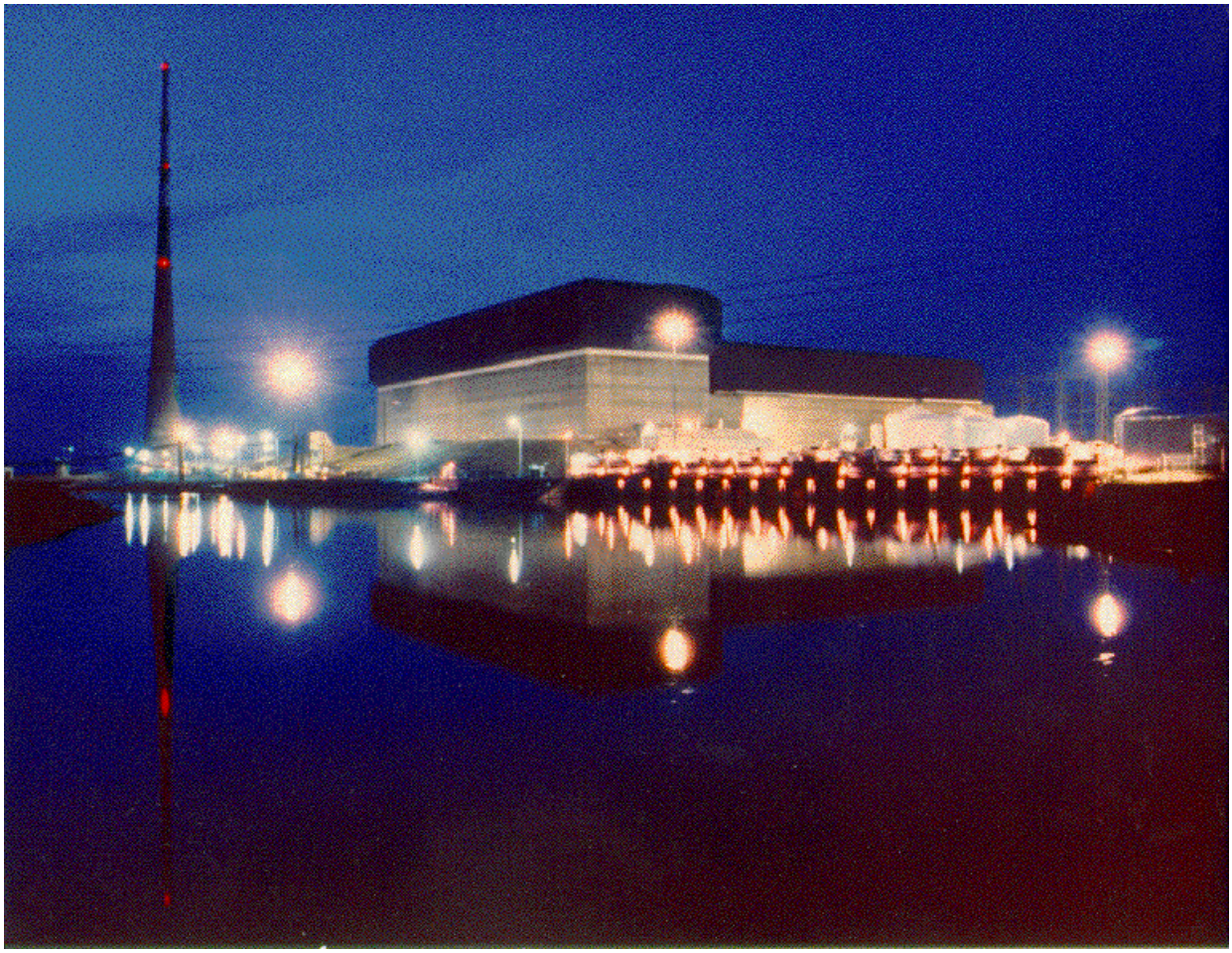
Biological Monitoring of the Tennessee River Near Browns Ferry Nuclear Plant Discharge 2002



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Acronyms

ADEM	Alabama Department of Environmental Management
BIP	Balanced Indigenous Populations
BFN	Browns Ferry Nuclear Plant
ERM	Elk River Mile
NPDES	National Pollutant Discharge Elimination System
PSD	Proportional Stock Density
QA	Quality Assurance
RFAI	Reservoir Fish Assemblage Index
RSDM	Relative Stock Density of Memorable-sized
RSDP	Relative Stock Density of Preferred-sized
RSDT	Relative Stock Density of Trophy-sized
SFI	Sport Fishing Index
TRM	Tennessee River Mile
TVA	Tennessee Valley Authority
USFWS	U.S. Fish and Wildlife Service
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 discharges. As required by the National Pollutant Discharge Elimination System (NPDES) permit (permit number AL0022080), Browns Ferry Nuclear Plant (BFN) is to provide "necessary technical data and relevant information to include supplemental data collected within the life of the permit to support the existing variance." In response to this requirement, and after discussions with Alabama Department of Environmental Management (ADEM) and the U.S. Fish and Wildlife Service (USFWS), the Tennessee Valley Authority (TVA) proposed use of its Vital Signs (VS) monitoring program, fish and benthic macroinvertebrate community data and analyses in its 1999 NPDES permit application. This method provides both a cost-effective and thorough means by which to evaluate aquatic communities in Wheeler Reservoir upstream and downstream of BFN discharge through the current permit cycle. Based on the findings from this study from 1992 when it was initiated (Dycus and Meinert 1993) until present, it can be concluded that the operations of BFN under the current thermal limitations has not had a significant impact on aquatic communities of Wheeler Reservoir. The purpose of this document is to briefly summarize and provide ADEM the results of the Calendar Year 2002 monitoring and comparisons between current and historical monitoring data.

Prior to 1990, TVA reservoir studies 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 in order to better represent ecological conditions. The outcome of this effort was development of multi-metric evaluation techniques for the fish assemblage, the Reservoir Fish Assemblage Index (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 2002 will be utilized.

The Sport Fishing Index (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.

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 Wheeler Reservoir inflow zone is located at Tennessee River Mile (TRM) 347; the transition zone is located at TRM 295.0, and the forebay zone is located at TRM 277. As a result of the discussions with ADEM and the USFWS beginning in the year 2000, an additional BFN transition station (TRM 292.5) was added downstream of the BFN discharge (TRM 294.0) to more closely monitor Wheeler Reservoir aquatic communities in close proximity to the BFN thermal effluent. For the 2000, 2001, and 2002 sample seasons, this VS station will be used for downstream comparisons of aquatic communities. The VS forebay zone (TRM 277) will be used to provide downstream data for the studies performed between 1993 and 1999. The VS transition zone (TRM 295.9) will be used for the upstream control station for comparison of all data.

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 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 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 the 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 BFN 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 station comparisons can be used to identify if BFN 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 BFN 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 these 54 paired sample sets collected over a seven year period range 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.

As mentioned in the introduction, modifications to the metrics used in RFAI are continually being evaluated in order to make the index better reflect reservoir conditions. For the 2002 sampling season, some RFAI metrics were changed. In addition, several years of RFAI and water quality data have revealed that largemouth bass, in the Tennessee Valley, are actually quite tolerant of poor water quality. The species has shown a tolerance for low dissolved oxygen, warm water temperatures, and highly eutrophic conditions. Therefore, its water quality tolerance rating has been changed to "Tolerant." Previous years' scores have been adjusted in this report to reflect these changes so as not to affect year-to-year comparisons and averages. Comparisons will be made between present and improved RFAI scores. Future versions of the RFAI will likely include more iterations as this analysis technique is continually fine tuned.

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 scored compared to reference conditions developed for VS inflow sample sites. Metric ratings were summed to produce a benthic score for each sample site. 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 BFN's thermal discharge is having no effect on the Wheeler 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 range 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. 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 such 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.

Prior to 2001, a sampling site in the forebay zone of Wheeler Reservoir (TRM 277) was used as the downstream comparison site. Other factors unrelated to influence from BFN have kept benthic communities depressed, both at the forebay site and in the Elk River embayment (Wheeler Reservoir, Elk River Mile [ERM] 6 – between BFN and the forebay site). In order to more accurately assess the effects from BFN, a second transition zone site two miles downstream from the BFN diffuser at TRM 291.7 was sampled in 2001. Benthic scores and community composition from this site are used for downstream comparisons.

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 the Valley natural resource agencies. Therefore, Wheeler Reservoir fish species scores will be compared to previous years.

Results and Discussion

Fish Community

In the autumn of 2002, both the upstream and downstream stations at BFN rated "Good" (Table 1). As indicated in Table 1, the RFAI scores for upstream and downstream stations, 45 and 43 respectively, were within the 6 point acceptable variation during autumn 2002 and are therefore considered similar in terms of demonstrating a BIP. Resident fish communities at the upstream location reached 75 percent of their potential and communities at the lower station reached 71.7 percent of their potential. Electrofishing and gill netting catch rates for individual species from both stations are listed in Table 2. VS monitoring data and TVA's Regional Natural Heritage Program's most recent database indicate no state- or federal-protected fish species were collected, or are currently known to occur in the vicinity of BFN.

RFAI scores obtained from VS monitoring stations located upstream and downstream of the BFN discharge over the past several years have revealed consistent historical fish community results. Regardless of analysis methodology or which downstream station was used, the upstream station rating remained in the "Fair" range, on average, and the downstream continued in the "Good" range, on average (Tables 3a and 3b). For sample years 1993 to 2002, the average RFAI score for these stations, using the original RFAI metrics, was 39 and 44 or 65.0 percent and 73.3 percent of the maximum score, respectively, as indicated in Table 3a. Using the new RFAI methodology, the scores were 39 and 46 or 65.0 percent and 77.0 percent respectively (Table 3b). Between 1993 and 1999, the Wheeler Reservoir VS monitoring forebay station located downstream of the BFN discharge had generally higher RFAI scores than the upstream transition station; the only exception was in 1994 when the upstream station scored two points higher using the old methodology and one point higher using the new methodology (Tables 3a and 3b and Figure 2). As mentioned earlier, a difference of 6 points or less between upstream and downstream stations can be used to define "similar" conditions between the two communities. Five of the last eight sampling seasons have had "similar" conditions between the upstream and downstream stations using the new RFAI methodology (Table 3b). Since the data does not indicate any clear trends, the dissimilar years are most likely an indication of variables other that BFN discharge (e.g., meteorology and reduced flow through the reservoir) influencing the fish assemblage in Wheeler Reservoir. All three sampling stations (one upstream and two

downstream of the discharge) scored "Good" for the 2002 sampling season further supporting the hypothesis that BFN thermal discharge is not adversely affecting the Wheeler Reservoir fish community (Figure 2).

Benthic Macroinvertebrate Community

Table 4 provides results and ratings for each metric as well as the overall benthic index score for both monitoring sites. Table 5 summarizes density by taxon at both collection sites. In 2002 samples, the upstream site (TRM 295.9) had a benthic index score of 29 ("Good") and the downstream site (TRM 291.7) scored 23 ("Fair"). Since the 2002 scores for these stations have a difference greater than 4 points, further investigation may be warranted in the future, if the trend continues, to determine if method variation can account for the change or if it is water quality related.

Table 6 provides benthic index scores from VS monitoring at the inflow, transition, and forebay zone sites from 1994 to 2002. The forebay zone sample site is of sufficient distance downstream (17 miles) that results would not be expected to reflect plant effects. Here again, the benthic community's overall score dropped. The 2001 score was 17 ("Poor") and the 2002 score was 13 ("Poor"). Although this difference is not greater than four points, it does indicate that factors other than BFN thermal discharge are most likely influencing the benthic community.

Results from VS monitoring in the Elk River embayment (ERM 6) are included in this assessment on a bi-annual basis to illustrate other problems with benthic community scores in the forebay portion of Wheeler Reservoir, that are not likely a result of operations at BFN. However, the 2002 sampling season was an off-year for sampling this station, so there will be no discussion of this embayment in this report.

Sport Fishing Index

In the autumn of 2002, Wheeler Reservoir's black bass, largemouth, smallmouth, and spotted bass received lower SFI scores than they did in 2001 but not the lowest scores recorded for them (Table 7 and Figure 3). Here again, this is only one year's dataset and not indicative of a trend. Therefore, if future scores would continue to decline, further investigation would be warranted. Sauger, bluegill, and channel catfish fisheries received either their highest SFI scores to date or matched their highest scores in 2002; striped bass were not collected in sufficient numbers to analyze (Table 7 and Figure 3). Tables 8 and 9 illustrate sport fish index scoring criteria for population metrics and creel quantity and quality.

Sauger population estimates based on rotenone data have increased annually since 1988 in Wheeler Reservoir. The 1994 sauger population estimate (38 fish/ha) and the estimated number of young-of-year (35 fish/ha) were the second highest reported for each category during the 1969-1997 time period. In 1997, the last year rotenone data was available, Wheeler Reservoir sauger population averaged 5.6 fish/ha (Baxter and Buchanan 1998).

Hickman et al., (1990) noted that sauger populations across the Tennessee Valley declined during the mid- to late-1980's due to a prolonged drought. The Tennessee Valley is currently in another drought cycle and populations may decline further. Maceina et al., (1998) described population characteristics and exploitation rates of sauger during 1993-1995 in the tailraces of Guntersville, Wheeler and Wilson

Dams. Maceina reported that total annual mortality between age-1 and age-2 fish was high (64 percent-83 percent) and that saugers were harvested at high rates before reaching their full growth potential.

Both 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.

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Table 1. Scoring Results for the Twelve Metrics and Overall Reservoir Fish Assemblage Index for Wheeler Reservoir Near Browns Ferry Nuclear Plant 2002.

		Transition Upstream TRM 295.9		Transition Downstream TRM 292.5	
Metric		**Obs**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of species		**27**	**3**	**26**	**3**
2. Number of centrarchid species		**4**	**5**	**4**	**5**
3. Number of benthic invertivores		**4**	**3**	**5**	**3**
4. Number of intolerant species		**6**	**5**	**5**	**5**
5. Percent tolerant individuals	Electro Fishing	**38.1**	**1.5**	**54.1**	**0.5**
	Gill Netting	**8.4**	**2.5**	**7.8**	**2.5**
6. Percent dominance by one species	Electro Fishing	**30.3**	**1.5**	**25.7**	**2.5**
	Gill Netting	**25.3**	**1.5**	**36.7**	**0.5**
7. Number non-native species	Electro Fishing	**0.5**	**2.5**	**0**	**2.5**
	Gill Netting	**7.2**	**0.5**	**5.6**	**0.5**
8. Number of top carnivore species		**8**	**5**	**8**	**5**
B. Trophic composition					
9. Percent top carnivores	Electro Fishing	**10.6**	**2.5**	**9.7**	**1.5**
	Gill Netting	**74.7**	**2.5**	**63.3**	**2.5**
10. Percent omnivores	Electro Fishing	**19.2**	**2.5**	**28.6**	**1.5**
	Gill Netting	**21.7**	**1.5**	**26.7**	**1.5**
C. Fish abundance and health					
11. Average number per run	Electro Fishing	**41.2**	**0.5**	**68.8**	**0.5**
	Gill Netting	**8.3**	**0.5**	**9.0**	**0.5**
12. Percent anomalies	Electro Fishing	**2.1**	**1.5**	**1.3**	**2.5**
	Gill Netting	**1.2**	**2.5**	**0**	**2.5**
RFAI			**45**		**43**
			Good		**Good**

Table 2. Species Listing and Catch Per Unit Effort at the Browns Ferry Nuclear Transition (Downstream) and Standard Transition (Upstream) Stations during Fall Electrofishing and Gill Netting Collections on Wheeler Reservoir 2002 (Electrofishing Effort = 300 Meters of Shoreline and Gill Netting Effort = Net-Nights).

	Transition 295.9			Forebay TRM 292.5			Transition TRM 292.5		
	Electrofishing Catch Rate		Gill Netting Catch Rate	Electrofishing Catch Rate		Gill Netting Catch Rate	Electrofishing Catch Rate		Gill Netting Catch Rate
Common Name	Per Run	Per Hour	Per Net Night	Per Run	Per Hour	Per Net Night	Per Run	Per Hour	Per Net Night
Bigmouth buffalo	0.07	0.41	-	-	-	-	-	-	-
Black buffalo	0.13	0.83	-	-	-	-	-	-	-
Black crappie	-	-	-	-	-	-	-	-	-
Black redhorse	0.2	1.24	-	0.13	0.79	-	0.4	2.42	-
Blue catfish	-	-	0.8	-	-	1.1	-	-	0.2
Bluegill	6.6	40.91	0.1	15.87	93.7	0.1	5.87	35.48	0.2
Bowfin	-	-	-	-	-	-	-	-	-
Bullhead minnow	0.13	0.83	-	-	-	-	-	-	-
Channel catfish	2.6	16.12	0.4	1.93	11.42	1.0	0.47	2.82	1.6
Chestnut lamprey	-	-	-	-	-	-	-	-	-
Common carp	0.13	0.83	-	-	-	-	-	-	-
Emerald shiner	0.13	0.83	-	0.2	1.18	-	-	-	-
Flathead catfish	-	-	0.2	0.07	0.39	0.2	0.27	1.61	1.1
Freshwater drum	0.2	1.24	0.2	0.47	2.76	0.5	1.0	6.05	0.9
Gizzard shad	3.73	23.14	0.6	17.67	104.33	0.2	25.33	153.23	1.4
Golden redhorse	-	-	-	-	-	-	0.13	0.81	0.2
Golden shiner	0.73	4.55	-	0.07	0.39	-	-	-	-
Green sunfish	0.13	0.83	-	0.13	0.79	-	0.2	1.21	-
Hybrid bass	-	-	-	0.07	0.39	-	-	-	-
Hybrid striped x white bass	-	-	0.5	-	-	-	-	-	0.1
Inland silverside	4.93	30.58	-	17.13	101.18	-	4.27	25.81	-
Largemouth bass	3.33	20.66	-	2.87	16.93	0.4	5.13	31.05	0.7
Logperch	-	-	-	0.6	3.54	-	-	-	-
Longear sunfish	0.27	1.65	-	3.2	18.9	-	1.47	8.87	-
Longnose gar	-	-	-	-	-	-	-	-	-
Northern hog sucker	0.07	0.41	-	-	-	-	-	-	-
Quillback	-	-	-	-	-	0.1	-	-	-
Redbreast sunfish	-	-	-						
Redear sunfish	1.87	11.57	-	1.07	6.3	0.3	1.0	6.05	0.3

Table 2. (Continued)

Common Name	Transition 295.9 Electrofishing Catch Rate Per Run	Transition 295.9 Electrofishing Catch Rate Per Hour	Transition 295.9 Gill Netting Catch Rate Per Net Night	Forebay TRM 292.5 Electrofishing Catch Rate Per Run	Forebay TRM 292.5 Electrofishing Catch Rate Per Hour	Forebay TRM 292.5 Gill Netting Catch Rate Per Net Night	Transition TRM 292.5 Electrofishing Catch Rate Per Run	Transition TRM 292.5 Electrofishing Catch Rate Per Hour	Transition TRM 292.5 Gill Netting Catch Rate Per Net Night
Rock bass	-	-	-						
Sauger	0.07	0.41	0.6	-	-	0.6	-	-	0.4
Silver redhorse	-	-	-	0.07	0.39	-	-	-	-
Skipjack herring	-	-	2.1	0.07	0.39	3.3	0.07	0.4	9.7
Smallmouth bass	0.07	0.41	-	2.6	15.35	-	1.47	8.87	0.1
Smallmouth buffalo	0.07	0.41	-	-	-	-	0.07	0.4	0.3
Spotfin shiner	-	-	-	0.6	3.54	-	-	-	-
Spotted bass	0.53	3.31	1.8	0.93	5.51	0.4	0.07	0.4	0.1
Spotted gar	-	-	-	-	-	-	0.07	0.4	-
Spotted sucker	0.73	4.55	-	0.13	0.79	-	0.27	1.61	0.3
Striped bass	0.07	0.41	0.1	-	-	0.5	-	-	-
Threadfin shad	11.67	72.31	-	2.87	16.93	-	2.2	13.31	-
White bass	-	-	0.5	-	-	0.2	0.07	0.4	0.2
White crappie	-	-	-	-	-	-	-	-	0.1
Yellow bass	-	-	0.4	0.07	0.39	0.1	0.13	0.81	2.4
Total	**38.46**	**238.44**	**8.3**	**68.82**	**406.28**	**9.0**	**49.96**	**302.01**	**20.3**
Number of samples	**15**		**10**	**15**		**10**	**15**		**10**
Number collected	**577**		**83**	**1032**		**90**	**749**		**203**
Species collected	**24**		**13**	**23**		**15**	**21**		**19**

Table 3a. Recent (1993-2001) RFAI Scores Developed Using the Original RFAI Metrics.

			Year								
Station	**Reservoir**	**Location**	**1993**	**1994**	**1995**	**1997**	**1999**	**1993-1999 Average**	**2000***	**2001**	**1993-2001 Average**
Upstream	Wheeler	TRM 295	47	43	37	38	30	39 (Fair)	38	37	39 (Fair)
Downstream	Wheeler	TRM 277	49	41	50	41	39	44 (Good)		46	44 (Good)
BFN Transition Downstream	Wheeler	TRM 292.5							43	43	43 (Good)

*****The 2000 sample year was not part of the VS monitoring program, however the same methodology was applied.

Table 3b. Recent (1993-2002) RFAI Scores Developed Using the New (2002) RFAI Metrics.

			Year									
Station	**Reservoir**	**Location**	**1993**	**1994**	**1995**	**1997**	**1999**	**1993-1999 Average**	**2000***	**2001**	**2002***	**1993-2002 Average**
Upstream	Wheeler	TRM 295	43	45	35	42	30	39 (Fair)	41	38	45	40 (Fair)
Downstream	Wheeler	TRM 277	52	44	49	44	42	46 (Good)		43	47	46 (Good)
BFN Transition Downstream	Wheeler	TRM 292.5							43	42	43	43 (Good)

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

Table 4. Individual Metric Ratings and the Overall Benthic Community Index Score for Upstream and Downstream Sites Near Browns Ferry Nuclear Plant, Wheeler Reservoir, November 2002.

	TRM 295.9 - Upstream		TRM 291.7- Downstream	
Metric	**Obs**	**Rating**	**Obs**	**Rating**
1. Average number of taxa	6.8	5	5.4	3
2. Proportion of samples with long-lived organisms	100%	5	100%	5
3. Average number of EPT taxa	1.1	3	0.9	3
4. Average proportion of oligochaete individuals	3.8%	5	10.9%	5
5. Average proportion of total abundance comprised by the two most abundant taxa	74.1%	5	88.2%	1
6. Average density excluding chironomids and oligochaetes	286.7	1	106.7	1
7. Zero-samples - proportion of samples containing no organisms	0	5	0	5
Benthic Index Score		**29 Good**		**23 Fair**

Scored with transition criteria

Table 5. Average Mean Density Per Square Meter of Benthic Taxa Collected at Upstream and Downstream Sites Near Browns Ferry Nuclear Plant, Wheeler Reservoir, November 2002.

Taxa	TRM 295.9 Upstream	TRM 291.7 Downstream
Annelida		
Oligocheata		
Lumbricidae	2	
Lumbriculidae	2	
Lumbriculus sp.	2	
Naididae	2	
Tubificidae	5	33
Branchiura sowerbyi	2	
Hirudinea	2	
Crustacea		
Amphipoda		
Corophiidae		
Corophium lacustre	58	
Gammaridae		
Gammarus sp.		2
Insecta		
Ephemeroptera		
Ephemeridae		
Hexagenia limbata <10mm	38	13
Hexagenia limbata >10mm	33	35
Heptageniidae		
Stenacron interpunctatum	2	
Trichoptera		
Leptoceridae		
Oecetis sp.		2
Polycentropodidae		
Cyrnellus fraternus	7	
Diptera		
Chironomidae		
Ablabesmyia annulata	3	17
Ablabesmyia mallochi	3	
Axarus sp.	18	
Chironomus sp.	13	58
Coelotanypus sp.	118	230
Coelotanypus tricolor	20	
Cryptochironomus sp.	2	
Mollusca		
Gastropoda		
Mesogastropoda		

Table 5. (Continued)

Taxa	TRM 295.9 Upstream	TRM 291.7 Downstream
Hydrobiidae		
Amnicola sp.	7	3
Birgella subglobosa		2
Pleuroceridae		
Pleurocera canaliculata	33	2
Viviparidae		
Campeloma decisum		2
Campeloma sp.	2	
Lioplax sulculosa	5	
Viviparus sp.	25	2
Bivalvia		
Veneroida		2
Corbiculidae		
Corbicula fluminea <10mm	32	7
Corbicula fluminea >10mm	7	23
Sphaeriidae		
Musculium transversum	32	13
Spaerium sp.		2
Number of Samples	**10**	**10**
Sum	**473**	**445**
Sum of area Sampled	**0.60**	**0.60**

Table 6. Recent (1994-2002) Benthic Index Scores Collected as Part of the Vital Signs Monitoring Program at Inflow, Transition (Upstream), and Forebay (Downstream) Sites.

			Year									
Site	**Reservoir**	**Location**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**Average**
Upstream	Wheeler	TRM 347	31	21		25		23		25	25	25 Good
Upstream	Wheeler	TRM 295.9	33	25		31			31	29	29	30 Excellent
Downstream	Wheeler	TRM 291.7								31	23	27 Good
(Tributary Embayment)	Wheeler	ERM 6	15	13		15		15		15		15 Poor
Downstream	Wheeler	TRM 277	19	15		23		19		17	13	18 Poor

*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 ranges from 30-35.

Table 7. Sport Fishing Index Results for Wheeler Reservoir, 2002

	Year						
Species	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**1997-2002 Average SFI Score**
Black bass	36	37	50	46	51	38	43
Largemouth bass	34	34	50	28	42	34	37
Smallmouth bass	44	28	52	44	40	36	41
Spotted bass	20	20	20	20	44	42	28
Sauger	36			20	26	42	31
Striped bass	20			20	24		21
Bluegill	20			24	26	26	24
Channel catfish	24			20	24	28	24

Table 8. Sport Fish 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 8. (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 9. Sport Fish 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

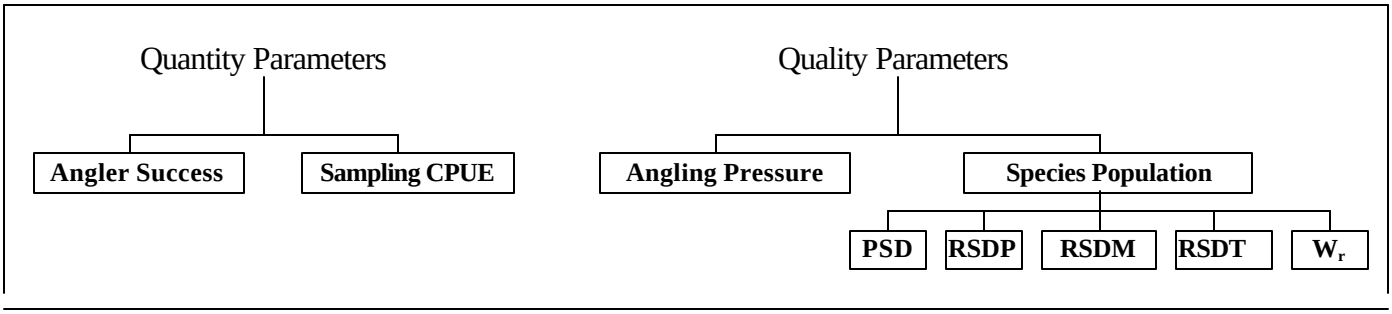

Figure 1. Parameters used to calculate the Sport Fishing Index (SFI).

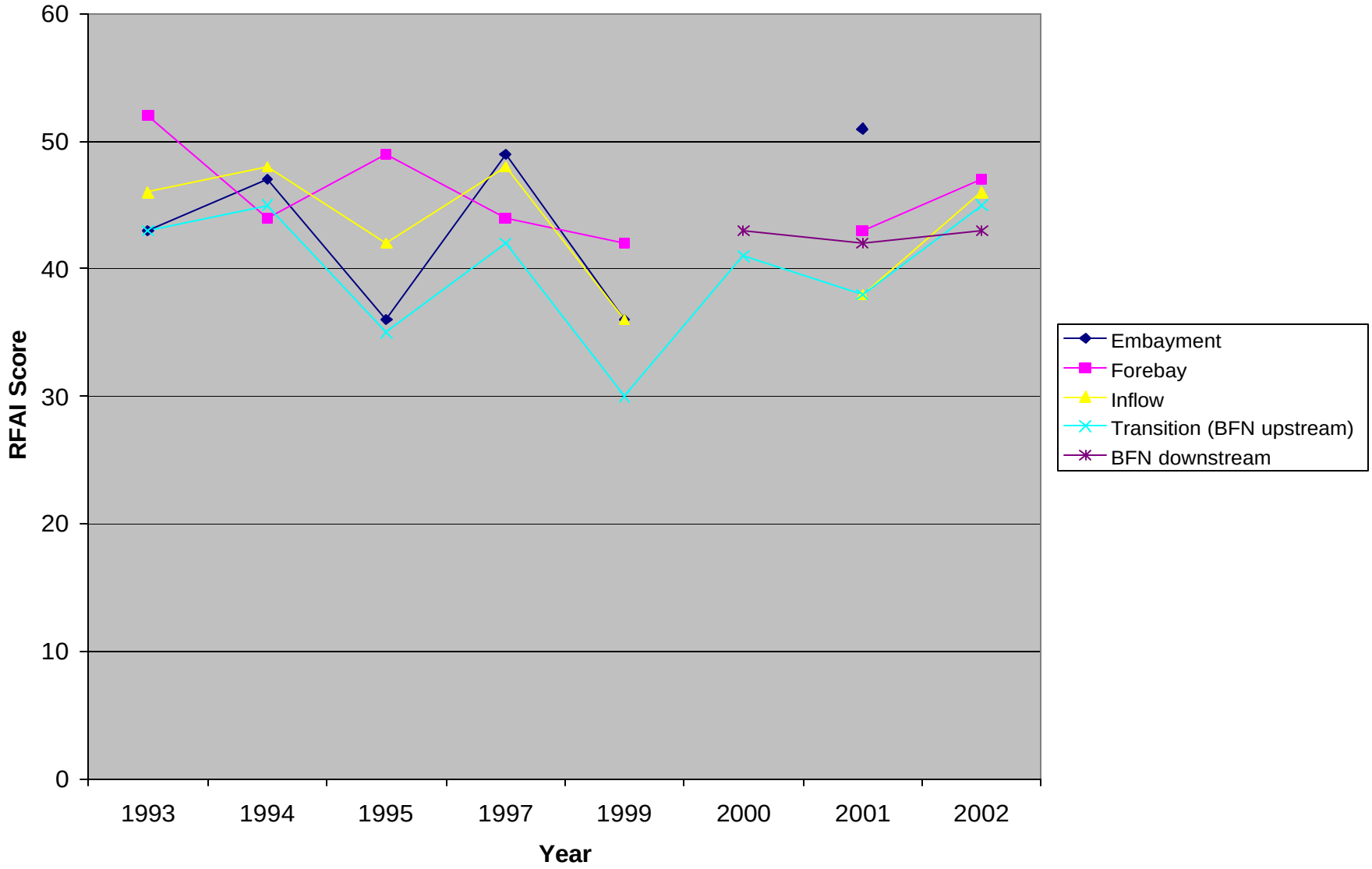

Figure 2. Annual RFAI scores between the years 1993 and 2002 using the new analysis methodology.

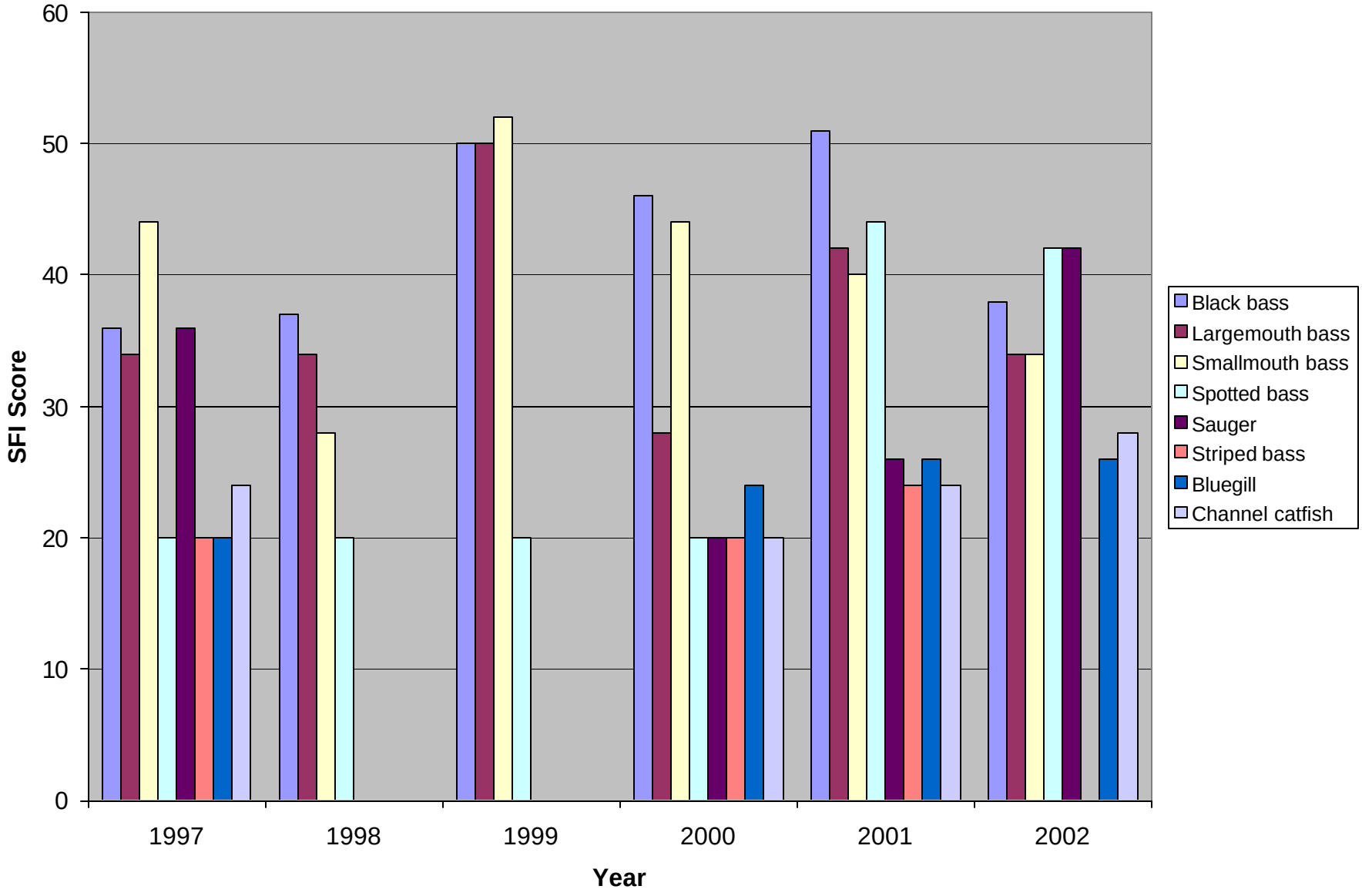

Figure 3. Sport Fishing Index results for Wheeler Reservoir between 1997 and 2002.