

Changes in Fish Communities in the Upper Patuxent River from 1966 to 1977

Chu-fa Tsai and Sandra Lee Golembiewski

Center for Environmental and Estuarine Studies

University of Maryland

College Park, Maryland 20742

Submitted to

Water Resources Administration

Department of Natural Resources

State of Maryland

Annapolis, Maryland

July 1979

TABLE OF CONTENTS

	<u>Page</u>
LIST OF TABLES	II
LIST OF FIGURES	III
ACKNOWLEDGEMENTS	IV
SUMMARY	V
INTRODUCTION	1
STUDY AREA	2
FISH SAMPLING STATIONS	6
MATERIALS AND METHODS	11
RESULTS AND DISCUSSION	13
The Middle Patuxent River	13
The Little Patuxent River	16
Piedmont Plateau Region	16
Coastal Plain Region	23
The Hammond Branch	26
The Dorsey Run	26
The Patuxent River	29
Piedmont Plateau Region	29
Coastal Plain Region	33
CONCLUSION	39
REFERENCES	40
APPENDIX	41

LIST OF TABLES

<u>Table</u>		<u>Page</u>
1.	Species composition, species diversity and evenness of fish communities sampled in the Middle Patuxent River, 1966-67 and 1977.	14
2.	Species composition, species diversity and evenness of fish communities sampled in the Piedmont Plateau section of the Little Patuxent River, 1966 and 1977.	18
3.	Species composition, species diversity, and evenness of fish communities sampled in the Coastal Plain section of the Little Patuxent River, 1966 and 1967.	20
4.	Species composition, species diversity, and evenness of fish communities sampled in the Coastal Plain section of the Little Patuxent River, 1977.	21
5.	Species composition, species diversity, and evenness of fish communities sampled in Hammond Branch, 1977.	27
6.	Species composition, species diversity, and evenness of fish communities sampled in the Dorsey Run, 1966 and 1977.	28
7.	Species composition, species diversity, and evenness of fish communities sampled in the Piedmont Plateau section of the Patuxent River, 1966 and 1977.	31
8.	Species composition, species diversity, and evenness of fish communities sampled in the Coastal Plain section of the Patuxent River, 1966 and 1967.	34
9.	Species composition, species diversity, and evenness of fish communities sampled in the Coastal Plain section of the Patuxent River, 1977.	35

III

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1.	Sampling stations and sewage treatment plants on the Upper Patuxent River.	5
2.	Longitudinal distribution of the species diversity indices of the fish communities in the Middle Patuxent River, 1966-67 and 1977.	15
3.	Longitudinal distribution of the species diversity indices of the fish communities in the Piedmont Plateau section of the Little Patuxent River, 1966 and 1977.	17
4.	Longitudinal distribution of the species diversity indices of the fish communities in the Coastal Plain section of the Little Patuxent River, 1966 and 1977.	22
5.	Longitudinal distribution of the species diversity indices of the fish communities in the Piedmont Plateau section of the Patuxent River, 1966 and 1977.	30
6.	Longitudinal distribution of the species diversity indices of the fish communities in the Coastal Plain section of the Patuxent River, 1966 and 1977.	36

ACKNOWLEDGEMENTS

We would like to express our deep appreciations to Dr. Aven Anderson, Mr. Geoffrey White and Dr. Mark Manak for their assistance in the field and laboratory work, and Mr. James T. Allison and Mr. George H. Harman in reviewing the manuscript.

SUMMARY

In 1977 fish collections were made in the upper Patuxent River of Maryland, and compared to collections from 1966-67 with respect to diversity, evenness and composition of fish communities. The upper Patuxent River was divided into Piedmont Plateau and Coastal Plain regions, not only for geographical purposes, but also because of the clustering of sewage treatment plants in the Coastal Plain region.

In the Piedmont Plateau region, the fish species diversity changed very little from 1966 to 1977 (Little Patuxent -- 2.82 to 2.66; Middle Patuxent -- 2.86 to 2.83; and main stem -- 2.46 to 2.63), except in a section of Little Patuxent River at and below the City of Columbia where the species diversity index showed a significant reduction from 2.97 to 1.99, and in a section of the main stem Patuxent River immediately downstream from the Brighton Dam of the Triadelphia Reservoir where the index increased significantly from 1.66 to 3.20.

In the Coastal Plain region, a significant reduction in the fish species diversity index occurred between 1966 and 1977 below the two sewage treatment plant outfalls: Savage -- 2.69 to 0 and Patuxent-Crofton -- 3.06 to 1.33. Also, the substantial reduction in the species diversity index which had already occurred in 1966 below the six other plant outfalls of Fort Meade No. 1, Fort Meade No. 2, Maryland House of Correction, Maryland City, Parkway and Bowie, remained depressed in 1977. On the other hand, below the Horsepen Sewage Treatment Plant (a tertiary plant practicing dechlorination) the species diversity index increased from 1.91 to 2.8.

INTRODUCTION

The Patuxent River, situated between the two metropolitan centers of Washington, D.C. and Baltimore, Maryland, has been rapidly deteriorating due to housing, highway and dam constructions, and sewage disposal, all designed to meet rapidly developing suburbs through the basin (Tsai, 1971). The pollution in this 112 mile long stream, the longest river which lies completely within the State of Maryland, has been of deep concern to the State management agencies.

Water quality surveys of the Patuxent River were made by the Maryland State Health Department in 1955 and 1956, and then by the Maryland Department of Water Resources in 1958 (Maryland Water Pollution Control Commission, 1958) and from 1961 to 1966 (Allison, 1967, 1970).

Mansueti (1950) made the first systematic fish survey of the Patuxent River and found 125 species of freshwater and brackish water fishes. However, the original data appears to be lost. In 1966-1971, the University of Maryland's Center for Environmental and Estuarine Studies made an extensive fish survey of the freshwater portion of the Patuxent River. The results showed that chlorinated sewage effluent acted as a toxicant to fish communities immediately below the effluent outfall, but it acted as an organic enricher and deoxygenator farther downstream (Tsai, 1968). The fish migration, the abundance of resident species, and the fish community in the Little Patuxent River changed from 1958 to 1967, due to an increase in sewage pollution (Tsai, 1970). Along with an increase in sewage pollution, a decrease in the darter (Etheostoma olmstedii Storer) population was observed in the main stem of the Patuxent River in the area just above

the Bowie-Belair Sewage Treatment Plant in 1966 and 1977 (Tsai, 1972). Also, female darters found in the sewage polluted station had a higher degree of fecundity than those in the clean water station. In the Little Patuxent River the natural hybridization of the three species of cyprinid fishes, Notropis cornutus (common shiner), Notropis rubellus (rosyface shiner) and Clinostomus funduloides (rosyside dace), was brought about by the high stream gradient and the extremely sandy bottom (Tsai and Ziesel, 1969).

The present study was designed as a part of a cooperative project between the Maryland Water Resources Administration and the University of Maryland's Center for Environmental and Estuarine Studies. The objectives of this study were: 1) to make an inventory of resident freshwater fishes in the Patuxent River and its tributaries in 1977; 2) to assess the changes in the fish community structure, species diversity and composition between 1966 and 1977; and 3) to augment the data collected by the Maryland Water Resources Administration for the purpose of defining problem areas in the Patuxent River system.

STUDY AREA

The upper Patuxent River, including the main stem of the Patuxent River, the Little Patuxent River, the Middle Patuxent River, Hammond Branch and Dorsey Run, was the area of this study (Fig. 1). The extent of the area was from their individual headwaters to the Patuxent-Little Patuxent confluence, about 100 yards above Priest Bridge on Md. Rte 3. The area is divided by the Fall Line into two topographically distinct regions, the Piedmont Plateau and the Coastal Plain. There are 12 sewage treatment plants of various sizes discharging their effluents into the river.

The Middle Patuxent River is located entirely in the Piedmont Plateau. In the areas seined the river was five to 40 feet wide and up to five feet deep. The substrate consisted mainly of rocks and sand. Both riffles and pools were plentiful, but aquatic vegetation was generally sparse. Three small sewage treatment plants, Johns Hopkins University's Applied Physics Laboratory, W.R. Grace Laboratory and the University of Maryland Agriculture Facility, are located on this river.

The Little Patuxent River flows through both the Piedmont Plateau and the Coastal Plain regions. In the areas seined the river was 20 to 50 feet wide and up to five feet deep. In the Piedmont Plateau region, the river bottom consisted almost entirely of sand, gravel and rocks, while in the Coastal Plain region, the river bottom consisted mainly of sand and silt. Except for the Coastal Plain region of the river and the area in and below the City of Columbia located in the Piedmont region, aquatic vegetation was generally sparse. There were four sewage treatment plants in the Coastal Plain section of the river; the Savage Plant serving the cities of Savage and Columbia, Fort Meade Number 1 and Number 2 Plants serving the Fort Meade Military Reservation, and the Patuxent-Crofton Plant serving the community of Crofton.

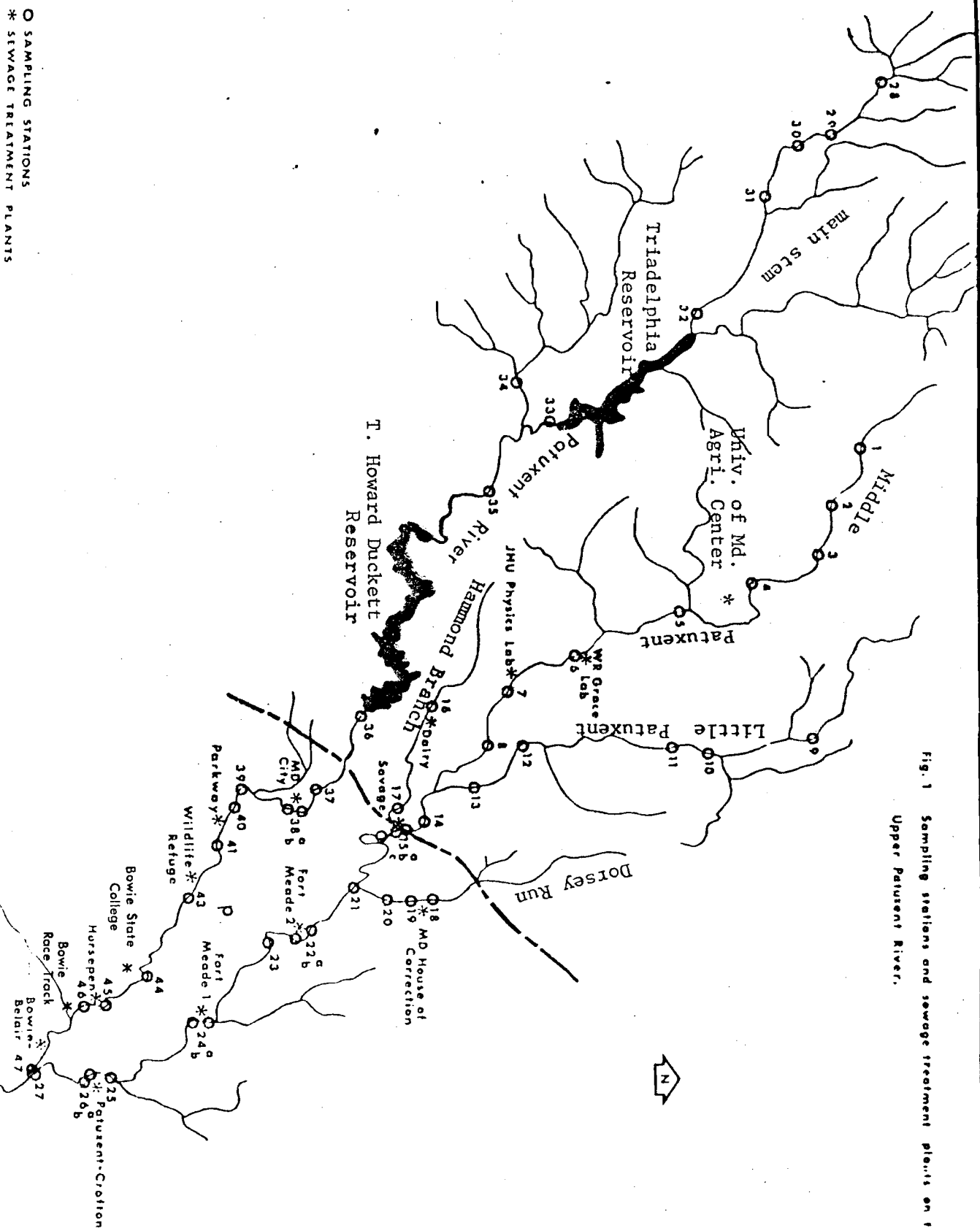
Dorsey Run, located almost entirely in the Coastal Plain region, is a small tributary of the Little Patuxent River. In the areas seined, the stream was six to 20 feet wide and as deep as four feet. Substrate consisted mainly of rocks and sand. Both riffles and pools were present. The Maryland House of Correction's Sewage Treatment Plant discharges its effluent into this stream.

Hammond Branch, located mainly in the Piedmont Plateau region, is also a small tributary of the Little Patuxent River. In the areas seined, the stream was five to 10 feet wide with a depth of up to four feet. The stream

bed was rocky and sandy. The Maryland-Virginia Milk Producer Association's Waste Treatment Plant discharges its effluent into this stream.

The main stem of the Patuxent River, like the Little Patuxent River, flows through both the Piedmont Plateau and the Coastal Plain regions. Unlike the Little Patuxent River, the main stem has two major reservoirs in the Piedmont Plateau region, Triadelphia -- North of the village of Sunshine, and T. Howard Duckett (Rocky Gorge) -- North of the City of Laurel. In the Piedmont Plateau region, the main stem ranged from 10 to 100 feet wide and had a depth of up to four feet where seining was conducted. In the Coastal Plain region where the river enlarged to an average width of over 60 feet, the river had many small islands. The river bottom was sand and gravel in the Piedmont Plateau and was sand and silt in the Coastal Plain. There are seven sewage treatment plants located on and discharging their effluents into the Coastal Plain section of the main stem of the Patuxent River. They are Maryland City, Laurel-Parkway, Patuxent Wildlife Research Center, Bowie State College, Horsepen, Bowie Race Track and Belair-Bowie Sewage Treatment Plants.

Fig. 1 Sampling stations and sewage treatment plants on the Upper Patuxent River.



FISH SAMPLING STATIONS

A total of 52 fish sampling stations were chosen in 1977; eight on the Middle Patuxent River, 19 on the Little Patuxent River, three on Dorsey Run, two on Hammond Branch, and 20 on the main stem of the Patuxent River. Their locations are shown in Fig. 1. In 1977 these stations were chosen to either correspond to the 1966 and 1967 locations or where additional sampling stations were needed due to excessive distances between the 1966-1967 stations. These new stations were chosen to be at or near water sampling stations used by the Maryland State Water Resources Administration. Whenever a major sewage treatment plant was encountered, paired stations (one upstream and one immediately downstream of the effluent discharge) were established to study the immediate impact of the sewage on the fish community. This pairing of stations was done in both 1966-67 and 1977, except in the Coastal Plain region of the main stem of the Patuxent River in 1977. In this area, because of the difficulty in reaching some of the outfalls, such pairing could only be done at the Maryland City Sewage Treatment Plant outfall. The detailed descriptions of the stations are as follows:

<u>Station</u>	<u>Description^{1/}</u>	<u>River Miles^{2/}</u>
1	The Middle Patuxent River at the bridge on Pfefferkorn Road, 2 miles SW of Friendship.	38.3
2	The Middle Patuxent River at the bridge on MD. 32, 1.1 miles SW of Friendship.	36.2
3	The Middle Patuxent River at the bridge on Triadelphia Road, 2.6 miles SE of Mayfield.	35.0
4	The Middle Patuxent River at the bridge on Folly Quarter Road, 2.6 miles SE of Mayfield.	32.6
5	The Middle Patuxent River at the bridge on MD. 108, (Clarksville Pike), 3.3 miles East of Linden Church or 4.6 miles SW of Columbia.	29.1
6	The Middle Patuxent River at the bridge on MD. 32, just outside of Simpsonville.	25.4
7	The Middle Patuxent River at the bridge on Kindler Road, near Hammond Park, between Gorman Road (0.6 mile) and Guilford Road (0.8 mile).	22.9
8	The Middle Patuxent River at the bridge on Murray Hill Road, between Guilford Road (0.5 mile) and Gorman Road (0.8 mile), 1.3 miles SE of Station 7.	20.6
9	The Little Patuxent River at the bridge on U.S. 40, east of MD. 144, 3 miles NW of Ellicott City.	30.2
10	The Little Patuxent River at the bridge on MD. 108, next to Maple Grove Church 0.5 miles West of U.S. 29.	27.4
11	The Little Patuxent River, 1.5 miles SW of the intersection of U.S. 29 and MD. 108, just below the pond at the Columbia development.	24.6
12	The Little Patuxent River at the bridge on MD. 32 next to Berger Road and Murray Hill Road intersection, 2.6 miles SE of Simpsonville.	21.4

1/ Distances on land were measured by a straight line from point to point.

2/ River miles were measured along the river course from the confluence of the main stem of the Patuxent River and the Little Patuxent River.

<u>Station</u>	<u>Description</u>	<u>River Miles</u>
13	The Little Patuxent River at the bridge on Vollmerhausen Road just North of Savage.	17.8
14	The Little Patuxent River at the bridge on U.S. 1 just SE of Savage.	17.2
15A	The Little Patuxent River immediately upstream from the Savage Sewage Treatment Plant outfall.	16.53
15B	The Little Patuxent River, about 50 yards downstream from the Savage Plant outfall.	16.51
15C	The Little Patuxent River on Brock Bridge Road, at the Maryland House of Correction's Water Pumping Station.	16.1
16	The Hammond Branch at the bridge on Leishear Road upstream from the Maryland-Virginia Milk Producer Association's Waste Treatment Plant outfall between Gorman Road (0.7 mile) and MD. 216 (0.3 mile).	20.9
17	The Hammond Branch at the bridge on U.S. 1, next to the Laurel Harness Racing Track, between Gorman (0.6 mile) and Whiskey Bottom Road (0.6 mile).	17.0
18	Dorsey Run at the Baltimore-Ohio railroad bridge (0.6 mile SW of Jessup).	16.3
19	Dorsey Run at the bridge on road about 100 yards downstream from the Maryland House of Corrections's Sewage Treatment Plant outfall, 1.2 miles South of Jessup.	15.5
20	Dorsey Run at the bridge on MD. 32, 3 miles South of Jessup.	14.5
21	The Little Patuxent River at the bridge in the Washington D.C. Children's Training Center.	13.2
22A	The Little Patuxent River at Simonds Bridge, immediately upstream from the Fort Meade Sewage Treatment Plant No. 2 outfall, 3.1 miles West of Odenton.	11.74
22B	The Little Patuxent River about 100 yards downstream from the Fort Meade No. 2 outfall, 3 miles West of Odenton.	11.67
23	The Little Patuxent River at the Old Forge Bridge on Switchboard Road in Fort Meade, 1 mile from MD. 198 and 3 miles SW of Odenton.	10.3

<u>Station</u>	<u>Description</u>	<u>River Miles</u>
24A	The Little Patuxent River, upstream from the Fort Meade No. 1 Sewage Treatment Plant outfall.	7.0
24B	The Little Patuxent River about 200 yards downstream from the Fort Meade No. 1 Plant outfall.	6.8
25	The Little Patuxent River at the bridge on MD. 424, 0.4 miles West of MD. 3 (Crain Hwy) near Conaways.	3.0
26A	The Little Patuxent River, immediately upstream from the Patuxent-Crofton Sewage Treatment Plant outfall.	2.18
26B	The Little Patuxent River about 500 yards downstream from the Patuxent-Crofton Plant outfall.	2.17
27	The Little Patuxent River about 0.25 miles above the Patuxent-Little Patuxent Confluence.	0.2
28	The Patuxent River, at the bridge on Long Corner Road, 2.75 miles SE from the Frederick-Montgomery County Line, or 1.75 miles East of Friendship.	46.8
29	The Patuxent River at the bridge on Mullinix Mill Road in Mullinix.	45.2
30	The Patuxent River at the bridge on Ellicott Road (MD. 94), 0.4 miles South of Annapolis Rock.	43.5
31	The Patuxent River at the bridge on Hipsley's Mill Road, 1 mile SW of Hipsley's Mill.	42.0
32	The Patuxent River at the bridge at MD. 97, 2.25 miles North of Sunshine, just before entering the Triadelphia Reservoir.	37.6
33	The Patuxent River about 200 yards downstream from the Brighton Dam of the Triadelphia Reservoir.	32.4
34	The Hawling River, a tributary to the Patuxent River, at the bridge on MD. 650, 1.3 miles South of Brighton or 0.6 miles NW of Brinklow.	31.5
35	The Patuxent River at the Snell Bridge on MD. 108.	27.8
36	The Patuxent River downstream from the Rocky Gorge Dam, adjacent to the Laurel swimming pool.	17.3
37	The Patuxent River at the bridge on MD. 198 in Laurel.	14.3

<u>Station</u>	<u>Description</u>	<u>River Miles</u>
38A	The Patuxent River immediately upstream from the Maryland City Sewage Treatment Plant outfall.	13.72
38B	The Patuxent River about 500 yards downstream from the Maryland City Plant outfall.	13.70
39	The Patuxent River at the bridge on Brock Bridge Road between MD. 197 (0.5 mile) and the Baltimore-Washington Parkway (0.75 mile).	11.7
40	The Patuxent River at the bridge on the Baltimore-Washington Parkway.	11.2
41	The Patuxent River in the Patuxent Wildlife Research Center, about 2.3 miles upstream from the DuVall Bridge.	10.9
43	The Patuxent River at the DuVall Bridge.	7.4
44	The Patuxent River below the Pennsylvania Railroad Bridge, 0.4 mile downstream of the Lemon Bridge.	4.8
45	The Patuxent River upstream from the Horsepen Sewage Treatment Plant outfall.	2.8
46	The Patuxent River at the bridge behind the Bowie Race Track.	1.9
47	The Patuxent River about 0.25 mile upstream from the Patuxent-Little Patuxent Confluence.	0.2

MATERIALS AND METHODS

Two series of fish collections were made in 1977. The first series was from 1 August to 16 August and the second series was from 30 August to 16 September. As done in 1966-67, at each station all habitats (riffle, pool, under vegetation, and various stream bottoms such as sand, gravel and mud) were sampled for approximately one hour to insure capture of species with different habitat preferences. A 10-foot seine with a quarter-inch mesh was used as in the 1966-67 collections (Tsai, 1968). The fish taken were preserved in a 15 percent formalin solution, except for trout which were counted and released, and for large sunfish which were counted and frozen. These frozen sunfish were to be used by the Maryland Department of Health and Mental Hygiene for toxic substance analysis. The preserved fish samples were taken to the laboratory, sorted by species, counted and recorded.

The quantitative measurements of species diversity and evenness indices were used to compare one community with another and to detect responses of the community to environmental stress and perturbation (Richards, 1976). The addition of a pollutant tends to eliminate or to reduce the number of species in the community and often favors the growth of some species which are tolerant to the pollutant. Therefore, a decrease in both diversity and evenness indices indicates the presence of some environmental stress on the community.

For each station the fish species diversity index (\bar{H}) was calculated with the Shannon-Weiner formula (Zajac, 1971). The evenness index (E) was calculated by the formula used by Richards (1976):

$$\bar{H} = 3.3219 \left(\log_{10} N - \frac{1}{N} \sum_{i=1}^S n_i \log_{10} n_i \right)$$
$$E = \frac{\bar{H}}{\bar{H}_{\max}}$$

Where N is the total number of individual fish collected; n_i is the number

of individuals per species collected; S is the total number of species; and \bar{H}_{\max} is the maximum diversity a collection can have, that is when all species in a collection have an equal number of individuals. Number 3.3219 is a constant used to change the logarithm from base 10 to base 2.

Using the above two indices, the fish community diversity and evenness at each station were compared between 1966 and 1977 to assess the change in fish community. A t-test (Zar, 1974) was performed for the species diversity indices at each station to determine the significant level of the change from 1966 to 1977:

$$t = \frac{\bar{H}_1 - \bar{H}_2}{\sqrt{S_{\bar{H}_1 - \bar{H}_2}}}$$

where \bar{H}_1 and \bar{H}_2 are the species diversity indices of 1966 and 1977 respectively and $S_{\bar{H}_1 - \bar{H}_2}$ is equal to $\sqrt{S_{\bar{H}_1}^2 + S_{\bar{H}_2}^2}$. The variance of \bar{H} is approximated by

$$S_{\bar{H}}^2 = \frac{\sum n_i \log^2 n_i - (\sum n_i \log n_i)^2 / N}{N^2}$$

In this study, the difference between the two indices is considered to be significant when the probability of the t-value is at or less than the 5% level ($P < 0.05$). Absolute values obtained for diversity (\bar{H}) and evenness (E) have no interpretative meaning and that only differences in values between years at a given station or between two adjacent stations have interpretative meaning. Therefore, except as noted, average values of \bar{H} and E for the two sampling periods are used in the discussion of the results.

RESULTS AND DISCUSSION

The Middle Patuxent River

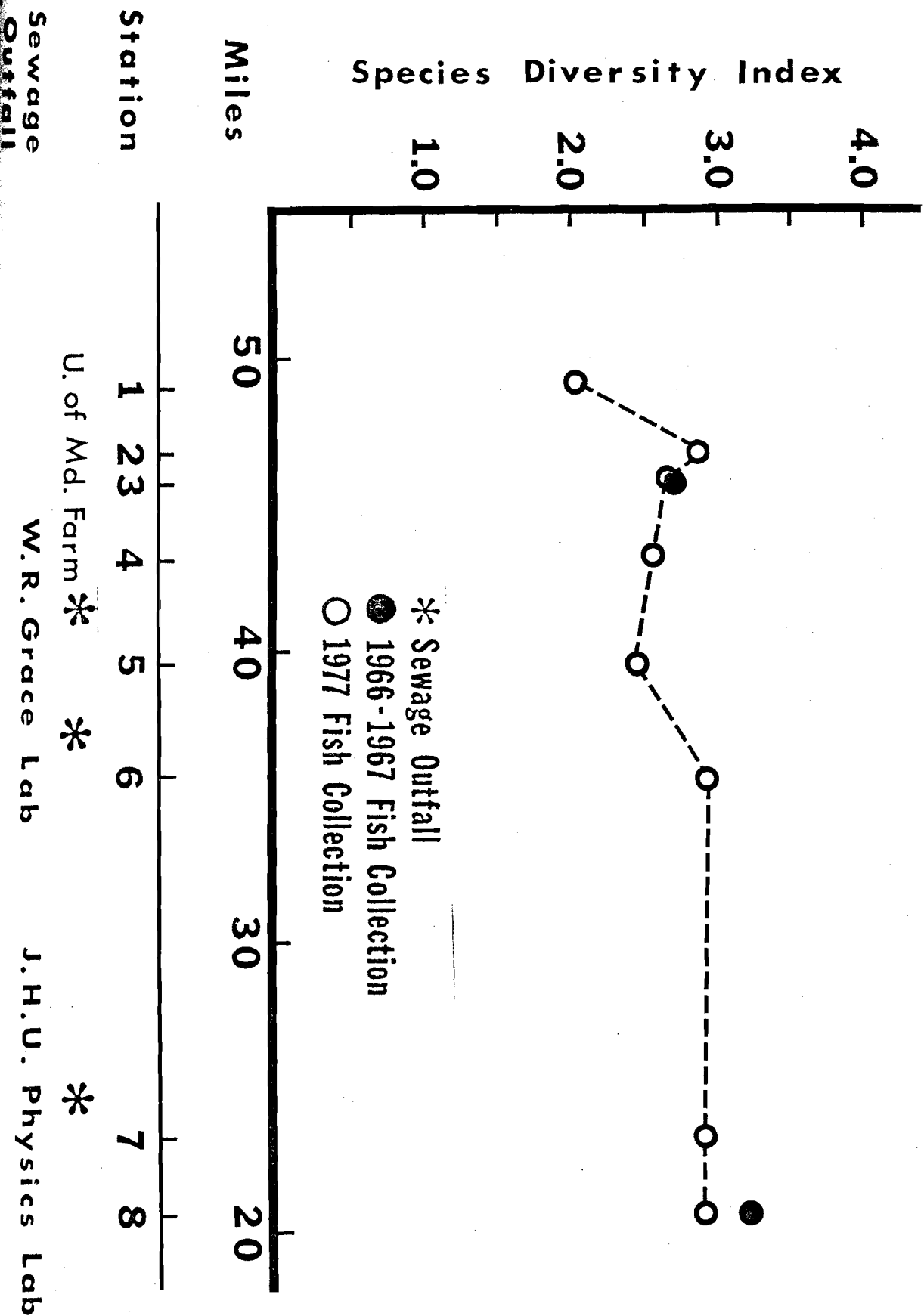
On 5 September 1977 when Station 6 (near Simpsonville) was visited, thousands of dead fish were floating in the water or washed up onto the rocks or the shores. Of the dead fish, large Anguilla rostrata (American eel), Semotilus corporalis (fall fish) and Exoglossum maxilllingua (cutlips minnow) were most visible. No live fish were observed in or collected from the river at this station. On the same day hundreds of fish were collected just upstream at Station 5 (4 miles upstream of Station 6). On 8 September 1977 Stations 7 and 8 were visited (2.5 miles and 4.8 miles downstream, respectively, of Station 6). Many dead fish were found at these two stations. No live fish were taken at Station 7 and only 52 specimens of Notropis cornutus (common shiner) and one specimen of Notropis procne (swallowtail shiner) were collected at Station 8. The section of the river where the fish kill was observed was just downstream from the W. R. Grace Laboratory's Waste Treatment Plant outfall. Because the fish kill was incidental and thus not representative of the river's condition, the fish observations at Stations 6, 7 and 8 in September were not used for comparison of data between 1966 and 1977.

The species composition, species diversity indices and evenness indices at the eight stations studied in 1966-67 and 1977 are shown in Table 1. The average species diversity indices are compared between 1966 and 1977 in Fig. 2. In 1966-67 fish collections were made only at Stations 3 and 8. At these two stations the average species diversity index was 2.69 and 3.19 respectively, which were not significantly different ($P > 0.5$) from 2.65 and

Table 1. Species composition, species diversity and evenness of fish community sampled from the Middle Patuxent River, 1966, 1967 and 1977.

Year	1966			1967		1977												
Station	3	8		8		1		2		3		4		5		6	7	8
Month	Jul	Jul	Aug	Apr	Jul	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Aug	Aug
<u>Clinostomus funduloides</u>	197	40	93	92	117	297	175	186	127	131	260	224	159	130	23	45	44	30
<u>Notropis cornutus</u>	24	33	130	513	126	26	-	94	69	40	45	140	175	349	695	130	311	92
<u>Notropis procne</u>	65	11	38	48	162	30	2	67	191	5	28	12	80	8	164	17	13	37
<u>Notropis analostanus</u>	16	11	29	13	114	1	-	16	79	18	6	31	5	21	447	4	36	13
<u>Etheostoma olmstedii</u>	29	30	10	33	7	36	18	33	246	41	55	28	45	19	29	9	26	43
<u>Rhinichthys atratulus</u>	16	68	28	6	4	32	12	20	40	35	23	34	5	28	-	29	53	31
<u>Semotilus corporalis</u>	116	9	-	2	13	60	29	69	73	87	103	85	21	5	46	15	48	10
<u>Notropis rubellus</u>	1	1	37	42	89	-	-	6	3	-	8	24	14	110	34	106	56	278
<u>Exoglossum maxillingua</u>	6	1	7	6	2	26	4	23	5	10	2	8	-	37	42	11	14	9
<u>Catostomus commersoni</u>	33	21	38	-	4	54	11	98	6	2	2	1	3	1	57	14	5	3
<u>Rhinichthys cataractae</u>	-	16	50	3	12	15	-	-	-	26	2	9	-	35	-	23	125	131
<u>Nocomis micropogon</u>	-	7	51	6	3	-	-	-	-	-	-	13	-	14	-	7	8	59
<u>Semotilus atromaculatus</u>	1	-	-	-	-	1	3	12	21	7	14	2	-	1	32	2	-	-
<u>Micropterus dolomieu</u>	5	-	-	-	2	-	1	8	-	6	-	2	3	7	-	1	5	2
<u>Lepomis auritus</u>	4	2	18	3	3	-	-	-	-	1	-	1	-	-	-	-	-	-
<u>Percina peltata</u>	1	2	4	4	1	-	-	-	-	2	-	-	1	-	-	2	10	14
<u>Anguilla rostrata</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	1	-
<u>Lepomis macrochirus</u>	5	-	-	-	-	2	-	1	-	1	-	-	-	-	18	1	1	-
<u>Hypentelium nigricans</u>	-	-	-	-	-	-	-	2	1	-	-	1	-	-	-	-	5	5
<u>Noturus insignis</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
<u>Etheostoma vitreum</u>	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<u>Micropterus salmoides</u>	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<u>Notemigonus crysoleucas</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Number of individuals	520	252	534	771	659	580	255	635	861	412	548	615	511	769	1588	417	761	757
Number of species	16	14	13	13	15	12	9	14	12	15	12	16	11	17	11	17	17	15
Species diversity index (H)	2.69	3.12	3.26	1.83	3.10	2.45	1.66	3.02	2.78	2.93	2.37	2.74	2.35	2.56	2.33	2.95	2.90	2.91
Evenness index (e)	0.67	0.82	0.86	0.49	0.81	0.68	0.52	0.79	0.78	0.75	0.67	0.69	0.68	0.63	0.67	0.72	0.71	0.75

Fig. 2. Longitudinal distribution of the species diversity indices of the fish communities in the Middle Patuxent River, 1966-67 and 1977.



2.91 in 1977. The evenness indices ranged between 0.69 and 0.80 in 1966 and 0.67 and 0.75 in 1977. At Stations 1, 2, 4, 5, 6 and 7 fish collections were made only in 1977. The species diversity and evenness indices ranged between 1.66 and 3.02 and between 0.52 and 0.79 respectively. These values were fairly similar to those at Stations 3 and 8 (Fig. 2).

A total of 24 species of fish were collected. Of them C. funduloides, N. cornutus, N. procne, N. rubellus, Notropis analostanus (satinfin shiner), Rhinichthys atratulus (blacknose dace), Rhinichthys cataractae (longnose dace) S. corporalis, E. maxillingua, Etheostoma olmstedii (tessellated darter) and Catostomus commersoni (white sucker) were dominant. Micropterus dolomieu (smallmouth bass) is the most important sport fishery species in the Middle Patuxent River. This species was fairly common through the river in both 1966 and 1977. On the other hand, Lepomis auritus (redbreast sunfish) which were common in 1966-67 were represented by only two specimens in 1977. Evidently, its population reduced drastically from 1966 to 1977. However, the causative factor(s) for the reduction is unknown. Except for the change in the redbreast sunfish population, species composition and community structure in the Middle Patuxent River remained stable from 1966 to 1977.

The Little Patuxent River

The Piedmont Plateau Region

Stations 9 and 10 were located upstream from the City of Columbia. Only Station 10 was sampled in 1966. At this station the average species diversity and evenness indices were 2.86 and 0.74 respectively. The former

Fig. 3. Longitudinal distribution of the species diversity indices of the fish communities in the piedmont plateau section of the Little Patuxent River, 1966 and 1977.

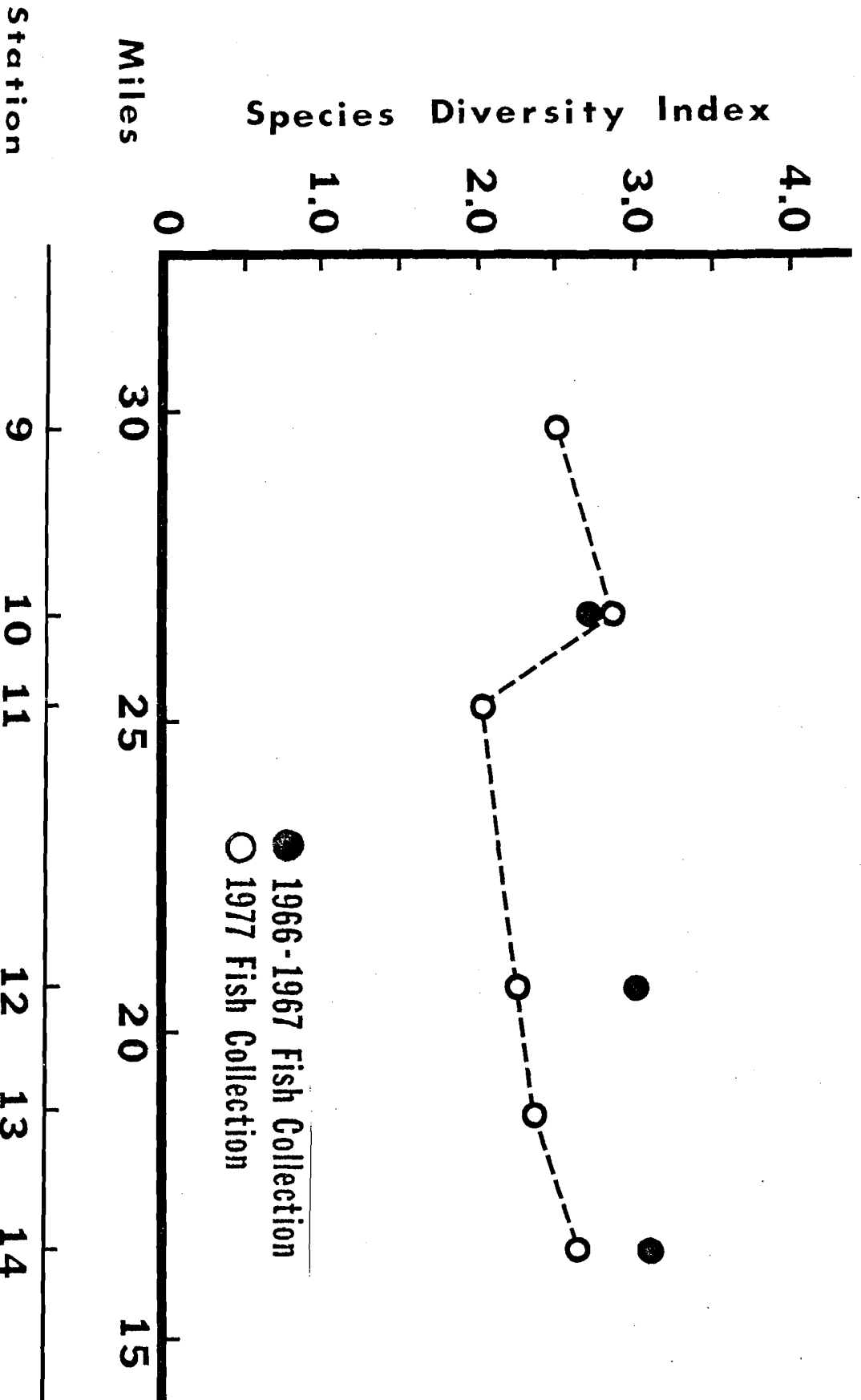


Table 2. Species composition, species diversity and evenness of fish communities sampled in the Piedmont Plateau section of the Little Patuxent River, 1966 and 1977.

Year	1966				1977											
Station	10	12		14	9		10		11		12		13		14	
Month	Aug	Aug	Aug	Jul	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep
<u>Clinostomus funduloides</u>	225	94	93	5	143	188	64	9	-	-	10	-	-	-	-	-
<u>Notropis cornutus</u>	9	125	130	105	15	20	42	22	43	-	553	113	158	235	75	104
<u>Notropis procne</u>	240	20	12	42	184	149	79	39	25	1	43	151	193	144	194	123
<u>Notropis analostanus</u>	124	68	61	81	105	55	127	92	14	2	105	260	186	189	311	267
<u>Etheostoma olmstedii</u>	86	14	9	3	94	-	26	11	5	3	5	9	7	18	19	44
<u>Rhinichthys atratulus</u>	153	9	42	32	632	426	305	176	-	-	25	-	-	-	-	-
<u>Semotilus corporalis</u>	18	14	12	21	146	47	91	53	8	1	3	11	12	32	10	-
<u>Notropis rubellus</u>	-	33	27	72	-	-	5	204	-	-	125	7	13	3	8	5
<u>Exoglossum maxillingua</u>	19	5	4	15	12	-	13	6	5	-	17	5	15	17	4	5
<u>Catostomus commersoni</u>	-	6	13	18	138	12	6	14	-	1	5	1	3	1	12	11
<u>Rhinichthys cataractae</u>	1	3	4	13	21	16	86	67	1	-	140	-	13	-	2	3
<u>Nocomis micropogon</u>	-	10	3	51	-	-	17	-	-	-	-	-	98	-	56	48
<u>Lepomis macrochirus</u>	2	3	1	-	18	17	-	4	87	157	1	9	1	8	15	33
<u>Lepomis auritus</u>	86	5	2	-	-	-	-	-	2	1	1	2	-	-	14	1
<u>Lepomis gibbosus</u>	-	1	5	-	4	2	-	2	5	14	1	1	-	2	8	3
<u>Hypentelium nigricans</u>	1	-	-	-	-	-	3	-	2	2	1	-	4	1	22	2
<u>Micropterus dolomieu</u>	-	-	6	-	7	-	-	-	2	-	2	-	3	-	5	-
<u>Semotilus atromaculatus</u>	-	-	-	-	1	-	2	-	-	-	57	-	-	-	-	-
<u>Micropterus salmoides</u>	-	1	1	-	-	3	-	-	-	2	-	2	-	-	3	2
<u>Ictalurus nebulosus</u>	-	1	-	-	-	-	-	-	4	3	-	-	-	-	-	-
<u>Noturus insignis</u>	-	-	-	-	-	2	-	-	-	2	-	-	-	-	-	-
<u>Notropis hudsonius</u>	-	2	-	4	-	-	-	-	-	-	-	-	-	-	-	-
<u>Etheostoma vitreum</u>	-	-	-	24	-	-	-	-	-	-	-	-	-	-	4	13
<u>Notemigonus crysoleucas</u>	-	-	-	-	-	-	-	-	3	-	2	-	-	-	-	-
<u>Percina peltata</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1
<u>Anguilla rostrata</u>	-	-	-	-	-	-	-	-	1	2	-	-	1	-	-	-
<u>Lepomis cyanellus</u>	-	-	-	-	-	-	-	-	-	2	-	7	-	-	-	2
<u>Ambloplites rupestris</u>	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
<u>Percina notogramma</u>	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-
Number of individuals	964	414	426	490	1520	936	866	699	207	193	1096	578	707	650	766	667
Number of species	12	18	18	15	14	12	14	13	15	15	18	13	14	11	18	17
Species diversity index (\bar{H})	2.73	3.00	2.98	3.12	2.72	2.33	2.90	2.81	2.66	1.31	2.41	2.08	2.53	2.19	2.66	2.63
Evenness index (e)	0.76	0.71	0.71	0.87	0.71	0.67	0.76	0.76	0.68	0.34	0.58	0.56	0.66	0.64	0.64	0.64

index was not significantly different ($P > 0.1$) from 2.89 in 1977 (Fig. 3). The evenness index in 1977 at these two stations were 0.76 and 0.79 respectively, which is fairly similar to that found at Station 10 in 1966. The dominant species were C. funduloides, N. procne, N. analostanus and R. atratulus at Station 10 in both 1966 and 1977. L. auritus decreased while R. cataractae and N. rubellus increased from 1966 to 1977 (Table 2). Except for the slight changes in some dominant species, the fish community structure and diversity in this upstream, clean water section of the Little Patuxent River, remained fairly stable from 1966 to 1977.

Stations 11, 12, 13 and 14 were located downstream from the City of Columbia. In 1966 fish collections were made at Stations 12 and 14. At these two stations, average species diversity index was 2.99 and 3.12 respectively in 1966 and significantly ($P < 0.005$) reduced to 2.25 and 2.64 respectively in 1977 (Fig. 3). The evenness indices also decreased from 0.71 and 0.87 in 1966 to 0.56 and 0.64 in 1977. At Stations 11 and 13 where fish collections were made only in 1977, the species diversity indices were 2.44 and 2.36 which were as low as those at the nearby Stations 12 and 14 and much lower than that at Station 10 upstream from the City of Columbia. In this section of the river, C. funduloides and R. atratulus which were common in 1966 were almost absent in 1977, while L. macrochirus and L. gibbosus became common in 1977. L. cyanellus which was not found in 1966 was found in 1977.

It is evident that in the section of the Little Patuxent River at Stations 11-14, fish community diversity and structure changed greatly from 1966 to 1977, apparently as a result of the development of the City of Columbia. There are no known point source discharges of either domestic or industrial waste to the river. However, thick growth of aquatic weeds, reduction in species

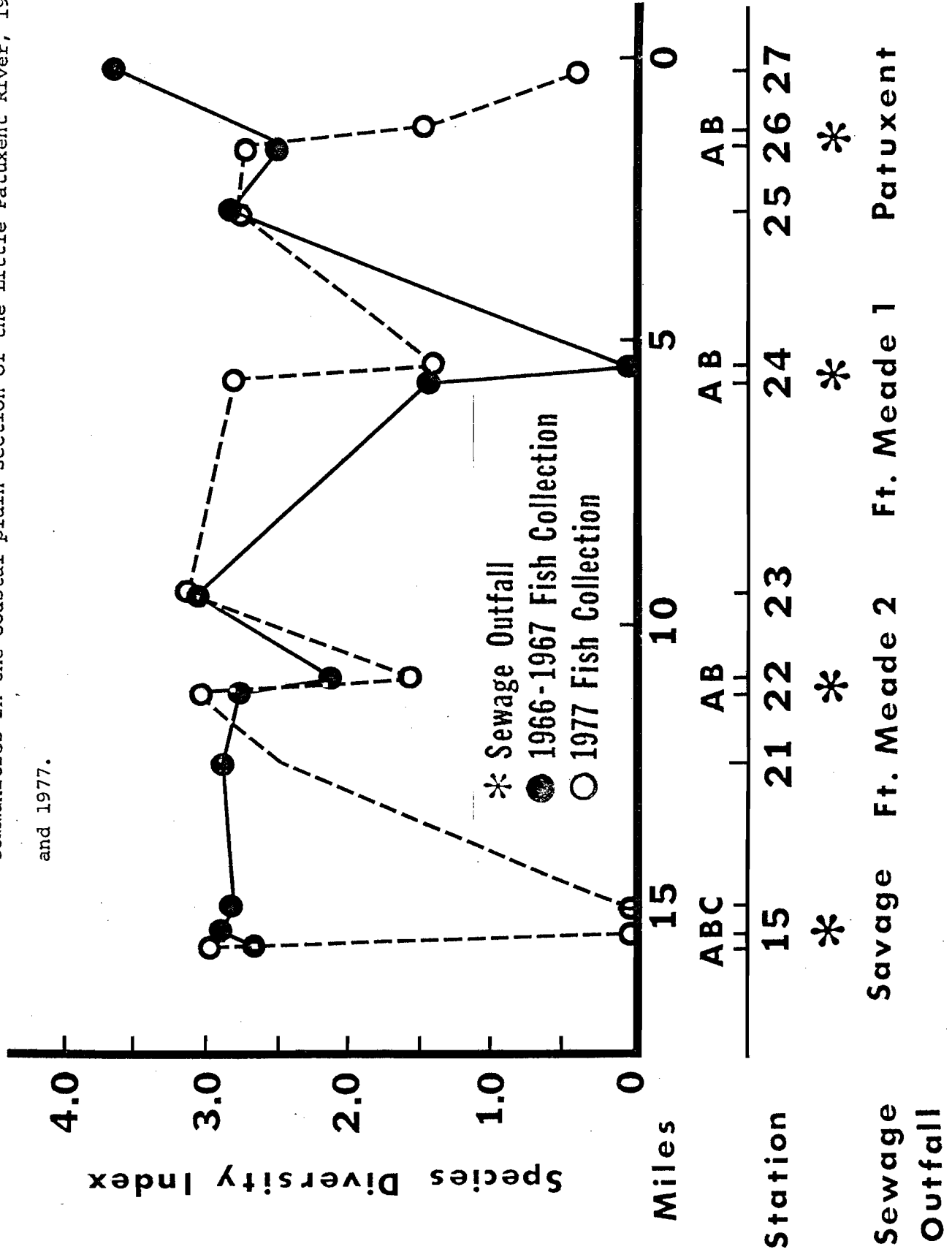
Table 3. Species composition, species diversity, and evenness of fish communities sampled in the coastal plain section of the Little Patuxent River, 1966 and 1967.

Year	1966																				1967												
Station	15A		15B		15C	21		22A		22B		23		24A		24B		25	26A		27		15A		15B	15C	21	22A		22B	24A		
Month	Jul	Aug	Aug	Jul	Aug	Jul	Aug	Jul	Aug	Jul	Aug	Jul	Aug	Jul	Aug	Aug	Aug	Jul	Jul	Aug	Jul	Aug	Apr	Jul	Jul	Jun	May	Apr	Apr	Jul	Jul	May	Apr
<i>Notropis analostanus</i>	203	176	206	177	240	125	97	-	-	20	16	50	225	-	-	8	24	41	2	7	110	136	172	252	237	98	5	130	20	6	5		
<i>Notropis procerne</i>	54	65	18	127	38	101	19	-	-	11	75	236	589	-	-	6	19	62	6	11	17	53	48	74	87	122	4	33	1	9	10		
<i>Semotilus corporalis</i>	30	6	6	34	52	-	8	-	-	26	32	14	11	-	-	11	18	7	2	6	4	5	-	6	14	16	1	3	-	-	1		
<i>Notropis cornutus</i>	398	224	382	106	154	27	19	-	7	5	26	1	3	-	-	-	-	-	-	-	336	67	81	246	90	73	9	37	47	-	-		
<i>Notropis rubellus</i>	65	66	113	88	72	29	81	-	-	8	-	-	-	-	-	-	-	-	-	-	244	53	38	270	137	38	8	43	3	1	-		
<i>Catostomus commersoni</i>	15	11	16	3	33	3	9	-	-	3	1	3	-	-	-	-	-	-	3	-	2	3	18	4	-	-	16	2	13	-	-		
<i>Clinostomus funduloides</i>	15	32	13	13	66	101	37	-	-	3	3	-	-	-	-	-	-	-	-	1	42	-	-	18	4	20	8	1	-	-	-		
<i>Etheostoma vitreum</i>	30	94	91	39	28	2	3	-	-	2	1	6	1	-	-	1	-	-	-	-	43	1	2	2	9	89	2	-	2	-	-		
<i>Etheostoma olmstedii</i>	3	8	9	-	1	1	1	-	-	-	1	-	4	-	-	1	2	1	1	-	7	-	-	-	2	31	3	1	5	-	1		
<i>Lepomis auritus</i>	42	1	17	3	6	6	4	-	3	5	21	1	16	-	-	-	-	1	2	-	3	2	3	1	-	-	-	-	1	-	-		
<i>Lepomis macrochirus</i>	-	30	-	-	-	10	7	-	-	-	2	11	1	2	-	3	4	16	10	10	-	-	-	-	-	-	-	2	1	-	-		
<i>Lepomis gibbosus</i>	-	-	-	-	-	53	3	7	3	1	2	-	1	-	-	-	4	1	6	13	-	-	-	-	-	-	-	6	1	-	-		
<i>Exoglossum maxillingua</i>	23	2	6	6	3	-	-	-	-	1	3	-	1	-	-	3	-	-	-	-	-	-	-	5	1	-	-	-	-	-	-	1	
<i>Nocomis micropogon</i>	7	4	5	17	10	-	-	-	-	3	2	-	-	-	-	-	-	-	-	1	3	8	-	1	-	3	-	-	-	-	-	-	
<i>Anguilla rostrata</i>	2	1	-	-	1	-	1	1	-	8	8	1	2	-	-	1	-	3	10	7	4	1	-	-	-	-	-	1	-	-	-	-	
<i>Notemigonus crysoleucas</i>	-	-	-	-	-	12	7	3	3	1	3	4	3	-	-	-	-	25	2	20	1	-	-	-	-	-	-	10	1	5	1	-	
<i>Rhinichthys atratulus</i>	16	14	8	2	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	2	-	-	-	-	-	-	-	-	
<i>Rhinichthys cataractae</i>	-	4	3	9	-	-	-	-	-	3	6	15	4	-	-	-	1	-	-	-	2	-	-	2	-	-	-	-	-	-	1	-	
<i>Hypentelium nigricans</i>	2	1	2	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	
<i>Ictalurus nebulosus</i>	-	-	-	-	11	3	-	-	-	2	-	-	-	-	-	1	-	1	2	2	-	-	-	-	-	-	1	1	-	-	-	-	
<i>Notropis hudsonius</i>	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	3	6	16	3	17	-	-	-	-	-	-	-	-	-	-	2	-	
<i>Percina peltata</i>	2	1	5	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	1	-	-	-	-	-	-	
<i>Noturus insignis</i>	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Noturus gyrinus</i>	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Percina notogramma</i>	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	
<i>Esox americanus</i>	-	-	1	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	1	-	
<i>Micropterus dolomieu</i>	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	4	-	-	-	-	-	1	-	-	-	
<i>Micropterus salmoides</i>	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Umbra pygmaea</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	5	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Erinnyx oblongus</i>	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Perca flavescens</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	8	1	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Moxostoma macrolepidotum</i>	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Morone americana</i>	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Ictalurus natalis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Cyprinus carpio</i>	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Eneacanthus gloriosus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Lepomis cyanellus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Aphredoderus sayanus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	4	-	-	-	-	-	-	-	-	-	-	-	
Number of individuals	911	740	900	629	718	476	297	14	18	103	202	342	865	2	0	38	80	177	86	109	825	324	368	882	588	488	67	261	99	21	18		
Number of species	18	18	17	15	15	15	15	5	6	17	16	11	15	1	0	10	9	13	19	16	17	11	10	12	13	9	11	13	11	7	5		
Species diversity index (H')	2.66	2.88	2.88	2.84	2.87	2.82	2.77	1.92	2.28	3.35	2.88	1.63	1.30	-	-	2.83	2.56	2.61	3.80	3.48	2.30	2.15	2.14	2.16	2.26	2.73	3.09	2.17	2.33	2.20	1.68		
Evenness index (c)	0.64	0.64	0.61	0.75	0.73	0.72	0.71	0.83	0.89	0.82	0.72	0.47	0.34	-	-	0.85	0.81	0.71	0.91	0.87	0.56	0.65	0.65	0.60	0.61	0.86	0.89	0.63	0.67	0.78	0.72		

Table 4. Species composition, species diversity, and evenness of fish communities sampled in the Coastal Plain section of the Little Patuxent River, 1977.

Year	1977																								
Station	15A		15B		15C		21		22A	22B		23		24A		24B		25		26A		26B		27	
Month	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep
<i>Notropis analostanus</i>	76	161	-	-	-	-	-	37	1	-	-	-	-	6	93	-	-	-	-	-	-	-	-	-	-
<i>Notropis procne</i>	2	19	-	-	-	-	-	-	1	-	-	2	-	11	63	-	-	5	5	-	-	-	-	-	-
<i>Semotilus corporalis</i>	40	51	-	-	-	-	2	1	-	-	2	5	3	119	19	-	-	19	5	7	6	-	-	73	-
<i>Notropis cornutus</i>	120	92	-	-	-	-	-	1	14	-	-	-	4	-	-	6	-	1	1	-	-	-	-	-	37
<i>Notropis rubellus</i>	49	2	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
<i>Catostomus commersoni</i>	13	6	-	-	-	-	-	12	8	1	-	6	7	20	6	-	-	1	1	-	-	-	-	-	-
<i>Clinostomus funduloides</i>	-	32	-	-	-	-	-	-	2	-	-	5	9	3	-	-	-	4	-	-	-	-	-	-	-
<i>Etheostoma vitreum</i>	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Etheostoma olmstedi</i>	9	61	-	-	-	-	14	9	5	-	6	10	18	9	17	2	10	7	20	4	10	-	-	3	2
<i>Lepomis macrochirus</i>	3	10	-	-	-	-	4	45	13	2	16	-	6	5	21	7	1	1	4	3	1	-	2	-	-
<i>Lepomis gibbosus</i>	-	-	-	-	-	-	-	2	35	10	1	3	2	1	5	-	-	3	1	1	-	1	-	-	-
<i>Exoglossum maxillingua</i>	6	4	-	-	-	-	1	2	2	-	-	-	1	1	2	-	1	-	1	2	-	-	-	-	-
<i>Nocomis micropogon</i>	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Anguilla rostrata</i>	7	4	-	-	-	-	-	4	4	-	-	12	-	12	-	-	-	9	19	11	7	3	11	8	4
<i>Notemigonus crysoleucas</i>	-	-	-	-	-	-	-	-	1	-	-	7	-	7	2	-	-	4	-	4	-	-	-	-	-
<i>Rhinichthys atratulus</i>	6	20	-	-	-	-	26	2	23	-	11	14	1	22	9	-	13	-	8	8	-	6	-	-	2
<i>Rhinichthys cataractae</i>	20	13	-	-	-	-	8	7	1	-	-	12	8	-	4	-	-	6	-	-	-	-	-	-	-
<i>Hypentelium nigricans</i>	4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Ictalurus nebulosus</i>	-	-	-	-	-	-	-	3	1	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-
<i>Notropis hudsonius</i>	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	6	1	-	-	-	-
<i>Semotilus atromaculatus</i>	-	-	-	-	-	-	1	3	59	-	-	1	-	3	5	-	-	-	-	4	1	2	-	-	-
<i>Percina peltata</i>	1	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-
<i>Esox americanus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
<i>Micropterus dolomieu</i>	3	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Micropterus salmoides</i>	1	-	-	-	-	-	-	1	1	-	1	-	1	5	3	-	-	-	2	1	-	-	-	-	1
<i>Umbra pygmaea</i>	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Morone americana</i>	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	3	1	-	-	1
<i>Enneacanthus gloriosus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	-	-	-	-	1	-	-	-	-	-
<i>Hybognathus nuchalis</i>	-	-	-	-	-	-	-	-	46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Lepomis cyanellus</i>	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Fundulus heteroclitus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
<i>Ictalurus catus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
<i>Noturus gyrinus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Number of individuals	396	427	0	0	0	0	56	136	222	13	38	77	63	231	255	9	32	55	71	42	36	16	14	83	47
Number of species	18	15	0	0	0	0	7	15	19	3	7	11	13	19	17	2	6	9	12	10	8	6	3	3	6
Species diversity index (H')	3.01	2.96	-	-	-	-	2.07	2.87	3.11	.99	2.11	3.19	3.13	2.71	2.84	.76	1.97	2.71	2.88	2.91	2.62	2.32	.95	.62	1.20
Evenness index (e)	.72	.76	-	-	-	-	.74	.73	.73	.63	.75	.92	.85	.64	.69	.76	.77	.86	.80	.87	.87	.90	.60	.39	.46

Fig. 4. Longitudinal distribution of the species diversity indices of the fish communities in the coastal plain section of the Little Patuxent River, 1966 and 1977.



diversity and evenness of the fish community, an increase in the pollution tolerant sunfish populations, and a reduction in the pollution sensitive minnow populations suggest the occurrence of organic enrichment in this section of the river.

The Coastal Plain Region

The species composition, species diversity indices and evenness indices at the 13 stations studied in 1966-67 and 1977 are shown in Tables 3 and 4. The average species diversity indices for 1966 and 1977 are compared in Fig. 4.

In 1977 at Station 15A located immediately above the Savage Sewage Treatment Plant outfall, the average species diversity index was 2.98, which is not significantly different ($P > 0.1$) from the index of 2.66 in 1966 and the index of 2.64 at the upstream Station 14 in 1977. The evenness indices ranged between 0.64 and 0.74, which are similar between 1966 and 1977. For both years the dominant species were N. cornutus, N. rubellus, N. analostanus, N. procne, R. atratulus, R. cataractae, S. corporalis and C. commersoni, as in the Piedmont Plateau section of the Little Patuxent River. Etheostoma vitreum (glassy darter) which was common in 1966 and 1967 became very rare in 1977. In general, the fish community at Station 15A remained fairly stable from 1966 to 1977.

Stations 15B, 15C, 21 and 22A were all located in the 5 mile section of the river downstream from the Savage Sewage Treatment Plant outfall. In 1966 the average species diversity and evenness indices for the four stations ranged between 2.77 and 2.88, and 0.61 and 0.75 respectively. These indices were similar to those at Station 15A located immediately upstream from the outfall for both 1966 and 1977. The dominant species

were also similar to those at Station 15A. In 1977 no fish were found at Stations 15B and 15C. Farther downstream the species diversity index increased to 2.47 at Station 21 and to 3.03 at Station 22A. These two index values were not significantly different ($P > 0.2$ and 0.4) from those in 1966. The evenness index also increased to 0.71 and 0.74 at the two stations. At these two recovery stations, R. atratulus, R. cataractae and E. olmstedii were still dominant in 1977 as in 1966, and two species of the pollution tolerant sunfishes, L. macrochirus and L. gibbosus, also became dominant.

In 1966 no detrimental effect on the fish community in the Little Patuxent River was observed due to the effluent discharged from the Savage Treatment Plant. However, since the sewage flow has increased greatly, in 1977 no fish were taken at Stations 15B and 15C. This section of the Little Patuxent River has become biologically impoverished.

Stations 22B, 23 and 24A were located downstream from the Fort Meade No. 2 Sewage Treatment Plant outfall. In 1966 at Station 22B which was located immediately downstream from the outfall, the adverse effects of the plant effluent were evident. The species diversity and evenness indices were 2.10 and 0.86, respectively, much lower than those at Station 22A immediately upstream from the outfall. L. macrochirus and L. gibbosus were the common resident species at this station. Farther downstream the species diversity and evenness indices improved to 3.17 and 0.79 at Station 23 and then decreased to 1.47 and 0.41 at Station 24A. N. procne and N. analostanus became dominant at these two stations. In 1977 the same trend of fish distribution was observed. The species diversity indices at the three stations (22B, 23 and 24A) were 1.50, 3.17 and 1.77 respectively,

which were not significantly different ($P > 0.2$) from those in 1966. The evenness indices ranged between 0.34 and 0.69. The dominant species were also similar for both years, except S. corporalis which was also dominant in 1977 at Stations 23 and 24A. In this section of the Little Patuxent River, fish diversity and community structure remained almost unchanged from 1966 to 1977. However, a slight change in dominant species was observed.

Station 24B, 25 and 26A were located downstream from the Fort Meade No. 1 Sewage Treatment Plant outfall. In 1966 the detrimental effect was observed at Station 24B, the area immediately downstream from the outfall. No fish were taken at this station. Farther downstream the diversity index increased to 2.83 at Station 25 and 2.59 at Station 26A, but the number of fish collected was low. In 1977 the same longitudinal distribution of species diversity indices was observed. The index increased to 1.37 at Station 24B, but it remained at 2.80 at Station 25 and 2.77 at Station 26A. No significant difference ($P < 0.1$ and 0.2 , respectively) was observed in the diversity indices between 1966 and 1977. For both years, the evenness indices at the three stations ranged between 0.71 and 0.87. The dominant species were N. analostanus, N. procne and S. corporalis in 1966, but S. corporalis and E. olmstedii in 1977. As was the case in the section of the stream below the Fort Meade No. 2 Plant outfall, the fish community structure and diversity remained relatively stable from 1966 to 1977 for this section of the Little Patuxent River.

Stations 26B and 27 were located downstream from the Patuxent-Crofton Sewage Treatment Plant outfall. In 1966 fish sampling was conducted only at Station 27. The species diversity index of 3.64 and the evenness index of 0.89 at this station suggested a high diversity in the fish community.

In 1977 the diversity index decreased to 0.91, significantly different ($P < 0.05$) from that in 1966. The evenness index also decreased from 0.89 in 1966 to 0.43 in 1977. Evidently this downstream section of the Little Patuxent River has deteriorated as a result of the effluent discharged from the Patuxent-Crofton Plant.

Hammond Branch

The Maryland-Virginia Milk Producer Association's Waste Treatment Plant outfall is located immediately downstream from Station 16 and about four miles upstream from Station 17. In 1966 no fish collection was made in Hammond Branch. In 1977 the species diversity and evenness indices averaged 2.89 and 0.79, respectively, at Station 17, and 2.32 and 0.66 at Station 16 (Table 5). A total of 23 species of fish were collected at the two stations. Of them E. olmstedii, R. atratulus, R. catractae, S. corporalis and N. procne were common at both stations. E. maxillingua, C. commersoni, N. rubellus and L. macrochirus were predominant at Station 16, while N. analostanus and N. cornutus were common at Station 17. No detrimental effects of the discharge from the Maryland-Virginia Milk Producer Association's Waste Treatment Plant effluent on the fish community in Hammond Branch could be determined in this study.

Dorsey Run

The Maryland House of Correction's Sewage Treatment Plant outfall is located about one mile downstream from Station 18 and a quarter mile upstream from Station 19. At these two stations fish collections were made in both 1966 and 1977. At upstream Station 18 the species diversity indices averaged 2.69 in 1977, not significantly different from 2.90 in 1966. The evenness indices were 0.72 and 0.74, respectively. R. atratulus,

Table 5. Species composition, species diversity, and evenness of fish communities sampled in Hammond Branch, 1977.

Station	16		17	
Month	Aug	Sep	Aug	Sep
<u>Etheostoma olmstedii</u>	130	186	61	37
<u>Rhinichthys atratulus</u>	487	195	16	10
<u>Rhinichthys cataractae</u>	47	36	69	6
<u>Semotilus corporalis</u>	66	19	62	19
<u>Notropis procne</u>	5	21	40	6
<u>Clinostomus funduloides</u>	30	-	20	9
<u>Semotilus atromaculatus</u>	28	11	-	-
<u>Exoglossum maxilllingua</u>	1	21	-	-
<u>Erimyzon oblongus</u>	3	1	-	-
<u>Notropis rubellus</u>	-	67	-	-
<u>Lepomis macrochirus</u>	-	63	-	1
<u>Catostomus commersoni</u>	2	6	-	1
<u>Lepomis auritus</u>	8	1	1	-
<u>Notropis cornutus</u>	-	-	66	9
<u>Notropis analostanus</u>	-	-	9	16
<u>Notemigonus crysoleucas</u>	4	-	-	-
<u>Nocomis micropogon</u>	1	-	1	-
<u>Micropterus salmoides</u>	1	-	1	-
<u>Anguilla rostrata</u>	-	1	1	-
<u>Lepomis gibbosus</u>	-	-	1	1
<u>Hypentelium nigricans</u>	-	2	-	-
<u>Noturus insignis</u>	-	-	-	1
Number of individuals	813	630	348	116
Number of species	14	14	13	12
Species diversity index (\bar{H})	1.98	2.67	2.87	2.90
Evenness index (e)	.52	.70	.77	.81

Table 6. Species composition, species diversity, and evenness of fish communities sampled in the Dorsey Run, 1966 and 1977.

Year	1966			1977					
Station	18		19	18		19		20	
Month	Jul	Aug	Jul	Aug	Sep	Aug	Sep	Aug	Sep
<u>Rhinichthys atratulus</u>	163	98	-	52	93	-	2	8	15
<u>Catostomus commersoni</u>	23	21	-	50	32	-	-	1	5
<u>Lepomis macrochirus</u>	6	16	-	2	3	-	-	4	3
<u>Clinostomus funduloides</u>	72	151	-	38	-	-	-	1	-
<u>Semotilus corporalis</u>	-	6	-	58	55	-	-	5	11
<u>Etheostoma olmstedii</u>	13	11	-	35	75	-	-	-	-
<u>Notropis cornutus</u>	29	52	-	1	2	-	-	-	-
<u>Notropis procne</u>	89	72	-	2	1	-	-	-	-
<u>Notemigonus crysoleucas</u>	3	10	-	1	2	-	-	-	-
<u>Rhinichthys cataractae</u>	10	1	-	-	2	-	-	-	-
<u>Ictalurus nebulosus</u>	12	11	-	9	-	-	-	-	-
<u>Lepomis cyanellus</u>	1	11	-	-	2	-	-	-	-
<u>Micropterus salmoides</u>	4	1	-	1	-	-	-	-	-
<u>Anguilla rostrata</u>	3	-	-	-	-	-	-	1	1
<u>Notropis analostanus</u>	36	38	-	-	-	-	-	-	-
<u>Umbra pygmaea</u>	-	2	2	-	-	-	-	-	-
<u>Etheostoma vitreum</u>	-	1	-	-	-	-	-	-	-
<u>Notropis rubellus</u>	-	-	-	-	48	-	-	-	-
<u>Semotilus atromaculatus</u>	-	-	-	1	1	-	-	2	2
<u>Lepomis gibbosus</u>	-	-	-	8	-	-	-	3	-
<u>Cyprinus carpio</u>	-	-	-	5	1	-	-	-	-
Number of individuals	464	502	2	263	317	0	2	25	37
Number of species	14	16	1	14	13	0	1	8	6
Species diversity index (\bar{H})	2.81	2.99	-	2.85	2.52	-	-	2.63	2.10
Evenness index (e)	.74	.75	-	.75	.68	-	-	.88	.81

C. commersoni and E. olmstedii were common in both years. N. analostanus, N. cornutus, N. procne and R. cataractae were common in 1966 but became rare or absent in 1977. In contrast, N. rubellus and S. corporalis which were not found or rare in 1966 became common in 1977. At this clean water station, although the fish community diversity remained fairly stable from 1966 to 1977, a great shift in dominant species in the fish community was observed.

At Station 19 only two specimens of Umbra pygmaea (eastern mudminnow) were taken in 1966 and two specimens of R. atratulus were taken in 1977. Farther downstream at Station 20, the species diversity and evenness indices increased to 2.37 and 0.85, respectively in 1977 from Station 19, but in number of fish collected was still extremely low. S. corporalis and R. atratulus were common at this station. The adverse effects of the effluent discharged from the Maryland House of Correction's Sewage Treatment Plant on the fish community in Dorsey Run was evident in 1966 and remained so in 1977.

The Patuxent River

The Piedmont Plateau Region

Stations 28 - 32 were located upstream from the Triadelphia Reservoir. Of them Stations 31 and 32 were sampled in both 1966 and 1977 and Stations 28, 29 and 30 were sampled only in 1977. At the former two stations, the species diversity indices averaged 2.77 at Station 31 and 2.85 at Station 32 in 1977. They were not significantly different ($P > 0.1$ and 0.2) from 2.47 and 3.11, respectively, at the two stations in 1966 (Fig. 5). The evenness indices were fairly similar between the two years, ranging between 0.73 and 0.80 in 1977 and 0.61 and 0.88 in 1966. At the latter three stations, the average species diversity index was slightly lower than those

Fig. 5. Longitudinal distribution of the species diversity indices of fish communities in the piedmont plateau section of the Patuxent River, 1966 and 1977.

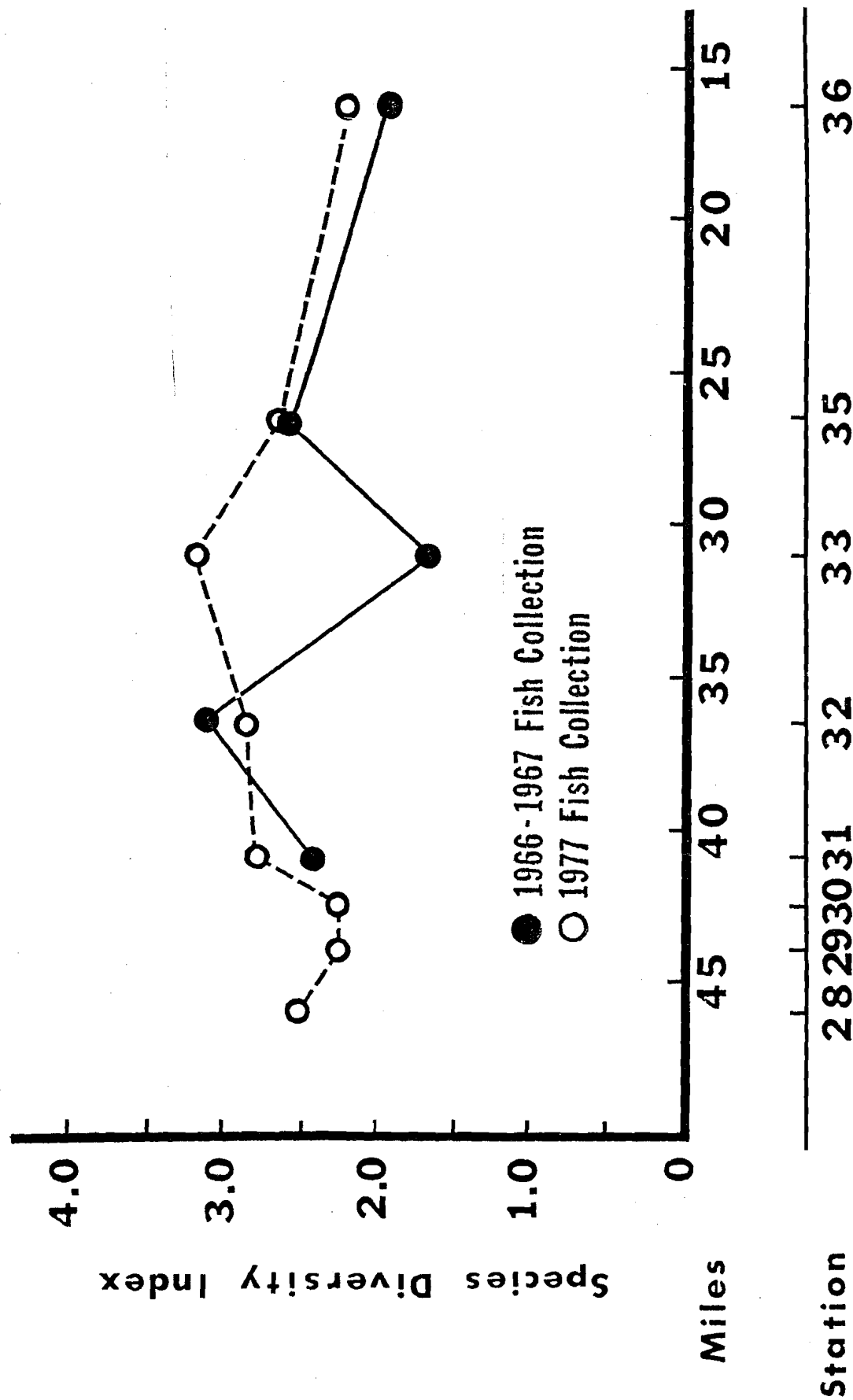


Table 7. Species compositions, species diversity, and evenness of fish communities sampled in the Piedmont Plateau section of the Patuxent River, 1966 and 1977.

Year	1966												1977																
Station	31		32		33		34		35	36	28		29		30		31		32		33		34		35		36		
Month	Jun	Aug	Jun	Jun	Jun	Jul	Jun	Aug	Aug	Jun	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	
<i>Clinostomus funduloides</i>	50	414	4	-	4	-	120	19	-	1	141	2	45	91	117	-	-	1	-	-	-	-	10	9	1	-	-	-	
<i>Notropis cornutus</i>	14	260	6	1	-	-	41	16	-	-	72	66	166	261	465	347	99	107	25	72	-	-	30	6	-	-	-	-	
<i>Notropis proce</i>	-	4	6	-	90	30	46	28	4	-	5	16	3	3	3	2	-	2	1	-	6	13	1	1	-	-	-	-	
<i>Notropis analostanus</i>	-	-	3	3	211	209	20	117	73	-	-	-	-	-	-	-	-	5	1	-	12	24	39	27	45	39	-	-	
<i>Etheostoma olmstedi</i>	-	14	3	-	2	2	33	35	23	1	2	8	5	2	18	40	4	34	4	19	2	12	64	51	51	13	86	112	
<i>Rhinichthys atratulus</i>	33	135	1	-	17	6	32	37	-	101	20	28	26	8	26	42	34	45	-	14	-	1	77	65	4	1	97	17	
<i>Semotilus corporalis</i>	2	35	1	1	10	1	78	153	1	-	9	2	22	13	4	43	5	39	8	10	3	2	57	12	28	7	2	-	
<i>Exoglossum maxillingua</i>	7	12	-	1	20	1	3	3	-	-	10	16	19	1	15	11	5	3	-	2	-	-	8	-	-	-	-	-	
<i>Catostomus commersoni</i>	5	13	-	14	-	-	11	2	-	15	3	1	4	2	16	15	4	35	2	1	1	-	3	3	-	1	55	19	
<i>Rhinichthys cataractae</i>	3	6	5	-	5	5	72	25	-	16	1	2	15	6	28	18	34	4	10	6	1	10	48	43	7	-	42	43	
<i>Nocomis micropogon</i>	1	9	1	-	1	-	-	-	-	-	13	5	30	6	8	-	15	-	11	31	3	-	40	73	-	-	-	-	
<i>Lepomis macrochirus</i>	-	-	-	-	1	3	1	83	69	-	9	12	-	1	1	-	-	1	3	-	12	14	13	13	18	9	-	-	
<i>Hypentelium nigricans</i>	2	1	-	2	1	-	12	4	-	-	5	1	15	3	2	-	-	-	-	-	3	-	4	-	-	-	-	-	
<i>Camptostoma anomalum</i>	31	22	-	4	-	-	-	-	-	-	82	24	6	-	53	23	51	8	35	9	-	-	-	-	-	-	-	-	
<i>Semotilus atramaculatus</i>	-	32	-	-	-	-	-	-	-	12	6	4	2	-	11	18	-	5	4	2	-	1	1	-	6	-	87	20	
<i>Notropis rubellus</i>	-	-	-	-	1	-	-	-	-	-	-	298	-	-	-	153	73	93	-	-	-	-	-	-	-	-	-	-	
<i>Notropis hudsonius</i>	-	-	-	-	2	12	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	2	5	1	1	3	25	-	-
<i>Micropterus salmoides</i>	-	-	-	-	1	-	9	-	-	-	9	2	-	-	4	1	-	4	1	-	-	1	4	-	-	-	-	-	
<i>Pomoxis annularis</i>	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	14	-	-	8	-	-	
<i>Lepomis gibbosus</i>	-	-	-	-	-	-	-	-	11	5	-	-	-	-	-	-	-	-	-	-	-	2	14	-	-	5	3	-	-
<i>Percina pellata</i>	-	1	-	-	2	-	6	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	
<i>Percia flavescens</i>	-	-	-	4	-	-	-	-	2	-	-	-	-	-	-	1	-	-	2	-	-	-	2	3	-	-	-	-	
<i>Salmo gairdneri</i>	-	-	-	-	-	-	-	-	-	-	2	-	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Salmo trutta</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Salvelinus fontinalis</i>	-	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	
<i>Micropterus dolomieu</i>	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Noturus insignis</i>	-	3	-	-	-	1	-	1	1	-	-	-	-	7	-	-	-	-	-	-	-	-	-	1	-	-	-	-	
<i>Pomoxis nigromaculatus</i>	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	1	-	1	-	2	1	-	-	-	-	-	-	
<i>Anguilla rostrata</i>	-	-	-	6	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	8	
<i>Esox americanus</i>	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Esox lucius</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	
<i>Cyprinus carpio</i>	-	-	-	2	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Notemigonus crysoleucas</i>	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Erymyzon oblongus</i>	-	-	1	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	39	-	-	-	-	
<i>Ictalurus catus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Ictalurus nebulosus</i>	-	-	-	-	-	-	-	-	47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	
<i>Lepomis cyanellus</i>	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Percina notogramma</i>	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	
<i>Fundulus diaphanus</i>	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Hybognathus nuchalis</i>	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	
<i>Moxostoma macrolepidotum</i>	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>Lepomis auritus</i>	-	-	-	-	-	-	-	2	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
											1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Number of individuals	148	971	33	44	366	275	475	538	257	161	391	467	370	403	769	716	330	378	111	167	56	113	404	348	185	98	384	219	
Number of species	10	15	11	11	14	13	13	16	16	12	18	16	16	14	16	14	13	14	13	11	13	13	19	16	14	8	7	6	
Species diversity index (H')	2.51	2.34	3.17	3.05	1.89	1.42	3.10	3.01	2.62	1.94	2.80	2.18	2.85	1.67	2.10	2.42	2.76	2.78	2.95	2.75	3.20	3.19	3.31	3.15	2.94	2.30	2.44	2.04	
Evenness index (e)	0.76	0.61	0.92	0.88	0.50	0.38	0.84	0.95	0.66	0.54	0.67	0.54	0.71	0.44	0.52	0.63	0.75	0.73	0.80	0.77	0.87	0.87	0.76	0.79	0.77	0.77	0.87	0.79	

at Stations 31 and 32; 2.49 at Station 28, 2.75 at Station 29 and 2.26 at Station 30. Apparently, this is due to a naturally restricted fauna in the lower stream order of the upstream three stations. The dominant species were N. cornutus, R. atratulus, C. funduloides, S. corporalis and E. maxilllingua. Campostoma anomalum (stoneroller) occurred only in the Piedmont section of the Patuxent River. N. rubellus was not taken in 1966 at Stations 31 and 32, but became abundant in 1977. C. funduloides which was common at Station 31 became rare in 1977. Two species of trout, Salmo gairdneri (rainbow trout) and Salmo trutta (brown trout) were found at Stations 28 and 29 in 1977. They were stocked in recent years by the Maryland State Fisheries Administration.

Stations 33 and 35 were located downstream from the Triadelphia Reservoir. At Station 33 immediately downstream from the reservoir, the species diversity index averaged 1.66 in 1966 and increased significantly ($P < 0.05$) to 3.20 in 1977. The index was 2.62 for the two years at Station 35. N. analostanus, N. procne and R. atratulus which are riffle dwelling species were dominant at Station 33, but L. gibbosus, L. macroshirus and N. hudsonius which are pool dwelling species were dominant at Station 35. C. funduloides, N. cornutus, E. maxilllingua and C. anomalum which are also riffle dwelling species were either absent or very rare at these two stations which contain riffles.

Station 34 was located on the Hawling River, a tributary which joins the main stem of the Patuxent River between Station 33 and Station 35. The fish community at this station was apparently not influenced by the reservoirs. The species diversity index at this station was 3.06 in 1966 and 3.23 in 1977, no significant difference ($P > 0.2$) for the two years. The evenness index was 0.79 in 1966 and 0.90 in 1977. The dominant species were C. funduloides,

N. procne, N. cornutus, N. analostanus, R. atratulus, C. commersoni, and R. catractae. These species represent a combination of the dominant species in the main stem of the Patuxent River above and below the Triadelphia Reservoir and are fairly similar to those in the Middle Patuxent River. Perhaps the fish community structure at this section of the Hawling River represents the natural community of fish in the Piedmont section of the Patuxent River where there is no influence of reservoirs.

Station 36 was located downstream from the T. Howard Duckett Reservoir. The species diversity index increased slightly but not significantly ($P > 0.2$) from 1.94 in 1966 to 2.24 in 1977. R. atratulus, R. catractae, C. commersoni and S. atramaculatus were common for 1966 and 1977.

The Coastal Plain Region

In 1966 there were five sewage treatment plants located in the Coastal Plain section of the Patuxent River. Recently two more plants, Horsepen and Patuxent Wildlife Research Center, were added, so that in 1977 there were seven plants discharging their effluents into the river.

The species composition, species diversity index, and evenness index of the fish communities at Stations 37 - 47 in 1966-67 and 1977 are respectively shown in Tables 8 and 9. Average species diversity indices are compared between 1966 and 1977 in Fig. 6.

At Stations 37 and 38A, upstream of the Maryland City Sewage Treatment Plant outfall, the average species diversity index was respectively 2.41 and 1.68 in 1966 and 1.84 and 2.03 in 1977. The indices were not significantly different ($P > 0.1$ and 0.4) at the two stations between the two years. The evenness indices ranged between 0.54 and 0.73 in 1966 and 0.45 and 0.72 in 1977. The dominant species at these two stations were C. commersoni,

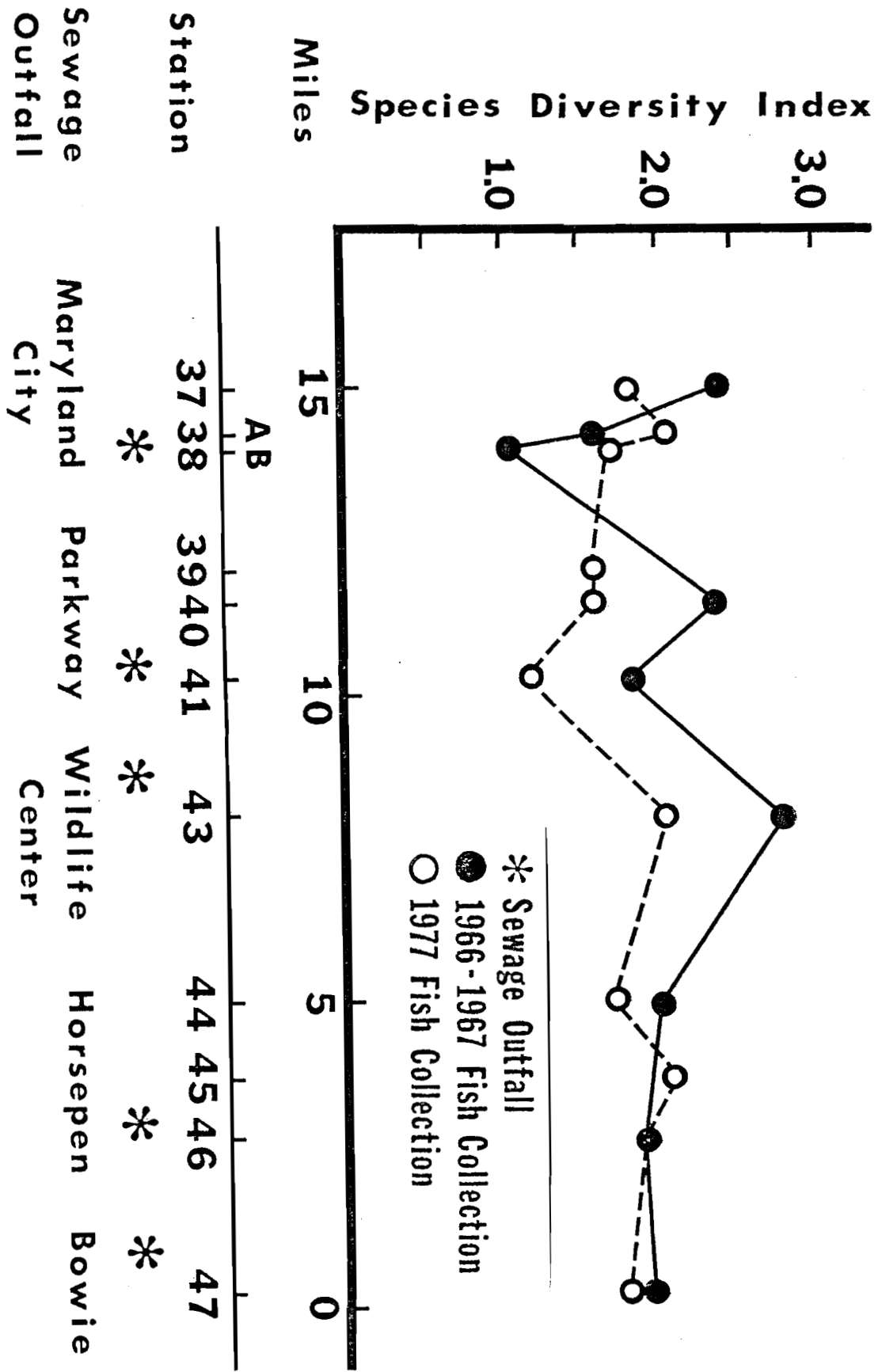
Table 8. Species composition, species diversity, and evenness of fish communities sampled in the Coastal plain section of the Patuxent River in 1966 and 1967.

Year	1966																		1967			
	37		38A		38B		40		41		43		44		46		47		37		46	
Month	Jun	Aug	Jun	Aug	Jun	Aug	Jun	Aug	Jun	Aug	Jun	Jun	Jul	Aug	Jun	Aug	Jul	Aug	Jun	Aug	Jun	Jun
<u>Anquilla rostrata</u>	-	5	-	2	-	4	7	2	4	3	8	8	4	2	2	-	-	-	1	1	-	-
<u>Notemigonus crysoleucas</u>	8	19	-	1	1	1	1	3	1	-	24	9	17	15	3	7	1	3	-	20	1	-
<u>Lepomis gibbosus</u>	23	30	1	7	-	-	4	4	-	1	9	11	3	2	8	7	1	-	-	-	1	-
<u>Catostomus commersoni</u>	11	37	6	42	-	45	4	6	-	-	7	1	-	-	-	1	-	-	32	96	1	-
<u>Etheostoma olmstedi</u>	15	29	28	17	1	-	12	10	-	-	-	-	-	-	7	14	-	-	100	110	41	46
<u>Lepomis macrochirus</u>	1	1	-	-	-	-	-	-	1	-	46	13	12	5	8	8	4	-	-	1	2	3
<u>Esox americanus</u>	-	2	2	-	-	-	-	-	3	2	15	10	1	3	6	5	2	-	-	-	2	-
<u>Ictalurus nebulosus</u>	-	1	-	2	-	5	-	-	-	-	3	8	-	1	-	-	-	2	-	-	-	-
<u>Semotilus corporalis</u>	-	2	-	-	-	-	-	1	-	-	-	-	-	-	5	5	-	-	-	1	5	2
<u>Umbra pygmaea</u>	-	2	-	4	-	2	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-
<u>Rhinichthys cararactae</u>	-	1	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<u>Enneacanthus gloriosus</u>	-	-	-	-	-	-	1	-	-	-	3	67	48	24	3	23	2	-	-	-	-	-
<u>Clinostomus funduloides</u>	-	-	-	-	-	-	-	-	-	-	2	-	-	1	203	122	-	-	1	-	82	21
<u>Notropis procne</u>	-	-	-	-	-	-	2	-	-	-	1	-	-	-	17	24	-	-	-	-	38	28
<u>Rhinichthys atratulus</u>	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	2	4	1	1
<u>Erimyzon oblongus</u>	1	-	-	-	-	-	-	-	-	-	3	1	-	-	-	2	-	3	-	-	-	-
<u>Etheostoma vitreum</u>	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<u>Perca flavescens</u>	-	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-	-	-	-
<u>Aphredoderus sayanus</u>	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-
<u>Esox niger</u>	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-
<u>Cyprinus carpio</u>	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
<u>Notropis analostanus</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
<u>Notropis hudsonius</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
<u>Notropis cornutus</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Number of individuals	62	129	38	77	2	57	31	27	9	7	125	131	86	53	262	220	11	8	136	233	174	104
Number of species	8	11	5	8	2	5	7	7	4	4	14	11	7	8	10	13	6	3	5	7	10	8
Species diversity index (H)	2.30	2.52	1.25	1.99	1	1.12	2.35	2.40	1.75	1.84	2.86	1.80	1.85	2.16	1.42	2.33	2.37	1.56	1.01	1.54	1.95	1.99
Evenness index (e)	.77	.73	.54	.66	1.00	.48	.84	.86	.88	.92	.75	.70	.66	.72	.43	.63	.92	.99	.44	.55	.59	.66

Table 9. Species composition, species diversity, and evenness of fish communities in the Coastal Plain section of the Patuxent River, 1977.

Station	37		38A		38B		39		40		41		43		44		45		46		47		
Month	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	
<u>Anguilla rostrata</u>	7	-	4	4	7	3	6	5	10	-	6	7	6	21	21	18	17	11	4	5	8	7	
<u>Lepomis gibbosus</u>	1	-	-	3	-	-	-	1	2	8	-	1	-	2	1	-	-	1	-	4	2	1	
<u>Catostomus commersoni</u>	65	4	6	2	4	1	5	2	-	1	-	-	-	-	1	1	-	4	-	1	1	-	
<u>Etheostoma olmstedii</u>	135	201	65	50	28	31	64	35	25	22	-	3	9	15	21	37	26	39	23	37	3	3	
<u>Lepomis macrochirus</u>	-	2	4	2	1	-	2	1	1	-	1	-	1	1	3	-	6	2	2	-	5	6	
<u>Semotilus corporalis</u>	122	43	-	12	4	9	2	4	-	-	-	8	6	12	86	59	94	97	136	121	-	-	
<u>Rhinichthys atratulus</u>	5	21	10	18	-	1	-	-	-	-	-	-	-	2	-	1	6	6	-	3	-	-	
<u>Rhinichthys cataractae</u>	6	3	-	6	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	
<u>Clinostomus funduloides</u>	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	1	14	6	24	47	-	-	
<u>Notropis procne</u>	2	6	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	9	8	110	-	-	
<u>Notemigonus crysoleucas</u>	-	-	-	-	1	3	-	-	-	-	-	-	-	1	-	-	-	-	-	-	94	98	
<u>Semotilus atromaculatus</u>	27	3	7	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	
<u>Esox americanus</u>	-	-	-	2	-	-	-	-	-	1	-	-	-	-	4	-	-	-	2	-	-	1	
<u>Erimyzon oblongus</u>	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	
<u>Exoglossum maxillingua</u>	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	
<u>Camptostoma anomalum</u>	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<u>Esox niger</u>	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<u>Notropis analostanus</u>	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	3	-	3	-	-	
<u>Notropis hudsonius</u>	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	51	
<u>Micropterus salmoides</u>	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	2	-	-	-	1	2	
<u>Umbra pygmaea</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	
<u>Notropis cornutus</u>	-	2	1	5	-	-	-	1	-	1	-	-	-	-	-	1	-	1	-	1	-	-	
<u>Noturus insignis</u>	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<u>Enneacanthus gloriosus</u>	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	
<u>Ictalurus nebulosus</u>	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	
<u>Pomoxis annularis</u>	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<u>Notropis rubellus</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21	-	
<u>Ictalurus catus</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	
<u>Aphredoderus sayanus</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	
<u>Noturus gyrinus</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	
Number of Individuals	370	287	97	105	46	48	83	53	40	36	7	19	23	55	138	118	166	180	202	333	140	174	
Number of species	9	11	7	11	7	6	8	10	5	8	2	4	5	8	8	7	8	12	10	11	10	12	
Species diversity index (H')	2.13	1.54	1.69	2.47	1.82	1.60	1.35	1.90	1.49	1.78	.59	1.70	1.93	2.18	1.67	1.67	1.99	2.17	1.65	2.17	1.71	1.84	
Evenness index (e)	.67	.45	.60	.71	.65	.62	.45	.57	.64	.59	.59	.85	.83	.73	.56	.59	.66	.60	.50	.63	.51	.50	

Fig. 6. Longitudinal distribution of the species diversity indices of the fish communities in the coastal plain section of the Patuxent River, 1966 and 1977.



E. olmstedii, and L. gibbosus in 1966. In 1977 the dominant species shifted to E. olmstedii, S. corporalis, C. commersoni, R. atratulus and S. atromaculatus. The shift in dominant species at these stations was noticeable.

Stations 38B and 40 were located on the section of the river below the Maryland City Sewage Treatment Plant outfall. In 1966 the fish community at Station 38B located immediately downstream from the outfall was adversely reduced, but gradually recovered by Station 40, 2.5 miles farther downstream. The average species diversity indices were 1.06 at Station 38B and 2.38 at Station 40. The average evenness indices were 0.74 and 0.85 at these two stations. From 1966 to 1977 at Station 38B the average species diversity index increased slightly to 1.55 but decreased to 1.64 at Station 40. However, such changes at the stations from 1966 to 1977 were not statistically significant ($P > 0.5$ and 0.2). In 1966 the dominant species was C. commersoni at Station 38B, and E. olmstedii was dominant at both stations. The adverse effects of the Maryland City Sewage Treatment Plant outfall observed in 1966 still remained so in 1977.

Stations 41 to 45 were located downstream from the outfall of the Parkway Sewage Treatment Plant, one of the largest plants in the Patuxent River basin. In 1966 only Stations 41, 43 and 44 were sampled. In that time the effects of the effluent on the fish community were already evident. The average species diversity index at these three stations was low; 1.79 at Station 41, 2.33 at Station 43, and 2.01 at Station 44. The evenness indices ranged between 0.66 and 0.92. Enneacanthus gloriosus (bluespotted sunfish), Esox americanus (redfin pickerel), N. crysoleucas, L. gibbosus and L. macrochirus were the dominant species in this section of the river which contained sewage polluted water and thick growths of aquatic vegetation.

In 1977 the species diversity indices were reduced but not enough to be statistically significant ($P > 0.1-0.5$). The species diversity indices were 1.19 at Station 41, 2.05 at Station 43 and 1.67 at Station 44. Aquatic vegetation was scarce. The dominant species were S. corporalis and E. olmstedii. Most of the species that were dominant in 1966 and associated with an aquatic vegetation habitat were either absent or rare in 1977. A substantial shift in the dominant species of the community from 1966 to 1977 was noticed in this section of the Patuxent River.

Station 46 was located at the bridge behind the Bowie Race Track and received an effluent from the Horsepen Sewage Treatment Plant. This plant is the newest one in the Patuxent River basin and is a tertiary treatment plant practicing dechlorination. In 1966 when there was no plant, the average species diversity index at this station was 2.18 and the evenness index was 0.64. The fish community was dominated by E. gloriosus, C. funduloides and N. procne. In 1977 after the plant was operating, the species diversity and evenness indices at Station 46 remained fairly similar ($P > 0.5$) at 1.91 and 0.57, respectively. However, there was a slight shift in dominant species in the community. In 1977, C. funduloides, N. procne and E. olmstedii remained common, S. corporalis became dominant, and E. gloriosus was absent. The effects of the Horsepen Plant effluent on the fish community is apparently minimal. The shift in dominant species could be due to the effect of the pollution resulting from the Parkway Sewage Treatment Plant. This station can be considered as part of the recovery zone extending from Station 41 to Station 47.

Station 47 was located on the main stem of the Patuxent River about a quarter mile upstream from the Patuxent-Little Patuxent confluence. This station receives sewage effluent from the Bowie Sewage Treatment Plant.

In 1966 the average species diversity and evenness indices were 1.97 and 0.96, respectively. In 1977 the species diversity index was 1.71, not significantly different ($P > 0.1$) from that in 1966. The average evenness index decreased to 0.51, due to the increase in number of N. crysoleucas which became the most dominant species in the fish community. The adverse effect of the Bowie plant effluent on fish community was evident in 1966 and remained so in 1977.

CONCLUSION

Fish collections taken in 1966-1967 from the upper Patuxent River, Maryland, were replicated in 1977. Substantial changes in the species composition, species diversity, and structure of the fish communities occurred in the sections of the river receiving sewage effluents from the Savage and Patuxent-Crofton Sewage Treatment Plants. Also, the fish communities in the sections of the river downstream from the City of Columbia and the Triadelphia Reservoir showed obvious changes.

REFERENCES

- Allison, J. T. 1967. The Patuxent River. Report No. 1, Physical, chemical and bacteriological water quality, January, 1961 - February, 1963. Maryland Department of Water Resources. 104 p.
- Allison, J. T. 1970. The Patuxent River. Report No. 4, Physical, chemical and bacteriological water quality, Summer Surveys 1964, 1965, 1966. Maryland Department of Water Resources. 70 p.
- Cox, G. W. 1967. Laboratory manual of general ecology. W. C. Brown Co. Dubuque, Iowa. 165 p.
- Edwards, R. J. 1978. The effect of hypolimnion reservoir releases on fish distribution and species diversity. Trans. Amer. Fish. Soc. 107(1):71-77.
- Mansuetti, R. 1950. An ecological and distributional study of the fishes of the Patuxent River watershed, Maryland. University of Maryland, M.S. thesis. 180 p.
- Maryland Water Pollution Control Commission. 1958. Little Patuxent River survey. 15 p. (mimeo).
- Richards, J. S. 1976. Changes in fish species composition in the Au Sable River, Michigan from the 1920's to 1972. Trans. Amer. Fish Soc. 105(1):32-40.
- Tsai, C. 1968. Effects of chlorinated sewage effluents on fishes in Upper Patuxent River, Maryland. Chesapeake Science 9(2):82-93.
- Tsai, C. 1970. Changes in fish populations and migration in relation to increased sewage pollution in Little Patuxent River, Maryland. Chesapeake Science 11(1):34-41.
- Tsai, C. 1971. The Patuxent River: People, Pollution & Pisces. Marine Pollut. Bull. 2:13-14.
- Tsai, C. 1972. Life history of the Eastern Johnny darter, *Etheostoma olmstedi*, in cold tailwater and sewage-polluted water. Trans. Amer. Fish. Soc. 101(1):80-88.
- Tsai, C. and R. B. Zeisel. 1969. Natural hybridization of cyprinid fishes in Little Patuxent River, Maryland. Chesapeake Science 10(2):69-74.
- Weber, C. I. 1973. Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents. EPA-640/4-73-001, U.S. Environmental Protection Agency, Cincinnati, Ohio.
- Zajac, J. E. 1971. Water Pollution, Disposal and Reuse. Vol. 1. Marcel and Dekker, Inc. 389 p.
- Zar, G. 1974. Biostatistical Analysis. Prentice Hall, Inc.

APPENDIX

FRESHWATER FISHES OF THE PATUXENT RIVER

A List of Fishes Collected in the Upper Patuxent River above
the Tidal Water Zone, 1966-1968 and 1977

Family Salmonidae -- trouts

Rainbow trout	<u>Salmo gairdneri</u> Richardson
Brown trout	<u>Salmo trutta</u> Linnaeus
Brook trout	<u>Salvelinus fontinalis</u> (Mitchill)

Family Umbridae -- mudminnows

Eastern mudminnow	<u>Umbra pygmaea</u> (DeKay)
-------------------	------------------------------

Family Esocidae -- pikes

Redfin pickerel	<u>Esox americanus</u> Gmelin
Northern pike	<u>Esox lucius</u> Linnaeus
Chain pickerel	<u>Esox niger</u> LeSueur

Family Cyprinidae -- minnows and carps

Stoneroller	<u>Campostoma anomalum</u> (Rafinesque)
Rosyside dace	<u>Clinostomus funduloides</u> Girard
Carp	<u>Cyprinus carpio</u> Linnaeus
Cutlip minnow	<u>Exoglossum maxillingua</u> (LeSueur)
Silvery minnow	<u>Hybognathus nuchalis</u> Agassiz
River chub	<u>Nocomis micropogon</u> (Cope)
Golden shiner	<u>Notemigonus crysoleucas</u> (Mitchill)
Satinfin shiner	<u>Notropis analostanus</u> (Girard)
Common shiner	<u>Notropis cornutus</u> (Mitchill)
Spottail shiner	<u>Notropis hudsonius</u> (Clinton)
Swallowtail shiner	<u>Notropis procne</u> (Cope)
Rosyface shiner	<u>Notropis rubellus</u> (Agassiz)
Blacknose dace	<u>Rhinichthys atratulus</u> (Hermann)
Longnose dace	<u>Rhinichthys cataractae</u> (Valenciennes)
Creek chub	<u>Semotilus atromaculatus</u> (Mitchill)
Fallfish	<u>Semotilus corporalis</u> (Mitchill)

Family Catostomidae -- suckers

White sucker	<u>Catostomus commersoni</u> (Lacépède)
Creek chubsucker	<u>Erimyzon oblongus</u> (Mitchill)
Northern hog sucker	<u>Hypentelium nigricans</u> (LeSueur)
Northern red horse	<u>Moxostoma macrolepidotum</u> (LeSueur)

Family Ictaluridae -- freshwater catfishes

White catfish	<u>Ictalurus catus</u> (Linnaeus)
Brown bullhead	<u>Ictalurus nebulosus</u> (LeSueur)
Tadpole madtom	<u>Noturus gyrinus</u> (Mitchill)
Margined madtom	<u>Noturus insignis</u> (Richardson)

Family Cyprinodontidae -- killifishes

Banded killifish	<u>Fundulus diaphanus</u> (LeSueur)
Mummichog	<u>Fundulus heteroclitus</u> (Linnaeus)

Family Aphredoderidae-- pirate perches

Pirate perch	<u>Aphredoderus sayanus</u> (Gilliams)
--------------	--

Family Percichthyidae -- temperate basses

White perch	<u>Morone americana</u> (Gmelin)
-------------	----------------------------------

Family Centrarchidae -- sunfishes

Rock bass	<u>Ambloplites rupestris</u> (Rafinesque)
Bluespotted sunfish	<u>Enneacanthus gloriosus</u> (Holbrook)
Redbreast sunfish	<u>Lepomis auritus</u> (Linnaeus)
Green sunfish	<u>Lepomis cyanellus</u> Rafinesque
Pumpkinseed	<u>Lepomis gibbosus</u> (Linnaeus)
Bluegill	<u>Lepomis macrochirus</u> Rafinesque
Smallmouth bass	<u>Micropterus dolomieu</u> Lacépède
Largemouth bass	<u>Micropterus salmoides</u> (Lacépède)
White crappie	<u>Pomotis annularis</u> Rafinesque
Black crappie	<u>Pomaxis nigromaculatus</u> (LeSueur)

Family Percidae -- perches

Tessellated darter	<u>Etheostoma olmstedii</u> Storer
Glassy darter	<u>Etheostoma vitreum</u> (Cope)
Yellow perch	<u>Perca flavescens</u> (Mitchill)
Stripe back darter	<u>Percina notogramma</u> (Raney and Hubbs)
Shield darter	<u>Percina peltata</u> (Stauffer)