ENVIRONMENTAL STUDY OF LAKE ANNA

AND THE LOWER NORTH ANNA RIVER

ANNUAL REPORT FOR 1999

Prepared by:

ENVIRONMENTAL BIOLOGY

ENVIRONMENTAL POLICY & COMPLIANCE

In an effort to conserve our natural resources, this report is being printed on both sides of recycled paper.

TABLE OF CONTENTS

PAGE

Executive Summary

Following the successful completion of the North Anna Power Station 316(a) Demonstration in 1986, Dominion (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 1999, the second year of the three year study period 1998-2000.

Station generation for 1999 was again outstanding with levels reaching the second highest yearly average for capacity since 1978 when the station began commercial operation. Water temperature and fish community data for 1999 both in the lake and downstream were similar to historical data. For example, numbers of fish collected in lake electrofishing surveys in 1999 returned to the historical ranges after record high numbers were recorded in 1998. It was theorized that low lake levels in 1998 concentrated bluegill sunfish Lepomis macrochirus at several sample sites resulting in the relatively large numbers of fish collected that year. The sampling for 1999 occurred at or near normal lake level. Numbers of fish collected by gill netting in 1999 were lower than in 1998 but similar to historical data. In 1999, Lake Anna anglers reported 73 citation largemouth bass Micropterus salmoides (greater than 55.9 cm in length or 3.6/g in weight) ranking Lake Anna as the third best trophy bass lake in the state.

The 1999 hydrilla Hydrilla verticillata survey indicated a minimal increase in acreage in the lake and a decrease in Waste Heat Treatment Facility (WHTF) acreage when compared to 1998 totals. Further, 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, numbers of fish collected by electrofishing increased relative to 1998 at all four sampling stations and were in the mid range of totals reported for the period 1981-1998. Underwater observations of largemouth bass and smallmouth bass in 1999 showed largemouth bass to be more abundant in the upper reaches of the river below Lake Anna with smallmouth bass more abundant in the lower reaches. Density estimates for both largemouth bass and smallmouth bass in 1999 were above average when compared to data from previous years.

Overall, the data collected in 1999 reveal that no major changes occurred in the lake or river ecosystem. The review of the data from the 1999 monitoring studies indicate that Lake Anna and the North Anna River continue to contain healthy, well-balanced ecological communities.

List of Figures

List of Figures (cont.)

List of Figures (cont.)

List of Tables

List of Tables (cont.)

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 lake.

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 1999, the second 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 92% of capacity for 1999. This represents the second highest yearly average for the station since it began commercial operation in 1978. The station operated at 97% of capacity for the first quarter and 93% for the fourth quarter. The station's two units set a national record for Westinghouse pressurized water reactors by operating continuously for 340 days, surpassing the old record of 312 days set by Commonwealth Edison's Byron Station. NAPS ended its record breaking run in September when Unit 2 was removed for service and refueling (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, 1988-1998).

3.0 Lake Anna

3.1 Temperature

Methods

Lake water temperature data in 1999 were collected using continuous monitors (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 1999 is presented in Table 3.1-1 as monthly 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 maximum temperature recorded for the lake in 1999 by continuous monitors was 31.3°C in August at Station NALTHIST which is located near mid-lake (Table 3.1-1). The lowest temperatures recorded was 4.8°C in January at Station NAL719NT which is located on the Pamunkey arm of the upper lake. These 1999 high and low temperatures as well the monthly temperature data in Table 3.1-1 are within the ranges of data reported in previous years.

The instantaneous temperature surveys were conducted in March and July to provide temperature data to assess seasonal thermal stratification patterns in the lake. The March survey data showed little stratification (Table 3.1-2). Temperatures varied less than 1°C surface to bottom at all stations with the exception of Station A. The difference for Station A, which is the deepest station at the dam, was 1.4°C. The July survey results show a thermocline at the 14 to 18 meter depth in the lower lake which was not present in the more shallow, upper portion of the lake. This stratification pattern in the lake is not unusual and is similar to previously reported patterns (Virginia Power 1986-1998).

Overall, temperatures recorded in the lake for 1999 were similar in both range and seasonal pattern to those recorded in 1998 and are likewise consistent with previously reported data (Virginia Power, 1998).

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 1999 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. Similar to previous years, 1999 gill net surveys were conducted during February, May, August, and October 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 (μmhos) were recorded at the time of each sample collection (Table 3.2-1).

Results

Sixteen (16) species of fish representing seven (7) families were collected in Lake Anna and the WHTF by quarterly gill netting in 1999 (Table 3.2-2). A total of 670 fish weighing 296.7 kg was collected from four stations in the lake and two stations in the WHTF. Of the 670 fish collected, 483 (223.0 kg) were collected in the lake and 187 (73.4

kg) in the WHTF (Table 3.2-3). Both the numerical total and the weight total collected in 1999 were lower than totals collected in 1998 (817 fish weighing 360.8 kg).

Figure 3.2-2 graphically presents the relative percentages of numbers and weights of species collected by gill netting in 1999. The numerically dominant species collected in the lake was gizzard shad Dorosoma cepedianum, followed by striped bass Morone saxatilis and white catfish Ameriurus catus. These results are similar to data collected in 1998 and 1997 when gizzard shad and striped bass were ranked as the most numerous fishes and are also consistent with other previous results (Figure 3.2-3).

When the 1999 weight data are compared, the dominant species in the lake in terms of biomass was striped bass followed by common carp Cyprinus carpio and gizzard shad. These data are similar to 1997 data with striped bass and gizzard shad ranking number one and three respectively (Virginia Power 1998).

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. These species have ranked among the top three numerically dominant species collected in each of the last six years (Figure 3.2-3). The weight-dominant species in the WHTF for 1999 was gizzard shad followed by common carp and channel catfish (Figure 3.2-4). These data likewise are similar to 1997 and 1998 which found the same species ranked in the top three (Virginia Power, 1996, 1997).

The catch per unit effort (CPUE) for gill netting for all stations combined was 27.9 fish per net in 1999 compared to 34.0 fish per net in 1998 and 33.4 fish per net in 1997 (Figure 3.2-5). The 1999 average weight of fish collected per gill netting sample also decreased relative to recent years, however these values fall well within historical ranges (Figure 3.2-6).

When the 1999 gill netting data are examined seasonally, the May collection yielded the greatest number and weight of fish collected representing 35% of the total number of fish collected and 34% of the total weight of fish collected (Table 3.2-4). Table 3.2-4 also includes the average number and weight of fish collected per survey for stations in both the lake and WHTF. The average number of fish collected per survey at each station ranged from a low of 15 fish recorded at the Dike 3 - Lake station to a high of 56 recorded at the North Anna Arm Station. The highest number in 1999 for any single set was 83 (48% gizzard shad) recorded in May at the same North Anna Arm Station. The average weight of fish collected per survey during 1999 ranged from a low of 6.3 kg recorded at the Dike 3 - Lake Station to a high of 29.7 kg recorded at the North Anna Arm Station. The greatest weight for any single set in 1999 was 44.2 kg recorded in May at the North Anna Arm Station (88% striped bass).

3.3 Fish Population Studies - Electrofishing

Methods

Boat electrofishing was used in 1999 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. Sampling was performed in February, June, August, and November at the stations identified in Figure 3.2-1. Each station is 100 meters in length and normally includes 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 3.2-1).

Results

Twenty (20) species of fish representing eight (8) families were collected by electrofishing operations in the lake and WHTF in 1999 (Table 3.3-1). A total of 5,277 fish weighing 106.9 kg was collected from the five stations in the lake and the four stations in the WHTF during the 1999 sampling period. Of the 5,277 fish collected, 2,491 (71.8 kg) were collected from the lake and 2,786 (35.1 kg) were collected from the WHTF (Table 3.3-8). The total number of fish collected in 1999 (5,277) was lower than the total number collected in 1998 (6,991) yet the total weight of fish collected in 1999 (106.9 kg) was higher than in 1998 (83.1 kg). In 1998, Lake Anna fell to 2.6′ below normal pool for an extended period. This relatively extreme low lake level consequently dewatered much of the shallow shoreline habitat and may have concentrated the smaller bluegill along the rip-rap stations. The large numbers of bluegill collected at dike stations in the last two quarters of 1998 support this hypothesis. During 1999 the lake levels were at or near full pool for the third and fourth quarter sampling. Numbers of bluegill collected during these two quarters in 1999 were well below the 1998 totals and account for the reduction in total annual catch.

The numerically dominant species collected in both the lake and WHTF was the bluegill Lepomis macrochirus (Figures 3.3-1 and 3.3-2). Bluegill ranked first in weight in the WHTF, followed by largemouth bass. In the lake, largemouth bass ranked first in weight followed by bluegill. These results are similar to those of 1998 and 1997 as well as those in the historical records (Virginia Power, 1988-1999). The overall species composition of the fish assemblage in 1999 was similar to 1998 also following the historical trend for both the lake and WHTF (Figure 3.3-3).

The 1999 electrofishing data are summarized by each individual station for number and weight for each survey in Table 3.3-3. The average number of fish collected per survey at each station ranged from a low of 79 at the North Anna Arm Station to a high of 322 at Dike 1-WHTF. The greatest average weight per collection was 8.0 kg recorded at the Thurman Island Station. The highest weight collected per station per survey in 1999 was 22.5 kg (63% largemouth bass) recorded in February at the Thurman Island Station. The highest number of fish collected per station per survey in 1999 was recorded in February at the Dike 1-WHTF Station when 698 (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 winter (February - 2,465 individuals) and fall (November - 1,285 individuals) collections. The February collection also resulted in the largest quarterly weight total of 44.6 kg. Largemouth bass comprised 34.5% of the February catch by weight. 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 1999 was 147, below the average for 1998, due to the decrease in bluegill numbers discussed previously (Figure 3.3-4). However, the average weight per electrofishing sample for 1999 was 2.9 kg which represents an increase from 1998. The majority of the bluegill that were concentrated at dike stations in 1998 were small individuals and therefore did not contribute greatly to biomass in 1998. The 1999 data for numbers and weight compare favorably to historical ranges (Figure 3.3-4).

When lake gill netting and electrofishing data for selected species are combined and examined for size class distribution, the data indicate certain population trends. Similar to 1997 and 1998, young-of-year (YOY) represented approximately 50% of the largemouth bass catch in 1999. The relative abundance of intermediate an harvestable size bass in the catch increased slightly from 1998 to 1999. A similar comparison for bluegill is provided in Figure 3.3-6 which demonstrates a decrease in the relative abundance of the YOY class and an increase in the relative abundance of the intermediate and harvestable size classes from 1998 to 1999.

Lake Anna ranked third in the state of Virginia for largemouth bass citations with 73 being reported in 1999. A citation for largemouth bass is awarded for fish greater than 55.9

cm in length or 3.6 kg in weight. The lake was fourth in black crappie Pomoxis nigromaculatus citations with 26 (greater than 38.1 cm in length or 0.91 kg in weight).

Overall, the data for gillnetting and electrofishing in 1999 reveal no major changes in the lake ecosystem when compared to past data. 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 1999 survey of Lake Anna was conducted in late November. 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 increased in Lake Anna from 97 acres in 1998 to 113 acres in 1999. A decrease was noted in the WHTF from 163 acres in 1998 to 35.5 in 1999 (Table 3.4-1). The totals for 1999 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 1999 are similar to those reported previously.

The 1998 lake total of 97 acres represented 2% of the maximum available habitat (areas of 15 feet or less, water depth). This percentage increased to 3% in 1999 (Figures 3.4-2, 3). The 1999 survey data for the WHTF also indicate a decrease from 10% of the available habitat in 1998 to 2% in 1999 (Figures 3.4-4, 5, 6).

During the 1999 aerial survey the observed hydrilla was uniform throughout the lake and WHTF with the plants observed consisting of short, stunted plants with minimal vertical growth and biomass. As reported in 1998, the 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 four (4) of 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 exclusion areas which were not dewatered were located in the main lake. These exclusion areas contained 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 1999 information is that the atypical weather conditions interfered with hydrilla growth in 1998 and continued with adverse conditions in 1999. 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

1999

- North Anna Power Station in 1999 operated at the second highest generation levels since 1978 when commercial operations began.
- The 1999 water temperature data from the continuous recorders indicated water temperatures within the ranges of data from previous years.
- Thermal stratification patterns measured in 1999 indicated similar stratification patterns to previously reported data.
- Gill netting surveys during 1999 produced total numbers and weights that were less than 1998. Both the numbers and weights were within historical ranges.
- Electrofishing surveys during 1999 produced total numbers and weights less than those of 1998 but remained within historical ranges.
- Based on numbers of citation largemouth bass reported by anglers, Lake Anna ranked as the third best trophy bass lake in the state of Virginia.

- Overall hydrilla acreage for 1999 increased in the lake and decreased 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 1999 (Figure 4.1-1) using an Onset temperature recorder. Station NAR-1 is located approximately 1 km below the Lake Anna dam.

Results and Discussions

Water temperatures for 1999 were highest from June through September with mean monthly water temperatures ≥ 25°C (Table 4.1-1). A maximum hourly temperature of 32.8° C was recorded at NAR-1 in July 1999. Historically, maximum water temperatures have occurred in July or August. A minimum hourly temperature of 1.6° C was recorded at NAR-1 in January 1999.

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.

Results and Discussion

The pattern of seasonal flows in the North Anna River has generally been 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.

In 1999, North Anna River flows for the period January - March were moderately low with mean daily flows exceeding 1500 cfs only four of the ninety days during the three-month period (Figure 4.2-1). In contrast, mean daily flows exceeded 1500 cfs on forty days during the same period in 1998. Mean monthly flows or the January - March period were between 100 and 600 cfs.

Flows decreased in April and May of 1999 with drought conditions evident in the summer months. Mean daily flows rarely exceeded 80 cfs in June, July and August and 71% of the daily means calculated for this period were below 50 cfs.

River flows increased in Autumn following a two-day rain event in September that produced flows greater than 1000 cfs. Several other rain or storm events on various days in October and December produced flows that exceeded 700-800 cfs. The maximum daily mean recorded in 1999 was 3410 cfs on March 16th. It was associated with a short-term flood event.

In summary, river flows in 1999 generally remained low for the entire year with the exception of short-term rain or storm events that produced high flows. Typically, low river flows (<80 cfs) were recorded due to drought-like conditions throughout the summer of 1999.

4.3 Fish Population Studies-Electrofishing

Methods

Abundance and species composition data for the North Anna River fish assemblage in 1999 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 1999, electrofishing surveys on the North Anna River were conducted in May, July, and October. It was necessary to delay the electrofishing survey scheduled for September in 1999 until October due to a rain event.

Results and Discussion

A total of 2,258 fish was collected from the North Anna River during electrofishing surveys conducted in 1999 (Table 4.3-1). This compares to a total of 1,628 fish in 1998. The 1999 total includes 27 species and eight (8) families. Over the past 18 years, 49 species have been collected from the North Anna River (Table 4.3-2) 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 4.3-3). This trend continued in 1999 with 7 species accounting for greater than 80 percent of all fish collected. These species were, in decreasing order by numbers, redbreast sunfish Lepomis auritus, satinfin shiner Cyprinella analostana, redfin shiner Lythrurus ardens, swallowtail shiner Notropis procne, fallfish Semotilis corporalis, margined madtom Noturus insignis and american eel Anguilla rostrata. These species have consistently been among the most abundant species collected from the North Anna River since 1981 (Table 4.3-3).

In 1999, NAR-2 yielded the greatest numerical catch followed by, in decreasing order, NAR-1, NAR-4, and NAR-6 (Table 4.3-1). NAR-1 yielded the highest biomass in 1999, followed by, in decreasing order, NAR-4, NAR-2, and NAR-6. A comparison to the 1998 catch revealed identical similarities in the numerical order, with NAR-1 remaining in the number one position.

There were also similarities in the 1999 and 1998 biomass data for the four stations. NAR-1 continued to yield the highest biomass in 1999, and NAR-6 again yielded the lowest. NAR-4 and NAR-2 exchanged positions in 1999 relative to 1998. Total biomass for all stations combined was lower in 1999 (15,576 grams) than in 1998 (16,120 grams) even though the total number of fish collected in 1999 (2,258) was larger than the total collected in 1998 (1,628).

It has been hypothesized that high flows in 1995 may have influenced annual fish abundance that year when fish numbers were low at all stations. Total fish numbers progressively increased in 1996 and 1997 and leveled off somewhat in 1998 (Figure 4.3-1). In 1999, total fish numbers increased at all four stations, with most noticeable increases at NAR-2 and NAR-4. Overall, 1999 fish totals at all stations improved greatly from 1998. This indicates recovery of the North Anna River fish assemblage from perturbations associated with the flooding in 1995. In addition, the river's fish assemblage did not appear adversely affected by drought conditions in 1999.

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 1999, snorkel surveys were conducted during July, August, and September. Four (4) stations were sampled twice per month in July and August; NAR-1, NAR-2, NAR-4, and NAR-5 (Figure 4.1-1). Due to a two-day rain event that occurred in mid-September and rescheduling difficulties afterwards, only one survey was conducted that month. 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≤120 mm) could be distinguished from YOY largemouth bass (TL≤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 and Discussion

Snorkel surveys for 1999 were conducted between 0900 and 1426 hours at river temperatures ranging from 22.2 to 30.5°C and average visibility ranging from 1.5 to 4.5 m. Similar to previous years, largemouth bass was the numerically dominant species observed at the upstream stations NAR-1 and NAR-2 (Table 4.4-1). In addition, fewer smallmouth bass were observed at station NAR-1 than at the other stations surveyed in 1999. 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.

Density estimates for largemouth bass and smallmouth bass observed in 1999 for stations NAR-1, NAR-2, NAR-4 and NAR-5 are compared to historical density estimates in Figures 4.4-1 through 4.4-4. These estimates do not include young of year (YOY) size fish (TL≤ 120 mm) as it is doubtful that the smaller individuals are as susceptable to the observation techniques as are larger fish. In general, largemouth bass have been more abundant at the two uppermost stations (NAR-1 and NAR-2) than at the lowermost stations (NAR-4 and NAR-5), with the opposite evident for smallmouth bass. Largemouth bass densities at NAR-1 and NAR-2 averaged approximately 35 and 26 fish/hectare respectively over the study period, while densities at both NAR-4 and NAR-5 averaged approximately 7 fish/hectare. Conversely smallmouth bass densities averaged approximately 6-8 fish/hectare at NAR-1 and NAR-2 with average densities of 17 and 31 fish/hectare at NAR-4 and NAR-5 respectively. These trends have been evident during most but not all surveys. Densities calculated for 1999 were consistent with these trends at all stations with the exception of NAR-4 where largemouth bass were nearly as abundant as smallmouth bass. Density estimates at all stations for both species in 1999 exceeded average densities calculated for the entire study period.

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 1999 are primarily presented for documentation purposes (Table 4.4-2). When cover use data are pooled for all stations in 1999 (Table 4.3-3) smallmouth bass were usually associated with wood, boulder, and open water while largemouth bass used primarily wood, vegetation and open water. 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, 1998). Smallmouth bass have generally been evenly distributed between all cover types and this was again the case in 1999.

4.5 Conclusions

1999 Studies

- River flows were lower than normal throughout the year with the exception of several short-term rain or storm events. Mean daily flows in the summer of 1999 rarely exceeded 80 cfs with 71% of the daily means below 50 cfs.

- Species composition of the 1999 North Anna River electrofishing catch was similar to previous years with seven (7) species comprising 80% of the electrofishing catch in terms of numbers, and seven (7) species comprising 82% of the electrofishing catch in terms of biomass.

- Numbers of fish collected by electrofishing increased relative to 1998 at all four stations and were in the mid-range of the historical trend for the period 1981-1998. Numbers collected in recent years indicate recovery of the river's fish assemblage from impacts of flooding in 1995.

- Underwater observations of smallmouth bass and largemouth bass made in 1999 indicated smallmouth bass were numerically dominant in the lower reaches of the North Anna River below the North Anna Dam, and largemouth bass were more abundant in the upper reaches.

- Density estimates for both largemouth bass and smallmouth bass at all stations in 1999 were higher than average densities calcaulted for the entire study period.

- Observations of cover use made in 1999 illustrate that smallmouth bass are evenly distributed among cover types while largemouth bass are most often associated with structure in the form of wood or vegetation.

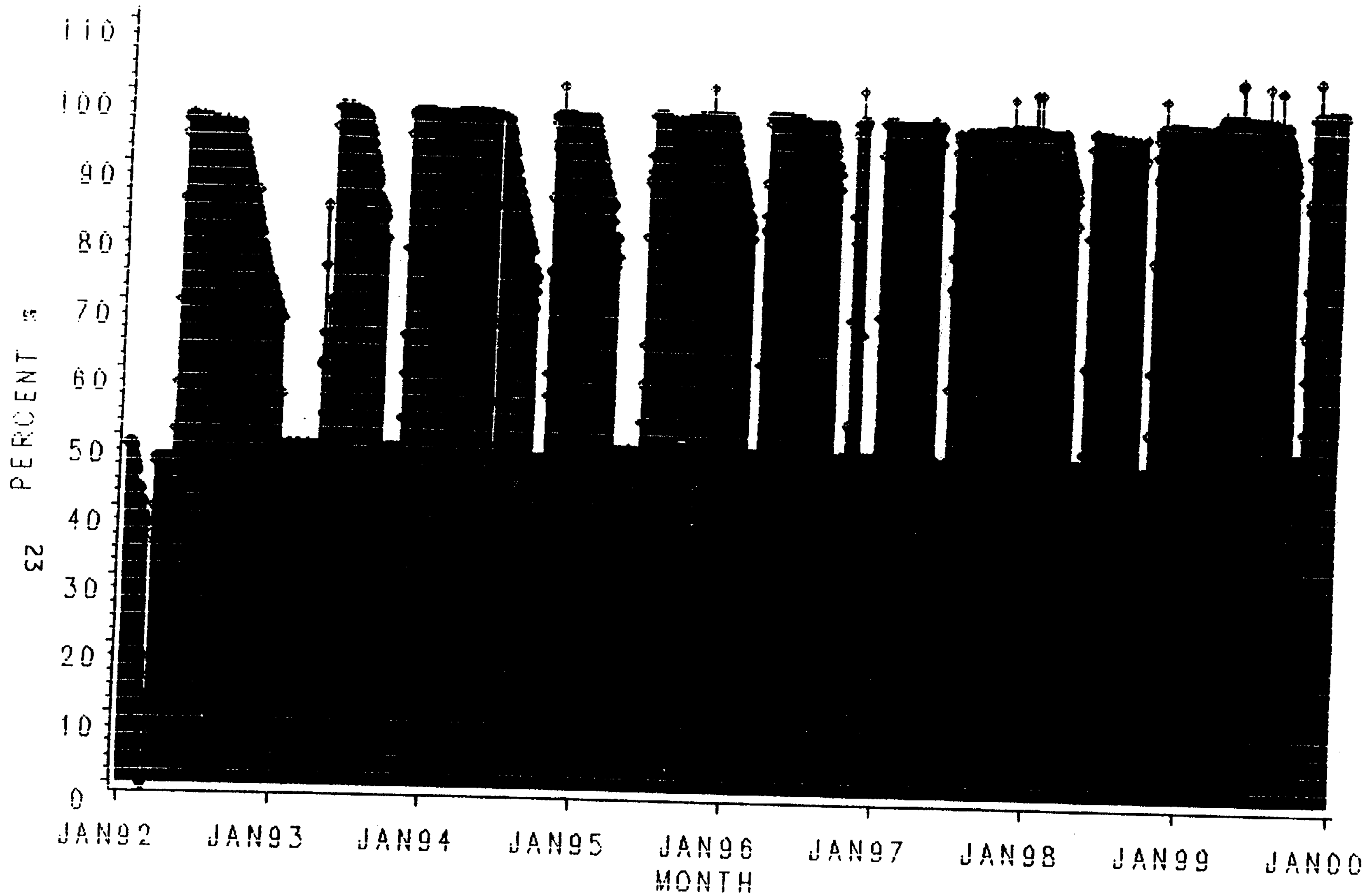
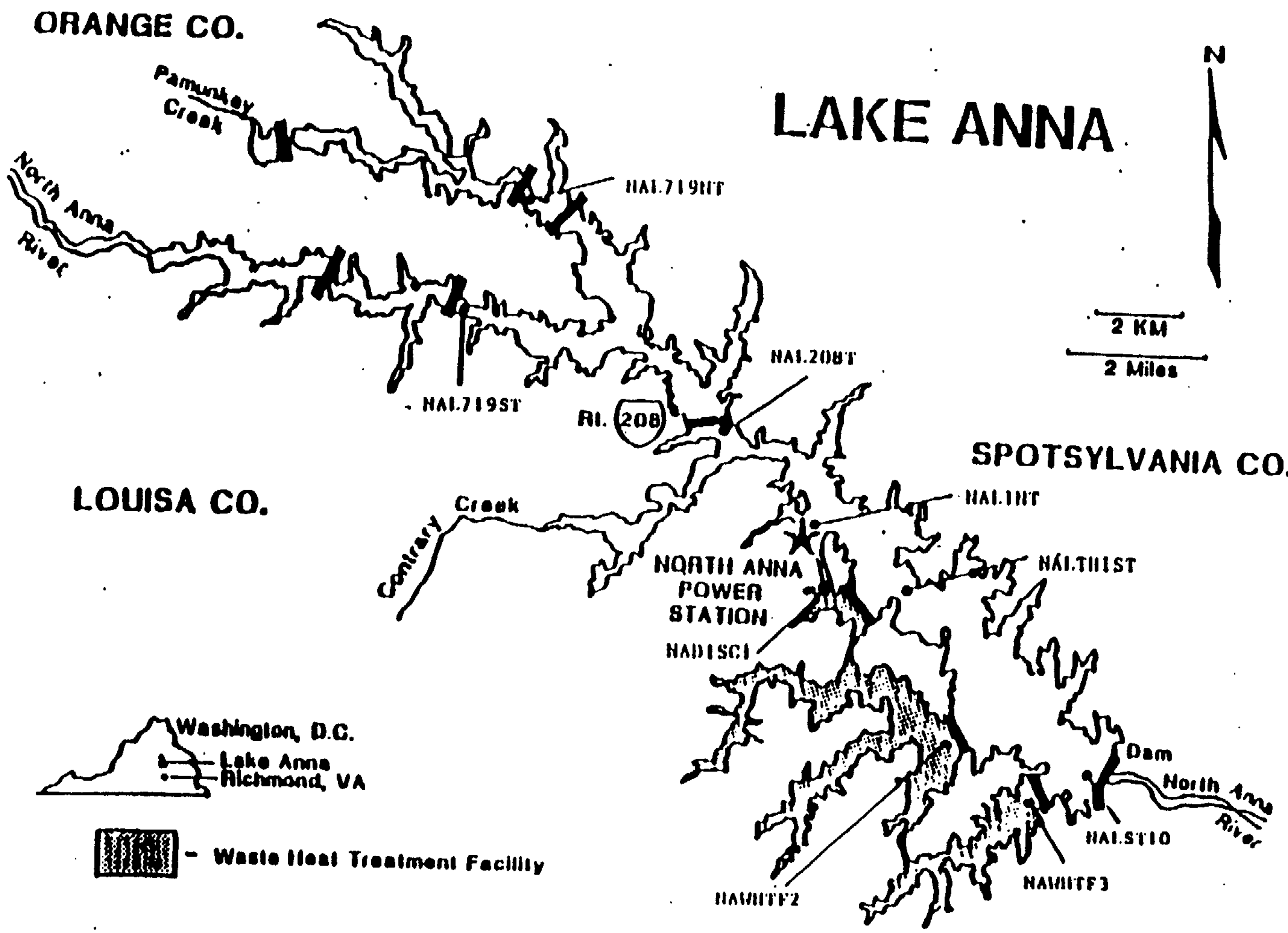
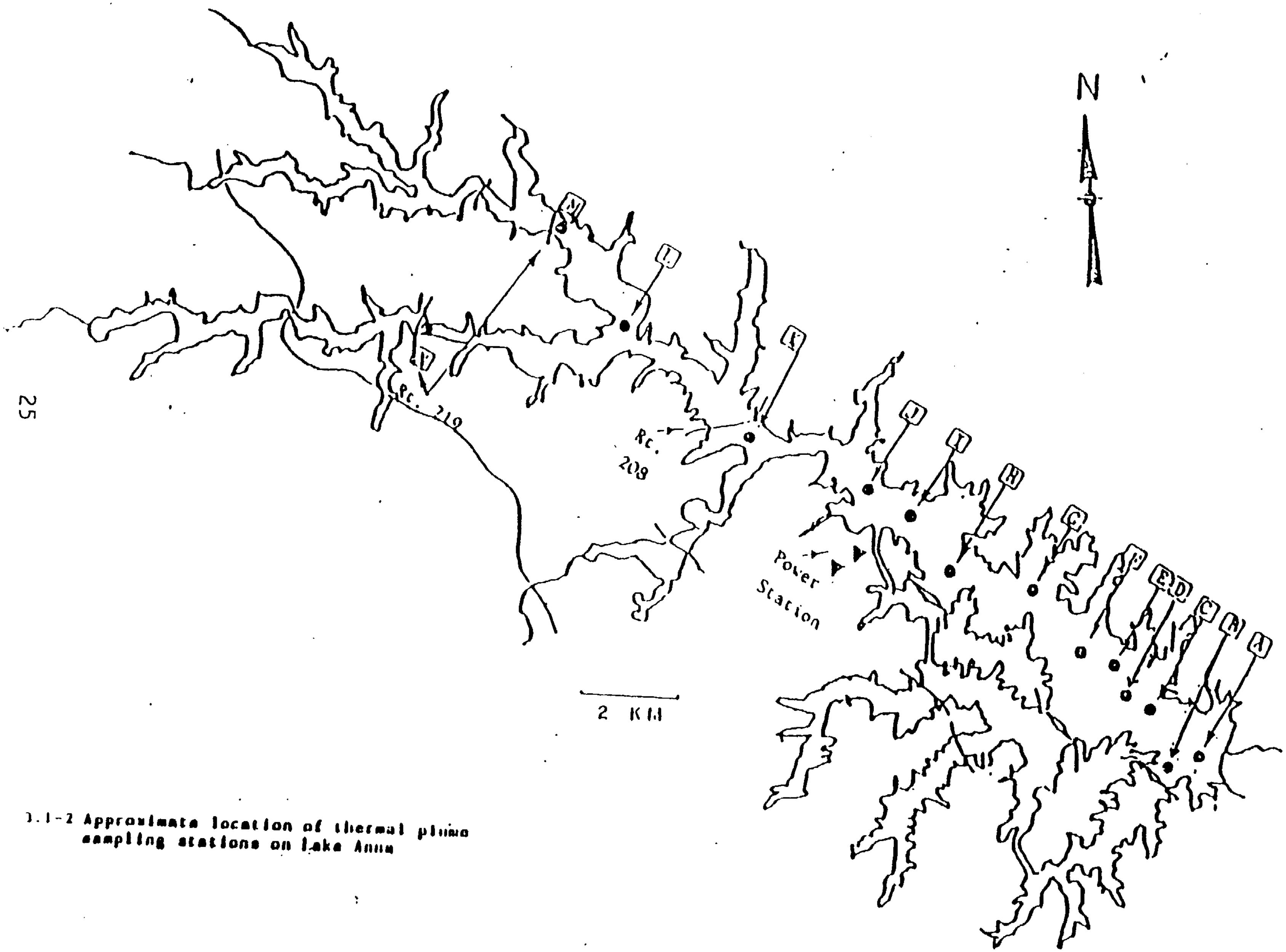


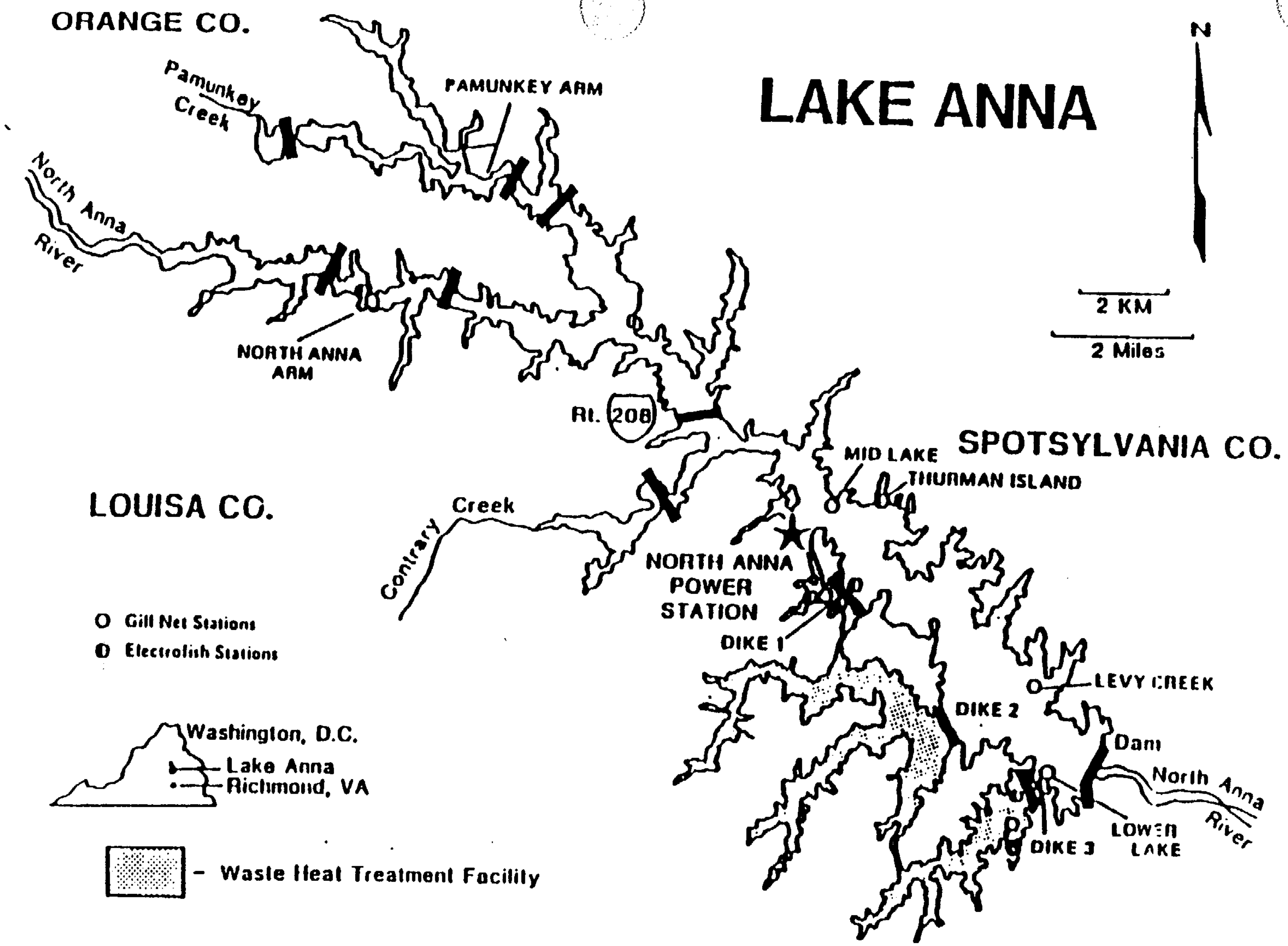
FIGURE 2.0-1. 1992-1999 NORTH ANNA UNITS 1 & 2 DAILY POWER LEVEL



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

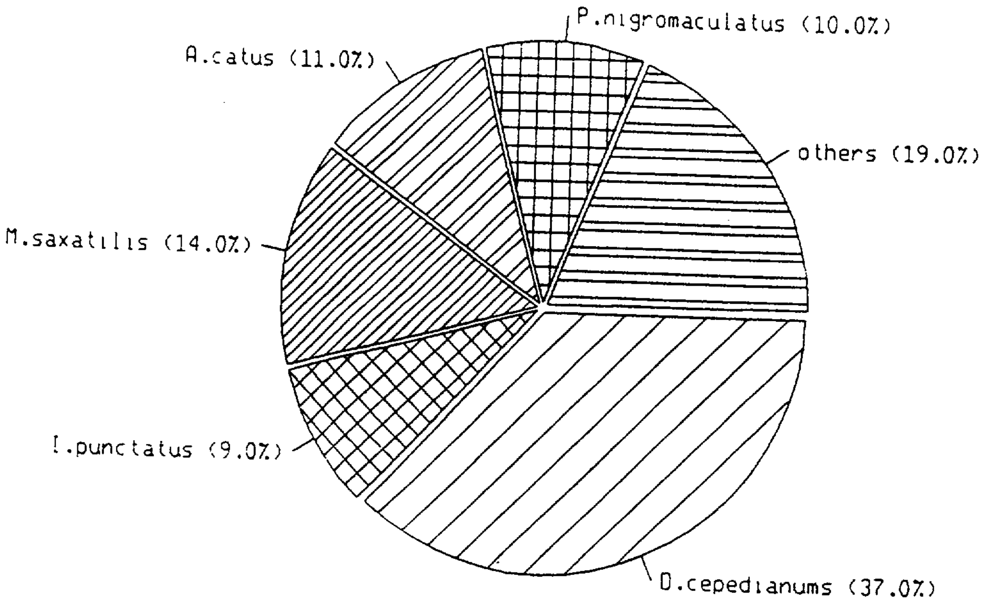


3.1-2 Approximate location of thermal plume sampling stations on Lake Anna



3.2-1 Location of electrofish and gill net stations.

FIGURE 3.2-2. GILL NETTING RESULTS
LAKE 1999
(% BY NUMBER)



GILL NETTING RESULTS
LAKE 1999
(% BY WEIGHT)

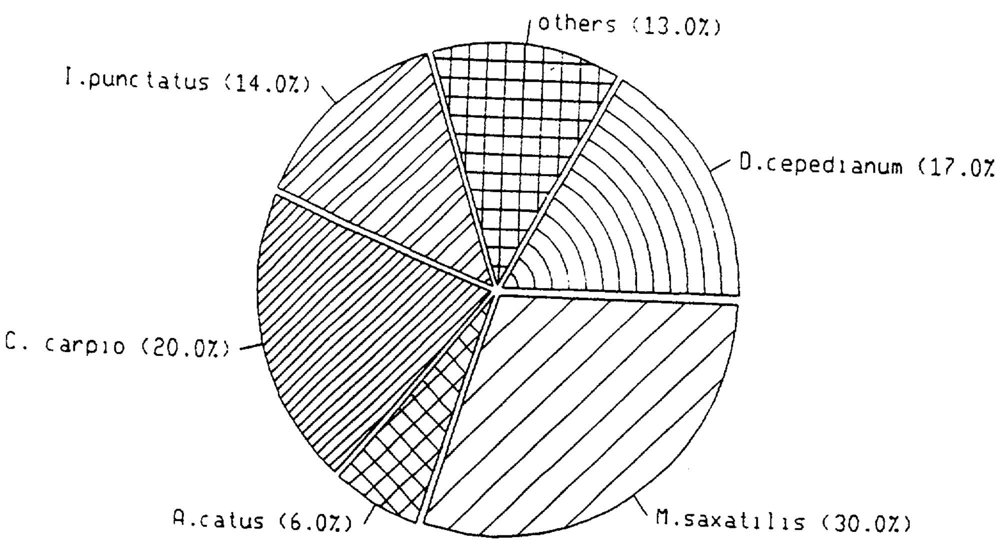


FIGURE 3.2-3 COMPOSITION OF GILL NET DATA FOR LAKE ANNA AND WHTF (1994-1999)

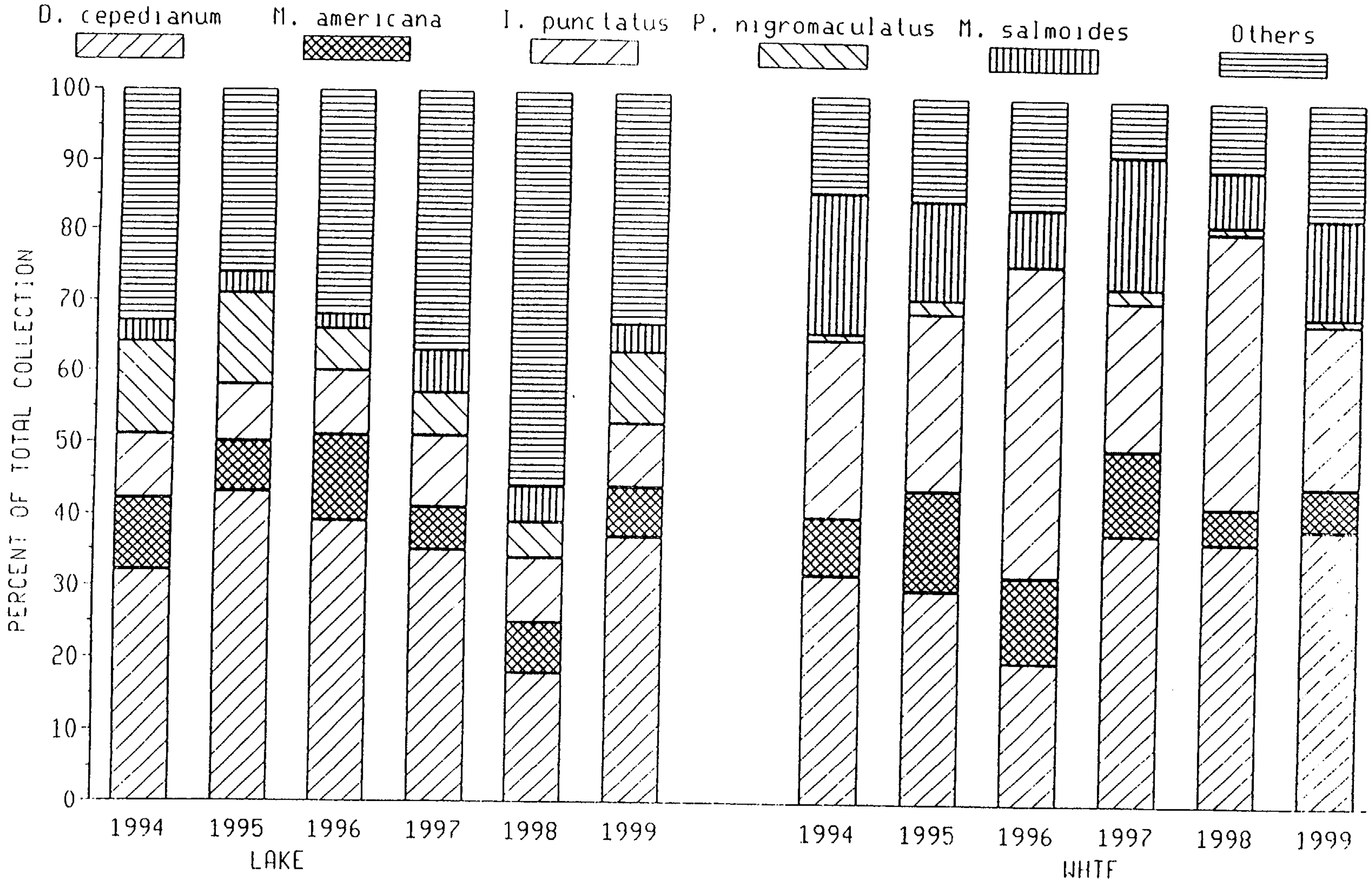
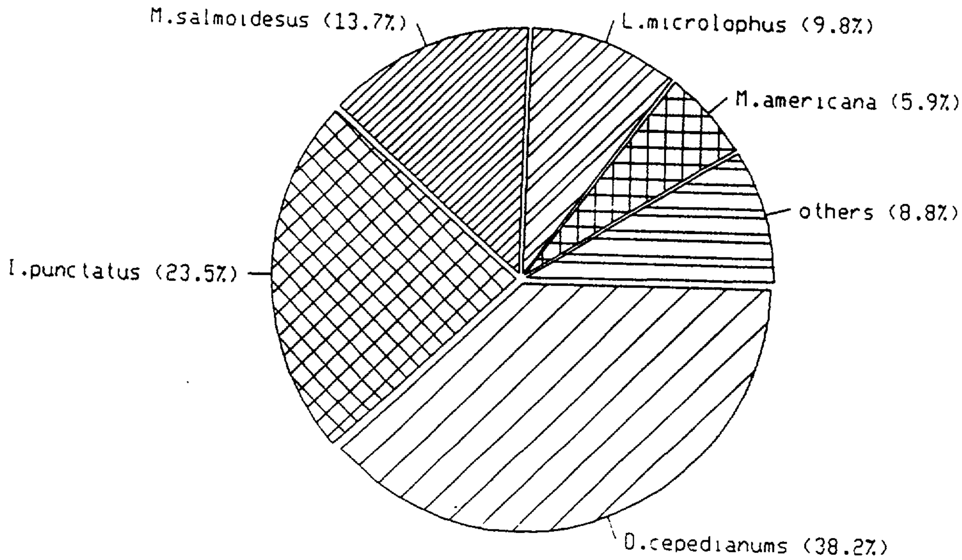


FIGURE 3.2-4. GILL NETTING RESULTS
WHTF 1999
(% BY NUMBER)



GILL NETTING RESULTS
WHTF 1999
(% BY WEIGHT)

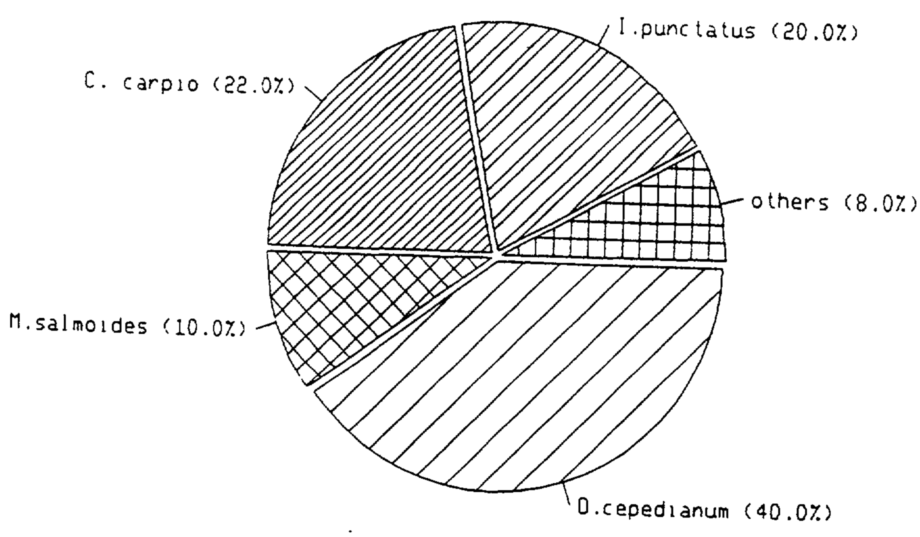


FIGURE 3.2-5 CATCH PER UNIT EFFORT

ELECTROFISH & GILL NET COLLECTION

Lake Anna, 1982 - 1999

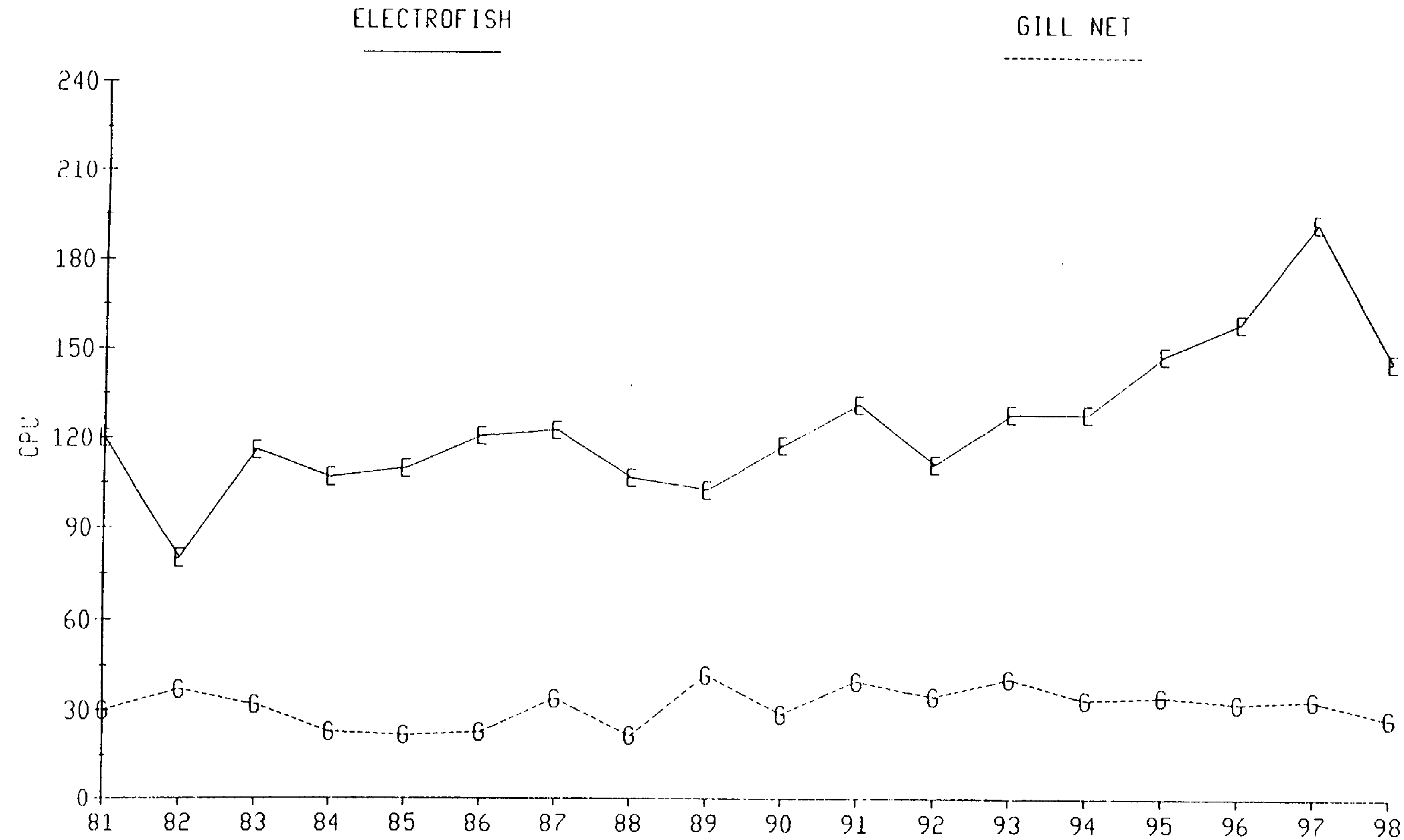


FIGURE 3.2-6 LAKE ANNA GILL NET DATA (1982-1999)
AVERAGE NUMBER AND AVERAGE WEIGHT(kg) YEAR

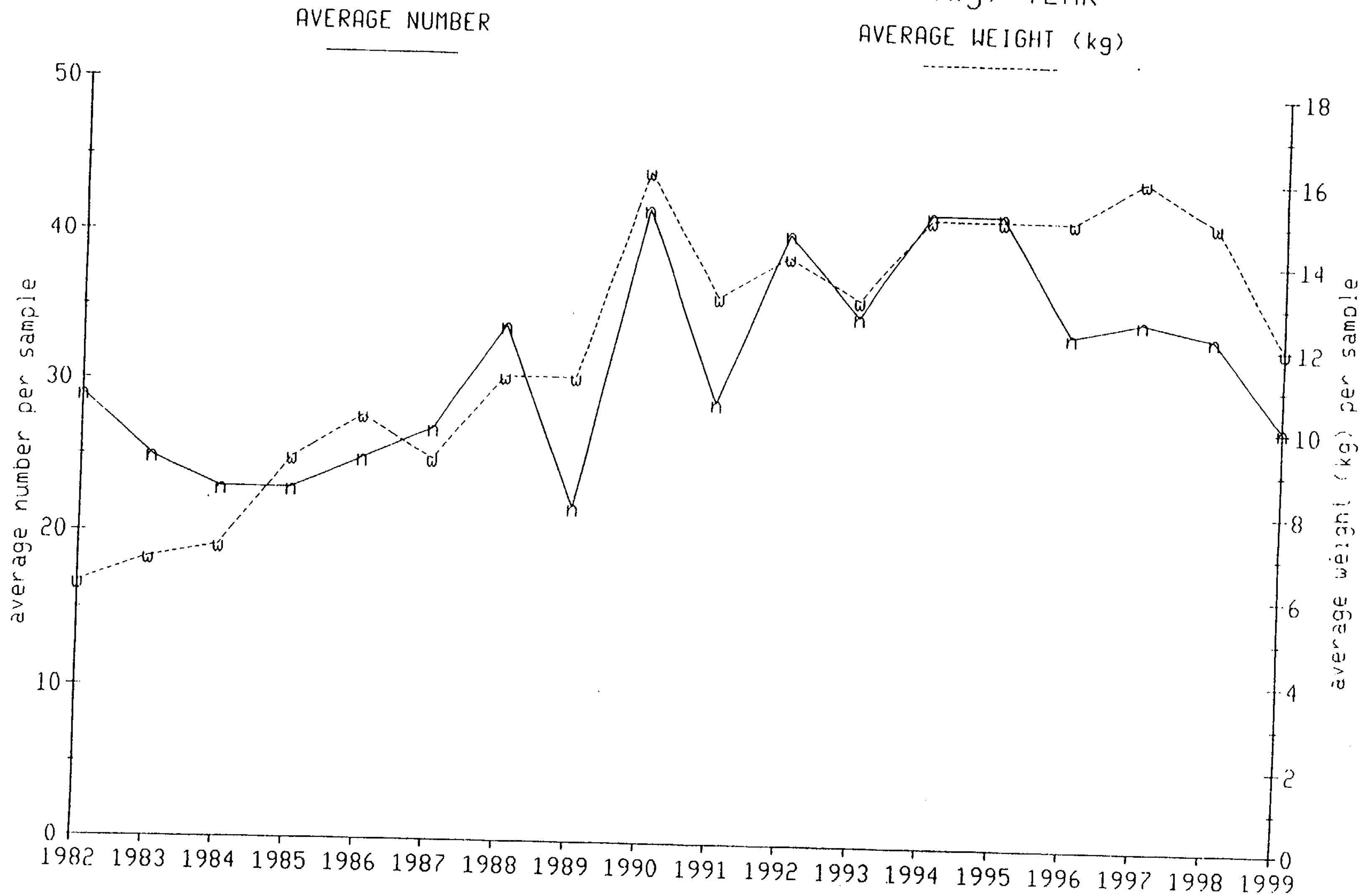
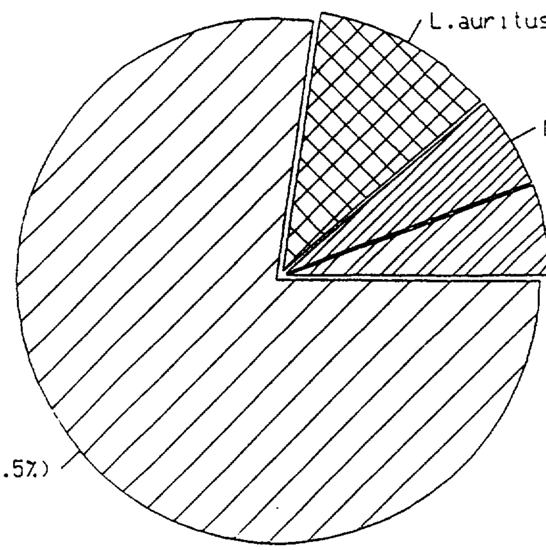


FIGURE 3.3-1. ELECTROFISHING RESULTS
LAKE 1999
(% BY NUMBER)



ELECTROFISH RESULTS
LAKE ANNA 1999
(% BY WEIGHT)

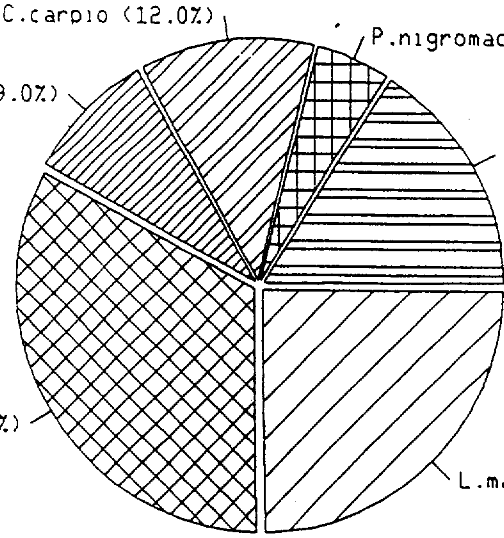
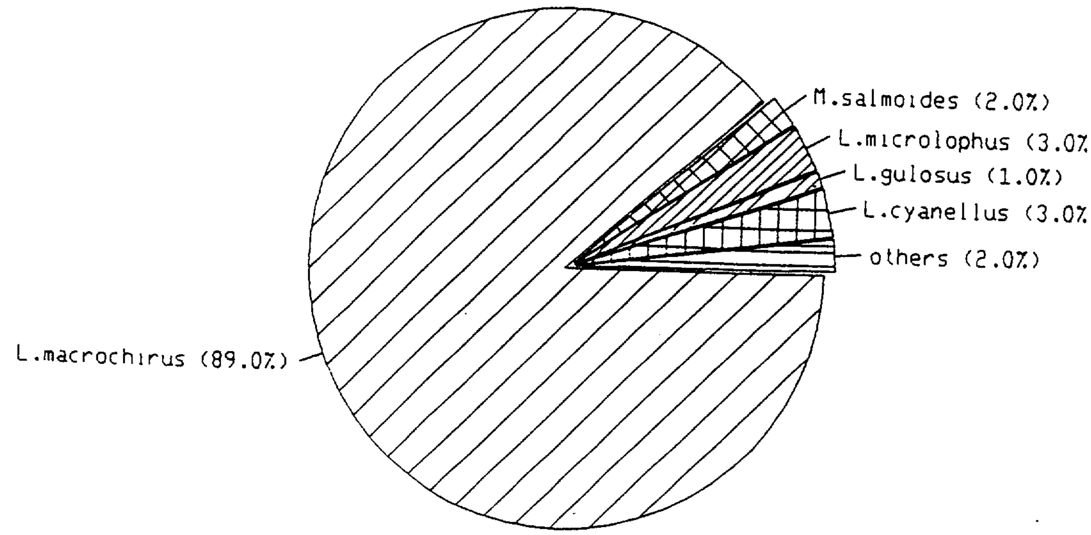


FIGURE 3.3-2. ELECTROFISH RESULTS

WHTF 1999

(% BY NUMBER)



ELECTROFISH RESULTS

WHTF 1999

(% BY WEIGHT)

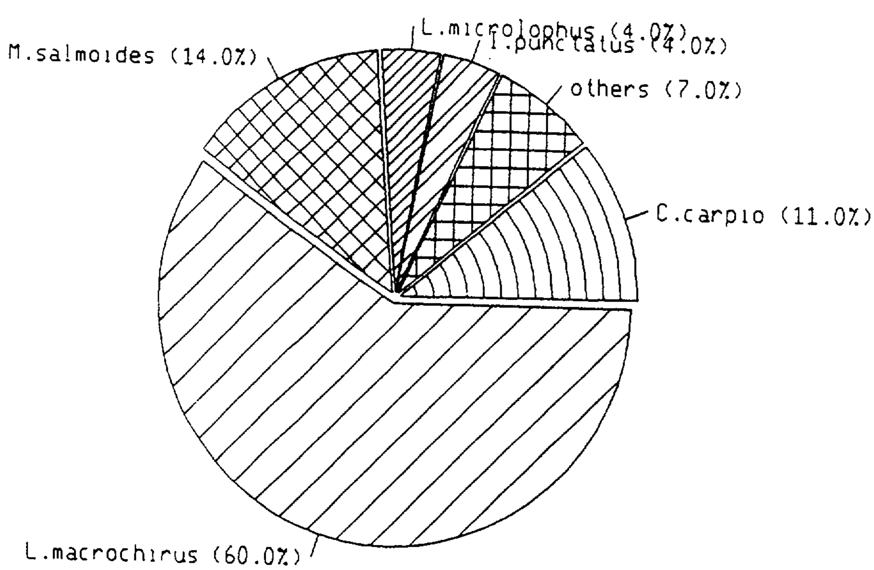


FIGURE 3.3-3 COMPOSITION OF ELECTROFISHING DATA FOR LAKE ANNA AND WHTF, (1994-1999)

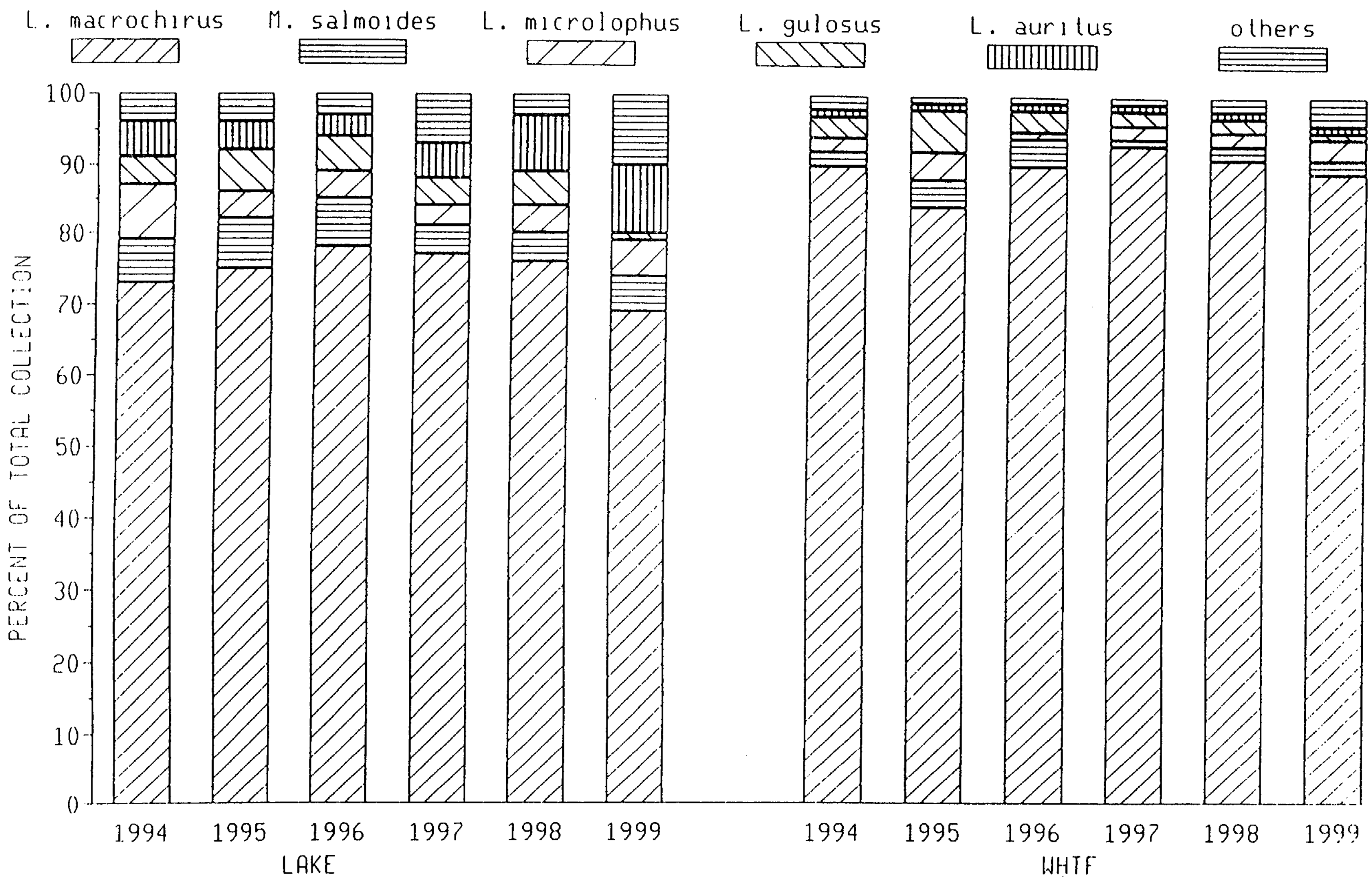


FIGURE 3.3-4 LAKE ANNA ELECTROFISH DATA (1982-1999)
AVERAGE NUMBER AND AVERAGE WEIGHT(kg) YEAR

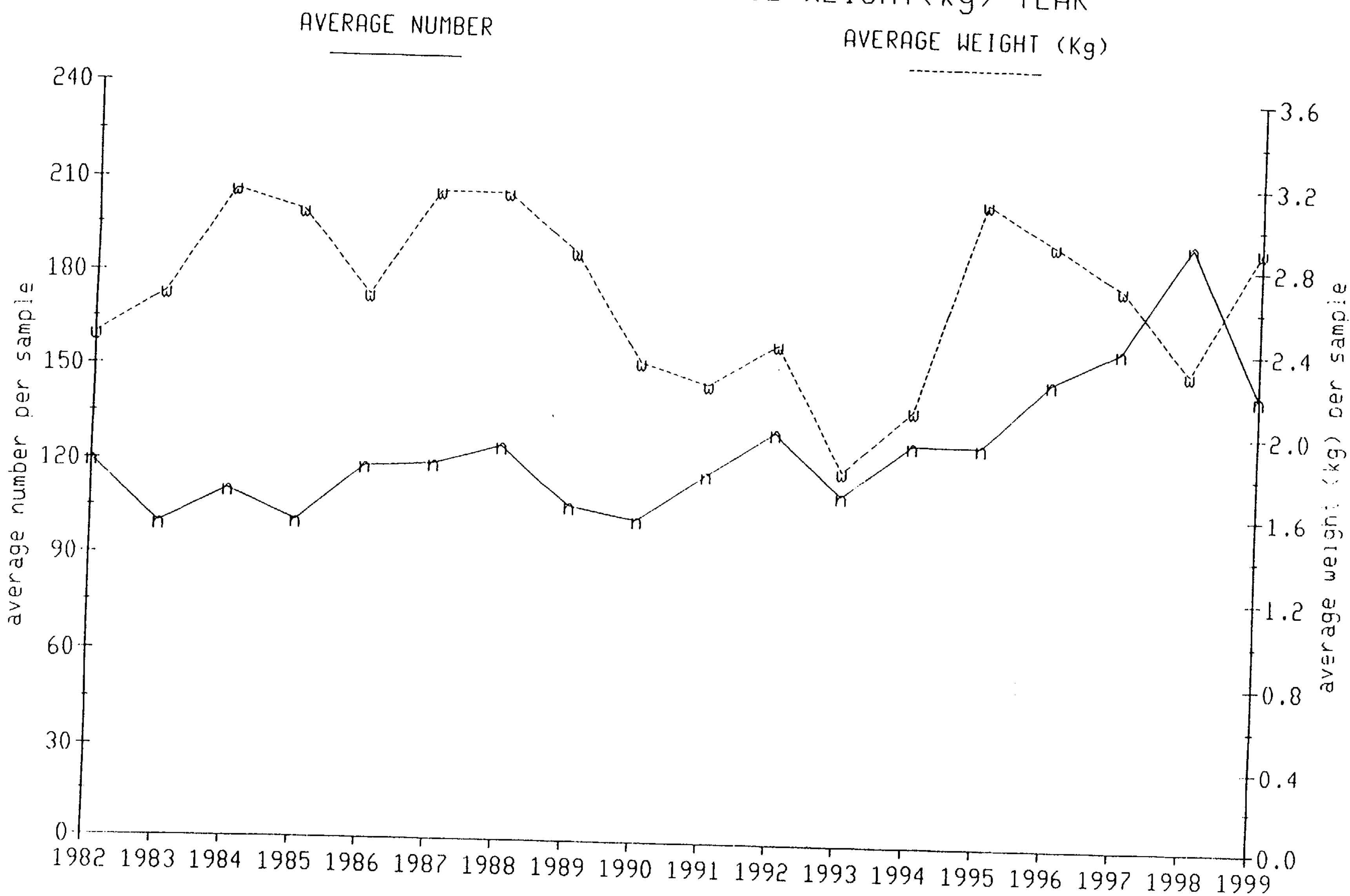


FIGURE 3.3-5 COMPOSITION OF LMB CATCH
(LAKE ANNA 1997-1999)

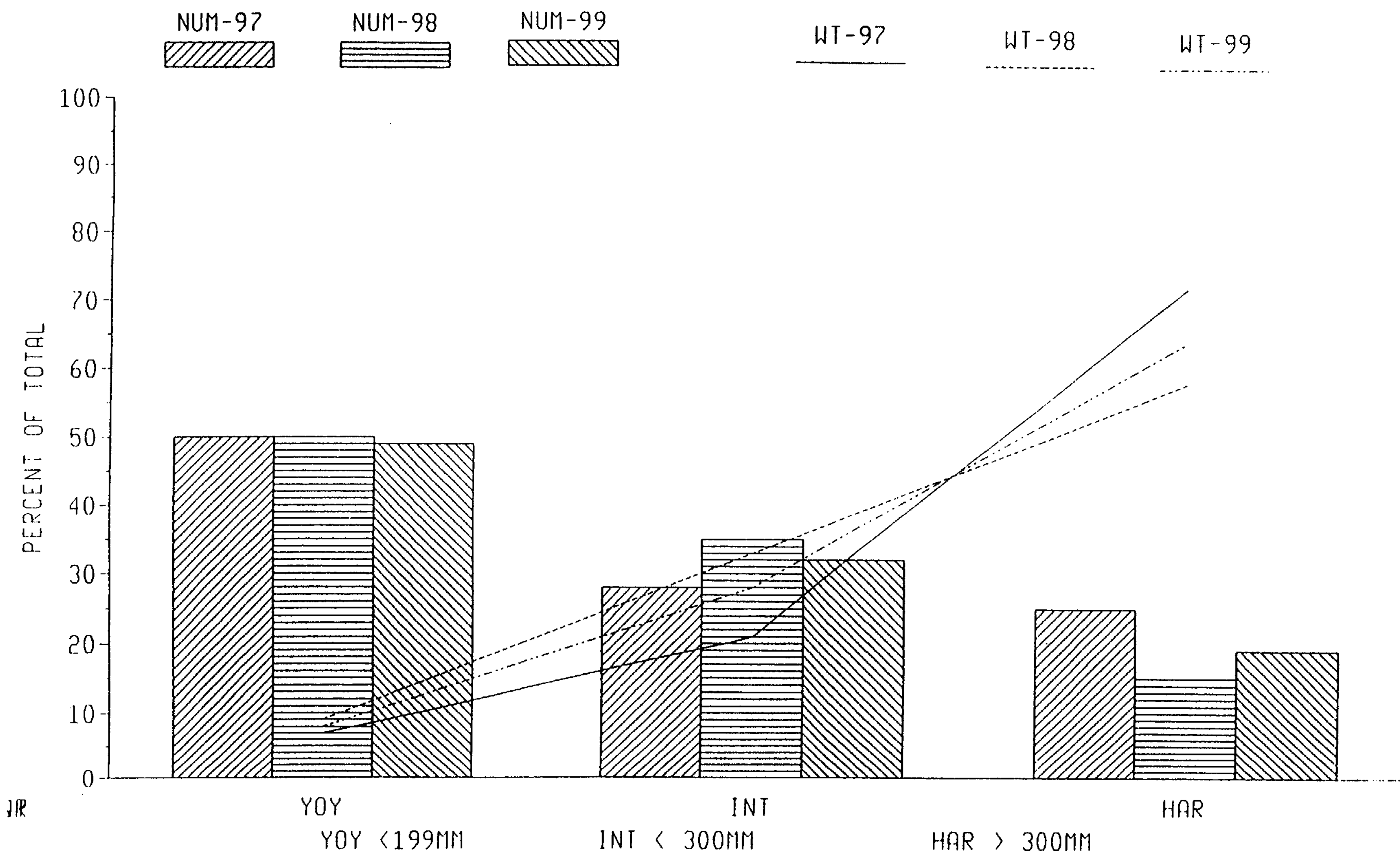


FIGURE 3.3-6 COMPOSITION OF BLUEGILL CATCH
(LAKE ANNA 1997-1999)

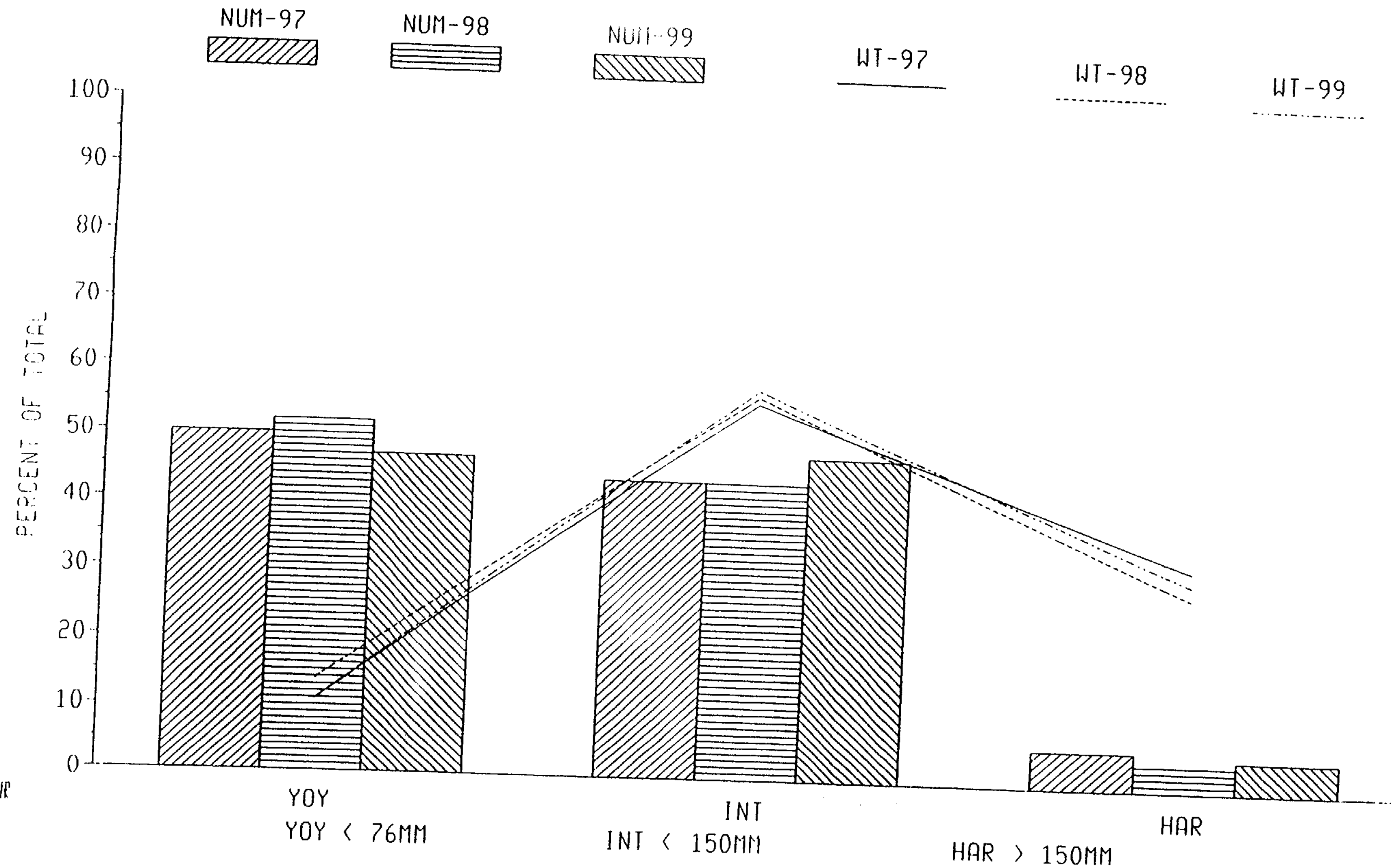
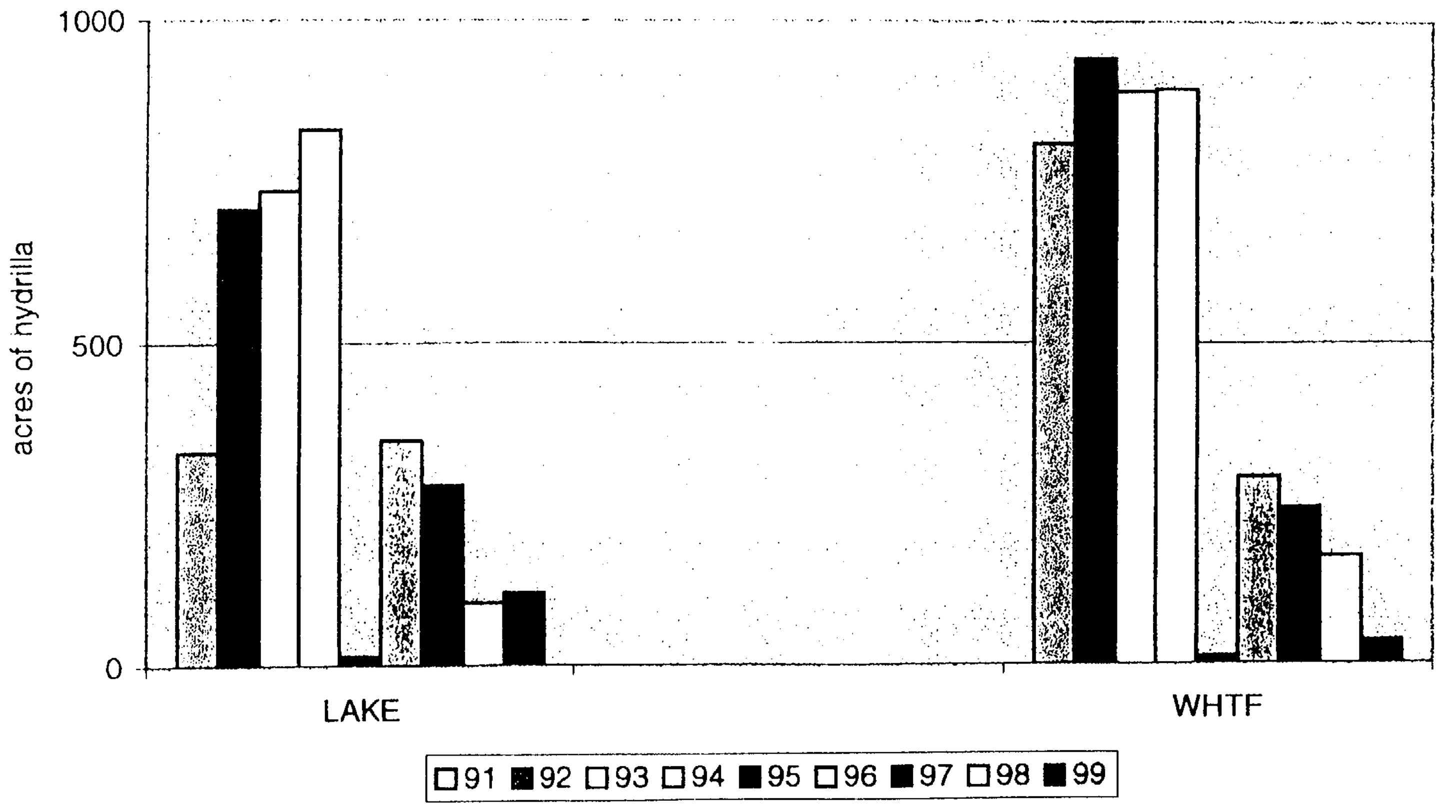


FIGURE 3.4 - 1: HYDRILLA SUMMARY - HYDRILLA TOTALS FOR 1991 - 1999



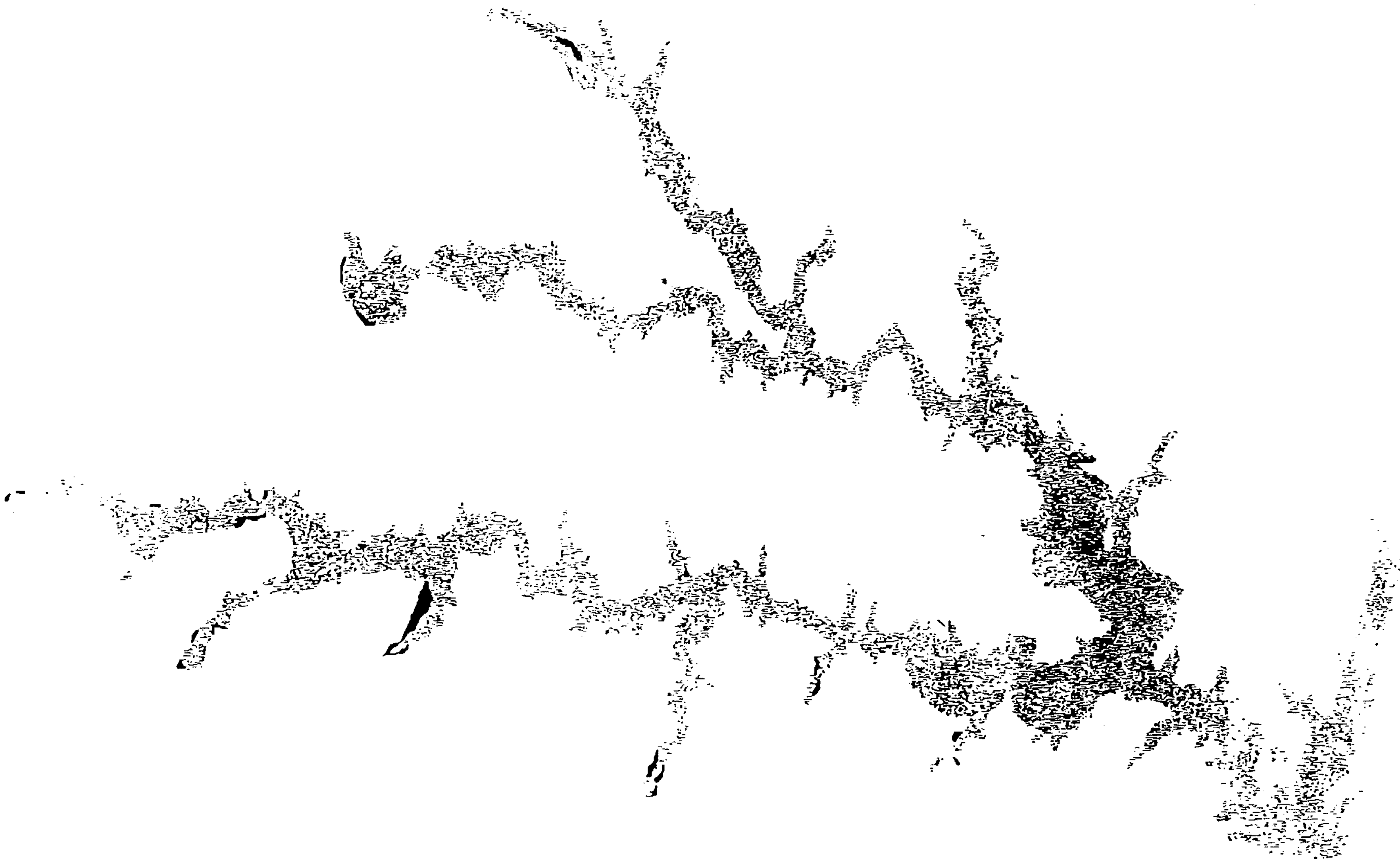


FIGURE 3.4 - 2 LAKE ANNA ABOVE 208 BRIDGE INDICATING HYRILLA IN 1999

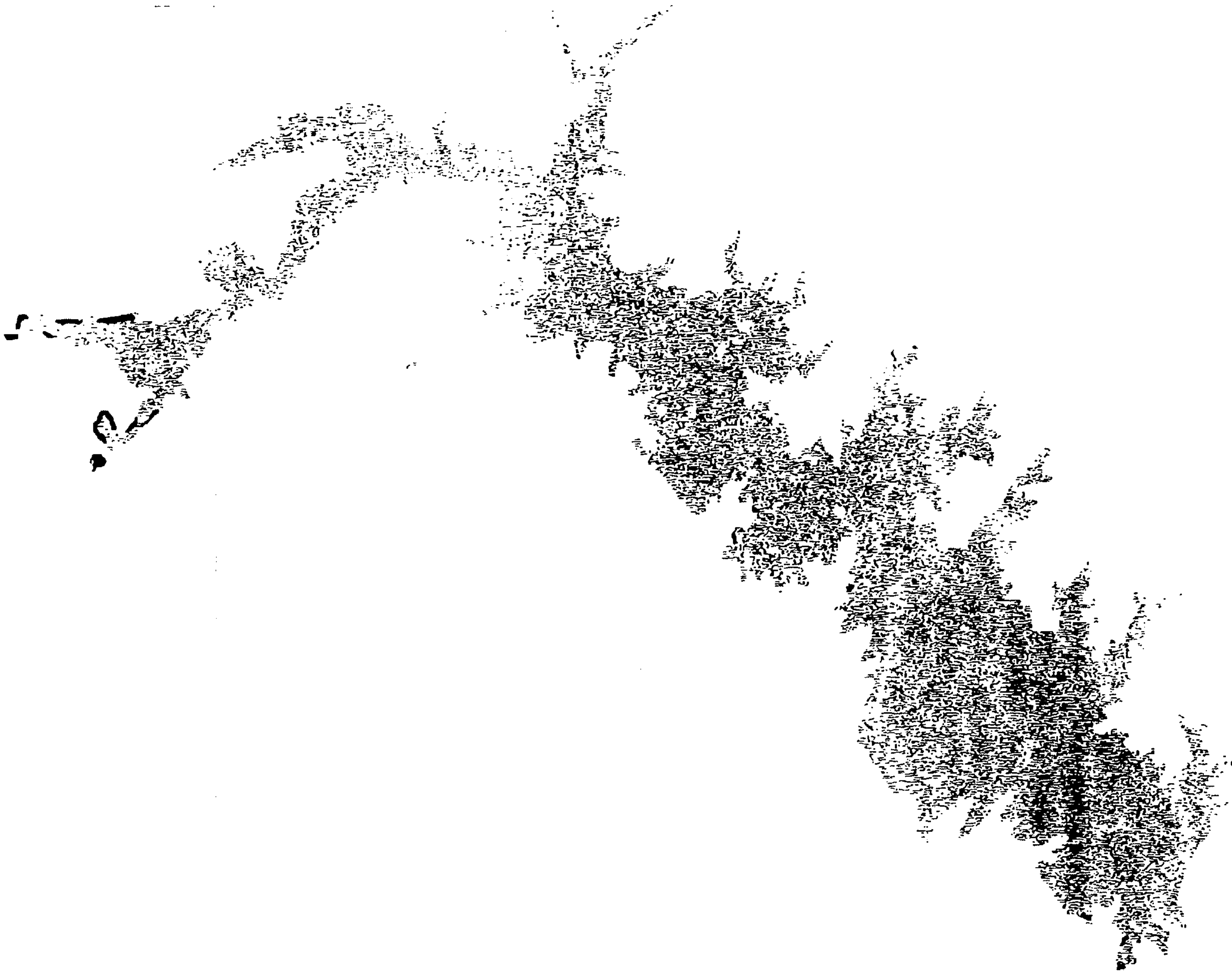
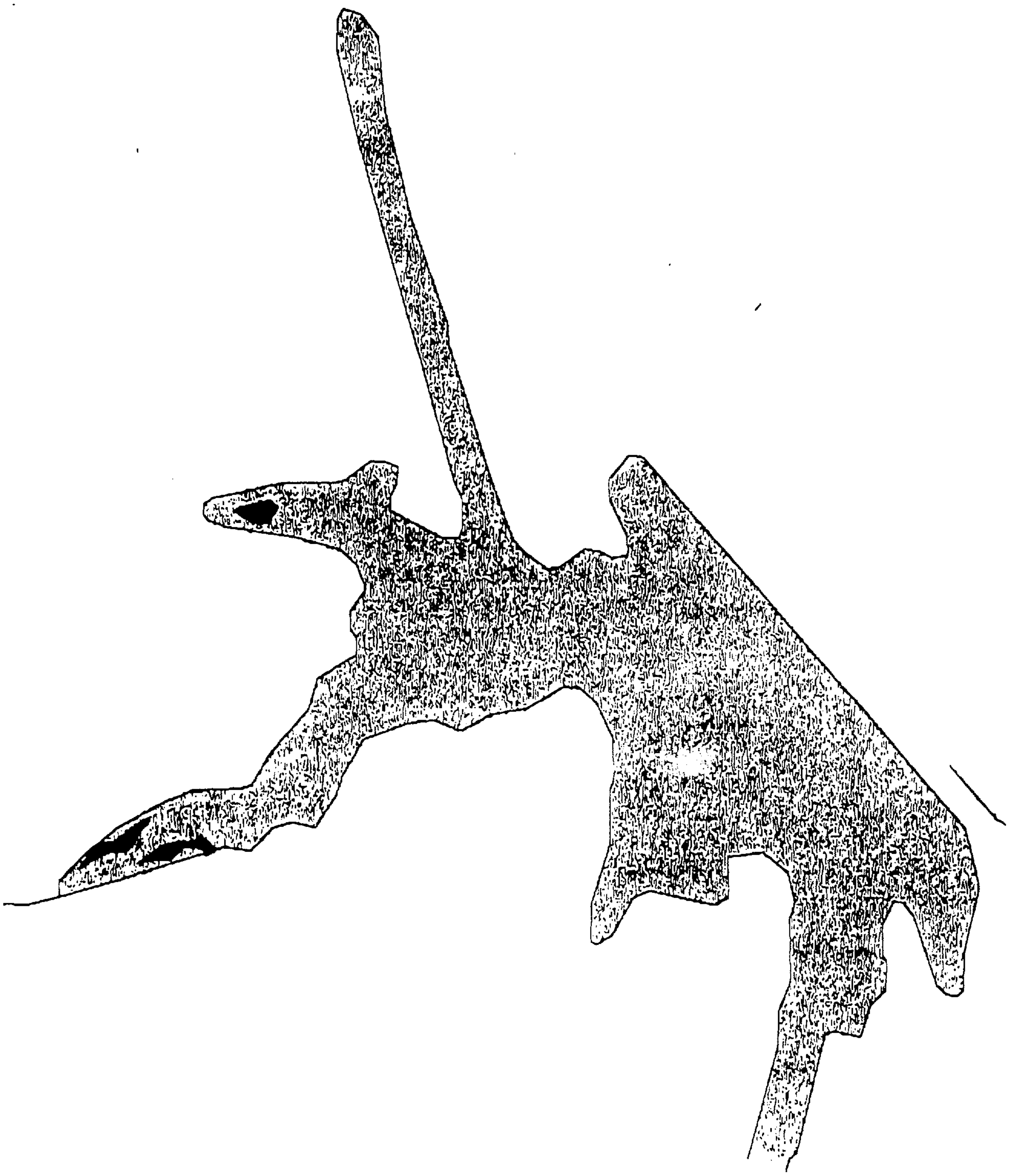


FIGURE 3.4-3: LAKE ANNA BELOW 208 BRIDGE INDICATING HYDRILLA IN 1999

FIGURE 3.4-4: LAGOON 1 INDICATING HYDRILLA IN 1999



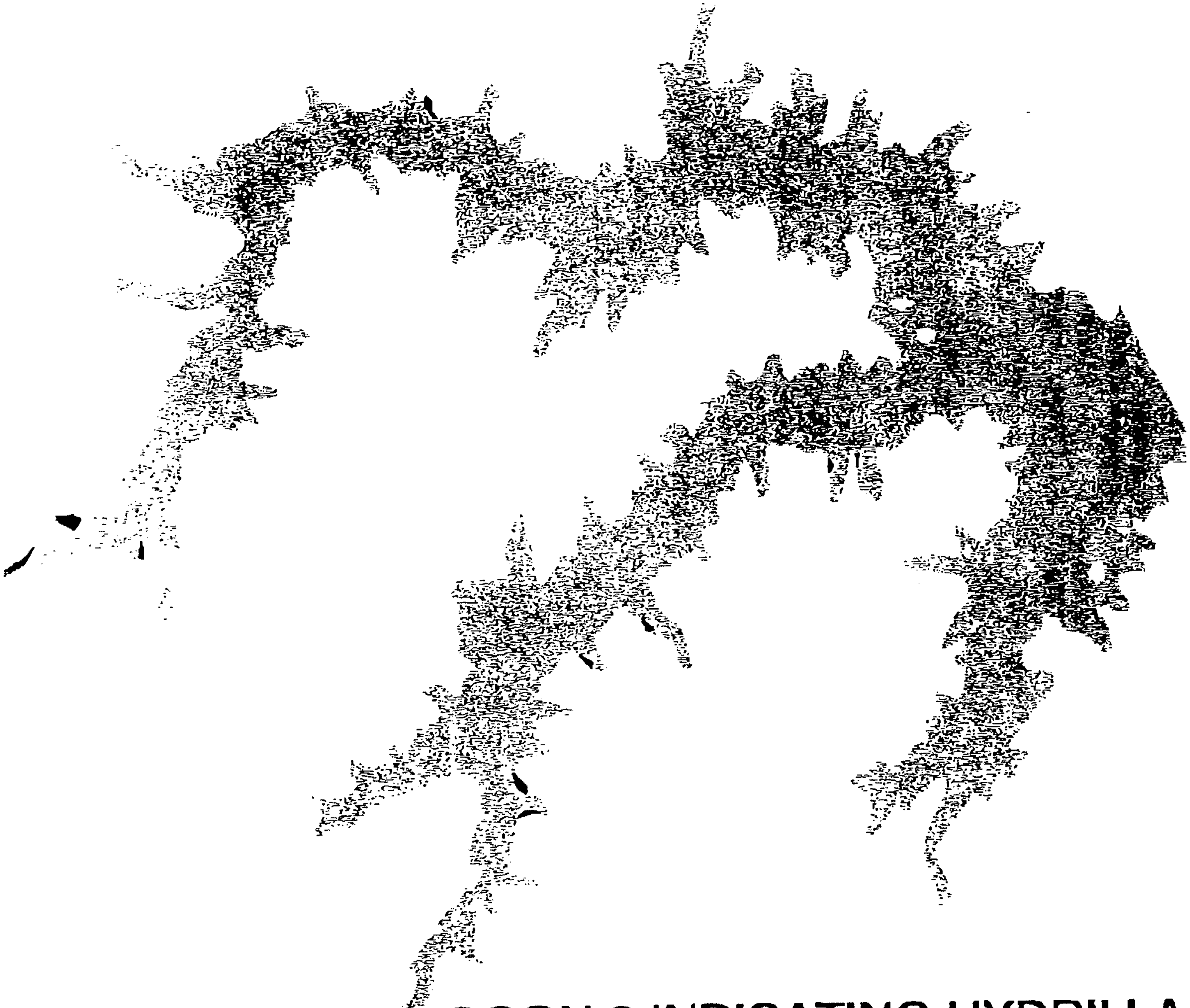


FIGURE 3.4-5: LAGOON 2 INDICATING HYDRILLA IN 1999

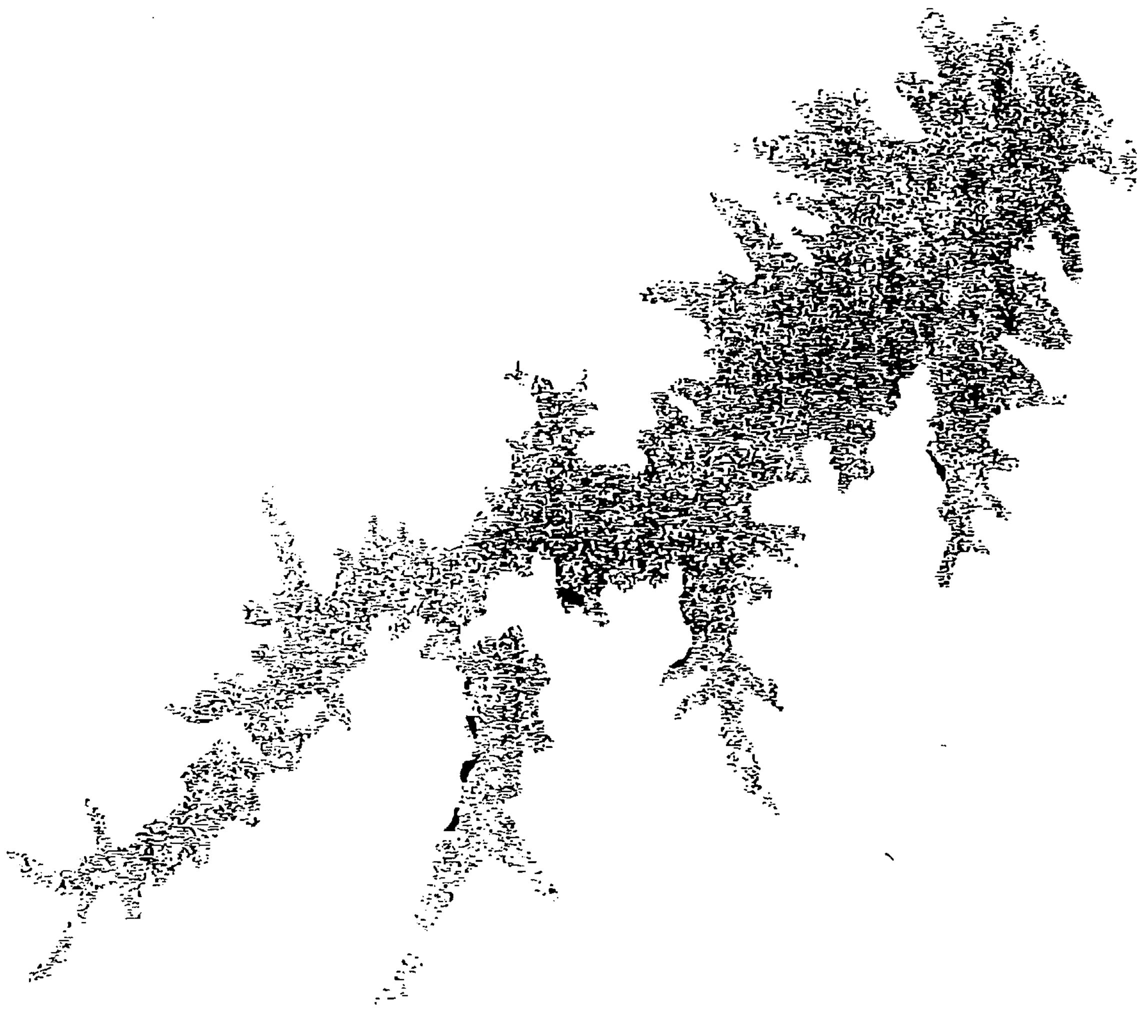


FIGURE 3.4-6: LAGOON 3 INDICATING HYDRILLA IN 1999

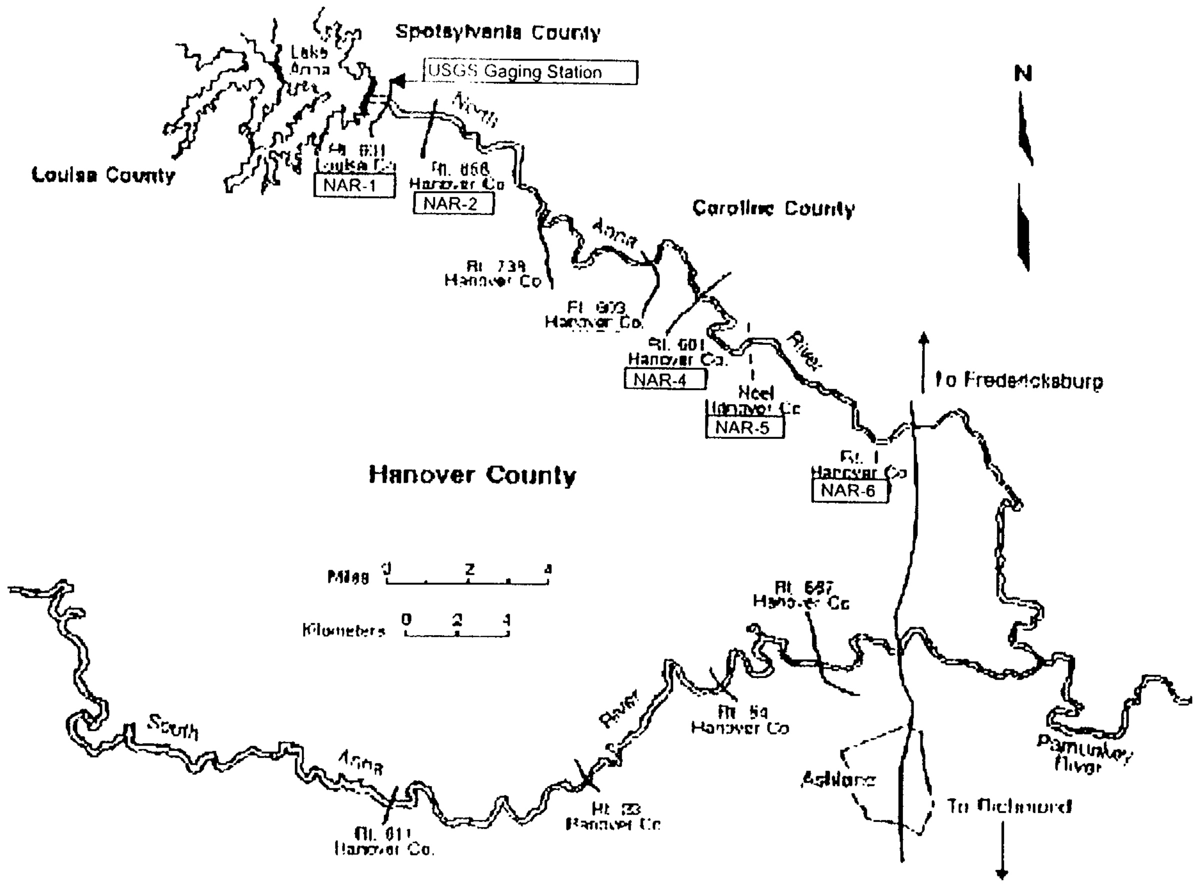


Figure 4.1-1 Location of North Anna River temperature recording, electrofishing, and snorkel survey stations.

Figure 4.2-1. Minimum, mean, and maximum discharge in the lower North Anna River during calendar year 1999. (USGS Station Number 01671020)

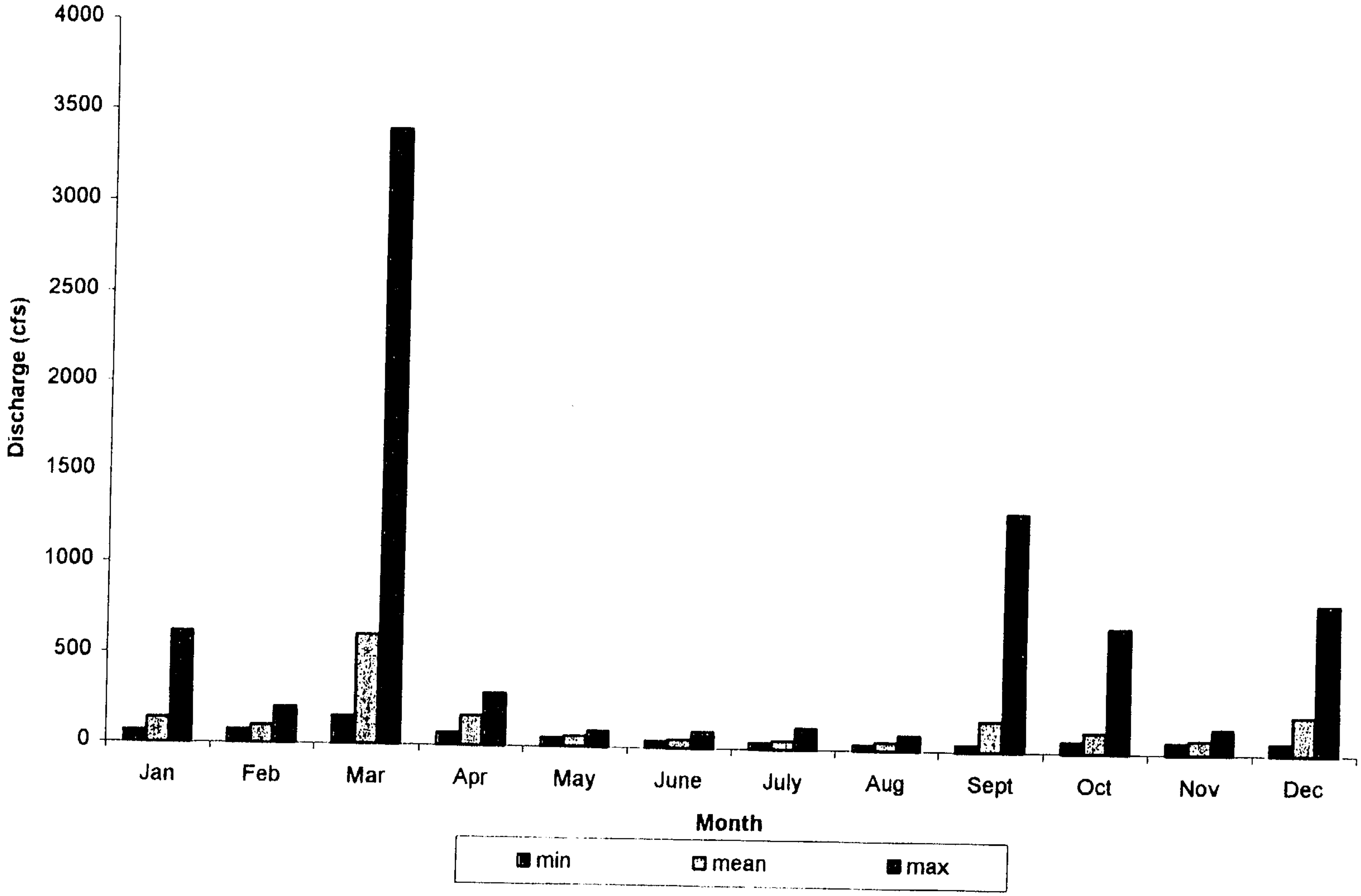


Figure 4.3-1. Number of fish collected annually from the North Anna River during electrofishing surveys, 1981-1999.

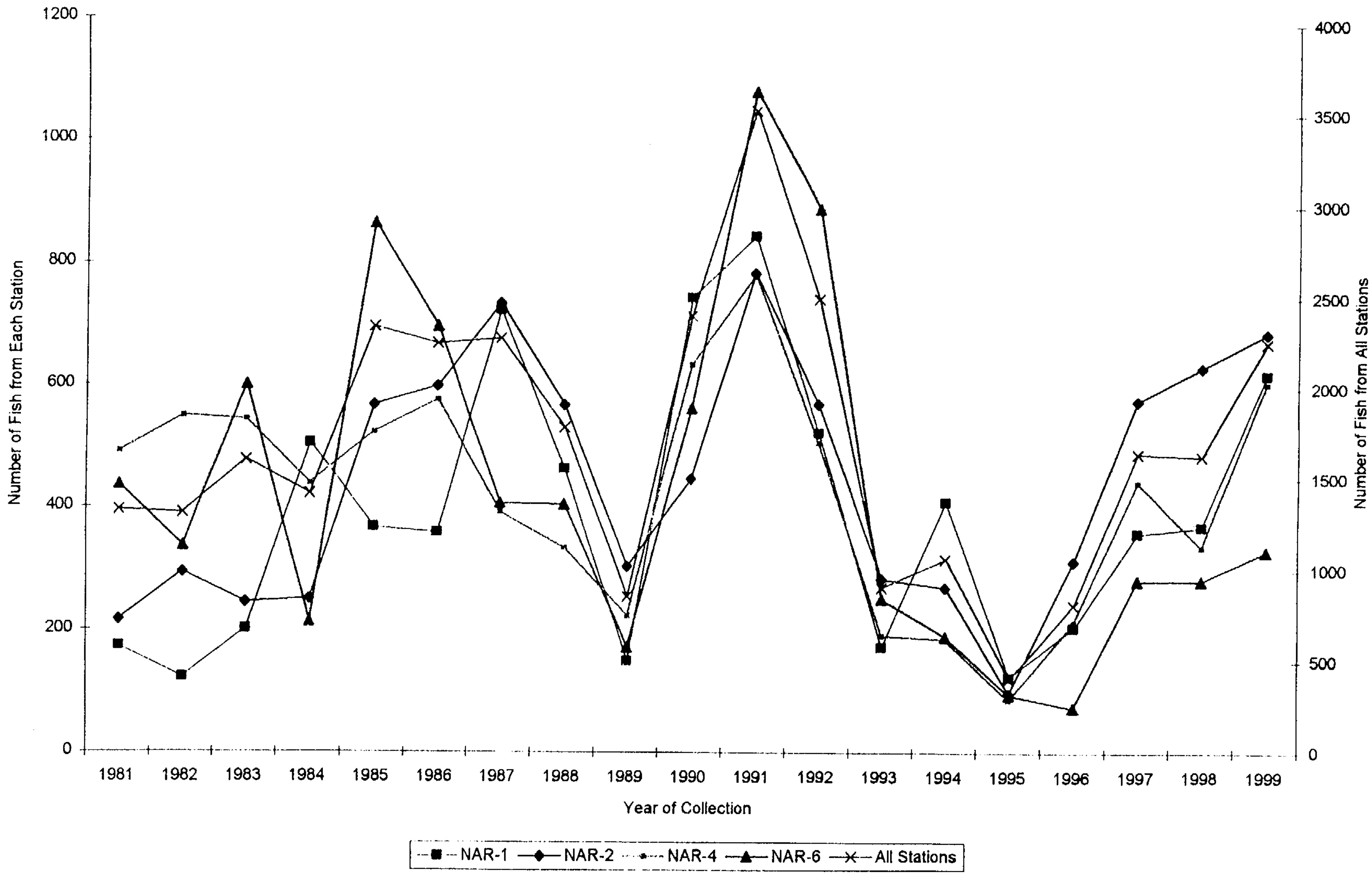


Figure 4.4-1. NAR-1 smallmouth and largemouth bass median densities, and mean visibility, 1987-1999.

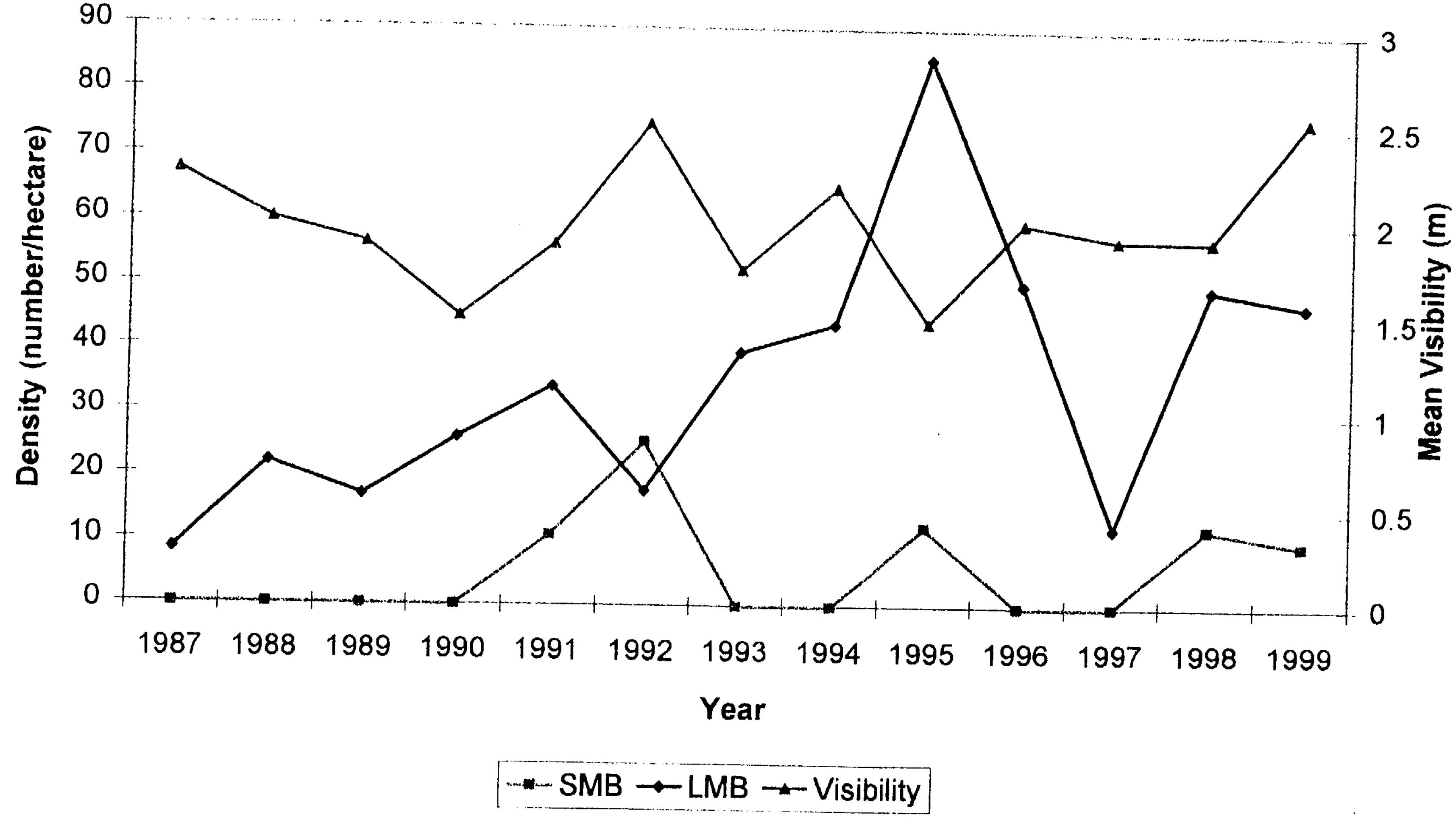


Figure 4. 4-2. NAR-2 smallmouth and largemouth bass median densities, and mean visibilities, 1987-1999.

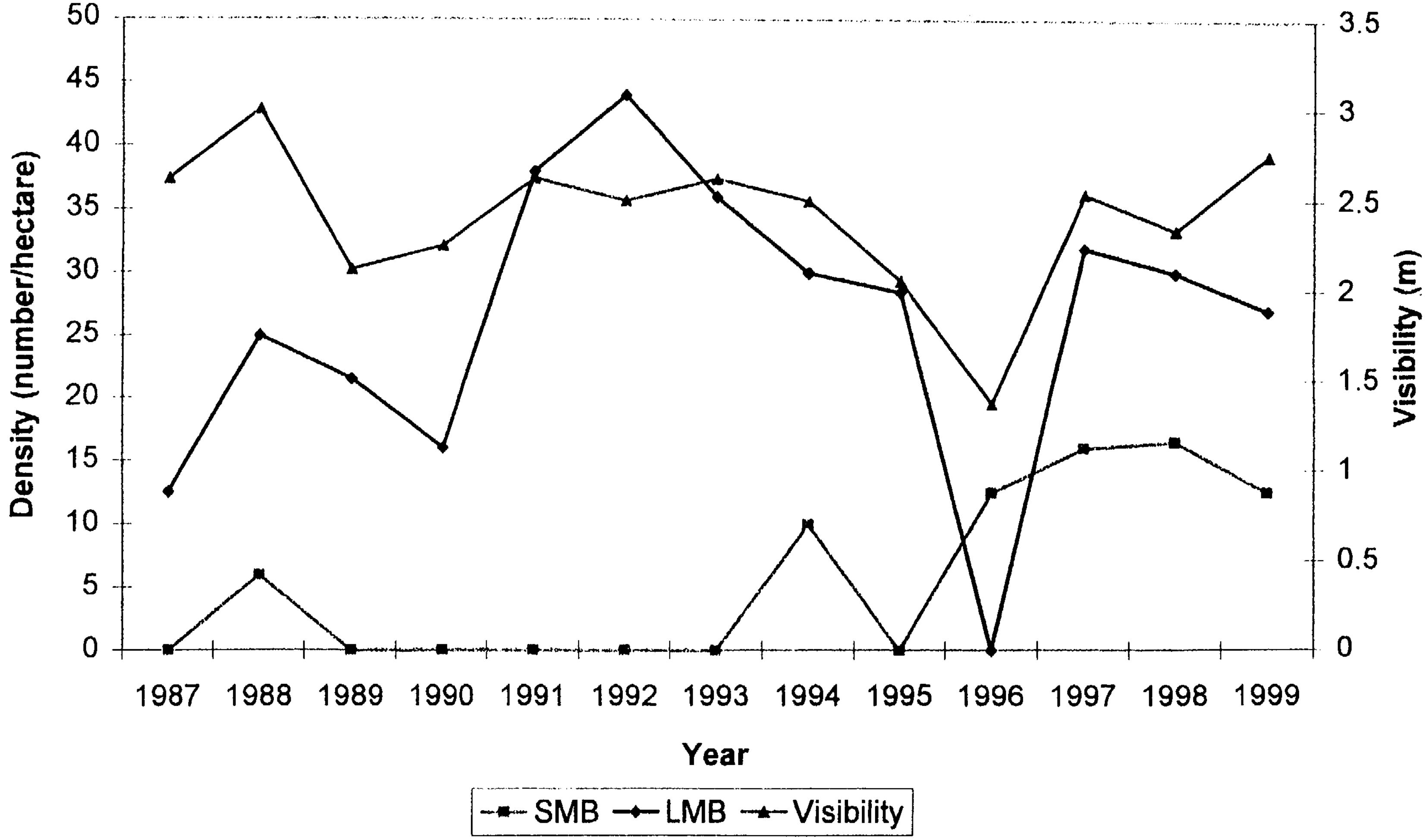


Figure 4. 4-3. NAR-4 smallmouth and largemouth bass median densities, and mean visibilities, 1987-1999.

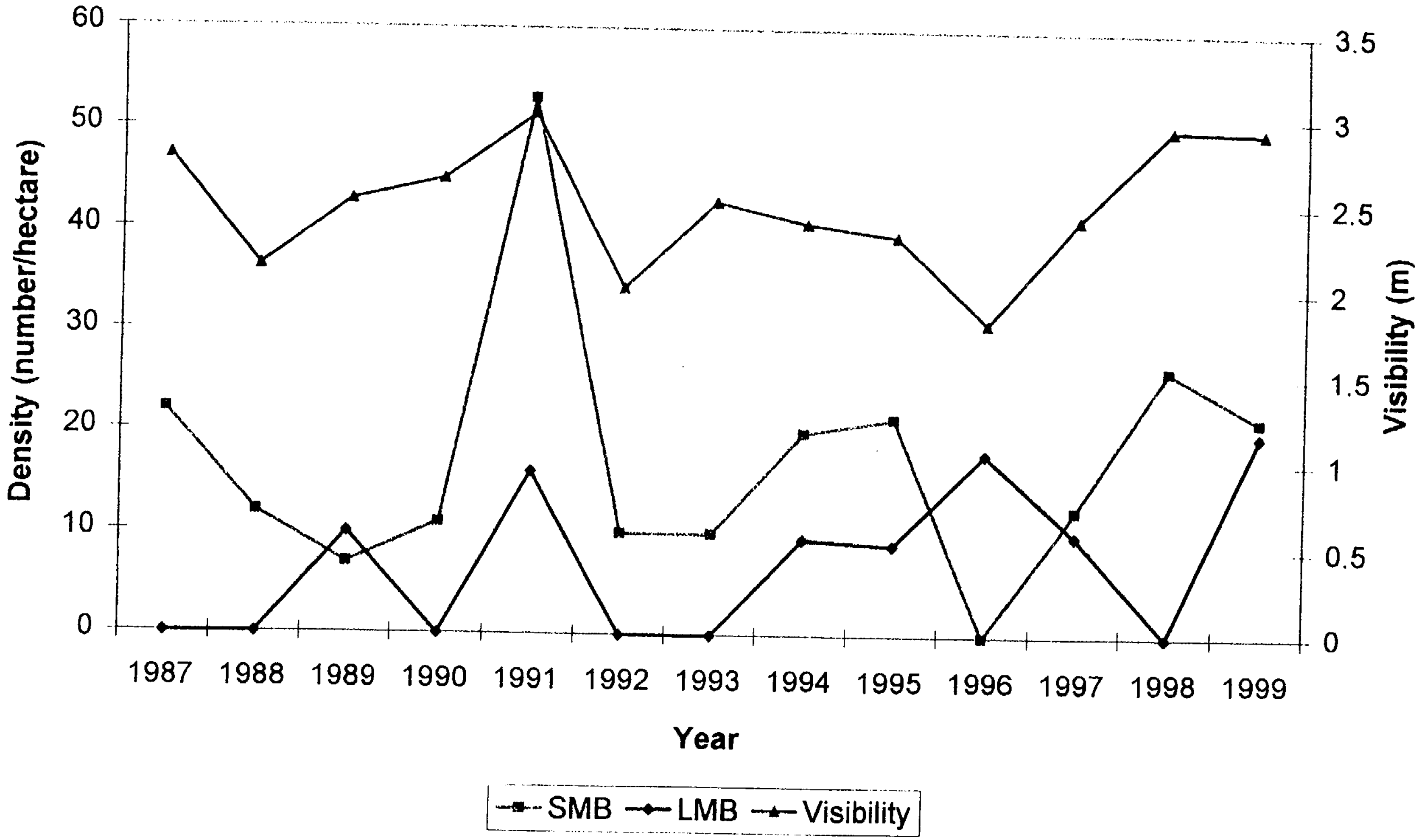


Figure 4. 4-4 . NAR-5 smallmouth and largemouth bass median densities, and mean visibilities, 1987-1999.

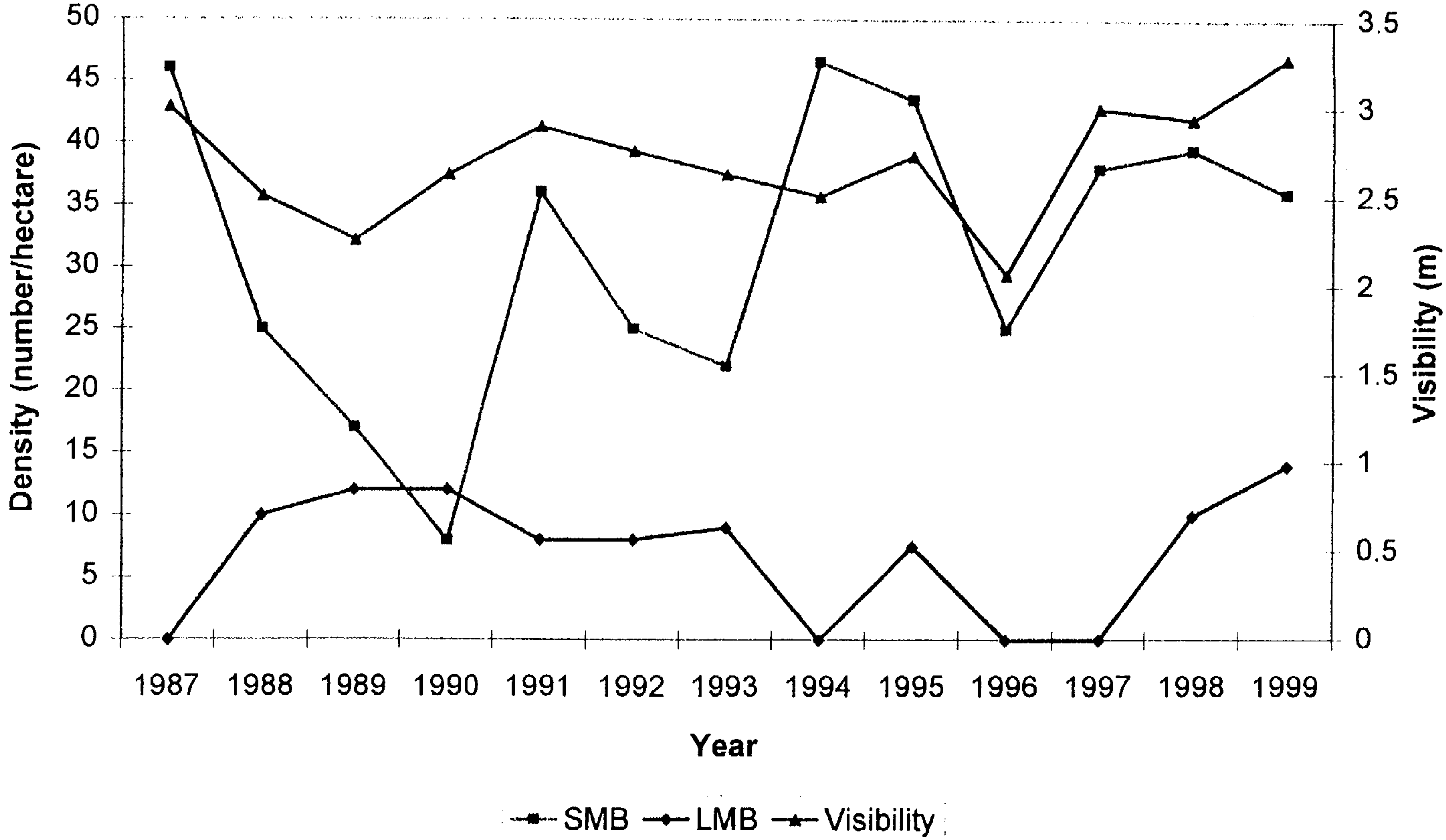


TABLE 2.0-1 Seasonal summary of North Anna Power Station operationg (percent of total Station load) 1978-1999.

Year	Winter	Spring	Summer	Fall	Quarterly Average
1978	0	23	42	45	27.5
1979	43	31	44	0	29.5
1980	31	37	53	65	46.5
1981	46	80	67	82	68.8
1982	78	26	19	48	42.8
1983	53	58	96	84	72.8
1984	76	64	16	66	55.5
1985	87	96	82	62	81.8
1986	75	88	62	80	76.3
1987	92	45	23	47	51.8
1988	75	99	94	97	91.3
1989	47	26	87	65	56.3
1990	98	98	69	61	81.5
1991	63	89	84	92	82
1992	35	80	92	71	69.5
1993	49	83	79	82	73.3
1994	96	91	75	91	88.5
1995	87	64	98	97	86.5
1996	76	98	83	66	80.8
1997	98	80	97	97	93
1998	96	81	85	94	89
1999	97	90	87	93	92
Quarters at 75-100%	13	13	12	11	

cjb/natable2.0-1/xls

TABLE 3.1-1. SUMMARY OF NORTH ANNA FIXED RECORDER TEMPERATURE DATA DURING 1999. VALUES ARE MEANS OF DAILY HIGH, MEAN AND LOW TEMPERATURES (IN DEGREES CELSIUS). ALL INSTRUMENTS ARE LOCATED AT THE SURFACE EXCEPT FOR NALST10 WHICH IS AT MID-DEPTH. "*" INDICATES DATA MISSING DUE TO INSTRUMENT MALFUNCTION OR DAMAGE. HOURS OF DATA COLLECTED ARE SHOWN.

STATION NO.	6	5	4	2	1	3	10	7	8	9	
YEAR=99 MONTH=JANUARY											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	*	5.5	7.4	8.6	9.7	10.7	11.4	19.8	16.0	13.3	9.7
MEAN	*	5.1	7.0	8.3	9.1	10.4	11.0	19.6	15.5	13.0	7.4
LOW	*	4.8	6.8	8.0	8.5	10.0	10.6	19.4	15.0	12.7	4.5
HOURS	0.0	744	744	744	744	744	743	743	743	744	80.0
YEAR=99 MONTH=FEBRUARY											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	8.0	7.8	9.1	9.9	10.3	11.9	12.5	21.2	17.2	14.9	11.5
MEAN	7.6	7.4	8.8	9.6	10.0	11.7	12.1	21.0	16.7	14.5	10.1
LOW	7.2	7.1	8.5	9.4	9.7	11.4	11.7	20.7	16.2	14.3	8.1
HOURS	672	672	672	672	672	672	672	672	672	672	672
YEAR=99 MONTH=MARCH											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	8.6	8.3	8.8	9.7	10.0	12.0	12.6	21.2	17.1	14.8	12.3
MEAN	8.0	7.8	8.4	9.4	9.7	11.6	12.2	20.9	16.5	14.4	11.5
LOW	7.6	7.4	8.0	9.1	9.3	11.3	11.8	20.6	15.9	14.0	10.8
HOURS	744	744	744	744	744	744	744	744	744	744	744
YEAR=99 MONTH=APRIL											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	16.3	16.3	16.2	16.4	16.5	17.2	17.0	26.6	23.1	21.0	17.9
MEAN	15.5	15.6	15.7	15.9	16.0	16.8	16.4	26.2	22.5	20.5	16.1
LOW	14.9	15.0	15.3	15.5	15.6	16.5	15.7	25.8	21.9	20.1	14.1
HOURS	719	719	720	719	720	718	719	719	720	719	718
YEAR=99 MONTH=MAY											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	22.6	*	21.4	22.0	22.1	22.1	21.7	*	27.2	25.7	23.0
MEAN	21.8	*	20.8	21.3	21.5	21.6	21.1	*	26.4	25.1	21.7
LOW	21.0	*	20.1	20.7	20.9	21.2	20.5	*	25.7	24.6	20.6
HOURS	744	0.0	541	744	744	744	744	0.0	744	744	744

TABLE 3.1-1(CONT.). SUMMARY OF NORTH ANNA FIXED RECORDER TEMPERATURE DATA DURING 1999. VALUES ARE MEANS OF DAILY HIGH, MEAN AND LOW TEMPERATURES (IN DEGREES CELSIUS). ALL INSTRUMENTS ARE LOCATED AT THE SURFACE EXCEPT FOR NALST10 WHICH IS AT MID-DEPTH. A "*" INDICATES DATA MISSING DUE TO INSTRUMENT MALFUNCTION OR DAMAGE. HOURS OF DATA COLLECTED ARE SHOWN.

STATION NO.	6	5	4	2	1	3	10	7	8	9	
YEAR=99 MONTH=JUNE											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	26.9	26.8	*	26.5	26.6	26.7	26.5	33.8	31.4	29.8	27.2
MEAN	26.2	26.1	*	26.0	26.0	26.3	26.0	33.5	30.7	29.3	26.1
LOW	25.6	25.5	*	25.5	25.5	25.9	25.5	33.2	30.1	28.9	25.2
HOURS	720	720	0.0	720	618	720	720	720	720	720	720
YEAR=99 MONTH=JULY											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	30.3	30.2	*	30.1	31.3	30.1	29.9	37.1	35.1	33.4	30.7
MEAN	29.5	29.5	*	29.4	30.5	29.6	29.4	36.8	34.2	32.8	29.5
LOW	28.8	28.9	*	28.9	29.7	29.2	28.9	36.5	33.4	32.3	28.5
HOURS	743	744	0.0	744	278	743	744	742	743	742	743
YEAR=99 MONTH=AUGUST											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	30.0	29.9	30.1	30.2	30.6	30.9	31.1	37.5	35.2	32.4	30.8
MEAN	29.3	29.2	29.5	29.6	30.0	30.5	30.8	37.2	34.4	31.9	29.7
LOW	28.8	28.6	29.1	29.2	29.6	30.2	30.4	37.0	33.7	31.6	28.9
HOURS	744	744	744	744	744	744	744	744	744	744	744
YEAR=99 MONTH=SEPTEMBER											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	25.0	24.9	26.7	25.5	25.9	26.2	26.5	32.6	29.5	27.0	25.9
MEAN	24.4	24.3	26.3	25.1	25.5	25.9	26.2	32.3	28.9	26.6	25.0
LOW	23.9	23.7	25.9	24.8	25.1	25.7	26.0	31.9	28.3	26.2	24.3
HOURS	720	720	369	720	720	720	720	720	720	720	720
YEAR=99 MONTH=OCTOBER											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	19.4	19.5	*	20.4	20.9	21.6	22.1	28.1	25.1	23.2	21.2
MEAN	18.9	18.9	*	20.1	20.5	21.4	21.9	27.8	24.6	22.5	20.4
LOW	18.6	18.5	*	19.9	20.2	21.1	21.7	27.5	24.1	22.1	19.7
HOURS	743	741	0.0	739	744	743	744	743	742	744	743

TABLE 3.1-1(CONT.). SUMMARY OF NORTH ANNA FIXED RECORDER TEMPERATURE DATA DURING 1999. VALUES ARE MEANS OF DAILY HIGH, MEAN AND LOW TEMPERATURES (IN DEGREES CELSIUS). ALL INSTRUMENTS ARE LOCATED AT THE SURFACE EXCEPT FOR NALST10 WHICH IS AT MID-DEPTH. A "*" INDICATES DATA MISSING DUE TO INSTRUMENT MALFUNCTION OR DAMAGE. HOURS OF DATA COLLECTED ARE SHOWN.

STATION NO.	6	5	4	2	1	3	10	7	8	9	
					YEAR=99 MONTH=NOVEMBER						
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	14.8	14.8	16.3	16.7	19.6	18.1	18.5	25.9	22.7	20.5	17.7
MEAN	14.4	14.3	16.0	16.4	19.3	17.9	18.3	25.6	22.2	20.2	17.0
LOW	14.1	14.0	15.6	16.2	18.9	17.6	18.0	25.3	21.7	19.9	16.4
HOURS	720	720	720	720	37.0	720	720	720	720	720	720
					YEAR=99 MONTH=DECEMBER						
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	9.3	9.4	11.3	12.0	*	14.1	14.6	22.9	18.5	15.9	13.7
MEAN	9.0	9.1	11.0	11.8	*	13.8	14.4	22.5	18.0	15.7	13.3
LOW	8.8	8.9	10.8	11.7	*	13.5	14.2	22.1	17.6	15.4	12.8
HOURS	744	744	744	744	0.0	744	744	744	744	744	744

TABLE 3.1-2. NORTH ANNA LAKE SURVEY SHOWING TEMPERATURES (IN CELSIUS DEGREES) MEASURED AT ONE METER INTERVAL DEPTHS FOR STATIONS IN LAKE ANNA.

DATE	DEPTH (M)	STATION A	B	C	D	E	F	G	H	I	J	K	L	M	N
990316	0	11.2	11.2	10.0	10.0	9.7	9.7	9.0	8.6	8.2	8.3	6.9	6.6	6.7	6.2
	1	11.1	11.1	10.0	10.0	9.7	9.6	8.9	8.6	8.1	8.2	6.8	6.5	6.6	6.0
	2	10.8	11.0	9.9	9.9	9.6	9.4	8.8	8.5	8.0	7.9	6.7	6.3	6.5	6.0
	3	10.7	11.0	9.8	9.7	9.5	9.4	8.7	8.4	8.0	7.8	6.6	6.3	6.2	5.9
	4	10.7	11.0	9.6	9.6	9.5	9.3	8.7	8.3	8.0	7.6	6.5	6.3	6.1	5.9
	5	10.7	11.0	9.6	9.6	9.4	9.3	8.7	8.3	8.0	7.5	6.4	6.2	6.1	5.9
	6	10.6	10.9	9.6	9.5	9.4	9.3	8.7	8.2	8.0	7.4	6.4	6.2	6.1	5.8
	7	10.6	10.9	9.5	9.5	9.4	9.3	8.7	8.2	8.0	7.2	6.4	6.2	6.1	5.8
	8	10.6	10.9	9.5	9.5	9.4	9.3	8.7	8.2	7.9	7.1	6.4		6.1	
	9	10.6	10.8	9.5	9.5	9.3	9.2	8.7	8.1	7.9	7.0	6.4			
	10	10.5	10.8	9.5	9.5	9.3	9.1	8.7	8.0	7.8	6.9	6.3			
	11	10.3	10.8	9.5	9.5	9.3	9.1	8.7	8.0	7.6	6.9	6.3			
	12	9.9	10.7	9.5	9.5	9.3	9.0	8.7	8.0	7.4	6.8	6.3			
	13	9.9	10.7	9.4	9.4	9.3	8.9	8.7	8.0	7.0	6.7	6.3			
	14	9.9	10.7	9.4	9.4	9.3	8.8	8.6	8.0		6.7				
	15	9.9	10.6	9.4	9.4	9.3	8.7	8.6	8.0						
	16	9.9	10.6	9.4	9.4	9.3	8.7	8.6							
	17	9.9		9.4	9.4	9.3	8.8	8.6							
	18	9.9		9.4	9.4	9.3	8.8	8.6							
	19	9.8			9.4		8.8	8.6							
	20	9.8					8.8	8.6							
	21	9.8													

TABLE 3.1-2(CONT.). NORTH ANNA LAKE SURVEY SHOWING TEMPERATURES (IN CELSIUS DEGREES) MEASURED AT ONE METER INTERVAL DEPTHS FOR STATIONS IN LAKE ANNA.

DATE	DEPTH (M)	STATION A	B	C	D	E	F	G	H	I	J	K	L	M	N
990720	0	30.2	29.6	29.2	29.6	29.4	30.1	29.7	29.7	29.6	29.5	29.2	28.9	29.5	29.4
	1	30.2	29.6	29.5	29.6	29.6	30.2	29.8	29.8	29.7	29.6	29.4	29.2	29.4	29.3
	2	30.2	29.7	29.6	29.7	29.6	30.1	29.9	29.8	29.7	29.6	29.4	29.3	29.3	28.8
	3	30.2	29.7	29.6	29.7	29.6	30.0	29.9	29.4	29.6	29.6	29.3	29.2	28.9	28.4
	4	30.2	29.6	29.4	29.5	29.5	29.7	29.8	29.1	29.1	29.6	29.1	28.8	28.2	28.1
	5	30.2	28.6	29.1	29.2	29.1	29.6	29.6	28.9	28.9	29.3	28.8	28.7	27.6	27.5
	6	30.2	27.9	29.0	29.0	29.0	29.3	29.1	28.6	28.5	28.3	28.1	27.7	27.0	27.0
	7	29.5	27.7	29.0	28.9	29.0	29.2	28.9	28.0	27.8	27.7	27.4	27.1	26.4	26.7
	8	29.1	27.4	28.9	28.8	28.7	29.0	28.4	27.5	27.4	27.4	27.1			
	9	28.4	27.1	28.7	28.7	28.6	28.6	27.8	27.3	27.3	27.2	26.9			
	10	28.1	26.8	28.1	27.9	28.1	28.0	27.6	27.0	27.2	27.0	26.7			
	11	27.5	26.5	27.8	27.6	27.7	27.5	27.3	26.8	27.1	26.8	26.5			
	12	27.2	25.8	27.4	27.5	27.4	27.2	27.0	26.7	26.8	26.5	26.2			
	13	27.0	24.9	26.8	27.1	26.7	26.9	26.8	26.5	26.6	26.2				
	14	26.1	24.6	25.9	26.0	26.0	26.1	26.5	26.1		22.4				
	15	25.2	24.5	24.8	25.0	25.0	25.5	25.2	25.8						
	16	23.9	24.3	24.0	24.3	23.9	24.3	24.2							
	17	23.0		23.4	23.3	23.1	23.6	23.4							
	18	21.6		21.7	21.7	21.7	22.0	22.8							
	19	19.9		20.3	20.2		19.5	20.5							
	20	18.6					18.6								

Table 3.2-1. Fishes collected in Lake Anna (1981-1999).

FAMILY	SPECIES	LAKE	WHTF
Anguillidae	Anguilla rostrata	X	X
Clupeidae	Alosa aestivalis	X	X
	Dorosoma cepedianum	X	X
	Dorosoma petenense	X	X
Esocidae	Esox americanus	X	X
	Esox lucius	X	
	Esox niger	X	X
Cyprinidae	Cyprinella analostana	X	X
	Cyprinus carpio	X	X
	Nocomis leptocephalus	X	
	Notemigonus crysoleucas	X	X
	Notropis hudsonius	X	X
	Notropis procne	X	X
Catostomidae	Carpoides cyprinus		X
	Catostomus commersoni	X	
	Erimyzon oblongus	X	X
	Moxostoma macrolepidotum	X	
Ictaluridae	Ameiurus catus	X	X
	Ameiurus natalis	X	X
	Ameiurus nebulosus	X	X
	Ictalurus furcatus	X	
	Ictalurus punctatus	X	X
Aphredoderidae	Aphredoderus sayanus	X	
Cyprinodontidae	Fundulus diaphanus	X	
Poeciliidae	Gambusia affinis	X	X
Moronidae	Morone americana	X	X
	Morone saxatilis	X	X
Centrarchidae	Lepomis auritus	X	X
	Lepomis cyanellus	X	X
	Lepomis gibbosus	X	X
	Lepomis gulosus	X	X
	Lepomis macrochirus	X	X
	Lepomis microlophus	X	X
	Micropterus salmoides	X	X
	Pomoxis nigromaculatus	X	X
Percidae	Etheostoma olmstedi	X	X
	Perca flavescens	X	X
	Stizostedion vitreum	X	X

Table 3.2-2. List of fishes collected in Lake Anna and the WHTF by gill netting in 1999.

FAMILY	SPECIES	LAKE ANNA	WHTF
Clupeidae	*Dorosoma cepedianum*	X	X
	Dorosoma petenense	X	
Cyprinidae	*Cyprinus carpio*	X	X
	Notropis hudsonius	X	
Catostomidae	*Erimyzon oblongus*	X	
Ictaluridae	*Ameiurus catus*	X	X
	Ameiurus natalis	X	
	Ameiurus nebulosus	X	
	Ictalurus punctatus	X	X
Moronidae	*Morone americana*	X	X
	Morone saxatilis	X	
Centrarchidae	*Lepomis macrochirus*	X	X
	Lepomis microlophus	X	X
	Micropterus salmoides	X	X
	Pomoxis nigromaculatus	X	X
Percidae	*Stizostedion vitreum*	X	

TABLE 3.2-3: Surface water temperature(C), dissolved oxygen(mg/l), pH, conductivity (umhos) recorded at time of sample collection during 1999

FEBRUARY

Electrofish Stations

	Temperature (C)	Conductivity	pH	Dissolved Oxygen
Dike 1 WHTF	21	33	7	12.9
Dike 3 WHTF	14	33	6.9	10.5
Lagoon 1	19.7	36	7.1	11.4
Lagoon 3	14.9	34	7.1	11.8
North Anna Arm	8.2	18	6.9	9.4
Thurman Island	9.3	18	7	9.1
Dike 1 Lake	10.9	17	7.1	9.8
Dike 3 Lake	12.8	17	7.1	9.3
Lower Lake Cove	12.5	17	6.9	9.5

Gillneting Stations

	Temperature (C)	Conductivity	pH	Dissolved Oxygen
Lagoon 1	21.2	34	7.1	11.9
Lagoon 3	15.4	36	7.1	11.7
North Anna Arm	7.5	35	7	9.9
Thurman Island	10.1	16	7	9.7
Levy Creek	11.9	17	7	9.4
Lower Lake	12.8	18	7.1	9.3

MAY

Electrofish Stations

	Temperature (C)	Conductivity	pH	Dissolved Oxygen
Dike 1 WHTF	29.4	52	8.3	8.7
Dike 3 WHTF	25.8	50	7.7	7.4
Lagoon 1	28.2	52	8	6.7
Lagoon 3	25.8	50	7.6	7.5
North Anna Arm	22.1	60	7.9	8.8
Thurman Island	23.3	50	7.8	8.2
Dike 1 Lake	22.5	50	7.9	8
Dike 3 Lake	23.6	50	7.9	8.3
Lower Lake Cove	24.1	49	8.1	8.6

Gillneting Stations

	Temperature (C)	Conductivity	pH	Dissolved Oxygen
Lagoon 1	29.6	51	7.9	8.6
Lagoon 3	26.4	50	7.9	8.3
North Anna Arm	22	52	7.9	8.7
Thurman Island	22.3	50	7.9	8.8
Levy Creek	23.3	50	7.8	8.4
Lower Lake	24	50	7.9	9

AUGUST

Electrofish Stations

	Temperature (C)	Conductivity	pH	Dissolved Oxygen
Dike 1 WHTF	36.5	64	6.9	6
Dike 3 WHTF	32.8	65	6.8	6.5
Lagoon 1	36.7	65	6.9	6.3
Lagoon 3	32.9	65	6.9	6.5
North Anna Arm	29.9	68	8.7	8.4
Thurman Island	31.6	64	7.3	8.4
Dike 1 Lake	30.5	51	6.7	6.4
Dike 3 Lake	31.2	52	6.7	5.9
Lower Lake Cove	32.1	52	7.2	6.4

Gillneting Stations

	Temperature (C)	Conductivity	pH	Dissolved Oxygen
Lagoon 1	37.2	65	6.8	6.4
Lagoon 3	33.1	65	6.9	6.3
North Anna Arm	29.8	66	8.4	8.8
Thurman Island	30.9	52	7.5	5.1
Levy Creek	31.6	52	6.7	6.1

OCTOBER

Electrofish Stations

	Temperature (C)	Conductivity	pH	Dissolved Oxygen
Dike 1 WHTF	27.2	40	6.9	7.2
Dike 3 WHTF	22.6	92	6.4	6.9
Lagoon 1	26.5	39	6.7	7
Lagoon 3	22.2	50	6.5	6.8
North Anna Arm	18.3	40	7.5	8.8
Thurman Island	19.7	37	7.2	7.2
Dike 1 Lake	19.3	44	7	7.9
Dike 3 Lake	21.3	34	6.8	7
Lower Lake Cove	19.7	35	6.9	7.2

Gillneting Stations

	Temperature (C)	Conductivity	pH	Dissolved Oxygen
Lagoon 1	28.6	38	6.7	7.2
Lagoon 3	22.8	41	6.5	7.3
North Anna Arm	18.3	45	6.9	8.9
Thurman Island	20.1	37	7.3	7.2
Levy Creek	20.4	36	6.9	7.5

TABLE 3.2-4 GILL NET SUMMARY 1999

GILL NET - LAKE

STATION:ALL STATIONS

SPECIES	FEBRUARY NUMBER	FEBRUARY WEIGHT	MAY NUMBER	MAY WEIGHT	AUGUST NUMBER	AUGUST WEIGHT	OCTOBER NUMBER	OCTOBER WEIGHT	TOTALS NUMBER	TOTALS WEIGHT	% OF TOTAL NUMBER	% OF TOTAL WEIGHT
D.cepedianum	11	2905	71	16023	64	13345	31	6184	177	38457	37	17
M. saxatilis	40	37293	23	27661	2	1749	3	647	68	67350	14	30
A. catus	20	4339	21	4874	8	3987	3	886	52	14086	11	6
P. nigromaculatus	13	1460	20	1201	6	1075	8	631	47	4367	10	2
I. punctatus	6	4924	13	12471	9	7549	15	5629	43	30572	9	14
M. americana	7	507	16	2019	1	9	9	744	33	3279	7	1
M. salmoides	4	5375	6	2500	3	407	4	3315	17	11597	4	5
C. carpio	2	5777	4	12949	7	20400	2	6263	15	45389	3	20
D. petenense	1	6	5	49	3	23	3	23	12	100	2	0
L. microlophus	1	148	4	773	1	7			6	927	1	0
S. vitreum	1	140	4	5118					5	5258	1	2
N. hudsonius	1	11	1	9	1	11			3	30	1	0
L. macrochirus			1	65			1	6	2	72	0	0
E.oblongus							1	1292	1	1292	0	1
A.nebulosus					1	97			1	97	0	0
A. natalis							1	85	1	85	0	0
Total No.	107		189		106		81		483		100	
Total Wt.	62882		85713		48657		25706		222957		100	

GILL NET TOTALS - WHTF

STATION:ALL STATIONS

SPECIES	FEBRUARY NUMBER	FEBRUARY WEIGHT	MAY NUMBER	MAY WEIGHT	AUGUST NUMBER	AUGUST WEIGHT	NOVEMBER NUMBER	NOVEMBER WEIGHT	TOTALS NUMBER	TOTALS WEIGHT	% OF TOTAL NUMBER	% OF TOTAL WEIGHT
D. cepedianum	31	14237	12	4428	20	6831	10	3813	73	29309	39	40
I. punctatus	24	6548	9	3574	4	1856	7	3009	44	14987	24	20
M. salmoides	1	198	11	3627	13	2534	1	832	26	7190	14	10
L. microlophus			5	679	11	1640	2	191	18	2510	10	3
M. americana	5	419	6	656	1	133			12	1207	6	2
A. catus	4	976	2	604			1	304	7	1884	4	3
C. carpio	1	3562	1	2751			3	10004	5	16317	3	22
L. macrochirus	1	5			1	39			2	44	1	0
P. nigromaculatus	1	255							1	255	1	0
Total No.	67		46		50		24		187		100	
Total Wt.	25944		16319		13031		18153		73447		100	

TABLE 3.2-5: NUMBER AND WEIGHT (g) OF FISHES BY STATION COLLECTED BY GILL NETTING ON LAKE ANNA DURING 1999

STATION		FEBRUARY	MAY	AUGUST	OCTOBER	TOTAL	AVERAGE
LAGOON 1							
	NUMBER	53	23	1	12	89	22.25
	WEIGHT	16818	9992	39	14246	41095	10273.75
LAGOON 3							
	NUMBER	15	23	49	12	99	24.75
	WEIGHT	9380	6327	12993	3907	32607	8151.75
LEVY CREEK							
	NUMBER	29	42	33	7	111	27.75
	WEIGHT	21281	14977	7536	1047	44841	11210.25
N. ANNA ARM							
	NUMBER	60	83	33	48	224	56
	WEIGHT	27360	44203	28677	18473	118713	29678.25
DIKE 3 LAKE							
	NUMBER	2	26	29	4	61	15.25
	WEIGHT	3385	9773	10445	1585	25188	6297
THURMAN ISLAN							
	NUMBER	16	37	11	22	86	21.5
	WEIGHT	10856	16760	1999	4600	34215	8553.75
TOTAL NUMBER		175	234	156	105	670	167.5
TOTAL WEIGHT		89080	102032	61689	43858	296659	74164.75

Table 3.3-1. List of fishes collected in Lake Anna and the WHTF by electrofishing in 1999.

FAMILY	SPECIES	LAKE ANNA	WHTF
Clupeidae	*Dorosoma cepedianum*	X	
	Dorosoma petenense	X	
Esocidae	*Esox niger*	X	
Cyprinidae	*Cyprinella analostana*	X	X
	Cyprinus carpio	X	X
	Notropis hudsonius	X	
Catostomidae	*Erimyzon oblongus*	X	
Ictaluridae	*Ameiurus natalis*	X	X
	Ameiurus nebulosus	X	X
	Ictalurus punctatus	X	X
Moronidae	*Morone americana*	X	
Centrarchidae	*Lepomis auritus*	X	X
	Lepomis cyanellus	X	X
	Lepomis gulosus	X	X
	Lepomis macrochirus	X	X
	Lepomis microlophus	X	X
	Micropterus salmoides	X	X
	Pomoxis nigromaculatus	X	
Percidae	*Etheostoma olmstedi*	X	
	Perca flavescens	X	

TABLE 3 3-2 ELECTROFISH SUMMARY 1999

ELECTROFISH - LAKE

STATION ALL STATIONS	FEBRUARY		MAY		AUGUST		OCTOBER		TOTALS		% OF TOTAL	
SPECIES	NUMBER	WEIGHT(g)	NUMBER	WEIGHT(g)	NUMBER	WEIGHT(g)	NUMBER	WEIGHT(g)	NUMBER	WEIGHT(g)	NUMBER	WEIGHT
L.macrochirus	698	8131	317	3079	257	2601	456	4113	1728	17925	69	25
L.auritus	84	1036	49	660	45	514	78	976	256	3186	10	4
M.salmoides	76	15318	12	2666	14	860	23	4574	125	23417	5	33
L.gulosus	53	827	22	522	15	312	34	384	124	2045	5	3
L.microlophus	86	5063	14	600	6	723	8	260	114	6645	5	9
P. nigromaculatus	1	6	13	897	20	1306	10	1047	44	3255	2	5
C analostana	3	7	16	54	6	9	1	1	26	70	1	0
D.cepedianum					12	1686	3	425	15	2110	1	3
L cyanellus	3	35	4	162	2	28	4	38	13	263	1	0
P.flavescens	2	180	4	71	2	38	2	11	10	300	0	0
D petenese					9	26			9	26	0	0
A natalis			5	204					5	204	0	0
I punctatus			4	2296					4	2296	0	3
M.americana	1	30	1	40	1	30	1	35	4	135	0	0
A nebulosus			2	533			2	201	4	734	0	1
E niger	2	173			1	15			3	188	0	0
C.carpio							3	8950	3	8950	0	12
E.olmstedi	1	1			1	1			2	2	0	0
N.hudsonius			1	2					1	2	0	0
E oblongus					1	37			1	37	0	0
Total No.	1010		464		392		625		2491		100	
Total Wt.(g)	30805		11786		8184		21015		71790		100	

ELECTROFISH TOTALS - WH1

STATION ALL STATIONS	FEBRUARY		MAY		AUGUST		OCTOBER		TOTALS		% OF TOTAL	
SPECIES	NUMBER	WEIGHT(g)	NUMBER	WEIGHT(g)	NUMBER	WEIGHT(g)	NUMBER	WEIGHT(g)	NUMBER	WEIGHT(g)	NUMBER	WEIGHT
L.macrochirus	1308	10367	162	2547	426	2300	594	6002	2490	21215	89	60
L.cyanellus	38	337	8	131	18	248	23	299	87	1014	3	3
L.microlophus	57	967	5	53	1	31	8	427	71	1477	3	4
M.salmoides	19	1021	13	2316	10	252	13	1280	55	4869	2	14
L.gulosus	14	286	3	30	8	134	7	100	32	550	1	2
L.auritus	16	189	1	14	6	26	9	313	32	543	1	2
I punctatus	1	640	2	759			3	27	6	1426	0	4
A.natalis			4	47					4	47	0	0
C.analostana	2	6	2	6					4	11	0	0
A.nebulosus							3	60	3	60	0	0
C.carpio			1	3434	1	433			2	3867	0	11
Total No.	1455		201		470		660		2786		100	
Total Wt.(g)	13810		9336		3424		8509		35079		100	

TABLE 3.3-3 NUMBER AND WEIGHT (g) OF FISHES BY STATION COLLECTED BY ELECTROFISHING ON LAKE ANNA DURING 1999

STATION		FEBRUARY	MAY	AUGUST	OCTOBER	TOTAL	AVERAGE
LAGOON 1	NUMBER	220	39	94	74	427	106.75
	WEIGHT	1371	4137	786	432	6726	1681.5
LAGOON 3	NUMBER	197	58	39	63	357	89.25
	WEIGHT	2159	3733	792	1586	8270	2067.5
DIKE 1-WHTF	NUMBER	698	72	249	270	1289	322.25
	WEIGHT	6265	1074	954	4128	12421	3105.25
DIKE 3-WHTF	NUMBER	340	32	88	253	713	178.25
	WEIGHT	4017	392	891	2364	7664	1916
DIKE 1-LAKE	NUMBER	481	117	58	258	914	228.5
	WEIGHT	5125	2038	1399	3079	11641	2910.25
DIKE 3-LAKE	NUMBER	142	99	93	58	392	98
	WEIGHT	1273	1643	1145	806	4867	1216.75
LOWER LAKE	NUMBER	107	89	100	127	423	105.75
	WEIGHT	900	2083	1258	1470	5711	1427.75
THURMAN ISLAN	NUMBER	237	46	65	98	446	111.5
	WEIGHT	22455	3517	2629	3360	31961	7990.25
NORTH ANNA AF	NUMBER	43	113	76	84	316	79
	WEIGHT	1053	2505	1754	12300	17612	4403
TOTAL NUMBER		2465	665	862	1285	5277	1319.25
TOTAL WEIGHT		44618	21122	11608	29525	106873	26718.25

TABLE 3.4 - 1: ESTIMATE OF HYDRILLA (*Hydrilla verticillata*) COLONIZATION OF LAKE ANNA AND WASTE HEAT TREATMENT FACILITY (WHTF). NORTH ANNA POWER STATION, 1999 SURVEY

	LAKE ANNA	WASTE HEAT TREATMENT FACILIY			
		LAGOON 1	LAGOON 2	LAGOON 3	TOTAL
	+++++++	++++++++	+++++++++	+++++++++	++++++
TOTAL ACRES	9600	225	2206	969	3400
AVAILABLE ACRES OF HABITAT(1)	3885	110	1158	442	1710
ACRES OF HYDRILLA COLONIZATION	113	4.2	19.7	11.6	35.5
PERCENT OF AVAILABLE HABITAT COLONIZED	3%	3.80%	1.70%	2.60%	2%

(1) ACRES OF 15 FEET OR LESS WATER DEPTH

Table 4.1-1 Mean, maximum, and minimum hourly water temperatures (C) recorded in the North Anna River, by month, during 1999. Sample size (n) equals the number of hourly observations recorded each month.

	NAR-1			
Month	Mean	Max	Min	n
January	7.4	13.0	1.6	80
February	10.1	15.0	1.9	672
March	11.5	15.2	7.6	744
April	16.1	21.3	6.2	718
May	21.7	26.8	16.4	744
June	26.1	30.0	23.9	720
July	29.5	32.8	26.5	743
August	29.7	32.5	26.4	744
September	25.0	28.4	21.4	720
October	20.4	23.7	17.4	743
November	17.0	20.2	14.3	720
December	13.3	15.5	10.4	744

na/xl/040698

Table 4.3-1. Number and biomass (g) of fishes collected during May, July and October 1999 electrofishing surveys of the North Anna River.

Family Species	NAR-1 Number	NAR-1 Mass	NAR-2 Number	NAR-2 Mass	NAR-4 Number	NAR-4 Mass	NAR-6 Number	NAR-6 Mass	Total Number	Total Mass
Petromyzontidae										
Lampetra appendix			1	4.3			3	18.5	4	22.8
Anguillidae										
Anguilla rostrata	80	1596.6	19	456.3	26	558.6	12	350.2	137	2961.7
Cyprinidae										
Cyprinella analostana	21	97.4	191	308.1	98	240.4	47	114.6	357	760.5
Lythrurus ardens	129	328.7	27	64.1	57	128.4	14	31.0	227	552.2
Nocomis leptocephalus	1	13.9	4	21.1	10	321.6			15	356.6
Nocomis micropogon	2	65.0			37	228.3	1	1.1	40	294.4
Notropis amoenus	6	23.0	1	1.6			3	8.7	10	33.3
Notropis procne	13	22.7	158	189.3	4	5	43	58.9	218	275.9
Notropis rubellus	15	40.8	19	31.3	26	44.3	16	20.0	76	136.4
Semotilus corporalis	17	356.1	44	111.9	118	318.3	22	285.3	201	1071.6
Catostomidae										
Erimyzon oblongus			1	83					1	83.0
Hypentelium nigricans	12	901.2	9	102.3	19	180.2	11	196.9	51	1380.6
Ictaluridae										
Ameiurus natalis	1	13.1							1	13.1
Ameiurus nebulosus			3	114.8	2	3.6			5	118.4
Ictalurus punctatus							1	5.6	1	5.6
Noturus insignis	77	385.5	29	143.5	69	264.8	23	117.9	198	911.7
Centrarchidae										
Enneacanthus gloriosus							1	5.0	1	5.0
Lepomis auritus	191	3219.4	141	747.3	110	789.7	69	601.0	511	5357.4
Lepomis gibbosus							1	69.5	1	69.5
Lepomis macrochirus	17	194.6	3	15.8			7	84.3	27	294.7
Lepomis microlophus					2	3.3	2	59.5	4	62.8
Micropterus dolomieu	1	231.0	2	15.1	1	3.5	3	27.0	7	276.6
Micropterus salmoides	13	168.5	7	17.9			9	35.3	29	221.7
Percidae										
Etheostoma olmstedi	10	19.1	13	11.9	20	29.1	9	11.5	52	71.6
Etheostoma vitreum			2	2.2			11	13.6	13	15.8
Percina peltata	18	64.4	19	34.3	10	27.6	23	47.2	70	173.5
Esocidae										
Esox niger							1	49.4	1	49.4
Total	624	7741.0	693	2476.1	609	3146.7	332	2212.0	2258	15575.8
Number of species	18		20		16		24		28	

Table 4.3-2 Fishes collected from the North Anna River during annual electrofishing surveys, 1981-1999.

Family	Species	NAR-1	NAR-1	NAR-4	NAR-6
Petromyzontidae	*Lampetra appendix*		X	X	X
	Petromyzon marinus	X	X	X	X
Anguillidae	*Anguilla rostrata*	X	X	X	X
Clupeidae	*Alosa aestivalis*	X			
	Dorosoma cepedianum	X			
Esocidae	*Esox americanus*				X
	Esox niger	X	X	X	X
Cyprinidae	*Cyprinella analostana*	X	X	X	X
	Hyboganthus regius			X	X
	Luxilus comutus			X	
	Lythrurus ardens	X	X	X	X
	Nocomis leptocephalus	X	X	X	X
	Nocomis micropogon	X	X	X	X
	Notemigonuxc crysoleucas	X	X	X	X
	Notropis amoenus	X	X	X	X
	Notropis hudsonius				X
	Notropis procne	X	X	X	X
	Notropis rubellus	X	X	X	X
	Phoxinus oreas			X	
	Rhinichthys atratulus				X
	Semotilus corporalis	X	X	X	X
Catostomidae	*Catostomus commersoni*		X		X
	Erimyzon oblongus	X	X	X	
	Hypentelium nigricans	X	X	X	X
	Moxostoma macrolepidotum		X	X	X
Ictaluridae	*Ameriurus natalis*	X	X	X	X
	Ameriurus nebulosus	X	X		X
	Ictalurus punctatus				X
	Noturus gyrinus				X
	Noturus insignis	X	X	X	X
Aphredoderidae	*Aphredoderus sayanus*			X	X
Percichthyidae	*Morone americana*	X			
Centrarchidae	*Acantharchur pomotis*	X			
	Centrarchus macropterus				X
	Enneacanthus gloriosus				X
	Lepomis auritus	X	X	X	X
	Lepomis gibbosus	X	X	X	X
	Lepomis gulosus				X
	Lepomis macrochirus	X	X	X	X
	Lepomis microlophus	X	X		X
	Micropterus dolomieu	X		X	X
	Micropterus salmoides	X	X	X	X
	Pomoxis nigromaculatus	X	X	X	X
Percidae	*Etheostoma olmstedi*	X	X	X	X
	Etheostoma vitreum	X	X	X	X
	Perca flavescens	X			X
	Percina notograma		X	X	X
	Percina peltata	X	X	X	X
Soleidae	*Trinectes maculatus*				X

na/xl/042298

Table 4.3-3. Ranked abundance of species comprising greater than 80 percent of the pooled annual North Anna River electrofishing catch from all stations, 1981-1999. A species rank of 1 indicates it was the most abundant fish collected.

Species	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Notropis procne	2	1	1	1	1	1	1	1	1	4	2	3	1	2	7	3	2	2	4
Cyprinella analostana	1	2	2	3	2	2	5	2	3	2	1	1	3	6	6	1	1	4	2
Lepomis auritus	3	3	3	2	3	4	2	3	2	1	4	2	2	1	1	2	3	1	1
Notropis rubellus	--	5	8	8	10	3	3	4	4	3	3	5	4	3	5	--	8	6	--
Noturus insignis	8	--	--	--	6	5	4	6	7	6	5	6	5	4	3	--	4	7	6
Percina peltata	--	--	7	4	5	8	--	5	--	5	6	--	8	5	8	6	10	--	--
Anguilla rostrata	4	4	4	6	9	--	6	--	6	7	--	7	6	7	4	4	6	5	7
Lythrurus ardens	--	--	--	--	7	7	7	--	--	--	7	4	7	--	2	--	5	3	3
Nocomis micropogon	6	--	5	--	--	8	--	--	--	--	8	8	--	--	9	--	--	--	--
Nocomis leptocephalus	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Semotilus corporalis	--	--	9	--	4	9	--	--	--	--	--	--	--	--	--	--	9	--	5
Notropis amoenus	7	6	--	7	--	--	--	--	5	--	--	--	--	--	--	5	7	8	--
Hypentelium nigricans	--	--	--	--	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Notemigonus crysoleucas	--	--	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pomoxis nigromaculatus	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lepomis macrochirus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7	--	--	--
Total number of species collected	26	27	29	31	31	29	32	30	18	25	25	29	25	25	22	20	24	28	28
Number of species accounting for >80%	8	6	9	7	10	9	7	6	7	7	8	8	8	7	9	7	10	8	7
Percent of electrofishing catch	83	82	81	83	83	83	80	82	80	80	84	83	83	85	82	82	84	80	82

*-- indicates species was not among those comprising greater than 80% of the electrofishing catch

Table 4.4-1. Number of smallmouth bass and largemouth bass observed during North Anna River snorkel surveys conducted in 1999. Sample size (n) equals the number of times each count was performed in 1999.

				Smallmouth bass [1]			Largemouth bass [2]		
Station	Bank	Count	n	SMBYOY	SMB<11	SMB>11	LMBYOY	LMB<12	LMB>12
NAR-1	North	1	5	2	1	0	15	4	11
		2	5	7	0	1	27	4	5
		3	5	1	0	0	27	3	4
	South	1	5	0	3	0	5	5	7
		2	5	2	1	0	2	3	10
		3	5	1	0	2	9	3	9
NAR-2	North	1	5	10	2	0	27	8	1
		2	5	9	5	6	32	4	1
		3	5	14	3	0	20	5	1
	South	1	5	7	5	0	31	7	6
		2	5	8	2	1	25	5	5
		3	5	9	18	4	47	2	3
NAR-4	North	1	5	3	4	0	8	6	4
		2	5	3	3	0	3	6	4
		3	5	1	4	2	8	4	1
	South	1	5	4	14	0	1	1	2
		2	5	2	5	3	3	3	0
		3	5	3	7	4	5	5	0
NAR-5	North	1	4	3	9	6	1	10	3
		2	4	3	11	8	1	7	2
		3	4	6	8	9	1	5	2
	South	1	4	6	2	0	0	0	1
		2	4	5	3	3	3	1	0
		3	4	7	4	1	2	1	0

[1] SMYOY were less than or equal to 120 mm, SMB<11 were 121-279 mm, SMB>11 were larger than or equal to 280 mm TL.

[2] LMBYOY were less than or equal to 120 mm, LMB<11 were 121-304 mm, LMB>11 were larger than or equal to 305 mm TL.

Table 4.4-2. Cover use by smallmouth bass and largemouth bass in the North Anna River observed during the first of three counts made during snorkel surveys conducted in 1999.

Cover Type

NAR-1	Ledge	Boulder	Wood	Vegetation	Open*
SMBYOY**	0	0	0	2	0
SMB<11	0	1	1	1	1
SMB>11	0	0	0	0	0
LMBYOY	0	0	4	15	0
LMB<12	0	0	3	3	3
LMB>12	0	0	9	6	3

NAR-2	Ledge	Boulder	Wood	Vegetation	Open
SMBYOY	0	0	3	0	0
SMB<11	0	0	2	0	4
SMB>11	0	0	0	0	0
LMBYOY	0	0	1	0	2
LMB<12	0	1	2	4	0
LMB>12	0	0	0	0	0

Cover Type

NAR-4	Ledge	Boulder	Wood	Vegetation	Open
SMBYOY	0	1	0	0	0
SMB<11	0	0	0	0	0
SMB>11	0	0	0	0	0
LMBYOY	0	0	0	0	0
LMB<12	0	0	1	0	1
LMB>12	0	0	1	0	0

NAR-5	Ledge	Boulder	Wood	Vegetation	Open
SMBYOY	0	0	0	0	0
SMB<11	0	1	0	0	0
SMB>11	1	2	0	0	0
LMBYOY	0	0	0	0	0
LMB<12	0	0	0	0	0
LMB>12	0	0	0	0	0

*Fish observed in open water were farther than 0.5 m from any cover type.
**See Table 4.3-1 for size category definitions.

Table 4.4-3. Cover use by smallmouth bass and largemouth bass in the North Anna River observed during the first of three counts made during snorkel surveys conducted in 1999. Data for observations at all stations are pooled.

All Stations	Ledge	Boulder	Wood	Vegetation	Open
	Cover Type				
SMBYOY	0	1	3	2	0
SMB<11	0	2	3	1	5
SMB>11	1	2	0	0	0
LMBYOY	0	0	5	15	2
LMB<12	0	1	6	7	4
LMB>12	0	0	10	6	3

na/xl/04/06/98

5.0 Literature Cited

Barko, J. W., D. G. Hardin, and M. S. Matthews. 1982. Growth and morphology of submerged freshwater macrophytes in relation to light and temperature. Canadian Journal of Botany, 60.6: 877-887. 1982.

Bettoli, P. W., M. J. Maceinia, R. L. Noble, R. K. Betsill. 1992. Piscivory in largemouth bass as a function of aquatic vegetation abundance. North American Journal of Fisheries Management. 12: 509-516, 1992.

Colle, D. E., and J. V. Shireman. 1980. Coefficients of condition for largemouth bass, bluegill, and redear sunfish in hydrilla-infested lakes. Transactions of the American Fisheries Society. 109: 521-531.

Hollander, M., and D.A. Wolfe. 1973. Non-parametric Statistical Methods. John Wiley and Sons, Inc., New York, New York.

Groshens, T.P., and D.J. Orth. 1995. Assessment of the transferability of habitat suitability criteria for smallmouth bass, Micropterus dolomieu. Environmental Biology of Fishes in press.

Jager, H.I., D.L. DeAngelis, M.J. Sale, W. Van Winkle, D.D. Schmoyer, M.J. Sabo, D.J. Orth, and J.A. Lukas. 1993. An individual-based model for smallmouth bass reproduction and young-of-year dynamics in streams. Rivers: Studies in the Science, Environmental Policy and Law of Instream Flow 4:91-113.

Sabo, M.J., and D.J. Orth. 1995c. Net rate of energy gain by age-0 smallmouth bass foraging in different microhabitats within the North Anna River, Virginia. Environmental Biology of Fishes. In press.

Virginia Power. 1986. Section 316(a) demonstration for North Anna Power Station. Virginia Power, Richmond, Virginia.

Virginia Power. 1990. Environmental study of Lake Anna and the lower North Anna River. Annual report for calendar year 1989. Virginia Power, Richmond, Virginia.

Virginia Power. 1992. Environmental study of Lake Anna and the lower North Anna River. Annual report for calendar year 1991, including summary of 1989-1991, Lake Anna and the lower North Anna River. Virginia Power, Richmond, Virginia.

Virginia Power. 1993. Annual report for 1992: Lake Anna and the lower North Anna River. Annual report for calendar year 1992. Virginia Power, Richmond, Virginia.

Virginia Power. 1995. Annual report for 1994: Lake Anna and the lower North Anna River. Annual report for calendar year 1994. Virginia Power, Richmond, Virginia.

Virginia Power. 1996. Annual report for 1995: Lake Anna and the lower North Anna River. Annual report for calendar year 1995. Virginia Power, Richmond, Virginia.

Wrenn, W. B., D. R. Lowery, M. J. Maceina, and W. C. Reeves. 1995. Relationships between largemouth bass and aquatic plants in Guntersville Reservoir Alabama. Third National Reservoir Symposium, Chattanooga, Tennessee. 1995.