# ENVIRONMENTAL STUDY OF LAKE ANNA

# AND THE LOWER NORTH ANNA RIVER

## ANNUAL REPORT FOR 1998

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## Executive Summary

Following the successful completion of the North Anna Power Station 316(a) Demonstration in 1986, Virginia Power (the Company) agreed to continue selected environmental monitoring studies on Lake Anna and the North Anna River. Correspondent with the recommendations in the three-year review of post-316(a) studies for 1989-1991, the Company requested and was granted a reduction in certain of the monitoring programs by the Department of Environmental Quality (DEQ). The revised annual study program was to be continued with a review every three years for possible revisions or changes. This report represents findings from monitoring programs conducted during 1998, the first year of the three year study period 1998-2000.

Station generation for 1998 was again outstanding with levels reaching the third highest yearly average for capacity since 1978 when the station began commercial operation. Water temperature and fish community data for 1998 both in the lake and downstream were similar to historical data with one exception: the electrofishing totals for 1998 were the highest recorded due to an increase in the numbers of bluegill Lepomis macrochirus. This increase is attributed to be the result of extremely low lake levels dewatering much of the natural habitat for bluegill and concentrating them in the rip-rap habitat found at the dike collection stations. The numbers collected from gill netting surveys for 1998 were similar to 1997 totals as well as historical data. In 1998, Lake Anna anglers reported 88 citation largemouth bass Micropterus salmoides (greater than 55.9 cm in length and 3.6/kg in weight) ranking Lake Anna first in the state.

The 1998 hydrilla Hydrilla verticillata survey indicated a decrease in the acreage in the lake

and in the Waste Heat Treatment Facility (WHTF) when compared to 1997 totals. Further, the hydrilla in both the lake and WHTF was represented by plants 10 to 20 cm in length with limited vertical shoots and minimal biomass.

In the lower North Anna River, electrofishing surveys conducted in 1998 found numbers of fish slightly less than those of 1997, and biomass greater. Density estimates of largemouth bass and smallmouth bass varied between species and station location but were generally greater than those in 1997.

Overall, the data collected in 1998 reveal that no major changes occurred in the lake or river ecosystem. The review of the data from the 1998 monitoring studies indicate that Lake Anna and the North Anna River continue to contain healthy, well-balanced ecological communities.

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## 1.0 Introduction

In 1972, the North Anna River was impounded to create Lake Anna, a 3885 hectare (9600 acres) reservoir (lake) that provides condenser cooling water for the North Anna Power Station (NAPS). Adjacent to Lake Anna is a 1376 hectare (3400 acre) Waste Heat Treatment Facility (WHTF) that receives the cooling water and transfers excess heat from the water to the atmosphere before discharging into the lower reservoir.

Aquatic monitoring studies have been conducted on Lake Anna since its inception. In January, 1984, the Company initiated an extensive Section 316(a) demonstration study (P.L. 95-500) to determine if proposed effluent limitations on thermal discharges from the power station were more stringent than necessary to assure the protection and propagation of a balanced, indigenous community of shellfish, fish and wildlife in Lake Anna and the lower North Anna River. The final report (Virginia Power 316(a) Report 1986) successfully demonstrated that the operation of the power station had not resulted in appreciable harm to the biological community. The Virginia Water Control Board (VWCB) accepted the study as a successful demonstration in September, 1986.

Subsequent to the 316(a) study, the Company committed with the VWCB to continue environmental monitoring on Lake Anna and the lower North Anna River as part of a post 316(a) agreement. Also, following each three year period of data collection, a summary report is provided with recommendations for future studies. This report presents the findings for calendar year 1998, the first year of the current three-year study for Lake Anna.

## 2.0 Station Operation

North Anna Power Station (NAPS) operated at a yearly average of 89% for 1998. This represents the third highest yearly average for the station since 1978 when it began commercial operation. The station operated at 96% of capacity for the first quarter and 93% for the fourth quarter. Unit 2 was removed from service during the second quarter for refueling which resulted in a drop to 81% of capacity for this quarter (Table 2.0-1). Past studies have shown that the levels of generation reported have not resulted in adverse impact on the ecology of Lake Anna (Virginia Power, 1988-1997).

## 3.0 Lake Anna

### 3.1 Temperature

#### Methods

Lake water temperature data in 1998 were collected using continuous measurements (fixed temperature recorders) and instantaneous field surveys. Continuous temperatures were measured using Endeco model 1144SSM temperature recorders which measure and record the water temperature at one hour intervals at seven (7) stations in the lake and three (3) stations in the WHTF. These instruments were located one meter below the lake surface at the stations depicted in Figure 3.1-1, the lone exception being Station NALST10. The instrument at this station was located at a depth of three meters due to the turbulence and surface mixing. A summary of the data recorded by these

instruments for 1998 is presented in Table 3.1-1 as the means of daily high, mean and low temperatures.

The instantaneous temperatures were measured using a Yellow Springs Model 3000 T-L-C model field temperature instrument. Temperatures were measured quarterly at one (1) meter intervals, surface to bottom, at the stations shown in Table 3.1-2.

**Results**

The continuous recording system indicated that the maximum temperature recorded for the lake in 1998 was 30.4°C recorded in August at Station NALBRPTT located mid-lake (Table 3.1-1). The lowest temperature was 5.9°C recorded in January at Station NAL719NT located on the Pamunkey arm of the upper lake. These 1998 high and low temperatures are similar to historical records and compare to the 1997 values of a maximum of 30.2°C and a minimum of 4.7°C, and a 1996 maximum value of 29.7°C and a minimum of 2.4°C..

The instantaneous temperature surveys were conducted in March, May, August, and December to provide temperature data to assess seasonal thermal stratification patterns in the lake. The March survey data indicated no stratification with the exception of the 16 to 18 meter depth at Station A. The May survey results indicate a metalimnion at the 10 to 13 meter depth in the lower lake, and at the 5-8 meter depth in the more shallow, upper portion of the lake. This metalimnion was again evident in the August survey but had migrated to a depth of 13 to 15 meters at the lower lake and mid-lake stations and disappeared in the upper lake stations. The temperatures recorded in the

November survey indicate uniform temperatures recorded throughout the lake with approximately 2°C change surface to bottom for each station in the lower lake and decreasing to approximately 1° in the upper lake stations (Table 3.1-2). These stratification patterns in the lake were not unusual and are similar to previously reported patterns (Virginia Power 1986-1997).

Also, the overall temperatures recorded in the lake for 1998 were similar in both range and seasonal pattern to those recorded in 1997 and are likewise consistent with previously reported data (Virginia Power, 1997).

## 3.2 Fish Population Studies - Gill Netting

### Methods

The monitoring of fish assemblage abundance and species composition for Lake Anna and the WHTF continued in 1998 using the same basic sampling technologies applied since 1972. Experimental gill netting was used to capture fishes which normally inhabit the deeper strata of the lake, or exhibit a diel movement to and from the shoreline (Table 3.2-1). Sampling frequency for 1998 was similar to historical sampling with samples collected during February, June, August, and November at the stations shown in Figure 3.2-1. Experimental gill nets were set near littoral drop-off areas with procedures remaining unchanged since 1972. Fish collected by gill netting were returned to the laboratory where all individuals were measured to the nearest millimeter total length and weighed to the nearest 0.1 gram. Surface water temperature (°C), dissolved oxygen

(mg/l), pH and conductivity ($\mu$mhos) were recorded at the time of each sample collection (Table 3.2-2).

**Results**

Nineteen (19) species of fish representing seven (7) families were collected in Lake Anna and the WHTF by quarterly gill netting in 1998. A total of 817 fish weighing 360.8 kg was collected from four stations in the lake and two stations in the WHTF. Of the 817 total fish collected, 470 (213.1 kg) were collected in the lake and 347 (147.6 kg) in the WHTF (Table 3.2-3). The numerical total is somewhat higher than the 1997 total while the weight is lower.

Figure 3.2-2 graphically presents the relative percentages of numbers and weights of species collected by gill netting in 1998. The numerically dominant species collected in the lake was threadfin shad Dorosoma petenense followed by striped bass Morone saxatilis, gizzard shad Dorosoma cepedianum and channel catfish Ictalurus punctatus. These results are most similar to 1996 when gizzard shad and striped bass were ranked as the most numberous fishes and are also similar to past results (Figure 3.2-3).

When the 1998 data are compared for weights, the dominant species in the lake was striped bass followed by common carp Cyprinus carpio and channel catfish. These data are similar to 1997 data with striped bass and gizzard shad ranking number one and three respectively (Virginia Power 1997).

The numerically dominant species collected by gill netting in the WHTF, as shown in Figure 3.2-4, was gizzard shad followed by channel catfish and largemouth bass. The

results are similar to historical trends over the last three years with these species comprising the top three each year (Figure 3.2-3). The weight-dominant species in the WHTF for 1998 was channel catfish followed by common carp and largemouth bass. These data likewise are similar to 1996 and 1997 which found the same species in the top three (Virginia Power, 1996, 1997).

The catch per unit effort (CPUE) for gill netting for all stations combined was 34.0 in 1998 compared to 33.4 in 1997 and 34.7 in 1996 (Figure 3.2-5). The 1998 average number of individuals per gill netting sample demonstrates a moderate increase compared to 1997 and, at the same time, the average weight of individuals per sample increased. These values fall within historical ranges (Figure 3.2-6).

When the 1998 gill netting data are examined seasonally, the June collection yielded the greatest number of fish representing 30% of the total annual catch; further, the February sample ranked first in weight with 149.7 kg (50% striped bass). Both of these trends are similar to results of past years.

Table 3.2-4 illustrates the 1998 gill netting data by number and weight for each individual collection in both the lake and WHTF. The average number of fish collected by station ranged from a low of 22 fish recorded at the Levy Creek station to a high of 57 recorded at the Lagoon 1 Station. The highest number in 1998 for any single set was 109 (48% gizzard shad) recorded in June at the same Lagoon 1 Station. The average weight of fish collected during 1998 ranged from a low of 11.4 kg recorded at Lower Lake Station to a high of 19.7 kg recorded at the Lagoon 1 Station. The greatest weight for

any single set in 1998 was 42.9 kg recorded in February at the Thurman Island Station (88% striped bass).

### 3.3 Fish Population Studies - Electrofishing

#### Methods

Boat electrofishing was again used in 1998 to evaluate the assemblage and abundance of fish populations which normally occupy the shoreline habitat. The techniques, stations, and frequency have remained virtually unchanged since 1972, i.e., sampling was performed in 1998 in February, June, August, and November at the stations identified in Figure 3.2-1 with the stations being 100 meters in length and normally containing a brush pile except for the dike stations which are comprised of uniform rip-rap.

All fish collected were either returned to the laboratory for processing or released in the field, e.g., larger game fish were measured, weighed, and released. In the laboratory, at least twenty-five (25) individuals per species from each station were measured to the nearest millimeter total length and weighed to the nearest 0.1 gram. Those individuals over twenty-five (25) per species were enumerated and bulk weighed. Surface water temperature (°C), dissolved oxygen (mg/l), pH and conductivity (μmhos) were recorded at the time of each sample collection (Table 3.2-2).

## Results

Twenty-two (22) species of fish representing eight (8) families were collected by electrofishing operations in the lake and WHTF in 1998 (Table 3.2-1). A total of 6,991 fish weighing 83.1 kg was collected from the five stations in the lake and the four stations in the WHTF during the 1998 sampling period. Of the 6,991 fish collected, 3,237 (53.1 kg) were collected from the lake and 3,754 (30.0 kg) were collected from the WHTF (Table 3.3-1). The dominant species for the lake and WHTF in terms of both number and weight was the bluegill Lepomis macrochirus (Figures 3.3-1 and 3.3-2). Largemouth bass ranked second in weight in both the lake and the WHTF. These results are similar to those of 1996 and 1997 as well as those in the historical records (Virginia Power, 1988-1997). The relative make-up of the species composition for 1998 was similar to 1997 also following the historical trend for both the lake and WHTF (Figure 3.3-3). The electrofishing totals for 1998 were the highest recorded due to an increase in the number of bluegill collected. In 1998, Lake Anna recorded the second lowest lake level of 247.4' since its impoundment in 1972, (2.6' below normal pool of 250'). The lowest lake level was 247.2' recorded in 1977. This extreme low lake level consequently dewatered much of the shallow shoreline habitat thereby concentrating the smaller bluegill along the rip-rap stations. The increased numbers of bluegill collected at these stations in the last three quarters support this hypothesis.

The 1998 electrofishing data are summarized by each individual station for number and weight in Table 3.3-2. This table reveals the average number of fish collected ranged from a low of 100 recorded at Lagon 3 Station to a high of 474 recorded at Dike 1-

WHTF. The greatest average weight per collection was 4.2 kg recorded at Thurman Island Station. The single greatest total weight for 1998 for any station was 7.1 kg (99% bluegill) recorded in November at the Dike 1 WHTF Station. The single highest numerical total occurred in February at the Dike 1-WHTF Station when 974 (99% bluegill) were captured.

When the data are compared seasonally, the electrofishing results are similar to previous years with the greatest number of fish being collected in the fall (November) (3,085) and winter (February) (2,508) collections. The November collection also resulted in the largest quarterly weight total of 35.2 kg mainly attributed to the numbers of bluegill (57%). Typically in the fall, recruitment of the young-of-the-year (YOY), plus the return of the fish to shallow water as the weather moderates, generally increases the number of fish available to collection by shoreline electrofishing.

The average number of fish collected per electrofishing sample for 1998 was 194 , above the average for 1997, due to the increase in bluegill numbers (Figure 3.3-4). The average weight per electrofishing sample for 1998 was 2.3 kg which represents a decrease from 1997. This decrease in average weight is primarily due to the numbers of small bluegill collected in 1998. The 1998 data for numbers and weight are similar to historical ranges (Figure 3.3-4).

When lake gill netting and electrofishing data are combined for selected species and examined for size class distribution, the data indicate certain population trends. The 1998 results indicate no real change in numbers of young-of-year (YOY) for largemouth bass. The intermediate size class showed some increase when compared to 1996 and 1997

results (Figure 3.3-5). A similar comparison for bluegill is provided in Figure 3.3-6 which demonstrates an increase in the YOY class and no real change in intermediate and decrease in the harvestable class.

Lake Anna led the state of Virginia for largemouth bass citations with 88 being reported in 1998. A citation for largemouth bass is greater than 55.9 cm in length or 3.6 kg in weight. The lake was third in black crappie Pomoxis nigromaculatus citations with 19 (greater than 38.1 cm in length or .91 kg in weight).

Overall, the data for gillnetting and electrofishing in 1998 reveal no major changes in the lake ecosystem. The data when compared to past data indicates that Lake Anna continues to support a healthy, well-balanced biological community.

## 3.4 Aquatic Vegetation

### Methods

Hydrilla is an exotic, submerged, aquatic macrophyte which, in most bodies of water, has the ability to grow and spread rapidly. The primary method of reproduction is by fragmentation. Hydrilla also produces overwintering structures in two (2) separate areas of the plant: tubers, produced by the roots in the hydrosoil; and turions, formed at the leaf axils of the plant. Each has the ability to produce new plants at the beginning of each new growing season.

An annual aerial survey is conducted to map hydrilla growth in Lake Anna. The 1998 survey of Lake Anna was conducted in late October. The survey is conducted by helicopter with personnel from VDGIF and the Company. The entire shoreline of the lake

and WHTF is surveyed to document areas of hydrilla colonization. The locations of observed hydrilla are marked on a topographic map of Lake Anna and returned to the laboratory for computerization. The computerization of the data allows the acreage of hydrilla to be calculated, and also the production of maps indicating the location of the hydrilla.

**Results**

Hydrilla acreage decreased in Lake Anna from 278 acres in 1997 to 97 acres in 1998. A decrease was also noted in the WHTF from 242 acres in 1997 to 163 in 1998 (Table 3.4-1). The totals for 1998 are similar to the totals reported in 1990, which was the first year of the aerial surveys (Figure 3.4-1). The hydrilla colonization patterns for 1998 are similar to those reported previously.

The 1997 lake total of 278 acres represented 7.9% of the maximum available habitat (areas of 15 feet or less, water depth). This percentage decreased to 0.3% in 1998 (Figures 3.4-2, 3). The 1998 survey data for the WHTF also indicate a decrease from 14% of the available habitat in 1997 to 10% in 1998 (Figures 3.4-4, 5, 6).

During the 1998 aerial survey the reduction in observed hydrilla was uniform throughout the lake and WHTF and the plants observed in both the lake and WHTF consisted of short, stunted plants with minimal vertical growth and biomass. As previously discussed, the 1998 drought conditions in the Lake Anna watershed resulted in a decrease in lake level to 247.4 feet above mean sea level or 2.6 feet below normal pool

of 250 feet. This low lake level consequently dewatered large areas of shallow lake bottom which normally support hydrilla growth.

The low lake water level resulted in dewatering five (5) of the six (6) exclusion areas. Exclusion areas are 10 foot by 10 foot square fenced areas used to measure the effectiveneess of hydrilla control by grass carp by "excluding" them from eating the vegetation in the fenced area. The only exclusion area which was not dewatered was located in the main lake around Thurman Island. This exclusion area contained good hydrilla growth. This pattern of growth within the protected areas of the exclusion plots has been reported in the literature in other lakes where grass carp have been introduced (Webb, et al, 1994).

One conclusion that can be made from the 1998 information is that the atypical weather conditions interfered with hydrilla growth in 1998. Further, the sterile grass carp seem to be producing the desired and predicted results, i.e., control of the growth and biomass of hydrilla without eliminating it from the lake's ecosystem.

## 3.5 Conclusions

**1998**

- North Anna Power Station in 1998 operated at lower generation levels compared to 1997.
- The 1998 water temperature data from the continuous recorders indicated water temperatures similar to those recorded in 1997 and follow reported historical trends.

- Thermal stratification patterns measured in quarterly surveys in 1998 indicated similar stratification patterns to previously reported data.
- Gill netting surveys during 1998 produced total numbers that were greater than 1997 but with weight totals less than 1997. Both the numbers and weights were within historical ranges.
- Electrofishing surveys during 1998 produced total numbers greater than those of 1997 and weight totals less than 1997.
- Overall hydrilla acreage for 1998 decreased in both the lake and in the WHTF, with the hydrilla plants being 10 to 20 cm in length and producing limited biomass.

# 4.0 North Anna River

## 4.1 Temperature

### Methods

Water temperatures (°C) were recorded hourly at station NAR-1 in the lower North Anna River during 1998 (Figure 4.1-1) using a fixed Endeco model 1144SSM temperature recorder. Station NAR-1 is located approximately 1 km below the Lake Anna dam.

### Results

Water temperatures for 1998 were highest from June through September when mean monthly water temperatures exceeded 25°C (Table 4.1-1). A maximum hourly temperature of 32.4° C was recorded at NAR-1 in July 1998. Historically, maximum water temperatures have occurred in July or August. Temperatures recorded in 1998 exceeded the range of maximum temperatures recorded previously (Virginia Power 1992). A minimum hourly temperature of 8.4° C was recorded at NAR-1 in February 1998, which is higher than previous temperatures for the period of record 1975-1998. This temperature is probably the result of several factors: a warmer than normal winter; lower lake levels; and generation levels.

## 4.2 River Flow

### Methods

River discharge (cfs) data were obtained from the United States Geological Survey (USGS) to document the timing and magnitude of hydrologic events. These events, along with water temperature, are among the most significant abiotic factors affecting the abundance and distribution of stream organisms. Data were obtained from the gage near Doswell, Virginia, located approximately 37 km downstream of the Lake Anna dam at NAR-6 (Figure 4.1-1). Historically, the USGS has provided river discharge data from the Partlow gaging station at NAR-1 (1 km below the Lake Anna dam) but this station was deactivated by the USGS in October, 1995.

The pattern of seasonal flows in the North Anna River is generally characterized by high flows in the winter and spring, reduced flows during summer, and very low flows during late summer and early autumn. This is a pattern commonly exhibited by many rivers draining the eastern United States, and is reflective of annual rainfall patterns.

### Results

In 1998, North Anna River flows for the period January - March were high with mean daily flows exceeding 1500 cfs on forty of the ninety days during the three month period (Figure 4.1-2). Mean monthly flows for the same period were between 1300 and 2700 cfs April - September where daily flows generally decreased from 898 cfs in April to 46 in September (Figure 4.1-2). Several rain or storm events produced flows that exceeded 1000 cfs on various days throughout the January - June period. Most notable in 1998 was the five or more consecutive days of high flows in January, February and March

with maximum high flows of 6920, 9070, and 8240 cfs being recorded. River flows generally decreased from September to the end of 1998 and remained above minimum flow (40 cfs)..

## 4.3 Fish Population Studies-Electrofishing

### Methods

Abundance and species composition data for the North Anna River fish assemblage in 1998 were collected during electrofishing surveys. Consistent sampling techniques have been used in all North Anna River electrofishing surveys since 1981.

An approximately 70-m reach of riffle/run type habitat is sampled at each station with an electric seine (Virginia Power 1986). Prior to sampling, each 70-m reach is blocked at the downstream ends with a 6.5-mm mesh net. Sampling is conducted by working the electric seine from bank to bank in a zigzag pattern from the upstream to the downstream end of the section. Nearby pool type habitats are then sampled for 10 minutes of effort with a backpack electrofisher. Fish sampled by electric seine and backpack electrofisher are collected using 6.5-mm mesh dip nets.

Most fish collected are preserved in 10% formalin, and transported to the laboratory for appropriate processing. Some larger fish are weighed and measured in the field and released. In the laboratory, a maximum of 15 specimens of each species is weighed to the nearest 0.1 g and measured to the nearest one (1) mm total length (TL). If more than 15 specimens of a species are collected, those in excess of 15 are counted and weighed in bulk. Electric seine and backpack electrofisher collections are then pooled by station and survey month for analyses.

Sample frequency for electrofishing is typically once per month each year in May, July and September. In 1998, electrofishing surveys on the North Anna River were conducted in May-June, July, and September. The May-June dates were necessary because of high water conditions on the scheduled May 31st survey necessitating follow-up sampling on June 1st.

## Results

A total of 1,628 fish was collected from the North Anna River during electrofishing surveys conducted in 1998 (Table 4.2-1). This compares to a total of 1667 fish in 1997. The 1998 totals include 27 species and seven (7) families. Over the past 13 years, 48 species have been collected from the North Anna River (Table 4.2-2) with annual totals ranging from 18 to 32 species.

A common characteristic of stream systems is the tendency for a few species to numerically dominate the stream fish assemblage (Matthews 1982). Six (6) to 10 species have accounted for greater than 80 percent of the North Anna River electrofishing catch from all stations in any year since sampling began in a consistent manner in 1981 (Table 4.2-3). This trend continued in 1998 with 8 species accounting for greater than 80 percent of all fish collected. These species were, in decreasing order by numbers, redbreast sunfish Lepomis auritus, swallowtail shiner Notropis procne, redfin shiner Lythrurus ardens, satinfin shiner Cyprinella analostana, american eel Anguilla rostrata, rosyface shiner Notropis rubellus, margined madtom Notropis insignis, and comely shiner Notropis amoenus. These species have consistently been among the most abundant species collected from the North Anna River since 1981 (Table 4.2-3).

In 1998, NAR-2 yielded the greatest numerical catch followed by, in decreasing order, NAR-1, NAR-4, and NAR-6 (Table 4.2-1). NAR-1 yielded the highest biomass in 1998, followed by, in decreasing order, NAR-2, NAR-4, and NAR-6. A comparison to the 1997 catch revealed both similarities and changes in the numerical order, with NAR-2 remaining in the number one position and NAR-4 and 1 exchanging positions.

The 1998 biomass for the four stations was identical in order to that of 1997, with NAR-1 yielding the highest biomass followed by NAR-2, NAR-4, and NAR-6.

It was hypothesized that high February and March flows may influence annual fish abundance because high flows increase mortality of fish that are already stressed from overwintering. Total fish numbers and biomass progressively increased in 1996 and 1997, but in 1998 the numbers tended to level off, with the exception of NAR-2 which continued to increase and NAR-4 which declined in number and biomass (Table 4.2-1). With the exception of NAR-4, no significant changes were noted when comparing 1997 and 1998 total fish numbers and biomass for all stations. The 1998 totals continue to remain above the low numbers of fish collected in 1995.

## 4.4 Fish Population Studies - Direct Observation

### Methods

To further amplify and understand fish population studies in the North Anna River, abundance and distribution data for smallmouth bass Micropterus dolomieu and largemouth bass were gathered via direct observation using snorkel surveys. Consistent observation techniques have been used in snorkel surveys since 1987 with some variation in sampling frequency at some stations among years.

In 1998, snorkel surveys were conducted during July, August, and September. Four (4) stations were sampled twice per month; NAR-1, NAR-2, NAR-4, and NAR-5 (Figure 4.1-1). Abundance estimation procedures were identical to those employed since 1987 (Virginia Power 1988). Counts of smallmouth bass (SMB) and largemouth bass (LMB) were made while swimming 100 m transects along the north and south banks of each station. Transects followed an approximately one meter depth contour.

All bass sighted were categorized by species as to young-of-year (YOY) ($\leq$120 mm), stock-size (120<SMB<280 mm or 120<LMB<305 mm), or quality-size (SMB$\geq$280 mm or LMB$\geq$305 mm). In addition to size group, all bass sighted were categorized as to type of cover being used; bedrock ledge (Ledge), boulders (Boulder), instream woody debris (Wood), aquatic vegetation (Vegetation), or no apparent cover use (Open). Fish had to be within 0.5 m of a cover object at the moment of sighting to be included in a cover use category other than the Open category. Aquatic vegetation was included as a cover type beginning in 1993 due to annual increases in the amount of vegetation observed from 1990 through 1992, and apparent increased use by fish.

During each station survey, three successive counts were made at each bankside transect. Each observer made an independent estimate of the distance that YOY smallmouth bass (TL$\leq$120 mm) could be distinguished from YOY largemouth bass (TL$\leq$120 mm) at each station. Lateral visibility at each station was estimated by averaging the independent estimates of both observers. Counts of smallmouth bass and largemouth bass were converted to density estimates (number/hectare of bankside channel) to account for differences in average visibility among survey days and sampling stations. Density estimates for all smallmouth bass and largemouth bass larger than YOY size were pooled

by species, station, and sample year to facilitate identification of species-specific and station-specific changes over time. Calculations of median density estimates by sample year and associated 95% confidence intervals were based on Walsh averages (Hollander and Wolfe 1973). YOY densities were not calculated as it was doubtful that YOY were as susceptible to the observation technique as were larger fish, due primarily to their small size and cryptic nature.

Cover utilization data from the first of three sets of observations obtained during each snorkel survey were used to examine differences in cover use by smallmouth bass and largemouth bass. Data from only the first count were used because it was assumed fish observed during the first count would be relatively undisturbed by divers, whereas fish observed on the second and third counts may have changed their positions in response to divers passing by during the first count.

## Results

Snorkel surveys for 1998 were conducted between 0848 and 1525 hours at river temperatures ranging from 24.8 to 33.1°C and average visibilities ranging from 1.0 to 4.0 m. Similar to previous years, smallmouth bass were most frequently observed at the downstream station NAR-5 (Table 4.3-1) and largemouth bass were most often observed at the upstream stations NAR-1 and NAR-2 (Table 4.3-1). Variability between the north and south bank at any station appeared to be related to habitat complexity, i.e., fewer fish were observed along banks characterized by monotypic habitat than along banks with a variety of habitat types.

Lower numbers of YOY smallmouth bass and largemouth bass were noted in 1998 when compared (NAR-1 and NAR-2) with the same information from 1997 for stations NAR-1 and NAR-2. Successful reproductive efforts by both species and relatively moderate river flows during the spring attributed to the higher numbers YOY observed in 1997; however, the 1998 smallmouth bass and largemouth bass spawning success may have been affected by high river flows during January through May when maximum flows of 7000 to 9000 cfs were recorded (Figure 4.1-2). The relationship between flow and fish abundance as performed in the 1993 Spearman's Correlation Analysis (Hollander and Wolfe, 1973) clearly show that high winter/spring flows result in reduced fish abundance.

The results for 1998 for NAR-1 continue to exhibit the trend of having a greater density of largemouth bass than smallmouth bass (Figure 4.3-1). Density estimates are based on fish larger than YOY size (TL $\leq$ 120 MM). It is noteworthy that previous information has shown that both bass species have declined over the last several years; however, in 1998, both species improved. The declines for both species in 1996 and 1997 at NAR-1 may possibly be attributed to the inability to penetrate extended stretches of hydrilla when making counts. This handicap was present again in 1998, but river flow conditions during the surveys were considerably lower in the summer months of 1998. These low flow conditions may have allowed the observers to see more fish.

Smallmouth bass and largemouth bass densities at NAR-2 in 1998 indicate a continued increase in smallmouth bass and a slight decrease in largemouth bass. Largemouth densities were similar to those of 1991-1995 (Figure 4.3-2).

At NAR-4, smallmouth bass densities in 1998 increased to the second highest level since the all time in 1991 (Figure 4.3-3). Largemouth bass densities decreased to the low values experienced in 1988 and 1993.

Aat NAR-5, smallmouth bass densities demonstrated an increase to levels approaching those of 1994 and 1995 (Figure 4.3-4). In addition, it is interesting to note that since 1996 the densities appear to correspond directly with the visibility at NAR-5 (Figure 4.3-4). Largemouth bass densities at NAR-5 increased to values slightly above those of 1991 through 1993. Historically, smallmouth bass have been most abundant at NAR-5 and largemouth found less abundant and this trend was again noted at NAR-5 in 1998.

Observations of cover use by smallmouth bass and largemouth bass are difficult to interpret without accounting for the availability of various cover types. For this reason, cover use data obtained in 1998 are primarily presented for documentation purposes (Table 4.3-2). Notable in 1998 was the significant reduction in the number of YOY largemouth bass observed at NAR-1. A total of 14 YOY largemouth bass was counted in the first of the three runs compared to 11 observed in 1997. The lower numbers observed in 1998 compare to those of 1995 (16) and 1996 (20) (Virginia Power 1995, 1996).

When cover use data are pooled for all stations in 1998 (Table 4.3-3) smallmouth bass were usually associated with wood, boulder, and open water while largemouth bass used primarily wood and vegetation. The largemouth bass cover usage follows a trend witnessed in recent years and it is thought that with recent increases in the abundance of aquatic vegetation in the lower North Anna River, largemouth bass appear to be shifting

from making nearly exclusive use of woody debris to dividing their use between woody debris and aquatic vegetation (Virginia Power 1996, 1997). Similarities observed in smallmouth bass cover usage in 1998 compare to those of 1995 and 1996 where usage was more evenly distributed between all cover types. For example, smallmouth bass were observed in associated with ledge, boulder, wood and vegetation during both 1995, 1996, and 1998 with the preferred or available cover in 1997 being wood and boulder material.

## 4.5 Conclusions

**1998 Studies**

- North Anna electrofishing surveys conducted in 1998 found numbers and biomass of fish collected at all four stations combined to be in the mid-range of the historical trend for the period 1981-1998.

- Species composition of the 1998 North Anna River electrofishing catch was similar to previous years with eight (8) species comprising 80% of the electrofishing catch in terms of numbers, and eight (8) species comprising 80% of the electrofishing catch in terms of biomass.

- Underwater observations of smallmouth bass and largemouth bass made in 1998 indicated smallmouth bass continue to dominate the lower reaches of the North Anna River below the North Anna Dam, and largemouth bass dominate the upper reaches.

- Lower numbers of YOY largemouth and smallmouth bass were observed at all stations during 1998. Fewer numbers may have been attributed to high river flows in the late winter and early spring months.

- Density estimates for juvenile and adult smallmouth bass and largemouth bass in 1998 varied between species and station location and were generally higher than those of 1997. Increased smallmouth bass densities were found at all stations while largemouth increases were noted at NAR-1 and NAR-5. Largemouth bass decreases were found at Nar-2 and NAR-4.

- Smallmouth bass in the uppermost reach (NAR-1) continue to demonstrate improved density populations when compared with 1996 and 1997; results, also, increases in annual densities since 1995 at NAR-2 may be indicative of a gradual movement of smallmouth upstream.

- Observations of cover use made in 1998 again illustrate that smallmouth bass and largemouth bass may segregate somewhat by habitat type. When a choice of cover is available, largemouth bass were primarily associated with wood and vegetation while smallmouth bass were found near wood, boulders, and in open water.

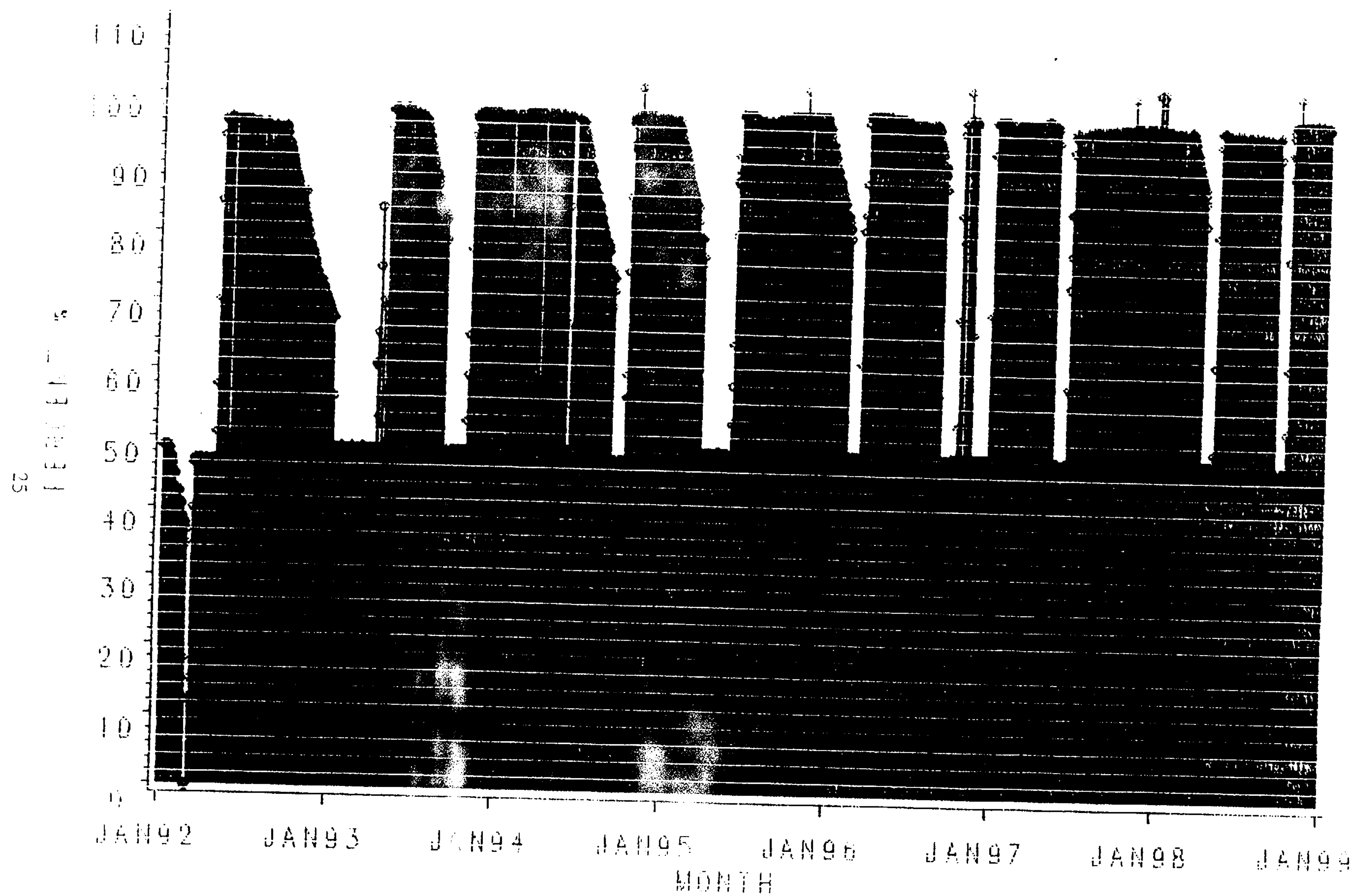
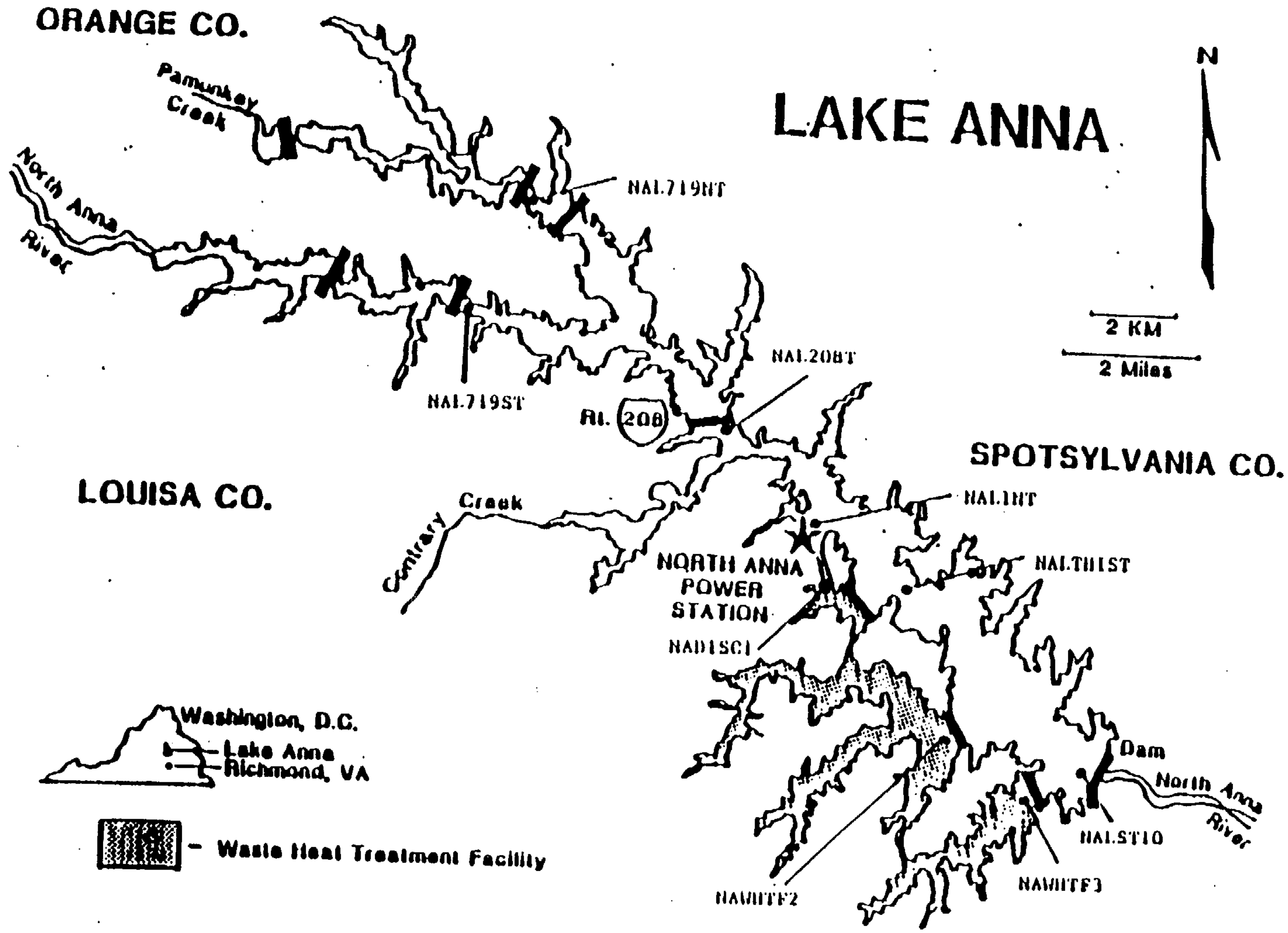
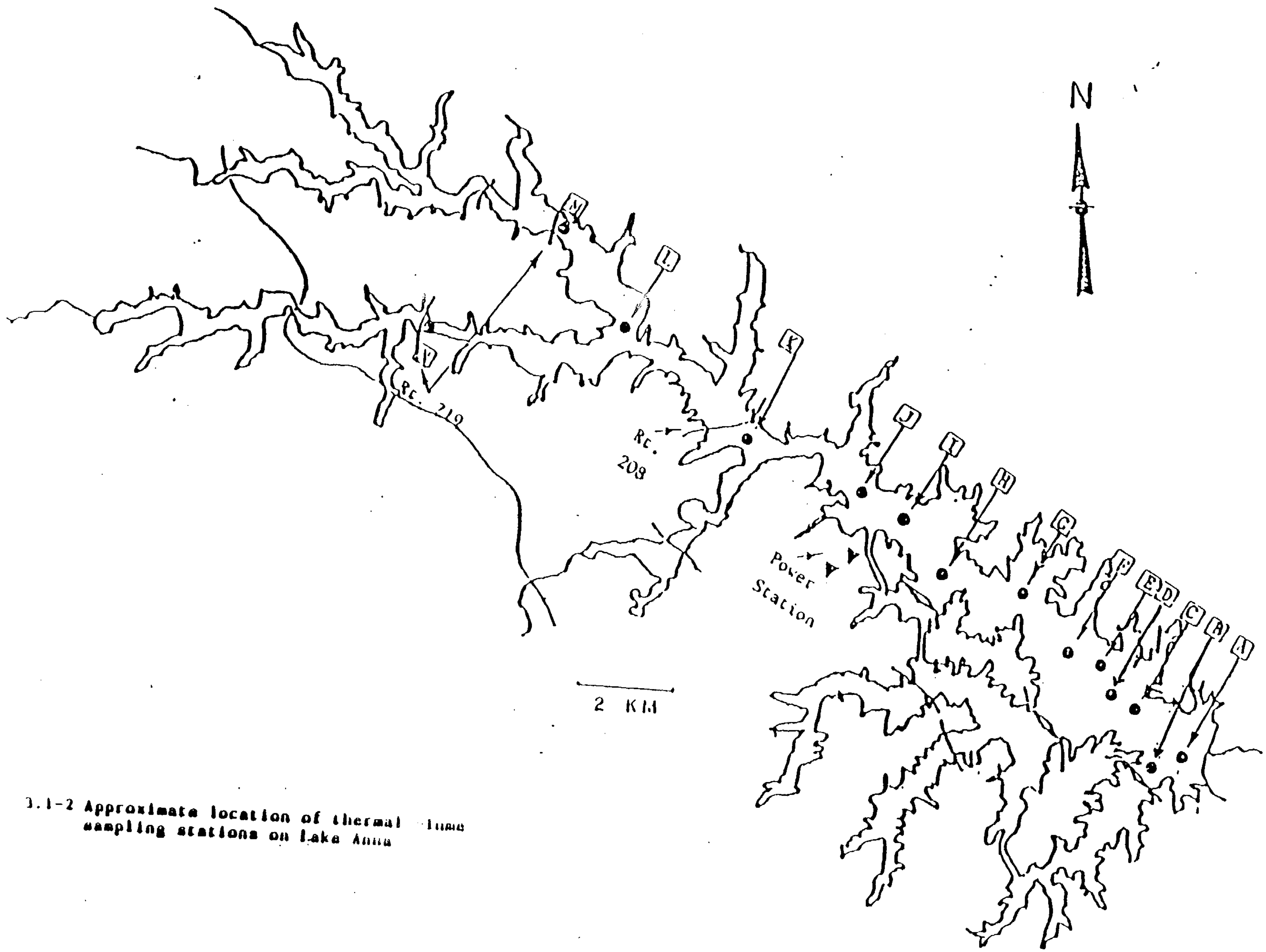


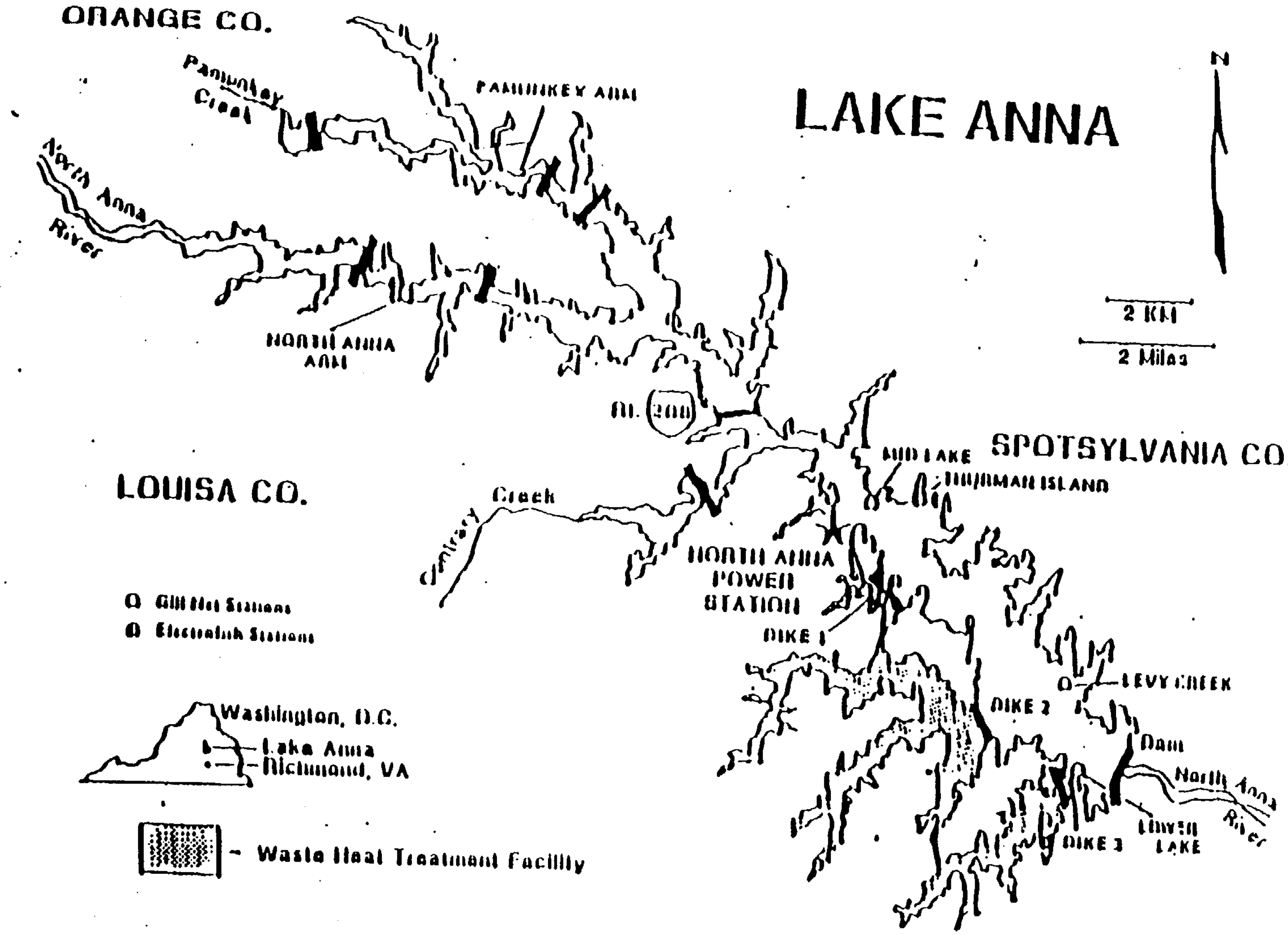

FIGURE 2.0-1. 1992-1998 NORTH ANNA UNITS 1 & 2 DAILY POWER LEVEL




3.1-1 Approximate locations of fixed Endeco temperature recorders on Lake Anna.

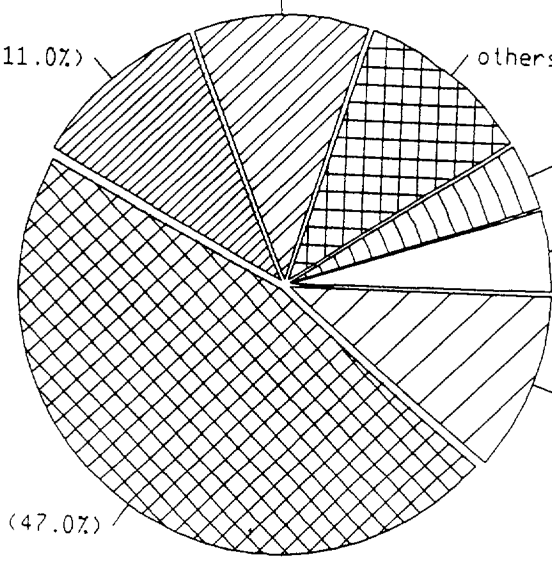



3.1-2 Approximate location of thermal plume sampling stations on Lake Anna




3.2-1 Location of electrofish and gill net stations.

## FIGURE 3.2-2 GILL NET RESULTS
LAKE 1998
(% BY WEIGHT)




## GILL NET RESULTS
LAKE ANNA 1998
(% BY NUMBER)

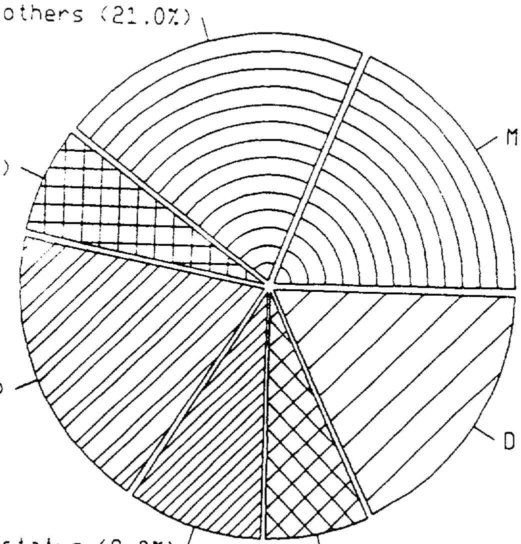
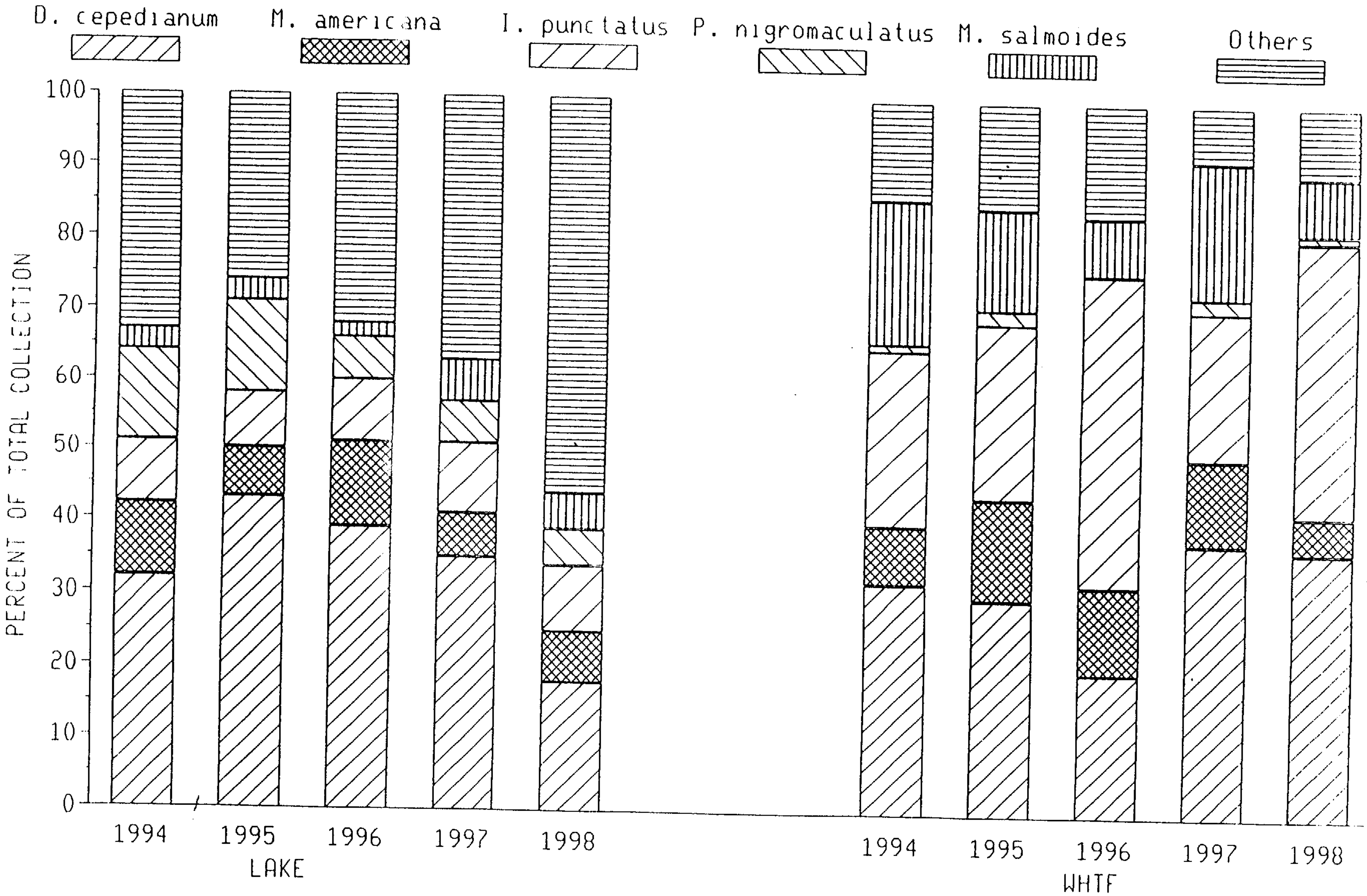


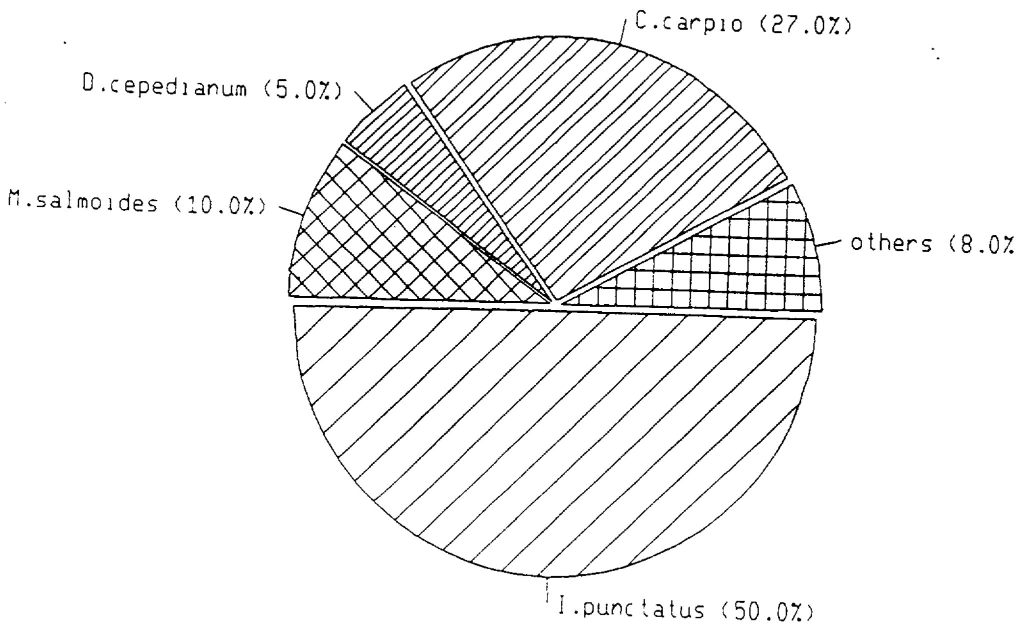
FIGURE 3.2-3 COMPOSITION OF GILL NET DATA FOR LAKE ANNA AND WHTF (1994-1998)



## FIGURE 3.2-4 GILL NET RESULTS

WHTF 1998

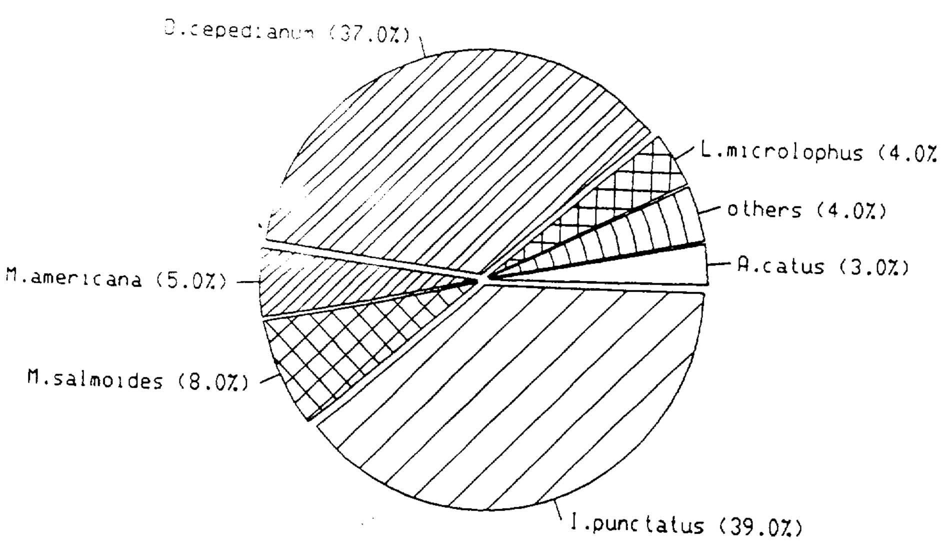
(% BY WEIGHT)




## GILL NET RESULTS

WHTF 1998

(% BY NUMBER)



# FIGURE 3.2-5 CATCH PER UNIT EFFORT

## ELECTROFISH & GILL NET COLLECTION

Lake Anna, 1981 - 1998

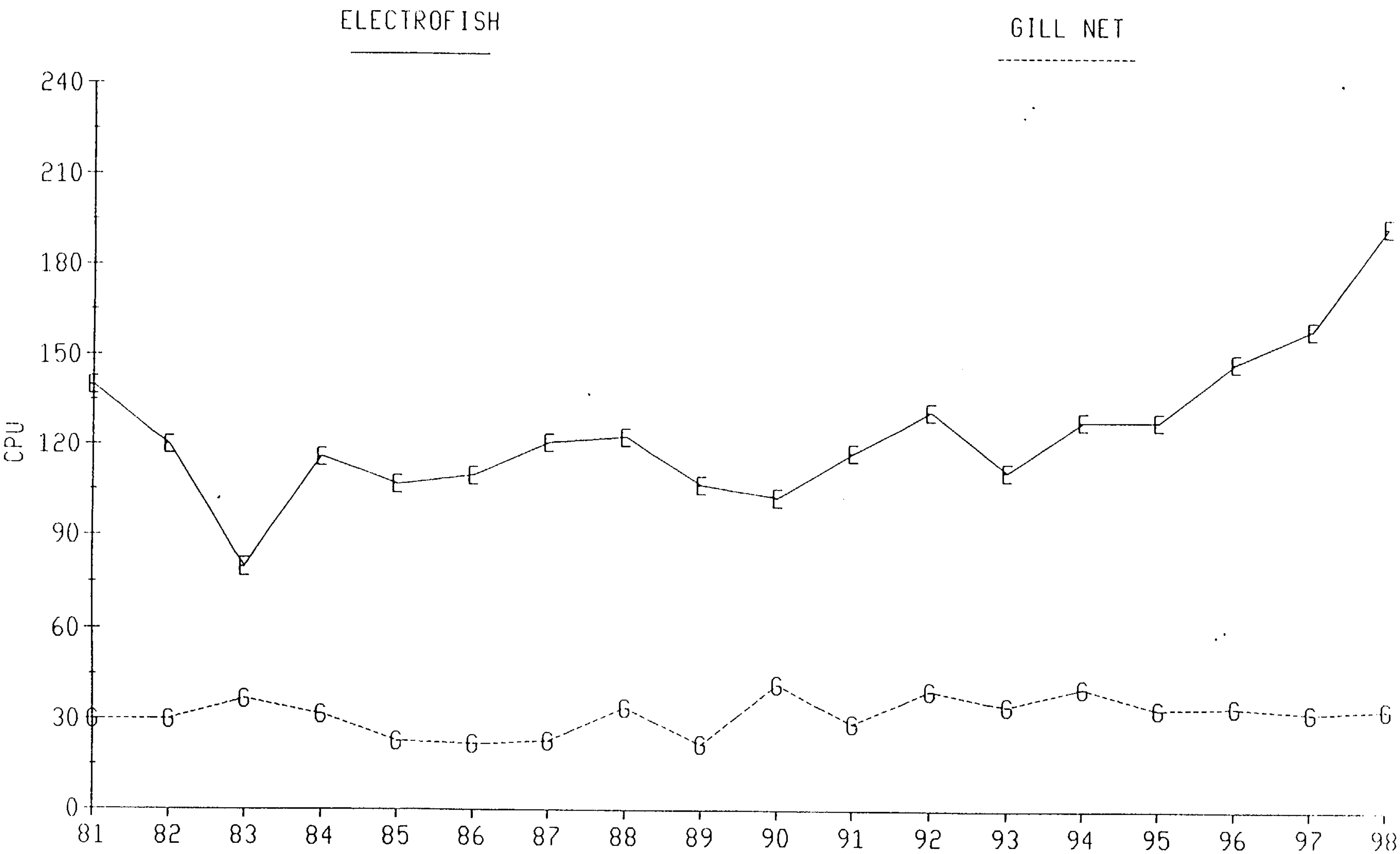


FIGURE 3.2-6 LAKE ANNA GILL NET DATA (1981-1998)
AVERAGE NUMBER AND AVERAGE WEIGHT(kg) YEAR

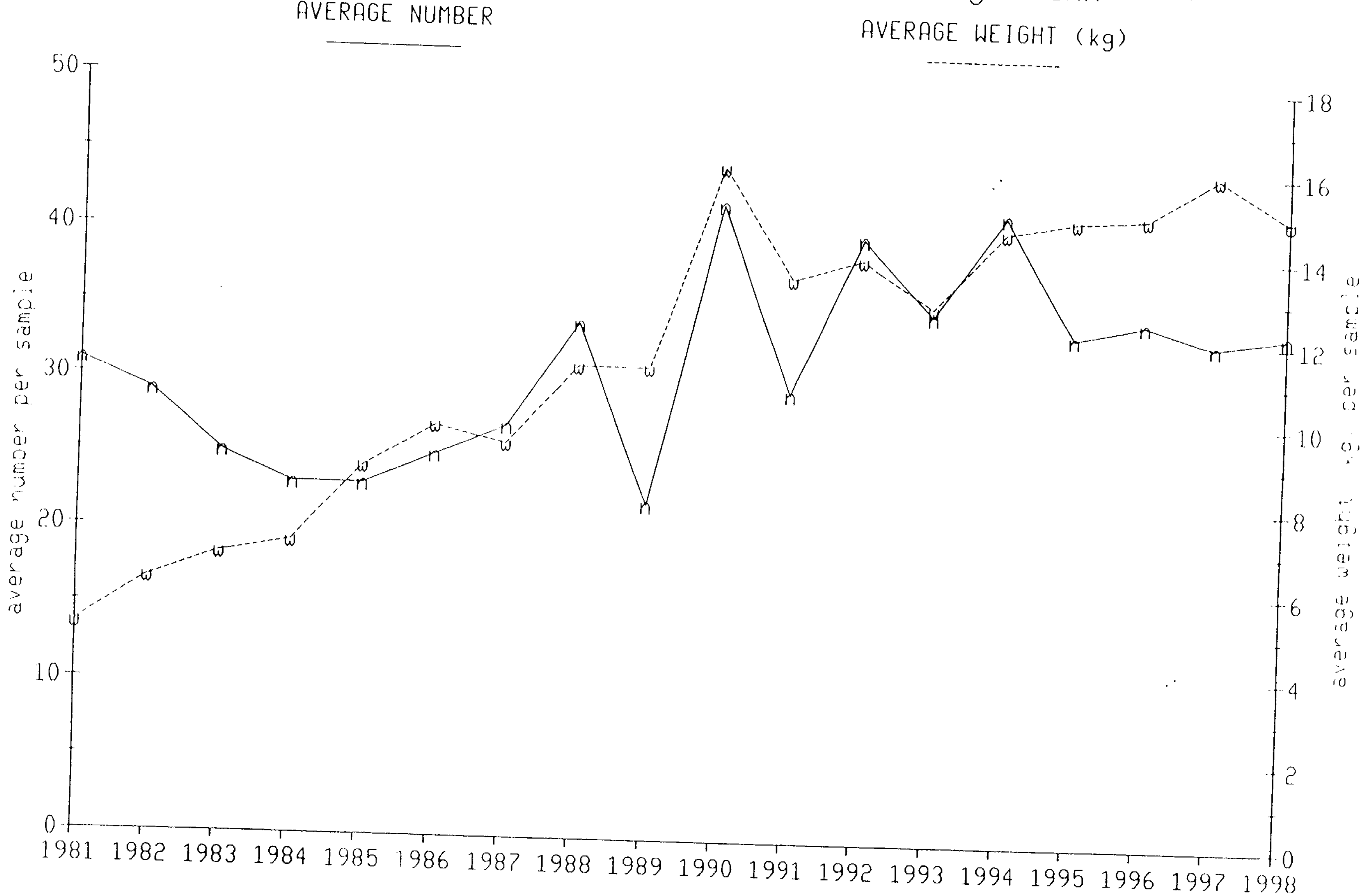
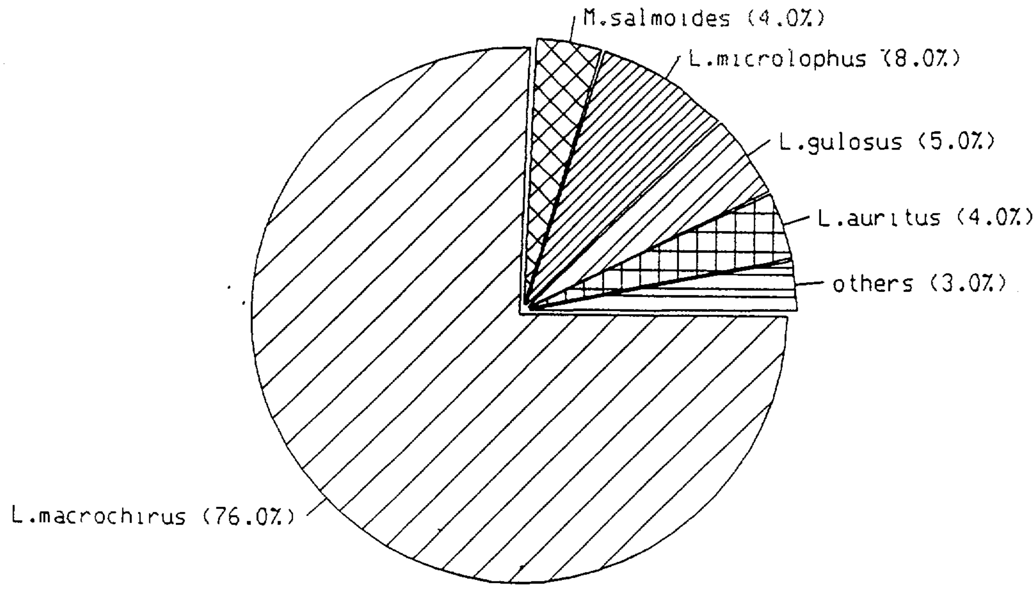


FIGURE 3.3-1. ELECTROFISH RESULTS

LAKE ANNA 1998

(% BY NUMBER)




ELECTROFISH RESULTS

LAKE ANNA 1998

(% BY WEIGHT)

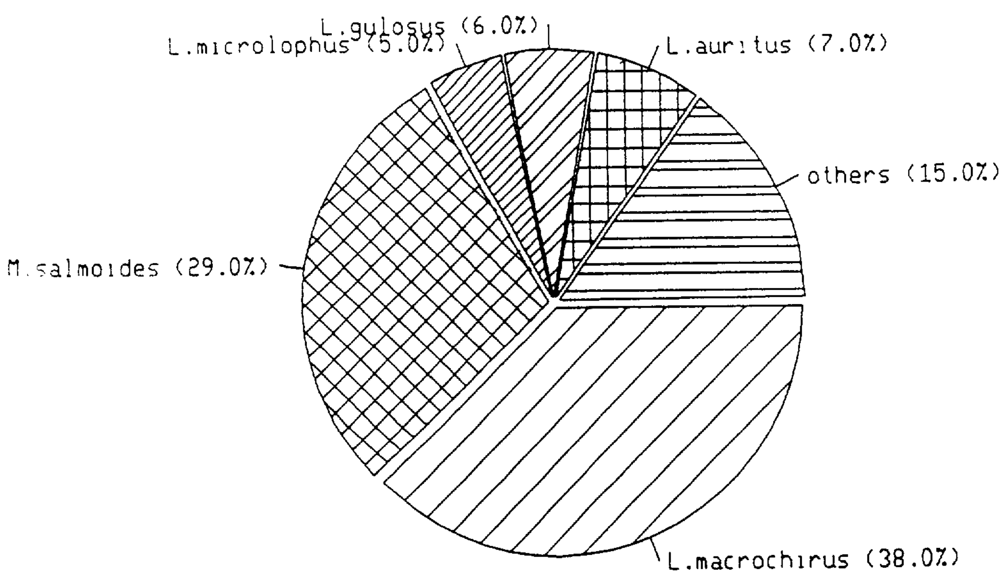
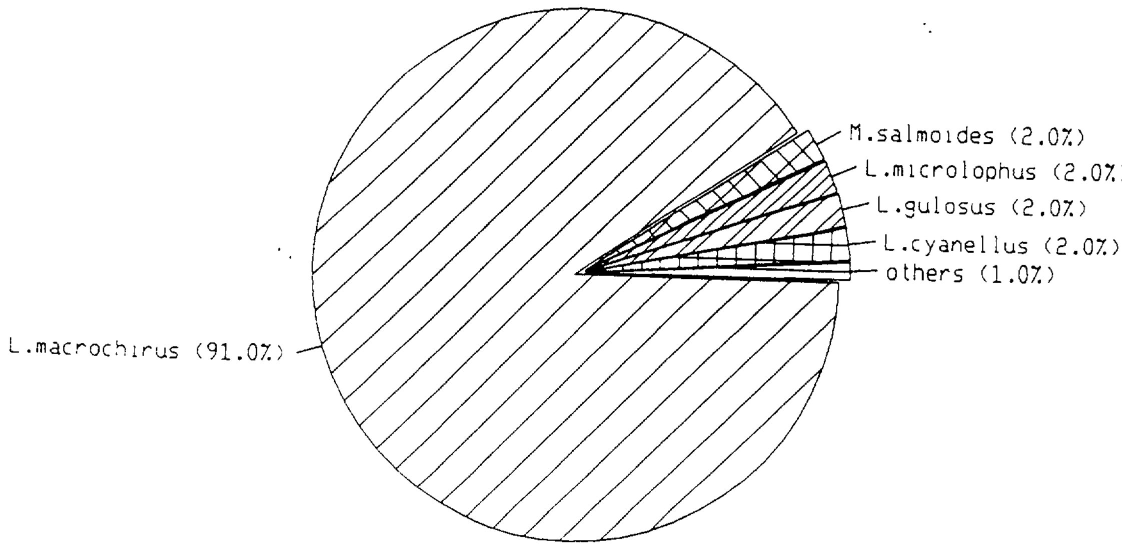


FIGURE 3.3-2. ELECTROFISH RESULTS
WHTF 1998
(% BY NUMBER)




ELECTROFISH RESULTS
WHTF 1998
(% BY WEIGHT)

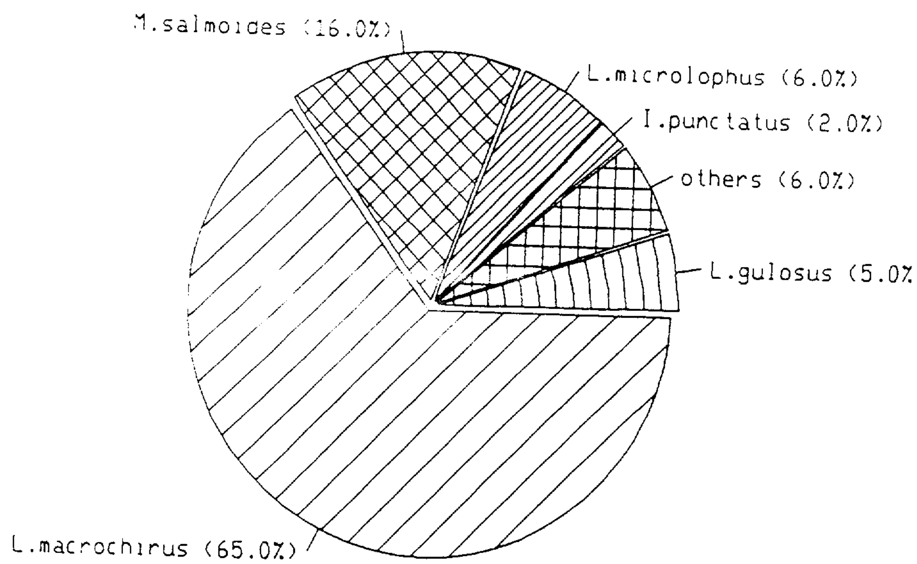


FIGURE 3.3-3 COMPOSITION OF ELECTROFISHING DATA FOR LAKE ANNA AND WHTF, (1994-1998)

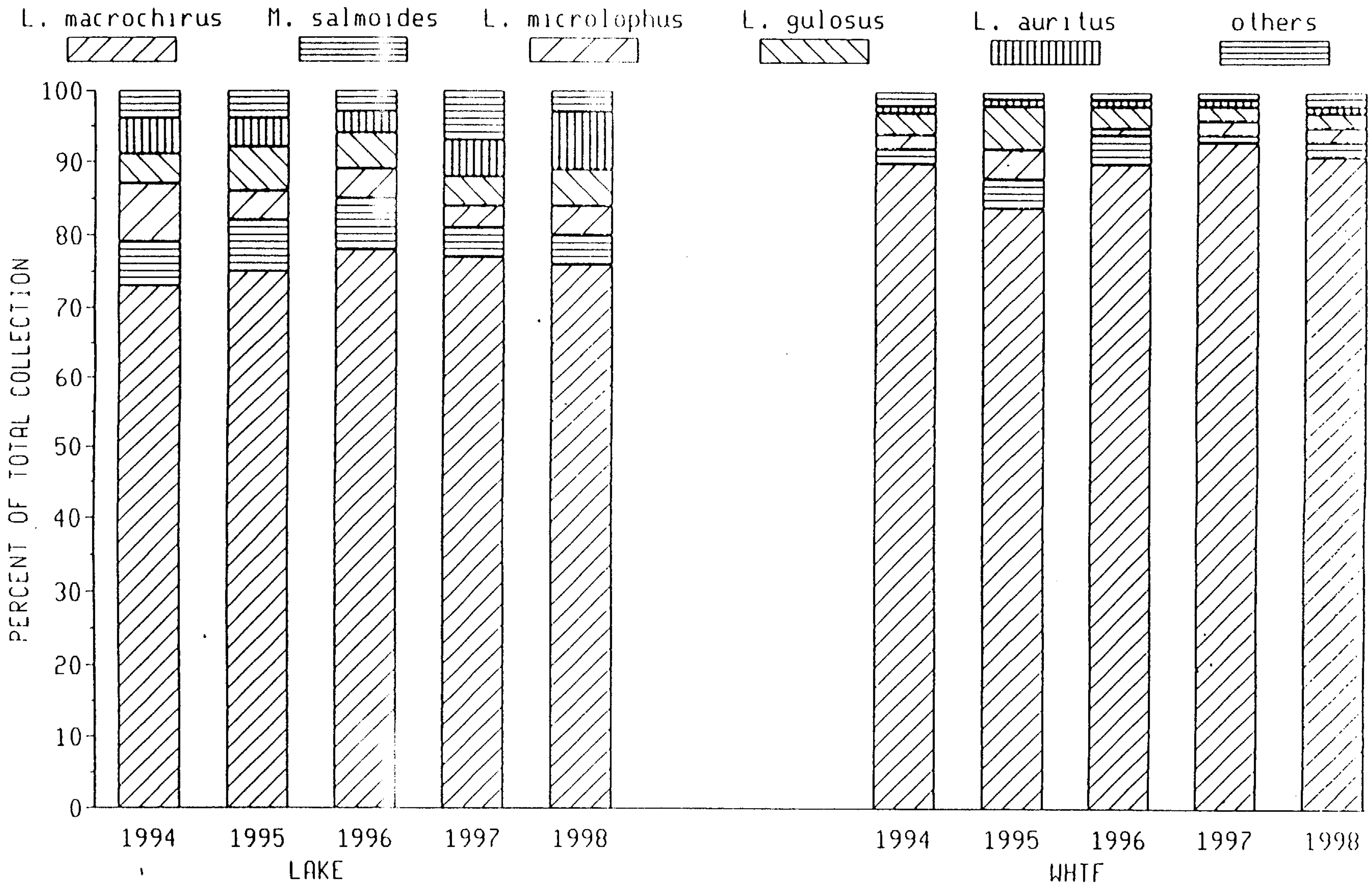
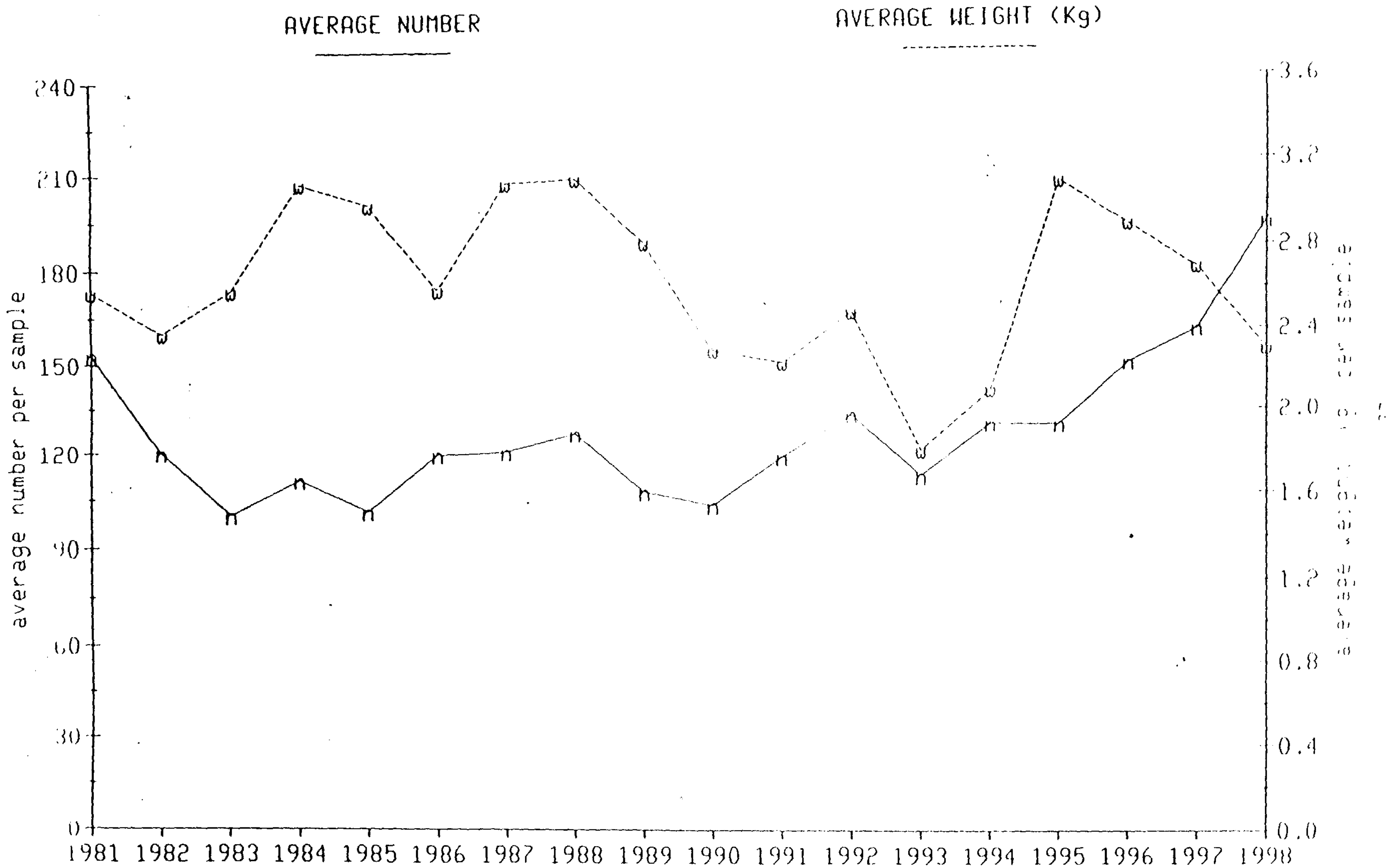
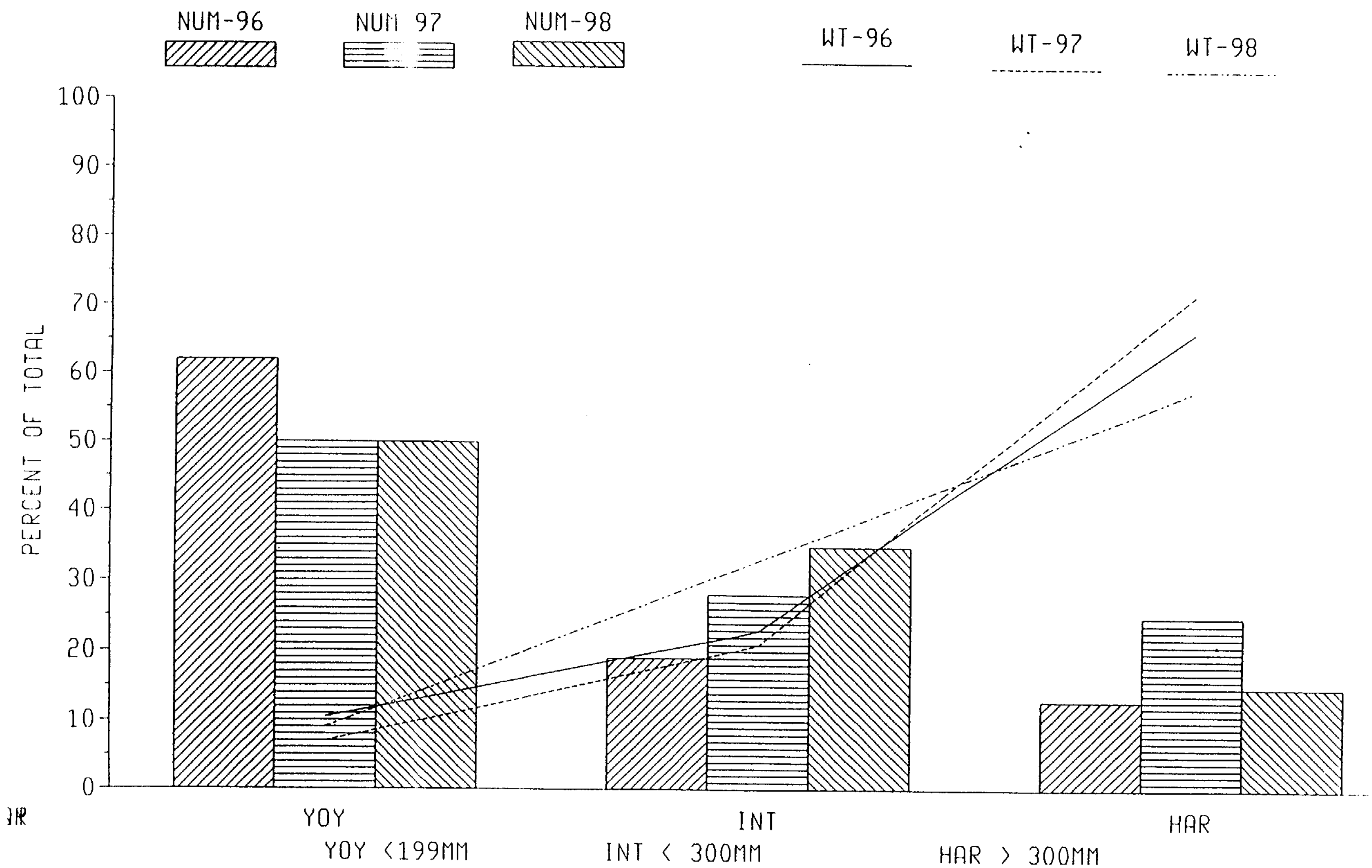


FIGURE 3.3-4 LAKE ANNA ELECTROFISH DATA (1981-1998)
AVERAGE NUMBER AND AVERAGE WEIGHT(kg) YEAR



# FIGURE 3.3-5 COMPOSITION OF LMB CATCH
(LAKE ANNA 1996-1998)



# FIGURE 3.3-6 COMPOSITION OF BLUEGILL CATCH

(LAKE ANNA 1996-1998)

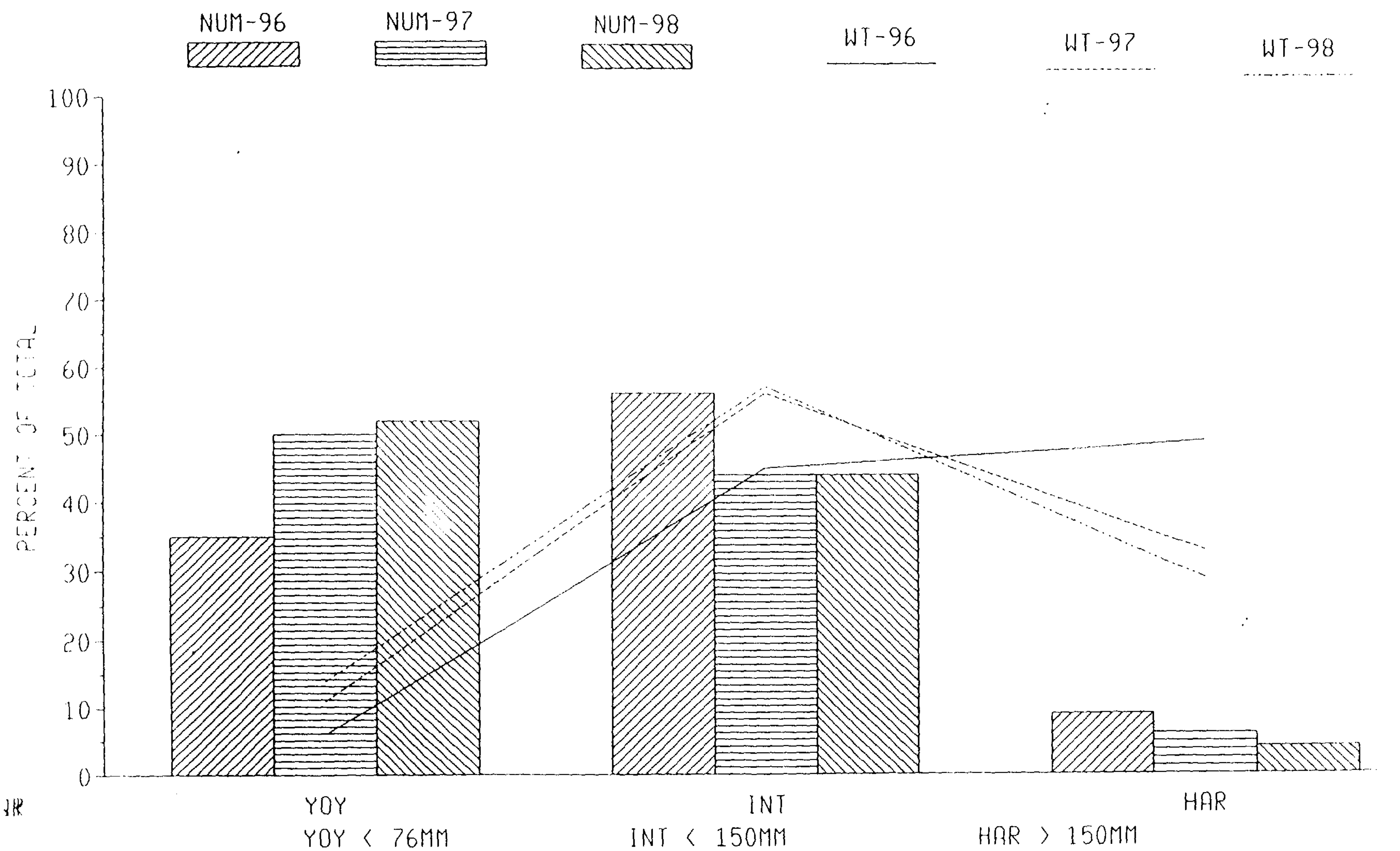


FIGURE 3.4-1 HYDRILLA SUMMARY 1991 - 1998

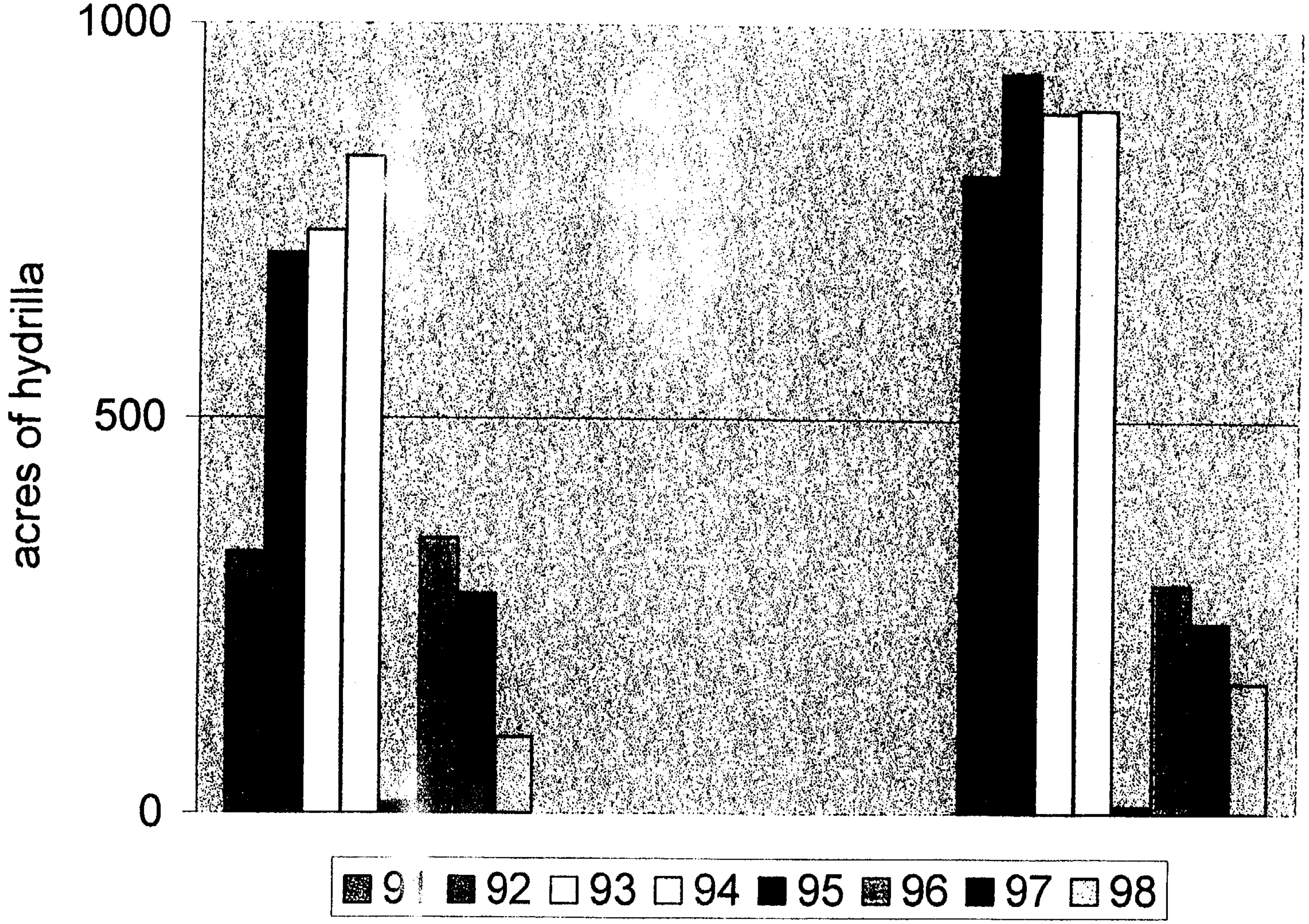


FIGURE 3.4-2 Lake Anna above Route 208 Bridge indicating hydrilla beds in 1998

FIGURE 3.4-3 Lake Anna below Route 208 Bridge indicating hydrilla beds in 1998

FIGURE 3.4- 4 Lake Anna Lagoon 1 indicating hydrilla during 1998

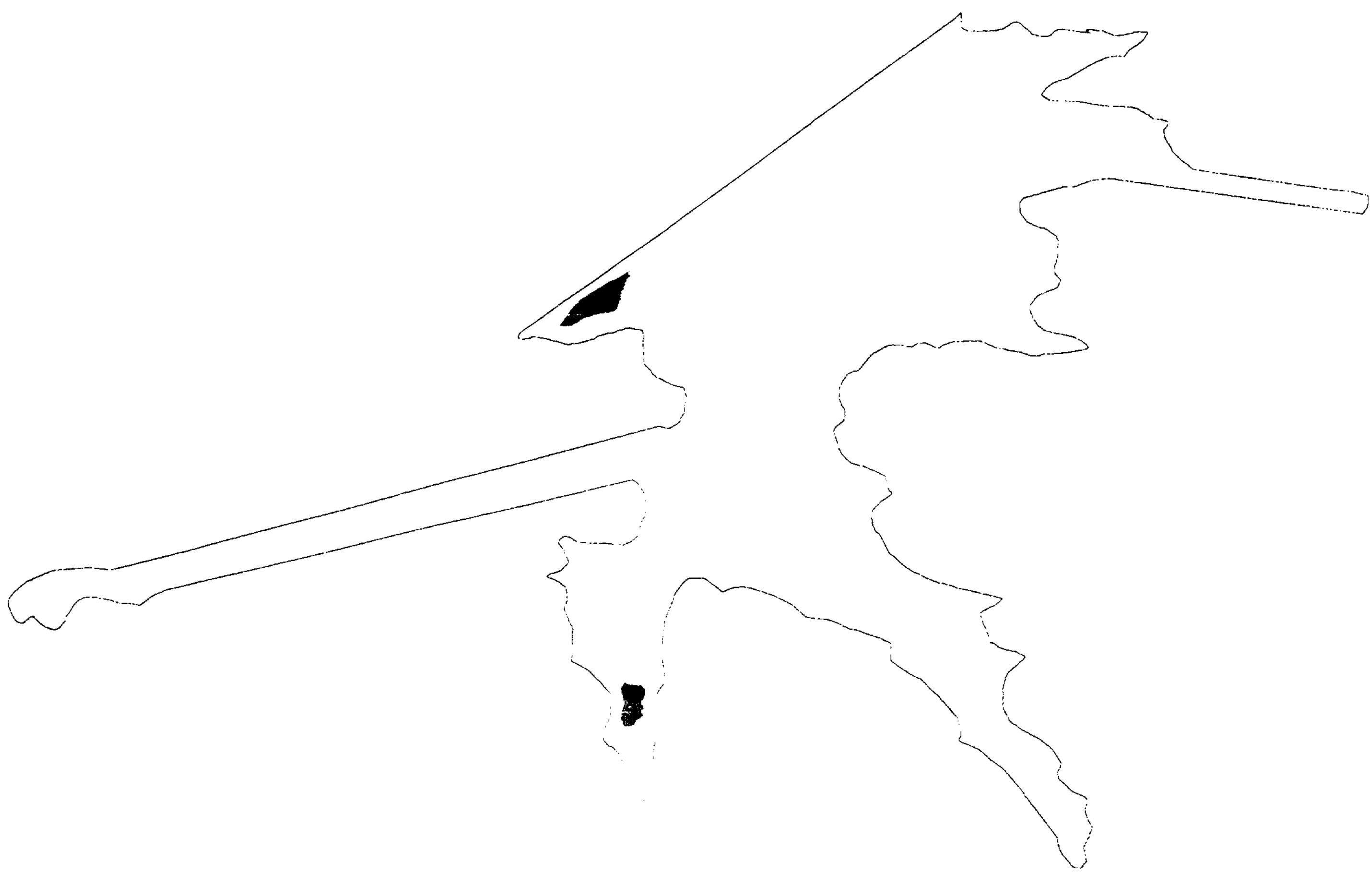


FIGURE 3.4-5 Lake Anna Lagoon 2 indicating hydrilla during 1998

FIGURE 3.4-6 Lake Anna Lagoon 3 indicating hydrilla during 1998

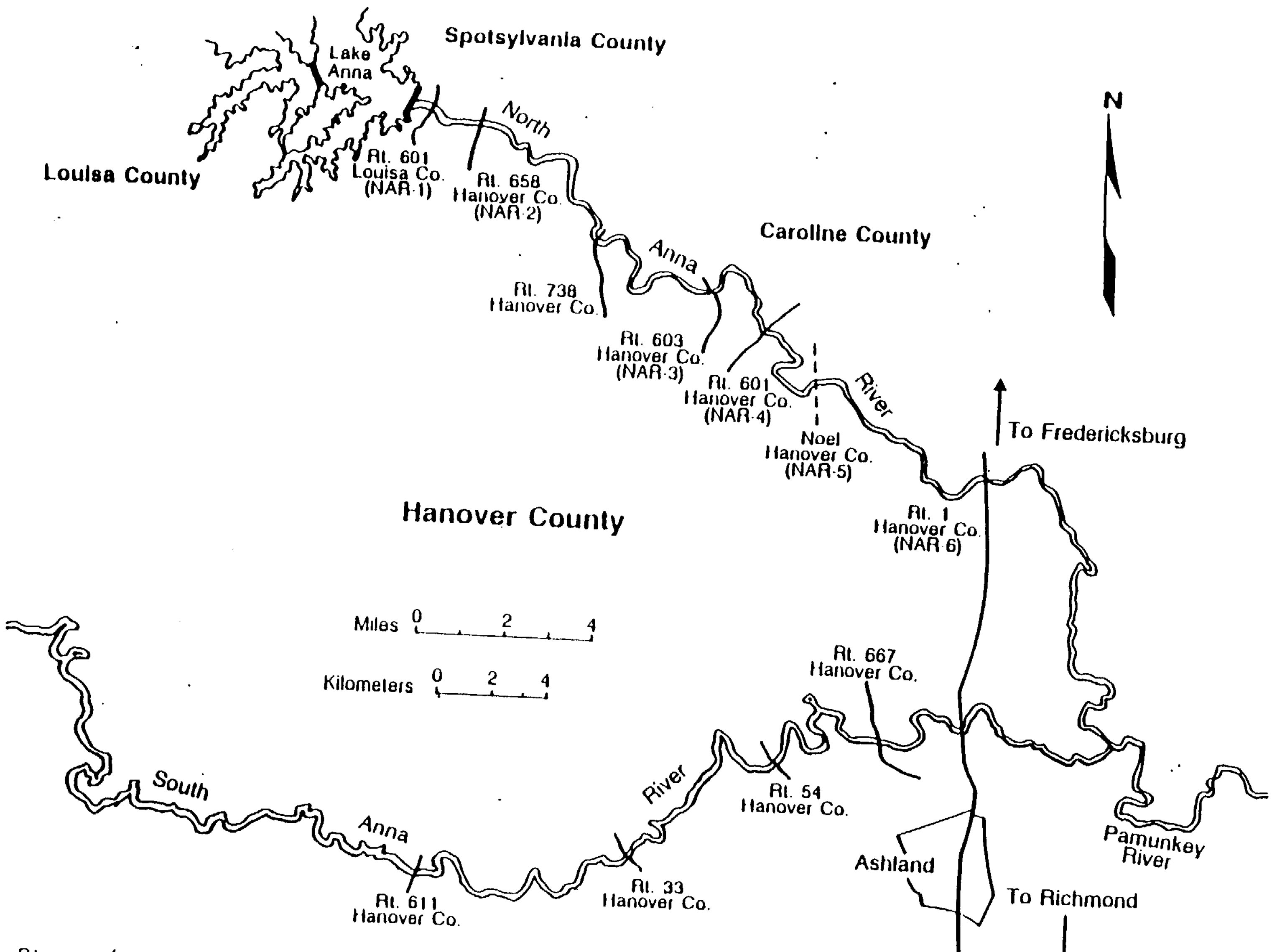



Figure 4.1-1. Location of North Anna River temperature recording, electrofishing, and snorkel survey stations.

Figure 4.1-2. Minimum, mean, and maximum discharge in the lower North Anna River during calendar year 1998. (USGS Station Number 01671020)

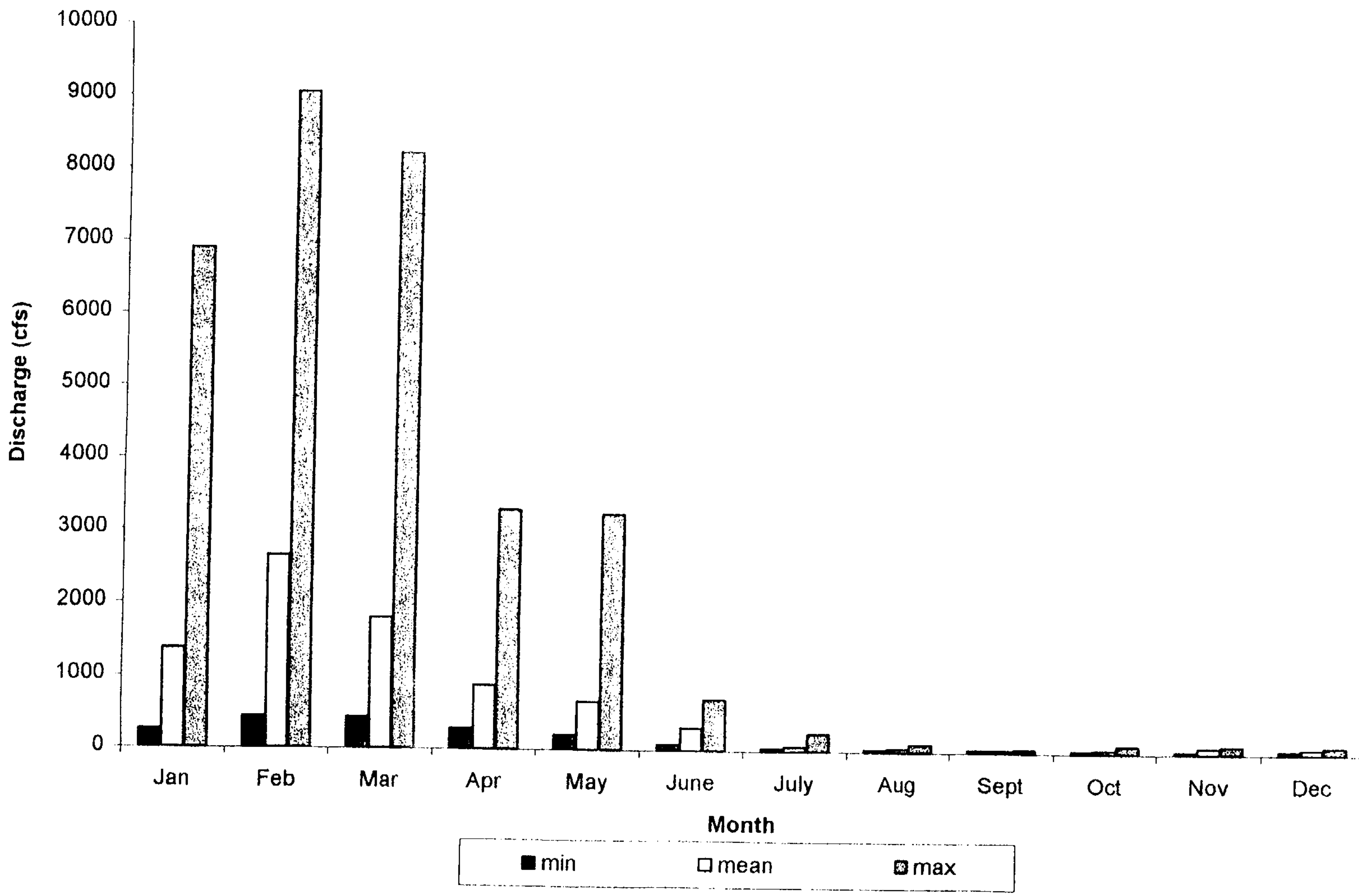


Figure 4.2-1. Number of fish collected annually from the North Anna River during electrofishing surveys, 1981-1998.

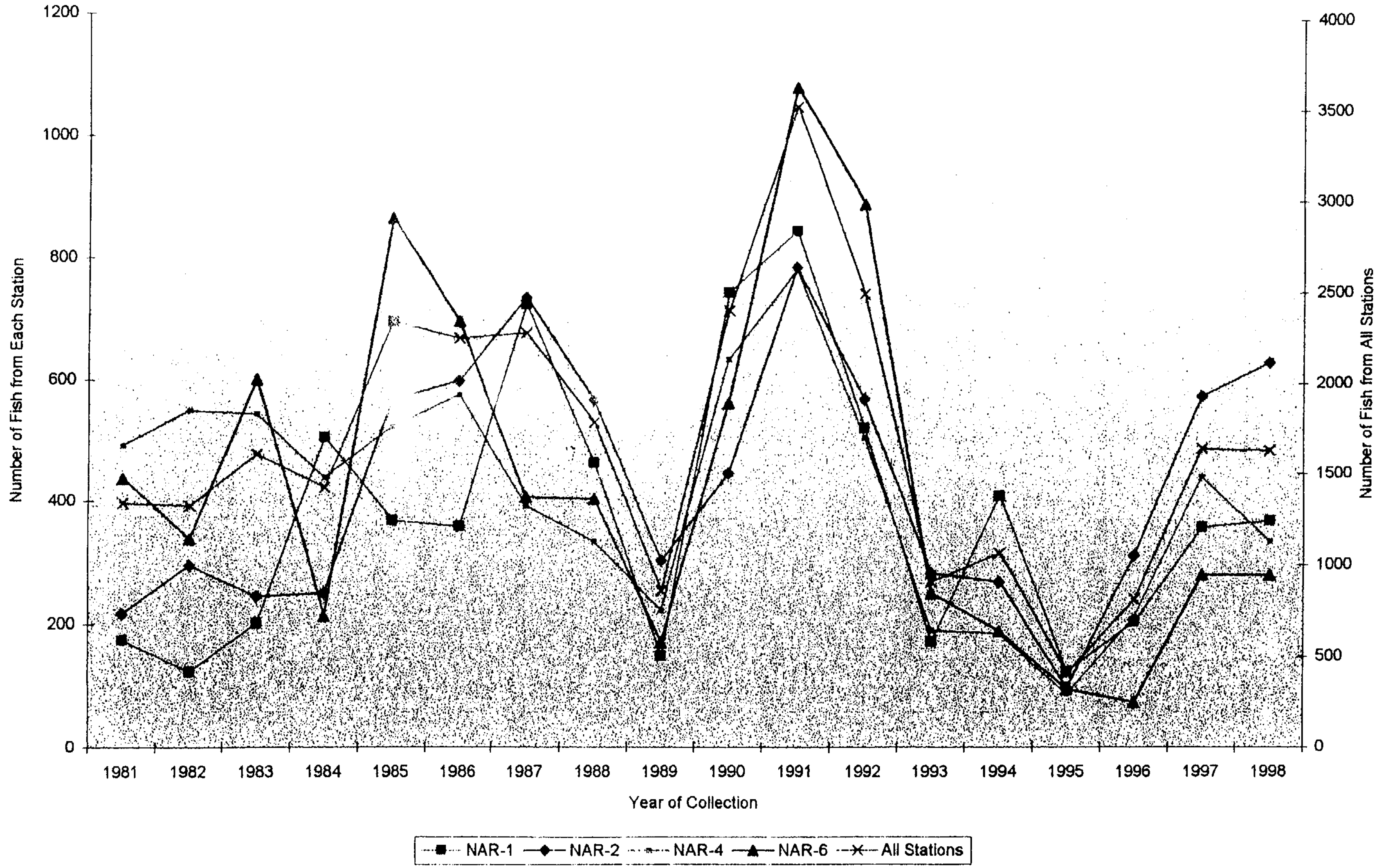


**Figure 4.3-1. NAR-1 smallmouth and largemouth bass median densities, and mean visibility, 1987-1998.**

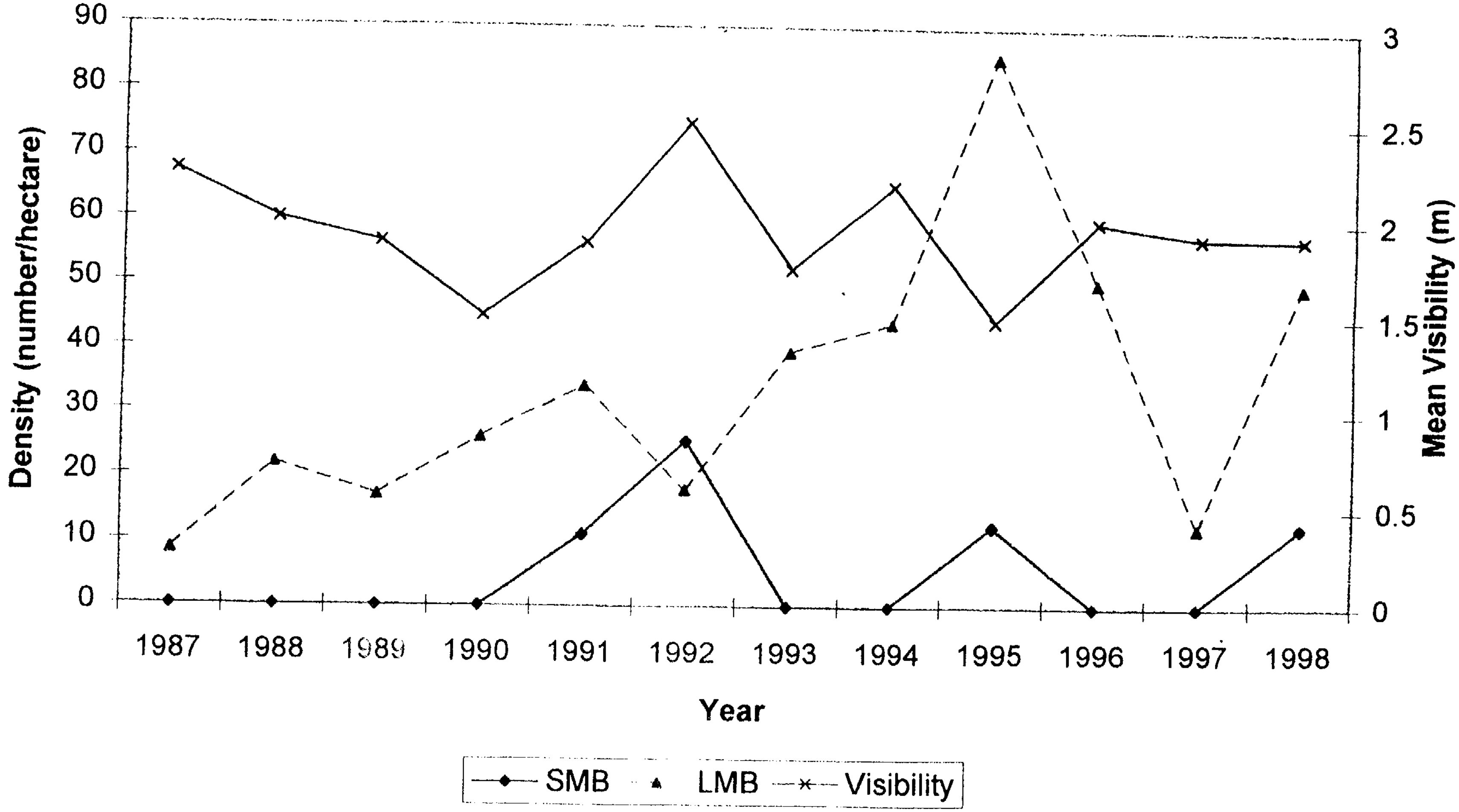


**Figure 4. 3-2. NAR-2 smallmouth and largemouth bass median densities, and mean visibilities, 1987-1998.**

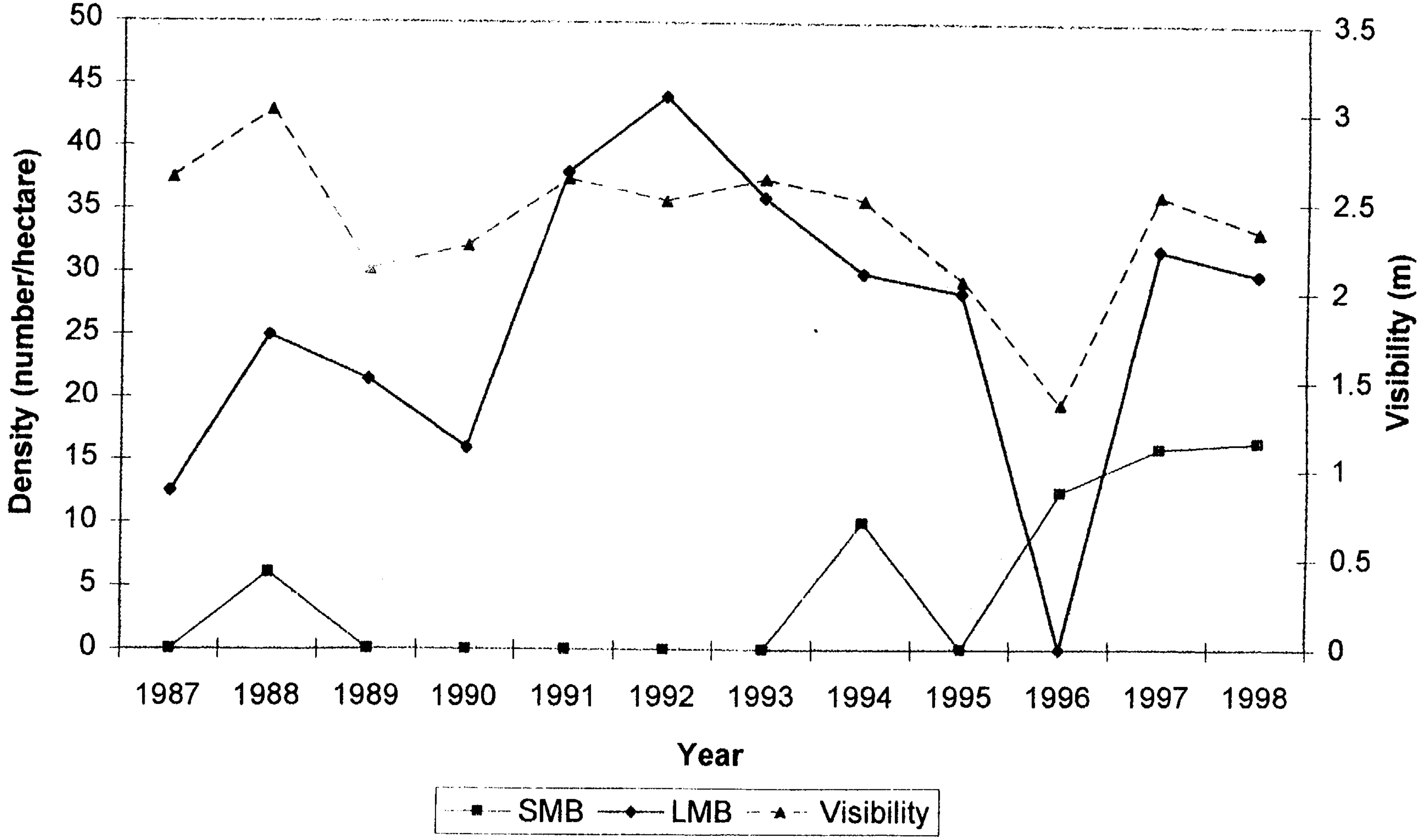


**Figure 4. 3-3. N R-4 smallmou and largemouth bass median densities, and mean visibilities, 1987-1998.**

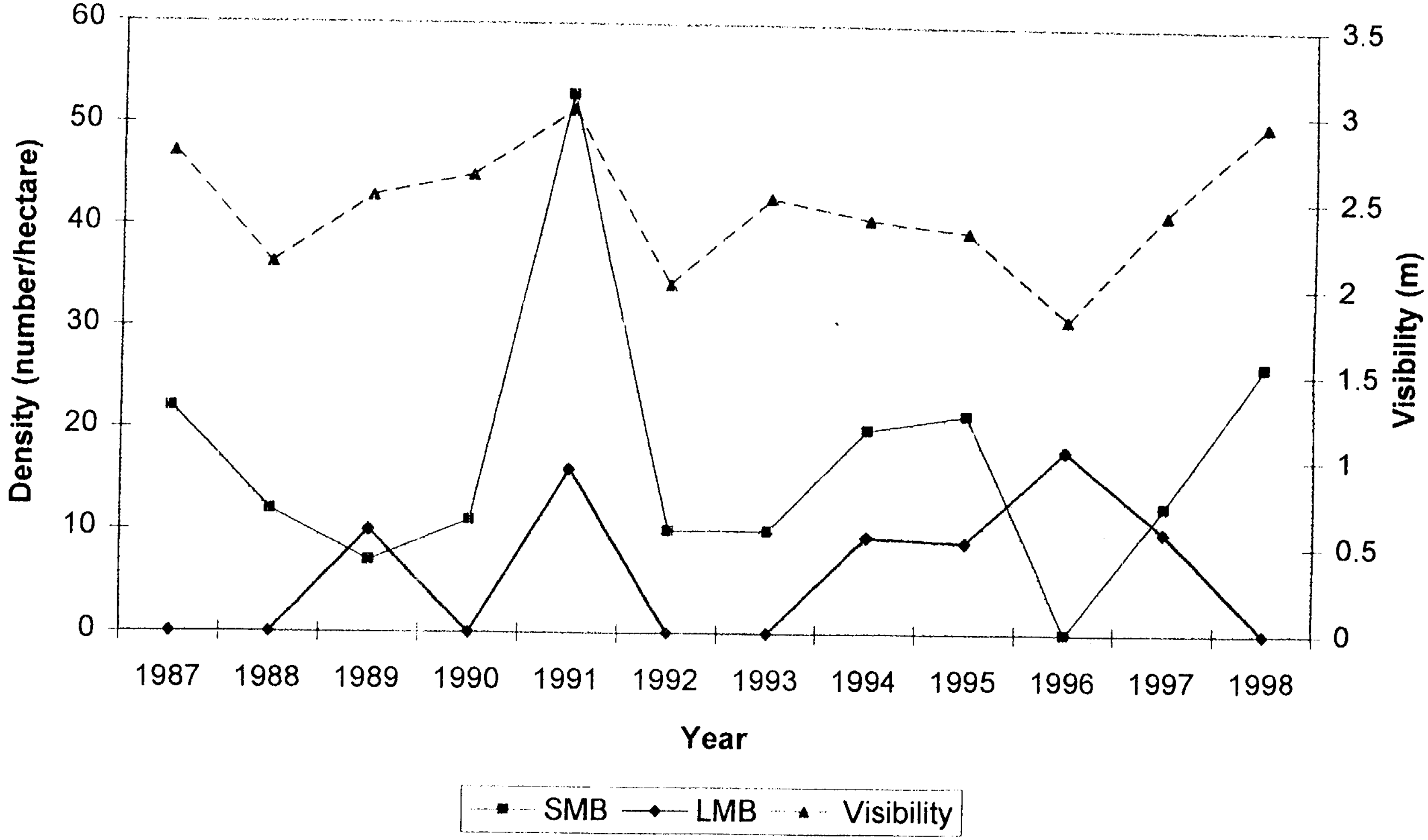


**Figure 4. 3-4 . NAR-5 smallmouth and largemouth bass median densities, and mean visibilities, 1987-1998.**