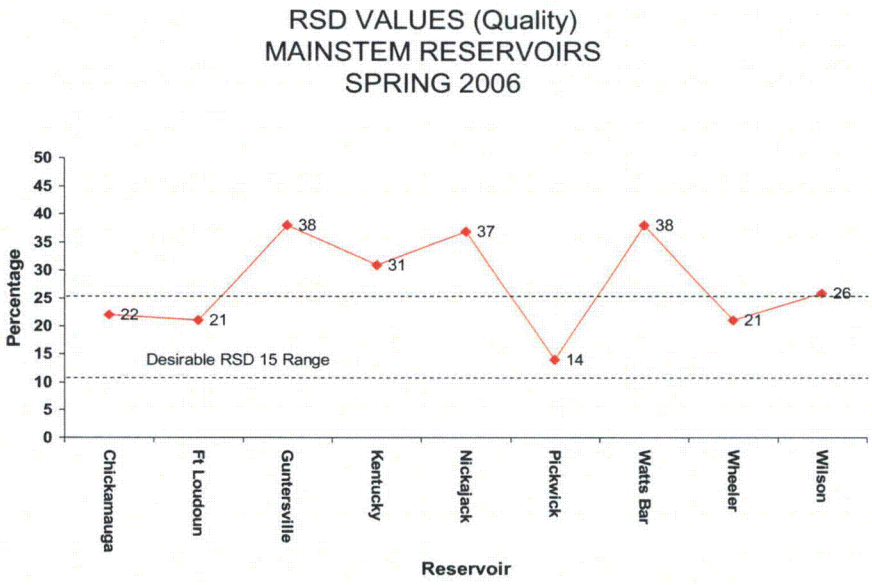

Figure 5. Relative stock density values for Tennessee River reservoirs calculated from 2006 Spring Sport Fish Survey samples.

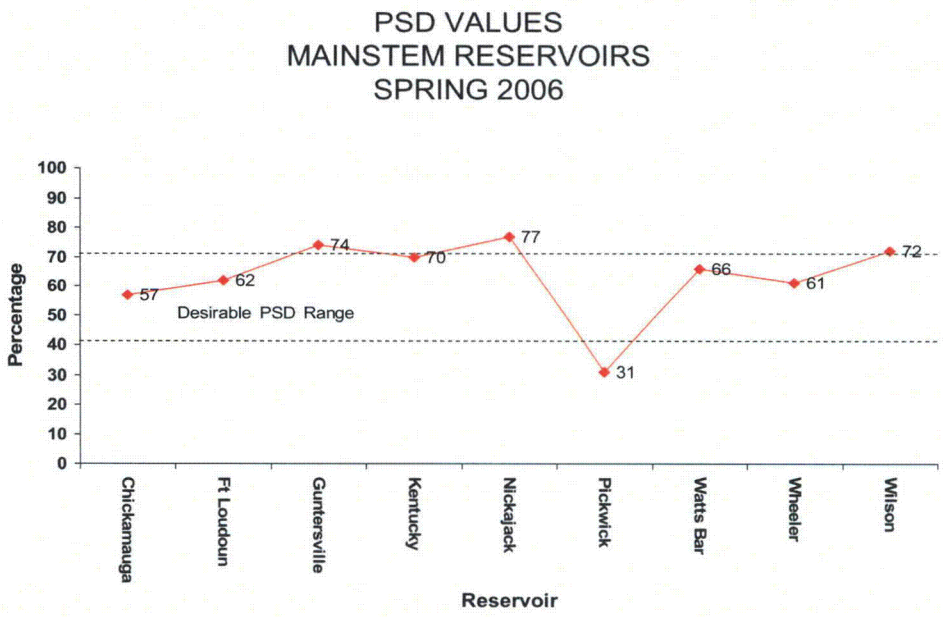

Figure 6. Proportional stock density values for Tennessee River reservoirs calculated from 2006 Spring Sport Fish Survey samples.

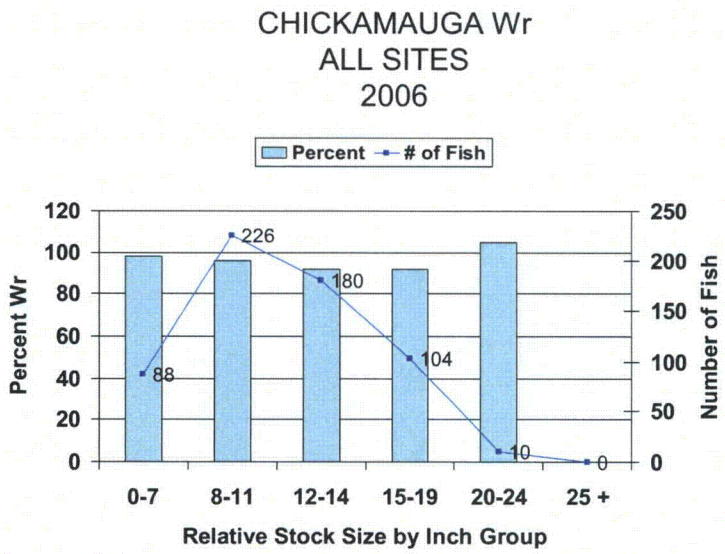

Figure 7. Chickamauga Reservoir mean relative weights (Wr) for largemouth bass by RSD category and number of fish during 2006.