RESULTS OF THE 1996 NAWQA FISH COMMUNITY ASSESSMENT IN THE MISSISSIPPI EMBAYMENT STUDY UNIT

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INTRODUCTION

The U.S. Geological Survey (USGS) National Water-Quality Assessment (NAWQA) Program is designed to assess status and trends in the quality of the Nation's water resources. The Program will eventually integrate physical, chemical, and biological data from about 50 study units across the Nation. The goal of NAWQA is to determine factors that affect water quality and to measure the extent of the effects on both national and regional levels.

Biological assessments of fish, macroinvertebrate, and periphyton communities are planned at selected sites in each of the study units for a 2 or 3-year period. The purpose of this paper is to characterize fish communities assessed in the Mississippi Embayment study unit (MISE) for the first of three annual collections. In 1996, ecologists assessed fish communities from eight sites located on seven rivers in Arkansas, Louisiana, Mississippi, Missouri, and Tennessee; all of which lie partially within the MISE boundary (Figure 1). Two of the sites (the Bogue Phalia and the Cache River at Cotton Plant) had three reaches sampled to evaluate sampling consistency, and a total of 12 reaches were sampled. Five of the rivers and 10 of the reaches are located in the Mississippi Alluvial Plain Ecoregion. Of the remaining two streams, one is located in the Mississippi Valley Loess Plains Ecoregion and one is in the Southeastern Plains Ecoregion.

METHODS

Land use in the MISE study unit is predominantly row-crop agriculture. Potential sites were selected based on the presence or absence of the crop types thought to be dominant for the localized area. At each site, a visual assessment of fish habitats was made; a 500-m reach containing most of the habitats identified in the stream was measured and marked, and sampling was conducted throughout the reach.

Fish were collected by seining and electrofishing between May 14 and August 1, 1996. All work for each reach was completed within an 8-hour period.

Seining was completed at each reach prior to electrofishing. Seining effort was qualitative and consisted of sampling distinct, wadeable habitats with a 4 m X 2 m seine having a mesh size of 0.47 cm. The time spent seining and the number of seine hauls were recorded for each site. Time spent seining at the 12 reaches ranged from 30 to 60 minutes, and the number of seine hauls ranged from 3 to 10. Fish collected were placed in plastic buckets with native water. Immediately after the seining effort, specimens large enough to be identified to species were weighed, measured, examined for anomalies, and then released. Smaller fish were preserved in 10 percent formalin and then were returned to the lab for processing.

Electrofishing was done with a commercially manufactured electrofishing unit mounted on a 4.7 m X 1 m aluminum boat. The electrofishing unit consisted of a 2,500-watt generator and a pulsator. Two anodes were suspended from booms in front of the boat. An anode consisted of four 4.75 cm diameter stainless steel cables suspended from an umbrella array of 1 m diameter. Approximately 1 m of electrode cable was submerged during electrofishing, and the boat was used as the cathode. Output power ranged from 2,500 to 3,500 watts.

An electrofishing team consisted of the boat driver and a person positioned on the bow to net fish. For sites having recognizable fish habitat, the boat was maneuvered slowly along the bank until the electrodes were positioned near fish habitat. Electrofishing was initiated by engaging a foot switch which supplied power to the pulsator. A slightly different method was used in areas that lacked fish habitat or where fish habitat was not visible due to water turbidity. This alternate method involved maneuvering the boat slowly along the bank with the electrofishing gear constantly engaged. The time that the foot switch was engaged was recorded from a timer on the pulsator after each electrofishing pass, regardless of the method used. Electrofishing was standardized at 11 of the reaches by electrofishing both banks of the reach. At the Skuna River, one bank was completely dominated by shallow sandbar habitat and was not sampled because the draft of the electrofishing boat exceeded the depth of the water (<15 cm).

As a preliminary attempt to analyze the data, seven biological metrics were modified from the Index of Biotic Integrity (IBI; Karr 1981). The IBI assumes that biotic integrity of a stream (the integration of factors that have a cumulative effect on fish survival such as water quality, habitat availability, and flow regimes) is reflected by the overall health of the fish community (Fausch et al. 1990; Karr et al. 1986).

DATA ANALYSIS

Three of the seven metrics used with this data set (taxa richness, number of minnow species, and number of intolerant species) are generally considered to be positive indicators of biotic integrity. Two other metrics, ratio of tolerant to intolerant species and percent of fish that are common carp, are generally considered to be inversely related to biotic integrity. The remaining two metrics, the number of individuals and total biomass, can be either positive or negative indicators of biotic integrity depending on the nature of the environmental situation.

Taxa Richness

As a general rule, taxa richness, or the number of species collected at a site, is directly associated with environmental condition: the better the environmental condition, the higher the taxa richness. Data generated for taxa richness (Figure 2) show that the greatest number of taxa were collected at the Little River Ditch and the Wolf River. Fewer than 20 species were collected at the three Bogue Phalia reaches, the Skuna and Tensas reaches, and the Cache River at Cotton Plant reach 2.

Number of Individuals

The number of individuals collected at a site can vary substantially depending on the environmental condition. For example, under eutrophic conditions, species intolerant of enriched environments often decline, thus reducing competition and predation on the remainder of the community. As a consequence, there may be a population explosion of nutrient tolerant species leading to an inordinately high number of individuals. Conversely, exposure of the community to a toxicant can lead to an extremely low number of individuals.

Three sites (Yazoo River, Little River Ditch and the Wolf River) had more individuals than the other sites (Figure 2). Most of the individuals collected at the Yazoo River belonged to four species: mosquito fish, gizzard and threadfin shad, and white crappie. Comparing the number of individuals to taxa richness for the Yazoo River (which was slightly less than the mean of 21.25 taxa for all sites) indications are that diversity at this site was much lower than for the Little River Ditch and the Wolf River reaches, which had both a high taxa richness and a high number of individuals.

Number of Minnow Species

The minnows are a large and diverse group. With the combination of diverse habitat and favorable water quality, several species may occur in the stream environment with minimal competition. As conditions degrade, only the more tolerant species persist in the community.

The Little River Ditch and Wolf River reaches had the largest number of minnow species of all reaches sampled (Figure 3). Only subtle differences are apparent for the remainder of the reaches; however, the lowest numbers of minnow species were at the Bogue Phalia reaches 1 and 3 and the Cache River at Egypt.

Number of Species Intolerant to Pollution

Some intolerant fish species are extremely susceptible to decline at the onset of environmental degradation, and under severely degraded conditions the occurrence of intolerant species is incidental at most. Some sources for species tolerances exist on a regional basis (Tennessee Valley Authority 1995; Plafkin et al. 1989; Miller et al. 1988; Bryn Tracey, North Carolina Department of Environmental Management, oral commun., 1997), but because of regional differences of fish species and tolerances, it was necessary to assign tolerance values based on localized observations for some of the most tolerant and intolerant species.

Numbers of species intolerant to pollution (Figure 3) were comparable to the numbers of minnow species. The Little River Ditch and Wolf River reaches had the largest number of intolerant species. Only subtle differences were apparent for the other reaches sampled, except that only one intolerant specie was collected at the Bogue Phalia reaches 1 - 3 and at the Skuna River.

Amount of Biomass

A major component of intolerant species are small minnows, darters, and madtoms. As environmental conditions degrade, many of these smaller fish species are replaced with less specialized omnivores. Some of the more tolerant of these "replacement" species have relatively large body sizes, thus an increase in biomass often results. In contrast, extremely low biomass may reflect a sparse fish community and indicate degraded conditions.

The amount of biomass (Figure 4) was more than 100 kg at Bogue Phalia reach 3 and at the Cache River at Egypt. These reaches have shifting, unstable substrates and banks, an environment poorly suited for most intolerant species. Both sites also lack diverse habitat, but a large part of the habitat available is large, woody debris. Some large omnivores such as carp and buffalo, the species which accounted for the largest part of the biomass, tend to concentrate near large tree tops and other woody debris. The lowest three biomass values were at the Skuna, the Wolf, and the Yazoo Rivers. The Skuna and the Yazoo River reaches lacked large, woody debris in the channel and had little habitat diversity, which may explain the low biomass numbers for these sites. Conversely, the Wolf River had diverse habitat and a diverse fish community: a small average body size (due to the presence of the intolerant species) resulted in a low biomass at this site.

Ratio of Tolerant to Intolerant Species

As environmental disturbance increases, the ratio of tolerant to intolerant species increases (>1:1) as well. A ratio near 1:1 indicates the fish community is well balanced and healthy.

Ratios of tolerant to intolerant species (Figure 5) were greater than 5:1 at four reaches: the Bogue Phalia reaches 1 - 3 and the Skuna River. These values reflect sparse fish communities and are typical for sites having low taxa richness (Figure 2). An indicator of the consistency of this metric with the other metrics is that the Little River Ditch and Wolf River reaches have ratios slightly less than 1:1, further support that fish communities at these sites are healthy.

Percentage of the Individuals that are Common Carp

The carp is an introduced species, very tolerant of degraded conditions, that thrives in the absence of other competitors and predators. The degree to which a tolerant specie, such as the carp, dominates a site often coincides with the level of environmental disturbance.

The percent of common carp individuals (Figure 6) in the fish collections was greater than 15 at the Bogue Phalia reaches 1 and 2 and between 10 and 15 at Bogue Phalia reach 3 and the four Cache River reaches. The five remaining reaches had less than 5 percent carp in the samples. Two of these five reaches were the Little River Ditch and Wolf River reaches where low carp numbers were expected because of the large number of taxa collected at these sites. Low carp numbers at the Skuna and Tensas River reaches may be due to a sparse representation of all individuals. The Yazoo River reach is located in a channelized section and shallow-water habitats preferred by carp are absent much of the year.

Special Considerations

Data for the Cache River at Cotton Plant reaches 1 and 3 are similar for almost every sample, but differed consistently with data from reach 2. Because reaches 1 and 3 are immediately upstream and downstream of reach 2 and no data differences were evident for the two reaches data for the Cache River at Cotton Plant reach 2 are considered outliers.

Data from Skuna River reflect a sparse fish community, but a factor to be considered is that the area sampled by electrofishing was half that of the other reaches.

Data from the Yazoo River should be interpreted with the understanding that the Yazoo River differs significantly in cross-section width (175 m compared to an average of 30 m) and drainage basin size (21,500 km^2 compared to less than 1,850 km^2) from the other sites sampled. The consensus of the scientific community is that the larger the river, the more species diversity there should be (Fausch 1990).

The Tensas River was sampled during heavy rains and was approximately one meter above low flow. Although it is not evident how this flooding event affected the 1996 results, it is noted and should be considered when data from future sampling are evaluated.

CONCLUSIONS

The four metrics expected to be positive indicators of biotic integrity (taxa richness, number of individuals, number of minnow species, and number of intolerant species) indicate that the fish communities at the Little River Ditch and Wolf River were the most healthy and diverse of the communities sampled. Only subtle differences in the data were apparent at the remainder of these reaches with exception of slightly lower numbers of minnow and intolerant species at the Bogue Phalia.

The three metrics expected to be negative indicators of biotic integrity (total biomass, ratio of tolerant to intolerant species, and percent of fish that are common carp) were highest at one of the three Bogue Phalia reaches on all occasions. These results indicate that the fish community of the Bogue Phalia was relatively unhealthy.

The data for the five intermediate sites were so similar that they could not be ranked. However, fish communities of the intermediate sites were more similar to communities at the three Bogue Phalia reaches than to communities in the Little River Ditch and Wolf River.

With the exception of the Cache River at Cotton Plant reach 2, multiple reach sampling on the Cache River and Bogue Phalia yielded similar results among reaches, for each stream. This indicated that the sampling techniques adequately assessed the fish communities at all sites.

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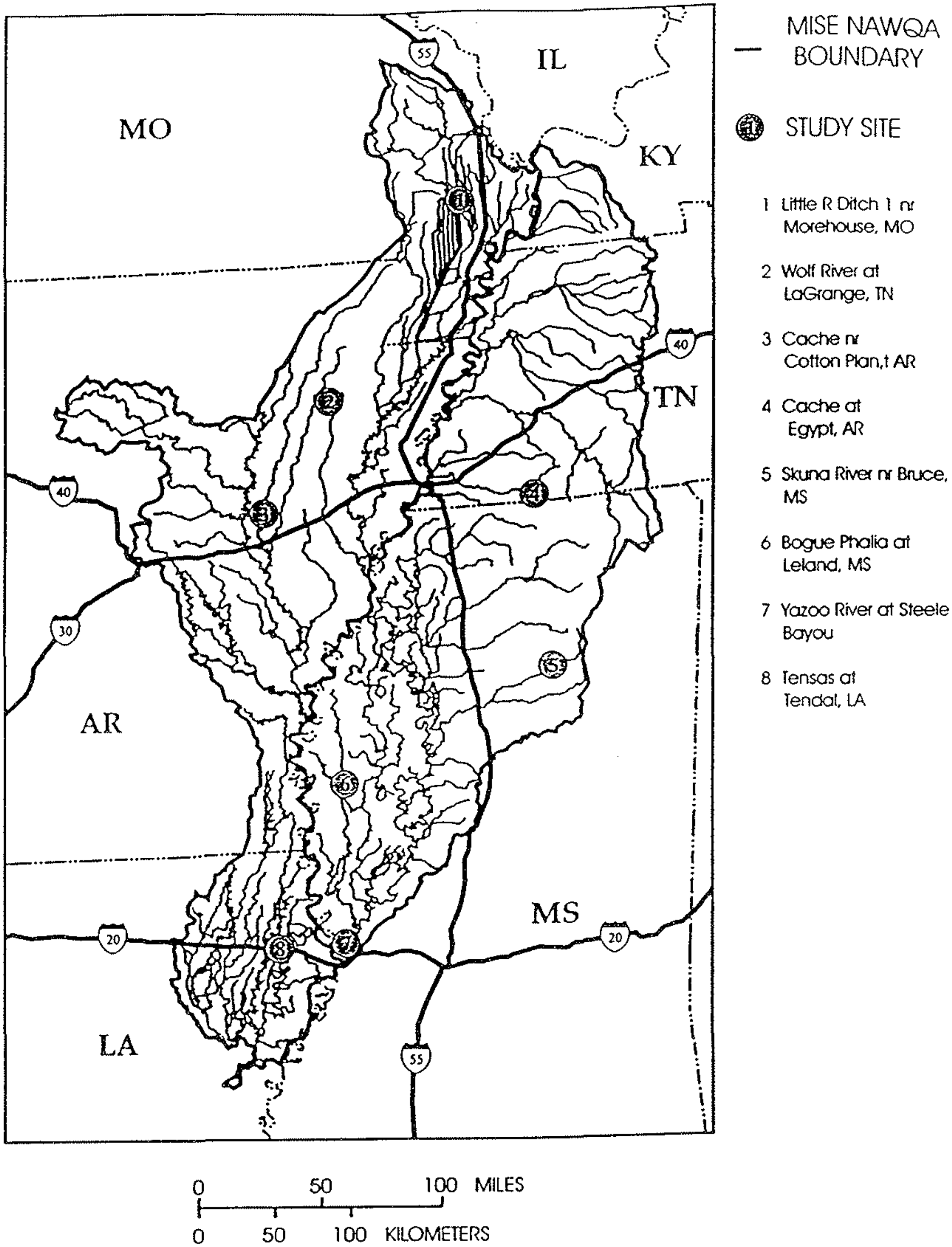

Figure 1. Fish community assessment sites in the Mississippi Embayment NAWQA.

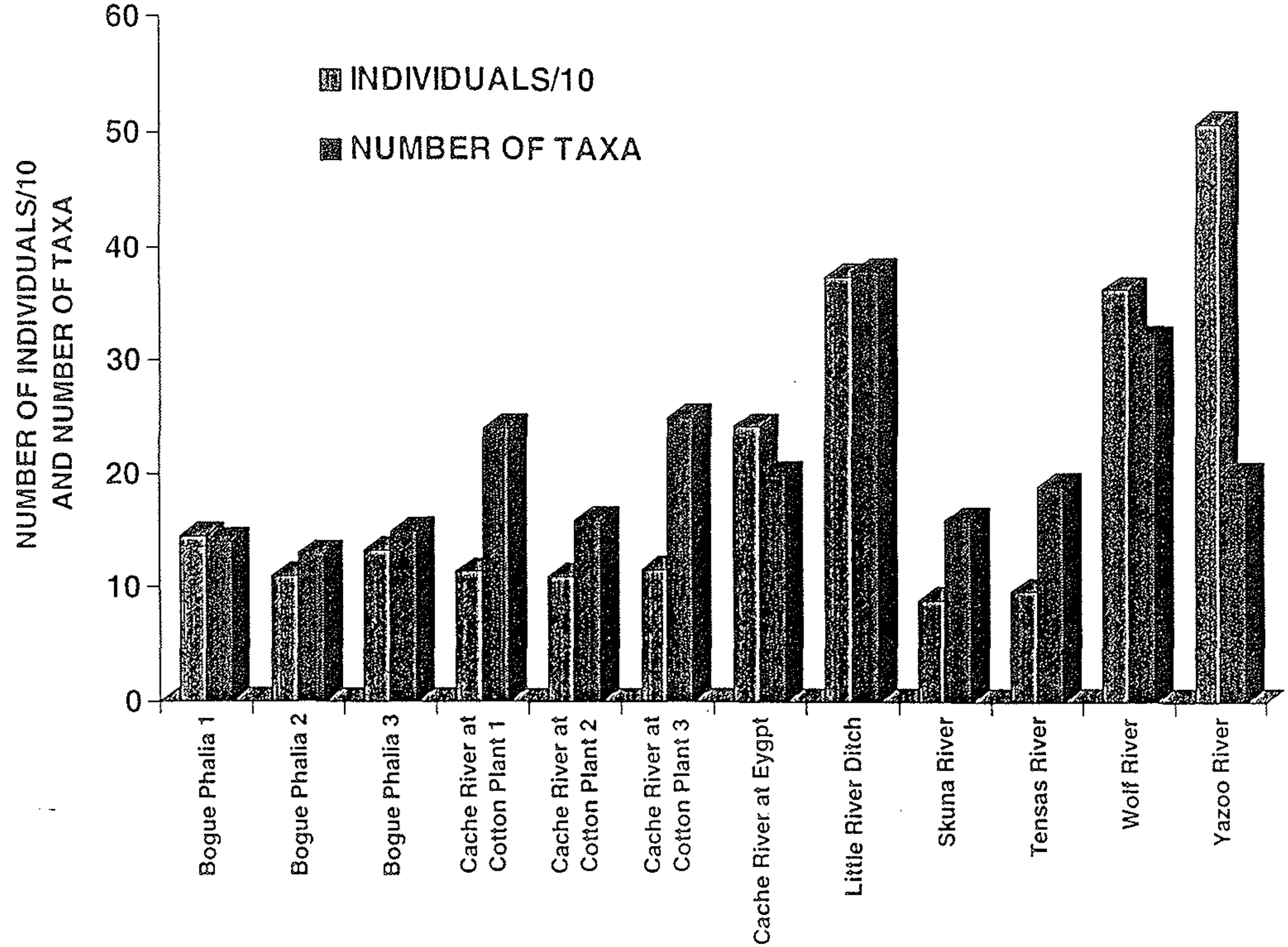

Figure 2. Number of individuals/10 and number of taxa at the basic fixed sites within the Mississippi Embayment NAWQA.

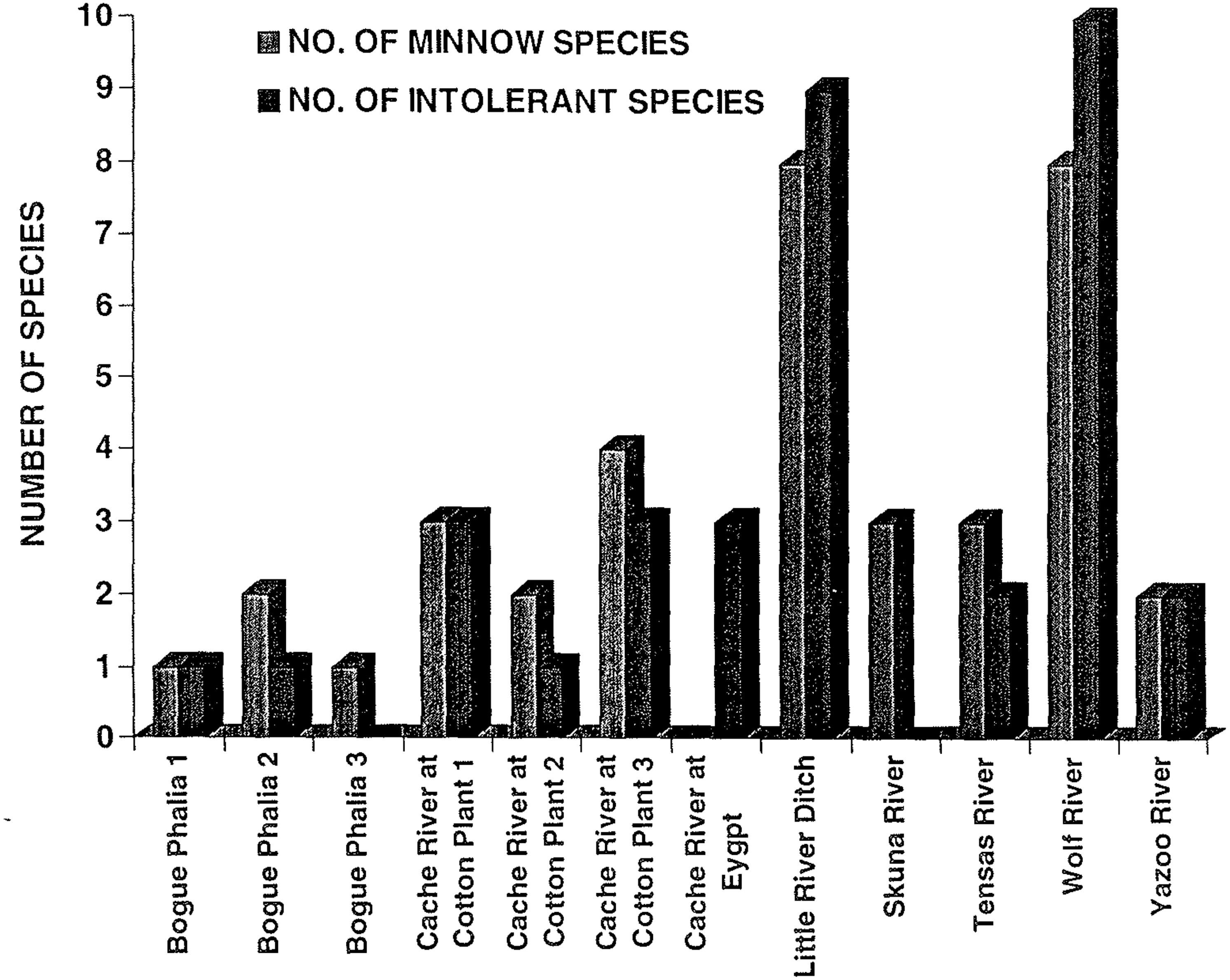

Figure 3. Number of minnow and intolerant species at basic fixed sites within the Mississippi Embayment NAWQA.

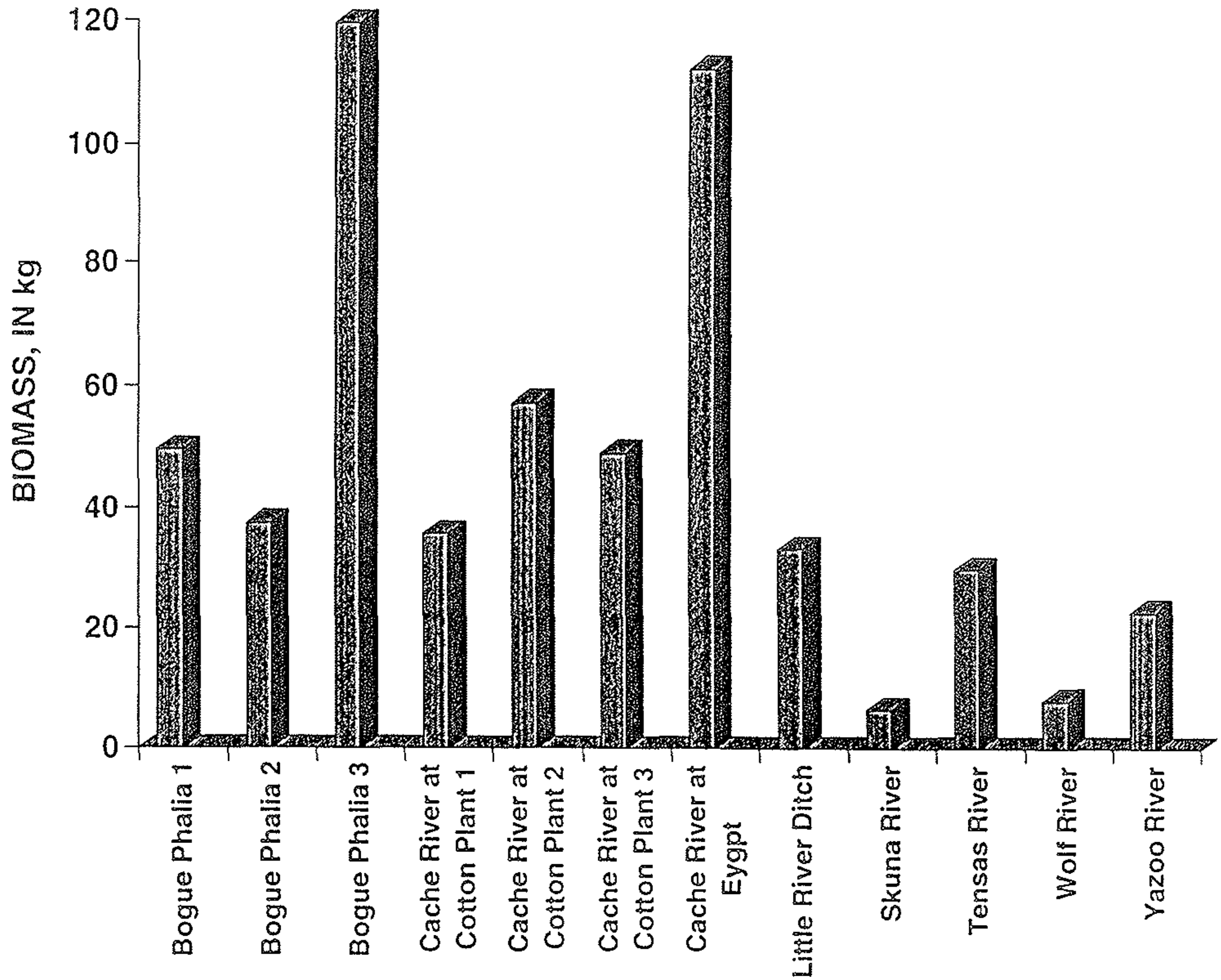

Figure 4. Total biomass of all fish at the basic fixed sites within the Mississippi Embayment NAWQA.

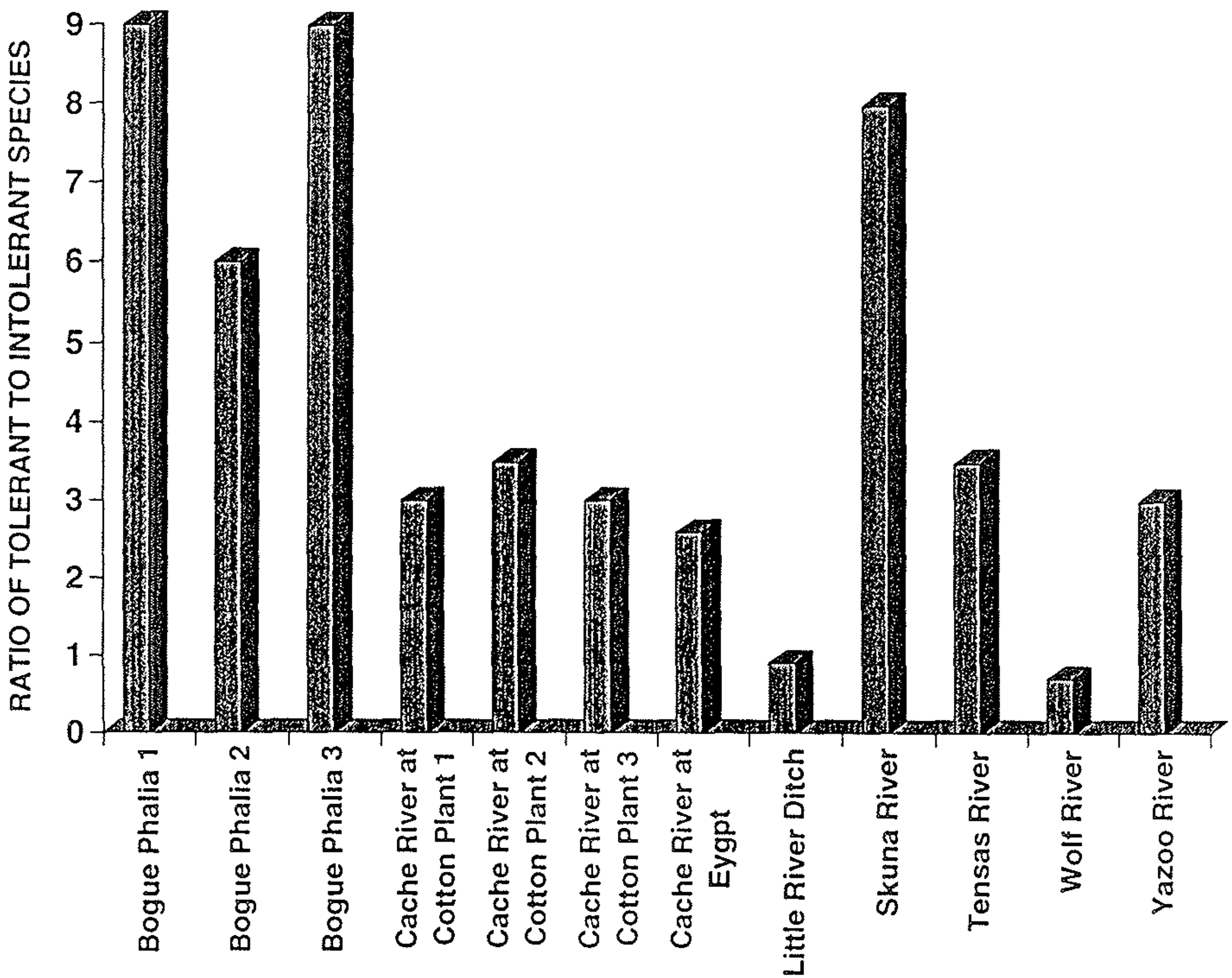

Figure 5. Ratio of tolerant to intolerant fish species at the basic fixed sites within the Mississippi Embayment NAWQA.

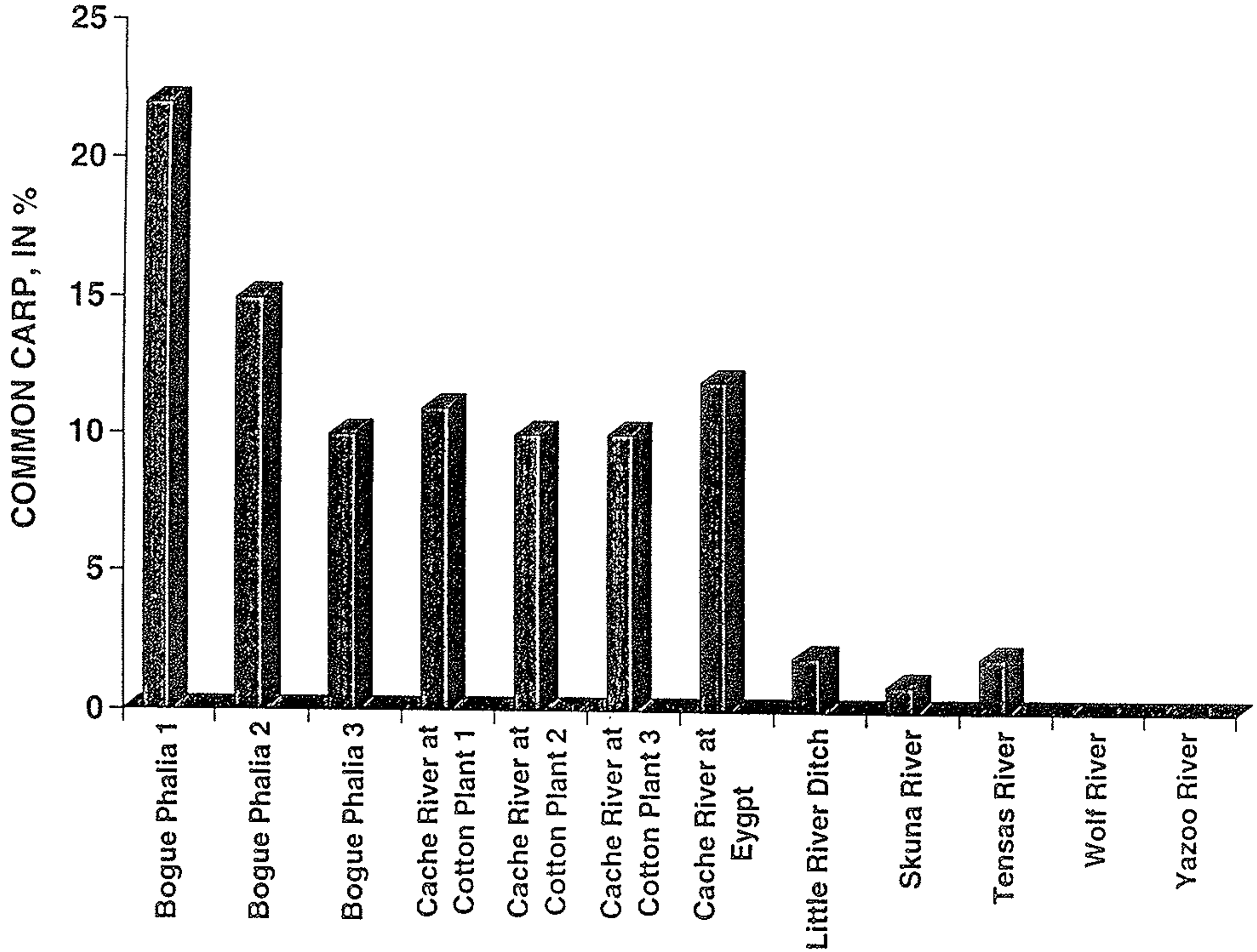

Figure 6. Percent of fish that were common carp, *Cyprinus carpio*, at the basic fixed sites within the Mississippi Embayment NAWQA.