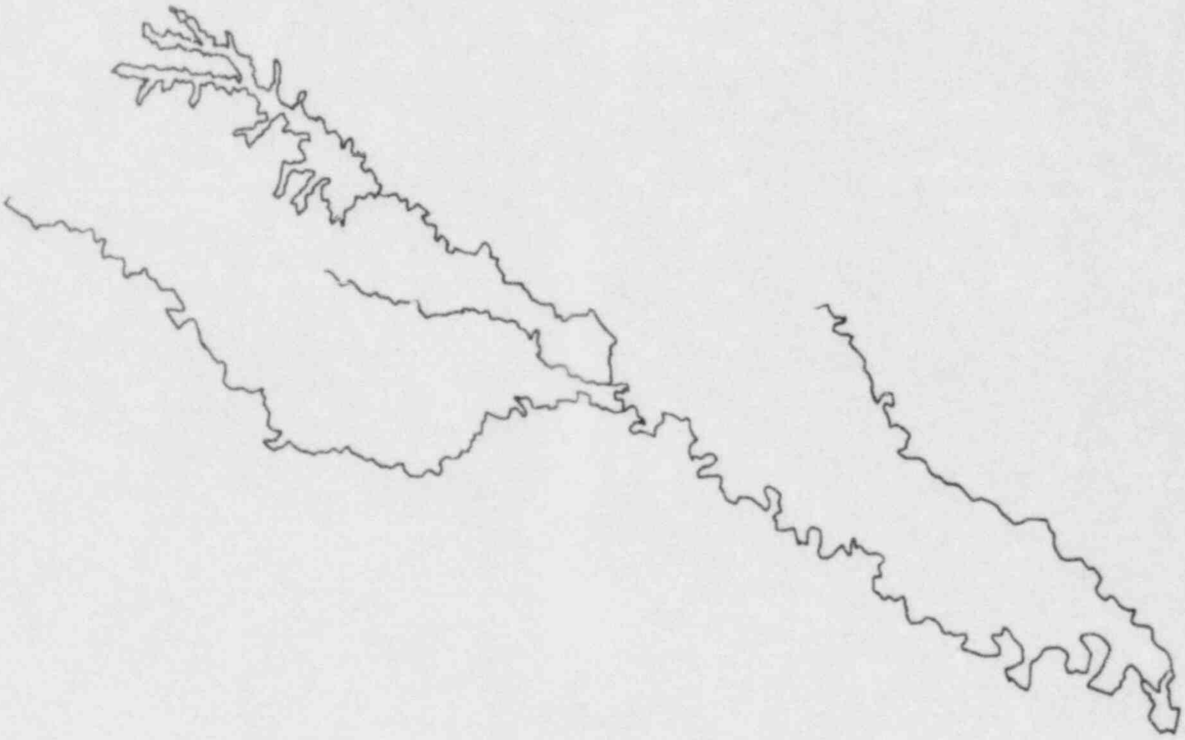
ENVIRONMENTAL STUDY OF THE LOWER NORTH ANNA RIVER

NORTH ANNA POWER STATION

ANNUAL REPORT

January 1 – December 31, 1981



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Environmental Services Department
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April, 1982

Environmental Study of The Lower North Anna River North Anna Power Station

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Introduction

INTRODUCTION

The North Anna River originates in the upper Piedmont Physiographic Province of Virginia in Albermarle and Orange Counties and is part of the York River Drainage Basin (Figure 1-1). The South Anna River joins the North Anna River near Doswell, Virginia to form the Pamunkey River. The Pamunkey River ultimately joins the Mattaponi at West Point, Virginia to form the York River, which eventually flows eastward into the Chesapeake Bay. In 1972, the Virginia Electric and Power Company impounded the North Anna River in Louisa, Spotsylvania and Orange Counties and formed Lake Anna to provide once-through cooling water for the planned nuclear facility.

The ecology of lakes and rivers is generally different and is reflected in the inherent physical, chemical and biological constituents of each. Thermal stratification and oxygen depletion rarely occur naturally in streams. The plankton populations are typically low in a river environment, whereas the benthic invertebrate populations may be relatively high. The source of energy input to maintain the biological community in a river and lake is generally different; allochthonus input for rivers and photosynthesis in lakes.

When rivers are impounded, the downstream effects are varied and may include changes in water quality (temperature, nutrient load, siltation, etc.), habitat and the biota. Baxter (1977) discussed the many environmental effects of dams and impoundments. The water quality of the river is determined primarily by inflows from the impoundment, and precipitation and run-off from the surrounding watershed. Impoundment discharges may either be from the epilimnion or hypolimnion with corresponding changes in water quality downstream (Spence and Hynes 1971; Edwards 1978).

The Lake Anna dam is an earth-fill structure about 1524 m in length, with a central concrete gravity spillway about 70 m in length. The spillway contains three radial crest gates (12 m wide by 11 m high) used for flood control when flow from Lake Anna exceeds 1,000 cfs. During flows of 40 cfs to 1,000 cfs, water passage is controlled by two skimmer gates, one on each end of the series of radial gates. Each skimmer gate (2.6 m by 2.6 m) is capable of releasing up to 500 cfs from the surface of Lake Anna to the North Anna River.

Prior to impoundment, the North Anna River was affected by acid and metal drainage from Contrary Creek, a major tributary where extensive mining operations occurred from 1882-1920. A complete review of the history and studies conducted in the area are given by Reed and Simmons (1976). The primary elements mined were iron and sulfur in the form of iron pyrite (FeS_2). The ores were mined, milled and washed at the mine sites and subsequently the tailings were deposited along the creek bank. When the old spoil banks were leached with water, acid and metal drainage were introduced into Contrary Creek. This drainage caused a 65% reduction in fish diversity and a 40% to 60% reduction in the macrobenthic standing crop in the North Anna River below the entrance of Contrary Creek (Simmons 1970; Simmons and Reed 1973). The impoundment of the river has ameliorated the effects of Contrary Creek with a significant improvement in water quality (Reed 1979, 1980, 1981).

The objectives of this study were to determine the effects of the Lake Anna impoundment and the operation of the North Anna Power Station on the downstream physical, chemical and biological properties. Study parameters included water quality, ichthyoplankton, benthic macroinvertebrates and adult and juvenile fishes. Eight sampling stations (Northeast Creek; North Anna River at Rt. 601 Louisa, Rt. 658, Rt. 601 Hanover, U. S. Rt. 1; Pamunkey River at U. S. Rt. 301; Little River at Rt. 685; and South Anna

River stations were considered as baseline control sites. Station descriptions are the same as those given by Reed (1981).

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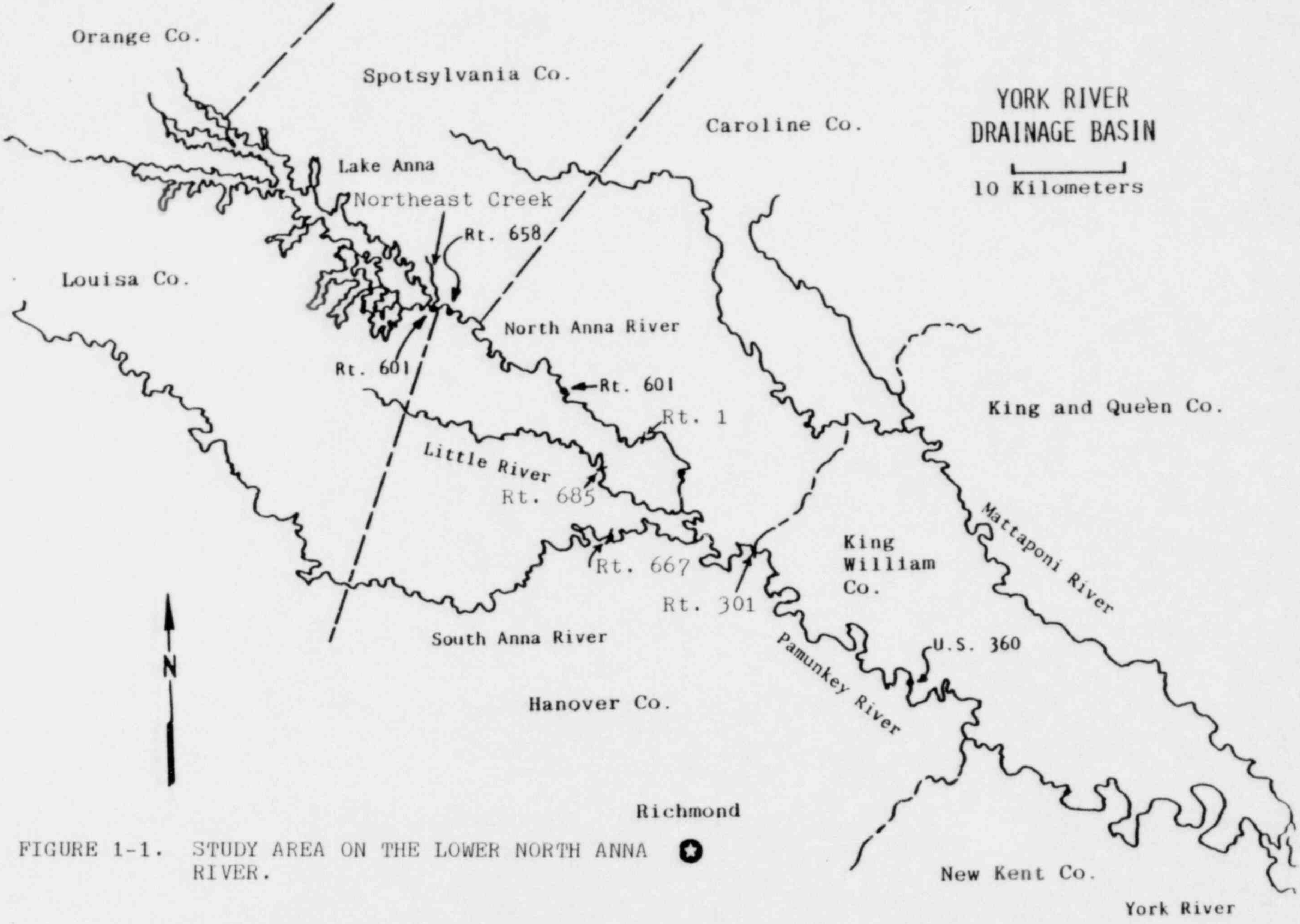

FIGURE 1-1. STUDY AREA ON THE LOWER NORTH ANNA RIVER.

Physical and Chemical

INTRODUCTION

The North Anna River receives heated effluent from the Reservoir/ Waste Heat Treatment Facility (W.H.T.F.) system designed for cooling the two nuclear power units, and must meet surface water standards set forth by the Virginia State Water Control Board (SWCB). These are as follows: Class III, free flowing streams (Coastal zone and Piedmont zone), dissolved oxygen minimum 4.0 mg/l, daily average 5.0 mg/l; pH 6.0-8.5; maximum temperature 32°C. Thermal effects downstream are of special concern to the SWCB since artificially induced changes can influence indigenous aquatic ecosystems. Reproduction, probably the most temperature-sensitive life process (Coutant 1972), could be impaired by unnatural short-term temperature fluctuations. A gradual change of a few degrees may not be as detrimental as a sudden change, nor would the effect of thermal additions in the winter, fall or spring months be as crucial as during the summer maximum when thermal tolerance limits are approached.

The objectives of the North Anna River physical and chemical studies were to define existing conditions and determine impacts of the power station and dam, if any, on river water quality.

METHODS AND MATERIALS

Three stations on the North Anna River were monitored hourly for temperature with Endeco Type 109 Recording Thermographs (Environmental Devices Corporation, Marion, Massachusetts). One station is located above the impoundment, NARIV651 (see Figure 1-1), another immediately below the dam, NARIV601, and the last approximately 10 kilometers downstream on the North Anna River, NARIV603.

Water quality samples were collected in conjunction with benthos and fish collections, which took place in alternating months. Four stations on the

North Anna River (Route 601, Louisa County; Route 658, Route 601, and Route 1 all in Hanover County) and two control stations (Little River, Route 658 and South Anna River, Route 667, both in Hanover County) were sampled for water quality determinations each month. The Pamunkey River at Route 301, below the confluences of the North Anna River with the Little and South Anna Rivers, was sampled semi-annually (July and November). Special samples from Northeast Creek were also taken in July and November. In each case where water samples were taken, determinations were made for temperature (Whitney Model TC-5C or TC-5 Field Thermometer, Montedoro-Whitney Corporation - San Luis Obispo, California), dissolved oxygen (Yellow Springs Instrument Company Model 54), pH (Corning pH Meter Model 7), alkalinity (potentiometric titration), and turbidity (Portable Field Turbidimeter, Fisher Model DRT-150).

RESULTS AND DISCUSSION

Endeco

Temperature data measured by the Endeco instruments in the North Anna River (Table 2-1) indicated that station NARIV651, located above the impoundment (Figure 1-1) consistently had the lowest temperatures throughout 1981 and had the lowest daily mean of 0.6 C which occurred in January. Station NARIV601, located just below the Lake Anna dam, was the warmest river Endeco station with the highest daily mean temperature of 29.4 C which occurred in July. Data were missing for NARIV603 in June and July, but for a relative comparison in August station NARIV601 located just below the dam averaged 7.0 C warmer than the uppermost station NARIV651 and 2.8 C warmer than the lowermost station NARIV603.

Water Quality

Water quality samples were collected and analyzed monthly in 1981 from the North Anna, Little and South Anna Rivers (Tables 2-2 through 2-13). Since the temperature data recorded by the Endeco instruments were more comprehensive, temperatures will not be discussed in detail with respect to monthly sampling.

The range of dissolved oxygen concentrations (or levels) on the North Anna River in 1981 based on monthly collections was 7.0 mg/l at Rt. 1 in August to 13.8 mg/l at Rt. 658 in January. A lower dissolved oxygen concentration (5.9 mg/l) was measured at the Rt. 301 Pamunkey River station in July, and a higher concentration (14.1 mg/l) was measured at the Rt. 667 South Anna River site in January. These values are within standards established by the State Water Control Board (1980).

The lowest dissolved oxygen saturation (80.4%) was observed in the North Anna River at Rt. 601, Hanover in October, and the highest (103.0%) was at Rt. 601 Louisa in April. A lower dissolved oxygen saturation (57.6%) was observed in October at the Little River site. The South Anna River saturation was high in September (102.2%) and other atypical readings were noted as well (Table 2-10).

The pH of the North Anna River in 1981 ranged from 6.5 at Rt. 601 Hanover to 7.3 at Rt. 601 Louisa, both recorded in January. At Rt. 1 in November, a pH of 7.3 was also recorded. The pH of the South Anna River was 8.0 in September, at which time a pH of 7.8 was noted in the Little River. These elevated readings cannot be fully explained, but there must be more variability in the contributing watershed above these two sites than on the North Anna River.

Alkalinities on the North Anna River ranged from 8.8 mg/l $CaCO_3$ at Rt. 601 Louisa in November to 26.7 mg/l $CaCO_3$ at Rt. 1 in July. Little and South Anna River alkalinities were typically higher than the North Anna River (15.0 - 45.7 mg/l $CaCO_3$), especially in June.

Turbidity values were low in September and October (lowest reading was 1.1 N.T.U. at Rt. 1 on the North Anna River for both months) and were highest in July (Rt. 1 North Anna River was 25.0 N.T.U., South Anna River was 68.0 N.T.U.).

SUMMARY

1) Endeco thermal measurements established that temperature maximums in the North Anna River occurred at the station downstream from the Reservoir closest to the dam. The station located upstream from the impoundment was always cooler than the stations downstream.

2) Dissolved oxygen concentrations were never known to violate Virginia standards for free flowing streams in Coastal and Piedmont zones, although several relatively low values were observed during the late summer months. It appears that the lowest dissolved oxygen measurements occurred at those stations farthest downstream on the Pamunkey River and on the Little River which is tributary to the Pamunkey River.

3) High pH readings were recorded on the Little and South Anna Rivers in September, but generally there were only small variations in pH on the North Anna River.

4) Alkalinity and turbidity values were highest in July at all the stations sampled. Typically the tributaries (Little and South Anna Rivers) had higher alkalinities and turbidities than the North Anna River.

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TABLE 2-1. MONTHLY MAXIMUM, MEAN, AND MINIMUM WATER TEMPERATURE VALUES FOR ENDECO STATIONS IN THE NORTH ANNA RIVER CALCULATED FROM DAILY HIGH, MEAN, AND LOW VALUES OF 1981 HOURLY READINGS. * INDICATES INSTRUMENT MALFUNCTION.

-- MONTH=1 --

TYPE	NARIV651	NARIV601	NARIV603
HIGH	1.2	*	2.0
MEAN	0.9	*	1.6
LOW	0.6	*	1.2

-- MONTH=2 --

TYPE	NARIV651	NARIV601	NARIV603
HIGH	3.9	7.3	5.6
MEAN	3.3	6.4	4.7
LOW	2.6	5.7	3.8

-- MONTH=3 --

TYPE	NARIV651	NARIV601	NARIV603
HIGH	7.5	10.4	8.9
MEAN	6.3	9.3	8.0
LOW	5.2	8.2	6.8

-- MONTH=4 --

TYPE	NARIV651	NARIV601	NARIV603
HIGH	16.1	16.8	17.2
MEAN	14.7	15.5	15.9
LOW	13.4	14.3	14.5

-- MONTH=5 --

TYPE	NARIV651	NARIV601	NARIV603
HIGH	17.5	21.9	19.8
MEAN	16.4	20.5	18.7
LOW	15.4	19.2	17.5

-- MONTH=6 --

TYPE	NARIV651	NARIV601	NARIV603
HIGH	23.2	28.1	*
MEAN	21.8	26.8	*
LOW	20.4	25.7	*

TABLE 2-1(CONT.). MONTHLY MAXIMUM, MEAN, AND MINIMUM WATER TEMPERATURE VALUES FOR ENDECO STATIONS IN THE NORTH ANNA RIVER CALCULATED FROM DAILY HIGH, MEAN, AND LOW VALUES OF 1981 HOURLY READINGS. * INDICATES INSTRUMENT MALFUNCTION.

MONTH=7

TYPE	NARIV651	NARIV601	NARIV603
HIGH	23.5	29.4	*
MEAN	22.4	28.2	*
LOW	21.3	27.1	*

MONTH=8

TYPE	NARIV651	NARIV601	NARIV603
HIGH	22.3	29.1	26.0
MEAN	20.8	27.8	25.0
LOW	19.2	26.8	23.9

MONTH=9

TYPE	NARIV651	NARIV601	NARIV603
HIGH	19.8	26.8	22.4
MEAN	18.5	25.7	21.6
LOW	17.2	24.9	20.6

MONTH=10

TYPE	NARIV651	NARIV601	NARIV603
HIGH	*	20.4	15.8
MEAN	*	19.6	14.9
LOW	*	18.9	13.9

MONTH=11

TYPE	NARIV651	NARIV601	NARIV603
HIGH	*	15.6	11.2
MEAN	*	14.9	10.4
LOW	*	14.4	9.7

MONTH=12

TYPE	NARIV651	NARIV601	NARIV603
HIGH	*	12.6	7.9
MEAN	*	12.2	7.3
LOW	*	11.8	6.9

TABLE 2-2. WATER QUALITY DATA FOR SAMPLES FROM THE NORTH ANNA RIVER (NAR), NORTHEAST CREEK, LITTLE RIVER (LR), SOUTH ANNA RIVER (SAR) AND PAMUNKEY RIVER (PR) FOR JANUARY,1981.

STATION	DATE	TIME	TEMPERATURE CELSIUS	DISSOLVED OXYGEN MG/L	PERCENT SATURATION	PH	ALKALINITY MG/L CACO3	TURBIDITY NTU
NAR, RT 601 (LOUISA)	810112	845	2.6	13.1	96.2	7.3	M	M
NAR, RT 658	810112	1200	1.3	13.3	94.3	7.2	M	M
NAR, RT 601 (HANOVER)	810130	1330	2.3	12.6	91.7	6.5	14.0	2.5
NAR, RT 1	810130	1330	2.2	13.8	100.2	6.6	14.0	2.4
LR, RT 685	810130	1100	0.5	13.5	93.6	6.6	18.0	7.0
SAR, RT 667	810130	1200	0.1	14.1	96.7	6.7	23.0	5.2

TABLE 2-3. WATER QUALITY DATA FOR SAMPLES FROM THE NORTH ANNA RIVER (NAR), NORTHEAST CREEK, LITTLE RIVER (LR), SOUTH ANNA RIVER (SAR) AND PAMUNKEY RIVER (PR) FOR FEBRUARY,1981.

STATION	DATE	TIME	TEMPERATURE CELSIUS	DISSOLVED OXYGEN MG/L	PERCENT SATURATION	PH	ALKALINITY MG/L CACO3	TURBIDITY NTU
NAR, RT 601 (LOUISA)	810226	1315	9.0	11.6	100.0	6.8	12.0	3.7
NAR, RT 658	810226	1230	7.4	11.4	94.6	6.9	13.0	4.8
NAR, RT 601 (HANOVER)	810226	1130	7.4	11.4	94.6	6.8	12.0	5.0
NAR, RT 1	810226	930	5.9	11.8	94.3	6.6	12.0	5.3
LR, RT 685	810226	1115	6.4	11.2	9[illegible].7	6.7	15.0	9.2
SAR, RT 667	810226	1015	6.8	11.8	96.5	6.8	19.0	20.0

TABLE 2-4. WATER QUALITY DATA FOR SAMPLES FROM THE NORTH ANNA RIVER (NAR), NORTHEAST CREEK, LITTLE RIVER (LR), SOUTH ANNA RIVER (SAR) AND PAMUNKEY RIVER (PR) FOR MARCH,1981.

STATION	DATE	TIME	TEMPERATURE CELSIUS	DISSOLVED OXYGEN MG/L	PERCENT SATURATION	PH	ALKALINITY MG/L CACO3	TURBIDITY NTU
NAR, RT 601 (LOUISA)	810310	900	8.0	11.2	94.3	7.1	14.0	3.1
NAR, RT 658	810310	1000	6.6	11.4	92.7	6.9	12.0	3.4
NAR, RT 601 (HANOVER)	810310	1114	6.3	11.9	96.1	7.0	13.0	3.4
NAR, RT 1	810310	1240	6.2	12.0	96.6	7.2	16.0	2.5
LR, RT 685	810311	915	4.5	11.7	90.3	7.1	18.0	5.2
SAR, RT 667	810311	1011	4.8	12.3	95.6	7.2	25.0	6.9

TABLE 2-5. WATER QUALITY DATA FOR SAMPLES FROM THE NORTH ANNA RIVER (NAR), NORTHEAST CREEK, LITTLE RIVER (LR), SOUTH ANNA RIVER (SAR) AND PAMUNKEY RIVER (PR) FOR APRIL,1981.

STATION	DATE	TIME	TEMPERATURE CELSIUS	DISSOLVED OXYGEN MG/L	PERCENT SATURATION	PH	ALKALINITY MG/L CACO3	TURBIDITY NTU
NAR, RT 601 (LOUISA)	810406	1358	13.6	10.8	103.3	6.9	13.0	3.6
NAR, RT 658	810406	1323	13.7	10.2	97.8	7.0	13.0	3.7
NAR, RT 601 (HANOVER)	810406	1215	15.4	5.9	98.4	7.0	16.0	3.9
NAR, RT 1	810406	943	14.5	10.0	97.5	6.8	15.0	4.4
LR, RT 685	810406	1145	15.1	8.7	85.9	7.2	25.0	24.0
SAR, RT 667	810406	1034	14.9	9.4	92.4	7.2	25.0	8.4

TABLE 2-6. WATER QUALITY DATA FOR SAMPLES FROM THE NORTH ANNA RIVER (NAR), NORTHEAST CREEK, LITTLE RIVER (LR), SOUTH ANNA RIVER (SAR) AND PAMUNKEY RIVER (PR) FOR MAY,1981.

STATION	DATE	TIME	TEMPERATURE CELSIUS	DISSOLVED OXYGEN MG/L	PERCENT SATURATION	PH	ALKALINITY MG/L CACO3	TURBIDITY NTU
NAR, RT 601 (LOUISA)	810512	1209	20.2	8.0	87.5	6.7	12.0	3.2
NAR, RT 658	810512	1037	18.2	8.6	90.5	6.6	15.0	5.2
NAR, RT 601 (HANOVER)	810518	1201	18.3	8.1	85.4	7.1	14.5	4.0
NAR, RT 1	810518	902	18.2	8.4	88.3	7.0	13.3	4.5
LR, RT 685	810518	1024	16.8	8.1	82.8	7.7	32.0	19.0
SAR, RT 667	810512	840	17.3	8.8	90.9	7.2	28.0	6.2

TABLE 2-7. WATER QUALITY DATA FOR SAMPLES FROM THE NORTH ANNA RIVER (NAR), NORTHEAST CREEK, LITTLE RIVER (LR), SOUTH ANNA RIVER (SAR) AND PAMUNKEY RIVER (PR) FOR JUNE,1981.

STATION	DATE	TIME	TEMPERATURE CELSIUS	DISSOLVED OXYGEN MG/L	PERCENT SATURATION	PH	ALKALINITY MG/L CACO3	TURBIDITY NTU
NAR, RT 601 (LOUISA)	810605	1200	24.8	7.5	89.3	6.7	13.8	3.4
NAR, RT 658	810605	1115	23.1	7.1	82.0	6.8	12.1	2.8
NAR, RT 601 (HANOVER)	810605	1030	23.9	7.3	85.5	6.7	14.9	3.4
NAR, RT 1	810607	830	22.7	7.6	87.1	6.7	15.2	2.2
LR, RT 685	810605	910	21.3	6.5	72.6	7.1	45.7	19.0
SAR, RT 667	810605	940	22.2	7.1	80.6	7.0	38.1	5.2

TABLE 2-8. WATER QUALITY DATA FOR SAMPLES FROM THE NORTH ANNA RIVER (NAR), NORTHEAST CREEK, LITTLE RIVER (LR), SOUTH ANNA RIVER (SAR) AND PAMUNKEY RIVER (PR) FOR JULY,1981.

STATION	DATE	TIME	TEMPERATURE CELSIUS	DISSOLVED OXYGEN MG/L	PERCENT SATURATION	PH	ALKALINITY MG/L CACO3	TURBIDITY NTU
NAR, RT 601 (LOUISA)	810707	921	26.9	7.1	87.9	6.6	9.5	24.0
NORTHEAST CREEK	810715	1400	24.0	7.1	83.3	6.9	21.4	11.0
NAR, RT 658	810707	1038	24.9	7.4	88.3	6.6	9.5	24.0
NAR, RT 601 (HANOVER)	810707	1240	25.7	7.5	90.8	6.8	13.0	16.0
NAR, RT 1	810708	933	25.6	7.7	93.1	6.8	26.7	25.0
LR, RT 685	810713	1253	26.2	7.0	85.5	7.1	39.5	17.0
SAR, RT 667	810713	1154	27.0	7.0	86.8	6.9	15.1	68.0
PR, RT 301	810713	952	26.4	5.9	72.3	7.0	23.7	25.0

TABLE 2-9. WATER QUALITY DATA FOR SAMPLES FROM THE NORTH ANNA RIVER (NAR), NORTHEAST CREEK, LITTLE RIVER (LR), SOUTH ANNA RIVER (SAR) AND PAMUNKEY RIVER (PR) FOR AUGUST,1981.

STATION	DATE	TIME	TEMPERATURE CELSIUS	DISSOLVED OXYGEN MG/L	PERCENT SATURATION	PH	ALKALINITY MG/L CACO3	TURBIDITY NTU
NAR, RT 601 (LOUISA)	810812	1330	27.3	7.1	88.5	6.8	12.3	3.0
NAR, RT 658	810812	1235	26.4	7.0	85.8	6.7	11.1	4.8
NAR, RT 601 (HANOVER)	810812	1145	25.0	7.1	84.9	6.8	12.4	2.0
NAR, RT 1	810812	900	25.1	6.8	81.4	6.9	13.2	2.1
LR, RT 685	810812	1100	23.9	7.1	83.2	7.3	37.7	13.0
SAR, RT 667	810812	1030	24.7	7.1	84.4	7.2	20.3	13.0

TABLE 2-10. WATER QUALITY DATA FOR SAMPLES FROM THE NORTH ANNA RIVER (NAR), NORTHEAST CREEK, LITTLE RIVER (LR), SOUTH ANNA RIVER (SAR) AND PAMUNKEY RIVER (PR) FOR SEPTEMBER,1981.

STATION	DATE	TIME	TEMPERATURE CELSIUS	DISSOLVED OXYGEN MG/L	PERCENT SATURATION	PH	ALKALINITY MG/L CACO3	TURBIDITY NTU
NAR, RT 601 (LOUISA)	810922	825	23.9	7.7	90.2	7.0	10.6	2.3
NAR, RT 658	810922	942	22.8	7.7	88.4	7.1	11.4	2.5
NAR, RT 601 (HANOVER)	810923	1023	19.0	8.5	90.8	7.2	11.9	1.6
NAR, RT 1	810923	900	18.5	8.3	87.8	7.1	12.4	1.1
LR, RT 685	810922	1108	17.8	7.5	78.3	7.8	36.7	2.9
SAR, RT 667	810922	1200	19.9	9.4	102.2	8.0	30.2	7.5

TABLE 2-11. WATER QUALITY DATA FOR SAMPLES FROM THE NORTH ANNA RIVER (NAR), NORTHEAST CREEK, LITTLE RIVER (LR), SOUTH ANNA RIVER (SAR) AND PAMUNKEY RIVER (PR) FOR OCTOBER,1981.

STATION	DATE	TIME	TEMPERATURE CELSIUS	DISSOLVED OXYGEN MG/L	PERCENT SATURATION	PH	ALKALINITY MG/L CACO3	TURBIDITY NTU
NAR, RT 601 (LOUISA)	811022	1255	18.0	9.2	96.4	7.0	9.9	4.4
NAR, RT 658	811022	1225	17.0	9.1	93.4	7.0	9.7	2.8
NAR, RT 601 (HANOVER)	811022	1132	12.8	8.6	80.9	M	M	2.1
NAR, RT 1	811022	925	11.0	9.8	88.5	7.0	11.4	1.1
LR, RT 685	811022	1100	10.2	6.5	57.6	7.3	37.3	5.0
SAR, RT 667	811022	1005	11.0	8.8	79.5	7.4	33.4	1.3

TABLE 2-12. WATER QUALITY DATA FOR SAMPLES FROM THE NORTH ANNA RIVER (NAR), NORTHEAST CREEK, LITTLE RIVER (LR), SOUTH ANNA RIVER (SAR) AND PAMUNKEY RIVER (PR) FOR NOVEMBER,1981.

STATION	DATE	TIME	TEMPERATURE CELSIUS	DISSOLVED OXYGEN MG/L	PERCENT SATURATION	PH	ALKALINITY MG/L CACO3	TURBIDITY NTU
NAR, RT 601 (LOUISA)	811116	1215	14.8	9.7	95.2	7.0	8.8	4.0
NORTHEAST CREEK	811118	1030	7.8	10.2	85.4	7.2	16.0	5.5
NAR, RT 658	811117	1110	13.5	8.8	84.0	7.1	9.0	5.6
NAR, RT 601 (HANOVER)	811117	1000	11.5	8.8	80.4	7.1	10.4	6.2
NAR, RT 1	811116	920	7.8	11.5	96.3	7.3	11.0	1.4
LR, RT 685	811116	1240	8.3	9.5	80.6	7.5	23.8	4.5
SAR, RT 667	811116	1150	8.9	11.0	94.6	7.8	30.8	3.6
PR, RT 301	811116	1030	8.9	11.6	99.8	7.6	24.2	3.0

TABLE 2-13. WATER QUALITY DATA FOR SAMPLES FROM THE NORTH ANNA RIVER (NAR), NORTHEAST CREEK, LITTLE RIVER (LR), SOUTH ANNA RIVER (SAR) AND PAMUNKEY RIVER (PR) FOR DECEMBER,1981.

STATION	DATE	TIME	TEMPERATURE CELSIUS	DISSOLVED OXYGEN MG/L	PERCENT SATURATION	PH	ALKALINITY MG/L CACO3	TURBIDITY NTU
NAR, RT 601 (LOUISA)	811207	1345	12.0	10.6	97.9	6.7	9.0	4.6
NAR, RT 658	811207	1315	10.1	10.8	95.5	6.9	10.0	3.8
NAR, RT 601 (HANOVER)	811207	1230	6.8	11.6	94.8	6.8	9.9	3.1
NAR, RT 1	811207	1045	4.9	12.2	95.1	7.0	10.0	3.8
LR, RT 685	811207	1200	4.0	11.3	86.0	7.0	18.4	5.3
SAR, RT 667	811207	1110	4.8	12.4	96.4	7.2	27.5	7.2

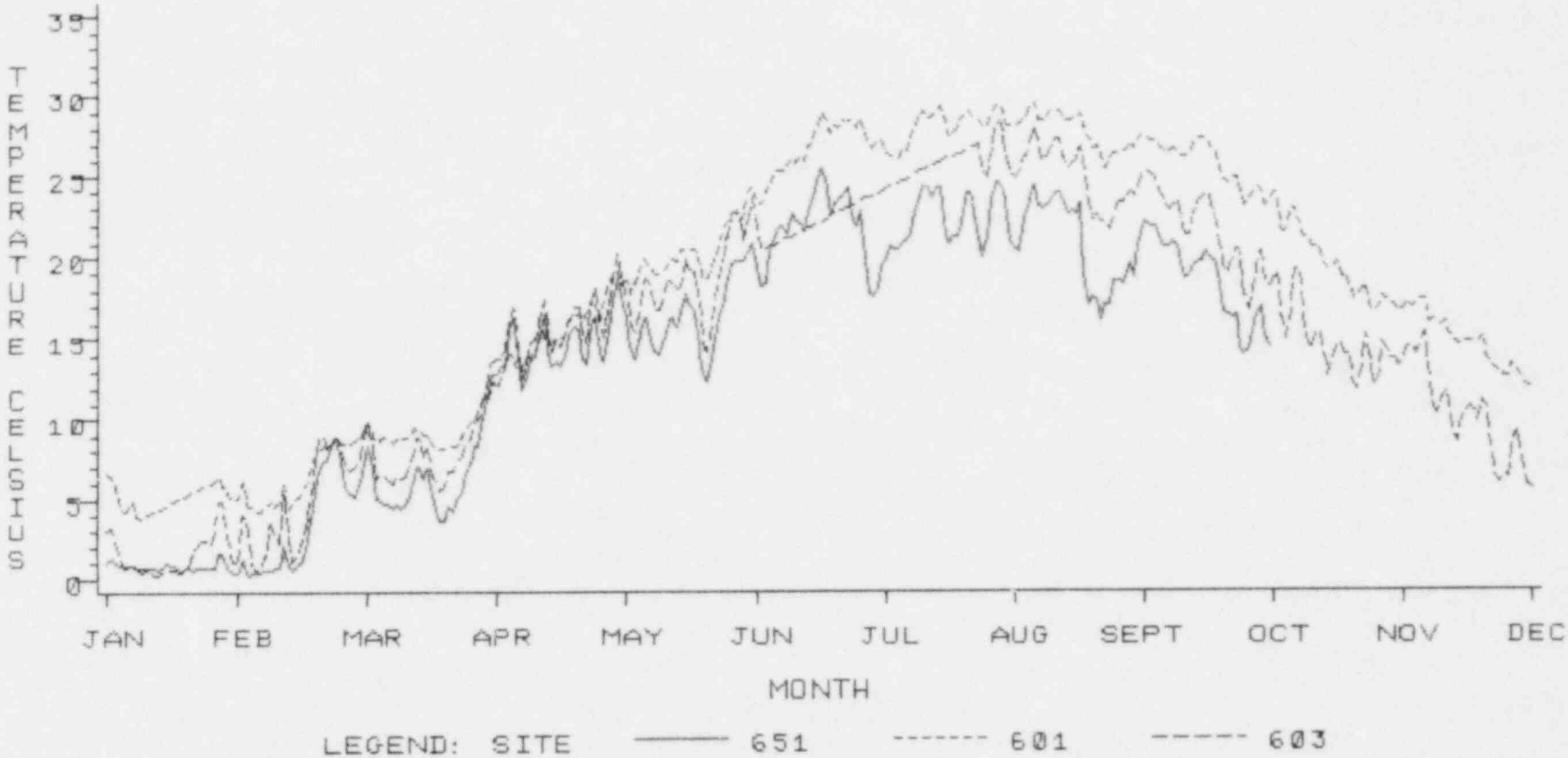

FIGURE 2-1. NORTH ANNA RIVER WATER TEMPERATURES RECORDED BY ENDECO INSTRUMENTS DURING 1981. STRAIGHT OR MISSING LINE SEGMENTS INDICATE MISSING DATA.

Benthic Macroinvertebrates

INTRODUCTION

Aquatic macroinvertebrates are considered by many to be excellent indicators of environmental stress due to their lack of mobility, sensitivity to various environmental perturbations and extended life cycles (Hynes 1965; Cairns and Dickson 1971; Lehmkuhl 1979). For these reasons, monitoring the benthic community is considered to be an integral part of any ecological evaluation.

An impoundment can have varied effects on downstream biota. A dam is a physical disruption of a river, and as such interferes with the normal energy processing of allocthonous material deposited from the watershed (Vannote et al. 1980). However, the newly formed reservoir can act as a new source of energy input due to its lacustrine productivity. Both downstream thermal influences and the type of seston discharged from the reservoir are regulated by the type of release at the dam (Hilsenhoff 1971; Wallace and Merritt 1980). Reservoirs with a hypolimnetic release tend to produce a thermal constancy downstream and discharge seston composed primarily of detritus and microflora (Spence and Hynes 1971; Baxter 1977). Epilimnetic releases result in lags in the normal temperature regimes downstream and discharge greater amounts of large seston, particularly zooplankton (Parker 1980; Kondratieff and Voshell 1981). Some surface release reservoirs are associated with electricity generating stations and may be subjected to additional thermal influences.

The purpose of the benthic macroinvertebrate sampling program downstream of the Lake Anna dam during 1981 was to provide data to assess the impact of the dam and the operation of the North Anna Power Station on the benthic community in the North Anna River.

METHODS AND MATERIALS

Two types of sampling devices were utilized in macroinvertebrate collections downstream of the Lake Anna dam: an Ellis-Rutter Portable Invertebrate Box Sampler and a Hester-Dendy Multiple Plate Artificial Substrate. The Ellis-Rutter sampler is operated by placing the box frame firmly on the river bottom and agitating the enclosed substrate (0.1 m^2). Water current carries any dislodged organisms into the attached tailbag (500 u mesh). Some of the more tenaciously adhered organisms, such as the case building Hydropsychidae, had to be removed individually from substrate pieces. The contents of the tailbag were carefully rinsed into quart jars for transport back to the laboratory, where organisms were removed and placed in 70% ethanol for preservation.

Hester-Dendy substrates, with a surface area of 0.09 m^2 each, were placed at each station four to six weeks prior to collection. The samplers were constructed from nine tempered hardboard plates, separated by brass spacers, and screwed into a lead weight with a six inch eyebolt. Samples were collected by slipping a muslin bag with a drawstring over the substrate and attached weight, quickly drawing the bag closed and removing it from the river bottom. Bags were placed in a metal washtub and kept moist while being transported back to the laboratory where samplers were disassembled; all organisms present were preserved in 70% ethanol. Two replicate Hester-Dendy samplers were collected bimonthly in conjunction with three replicate Ellis-Rutter bottom samples at stations in the North Anna River, South Anna River and Little River (Figure 1-1). Macroinvertebrates collected in both types of samplers were identified to the lowest possible taxon.

An ANOVA and Duncan's multiple range test were performed on macroinvertebrate densities to determine if significant differences existed between stations. Species composition differences were compared at all stations using the Coefficient of Community which is calculated as follows:

$$\text{Coeff. of Comm.} = 2S_{(A+B)} \Big/ S_A + S_B$$

where:

$S_{(A+B)}$ = No. of species in common at both Stations A and B

S_A = No. of species collected at Station A

S_B = No. of species collected at Station B

Stations were also examined at the trophic level. All organisms collected were classified by a system modified from Merritt and Cummins (1978). The latter lists five trophic categories: shredder, collector-gatherer, scraper, collector-filterer and predator. For this study, the first three categories were combined since many of the macroinvertebrates collected occupied more than one of these trophic levels.

RESULTS

During 1981, 128 different taxa were collected in the South Anna River, Little River and North Anna River donwstream of the Lake Anna dam (Table 3-1). A greater number of taxa were collected in the Ellis-Rutter samples (156) than in the Hester-Dendy samples (114). Members of two classes, Arachnoidae and Crustacea, were never collected in Hester-Dendy samples. The most abundant organisms collected in Ellis-Rutter samples in the Little River was the caddisfly, Hydropsyche sp., followed by the winter stonefly, Strophopteryx sp., and the gastropod, Amnicola sp. (Table 3-2). The South Anna River collections showed Hydropsyche sp. to be the most prominent organism, followed by Amnicola sp. and Cheumatopsyche sp. Members of the Trichoptera dominated all the Ellis-Rutter samples in the North Anna River, but were particularly numerous at 601-Louisa. Hydropsyche sp. was the most abundant organism at 601-Louisa but was reduced with increasing distance from the Lake Anna dam. The same pattern held true for Macronema zebratum and Cheumatopsyche sp. The latter was the most abundant organism at 658-Hanover and Rt. 1, and was second in abundance to Chimarra obscura at 601-Hanover. Hester-Dendy collections were dominated by Cheumatopsyche sp. at the South Anna River and Hydropsyche sp. at 601-Louisa (Table 3-3). The chironomid, Dicrotendipes neomodestus, was most often collected on Hester-Dendy substrates in the Litter River; however, Stenonema (pulchellum) sp. dominated 658-Hanover and Rt. 1 collections. The Chironomidae were well represented in most collections of both sampler types by the Orthocladiinae, particularly Cricotopus spp. and Eukiefferiella spp., and a large number of Cardiocladius sp. was collected at 601-Louisa. Members of the subfamily Chironominae included Rheotanytarsus sp. and Polypedilum convictum. Among the mayflies, Ephemeroptera, Stenonema (pulchellum) sp. was collected in relatively high numbers in both sampler types. The stoneflies, Plecoptera, were well represented by the Taeniopterygidae (Taeniopteryx sp. and Strophopteryx sp.) at all stations except 601-Louisa. Among the spring and summer stoneflies, Perlodidae and Perlidae, Acroneuria sp., Helopicus sp. and Perlesta sp. were collected at all stations, but in reduced numbers. Phasganophora capitata was collected only at South Anna River and Rt. 1 stations. Isoperla sp. was collected at Rt. 1, South Anna River and Little River stations. Representing Class Pelycypoda, Corbicula fluminia was collected at all sampling stations; other pelycypods collected were Sphaerium sp. and Elliptio complanata, both of which were collected only in the North Anna River.

Both Hester-Dendy and Ellis-Rutter showed 601-Louisa to be the most abundant stations, but with a low number of taxa. If the Ellis-Rutter samples are examined on a bimonthly basis, 601-Louisa is consistently highest in total abundance, and exhibits the lowest number of taxa only during the December collection (Table 3-4). It should be noted that the South Anna River bimonthly Hester-Dendy samples frequently exhibited low or non-existent values due to vandalism of substrates at this station, thereby making comparisons impossible.

All sampling stations exhibited fluctuating levels of abundance and taxa numbers throughout the year (Figures 3-1 through 3-4). The most prominent change occurred at 601-Louisa in June and August samples. The Trichoptera underwent a large reduction in the Ellis-Rutter samples during these two months (Fig. 3-1); however, the Hester-Dendy samples exhibit a large increase in this group (Figure 3-2). The Plecoptera underwent a reduction in numbers in both Ellis-Rutter (Fig. 3-3) and Hester-Dendy samples (Fig. 3-4) after February due to winter stonefly (Taeniopterygidae) emergence. Their numbers increased again in December samples. Plecoptera were collected infrequently throughout the year at 601-Louisa. Numbers of Chironomidae in Ellis-Rutter samples were reduced at most stations from June through October. The 658-Hanover samples showed relatively high numbers except during August and October. Hester-Dendy samples yielded the greatest number of Chironomidae from April to August. Collections of Ephemeroptera fluctuated over the year in both sampler types with no clearly delineated trend. Ellis-Rutter samples collected in the South Anna River consistently yielded relatively large numbers in the group "OTHER" due primarily to large numbers of gastropods (Figure 3-3). A large number of the blackfly, Simulium sp., was collected in the February Hester-Dendy samples at 601-Louisa, causing the group "OTHER" to be relatively large (Table 3-4).

When species composition was compared between each station, the lowest community coefficient was between 601-Louisa and South Anna River for both Ellis-Rutter (Table 3-5) and Hester-Dendy samples (Table 3-6). Stations 601-Hanover and 658-Hanover had the highest community coefficient among Ellis-Rutter samples (0.68456) while Hester-Dendy samples exhibited the highest coefficient between 658-Hanover and Rt. 1 (0.67241). Species composition in the South Anna River and Little River was relatively similar for Ellis-Rutter samples (0.67857), but yielded a low coefficient for Hester-Dendy samples (0.45783). The four lowest coefficients for Ellis-Rutter sample comparisons involved 601-Louisa. When species composition was compared between sample types at each station for each monthly sample (Table 3-7), fluctuating values were produced, with many months exhibiting a low community coefficient.

When Duncan's multiple range test was performed on station macrobenthic densities found during each month in Ellis-Rutter samples, 601-Louisa was significantly higher (.05 level) than all other stations during every month except June (Table 3-8). During June, 601-Louisa was not significantly different from the South Anna River Station. Rt. 1, Little River and 658-Hanover stations were not significantly different for any collection. Mean density was highest during every month at 601-Louisa.

Duncan's multiple range test was also performed on Ellis-Rutter bimonthly densities at each station (Table 3-9). Little River, South Anna and Rt. 1 showed no significantly different densities throughout the year.

Duncan's test, applied to bimonthly mean densities for Hester-Dendy samples, showed no significant differences at any of the sampling stations during February and April (Table 3-10). Little River, 658-Hanover and Rt. 1 exhibited no statistically significant differences in the remaining months. When examined at each station (Table 3-11), South Anna River and Little River stations showed no statistically significant difference in any month's sample. Varying results were found at other stations with no observable trends.

Macroinvertebrates collected in Ellis-Rutter samples were categorized into trophic levels (Figure 3-5). Organisms collected at 601-Louisa were found to be primarily collector-filterers (CF). Predators (PRED) increased in abundance at 601-Louisa in February and April, primarily due to <u>Cardiocladius</u> sp. and <u>Eukiefferiella</u> spp. Shredders, scrapers and collector-gatherers (SSCG) formed a sizeable percentage of the organisms collected at all other stations throughout most of the year; an exception was the Little River Station in August and October.

Hester-Dendy samples were also examined at the trophic level (Figure 3-6). Collector-filterers dominated 601-Louisa samples all but one month (April). Shredders, scrapers and collector-gatherers dominated most samples with the exception of 658-Hanover in June and October, 601-Hanover in August and the South Anna River in June. A sudden rise in predators occurred at most stations from April to August.

DISCUSSION

Several changes in sampling procedure were initiated in the 1981 macrobenthic sampling program in the lower North Anna River downstream of Lake Anna dam. The use of D-frame dip nets was abandoned in favor of 0.1 m^2 Ellis-Rutter bottom samplers and Hester-Dendy multiple plate artificial substrate. Ellis-Rutter samples provided a quantitative monitoring of the natural substrate populations. Hester-Dendy samples provided supplemental information, particularly among organisms susceptible to drift; unfortunately, the Little River and South Anna River collections proved somewhat unreliable due to vandalism of the samplers. Also, sampling frequency was increased from quarterly to bimonthly. In addition, stations in both the South Anna River and Little River were added for comparative purposes. These changes, coupled with more extensive taxonomic identification, help explain why 128 taxa were collected in 1982 while only 48 taxa were reported in 1980 (Reed 1981) and 38 taxa were collected in 1979 (Reed 1980).

The filter feeding Trichoptera dominated Ellis-Rutter samples in all three rivers. Hydropsyche sp., Cheumatopsyche sp. and Macronema zebratum coexisted in large numbers at 601-Louisa. Their numbers decreased in the North Anna River with increasing distance from the Lake Anna dam. Wallace (1975) showed these same three genera to successfully partition different size seston being discharged into a river from an upstream impoundment. Food partitioning occurred due to the specific mesh size of capture nets of each genus. Although Hydropsyche sp. was prevalent in both the South Anna River and Little River, it did not occur in the large numbers found in the North Anna River, particularly at 601-Louisa. Large numbers of filter feeders are usually prevalent below reservoirs with epilimnetic releases (Wallace and

Merritt 1980). The effects of the lacustrine input from Lake Anna, which supports the large filter feeding populations in the North Anna River, dissipates quickly with distance from the dam (Voshell and Parker 1980). Parker (1980) found the seston to consist primarily of a larger size range, which might explain why M. zebratum is the least abundant of the Hydropsychidae, since its capture net has an extremely fine mesh size (Wiggins 1977).

The large numbers of Hydropsychidae at 601-Louisa in turn supported a relatively abundant chironomid, Cardiocladius sp., which feeds on Hydropsychid pupae (Parker and Voshell 1979). Significant numbers of Cardiocladius sp. were found in February and April collections, when the largest number of Hydropsychidae pupae were collected. The chironomid, Rheotanytarsus sp., was also abundant at most stations. This species is well adapted to a rheobiontic existence since it spins a capture net between the arm-like extensions of its case (Simpson and Bode 1980).

The Plecoptera were well represented, as in previous years (Reed 1979, Reed 1980, Reed 1981), by the winter stoneflies Taeniopteryx sp. and Strophopteryx sp. However, four species of Plecoptera were collected in the North Anna River that have not been reported since impoundment. They are Phasganophora capitata, Paragnetina sp., Isoperla sp. and Helopicus subvarians. Surdick and Gaufin (1978) describe most species of these genera as preferring neutral to alkaline habitats. The collection of these species lends credence to the theory that Lake Anna is ameliorating the effects of acid mine drainage from Contrary Creek, located above Lake Anna dam (see Special Studies: Podostemum ceratophyllum transplant). Most Perlidae take 2 to 3 years to develop (Hynes 1976) which may help explain the length of time from impoundment to their collection. Furthermore, Elliptio complanata, a mussel which was previously found only in the Pamunkey River and was considered to be an indicator of the recovery zone of acid mine runoff

(Simmons and Reed 1973) for the North Anna River, was collected as far upstream in the North Anna River as the 601-Louisa sampling station.

Emergence of the Hydropsychidae accounts for reduction in total abundance during the warmer months in Ellis-Rutter samples. The increase in Hydropsychidae in Hester-Dendy samples during these months is due to the colonization on available artificial substrates by newly hatched larvae. Many species of Hydropsychidae are present in the North Anna, South Anna and Little Rivers (Flint et al. 1979). Different species have different emergence periods and some are bi-and trivoltine (Parker 1980), which explains the fluctuating Hydropsychidae abundance in both samplers.

The station at 601-Louisa proved to be the most unique of the sampling stations with regards to both species composition and abundance. Similarities existed in both species composition and abundance among Little River, Rt. 1 and 658-Hanover stations.

The North Anna River appears to support diverse and stable macrobenthic populations. The Lake Anna dam appears to have improved water quality downstream since impoundment allowing for colonization by additional macrobenthic fauna. Any elevated temperature resulting from the impoundment and/or the operation of the North Anna Power Station has apparently not resulted in any adverse effects downstream.

SUMMARY

1. The North Anna River is dominated by a filter-feeding benthic community, composed primarily of Trichoptera.

2. The Route 601-Louisa station is dominated by an unusually large number of Hydropsychidae due to seston discharge from the epilimnion drain of Lake Anna dam. The effects of this seston release dissipates quickly with distance from the dam.

3. The macrobenthic fauna of the North Anna River continued to increase in diversity during 1981; the increase was attributed to the amelioration of effects of acid mine runoff by Lake Anna.

SPECIAL STUDIES: PODOSTEMUM CERATOPHYLLUM (RIVER WEED) TRANSPLANT

Podostemum ceratophyllum, river weed, is an abundant macrophyte in the South Anna and Little Rivers. It is a submerged rheophile which attaches itself to the substrate with disc-like processes. Although having many varieties, P. ceratophyllum is the only species of the family Pedostomaceae found in the United States (Fassett 1957). This macrophyte was not found in the North Anna River prior to its impoundment. The reason for its absence was attributed to a source of acid mine drainage in Contrary Creek, which is located above Lake Anna Dam (Kondratieff and Voshell 1981). Lake Anna is believed to act as a sink for metals and sediment, thus ameliorating the effects of acid mine runoff and improving the water quality downstream (Simmons and Voshell 1978). Therefore, it seemed if P. ceratophyllum was introduced to the North Anna River, subsequent colonization might occur.

The purpose of a P. ceratophyllum transplant would be for habitat enrichment. Edmunds et al. (1979) reported P. ceratophyllum to be a preferred habitat for some species of baetid mayflies. The macrophyte is also a possible food source for some caddis-flies (Mackay and Wiggins 1979) and increases habitat surface area for the rheotactic Trichoptera (Wallace 1975).

On May 6, 1981, samples of P. ceratophyllum were collected from the South Anna River and transplanted to three locations on the North Anna River. The locations coincided with stations included in the North Anna River downstream sampling program and are as follows: Route 601 (Louisa County), Route 658 (Hanover County) and Route 601 (Hanover County). Samples collected were attached to substrate material which was judged large enough to remain in swift current. The macrophyte was placed in tubs and covered with water for transport to the North Anna River. At the time of transplant there was no observable new growth; the plant apparently was in a dormant stage.

At each station, two quadrats of P. ceratophyllum approximately 0.5 m^2 each were placed in the river bed. Sites selected in the North Anna River were comparable to the South Anna River collection station with respect to depth and current velocity.

Observations on the condition of the quadrats were made monthly. The two stations nearest the dam (Route 601 Louisa County and Route 658 Hanover County) showed the greatest amount of growth, up to 10 cm during some months. These two stations also showed the longest growing season, with plants having new growth up until December. Leaves of P. ceratophyllum observed in the South Anna River reached lengths of 6 cm and plants were in a dormant state by November. The quadrat at Route 601 (Hanover County) never became firmly established. A prominent Aufwuchs community seemed to be present throughout most of the year at this station and may have been responsible for retarding photosynthesis and growth. P. ceratophyllum at Route 601 (Louisa County) has spread extensively beyond the borders of the initial quadrats. Patches of the macrophyte were observed up to 40 m downstream of the initial transplant.

Observations on the condition of P. ceratophyllum will continue through 1982. Initial observations during 1981 indicate that the macrophyte will be successsful in the North Anna River.

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TABLE 3-1. TAXONOMIC LISTING OF MACROBENTHIC ORGANISMS COLLECTED BY ELLIS-RUTTER AND HESTER-DENDY SAMPLERS IN THE SOUTH ANNA RIVER, LITTLE RIVER AND NORTH ANNA RIVER DOWNSTREAM OF LAKE ANNA DAM DURING 1981.

	Ellis-Rutter	Hester-Dendy
Phylum Platyhelminthes		
Class Turbellaria	+	
Phylum Nematomorpha		
Class Gordioidea		
Family Gordiidae		
Gordius sp.	+	
Phylum Annelida		
Class Hirudinea		+
Class Oligochaeta	+	
Order Plesiopora		
Family Lumbricidae	+	+
Family Lumbriculidae	+	
Family Naididae	+	
Phylum Arthropoda		
Class Arachnoidea		
Order Hydracarina		
Family Lebertiidae	+	
Lebertia sp.	+	
Class Crustacea		
Order Amphipoda		
Family Gammaridae		
Crangonyx sp.	+	
Order Decapoda		
Family Astacidae		
Cambarus sp.	+	
Family Palaemonidae		
Palaemonetes sp.	+	
Order Isopoda		
Family Asellidae		
Asellus sp.	+	
Class Insecta		
Order Coleoptera		
Family Dytiscidae		
Agabus sp.	+	
Family Elmidae		
Ancyronyx sp.		+
Dubiraphia sp.	+	
Macronychus sp.	+	+
Microcylloepus sp.	+	+
Optioservus sp.	+	+
Stenelmis sp.	+	+
Family Gyrinidae		
Dineutus sp.	+	+
Family Hydrophilidae		
Berosus sp.	+	+
Family Psephenidae		
Ectopria nervosa	+	

TABLE 3-1 (Continued)

	Ellis-Rutter	Hester-Dendy
Phylum Arthropoda (Continued)		
Class Insecta (Continued)		
Order Collembola		
Family Isotomidae		+
Isotoma sp.	+	
Order Diptera		
Family Athericidae		
Atherix sp.		+
Atherix variegata	+	+
Family Empididae		
Hemerodromia sp.	+	
Family Tabanidae		
Tabanus sp.	+	
Family Muscidae (Anthomyiidae)		
Limnophora aequifrons	+	
Family Blephariceridae		
Blephericera sp.	+	
Family Ceratopogonidae		
Palpomyia sp.	+	+
Family Chironomidae		
Subfamily Chironominae		
Tribe Chironomini		
Cryptochironomus sp.	+	
Dicrotendipes neomodestus	+	+
Glyptotendipes sp.		+
Goeldichironomus sp.		+
Harnischia sp.	+	
Microtendipes sp.	+	+
Phaenopsectra sp.	+	
Phaenopsectra flavipes	+	+
Polypedilum convictum	+	+
P. fallax		+
P. illinoense	+	+
Stenochironomus sp.	+	
Stictochironomus sp.		+
Tribelos sp.		+
Tribelos jucundus	+	
Xenochironomus sp.	+	+
Tribe Tanytarsini		
Micropsectra sp.		+
Rheotanytarsus sp.	+	+
Tanytarsus sp.	+	+
Subfamily Diamesinae		
Potthastia longimannus	+	+
Subfamily Orthocladiinae		
Orthocladiinae pupae	+	+
Brillia sp.		+
Brillia flavifrons		+
Cardiocladius sp.	+	+
Cricotopus sp.	+	
Cricotopus/Orthocladius sp.	+	+
Cricotopus bicinctus	+	+
C. intersectus	+	
C. tremulus	+	+
Eukiefferiella sp.		+

TABLE 3-1 (Continued)

	Ellis-Rutter	Hester-Dendy
Phylum Arthropoda (Continued)		
Class Insecta (Continued)		
Order Diptera (Continued)		
Family Chironomidae (Continued)		
Subfamily Orthocladiinae (Continued)		
Eukiefferiella bavarica	+	+
E. claripennis	+	+
E. discoloripes	+	+
E. potthasti	+	
Heterotrissocladius sp.	+	
Hydrobaena sp.	+	
Metriocnemus sp.	+	
Nanocladius sp.	+	+
Orthocladius sp.	+	+
Parakiefferiella sp.		+
Psectrocladius sp.	+	+
Rheocricotopus sp.	+	+
Synorthocladius sp.	+	
Thienemanniella prob. *xena*	+	+
Subfamily Tanypodinae		
Ablabesmyia sp.		+
Ablabesmyia mallochi		+
A. parajanta	+	+
A. tarella	+	+
Nilotanypus sp.		+
Pentaneura sp.	+	+
Procladius sp.	+	
Family Simuliidae		
Simulium sp.	+	+
Simulium venustrum		+
S. vittatum	+	+
Family Tipulidae		
Antocha saxicola	+	
Tipula sp.	+	+
Order Ephemeroptera		
Family Baetidae		
Baetis sp.	+	+
Centroptilum sp.	+	
Cloeon sp.	+	
Heterocloeon sp.	+	+
Pseudocloeon sp.	+	+
Family Baetiscidae		
Baetisca sp.	+	
Family Caenidae		
Brachycerus sp.	+	
Caenis sp.	+	+
Family Ephemerellidae		
Ephemerella (Attenella) sp.	+	
E. (Dannella) sp.	+	
E. (Drunella) sp.	+	+
E. (Ephemerella) sp.	+	
E. (Eurylaphella) sp.		+
E. (Serratella) sp.	+	+

TABLE 3-1 (Continued)

	Ellis-Rutter	Hester-Dendy
Phylum Arthropoda (Continued)		
Class Insecta (Continued)		
Order Ephemeroptera (Continued)		
Family Heptageniidae		
Heptagenia sp.	+	+
Stenacron sp.		+
Stenonema (*pulchellum*) sp.	+	+
Family Siphlonuridae		
Isonychia sp.	+	+
Family Tricorythidae		
Tricorythodes sp.	+	
Order Lepidoptera		
Family Pyralidae		
Paraponyx sp.	+	
Order Megaloptera		
Family Corydalidae		
Corydalus sp.	+	
Corydalus cornutus	+	+
Nigronia sp.	+	+
Order Neuroptera		
Family Sisyridae		
Climacia sp.	+	
Order Odonata		
Suborder Anisoptera		
Family Aeschnidae		
Basiaeschna janata	+	
Boyeria vinosa		+
Family Corduliidae		
Neurocordulia sp.		+
Family Gomphidae	+	
Dnomogomphus sp.	+	
Dnomogomphus spinosus	+	
Gomphus sp.	+	
Hagenius brevistylus	+	+
Ophiogomphus sp.	+	
Progomphus sp.	+	
Progomphus obscurus	+	
Family Libellulidae	+	+
unknown sp.		
Family Macromiidae		
Macromia sp.	+	
Macromia illinoiensis		+
Suborder Zygoptora		
Family Coenagrionidae		
Argia sp.	+	
Enallagma sp.	+	+

TABLE 3-1 (Continued)

	Ellis-Rutter	Hester-Dendy
Phylum Arthropoda (Continued)		
Class Insecta (Continued)		
Order Plecoptera		
Family Nemouridae		
Amphinemura sp.	+	+
Amphinemura delosa	+	
Prostoia sp.	+	+
Prostoia similis	+	+
Family Perlidae		
Acroneu-ia sp.	+	+
Paragnetina sp.	+	+
Perlesta sp.	+	+
Perlesta placida	+	
Phasganophora capitata	+	+
Family Perlodidae		
Helopicus subvarians	+	+
Isoperla sp.	+	+
Family Pteronarcyidae		
Pteronarcys sp.	+	
Family Taeniopterygidae		
Strophopteryx sp.	+	+
Strophopteryx fasciata	+	
Taeniopteryx sp.	+	+
Taeniopteryx parvula	+	+
Order Trichoptera		
Family Brachycentridae		
Brachycentrus sp.	+	+
Bnachycentrus numerous	+	+
Micrasema sp.	+	
Family Glossosomatidae		
Glossosoma sp.	+	
Agapetus sp.	+	
Family Hydropsychidae		
Cheumatopsyche sp.	+	+
Hydropsyche sp.	+	+
Macnonema zebratum	+	+
Hydropsychidae pupae	+	+
Family Hydroptilidae		
Hydroptila sp.	+	+
Oxyethira sp.	+	
Protoptila sp.	+	
Hydroptilidae pupae		+
Family Lepidostomatidae		
Lepidostoma sp.	+	+
Family Leptoceridae		
Nectopsyche candida	+	+
Oecetis sp.	+	+
Triaenodes injusta	+	

TABLE 3-1 (Continued)

	Ellis-Rutter	Hester-Dendy
Phylum Arthropoda (Continued)		
Class Insecta (Continued)		
Order Trichoptera (Continued)		
Family Philopotamidae		
Chimarra aterrima	+	+
C. obscura	+	+
C. socia	+	+
Wormaldia sp.	+	+
Family Phryganeidae		
Ptilostomis sp.		+
Family Polycentropodidae		
Cyrnellus sp.	+	
Neureclipsis sp.	+	+
Neureclipsis crepuscularis	+	+
Nyctiophylax sp.	+	+
Polycentropus sp.	+	+
Phylum Mollusca		
Class Gastropoda		
Order Prosobranchia		
Family Blythiniidae		
Amnicola sp.	+	+
Family Pleuroceridae	+	+
Goniobasis sp.	+	+
Pleurocera sp.	+	+
Order Pulmonata		
Family Lymnaeidae	+	+
Physa sp.	+	+
Family Planorbidae		
Helisoma sp.	+	+
Class Pelycypoda		
Order Heterodonta		
Family Corbiculiidae		
Corbicula fluminea	+	+
Family Sphaeridae		
Sphaerium sp.	+	
Order Palaeoheterodonta		
Family Unionidae		
Elliptio complanata	+	

TABLE 3-2. MACROBENTHIC ORGANISMS COLLECTED BY STATION IN ELLIS-RUTTER SAMPLES IN THE SOUTH ANNA RIVER, LITTLE RIVER AND NORTH ANNA RIVER DOWNSTEAM OF LAKE ANNA DAM DURING 1981.

SPECIES	NAR601L	NAR658H	NAR604H	RT1	SAR667	LR685
HIRUDINEA	1	.	.	.	.	.
OLIGOCHAETA	.	2	9	1	6	9
LUMBRICIDAE	.	.	1	1	.	.
LUMBRICULIDAE	.	.	4	.	2	.
NAIDIDAE	.	.	3	3	19	.
LEBERTIIDAE	.	.	.	.	.	3
LEBERTIA SP.	1	1	6	.	19	.
CRANGONYX SP.	.	.	1	5	.	6
CAMBARUS SP.	.	.	.	.	.	1
PALAEMONETES SP.	.	.	.	.	.	1
ASELLUS SP.	.	.	.	.	.	3
AGABUS SP.	.	1	.	.	.	.
DUBIRAPHIA SP.	.	.	.	4	2	10
MACRONYCHUS SP.	.	.	.	.	3	.
MICROCYLLOEPUS SP.	5	10	76	26	16	2
OPTIOSERVUS SP.	.	.	2	.	.	.
STENELMIS SP.	.	2	31	36	52	4
DINEUTUS SP.	.	.	.	.	4	1
BEROSUS SP.	.	3	7	8	2	13
ECTOPRIA NERVOSA	.	.	.	.	1	.
ISOTOMA SP.	.	1	.	.	.	.
ATHERIX VARIEGATA	7	16	11	1	.	.
HEMERODROMIA SP.	.	.	.	2	.	1
TABANUS SP.	.	.	.	.	.	10
LIMNOPHORA AEQUIFRONS	.	.	.	2	.	.
BLEPHARICERA SP.	.	.	14	.	7	3
PALPOMYIA SP.	.	.	2	.	.	4
CRYPTOCHIRONOMUS SP.	.	2	.	.	.	.
DICROTENDIPES NEOMODESTUS	7	53	13	3	.	8
HARNISCHIA SP.	1	.	.	.	.	.
MICROTENDIPES SP.	.	86	.	.	2	.
PHAENOPSECTRA SP.	3	.	.	.	.	.
PHAENOPSECTRA FLAVIPES	1	.	.	.	.	.
POLYPEDILUM CONVICTUM	21	75	6	20	7	.
POLYPEDILUM ILLINOENSE	9	.	.	.	.	.
STENOCHIRONOMUS SP.	.	1	.	.	.	2
TRIBELOS JUCUNDUS	.	.	.	.	.	1
XENOCHIRONOMUS SP.	.	.	.	.	4	.
RHEOTANYTARSUS SP.	120	288	132	50	35	12
TANYTARSUS SP.(CALOPSECTRA)	.	6	.	1	.	2
POTTHASTIA LONGIMANUS	5	.	1	23	1	1
ORTHOCLADIINAE PUPAE	12	4	2	1	2	1
CARDIOCLADIUS SP.	226	.	.	1	1	1
CRICOTOPUS SP.	.	.	.	10	.	.
CRICOTOPUS/ORTHOCLADIUS SP.	24	9	66	9	7	11
CRICOTOPUS BICINCTUS GR.	1	1	1	1	.	.
CRICOTOPUS INTERSECTUS GR.	1	.	.	.	.	.
CRICOTOPUS TREMULUS GR.	77	11	56	21	16	17
EUKIEFFERIELLA BAVARICA GR.	1	.	.	2	.	6
EUKIEFFERIELLA CLARIPENNIS GR.	17	2	5	2	1	17
EUKIEFFERIELLA DISCOLORIPES GR.	162	94	34	21	18	6
EUKIEFFERIELLA POTTHASTI GR.	.	.	7	.	.	.
HETEROTRISSOCLADIUS SP.	.	.	2	.	1	.

TABLE 3-2. MACROBENTHIC ORGANISMS COLLECTED BY STATION IN ELLIS-RUTTER SAMPLES IN THE SOUTH ANNA RIVER, LITTLE RIVER AND NORTH ANNA RIVER DOWNSTEAM OF LAKE ANNA DAM DURING 1981.

SPECIES	NAR601L	NAR658H	NAR601H	RT1	SAP667	LR685
HYDROBAENA SP.	.	.	.	.	1	2
METRIOCNEMUS SP.	5	.	.	.	.	.
NANOCLADIUS SP.	3	.	1	1	.	.
ORTHOCLADIUS SP.	7	.	2	.	.	3
PSECTROCLADIUS SP.	.	3	4	9	1	5
RHEOCRICOTOPUS SP.	.	.	.	5	1	2
SYNORTHOCLADIUS SP.	2	.	1	.	.	.
THIENEMANNIELLA PROB. XENA	1	.	.	.	.	.
ABLABESMYIA PARAJANTA	.	.	1	.	.	1
ABLABESMYIA TARELLA	1	2	1	.	.	3
PENTANEURA SP.	.	1	3	.	1	.
PROCLADIUS SP.	.	13	.	.	.	.
SIMULIUM SP.	148	23	3	20	37	6
SIMULIUM VITTATUM	.	2	4	1	.	17
ANTOCHA SAXICOLA	5	3	2	4	9	4
TIPULA SP.	.	1	.	.	1	1
BAETIS SP	17	6	3	3	3	6
CENTROPTILUM SP.	.	1	.	4	.	.
CLOEON SP.	.	.	.	22	.	.
HETEROCLOEON SP.	5	1	7	.	.	4
PSEUDOCLOEON SP.	12	.	.	1	4	.
BAETISCA SP.	.	.	.	7	.	.
BRACHYCERUS SP.	.	.	4	.	.	.
CAENIS SP.	.	7	1	3	.	15
EPHEMERELLA (ATTENELLA) SP.	.	.	.	.	.	17
EPHEMERELLA (DANNELLA) SP.	.	.	.	.	2	.
EPHEMERELLA (DRUNELLA) SP.	.	.	.	.	5	8
EPHEMERELLA (EPHEMERELLA) SP.	1	.	.	.	82	9
EPHEMERELLA (SERRATELLA) SP.	7	1	2	.	44	6
HEPTAGENIA SP.	.	.	.	6	.	.
STENONEMA (PULCHELLUM) SP.	67	138	144	77	53	20
ISONYCHIA SP.	1	1	49	8	5	6
TRICORYTHODES SP.	20	3	2	.	3	.
PARAPONYX SP.	.	1	2	.	.	.
CORYDALUS CORNUTUS	91	23	25	16	20	4
NIGRONIA SP.	.	2	3	1	1	1
CLIMACIA SP.	.	.	2	.	.	.
BASIAESCHNA JANATA	.	1	.	.	.	.
GOMPHIDAE	.	.	1	.	.	.
DROMOGOMPHUS SP.	1	3	.	14	1	1
DROMOGOMPHUS SPINOSUS	.	4	.	.	2	.
GOMPHUS SP.	.	.	1	.	.	.
HAGENIUS BREVISTYLUS	.	.	.	1	1	2
OPHIOGOMPHUS SP.	.	.	.	.	1	.
PROGOMPHUS SP.	.	1	.	.	.	.
PROGOMPHUS OBSCURUS	.	1	.	.	.	.
LIBELLULIDAE	.	.	.	.	1	.
MACROMIA SP.	.	1	3	.	.	.
ARGIA SP.	1	.	8	.	8	.
ENALLAGMA SP.	.	.	.	.	1	1
AMPHINEMURA SP.	.	.	1	.	.	.
AMPHINEMURA DELOSA	.	1	.	.	2	.
PROSTOIA SP.	1	48	37	7	12	25

TABLE 3-2. MACROBENTHIC ORGANISMS COLLECTED BY STATION IN ELLIS-RUTTER SAMPLES IN THE SOUTH ANNA RIVER, LITTLE RIVER AND NORTH ANNA RIVER DOWNSTEAM OF LAKE ANNA DAM DURING 1981.

SPECIES	NAR601L	NAR658H	NAR601H	RT1	SAR667	LR685
PROSTOIA SIMILIS	.	.	.	.	4	.
ACRONEURIA SP.	.	.	5	2	7	.
PARAGNETINA SP.	.	.	.	.	7	.
PERLESTA SP.	4	10	36	15	21	21
PERLESTA PLACIDA	.	.	.	.	.	17
PHASGANOPHORA CAPITATA	.	.	.	.	12	.
HELOPICUS SUBVARIANS	.	.	.	1	1	1
ISOPERLA SP.	.	.	.	.	1	9
PTERONARCYS SP.	.	1	.	.	2	1
STROPHOPTERYX SP.	5	82	27	38	67	201
STROPHOPTERYX FASCIATA	.	.	.	.	.	1
TAENIOPTERYX SP.	.	24	90	26	9	26
TAENIOPTERYX PARVULA	.	2	38	4	1	14
BRACHYCENTRUS SP.	1	.	12	.	10	21
BRACHYCENTRUS NUMEROSUS	2	3	60	30	2	6
MICRASEMA SP.	1	.	.	.	.	.
GLOSSOSOMA SP.	.	.	2	1	2	.
AGAPETUS SP.	.	.	.	.	.	1
CHEUMATOPSYCHE SP.	1668	315	203	191	121	59
HYDROPSYCHE SP.	3882	256	130	34	625	513
MACRONEMA ZEBRATUM	1218	95	106	6	3	55
HYDROPSYCHIDAE PUPAE	869	39	3	10	.	1
HYDROPTILA SP.	7	16	7	4	3	2
OXYETHIRA SP.	.	5	1	.	.	.
PROTOPTILA SP.	.	.	.	2	7	3
LEPIDOSTOMA SP.	.	.	.	.	1	.
NECTOPSYCHE CANDIDA	.	5	.	15	.	.
OECETIS SP.	4	7	10	.	10	3
TRIAENODES INJUSTA	.	.	.	.	1	.
CHIMARRA ATERRIMA	.	.	.	.	.	1
CHIMARRA OBSCURA	42	63	209	82	4	38
CHIMARRA SOCIA	.	.	5	1	.	.
WORMALDIA SP.	.	.	.	.	.	4
CYRNELLUS SP.	1	.	.	.	.	.
NEURECLIPSIS SP.	.	.	2	.	2	.
NEURECLIPSIS CREPUSCULARIS	19	5	1	.	2	.
NYCTIOPHYLAX SP.	.	1	.	.	.	.
POLYCENTROPUS SP.	.	1	1	.	.	.
AMNICOLA SP.	.	.	2	.	547	134
PLEUROCERIDAE	.	3	.	5	45	4
GONIOBASIS SP.	.	.	.	.	35	1
PLEUROCERA SP.	.	.	.	.	2	.
LYMNAEIDAE	.	.	.	.	2	1
PHYSA SP.	.	.	4	3	8	1
HELISOMA SP.	3	1	25	2	7	7
CORBICULA FLUMINEA	163	61	115	165	46	8
SPHAERIUM SP.	.	2	1	.	.	.
ELLIPTIO COMPLANATA	1	.	.	.	.	.
GORDIUS SP.	1	.	.	.	.	.
TURBELLARIA	4	.	7	.	7	5
TOTAL # TAXA	60	70	79	66	85	83
TOTAL CATCH	8993	1957	1911	1101	2154	1484

TABLE 3-3. MACROBENTHIC ORGANISMS COLLECTED BY STATION IN HESTER-DENDY SAMPLER IN THE SOUTH ANNA RIVER, LITTLE RIVER AND NORTH ANNA RIVER DOWNSTREAM OF LAKE ANNA DAM DURING 1981.

SPECIES	NAR601L	NAR658H	NAR601H	RT1	SAR667	LR685
HIRUDINEA	.	.	.	.	.	1
LUMBRICIDAE	.	.	.	.	.	2
ANCYRONYX SP.	.	.	.	3	.	.
MACRONYCHUS SP.	.	1	.	7	.	.
MICROCYLLOEPUS SP.	.	4	13	11	3	6
OPTIOSERVUS SP.	.	.	.	4	.	.
STENELMIS SP.	.	5	.	1	.	1
DINEUTUS SP.	.	1	.	1	3	.
BEROSUS SP.	.	.	1	.	.	.
ISOTOMIDAE	.	.	.	.	.	1
ATHERIX SP.	1	.	.	.	.	.
ATHERIX VARIEGATA	4	.	2	1	.	.
PALPOMYIA SP.	.	.	.	.	.	2
DICROTENDIPES NEOMODESTUS	3	17	2	12	.	93
GLYPTOTENDIPES SP.	.	.	1	.	.	.
GOELDICHIRONOMUS SP.	.	.	.	.	.	2
MICROTENDIPES SP.	.	1	.	.	1	.
PHAENOPSECTRA FLAVIPES	2	.	.	.	.	.
POLYPEDILUM CONVICTUM	12	12	.	8	.	.
POLYPEDILUM FALLAX	.	.	.	1	.	7
POLYPEDILUM ILLINOENSE	3	.	.	2	.	.
STICTOCHIRONOMUS SP.	.	2	.	.	.	.
TRIBELOS SP.	.	.	.	.	.	17
XENOCHIRONOMUS SP.	.	1	.	.	.	.
MICROPSECTRA SP.	.	.	.	.	.	1
RHEOTANYTARSUS SP.	38	45	65	50	20	21
TANYTARSUS SP.(CALOPSECTRA)	2	3	.	.	.	2
POTTHASTIA LONGIMANUS	.	.	.	1	.	.
ORTHOCLADIINAE PUPAE	.	1	1	6	.	.
BRILLIA SP.	.	1	.	.	.	.
BRILLIA FLAVIFRONS	.	.	1	.	.	2
CARDIOCLADIUS SP.	8	.	3	.	.	.
CRICOTOPUS/ORTHOCLADIUS SP.	20	20	8	47	8	10
CRICOTOPUS BICINCTUS GR.	.	.	2	.	.	.
CRICOTOPUS TREMULUS GR.	61	18	3	19	27	2
EUKIEFFERIELLA SP.	.	5	2	2	.	.
EUKIEFFERIELLA BAVARICA GR.	.	.	2	.	.	.
EUKIEFFERIELLA CLARIPENNIS GR.	.	.	5	.	.	.
EUKIEFFERIELLA DISCOLORIPES GR.	57	11	3	26	1	2
NANOCLADIUS SP.	.	.	.	1	.	.
ORTHOCLADIUS SP.	.	.	2	6	.	.
PARAKIEFFERIELLA SP.	1	.	.	.	.	.
PSECTROCLADIUS SP.	2	2	.	2	.	3
RHEOCRICOTOPUS SP.	.	8	1	26	.	2
THIENEMANNIELLA PROB. XENA	8	11	7	8	8	.
ABLABESMYIA SP.	.	.	.	1	.	.
ABLABESMYIA MALLOCHI	.	.	.	.	.	1
ABLABESMYIA PARAJANTA	.	2	.	1	.	4
ABLABESMYIA TARELLA	.	.	.	.	.	3
NILOTANYPUS SP.	.	.	1	2	.	.
PENTANEURA SP.	1	3	1	1	.	.
SIMULIUM SP.	8	11	43	6	.	.
SIMULIUM VITTATUM	156	16	29	15	3	11

TABLE 3-3. MACROBENTHIC ORGANISMS COLLECTED BY STATION IN HESTER-DENDY SAMPLER IN THE SOUTH ANNA RIVER, LITTLE RIVER AND NORTH ANNA RIVER DOWNSTREAM OF LAKE ANNA DAM DURING 1981.

SPECIES	NAR601L	NAR658H	NAR601H	RT1	SAR667	LR685
SIMULIUM VENUSTRUM	1	1	.	5	.	.
TIPULA SP.	1	.	.	.	.	.
BAETIS SP.	6	.	.	.	.	.
HETEROCLOEON SP.	5	.	1	.	1	.
PSEUDOCLOEON SP.	1	1	2	.	.	1
CAENIS SP.	3	4	.	2	.	10
EPHEMERELLA (DRUNELLA) SP.	.	.	.	.	14	11
EPHEMERELLA (EURYLOPHELLA) SP.	.	.	.	1	.	8
EPHEMERELLA (SERRATELLA) SP.	.	.	.	.	2	.
HEPTAGENIA SP.	.	.	.	1	.	.
STENACRON SP.	1	.	.	.	.	1
STENONEMA (PULCHELLUM) SP.	50	213	75	118	40	37
ISONYCHIA SP.	.	10	5	16	.	24
CORYDALUS SP.	.	.	.	2	.	.
CORYDALUS CORNUTUS	10	3	2	18	.	.
NIGRONIA SP.	.	1	.	.	.	.
BOYERIA VINOSA	.	.	.	.	.	1
NEUROCORDULIA SP.	.	.	1	.	.	.
HAGENIUS BREVISTYLUS	.	.	1	.	.	.
LIBELLULIDAE	.	2	.	.	.	.
MACROMIA ILLINOIENSIS	1	.	.	.	.	.
ENALLAGMA SP.	.	1	.	.	.	2
AMPHINEMURA SP.	.	.	.	1	.	.
PROSTOIA SP.	1	21	7	25	.	2
PROSTOIA SIMILIS	.	.	2	.	4	.
ACRONEURIA SP.	1	2	1	7	4	7
PARAGNETINA SP.	.	.	.	3	.	.
PERLESTA SP.	.	1	19	13	7	23
PHASGANOPHORA CAPITATA	.	.	.	1	.	.
HELOPICUS SUBVARIANS	.	2	2	1	.	.
ISOPERLA SP.	.	.	.	26	1	.
STROPHOPTERYX SP.	.	16	26	29	1	20
TAENIOPTERYX SP.	2	20	69	41	6	62
TAENIOPTERYX PARVULA	.	.	36	1	.	19
BRACHYCENTRUS SP.	2	.	.	40	1	12
BRACHYCENTRUS NUMEROSUS	.	.	.	4	.	.
CHEUMATOPSYCHE SP.	102	36	6	16	29	10
HYDROPSYCHE SP.	784	68	29	23	24	8
MACRONEMA ZEBRATUM	32	11	.	.	.	1
HYDROPSYCHIDAE PUPAE	5	.	.	.	.	.
HYDROPTILA SP.	2	2	2	1	.	7
HYDROPTILIDAE PUPAE	5	.	.	.	.	.
LEPIDOSTOMA SP.	.	.	.	.	8	.
NECTOPSYCHE CANDIDA	.	.	.	1	.	1
OECETIS SP.	2	15	2	2	1	1
CHIMARRA ATERRIMA	.	6	.	.	.	.
CHIMARRA OBSCURA	5	46	3	6	.	1
CHIMARRA SOCIA	.	1	.	1	.	.
WORMALDIA SP.	.	.	.	.	.	2
PTILOSTOMIS SP.	.	1	.	.	.	.
NEURECLIPSIS SP.	.	.	.	1	.	.
NEURECLIPSIS CREPUSCULARIS	21	13	.	1	.	.
NYCTIOPHYLAX SP.	.	.	.	2	.	.

TABLE 3-3. MACROBENTHIC ORGANISMS COLLECTED BY STATION IN HESTER-DENDY SAMPLER IN THE SOUTH ANNA RIVER, LITTLE RIVER AND NORTH ANNA RIVER DOWNSTREAM OF LAKE ANNA DAM DURING 1981.

SPECIES	NAR601L	NAR658H	NAR601H	RT1	SAR667	LR685
POLYCENTROPUS SP.	.	3	.	.	.	.
AMNICOLA SP.	.	.	1	.	15	18
PLEUROCERIDAE	.	1	1	1	1	.
GONIOBASIS SP.	.	.	.	.	2	3
PLEUROCERA SP.	.	.	.	.	.	2
LYMNAEIDAE	.	.	.	.	1	.
PHYSA SP.	.	1	.	.	.	5
HELISOMA SP.	.	.	.	5	.	3
CORBICULA FLUMINEA	.	1	.	3	.	1
MISSING SUBSTRATE	.	.	.	.	.	.
TOTAL # TAXA	41	53	45	63	28	53
TOTAL CATCH	1430	704	491	689	236	499

TABLE 3-4. TOTAL NUMBER OF MACROBENTHIC TAXA AND TOTAL ABUNDANCE COLLECTED BY STATION, BY SAMPLER TYPE AND BY MONTH, IN THE SOUTH ANNA RIVER, LITTLE RIVER AND NORTH ANNA RIVER DOWNSTREAM OF THE LAKE ANNA DAM DURING 1981.

GEAR=ELLIS-RUTTER

MONTH	NAR601LT	NAR601LA	NAR658HT	NAR658HA	NAR601HT	NAR601HA	RT1T	RT1A	SAR667T	SAR667A	LR685T	LR685A
2	27	2114	21	272	27	310	25	301	26	282	20	287
4	28	2551	32	371	30	534	25	253	32	415	31	130
6	21	488	23	218	31	143	17	91	33	382	33	158
8	24	506	15	81	27	232	29	204	30	267	22	172
10	23	1428	17	194	26	238	16	127	32	553	26	400
12	22	1906	31	821	41	454	22	125	34	255	28	337

GEAR=HESTER-DENDY

MONTH	NAR601LT	NAR601LA	NAR658HT	NAR658HA	NAR601HT	NAR601HA	RT1T	RT1A	SAR667T	SAR667A	LR685T	LR685A
2	8	174	12	81	9	39	11	74	1	1	6	39
4	9	95	17	175	16	96	26	163	17	140	15	38
6	21	380	19	126	20	67	25	107	15	80	21	133
8	22	442	17	63	11	60	22	143	0	.	17	122
10	14	269	24	199	10	60	24	139	0	.	20	88
12	15	70	15	60	15	169	9	63	8	15	4	79

TABLE 3-5. COEFFICIENT OF COMMUNITY COMPARISONS BETWEEN ALL STATIONS FOR ELLIS-RUTTER SAMPLES COLLECTED IN THE SOUTH ANNA RIVER, LITTLE RIVER, AND NORTH ANNA RIVER DOWNSTREAM OF THE LAKE ANNA DAM DURING 1981.

STATION	_601L	_658H	_601H	PT1	SAR	LR
601-L	1.00000	0.56923	0.61871	0.55556	0.52414	0.53147
658-H	0.56923	1.00000	0.68456	0.63235	0.58065	0.58824
601-H	0.61871	0.68456	1.00000	0.64828	0.62195	0.60494
US 1	0.55556	0.63235	0.64828	1.00000	0.60927	0.65772
S.A.R.	0.52414	0.58065	0.62195	0.60927	1.00000	0.67857
L.R.	0.53147	0.58824	0.60494	0.65772	0.67857	1.00000

TABLE 3-6. COEFFICIENT OF COMMUNITY COMPARISONS BETWEEN ALL STATIONS FOR HESTER-DENDY SAMPLES COLLECTED IN THE SOUTH ANNA RIVER, LITTLE RIVER, AND NORTH ANNA RIVER DOWNSTREAM OF THE LAKE ANNA DAM DURING 1981.

STATION	_601L	_658H	_601H	RT1	SAR	LR
601-L	1.00000	0.57447	0.52874	0.51923	0.40000	0.46316
658-H	0.57447	1.00000	0.58586	0.67241	0.43902	0.56075
601-H	0.52874	0.58586	1.00000	0.58716	0.53333	0.50000
US 1	0.51923	0.67241	0.58716	1.00000	0.41304	0.52991
S.A.R.	0.40000	0.43902	0.53333	0.41304	1.00000	0.45783
L.R.	0.46316	0.56075	0.50000	0.52991	0.45783	1.00000

TABLE 3-7. COEFFICIENT OF COMMUNITY COMPARISONS BETWEEN ELLIS-RUTTER AND HESTER-DENDY SAMPLES, BY MONTH AND BY STATION COLLECTED IN THE SOUTH ANNA RIVER, LITTLE RIVER AND NORTH ANNA RIVER DOWNSTREAM OF THE LAKE ANNA DAM DURING 1981.

	MONTH					
STATION	_2	_4	_6	_8	_10	_12
NAR601L	0.34	0.43	0.57	0.52	0.59	0.49
NAR659H	0.55	0.41	0.48	0.31	0.34	0.43
NAR601H	0.33	0.39	0.47	0.37	0.33	0.39
RT1	0.33	0.55	0.38	0.51	0.40	0.45
SAR667	0.07	0.45	0.58	.	.	0.38
LR685	0.38	0.39	0.56	0.41	0.52	0.13

TABLE 3-8. DUNCAN'S MULTIPLE RANGE TEST, DATE BY STATION, FOR MACROBENTHIC MEAN DENSITIES IN ELLIS-RUTTER SAMPLES COLLECTED IN THE SOUTH ANNA RIVER, LITTLE RIVER AND NORTH ANNA RIVER DOWNSTREAM OF LAKE ANNA DAM DURING 1981. VALUES CONNECTED BY THE SAME LINE INDICATES NO SIGNIFICANT DIFFERENCE. (.05 LEVEL)

FEBRUARY

STATION	658-H	S.A.R.	L.R.	Rt.1	601-H	601-L
$\bar{x}$	90.7	94.0	95.7	100.3	103.3	704.7

APRIL

STATION	L.R.	Rt.1	658-H	S.A.R.	601-H	601-L
$\bar{x}$	43.3	84.3	123.7	138.3	178.0	850.3

JUNE

STATION	Rt. 1	601-H	L.R.	658-H	S.A.R.	601-L
$\bar{x}$	30.3	47.7	52.7	72.7	127.3	162.7

AUGUST

STATION	658-H	L.R.	Rt. 1	601-H	S.A.R.	601-L
$\bar{x}$	27.0	57.3	68.0	77.3	89.0	168.7

OCTOBER

STATION	Rt. 1	658-H	601-H	L.R.	S.A.R.	601-L
$\bar{x}$	42.3	64.7	79.3	133.3	184.3	476.0

DECEMBER

STATION	Rt. 1	S.A.R.	L.R.	601-H	658-H	601-L
$\bar{x}$	41.7	85.0	112.3	151.3	273.6	635.3

TABLE 3-9. DUNCAN'S MULTIPLE RANGE TEST, STATION BY DATE, FOR MACROBENTHIC MEAN DENSITIES IN ELLIS-RUTTER SAMPLES COLLECTED IN THE SOUTH ANNA RIVER DOWNSTREAM OF LAKE ANNA DAM DURING 1981. VALUES CONNECTED BY THE SAME LINE INDICATES NO SIGNIFICANT DIFFERENCE. (.05 LEVEL).

601-L

MONTH	Jun.	Aug.	Oct.	Dec.	Feb.	Apr.
$\bar{x}$	162.7	168.7	476.0	635.3	704.7	850.3

658-H

MONTH	Aug.	Oct.	Jun.	Feb.	Apr.	Dec.
$\bar{x}$	27.0	64.7	72.7	90.7	123.7	273.7

601-H

MONTH	Jun.	Aug.	Oct.	Feb.	Dec.	Apr.
$\bar{x}$	47.7	77.3	79.3	103.3	151.3	178.0

Rt. 1

MONTH	Jun.	Dec.	Oct.	Aug.	Apr.	Feb.
$\bar{x}$	30.3	41.7	42.3	68.0	84.3	100.3

South Anna R.

MONTH	Dec.	Aug.	Feb.	Jun.	Apr.	Oct.
$\bar{x}$	85.0	89.0	94.0	127.3	138.3	184.3

Little R.

MONTH	Apr.	Jun.	Aug.	Feb.	Dec.	Oct.
$\bar{x}$	43.3	52.7	57.3	95.7	112.3	133.3

Table 3-10. DUNCAN'S MULTIPLE RANGE TEST, DATE BY STATION, FOR MACROBENTHIC MEAN DENSITIES IN HESTER-DENDY SAMPLES COLLECTED IN THE SOUTH ANNA RIVER, LITTLE RIVER AND NORTH ANNA RIVER DOWNSTREAM OF LAKE ANNA DAM DURING 1981. VALUES CONNECTED BY THE SAME LINE INDICATE NO SIGNIFICANCE DIFFERENCE (.05 LEVEL).

FEBRUARY

STATION	S.A.R.*	601-H	L.R.	Rt. 1	658-H	601-L
$\bar{x}$	1.0	19.5	19.5	37.0	40.5	87.0

APRIL

STATION	L.R.*	601-L	601-H	S.A.R.	Rt.1	658-H
$\bar{x}$	38.0	47.5	48.0	70.0	81.5	87.5

JUNE

STATION	601-H	Rt.1	658-H	L.R.	S.A.R.*	601-L
$\bar{x}$	33.5	53.5	63.0	66.5	80.0	190.0

AUGUST

STATION	658-H	601-H*	L.R.	Rt.1	601-L
$\bar{x}$	31.5	60.0	61.0	71.5	221.0

OCTOBER

STATION	601-H	L.R.	Rt.1	658-H	601-L
$\bar{x}$	30.0	44.0	69.5	99.5	134.5

DECEMBER

STATION	S.A.R.	658-H	Rt.1	601-L	L.R.	601-H
$\bar{x}$	7.5	30.0	31.5	35.0	39.5	84.5

*indicates only one sampler retrieved

TABLE 3-11. DUNCAN'S MULTIPLE RANGE TEST, STATION BY DATE, FOR MACROBENTHIC MEAN DENSITIES IN HESTER-DENDY SAMPLES COLLECTED IN THE SOUTH ANNA RIVER, LITTLE RIVER AND NORTH ANNA RIVER DOWNSTREAM OF LAKE ANNA DURING 1981. VALUES CONNECTED BY THE SAME LINE INDICATE NO SIGNIFICANT DIFFERENCE (.05 LEVEL).

601-L

MONTH	Dec.	Apr.	Feb.	Oct.	Jun.	Aug.
$\bar{x}$	35.0	47.5	87.0	134.5	190.0	221.0

658-H

MONTH	Dec.	Aug.	Feb.	Jun.	Arp.	Oct.
$\bar{x}$	30.0	31.5	40.5	63.0	87.5	99.5

601-H

MONTH	Feb.	Oct.	Jun.	Apr.	Aug.*	Dec.
$\bar{x}$	19.5	30.0	33.5	48.0	60.0	84.5

Rt. 1

MONTH	Dec.	Feb.	Jun.	Oct.	Aug.	Apr.
$\bar{x}$	31.5	37.0	53.5	69.5	71.5	81.5

South Anna R.

MONTH	Feb.*	Dec.	Apr.	Jun.*
$\bar{x}$	1.0	7.5	70.0	80.0

Little River

MONTH	Feb.	Apr.*	Dec.	Oct.	Aug.	Jun.
$\bar{x}$	19.5	38.0	39.5	44.0	61.0	66.5

*indicates only one sampler retrieved

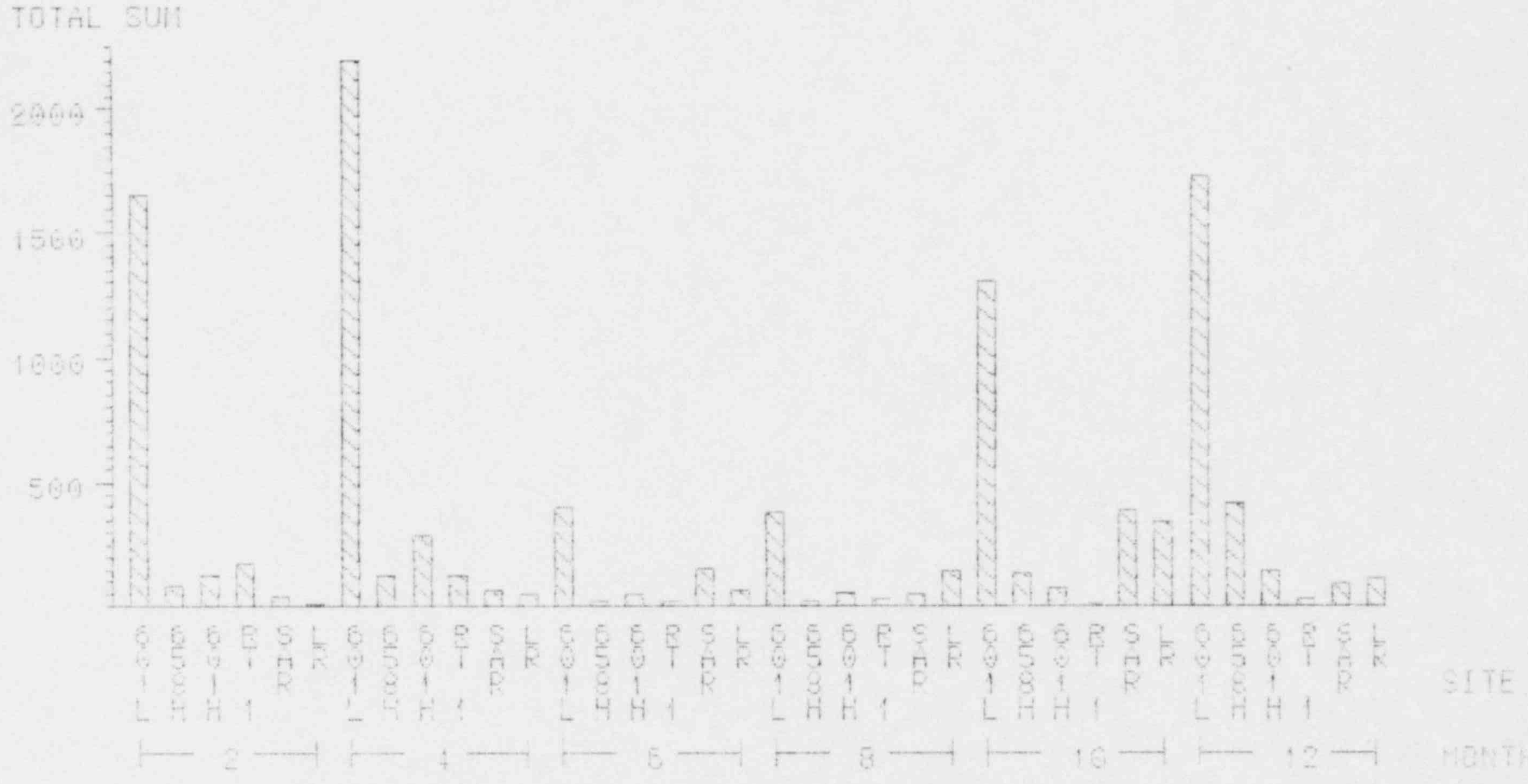

FIGURE 3-1 TRICHOPTERA COLLECTED BIMONTHLY IN ELLIS-RUTTER SAMPLES IN THE SOUTH ANNA RIVER, LITTLE RIVER AND NORTH ANNA RIVER DOWNSTREAM OF LAKE ANNA DAM DURING 1981

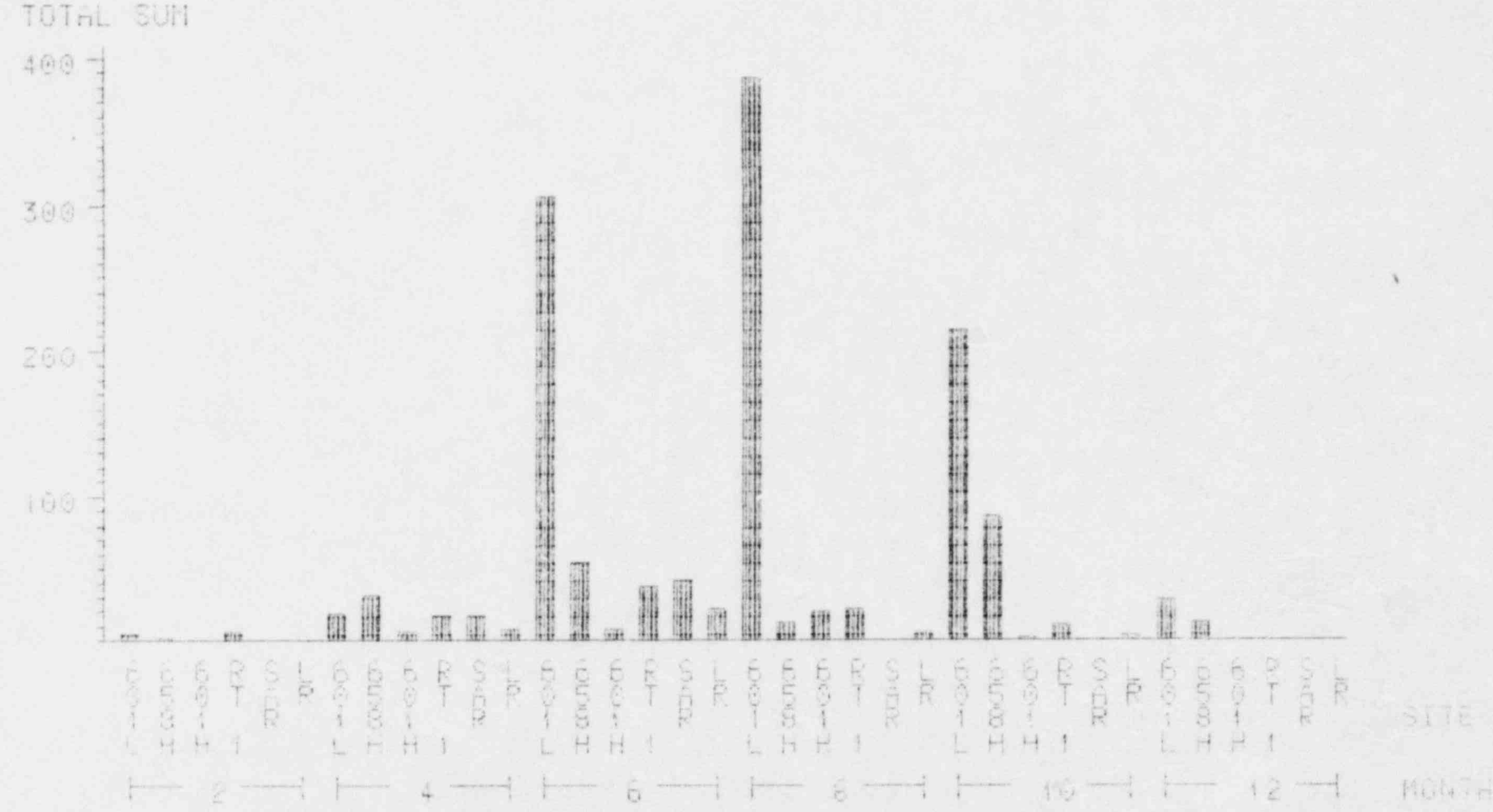

FIGURE 3-2 TRICHOPTERA COLLECTED BIMONTHLY IN HESTER-DENDY SAMPLES IN THE SOUTH ANNA RIVER, LITTLE RIVER AND NORTH ANNA RIVER DOWNSTREAM OF LAKE ANNA DAM DURING 1981

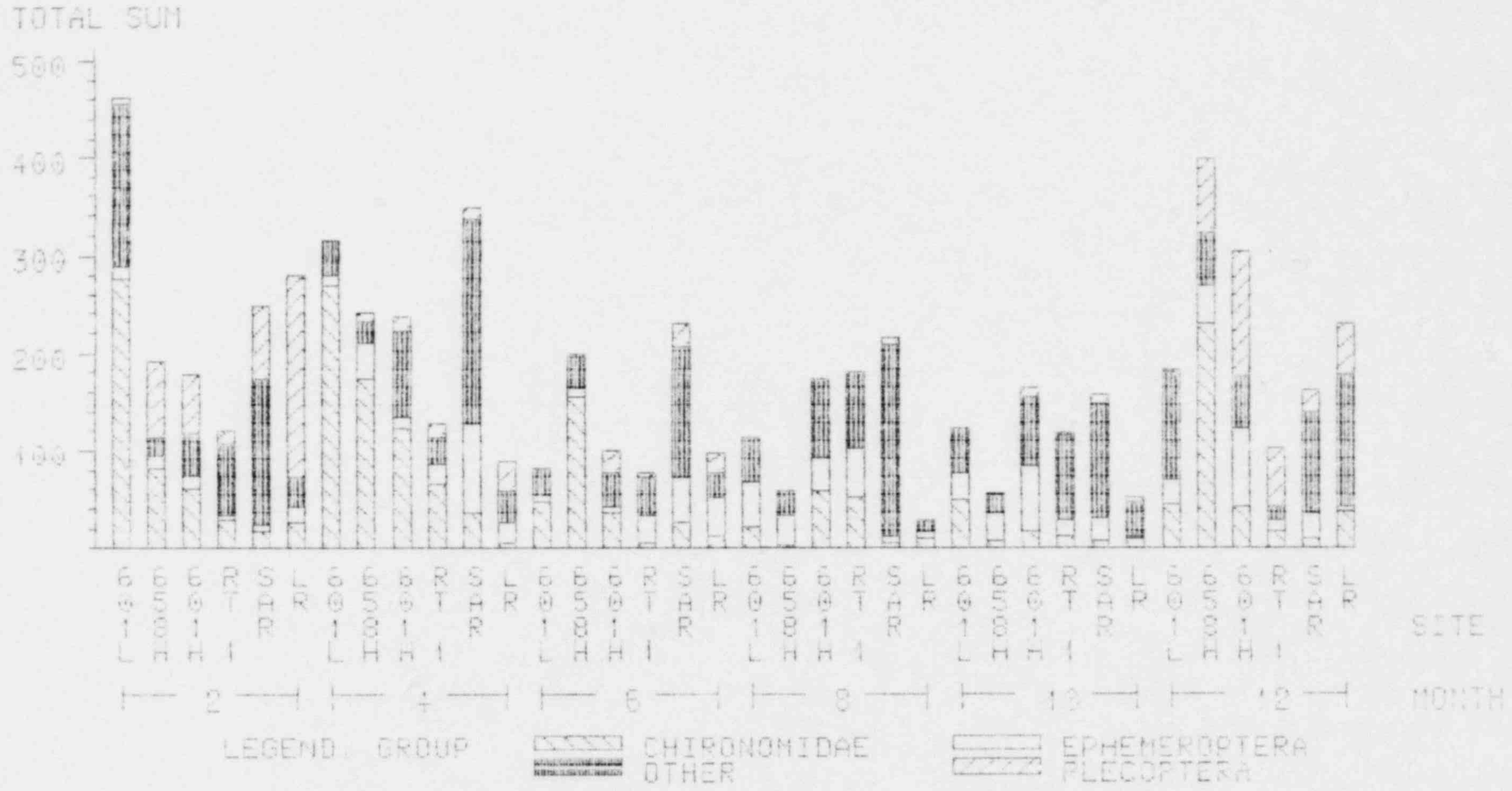

FIGURE 3-3. MAJOR TAXONOMIC GROUPS OF BENTHIC INVERTEBRATES (OTHER THAN TRICHOPTERA) COLLECTED BIMONTHLY IN ELLIS-RUTTER SAMPLES IN THE SOUTH ANNA RIVER, LITTLE RIVER AND NORTH ANNA RIVER DOWNSTREAM OF LAKE ANNA DAM DURING 1981.

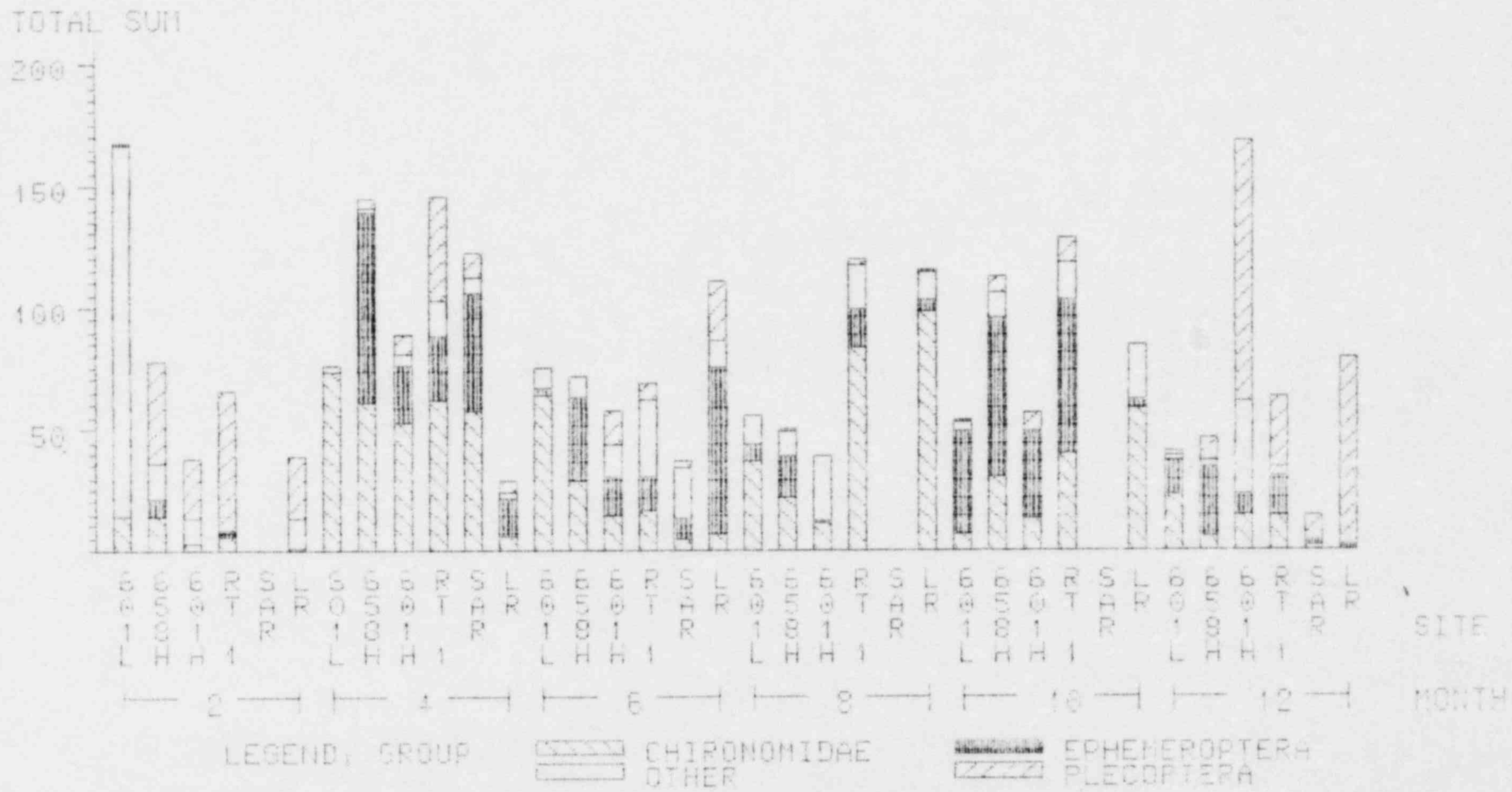

FIGURE 3-4. MAJOR TAXONOMIC GROUPS OF BENTHIC INVERTEBRATES (OTHER THAN TRICHOPTERA) COLLECTED BIMONTHLY IN HESTER-DENDY SAMPLES IN THE SOUTH ANNA RIVER, LITTLE RIVER AND NORTH ANNA RIVER DOWNSTREAM OF LAKE ANNA DAM DURING 1981

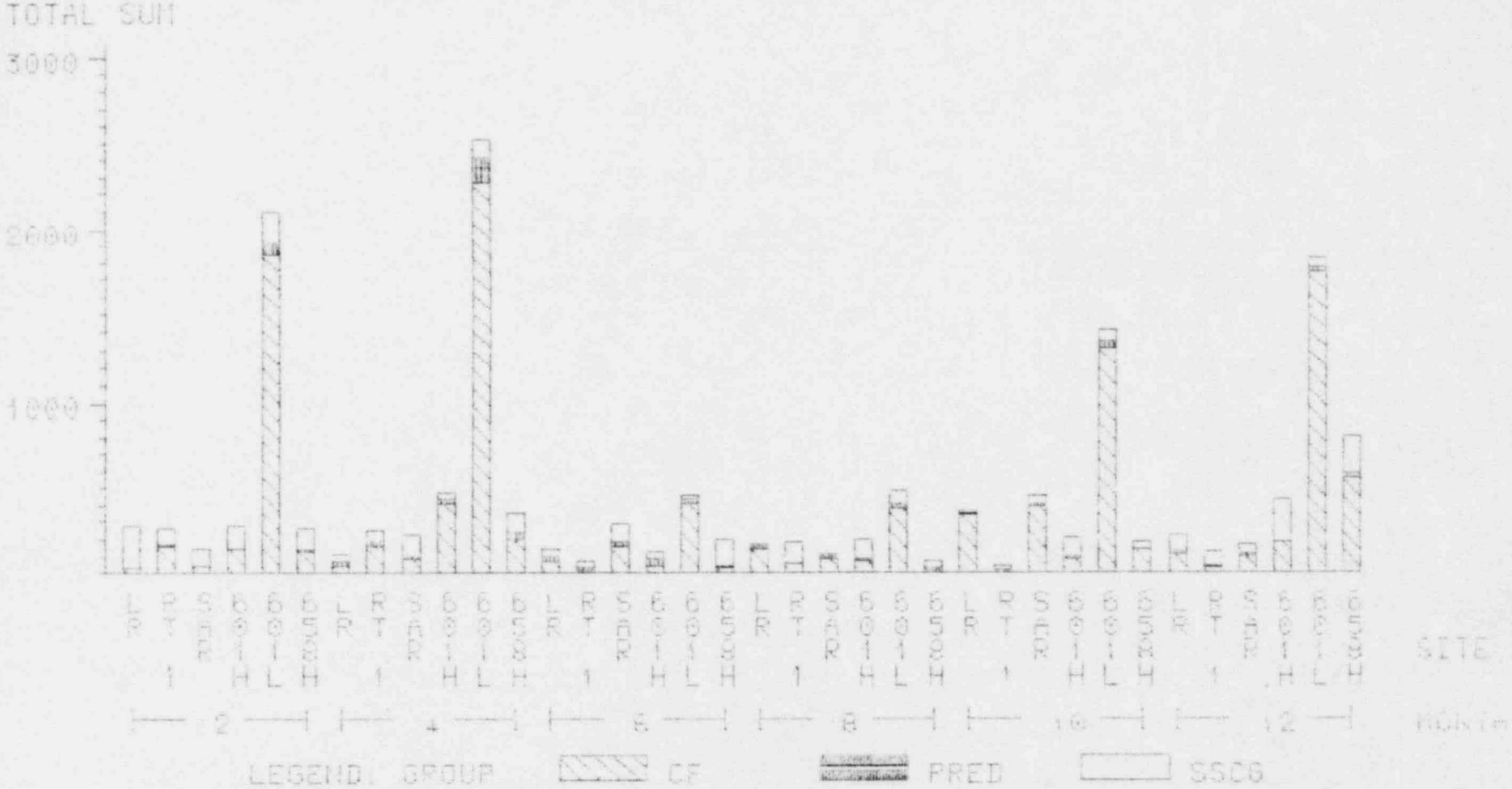

FIGURE 3-5. COMPOSITION OF MAJOR TROPHIC LEVELS OF MACROBENTHIC ORGANISMS COLLECTED BIMONTHLY IN ELLIS-RUTTER SAMPLES IN THE SOUTH ANNA RIVER, LITTLE RIVER, AND NORTH ANNA RIVER DOWNSTREAM OF LAKE ANNA DAM DURING 1981.

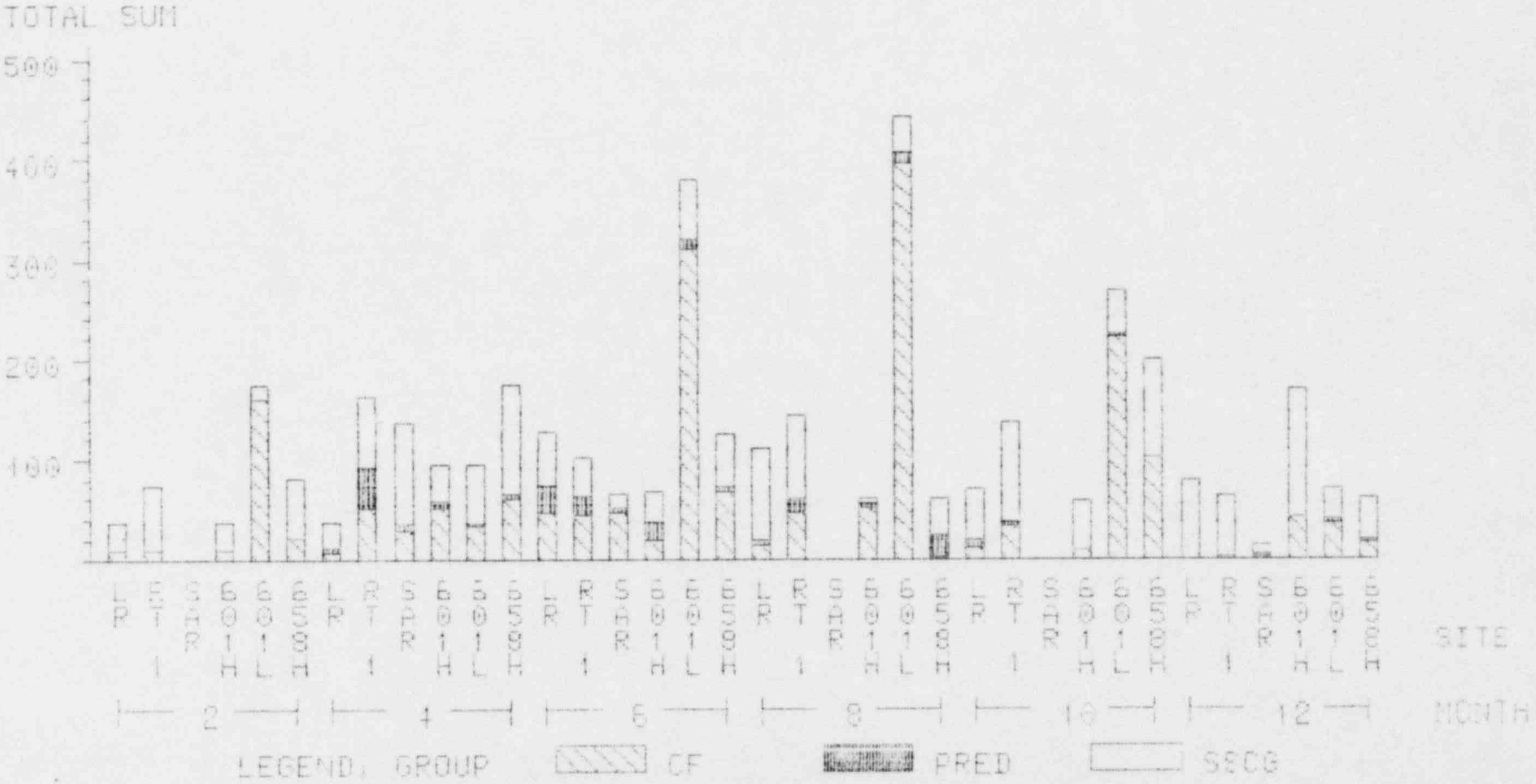

FIGURE 3-6. COMPOSITION OF MAJOR TROPHIC LEVELS OF MACROBENTHIC ORGANISMS COLLECTED BIMONTHLY IN HESTER-DENDY SAMPLES IN THE SOUTH ANNA RIVER, LITTLE RIVER, AND NORTH ANNA RIVER DOWNSTREAM OF LAKE ANNA DAM DURING 1981.

Ichthyoplankton

Introduction

The eggs and/or larvae of many riverine fishes enter a river as plankton (ichthyoplankton) and drift with the current through various developmental stages. In some species the larvae enter and leave the river currents at will until an acceptable habitat is found. Ichthyoplankton studies have contributed to our knowledge of the early life history of many fishes and also an understanding of the population dynamics within a given system. In addition, these studies are often the basis for fishery management and predictions (Kramer and Smith 1972, Van Winkle ed. 1977, Krause and Van Den Avyle 1979, Ulanowicz and Polgar 1980).

The North Anna River, was severely impacted by acid mine drainage for nearly 100 years (Reed and Simmons 1972). The creation of Lake Anna through impoundment in 1972 has significantly improved water quality in the region and a repopulation of fishes in the lower river has progressed since impoundment (Reed 1981). Recruitment was undoubtedly the initial mechanism of repopulation, but recent population increases may be due, in part, to local spawning by the newly established fish stocks.

Past studies in the lower North Anna River have not included ichthyoplankton. The purpose of this study was to determine which fishes utilize the lower North Anna River as a spawning and/or nursery ground and to describe the spatial and temporal distribution of the ichthyoplankters collected.

Methods and Materials

Ichthyoplankton samples were collected in the lower North Anna River at four stations (Figure 1-1) from March through September 1981. Additional samples were also collected in the South Anna and Little Rivers (Figure 1-1) during this period. Samples were collected biweekly, except on several occasions when scheduling conflicts necessitated a 1 week delay.

The North Anna River stations were sampled for 20 minutes using a fixed ichthyoplankton net (FIN). The net has a 0.38 m square aperture and is 1.6 m long with 505 μ mesh. The net frame was attached to two reinforcing rods that were driven into the river bed. The sample depth was recorded and a digital flowmeter (General Oceanics Model 2030 MK II) was attached to the center of the net to determine the volume of water filtered.

The shoreline and weed beds of all stations were sampled by pushing a dip ichthyoplankton net (DIN) through the water for 10 minutes. This net was fabricated by rigging a long handled dip net with a plankton net (0.28 x 0.38 m aperture; 1.10 m long; 505 μ mesh). All collections were recorded as catch-per-unit-effort.

Water temperature was recorded at the time of each FIN and DIN sample. All samples were fixed in the field by adding a small volume of 25% buffered formalin which dilutes to a fixative concentration of approximately 5% in the sample. The samples were returned to the laboratory for sorting and preservation in 3% buffered formalin. All fish eggs and larvae were identified to the lowest possible taxon.

Results

Fish eggs were collected in low numbers in the North Anna River during early April through mid-July (Table 4-1). They were found drifting as single or clumped eggs and were often attached to leaf or twig fragments. None were collected at the Little River and South Anna River stations.

At least five different types of eggs were found. Egg diameters ranged from 0.5 to 2.3 mm. Most eggs were detritus covered and had the characteristics of demersal eggs. None were identified, although some compared favorably with published descriptions for several fishes known to inhabit the North Anna River.

A total of 482 fish larvae was collected in the North Anna River during April through July. In addition, 118 larvae were collected in the South Anna River during late April through September and 10 larvae were taken in the Little River during mid-July and September (Table 4-2, Table 4-3).

The dip ichthyoplankton net (DIN) was used to collect the semi-planktonic larval/young riverine fishes that inhabit the sheltered waters near the shoreline, obstructions and weedbeds. The highest number and greatest diversity of semi-planktonic larvae were found in the North Anna River at Station 601 Hanover (six species) and at the South Anna River station (six species).

The fixed ichthyoplankton net (FIN) was most effective in collecting the truly planktonic species of larvae (gizzard shad, Dorosoma cepedianum; white perch, Morone americana; yellow perch, Perca flavescens; and Lepomis spp.). These larvae were most numerous at the 601 Louisa station which suggested a Lake Anna origin. In addition, many prolarvae of three riverine fishes (shield darter, Percina peltata; satinfin shiner, Notropis analostanus; white sucker, Catostomus commersoni) were collected further downstream at the Route 1 Hanover station.

Eleven species of fish larvae were identified from the North Anna, while six species were taken in the South Anna River and three were found in the Little River. Satinfin shiner and rosefin shiner (N. ardens) larvae were foun all three river systems. White sucker and redbreast sunfish (Lepomis auritus) larvae were taken from the North Anna and South Anna Rivers, but none were collected in the Little River. Mosquitofish (Gambusia affinis) larvae were not found in the North Anna River but were taken from the other two river systems. Eastern mudminnow (Umbra pygmaea) larvae were only found in the

South Anna River. The remaining seven species of larvae (gizzard shad; white perch; yellow perch; Lepomis spp.; shield darter; northern hog sucker, Hypentelium nigricans; river chub, Nocomis micropogon) were only collected in the North Anna River.

Redbreast sunfish and satinfin shiner were the most abundant larvae taken with the DIN in the North Anna River, while gizzard shad, white perch, satinfin shiner, shield darter and unidentified sunfish (Lepomis spp.) larvae were numerous in the FIN samples. Rosefin shiner larvae dominated the South Anna River samples. Very few larvae were collected at the Little River station.

The seasonal composition of larvae varied among the three rivers. During April through May, larval populations in the North Anna River were dominated by shield darter, white sucker, white perch, satinfin shiner and gizzard shad larvae. In June and July, the larvae of the satinfin shiner, redbreast sunfish and Lepomis spp. were numerous. Larvae were not collected during August and September in the North Anna River. In the South Anna River, satinfin shiner larvae were collected from May through September and rosefin shiner larvae were abundant during June through September. Larvae were not collected in the Little River during March through June and in August although few satinfin shiner and rosefin shiner larvae were taken during July and September.

Discussion

There are many factors that determine which species successfully spawn in a riverine environment (Gerlach and Kahnle 1981). Historically, the poor water quality of the North Anna River was a primary limiting factor. With impoundment and the subsequent water quality improvement, numerous fishes have migrated into the formally depleted waters, often in response to reproductive cycles. However, the larval populations observed may not totally represent the adult populations of the river (Hey and Mauney 1981). In many rivers, upstream spawning migrations have concentrated fishes below dams and resulted in competition and/or predation with a negative influence on reproductive success. As a result, higher success rates were often encountered further downstream where adult populations were lower (Hey and Mauney 1981). In addition, many larval fishes have higher drift rates during nocturnal hours and are rarely collected during daylight hours (Geen et al. 1966, Clifford 1972, Clautman and Edwards 1977, Gale and Mohr 1978). Also those species that drift during the daylight hours often exhibit varying degrees of net avoidance (Coda et al. 1980).

To help reduce the effects of variable drift rates and the lack of drift exhibited by the larvae and juveniles of many riverine fishes, DIN samples were collected along the shorelines and in the weedbeds of all stations. This resulted in the capture of additional species not collected with the more traditional FIN. Gerlach and Kahnle (1981), using a push net collected from vegetated areas, the larvae of 70% of the species that commonly reproduced within the river sampled. They found few larvae in the unvegetated areas. Unfortunately, poor quantification is inherent with DIN samples.

Thirty-three species of adult fishes were collected in the North Anna River during 1981 with 15 of these fishes found to be relatively abundant (see Fish Section). The larvae of five of the common species were collected along with the larvae of six less common species. A few species, including the very abundant American eel (Anguilla rostrata), spend a portion of their life cycle in the riverine environment and spawn elsewhere. Most of the remaining common fishes whose larvae were not collected can potentially spawn in the North Anna River since the river habitat is sufficiently diverse to accommodate the spawning requirements that are known for these fishes (Lippson and Moran 1974, Pflieger

1975, Hardy 1978 and Jones et al. 1978).

The larvae of three cyprinids (satinfin shiner, rosefin shiner and river chub) were collected during this study. The larvae of the remaining five dominant adult cyprinids found in the North Anna River (bluehead chub, Nocomis leptocephalus; comely shiner, Notropis amoenus; swallowtail shiner, N. procne; rosyface shiner, N. rubellus; fallfish, Semotilis corporalis) were not collected. Apparently, these fishes spawned in areas that were not sampled or the larvae hatched and drifted on dates not sampled. In addition, most cyprinid larvae are capable of entering and leaving the current at will.

The two rosefin shiner larvae collected in the North Anna River were identified by comparing them with a complete series of rosefin shiner larvae obtained from the South Anna River. There is a possibility that these two larvae are in fact rosyface shiner larvae. In the North Anna River, the adults of both species are present, but the rosyface shiner is the dominant species. Raney (1947) considers the rosyface shiner to be a northern ecological replacement of the rosefin shiner and the eggs and newly hatched larvae are similar (Loos et al. 1979).

Three species of darters are commonly collected in the North Anna River but only the larvae of the shield darter were taken. Larvae of the remaining two adult species found in the North Anna River (tessellated darter, Etheostoma olmstedi; glassy darter, E. vitreum) were not found. All three species are crevice spawners and remain lodged in between pebbles and rocks for most of their life history.

The margined madtom (Noturus insignis) is commonly collected as an adult, yet no larvae were collected. Like the darters, their eggs are released in crevices and guarded by the adults. The prolarvae are advanced in development when hatched, and develop directly into juveniles omitting the larval stage.

The black crappie (Pomoxis nigromaculatus) is often abundant in the North Anna River immediately below the lake. Their larvae have on occasion been collected in a riverine environment, but this fish prefers quiet clear waters with dense aquatic vegetation, typical of many lakes and ponds. The black crappie populations observed in the river were probably displaced from the lake. Such recruitment of fish to tailwaters via reservoir loss has been commonly observed for many species of fishes in other regions (Louder 1958, Elser 1960, Nelson 1969).

In conclusion, fish eggs and 11 species of larvae were taken in the North Anna River during April through July 1981. The failure to collect the larvae of some of the dominant fishes is due in part to sampling inadequacies and to the lack of spawning by several migrating fishes. But, the collection of fish eggs and larvae within the formerly impacted North Anna River strongly suggests that environmental conditions have improved and that self-sustaining populations of fishes presently inhabit the river.

Summary

1. Fish eggs and 11 species of larvae were taken in the North Anna River during April through July 1981.

2. Most of the larval species collected were spawned locally within the river, although the larvae of a few species (e.g., black crappie and gizzard shad) may be of Lake Anna origin.

3. Captures of fish eggs and larvae within the river strongly suggests that environmental conditions have improved substantially to permit the establishment of self-sustaining populations within the formerly impacted river.

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TABLE 4-1. DENSITY (NO./1000 CUBIC METERS) OF UNIDENTIFIED EGGS COLLECTED WITH A FIXED ICHTHYOPLANKTON NET (FIN) IN THE LOWER NORTH ANNA RIVER, VIRGINIA, DURING 1981.

DATE	NAR601H	NAR601L	NAR658H	RT1
810401	11.5741	130.577	10.941	115.132
810414	.	.	277.778	581.162
810522	.	.	.	22.124
810603	.	11.862	.	.
810714	.	.	.	78.493
810810	.	.	.	27.248

TABLE 4-2. NUMBER (NO./10 MINUTES EFFORT) OF FISH LARVAE COLLECTED WITH A DIP ICHTHYOPLANKTON NET (DIN) IN THE NORTH ANNA RIVER (NAR), SOUTH ANNA RIVER (SAR), AND LITTLE RIVER (LR), VIRGINIA, DURING 1981.

DATE	SPECIES	NAR601L	NAR658H	NAR601H	RT1	SAR667	LR685
810414	CATOSTOMUS COMMERSONI	.	1.0	.	1.0	.	.
810430	CATOSTOMUS COMMERSONI	.	.	.	.	1.0	.
810522	NOCOMIS MICROPOGON	.	.	1.0	.	.	.
	NOTROPIS ANALOSTANUS	.	.	.	.	4.0	.
810603	CATOSTOMUS COMMERSONI	.	.	1.0	.	.	.
	HYPENTELIUM NIGRICANS	.	.	7.0	.	.	.
	LEPOMIS AURITUS	89.0	.	.	.	.	.
	NOTROPIS ANALOSTANUS	1.0	.	10.0	.	.	.
810616	LEPOMIS AURITUS	.	11.0	.	.	.	.
	NOTROPIS ANALOSTANUS	.	.	1.0	3.0	.	.
	NOTROPIS ARDENS	.	.	.	.	61.0	.
	PERCINA PELTATA	.	1.0	.	.	.	.
	UMBRA PYGMAEA	.	.	.	.	1.0	.
810630	GAMBUSIA AFFINIS	.	.	.	.	1.0	.
	LEPOMIS AURITUS	1.0	.	.	.	.	.
	NOTROPIS ANALOSTANUS	.	.	.	.	1.0	.
	NOTROPIS ARDENS	.	.	2.0	.	21.0	.
810714	LEPOMIS AURITUS	.	1.0	69.0	.	.	.
	NOTROPIS ANALOSTANUS	.	15.0	62.0	.	.	2.0
810728	NOTROPIS ANALOSTANUS	.	.	4.0	.	.	.
	NOTROPIS ARDENS	.	.	.	.	.	3.0
810810	LEPOMIS AURITUS	.	.	.	.	3.0	.
	NOTROPIS ARDENS	.	.	.	.	14.0	.
810903	NOTROPIS ARDENS	.	.	.	.	1.0	.
810922	GAMBUSIA AFFINIS	.	.	.	.	.	4.0
	NOTROPIS ANALOSTANUS	.	.	.	.	4.0	1.0
	NOTROPIS ARDENS	.	.	.	.	7.0	.

TABLE 4-3. DENSITY (NO./1000 CUBIC METERS) OF FISH LARVAE COLLECTED WITH A FIXED ICHTHYOPLANKTON NET (FIN) IN THE LOWER NORTH ANNA RIVER, VIRGINIA, DURING 1981.

DATE	SPECIES	NAR601L	NAR658H	NAR601H	RT1
810401	PERCA FLAVESCENS	21.7628	.	.	.
	PERCINA PELTATA	.	.	.	230.263
810414	CATOSTOMUS COMMERSONI	.	9.57854	.	20.0401
	NOTROPIS ANALOSTANUS	.	.	.	20.0401
	PERCA FLAVESCENS	7.76398	.	.	.
810430	CATOSTOMUS COMMERSONI	.	.	.	14.4092
	DOROSOMA CEPEDIANUM	683.761	.	.	.
	MORONE AMERICANA	53.419	.	.	.
810522	DOROSOMA CEPEDIANUM	637.860	.	.	.
	MORONE AMERICANA	113.169	.	.	.
	NOTROPIS ANALOSTANUS	.	.		22.1239
810603	LEPOMIS SP.	11.8624	.	23.9234	.
	MORONE AMERICANA	11.8624	.	.	.
	NOTROPIS ANALOSTANUS	.	.	23.9234	.
810616	NOTROPIS ANALOSTANUS	.	.	.	117.647
810630	LEPOMIS SP.	12.8370	.	.	.
	NOTROPIS ANALOSTANUS	12.8370	.	.	.
810714	LEPOMIS SP.	98.1194	125.392	11.2613	.
810728	LEPOMIS SP.	9.63391	.	.	.
	NOTROPIS ANALOSTANUS	.	.	.	63.2911

Fishes

INTRODUCTION

Fish population studies have been conducted on the lower North Anna and adjacent rivers since 1973. As of January 1, 1981 Virginia Electric and Power Company has conducted all studies "in house" by Environmental Services personnel. Prior to that date the majority of this work was handled on a contractual basis by consulting firms. The major objective of this study was to determine the effects of the Lake Anna impoundment and operation of the North Anna Power Station on the downstream fish fauna of the lower North Anna River.

Due to the nature of impounded water, changes in water chemistry downstream can be affected, influencing resident fish communities. If water is released from the hypolimnion, downstream temperatures may be reduced due to thermal stratification in the reservoir (Edwards 1978). If water is released from the epilimnion, as it is from Lake Anna, the reverse could occur. Just the physical presence of a dam and reservoir with an epilimnetic release can raise the temperature, as occurred in the lower North Anna River (Kondratieff and Voschell, 1981). The operation of Units 1 and 2 with the accompanying thermal discharge added to this increase. This increased downstream temperature could result in the loss of certain cold water species from that section of the river (Young and Vaughan 1980).

The impoundment of the North Anna River appears to have completely ameliorated the effects of acid mine drainage in downstream areas by acting as a sink for sediments and metals (Simmons and Voschell 1978). There also appears to have been a decrease in nutrient availability below the dam, reflected by decreases in nitrates, phosphates and dissolved elements due to metabolism of these substances within the Reservoir, or settling out of those bound to sediments. This could lower the primary productivity below the dam, reducing the productivity of the community as a whole (Edwards 1981).

Any changes in fish community structure should be apparent in diversity comparisons between North Anna River stations and similar stations on adjacent rivers. Since diversity is high in healthy communities but decreases with stress (Stauffer et al. 1974).

Electroshocking was the collection method used for this survey. The validity of electroshocking the same general area repeatedly during a year has been demonstrated for reservoir shoreline areas (King et al. 1981) and should also be valid for stream situations because of immigration from above and below shocked areas.

METHODS AND MATERIALS

Fish were collected bimonthly by electroshocking four stations on the North Anna River (Route 601, Louisa County; Route 658, Hanover County; Route 601, Hanover County; and U. S. Route 1, Hanover County), and one each on the South Anna River (Route 667, Hanover County) and Little River (Route 685, Hanover County) (Figure 1-1). Collections were made semi-annually at one station on Northeast Creek and one on Pamunkey River (U. S. Route 301, Hanover County).

Fishes were collected by utilizing two types of electroshocking equipment, an electric ceine power by a 240 v AC generator and a Smith-Root type VII backpack electrofisher. Dip nets and two block nets, 4.5 m and 9.1 m x 1.2 m x 6.4mm were also utilized.

Stations were sampled with approximately equal effort so comparable data could be obtained. All accessable habitats in a 60-80 m length of stream were sampled using the electric seine, block net and dip nets. Pool areas within the sampling area were sampled using the backpack shocker and dip nets. Collected fish were preserved, returned to the laboratory, enumerated, weighed and measured; gamefish in good condition were weighed, measured and released in the field. Temperatures (^{o}C), dissolved oxygen (ppm), alkalinity (mg/l as $CaCO_3$), pH, and turbidity (NTU) were measured for each station.

Little River and South Anna River were considered as baseline rivers and were utilized for comparison to observe effects of the Lake Anna dam and North Anna Power Station operation on dowmstream fish populations in the lower North Anna River. Seasonal comparisons among stations were also studied , as was the possibility of the use of Northeast Creek as a cool water refuge during periods of extreme temperatures. Fish diversity was determined for each station by the Shannon-Weiner method and examined statistically between stations by analysis of variance and Duncan's multiple range test.

RESULTS AND DISCUSSION

The fish fauna of the York River drainage, of which the North Anna River, South Anna River and Little River form a part, is relatively small and contains no known endangered or endemic species (Reed 1981).

Thirty-six collections were made at four stations on the lower North Anna River (Figure 1-1)plus two collections at a station on Northeast Creek and two collections at a station on the upper Pamunkey River. An attempt was made to sample all available habitats at each station during the 1981 study in order to collect a representative sample of all fishes inhabiting that section of the river. A total of 2,856 fishes, representing 36 species and 12 families was collected (Tables 5-1 through 5-9).

Eleven collections were made on Little River and South Anna River (Figure 1-1). One South Anna River collection was canceled due to ice cover in January. A total of 394 fishes, representing 24 species and eight families was collected from South Anna River and 814 fishes, representing 25 species and seven families from Little River (Tables 5-1 through 5-9).

Surface temperature, dissolved oxygen, pH, turbidity and alkalinity were recorded for each station during the sampling period except January when turbidity and alkalinity were not recorded for two stations (Table 5-10). The highest temperature for the North Anna River was recorded in July at the 601 Louisa station (26.9 C), however, the South Anna station was slightly higher that month (27.0 C). The lowest temperatures were recorded in January, 1.3 C for Route 658 Hanover and 0.1 C for the South Anna River (Table 5-10). Temperatures generally decreased downstream on the North Anna River, this trend was also noted during pre-operational downstream studies (Reed and Simmons 1972).

Lower temperatures were found in Northeast Creek than in adjacent river stations. North Anna River station temperatures were comparable to the South Anna River and Little River stations and maximums were well below the upper incipient lethal limits for the species present (Talmage and Opresko 1981), and below the permitted maximum of 32 C (Virginia State Water Control Board 1980).

Dissolved oxygen levels from North Anna River ranged from 13.8 ppm in January at the Route 1 station to 5.9 ppm in July at the Pamunkey River station (Table 5-10). These values are similar to the control river extremes (14.1 and 7.0 ppm) and well within accepted levels (Virginia State Water Control Board 1980).

On North Anna River pH ranged from 6.5 to 7.3 which was comparable to the South Anna River and Little River system of 6.6 to 8.0 (Table 5-10). These values are, again, within acceptable levels (6.0-8.5) set by the State (Virginia State Water Control Board 1980).

Turbidity values fluctuated (Table 5-10) due primarily to the amount of runoff at the time of sampling but were generally higher at the control, South Anna River and Little River stations than the North Anna River stations due, probably, to the ameliorating influence of Lake Anna acting as a settling basin. Alkalinity values also varied and were generally highest at the South Anna and Little River station and lowest nearer the dam, again due to the influence of the lake (Table 5-10).

The two most abundant species found during the lower North Anna River survey were cyprinids (minnows): swallowtail shiner, Notropis procne, and satinfin shiner, N. analostanous. These were followed in abundance by the redbreast sunfish, Lepomis auritus (Table 5-9). The most abundant species from the South Anna and Little River system was the bluehead chub, Nocomis leptocephalus followed by the fallfish, Semotilus corporalis.

Fewer species were collected during the 1981 study than during the 1980 study at three of the four North Anna River stations sampled. Generally, however, more species were collected than during preceeding years (Table 5-11). These 1980-81 differences may be due to the fact that fewer samples were taken per station during 1981 (six compared with eight during 1980). However, in most cases the species collected during 1980 and not during 1981 were represented by only a few individuals (≤ 5) and two to five new species were collected at each of the four stations sampled during 1981, also usually represented by few individuals (≤ 5) (Table 5-12). Therefore, all of these sparsely represented species collected during 1980 and 1981 are probably present in the vicinity of these stations but are uncommon. In any case there appears to have been a general increase in number of species at each station since 1973 (Table 5-11).

Representatives of the lamprey family, Petromyzontidae, were collected from the North Anna and South Anna Rivers. A single species, sea lamprey (Petromyzon marinus) was collected from three of the six North Anna system stations (Table 5-9), while the American brook iambrey, Lampetra appendix, and least brook lamprey, L. aepyptera, were collected only from the South Anna River (Table 5-9).

American eel, Anguilla rostrata, family Anguillidae, were collected from all stations during 1981 and, as has been the case in previous years, were most numerous nearer the dam (Table 5-9), (Reed 1981).

The herring family, Clupeidae, was represented by a single specimen of a single species, gizzard shad, Dorosoma cepedianum, collected from the 601 Louisa station (Tabie 5-9). This species prefers deep pools and is fast moving, not generally susceptable to backpack or accessable to electric seine shocking. Other members of the herring family, some of which are anadromous, have reportedly been sighted as far up river as the Route 738 Hanover County bridge during spring spawning runs.

Chain pickerel, Esox niger, family Esocidae, were collected at three of the five North Anna River-Pamunkey River stations (not at 601 Louisa or Upper Pamunkey), both South Anna River and Little River and from Northeast Creek (Table 5-9).

The carp and minnow family Cyprinidae, was represented by 13 species from the North Anna river system and an additional three species found only in the Little and/or South Anna Rivers. Overall the four dominant species were, in decreasing number of fishes collected, swallowtail shiner, satinfin shiner, bluehead chub and fallfish (Table 5-9). This order of abundance was the same as found during the 1980 study and these four species have dominated the total numbers of cyprinids collected since 1973 (Reed and Simmons 1975, Reed 1981). One hybrid chub, Nocomis spp. was collected during the 1981 survey and it was determined to be a cross between the bluehead chub and the river chub, N. micropogon as confirmed by Dr. Robert Jenkins of Roanoke College. These two species, normally occupying different habitats (Potter et al, 1980) were both collected from the four primary North Anna River stations, the South Anna River and Little River stations during 1981.

The sucker family, Catostomidae, was represetned by four species (Table 5-9), and, as in the 1980 study (Reed 1981), they were collected in low numbers and only from the lower river stations. No sucker were collected from the two stations nearest the dam (601 Louisa and 658 Hanover).

Shorthead redhorse, Moxostoma macrolepidotum, were collected only from the South Anna River and Little River stations (one individual each) during 1981 (Table 5-9).

The bullhead catfish family, Ictaluridae, was represented by a single species during 1981, the margined madtom, Noturus insignis, which was collected from all stations except the upper Pamunkey River station and was most abundant at the South Anna River and 601 Hanover stations (Table 5-9). During the 1980 study three other catfish species, common to Lake Anna, were also collected downstream (Reed 1981).

Pirate perch, Aphredoderus sayanus, were collected from the lower North Anna River during 1981 (Route 1 station and upper Pamunkey River station - one individual each). This species was not collected during the 1980 study. Pirate perch are normally active nocturnally and found in tidal or brackish waters (Jones et al. 1978).

Another species not collected during the 1980 study is from the livebearer family, Poeciliidae. Mosquitofish, Gambusia affinis, were collected only at the upper Pamunkey River station (Table 5-9) but this is, essentially, an ubiquitous species (Jones et al. 1978).

White perch, Morone americana, the only representative of the temperate bass family, Perchchthyidae, were collected exclusively from the 601 Louisa station (Table 5-9) as they were during the 1980 study (Reed 1981).

The sunfish family, Centrarchidae, was represented by seven species during the 1981 collections (Table 5-9). The most abundant sunfish was the redbreast sunfish, as was found during previous study years (Reed 1981). This species was common at all stations and most numerous at the 601 Hanover station. Bluegill, L. macrochirus, were also common and ubiquitous, however pumpkinseed, L. gibbosus, found to be common during the 1980 study was represented by only two individuals from the combined North Anna River, South Anna River and Little River stations during 1981. Largemouth bass, Micropterus salmoides, were collected from two of the four primary North Anna River Stations and also from the upper Pamunkey River, Northeast Creek and South Anna River stations (Table 5-9), similar to distributions reported from past surveys (Reed 1981). This species appears to be doing well in the lower North Anna river. Smallmouth bass, Micropterus dolomieu, were collected only from the 601 Hanover station and the South Anna station during 1981 (Table 5-9), and were represented by two individuals from each station. The 601 Hanover station collection is farther upriver than the species was collected during 1980 and, given the small size of the specimens collected (young-of-the-year), indicates successful spawning in the North Anna River by this pollution intolerant species. Black crappie, Pomoxis nigromaculatus, were collected only from the two stations nearest the dam on the North Anna River during 1981 (Table 5-9).

The 601 Louisa station, containing extensive pool areas, exhibited the higher density. The only sunfish species collected during the 1981 survey which was not found during the 1980 study was the redear sunfish, Lepomis microlophus, represented by a single individual from the 601 Louisa station. This individual was probably a derivative of the expanding redear population in Lake Anna.

The perch family, Percidae, was represented by five species collected during 1981. The most numerous percidae collected was the shield darter, Percina peltata, followed by the tesselated darter, Etheostoma olmstedi (Table 5-9). These results were the same as found during 1980 (Reed 1981). No stripeback darter, Percina notogramma, and only one yellow perch, Perca flavescens, were collected from the North Anna River in 1981. This is a reduction in numbers of yellow perch collected compared to the 1980 study and may be related to the general decline of this species in Lake Anna.

Under-representation of some species in 1981, compared to the 1980 data, could well be due to the fact that two more collections were made at all stations during 1980 than during 1981. In addition, more North Anna River stations were sampled during 1980.

More fishes (767) were collected from North Anna River stations in November than any other sample month, closely followed by September with 667 fishes (Tables 5-5 and 5-6). The fewest fishes (204) were collected during January (Table 5-1) followed by March with 217 (Table 5-2). For the South Anna River and Little River systems the most fish were collected during September (345) and the fewest during July (150), with no sample collected from the South Anna River during January due to ice cover (Tables 5-1, 5-4 and 5-5). One would expect more fishes to be collected during the late fall/early winter months after spawning and growth to a size retained by blocking nets, since predation and possible winter die off would then steadily reduce population numbers.

The fish faunas of the South Anna River and Little River are very similar to those of the lower North Anna River-upper Pamunkey River system. Some differences have already been mentioned, however there were two cyprinid species collected in relatively large numbers from the Little River not found in either the North Anna River or South Anna River. (rosyside dace, Clinostomus funduloides and the cutlips minnow, Exoglossum maxillingua) (Table 5-9). Also, fish diversity indices were higher for the Little River and South Anna River than for the lower North Anna River-upper Pamunkey River system (Tables 5-9). Also, fish diversity indices were higher for the Little River and South Anna River than for the lower North Anna River-upper Pamunkey River system (Tables 5-9).

This higher density plus the abundance of certain darter and minnow species would appear to indicate that the fish fauna of the lower North Anna River has not yet attained a state comparable to that of the South Anna River and Little River systems. However, an analysis of variance procedure of mean diversities with Duncan's multiple range test (0.05 level) indicated the following: (means underscored by the same line are not significantly different)

601 Louisa	Route 1	658	601 Hanover	Little	South Anna
2.21	2.41	2.59	3.02	3.15	3.28

According to this analysis the 601 Louisa and Route 1 stations are the only two stations which have diversities significantly different from the Little River and South Anna River stations, and 601 Louisa is also significantly different from the 601 Hanover station.

The Route 1 station had a low diversity due, primarily, to the large numbers of minnows collected there. The 601 Louisa station had a low diversity, possibly due to the fact that the fish fauna found here is not a true riverine assemblage. Lentic species from Lake Anna are periodically and inadvertently washed down to this station (i.e. white perch) and try to establish themselves while competing with true lotic species already present. Due to these introductions and interspecific competition fish diversity at this station may never be as high as that of stations farther down the North Anna River or control stations.

Fish diversity was plotted against temperature for all four major North Anna River stations, South Anna River and Little River (Figure 5-1 through 5-6). Diversity appears to be relatively constant and independent of temperature at all stations except 601 Louisa, where diversity appears to be somewhat inversely related to temperature. This may be due to the influence of lentic species mentioned previously, however, and not to temperature.

Pre-impoundment studies which reported the North Anna river fish populations much reduced below the confluence with Contrary Creek indicate how much the lower North Anna River has imporved in numbers and diversity since impoundment (Reed and Simmons 1972).

The use of Northeast Creek as a refuge area during periods of relatively high surface water temperature in the North Anna River below the dam appears to be a viable hypothesis. Temperature differences between the Northeast Creek station and the first river station, 601 Louisa, were 3 C and 7 C during the two sampling periods in 1981. Fish diversity for Northeast Creek was higher than the adjacent river station and comparable to the control stations (Table 5-9). The Northeast Creek station has been added as a bimonthly sampling station for the 1982 sampling period, which should further delineate this possibility.

The results of this 1981 downstream study indicate that, generally, the lower North Anna River has attained a diversity similar to that of the control rivers. The upper station, however, has not yet attained this goal, and may not be expected due to lake fish introduction.

No effects of power plant operation on the fish fauna of the North Anna River were noted during 1981.

SUMMARY

(1) Physical and chemical data collected at North Anna River stations during 1981 studies were well within state standards and accepted metabolic extremes of resident fishes.

(2) The dominant species from the North Anna River were the swallowtail shiner (Notropis procne) and satinfin shiner(N. analostanous),and redbreast sunfish (Lepomis auritus).

(3) Largemouth bass (Micropterus salmoides), appear to be thriving in the North Anna River and were most abundant nearest the dam.

(4) Smallmouth bass (Micropterus dolomieui) were collected from a station closer to the dam during 1981 than during 1980. This species appears to be increasing in the North Anna River, indicating increasingly better water quality.

(5) More fishes were collected during late fall, from the North Anna River, than any other sampling period.

(6) Northeast Creek could possibly serve as a refuge for species in the North Anna River during periods of relatively high water temperatures.

(7) Fish diversity appears to be relatively constant and independent of temperature at all North Anna River stations except the station nearest the dam where fluctuations are evident.

(8) There has been an increase in numbers and diversity of fishes at stations on the North Anna River below the dam. This area was previously affected by acid mine drainage from Contrary Creek.

(9) The fish fauna of the Little River and South Anna River closely resembled the fish fauna in the lower North Anna River.

(10) Fish diversity of the lower North Anna River is generally not significantly different from that in the Little River and the South Anna River.

(11) No effects of power plant operation on the fish fauna of the North Anna River were noted during 1981.

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TABLE 5- 1. NUMBER AND WEIGHT PER SPECIES OF FISH COLLECTED BY ELECTROFISHING AT EACH DOWNSTREAM STATION (EXCEPT NORTHEAST CREEK AND PAMUNKEY) DURING 1981.

JANUARY

	RT601L	RT658	RT601H	RT 1	SOUTH ANNA	LITTLE RIVER	TOTAL
ANGUILLA ROSTRATA	1 (1)	2 (11)	4 (17)	3 (3)	NO SAMPLE TAKEN	9 (136)	19 (168)
CLINOSTOMUS FUNDULOIDES						2 (10)	2 (10)
ETHEOSTOMA OLMSTEDI		2 (3)	2 (3)	12 (19)		1 (2)	17 (27)
ETHEOSTOMA VITREUM				3 (3)		1 (1)	4 (4)
HYBOGNATHUS REGIUS				1 (3)			1 (3)
HYPENTELIUM NIGRICANS						1 (181)	1 (181)
LEPOMIS AURITUS		1 (1)	1 (2)	1 (1)			3 (3)
LEPOMIS MACROCHIRUS		1 (1)					1 (1)
MICROPTERUS SALMOIDES		1 (15)					1 (15)
MORONE AMERICANA	2 (210)						2 (210)
NOCOMIS LEPTOCEPHALUS			6 (44)	2 (6)		6 (66)	14 (116)
NOCOMIS MICROPOGON						2 (13)	2 (13)
NOTROPIS ANALOSTANUS		1 (3)	5 (13)	9 (12)			15 (28)
NOTROPIS PROCNE		5 (6)	1 (0)	6 (4)		1 (0)	13 (11)
NOTROPIS RUBELLUS			1 (1)				1 (1)
NOTURUS INSIGNIS		6 (6)	6 (53)	4 (11)		2 (24)	18 (94)
PERCINA PELTATA				8 (22)		4 (3)	12 (26)
PETROMYZON MARINUS		1 (.)					1 (.)
POMOXIS NIGROMACULATUS	103 (3920)						103 (3920)
SEMOTILUS CORPORALIS		2 (11)	1 (3)			6 (7)	9 (21)
NUMBER OF SPECIES	3	10	9	10		11	20
NUMBER OF FAMILIES	3	6	5	5		5	8
TOTAL CATCH	106	22	27	49		35	239
TOTAL WEIGHT	4132	56	136	86		443	4853

TABLE 5- 2. NUMBER AND WEIGHT PER SPECIES OF FISH COLLECTED BY ELECTROFISHING AT EACH DOWNSTREAM STATION (EXCEPT NORTHEAST CREEK AND PAMUNKEY) DURING 1981.

MARCH

	RT601L	RT658	RT601H	PT 1	SOUTH ANNA	LITTLE RIVER	TOTAL
ANGUILLA ROSTRATA	14 (249)	8 (59)	13 (169)		12 (162)	2 (138)	49 (777)
CATOSTOMUS COMMERSONI						3 (16)	3 (16)
CLINOSTOMUS FUNDULOIDES						13 (17)	13 (17)
ERIMYZON OBLONGUS					1 (2)	1 (5)	2 (7)
ETHEOSTOMA OLMSTEDI		5 (11)	6 (11)	5 (6)	9 (9)	5 (10)	30 (47)
ETHEOSTOMA VITREUM				10 (15)	2 (1)		12 (16)
EXOGLOSSUM MAXILLINGUA						6 (6)	6 (6)
HYPENTELIUM NIGRICANS					5 (25)	4 (188)	9 (213)
LAMPETRA AEPYPTERA				1 (5)	11 (60)		12 (64)
LEPOMIS AURITUS		4 (12)	4 (3)	1 (1)	6 (33)		15 (49)
LEPOMIS MACROCHIRUS	2 (26)						2 (26)
LEPOMIS MICROLOPHUS	1 (88)						1 (88)
MICROPTERUS DOLOMIEUI					1 (14)		1 (14)
MORONE AMERICANA	2 (180)						2 (180)
NOCOMIS LEPTOCEPHALUS		1 (2)	11 (123)	6 (60)	4 (29)	23 (180)	45 (395)
NOCOMIS MICRO. X N. LEPTO.						1 (100)	1 (100)
NOCOMIS MICROPOGON	1 (112)		1 (25)		3 (159)		5 (295)
NOTEMIGONUS CRYSOLEUCAS	1 (17)						1 (17)
NOTROPIS ANALOSTANUS		1 (1)	6 (20)	8 (7)	2 (1)		17 (29)
NOTROPIS PROCNE		2 (1)	6 (4)	42 (24)	1 (2)		51 (31)
NOTROPIS RUBELLUS				6 (4)	8 (8)		14 (13)
NOTURUS INSIGNIS	1 (15)	2 (5)	7 (31)	3 (8)	9 (21)	1 (11)	23 (91)
PERCA FLAVESCENS	1 (51)						1 (51)
PERCINA NOTOGRAMMA						2 (4)	2 (4)
PERCINA PELTATA	3 (26)	8 (40)	1 (6)	2 (5)	21 (61)	3 (4)	38 (143)
POMOXIS NIGROMACULATUS	20 (1499)						20 (1499)
SEMOTILUS CORPORALIS			1 (2)		13 (25)	35 (51)	49 (78)
NUMBER OF SPECIES	10	8	10	10	16	13	27
NUMBER OF FAMILIES	6	5	5	5	7	5	8
TOTAL CATCH	46	31	56	84	108	99	424
TOTAL WEIGHT	2264	130	394	135	614	731	4268

TABLE 5- 3. NUMBER AND WEIGHT PER SPECIES OF FISH COLLECTED BY ELECTROFISHING AT EACH DOWNSTREAM STATION (EXCEPT NORTHEAST CREEK AND PAMUNKEY) DURING 1981.

MAY

	RT601L	RT658	RT601H	RT 1	SOUTH ANNA	LITTLE RIVER	TOTAL
ANGUILLA ROSTRATA	17 (.)	5 (11)	7 (58)	6 (.)	1 (.)	4 (.)	40 (70)
ERIMYZON OBLONGUS			1 (45)				1 (45)
ESOX NIGER		1 (78)		1 (.)		1 (.)	3 (78)
ETHEOSTOMA OLMSTEDI				5 (10)	5 (8)	4 (5)	14 (23)
ETHEOSTOMA VITREUM			1 (1)	9 (12)	4 (3)	1 (0)	15 (16)
EXOGLOSSUM MAXILLINGUA						16 (53)	16 (53)
HYPENTELIUM NIGRICANS						1 (.)	1 (.)
LEPOMIS AURITUS	10 (388)	17 (121)	34 (443)	8 (99)	10 (29)	9 (34)	88 (1115)
LEPOMIS MACROCHIRUS	2 (89)			6 (3)			8 (92)
MICROPTERUS DOLOMIEUI					1 (42)		1 (42)
MICROPTERUS SALMOIDES	1 (.)	1 (7)					2 (7)
MORONE AMERICANA	1 (89)						1 (89)
NOCOMIS LEPTOCEPHALUS	2 (25)	7 (60)	17 (348)		2 (17)	26 (133)	54 (582)
NOCOMIS MICROPOGON			11 (46[illegible])			14 (43)	25 (507)
NOTROPIS AMOENUS			1 (7)				1 (7)
NOTROPIS ANALOSTANUS	3 (19)	4 (20)	20 (72)	101 (210)	1 (3)	5 (14)	134 (339)
NOTROPIS CORNUTUS						44 (102)	44 (102)
NOTROPIS PROCNE	6 (16)	14 (26)	12 (20)	62 (77)	8 (12)	16 (12)	118 (163)
NOTROPIS RUBELLUS			1 (3)		3 (6)		4 (8)
NOTURUS INSIGNIS		5 (21)	7 (39)	4 (16)	35 (53)	4 (2)	55 (132)
PERCINA NOTOGRAMMA					2 (10)		2 (10)
PERCINA PELTATA	4 (23)	2 (10)	1 (2)	3 (10)	5 (13)	3 (8)	18 (66)
PHOXINUS OREAS						1 (1)	1 (1)
POMOXIS NIGROMACULATUS	2 (120)						2 (120)
SEMOTILUS CORPORALIS			2 (17)	1 (152)	5 (32)	24 (34)	32 (235)
NUMBER OF SPECIES	10	9	13	11	13	16	25
NUMBER OF FAMILIES	5	6	6	6	5	7	8
TOTAL CATCH	48	56	135	206	82	173	680
TOTAL WEIGHT	770	356	1519	590	227	440	3901

TABLE 5- 4. NUMBER AND WEIGHT PER SPECIES OF FISH COLLECTED BY ELECTROFISHING AT EACH DOWNSTREAM STATION (EXCEPT NORTHEAST CREEK AND PAMUNKEY) DURING 1981.

JULY

	RT601L	RT658	RT601H	RT 1	SOUTH ANNA	LITTLE RIVER	TOTAL
ANGUILLA ROSTRATA	3 (20)	9 (278)	4 (123)	1 (1)		5 (201)	22 (622)
CLINOSTOMUS FUNDULOIDES						5 (11)	5 (11)
ESOX NIGER					1 (4)		1 (4)
ETHEOSTOMA OLMSTEDI						2 (2)	2 (2)
ETHEOSTOMA VITREUM				3 (5)			3 (5)
EXOGLOSSUM MAXILLINGUA						3 (11)	3 (11)
HYBOGNATHUS REGIUS						2 (25)	2 (25)
LEPOMIS AURITUS	12 (122)	13 (409)	15 (268)	6 (25)	9 (55)	11 (103)	66 (982)
LEPOMIS GIBBOSUS		1 (30)					1 (30)
LEPOMIS MACROCHIRUS	1 (1)	3 (81)	4 (92)	1 (1)	5 (12)		14 (186)
MICROPTERUS DOLOMIEUI			1 (.)				1 (.)
MICROPTERUS SALMOIDES		1 (1)			3 (5)		4 (6)
NOCOMIS LEPTOCEPHALUS	3 (13)	3 (118)	3 (39)		12 (82)	20 (128)	41 (380)
NOCOMIS MICROPOGON			6 (114)				6 (114)
NOTEMIGONUS CRYSOLEUCAS	1 (1)						1 (1)
NOTROPIS AMOENUS						2 (4)	2 (4)
NOTROPIS ANALOSTANUS	16 (85)		21 (56)	26 (105)	2 (3)	4 (8)	69 (256)
NOTROPIS ARDENS					4 (7)		4 (7)
NOTROPIS CORNUTUS					6 (8)	2 (9)	8 (17)
NOTROPIS PROCNE	4 (6)		3 (3)	17 (28)	3 (2)	6 (6)	33 (44)
NOTROPIS PUSILLUS	1 (5)		6 (15)		4 (6)	1 (3)	12 (28)
NOTURUS INSIGNIS	2 (3)		5 (35)	6 (90)	7 (19)	3 (25)	23 (172)
PERCINA NOTOGRAMMA						6 (18)	6 (18)
PERCINA PELTATA	7 (11)	1 (6)	1 (4)	5 (3)	3 (7)	1 (3)	18 (34)
POMOXIS NIGROMACULATUS		5 (308)					5 (308)
SEMOTILUS CORPORALIS		2 (40)		11 (180)	5 (2)	13 (40)	31 (263)
NUMBER OF SPECIES	10	9	11	9	13	16	26
NUMBER OF FAMILIES	5	4	5	5	5	5	6
TOTAL CATCH	50	38	69	76	64	86	383
TOTAL WEIGHT	267	1269	748	438	213	597	3532

TABLE 5-5. NUMBER AND WEIGHT PER SPECIES OF FISH COLLECTED BY ELECTROFISHING AT EACH DOWNSTREAM STATION (EXCEPT NORTHEAST CREEK AND PAMUNKEY) DURING 1981.

SEPTEMBER

	RT601L	RT658	RT601H	RT 1	SOUTH ANNA	LITTLE RIVER	TOTAL
ANGUILLA ROSTRATA	20 (220)	1 (.)	4 (64)	1 (54)	12 (78)	1 (3)	39 (420)
APHREDODERUS SAYANUS				1 (2)			1 (2)
CATOSTOMUS COMMERSONI				2 (28)		5 (111)	7 (139)
CLINOSTOMUS FUNDULOIDES						33 (75)	33 (75)
DOROSOMA CEPEDIANUM	1 (250)						1 (250)
ESOX NIGER		1 (4)	3 (133)	1 (21)		2 (80)	7 (238)
ETHEOSTOMA OLMSTEDI		3 (4)	3 (1)	10 (12)	10 (8)	4 (6)	30 (31)
ETHEOSTOMA VITREUM				5 (10)			5 (10)
EXOGLOSSUM MAXILLINGUA						18 (86)	18 (86)
HYPENTELIUM NIGRICANS			1 (420)	1 (12)	1 (20)	4 (134)	7 (586)
LEPOMIS AURITUS	33 (848)	13 (152)	47 (513)	12 (60)	17 (164)	30 (159)	152 (1897)
LEPOMIS GIBBOSUS				1 (13)			1 (13)
LEPOMIS MACROCHIRUS	5 (311)			3 (20)			8 (331)
MICROPTERUS SALMOIDES	2 (149)				3 (498)		5 (647)
MOXOSTOMA MACROLEPIDOTUM						1 (52)	1 (52)
NOCOMIS LEPTOCEPHALUS	1 (11)	6 (144)	20 (352)	2 (4)	3 (35)	59 (316)	91 (861)
NOCOMIS MICROPOGON	2 (67)	1 (13)	36 (379)	1 (17)	1 (20)	32 (265)	73 (761)
NOTROPIS AMOENUS		2 (2)	45 (44)	4 (3)	3 (1)	4 (3)	58 (52)
NOTROPIS ANALOSTANUS		30 (44)	48 (55)	71 (194)		22 (48)	171 (342)
NOTROPIS CORNUTUS						19 (104)	19 (104)
NOTROPIS PROCNE		39 (29)	58 (46)	21 (33)	4 (5)		122 (114)
NOTROPIS RUBELLUS		2 (4)	15 (13)	1 (1)	2 (1)		20 (19)
NOTURUS INSIGNIS		10 (46)	9 (57)	3 (24)	12 (30)	4 (55)	38 (212)
PERCINA NOTOGRAMMA					1 (1)	7 (17)	8 (17)
PERCINA PELTATA	1 (4)	13 (24)	2 (3)	10 (27)	1 (2)	3 (8)	30 (67)
POMOXIS NIGROMACULATUS	6 (467)						6 (467)
SEMOTILUS CORPORALIS	5 (558)	2 (22)	22 (143)	5 (40)	4 (362)	23 (134)	61 (1260)
NUMBER OF SPECIES	10	13	14	19	14	18	27
NUMBER OF FAMILIES	5	6	7	8	6	7	9
TOTAL CATCH	76	123	313	155	74	271	1012
TOTAL WEIGHT	2885	487	2224	575	1225	1656	9052

TABLE 5- 6. NUMBER AND WEIGHT PER SPECIES OF FISH COLLECTED BY ELECTROFISHING AT EACH DOWNSTREAM STATION (EXCEPT NORTHEAST CREEK AND PAMUNKEY) DURING 1981.

NOVEMBER

	RT601L	RT658	RT601H	RT 1	SOUTH ANNA	LITTLE RIVER	TOTAL
ANGUILLA ROSTRATA	9 (438)	8 (164)	11 (367)	5 (67)	1 (66)	4 (94)	38 (1196)
CATOSTOMUS COMMERSONI				1 (10)		2 (38)	3 (48)
CLINOSTOMUS FUNDULOIDES						7 (7)	7 (7)
ESOX NIGER		1 (24)			1 (30)		2 (54)
ETHEOSTOMA OLMSTEDI		1 (2)	9 (12)	5 (5)	9 (13)	6 (8)	30 (41)
ETHEOSTOMA VITREUM				4 (6)			4 (6)
EXOGLOSSUM MAXILLINGUA						5 (30)	5 (30)
HYPENTELIUM NIGRICANS			3 (371)		1 (460)		4 (831)
LAMPETRA APPENDIX					1 (6)		1 (6)
LEPOMIS AURITUS	8 (190)	7 (120)	5 (45)	3 (12)	1 (1)		24 (369)
LEPOMIS MACROCHIRUS	12 (105)			1 (3)			13 (108)
MICROPTERUS DOLOMIEUI			1 (26)				1 (26)
MICROPTERUS SALMOIDES	5 (126)						5 (126)
NOCOMIS LEPTOCEPHALUS	2 (101)	1 (49)	26 (290)	3 (91)	1 (25)	20 (219)	53 (775)
NOCOMIS MICROPOGON	4 (171)		14 (53)	1 (5)	7 (203)	6 (120)	32 (553)
NOTEMIGONUS CRYSOLEUCAS	2 (25)						2 (25)
NOTROPIS AMOENUS		1 (1)	1 (1)	7 (4)	4 (2)	1 (2)	14 (11)
NOTROPIS ANALOSTANUS	1 (2)	28 (41)	9 (6)	131 (138)			169 (188)
NOTROPIS ARDENS				4 (5)	16 (12)		20 (17)
NOTROPIS CORNUTUS			1 (31)		3 (52)	54 (436)	58 (519)
NOTROPIS PROCNE		83 (83)	3 (3)	305 (316)		2 (2)	393 (403)
NOTROPIS RUBELLUS					2 (3)		2 (3)
NOTURUS INSIGNIS	2 (29)	2 (7)	13 (108)	1 (13)	9 (35)	5 (29)	32 (221)
PERCINA NOTOGRAMMA						2 (4)	2 (4)
PERCINA PELTATA		6 (17)	2 (7)	4 (12)	6 (18)	5 (13)	23 (68)
PETROMYZON MARINUS			1 (4)				1 (4)
SEMOTILUS CORPORALIS	2 (87)		6 (18)	2 (10)	4 (21)	31 (162)	45 (297)
NUMBER OF SPECIES	10	10	15	15	15	14	27
NUMBER OF FAMILIES	4	6	7	6	8	5	8
TOTAL CATCH	47	138	105	477	66	150	983
TOTAL WEIGHT	1275	510	1343	696	948	1163	5936

TABLE 5-7. NUMBER AND WEIGHT PER SPECIES OF FISH COLLECTED BY ELECTROFISHING AT PAMUNKEY STATION AND NORTHEAST CREEK DURING 1981.

	JULY	
	PAMUNKEY	NORTH EAST CREEK
ANGUILLA ROSTRATA		6 (71)
APHREDODERUS SAYANUS		1 (1)
ERIMYZON OBLONGUS		1 (10)
ESOX NIGER		6 (.)
ETHEOSTOMA OLMSTEDI	1 (2)	6 (8)
GAMBUSIA AFFINIS	1 (1)	
HYBOGNATHUS REGIUS	1 (10)	
LEPOMIS AURITUS	6 (50)	6 (37)
LEPOMIS GIBBOSUS		1 (12)
LEPOMIS MACROCHIRUS	1 (10)	
MICROPTERUS SALMOIDES	1 (1)	1 (.)
NOCOMIS LEPTOCEPHALUS		6 (33)
NOTROPIS ANALOSTANUS	8 (29)	6 (14)
NOTROPIS HUDSONIUS	1 (7)	
NOTROPIS PROCNE		15 (19)
NOTURUS INSIGNIS		9 (48)
PERCINA PELTATA		9 (21)
SEMOTILUS CORPORALIS		1 (12)
NUMBER OF SPECIES	8	14
NUMBER OF FAMILIES	4	8
TOTAL CATCH	20	74
TOTAL WEIGHT	109	286

TABLE 5-8. NUMBER AND WEIGHT PER SPECIES OF FISH COLLECTED BY ELECTROFISHING AT PAMUNKEY STATION AND NORTHEAST CREEK DURING 1981.

	NOVEMBER	
	PAMUNKEY	NORTH EAST CREEK
ANGUILLA ROSTRATA	1 (3)	2 (276)
ESOX NIGER		3 (31)
ETHEOSTOMA OLMSTEDI	4 (5)	1 (1)
ETHEOSTOMA VITREUM	2 (1)	
GAMBUSIA AFFINIS	1 (0)	
LAMPETRA APPENDIX	1 (6)	
LEPOMIS AURITUS	2 (86)	12 (339)
LEPOMIS GIBBOSUS		3 (24)
LEPOMIS MACROCHIRUS	1 (30)	5 (54)
NOCOMIS LEPTOCEPHALUS		12 (193)
NOTEMIGONUS CRYSOLEUCAS		13 (52)
NOTROPIS AMOENUS	1 (0)	
NOTROPIS ANALOSTANUS	39 (4)	78 (122)
NOTROPIS HUDSONIUS	1 (8)	
NOTROPIS PROCNE	29 (9)	15 (16)
NOTURUS INSIGNIS		6 (55)
PERCINA PELTATA		1 (2)
PETROMYZON MARINUS	2 (10)	
SEMOTILUS CORPORALIS		14 (347)
NUMBER OF SPECIES	12	13
NUMBER OF FAMILIES	6	6
TOTAL CATCH	84	165
TOTAL WEIGHT	162	1512

TABLE 5-9. NUMBER, WEIGHT, NUMBER OF SPECIES, NUMBER OF FAMILIES AND DIVERSITY OF ALL FISHES COLLECTED BY ELECTROFISHING AT ALL DOWNSTREAM STATION DURING 1981.

	RT. 601 LOUISA	RT 658	RT. 601 HANOVER	RT. 1	NORTH EAST CREEK	PAMUNKEY RIVER	TOTAL DOWNSTREAM	SOUTH ANNA	LITTLE RIVER	TOTAL
ANGUILLA ROSTRATA	64	33	43	16	8	1	165	26	25	216
APHREDODERUS SAYANUS	.	.	.	1	1	.	2	.	.	2
CATOSTOMUS COMMERSONI	.	.	.	3	.	.	3	.	10	13
CLINOSTOMUS FUNDULOIDES	.	.	.	.	.	.	.	.	60	60
DOROSOMA CEPEDIANUM	1	.	.	.	.	.	1	.	.	1
ERIMYZON OBLONGUS	.	.	1	.	1		2	1	1	4
ESOX NIGER	.	3	3	2	9	.	17	2	3	22
ETHEOSTOMA OLMSTEDI	.	11	20	37	7	5	80	33	22	135
ETHEOSTOMA VITREUM	.	.	1	34	.	2	37	6	2	45
EXOGLOSSUM MAXILLINGUA	.	.	.	.	.	.	.	.	48	48
GAMBUSIA AFFINIS	.	.	.	.	.	2	2	.	.	2
HYBOGNATHUS REGIUS	.	.	.	1	.	1	2	.	2	4
HYPENTELIUM NIGRICANS	.	.	4	1	.	.	5	7	10	22
LAMPETRA AEPYPTERA	.	.	.	1	.	.	1	11	.	12
LAMPETRA APPENDIX	.	.	.	.	.	1	1	1	.	2
LEPOMIS AURITUS	63	55	106	31	18	8	281	43	50	374
LEPOMIS GIBBOSUS	.	1	.	1	4	.	6	.	.	6
LEPOMIS MACROCHIRUS	22	4	4	11	5	2	48	5	.	53
LEPOMIS MICROLOPHUS	1	.	.	.	.	.	1	.	.	1
MICROPTERUS DOLOMIEUI	.	.	2	.	.	.	2	2	.	4
MICROPTERUS SALMOIDES	8	3	.	.	1	1	13	6	.	19
MORONE AMERICANA	5	.	.	.	.	.	5	.	.	5
MOXOSTOMA MACROLEPIDOTUM	.	.	.	.	.	.	.	.	1	1
NOCOMIS LEPTOCEPHALUS	8	18	83	13	18	.	140	22	154	316
NOCOMIS MICRO. X N. LEPTO	.	.	.	.	.	.	.	.	1	1
NOCOMIS MICROPOGON	7	1	68	2	.	.	78	11	54	143
NOTEMIGONUS CRYSOLEUCAS	4	.	.	.	13	.	17	.	.	17
NOTROPIS AMOENUS	.	3	47	11	.	1	62	7	7	76
NOTROPIS ANALOSTANUS	20	64	109	346	84	47	670	5	31	706
NOTROPIS ARDENS	.	.	.	4	.	.	4	20	.	24
NOTROPIS CORNUTUS	.	.	1	.	.	.	1	9	119	129
NOTROPIS HUDSONIUS	.	.	.	.	.	2	2	.	.	2
NOTROPIS PROCNE	10	143	83	453	30	29	748	16	25	789
NOTROPIS RUBELLUS	1	2	23	7	.	.	33	19	1	53
NOTURUS INSIGNIS	5	25	47	21	15	.	113	72	19	204
PERCA FLAVESCENS	1	.	.	.	.	.	1	.	.	1
PERCINA NOTOGRAMMA	.	.	.	.	.	.	.	3	17	20
PERCINA PELTATA	15	30	7	32	10	.	94	36	19	149
PETROMYZON MARINUS	.	1	1	.	.	2	4	.	.	4
PHOXINUS OREAS	.	.	.	.	.	.	.	.	1	1
POMOXIS NIGROMACULATUS	131	5	.	.	.	.	136	.	.	136
SEMOTILUS CORPORALIS	7	6	32	19	15	.	79	31	132	242
NUMBER OF INDIVIDUALS	373	408	685	1047	239	104	2856	394	814	4064
TOTAL WEIGHT	11593	2808	6365	2520	1798	271	25354	3226	5030	33611
NUMBER OF FAMILIES	7	7	8	9	8	6	12	8	7	12
NUMBER OF SPECIES	18	18	20	22	16	14	36	24	25	42
H_PRIME	2.9751	2.9859	3.4762	2.3986	3.1954	2.3970	3.4160	3.9466	3.6560	3.9110
EVENNESS	0.7135	0.7161	0.8043	0.5379	0.7909	0.6296	0.6607	0.8608	0.7873	0.7253

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TABLE 5-10. PHYSICAL PARAMETERS RECORDED AT DOWNSTREAM STATIONS DURING EACH SAMPLING PERIOD DURING 1981. TEMPERATURE (DEGREES C), DISSOLVED OXYGEN (PPM), PH, TURBIDITY (NTU), AND ALKALINITY (MG/L CACO3).

MONTH	SITE	TEMP	O2	PH	TURB	ALK
JANUARY	NAR 601	2.6	13.1	7.3	.	.
	NAR 658	1.3	13.3	7.2	.	.
	HAN 601	2.3	12.6	6.5	2.5	14.0
	RT1 NAR	2.2	13.8	6.6	2.4	14.0
	S ANNA	0.1	14.1	6.7	5.2	23.0
	LITTLE R	0.5	13.5	6.6	7.0	18.0
MARCH	NAR 601	8.0	11.2	7.1	3.1	14.0
	NAR 658	6.6	11.4	6.9	3.4	12.0
	HAN 601	6.3	11.9	7.0	3.4	13.0
	RT1 NAR	6.2	12.0	7.2	2.5	16.0
	S ANNA	4.8	12.3	7.2	6.9	25.0
	LITTLE R	4.5	11.7	7.1	5.2	18.0
MAY	NAR 601	20.2	8.0	6.7	3.2	12.0
	NAR 658	18.2	8.6	6.6	5.2	15.0
	HAN 601	18.3	8.1	7.1	4.0	14.5
	RT1 NAR	18.2	8.4	7.0	4.5	13.3
	S ANNA	17.3	8.8	7.2	6.2	28.0
	LITTLE R	16.8	8.1	7.7	19.0	32.0
JULY	NAR 601	26.9	7.1	6.6	24.0	9.5
	NAR 658	24.9	7.4	6.6	24.0	9.5
	HAN 601	25.7	7.5	6.8	16.0	13.0
	RT1 NAR	25.6	7.7	6.8	25.0	26.7
	S ANNA	27.0	7.0	6.9	68.0	15.1
	LITTLE R	26.2	7.0	7.1	17.0	39.5
	NE CRK L	24.0	7.1	6.9	11.0	21.4
	RT302 PA	26.4	5.9	7.0	25.0	23.7
SEPTEMBER	NAR 601	23.9	7.7	7.0	2.3	10.6
	NAR 658	22.8	7.7	7.1	2.5	11.4
	HAN 601	19.0	8.5	7.2	1.6	11.9
	RT1 NAR	18.5	8.3	7.1	1.1	12.4
	S ANNA	19.9	9.4	8.0	7.5	30.2
	LITTLE R	17.8	7.5	7.8	2.9	36.7
NOVEMBER	NAR 601	14.8	9.7	7.0	4.0	8.8
	NAR 658	13.5	8.8	7.1	5.6	9.0
	HAN 601	11.5	8.8	7.1	6.2	10.4
	RT1 NAR	7.8	11.5	7.3	1.4	11.0
	S ANNA	8.9	11.0	7.8	3.6	30.8
	LITTLE R	8.3	9.5	7.5	4.5	23.8
	NE CRK L	7.8	10.2	7.2	5.5	16.0
	RT302 PA	8.9	11.6	7.6	3.0	24.2

TABLE 5-11 NUMBER OF FAMILIES, SPECIES AND TOTAL NUMBERS OF FISHES COLLECTED AT SELECTED STATIONS ON THE LOWER NORTH ANNA RIVER, 1973-1981

Year	Number of Collections	Route 601 Louisa County			Route 658 Hanover County			Route 601 Hanover County			U. S. Route 1 Hanover County		
		Family	Species	Total	Family	Species	Total	Family	Species	Total	Family	Species	Total
1973	1				5	8	115	5	10	53			
1974	1	3	8	50	5	8	115	3	7	10			
1975	3				5	13	224	7	16	245			
1976	2	4	14	416	6	14	360	5	13	318	8	22	161
1977	4	8	17	489	7	15	299	6	13	360	8	22	520
1978	4	7	18	443	7	19	232	6	18	322	7	23	273
1979	4	5	14	446	7	20	224	7	16	319	7	17	146
1980	8	8	21	626	7	21	317	7	19	551	8	24	788
1981	6	7	18	373	7	18	408	8	20	685	9	22	1047

Year	Number of Collections	Northeast Creek Spotsylvania County			U. S. Route 301 Hanover County		
		Family	Species	Total	Family	Species	Total
1980	2				10	22	532
1981	2	8	16	239	6	14	104

TABLE 5-12 COMPARISON OF FISH COLLECTIONS FROM FOUR NORTH ANNA RIVER STATIONS BETWEEN 1980 AND 1981*, BY SPECIES AND NUMBER

Station	Collected 1980 Only	Collected 1981 Only
601 Louisa	Esox niger (1)	Notropis rubellus (1)
	Notropis amoenus (1)	Notemigonus crysoleucas (4)
	N. cornutus (1)	Lepomis microlophus (1)
	Ictalurus natalis (3)	Noturus insignis (5)
	I. nebulosus (2)	
	Lepomis gibbosus (19)	
	Percina notogramma (1)	
658 Hanover	Ictalurus natalis (1)	Notropis amoenus (3)
	I. nebulosus (1)	N. rubellus (2)
	Perca flavescens (2)	
	Etheostoma vitreum (2)	
	Percina notogramma (6)	
601 Hanover	Percina notogramma (1)	Esox niger (4)
	Lepomis gibbosus (5)	Catostomus commersoni (1)
	Moxostoma macrolepitodum (1)	Hypentelium nigricans (7)
	Micropterus salmoides (1)	Notropis cornutus (1)
		Micropterus dolomieui (2)
Route 1 Hanover	Petromyzon marinus (9)	Aphredoderus sayanus (1)
	Moxostoma macrolepitodum (1)	Catostomus commersoni (2)
	Micropterus dolomieui (1)	Nocomis micropogon (2)
	M. salmoides (1)	Notropis rubellus (7)
	Perca flavescens (4)	N. ardens (4)
	Percina notogramma (7)	
	Ictalurus natalis (1)	

*Eight collections per station during 1980, six collections per station during 1981

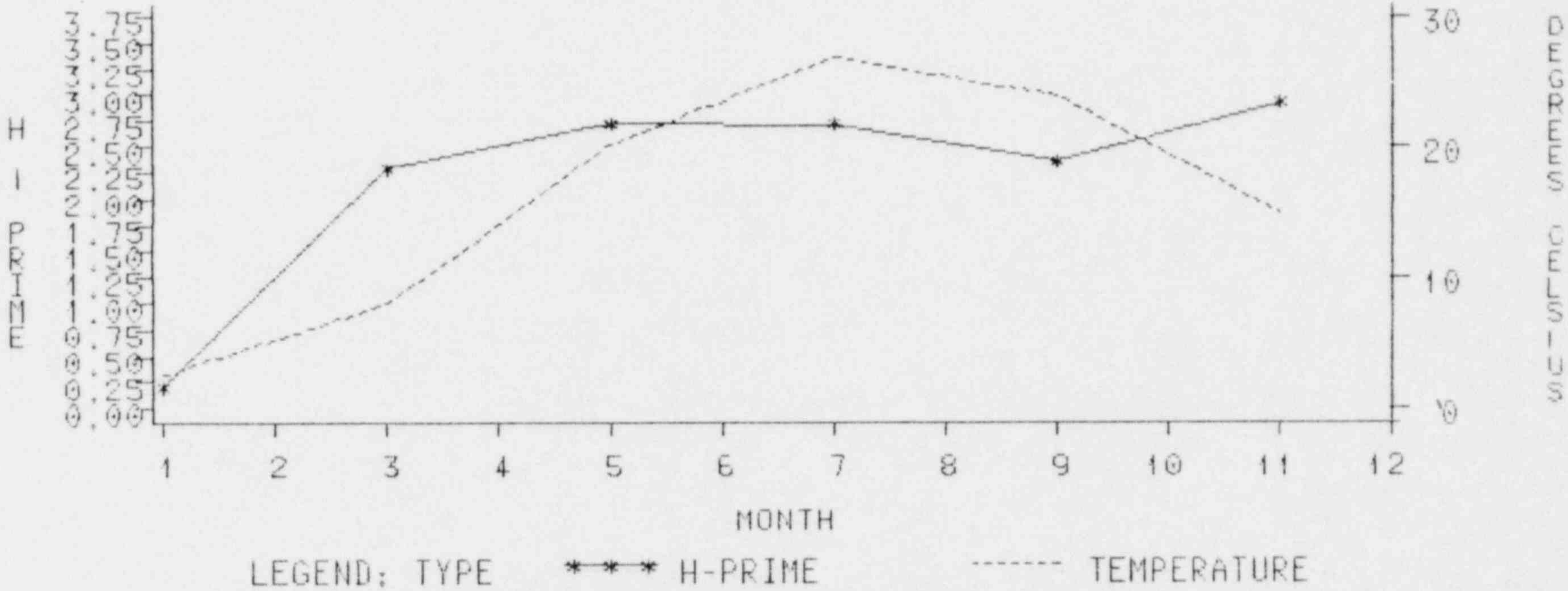

FIGURE 5-1. SPECIES DIVERSITY (H') AND SURFACE WATER TEMPERATURES AT RT. 601 (LOUISA) ELECTROFISHING STATION FOR EACH COLLECTION PERIOD DURING 1981.

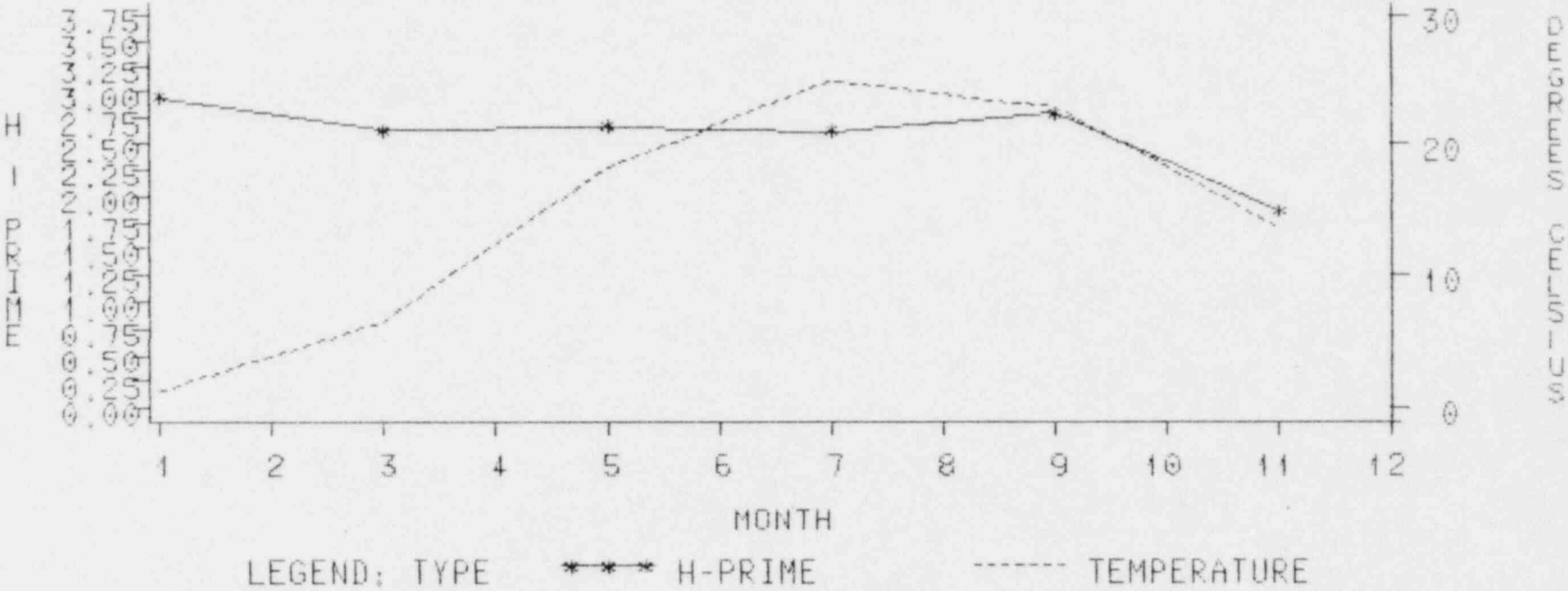

FIGURE 5-2. SPECIES DIVERSITY (H') AND SURFACE WATER TEMPERATURES AT RT. 658 (HANOVER) ELECTROFISHING STATION FOR EACH COLLECTION PERIOD DURING 1981.

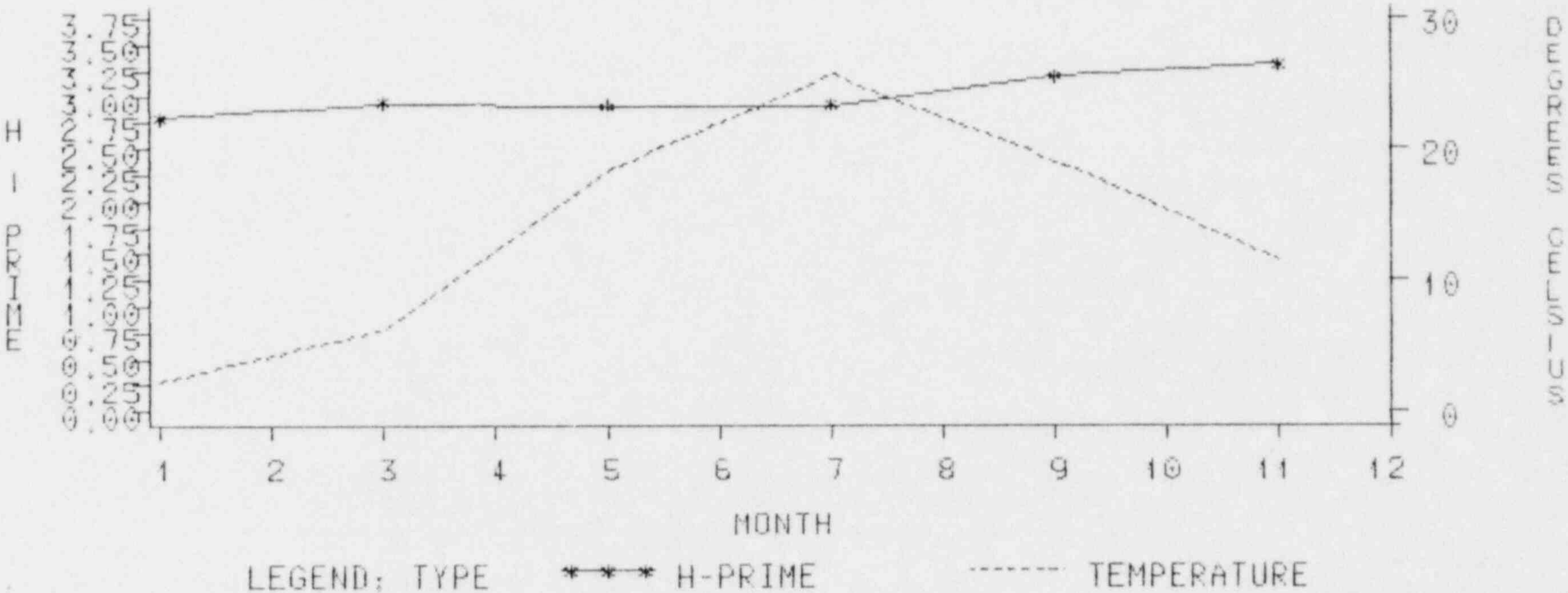

FIGURE 5-3. SPECIES DIVERSITY (H') AND SURFACE WATER TEMPERATURES AT RT. 601 (HANOVER) ELECTROFISHING STATION FOR EACH COLLECTION PERIOD DURING 1981.

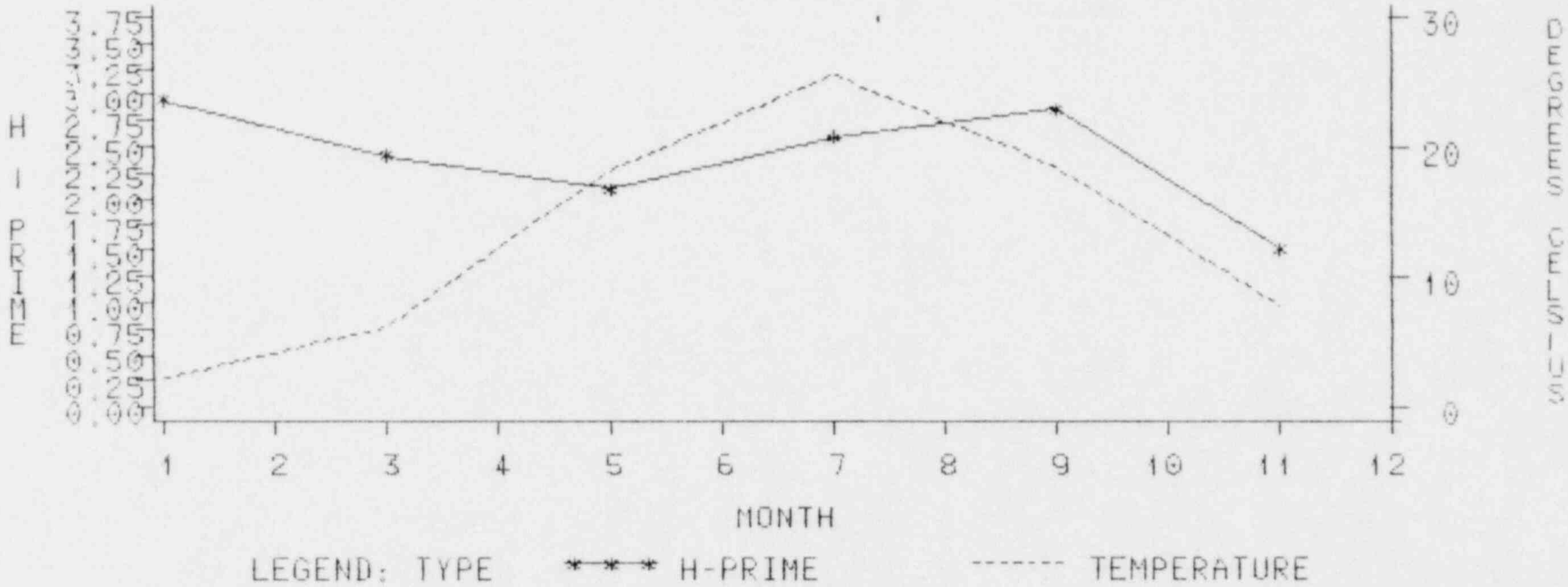

FIGURE 5-4. SPECIES DIVERSITY (H') AND SURFACE WATER TEMPERATURES AT ROUTE 1 (HANOVER) ELECTROFISHING STATION FOR EACH COLLECTION PERIOD DURING 1981.

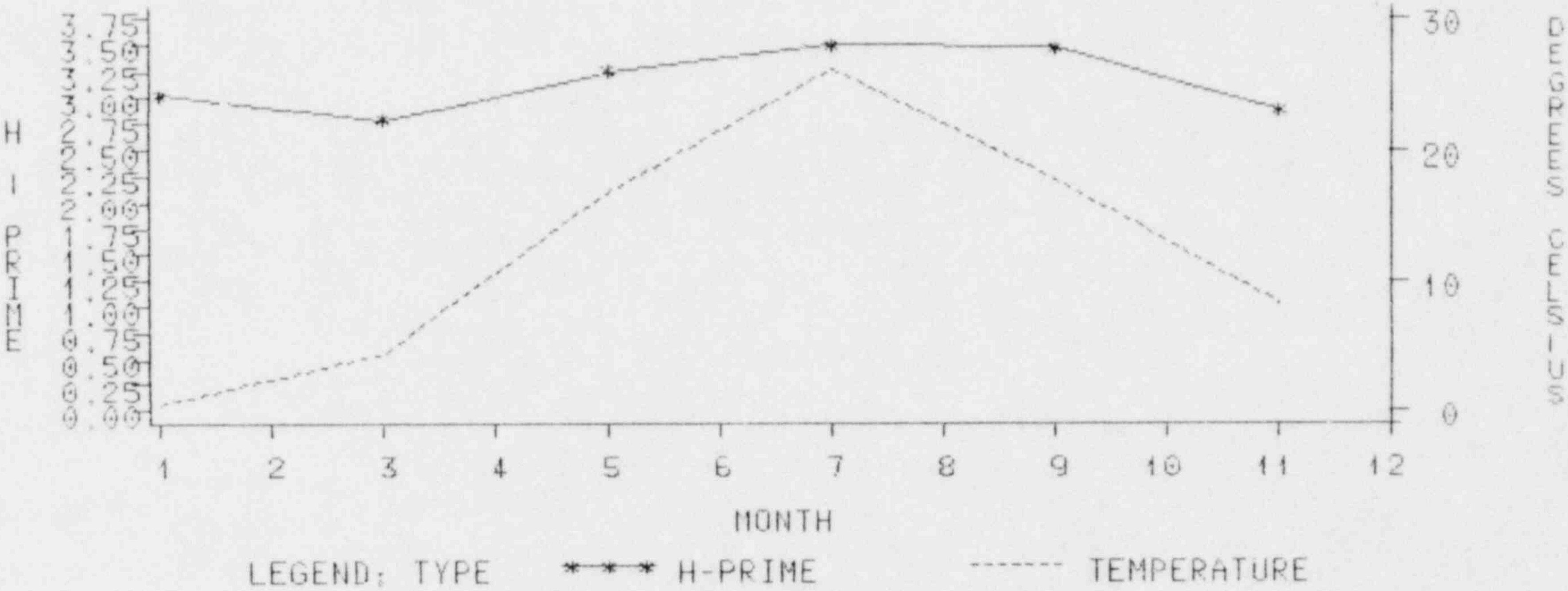

FIGURE 5-5. SPECIES DIVERSITY (H') AND SURFACE WATER TEMPERATURES AT LITTLE RIVER ELECTROFISHING STATION FOR EACH COLLECTION PERIOD DURING 1981.

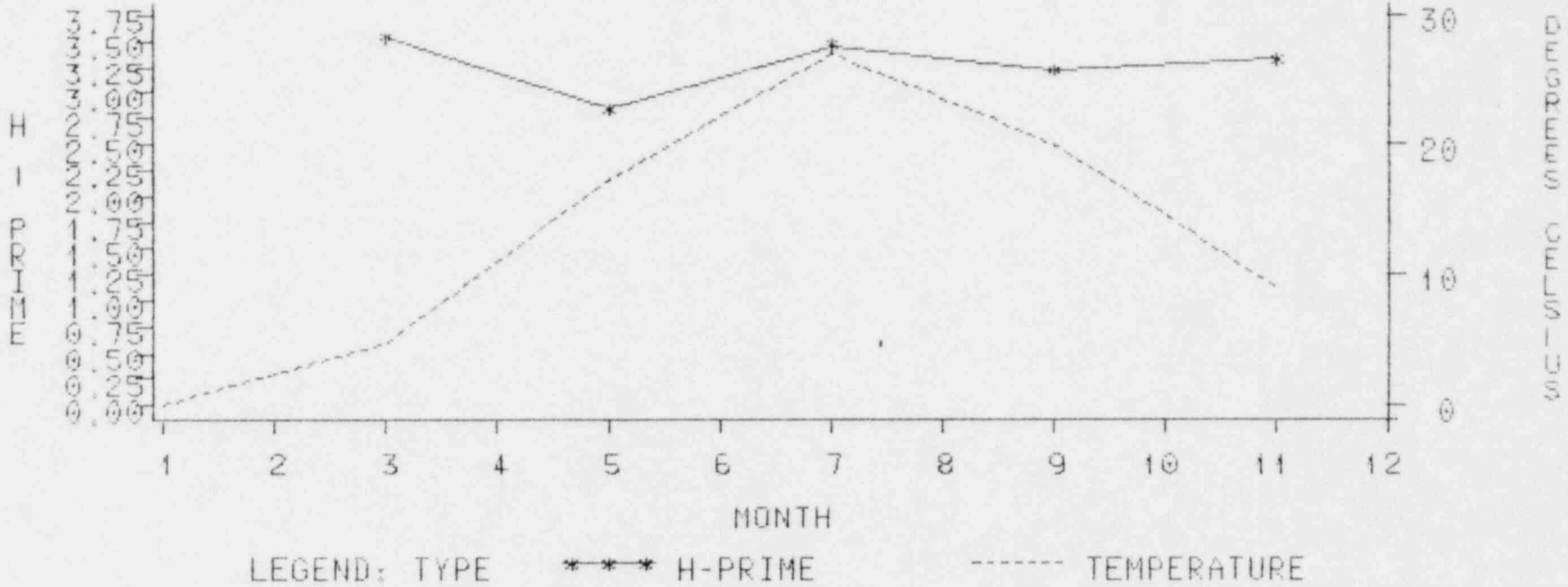

FIGURE 5-6. SPECIES DIVERSITY (H') AND SURFACE WATER TEMPERATURES AT SOUTH ANNA RIVER ELECTROFISHING STATION FOR EACH COLLECTION PERIOD DURING 1981.

Summary and Conclusions

SUMMARY

Physical and Chemical

1) Endeco thermal measurements established that temperature maximums in the North Anna River occurred at the station downstream from the Reservoir closest to the dam. The station located upstream from the impoundment was always cooler than the stations downstream.

2) Dissolved oxygen concentrations were never known to violate Virginia standards for free flowing streams in Coastal and Piedmont zones, although several relatively low values were observed during the late summer months. It appears that the lowest dissolved oxygen measurements occurred at those stations farthest downstream on the Pamunkey River and on the Little River which is tributary to the Pamunkey River.

3) High pH readings were recorded on the Little and South Anna Rivers in September, but generally there were only small variations in pH on the North Anna River.

4) Alkalinity and turbidity values were highest in July at all the stations sampled. Typically the tributaries (Little and South Anna Rivers) had higher alkalinities and turbidities than the North Anna River.

Benthic Macroinvertebrates

5) The North Anna River is dominated by a filter-feeding benthic community, composed primarily of Trichoptera.

6) The Route 601-Louisa station is dominated by an unusually large number of Hydropsychidae due to seston discharge from the epilimnion drain of Lake Anna dam. The effects of this seston release dissipates quickly with distance from the dam.

7) The macrobenthic fauna of the North Anna River continued to increase in diversity during 1981; the increase was attributed to the amelioration of effects of acid mine runoff by Lake Anna.

Ichthyoplankton

8) Fish eggs and 11 species of larvae were taken in the North Anna River during April through July 1981.

9) Most of the larval species collected were spawned locally within the river, although the larvae of a few species (e.g., black crappie and gizzard shad) may be of Lake Anna origin.

10) Captures of fish eggs and larvae within the river strongly suggests that environmental conditions have improved substantially to permit the establishment of self-sustaining populations within the formerly impacted river.

Fishes

11) Physical and chemical data collected at North Anna River stations durin 1981 studies were well within state standards and accepted metabolic extremes of resident fishes.

12) The dominant species from the North Anna River were the swallowtail shiner (Notropis procne) and satinfin shiner (N. analostanous), and redbreast sunfish (Lepomis auritus).

13) Largemouth bass (Micropterus salmoides), appear to be thriving in the North Anna River and were most abundant nearest the dam.

14) Smallmouth bass (Micropterus dolomieui) were collected from a station closer to the dam during 1981 than during 1980. This species appears to be increasing in the North Anna River, indicating increasingly better water quality.

15) More fishes were collected during late fall, from the North Anna River, than any other sampling period.

16) Northeast Creek could possibly serve as a refuge for species in the North Anna River during periods of relatively high water temperatures.

17) Fish diversity appears to be relatively constant and independent of temperature at all North Anna River stations except the station nearest the dam where fluctuations are evident.

18) There has been an increase in numbers and diversity of fishes at stations on the North Anna River below the dam. This area was previously affected by acid mine drainage from Contrary Creek.

19) The fish fauna of the Little River and South Anna River closely resembled the fish fauna in the lower North Anna River.

20) Fish diversity of the lower North Anna River is generally not significantly different from that in the Little River and the South Anna River.

21) No effects of power plant operation on the fish fauna of the North Anna River were noted during 1981.

During 1981, no adverse environmental impact on the lower North Anna River was noted as a result of the operation of North Anna Power Station, Units 1 and 2, and/or the Lake Anna dam. Instead, in reality water quality has improved since impoundment of the river, with a subsequent increase in macroinvertebrate and fish diversity. Ichthyoplankton studies were initiated this year and have indicated that environmental conditions have improved sufficiently downstream to permit the establishment of self-sustaining populations within the formerly impacted river.