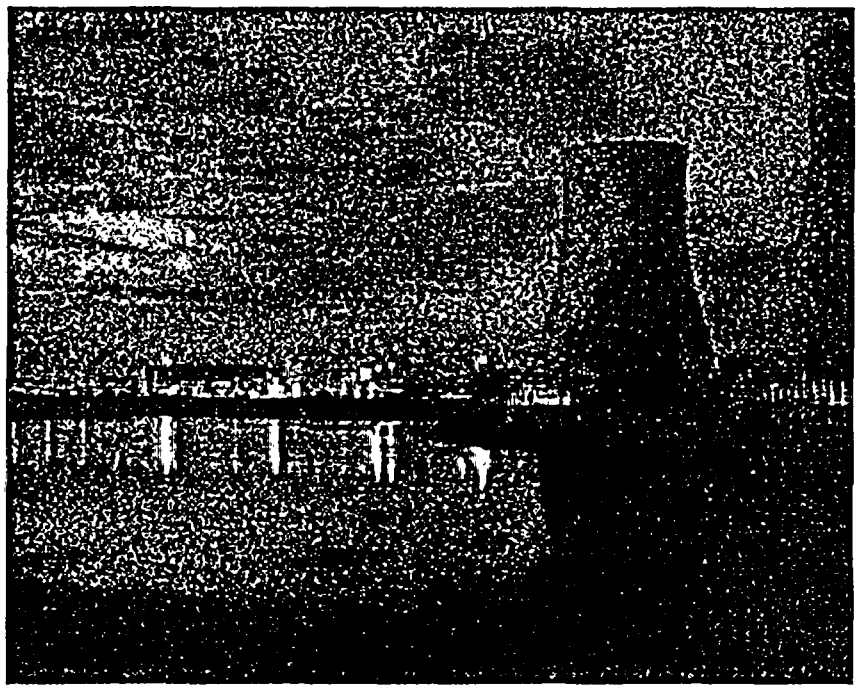
Biological Monitoring of the Tennessee River Near Sequoyah Nuclear Plant Discharge 2004



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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 the Tennessee Department of Environment and Conservation 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 2004 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 Browns Ferry Nuclear, 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 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 site 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 2004. 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 2004 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 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 2004 State Fisheries gill netting and creel data were not available for analysis before this report was submitted; therefore 2003 SFI data were used for analysis.

Spring Sport Fish Survey

A spring sportfish survey was conducted on Chickamauga Reservoir March 2004. Twelve sites at three locations including Harrison Bay, Ware Branch and Sale Creek were sampled using boat-mounted electrofishers. Each run consisted of thirty minutes of continuous electrofishing in the littoral zones of prominent habitat types represented in the reservoir. Summer pool level for Chickamauga is 682.5 msl and sampling was conducted at 676.6 msl.

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 twenty-four 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 2004, both the SQN downstream and the upstream station scored "Good" (41 and 49), respectively 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 2004, the average RFAI score for the upstream station was 45 (75 percent of the maximum score). The two downstream stations (i.e., SQN transition and forebay) both averaged 44 "Good" (73 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, 2004 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 ten 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. The upstream and downstream comparisons produced benthic index scores of 29 (Good) and 35 (Excellent), respectively, indicative of a BIP (Table 8). 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 2004. 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. Historical data indicate that SFI scores typically vary among 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 SFI 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 creel surveys.

Spring Sport Fish Survey

A total of 18 hours of electrofishing resulted in 736 black bass collected; of these, 60.2% were harvestable size (10" or greater). Of the total black bass collected, 579 were largemouth, 120 were spotted and 37 were smallmouth bass. Overall catch rate (40.9 fish/hr.) was less than the 2003 survey (62.0/hour) (Table 12). The average weight of harvestable sized black bass was 1.3

pounds. The largest black bass collected was a 6.6 pound largemouth bass taken from Skull Island. Numbers of lunker bass were well represented with a total of 21 bass greater than three pounds, 13 greater than four pounds and 6 over five pounds. In 2003, 23 bass over four pounds were collected and eight of them were five pounds plus.

Length frequency histograms illustrated a bimodal distribution with the dominant size classes being the 10-11 inch and 13-14 inch groups (Figure 4). Good representation of the memorable category sized fish was also evident.

Habitat type is a critical component that has been incorporated into the spring sportfish survey. This metric is derived from the SAHI developed by Resource Stewardship Group. The resultant habitat designations (good, fair and poor) are correlated to black bass abundance (numbers/hour). A positive correlation of habitat type-to-black bass abundance was evident on Chickamauga Reservoir during the 2004 survey. Among the three areas sampled, the correlations at Skull Island were positive but Sale Creek and Harrison Bay showed some variability among habitat types, i.e., the catch rates (abundance) did not align with the habitat designation types (Tables 13). Overall catch rates for the reservoir were 49, 41 and 34 at the good, fair and poor habitats, respectively (Table 14).

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. The RSD value (15) fell within the desirable range (10-25) (Figure 5). The 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. The PSD value (53) was also within the preferred range (40-70) (Figure 6). 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. 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 available forage for all size classes of black bass.

A total of 106 crappie (88 black and 18 white crappie) was 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, 2004.

		Forebay TRM 472.3		Transition TRM 482.0 *Downstream Station*	
Metric		**Obs**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of species		25	3	27	3
2. Number of centrachid species		7	5	6	5
3. Number of benthic invertivores		3	1	3	1
4. Number of intolerant species		5	5	5	5
5. Percent tolerant species	electrofishing	37.2	1.5	58.8	1.5
	gill netting	30.6	0.5	45.9	0.5
6. Percent dominance by one species	electrofishing	33.8	1.5	30.4	1.5
	gill netting	27.8	1.5	29.6	0.5
7. Number non-native species	electrofishing	0.4	2.5	0.9	2.5
	gill netting	0	2.5	0.6	2.5
8. Number of top carnivore species		8	5	9	5
B. Trophic composition					
9. Percent top carnivores	electrofishing	10.9	2.5	9.6	1.5
	gill netting	48.9	1.5	39.6	1.5
10. Percent omnivores	electrofishing	9.5	2.5	19.4	2.5
	gill netting	42.8	0.5	48.4	0.5
C. Fish abundance and health					
11. Average number per run	electrofishing	51.3	0.5	60.8	0.5
	gill netting	18.0	1.5	15.9	1.5
12. Percent anomalies	electrofishing	1.0	2.5	1.5	2.5
	gill netting	0	2.5	0	2.5
RFAI			**43 Good**		**41 Good**

Table 2. Scoring Results for the Twelve Metrics and Overall Reservoir Fish Assemblage Index for Chickamauga Reservoir at the Upstream Sampling Station, 2004.

		Transition TRM 490.5 *Upstream Station*		Inflow TRM 529.0	
Metric		**Obs**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of species		32	5	29	5
2. Number of centrachid species		8	5	7	5
3. Number of benthic invertivores		4	3	4	3
4. Number of intolerant species		5	5	4	3
5. Percent tolerant species	electrofishing	55.1	1.5	64.8	1.0
	gill netting	22.9	1.5	0	0
6. Percent dominance by one species	electrofishing	29.6	1.5	50.0	1
	gill netting	20.7	1.5	0.0	0
7. Number non-native species	electrofishing	0.8	2.5	0.5	5
	gill netting	0.5	2.5	0	0
8. Number of top carnivore species		11	5	10	5
B. Trophic composition					
9. Percent top carnivores	electrofishing	19.9	2.5	16.9	3
	gill netting	50.5	1.5	0	0
10. Percent omnivores	electrofishing	15.0	2.5	51.2	3
	gill netting	33.0	1.5	0	0
C. Fish abundance and health					
11. Average number per run	electrofishing	49.3	0.5	99.9	3
	gill netting	18.8	1.5	0	0
12. Percent anomalies	electrofishing	1.2	2.5	1.3	5
	gill netting	0.5	2.5	0	0
RFAI			**49 Good**		**42 Good**

Table 3. Recent (1993-2004) 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	2004	1993-2004 Average
Upstream	Chickamauga	TRM 490.5	49	40	46	39	45	44 (Good)	46	45	51	42	49	45 (Good)
Sequoyah Transition	Chickamauga	TRM 482.0					41	41 (Good)	48	46	43	45	41	44 (Good)
Forebay	Chickamauga	TRM 472.3	44	44	47	39	45	44 (Good)	45	48	46	43	43	44 (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, 2004 (Electrofishing Effort = 300 Meters of Shoreline and Gill Netting Effort = 10 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	-	-	-	0.53	2.68	-
Skipjack herring	-	-	3.30	-	-	1.50
Gizzard shad	3.13	16.73	5.00	9.80	49.16	4.70
Threadfin shad	3.40	18.15	-	1.07	5.35	-
Common carp	0.20	1.07	-	0.53	2.68	-
Golden shiner	0.80	4.27	0.10	0.20	1.00	1.50
Emerald shiner	17.33	92.53	-	12.20	61.20	-
Spotfin shiner	0.20	1.07	-	0.07	0.33	-
Bluntnose minnow	-	-	-	0.20	1.00	-
Smallmouth buffalo	-	-	-	0.07	0.33	-
Spotted sucker	0.40	2.14	0.20	0.40	2.01	0.10
Blue catfish	-	-	1.40	-	-	0.80
Channel catfish	0.73	3.91	1.20	1.00	5.02	0.70
Flathead catfish	0.40	2.14	0.50	-	-	0.20
White bass	0.07	0.36	0.10	-	-	-
Yellow bass	-	-	2.80	-	-	1.70
Striped bass	-	-	-	-	-	0.10
Warmouth	0.33	1.78	-	-	-	-
Redbreast sunfish	4.53	24.20	-	3.73	18.73	-
Green sunfish	0.33	1.78	-			
Bluegill	7.47	39.86	0.20	18.47	92.64	0.50
Longear sunfish	0.27	1.42	-	0.47	2.34	-
Redear sunfish	2.13	11.39	0.40	5.07	25.42	0.80
Smallmouth bass	0.33	1.78	-	0.33	1.67	-
Spotted bass	2.07	11.03	0.50	1.93	9.70	1.80
Largemouth bass	2.40	12.81	0.20	2.73	13.71	0.40
White crappie	-	-	-	-	-	0.20
Black crappie	0.33	1.78	1.40	0.33	1.67	0.40
Logperch	0.40	2.14	-	0.07	0.33	-
Freshwater drum	1.27	6.76	0.70	0.87	4.35	0.50
Brook silverside	2.73	14.59	-	0.67	3.34	-
Chestnut lamprey	-	-	-	0.07	0.33	-
Total	**51.25**	**273.69**	**18.00**	**60.81**	**304.99**	**15.9**
Number Samples	**15**		**10**	**15**		**10**
Number Collected	**769**		**180**	**912**		**159**
Species Collected	**26**		**15**	**23**		**16**

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, 2004 (Electrofishing Effort = 300 Meters of Shoreline and 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	-	-	0.10	1.20	6.21
Spotted gar	0.53	2.73	-	0.07	0.34
Skipjack herring	-	-	2.80	-	-
Gizzard shad	5.73	29.35	3.90	50.00	258.62
Threadfin shad	0.33	1.71	-	13.07	67.59
Largescale stoneroller	-	-	-	0.07	0.34
Common carp	0.27	1.37	-	0.40	2.07
Golden shiner	0.40	2.05	0.10	0.07	0.34
Emerald shiner	4.13	21.16	-	0.60	3.10
Spotfin shiner	0.13	0.68	-	0.73	3.79
Bluntnose minnow	0.33	1.71	-	0.07	0.34
Smallmouth buffalo	-	-	-	0.07	0.34
Spotted sucker	0.20	1.02	0.20	0.27	1.38
Golden redhorse	0.07	0.34	0.10	0.13	0.69
Blue catfish	-	-	1.50	-	-
Channel catfish	0.67	3.41	0.70	0.60	3.10
Flathead catfish	0.40	2.05	0.40	0.60	3.10
White bass	-	-	-	2.13	11.03
Yellow bass	0.07	0.34	3.10	1.73	8.97
Warmouth	0.53	2.73	0.20	-	-
Striped bass	-	-	0.10	-	-
Redbreast sunfish	2.87	14.68	-	1.27	6.55
Green sunfish	0.07	0.34	-	0.33	1.72
Bluegill	14.60	74.74	0.20	5.93	30.69
Longear sunfish	0.87	4.44	-	2.13	11.03
Redear sunfish	5.07	25.94	1.90	4.27	22.07
Hybrid sunfish	-	-	-	0.07	0.34
Smallmouth bass	1.20	6.14	-	1.67	8.62
Spotted bass	3.27	16.72	1.80	3.27	16.90
Largemouth bass	2.67	13.65	-	4.33	22.41
White crappie	0.13	0.68	-	0.40	2.07

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
Black crappie	1.53	7.85	1.00	1.53	7.93
Yellow perch	0.13	0.68	-	0.07	0.34
Logperch	0.20	1.02	-	1.20	6.21
Sauger	-	-	0.20	-	-
Freshwater drum	1.27	6.48	0.50	1.13	5.86
Brook silverside	0.87	4.44	-	0.53	2.76
Inland silverside	0.67	3.41	-	-	-
Chestnut lamprey	0.13	0.68	-	-	-
Total	**49.34**	**252.54**	**18.80**	**99.94**	**516.85**
Number Samples	**15**		**10**	**15**	
Number Collected	**740**		**188**	**1,499**	
Species Collected	**30**		**18**	**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 2004.

	TRM 490.5 Upstream		TRM 482 Downstream	
Metric	**Obs**	**Rating**	**Obs**	**Rating**
1. Average number of taxa	7.4	5	7.2	5
2. Proportion of samples with long-lived organisms	90%	3	90%	5
3. Average number of EPT taxa	1.3	3	1.4	5
4. Average proportion of oligochaete individuals	7%	5	13.7%	5
5. Average proportion of total abundance comprised by the two most abundant taxa	70.9%	5	64.9%	5
6. Average density excluding chironomids and oligochaetes	480	3	505	5
Zero-samples - proportion of samples containing no organisms	0	5	0	5
Benthic Index Score		**29 Good**		**35 Excellent**

*Scored with transition 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 and Downstream Stations near Sequoyah Nuclear Plant, Chickamauga Reservoir, November 2004.

Chickamauga Reservoir	TRM 490.5 Upstream	
Species	Mean Density	Occurrence per site
Annelida		
Oligocheata		
Tubificidae	45	6
Branchiura sowerbyi	13	1
Limnodrilus hoffmeisteri	17	5
Hirudinea		
Rhynchobdellida		
Glossiphoniidae		
Helobdella stagnalis	22	6
Insecta		
Ephemeroptera		
Ephemeridae		
Hexagenia limbata <10mm	45	5
Hexagenia limbata >10mm	23	5
Trichoptera		
Polycentropodidae		
Cyrnellus fraternus	2	1
Cernotina sp.	3	1
Leptoceridae		
Oecetis sp.	2	1
Diptera		
Chironomidae		
Ablabesmyia annulata	7	4
Chironomus sp.	38	5
Coelotanypus sp.	305	10
Mollusca		
Gastropoda		
Lymnophila		
Planorbidae		
Gyralus parvus	2	1
Mesogastropoda		
Pleuroceridae		
Pleurocera canaliculata	2	1
Viviparidae		
Campeloma decisum	2	1
Viviparus Georgianus	75	9

Table 7. (Continued)

Chickamauga Reservoir	TRM 490.5 Upstream	
Species	Mean Density	Occurrence per site
Bivalvia		
Veneroida		
Corbiculidae		
Corbicula fluminea <10mm	20	3
Corbicula fluminea >10mm	103	9
Dreissenidae		
Dreissena polymorpha	7	1
Sphaeriidae		
Musculium transversum	172	10
Number of samples	10	
Sum	903	
Number of taxa	17	
Number of EPT taxa	4	
Sum of area sampled	0.60	

Chickamauga Reservoir	TRM 482 Downstream	
Species	Mean Density	Occurrence per site
Annelida		
Oligocheata		
Naididae	2	1
Tubificidae	110	5
Branchiura sowerbyi	8	4
Limnodrilus hoffmeisteri	23	2
Hirudinea	7	3
Rhynchobdellida		
Glossiphoniidae		
Helobdella stagnalis	7	3
Pharyngobdellida		
Erpobdellidae	3	2
Crustacea		
Amphipoda		
Gammaridae		
Gammarus sp.	5	3

Table 7. (Continued)

Chickamauga Reservoir	TRM 482 Downstream	
Species	Mean Density	Occurrence per site
Insecta		
Ephemeroptera		
Ephemeridae		
Hexagenia limbata <10mm	25	4
Hexagenia limbata >10mm	37	4
Trichoptera		
Polycentropodidae	2	1
Cyrnellus fraternus	13	5
Diptera		
Chironomidae		
Ablabesmyia annulata	12	3
Axarus sp.	2	1
Coelotanypus sp.	87	8
Mollusca		
Gastropoda		
Mesogastropoda		
Viviparidae		
Viviparus georgianus	13	2
Viviparus sp.	92	6
Bivalvia		
Veneroida		
Corbiculidae		
Corbicula fluminea <10mm	77	4
Corbicula fluminea >10mm	100	9
Sphaeriidae	13	1
Musculium transversum	105	9
Number of samples	10	
Sum	742	
Number of taxa	14	
Number of EPT taxa	2	
Sum of area sampled	0.60	

Table 8. Recent (1994-2004) 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.

Site	Reservoir	Location	1994	1995	1997	1999	2000	2001	2002	2003	2004	Average
Upstream	Chickamauga	TRM 490.5	33	29	31	31	23	25	23	31	29	**28**
Downstream	Chickamauga	TRM 482					23	31	27	29	35	**29**
Downstream	Chickamauga	TRM 472.3	31	27	29	25	27	27	23	27	27	**27**

Note: No data were collected for 1996 and 1998.
Scores that are considered very poor range from 7-12, poor range from 13-18, fair range from 19-23, good range from 23-29 and excellent range from 30-35.

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	27
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, 1995-2004.

Year	EF Catch Rate (no./hr.)	Mean Weight (lbs.)	% Harvestable	Bass >4 lbs.	Bass >5 lbs.	Largest bass (lbs.)
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

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

	Habitat Designation		
Reservoir and Site	**Good**	**Fair**	**Poor**
Chickamauga			
Harrison Bay	62(4)	30(4)	47(4)
Sale Creek	35(4)	58(4)	30(4)
Skull Island	50(2)	37(8)	17(2)
Watts Bar			
Blue Springs	57(3)	42(4)	42(5)
Caney Creek	61(4)	56(4)	59(4)
Kingston	70(4)	31(3)	28(5)
Watts Bar Dam	87(3)	51(6)	54(3)

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	49	41	34
Watts Bar	68	47	44
Wheeler	99	75	43

Catch per hour = number of fish collected per hour

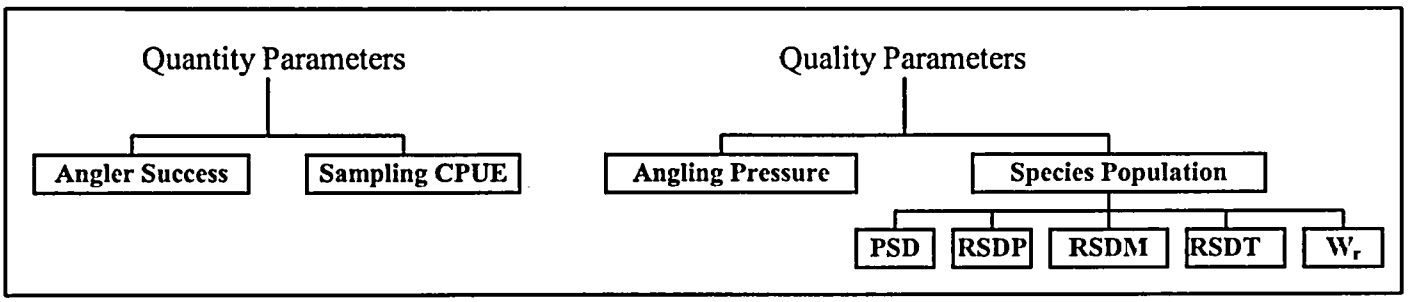

Figure 1. Parameters used to calculate the Sport Fishing Index (SFI).

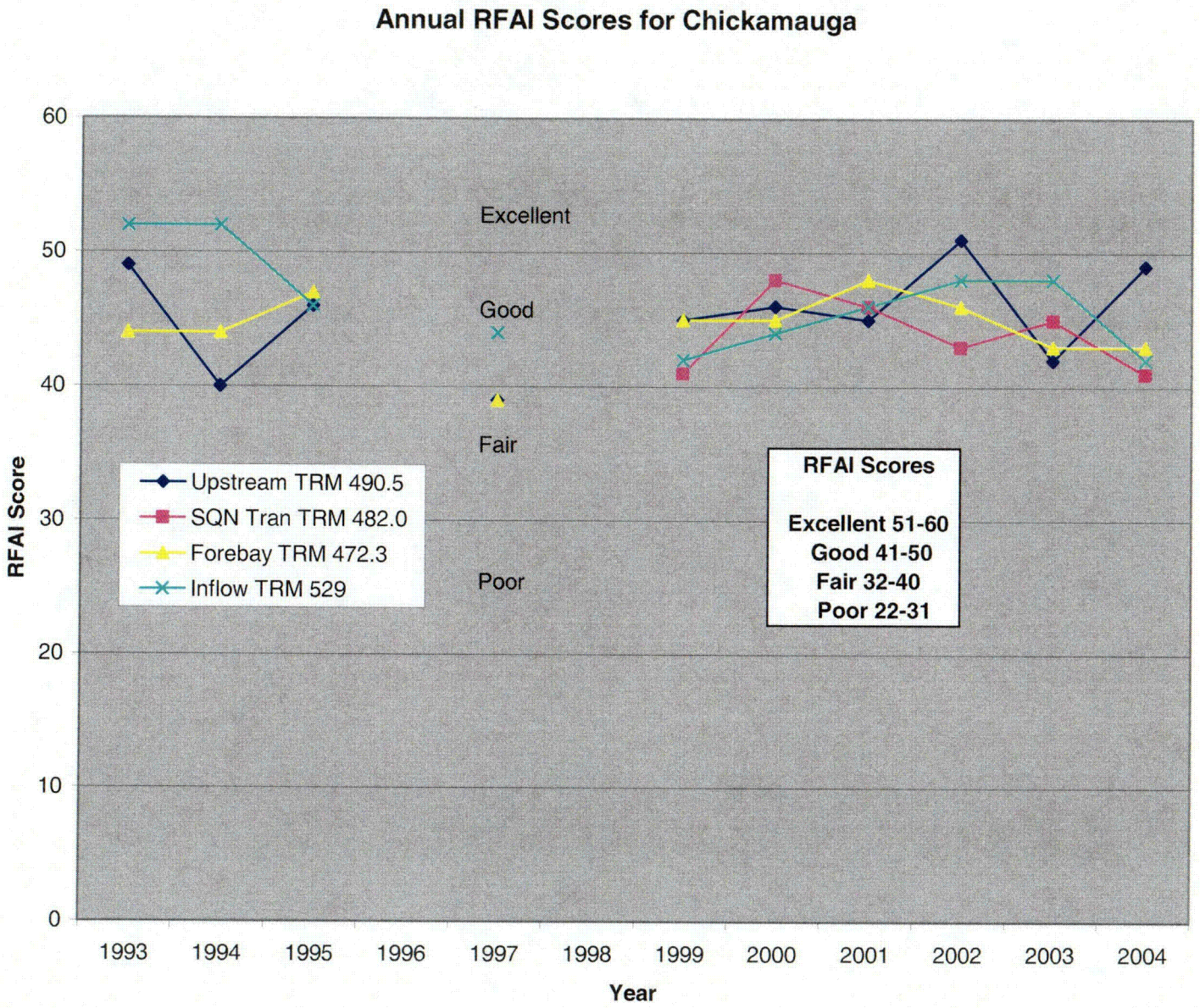

Figure 2. RFAI scores from sample years between 1993 and 2004.

C01

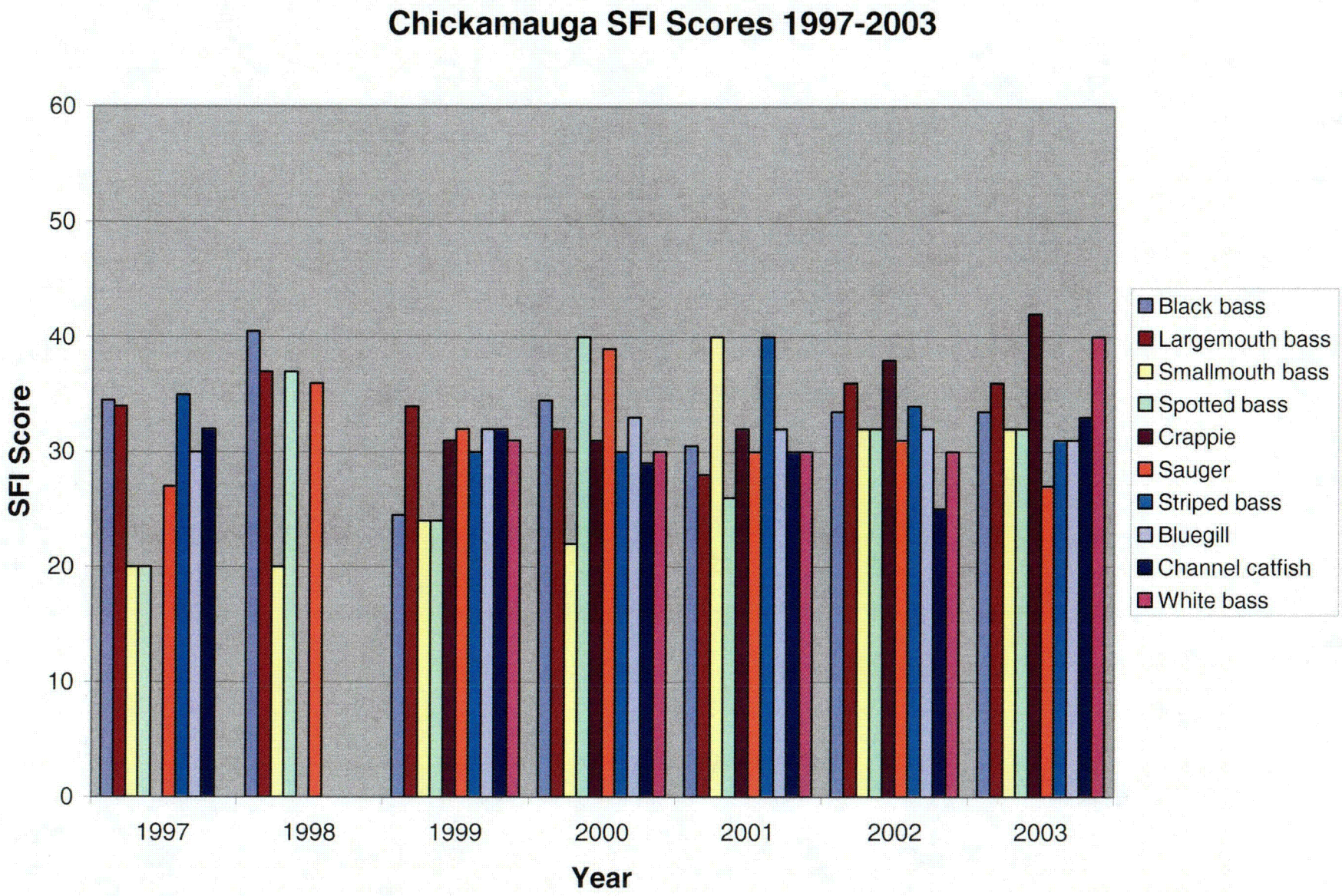

Figure 3. Sport Fishing Index results for Chickamauga Reservoir between 1997 and 2003.

C02

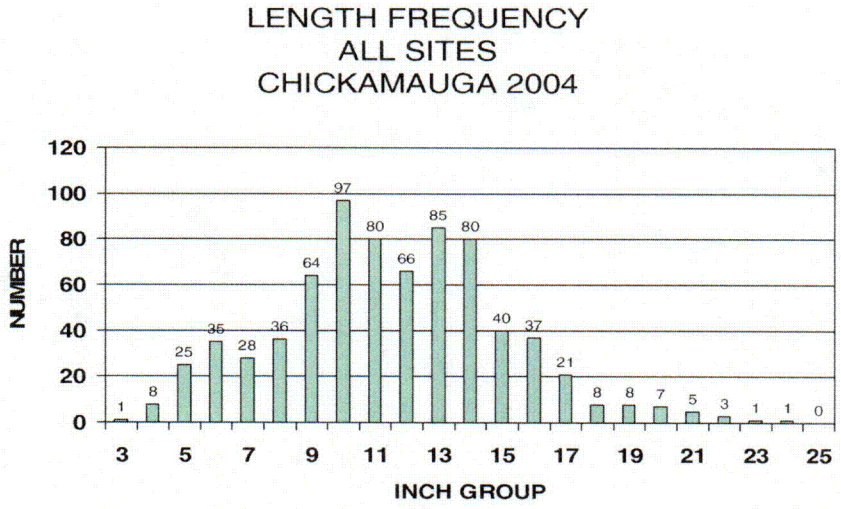

Figure 4. Chickamauga Reservoir length frequency histogram, (all sites) spring 2004.

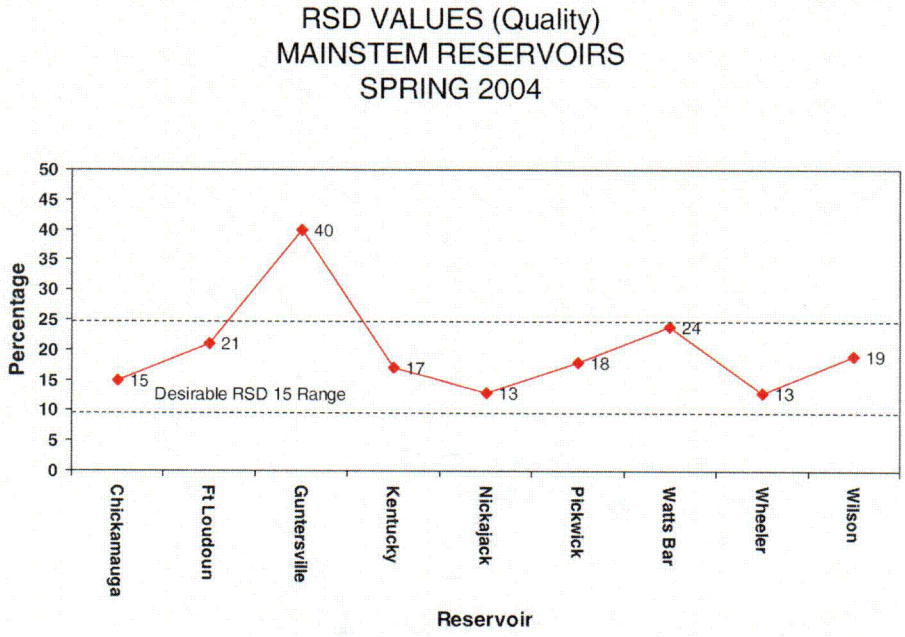

Figure 5. Relative stock density values for Tennessee River Reservoirs.

C03

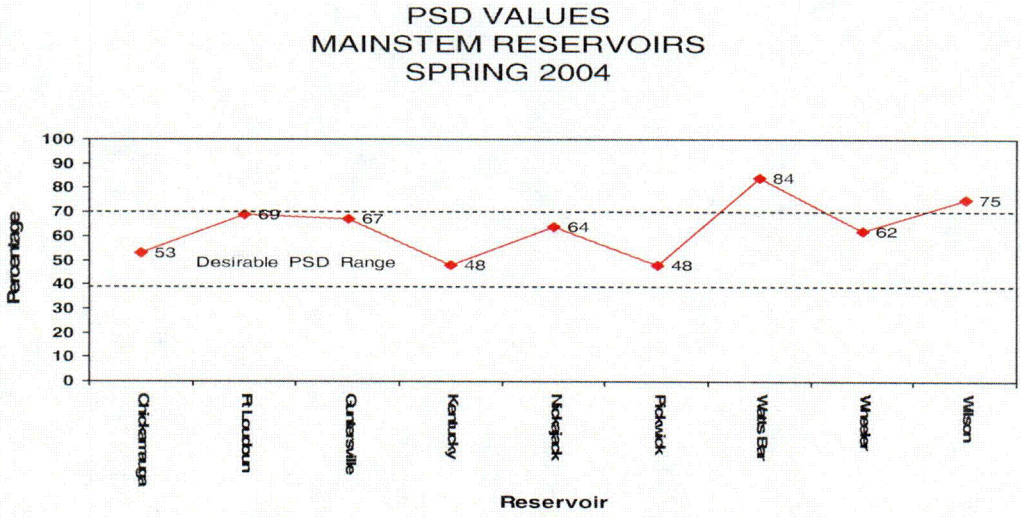

Figure 6. Proportional stock density values for Tennessee River Reservoirs.

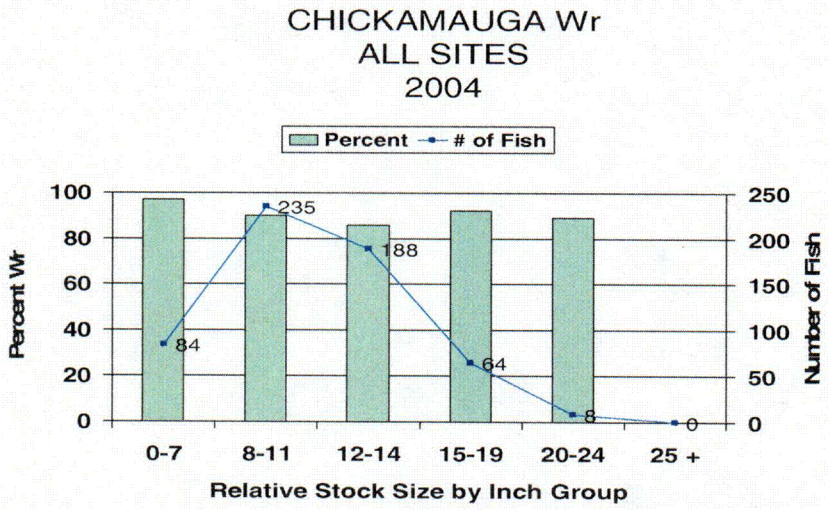

Figure 7. Chickamauga Reservoir mean relative weights (Wr) for largemouth bass broken out by RSD category and fish numbers.

C04