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Seasonal Abundance & Diversity of Fishes at Three Stations on the Middle Fork of Drake's Creek, Warren & Allen Counties, Kentucky

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SEASONAL ABUNDANCE AND DIVERSITY OF FISHES AT THREE STATIONS ON THE MIDDLE FORK OF DRAKE'S CREEK, WARREN AND ALLEN COUNTIES, KENTUCKY

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SEASONAL ABUNDANCE AND DIVERSITY OF FISHES AT THREE
STATIONS ON THE MIDDLE FORK OF DRAKE'S CREEK,
WARREN AND ALLEN COUNTIES, KENTUCKY

David Ellis Bell August, 1977 59 pages
Directed by: R. Hoyt, R. Prins, and G. Dillard
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A total of 7,485 fish, representing 49 species, 25 genera, and 11 families, were electroshocked from three stations on the Middle Fork of Drake's Creek during the period January, 1972 through January, 1973. Community structure was influenced by seasonal changes in both numbers of species and numbers of individuals. The number of species per collection was at its highest, at all stations, during the month of September. The total number of species and individuals collected at each station progressively increased toward the upstream areas. Eleven of the forty-nine species collected during the course of the study provided 91.8% of the total number collected.

Diversity ($\bar{D}$) values were used to compare average diversities for each of the monthly samples at each station. Monthly diversity values tended to fluctuate erratically, with the greatest stability being observed at the "mid-stream" study area. Individual species' contribution to diversity were computed using "information units" expressed as a percentage of the total diversity to find dominant species at each station and during each season.

Species were categorized, according to frequency of occurrence, into permanent residents, seasonal residents, and transients. Monthly contributions to diversity, expressed in per cent, were used to compare dominant species of each category at each station. Transient species

were observed to be most prominent in the lower stream reaches during the period June through September.

Attempts were made to detect movement of stream fishes by mark-and-recapture techniques. The recapture of marked fish represented a return of 10.9%, as 16 of 146 marked fish were recaptured. The home range concept of some stream fishes was supported in some instances; however, streams were found to be open systems which do not lend themselves readily to mark-and recapture studies.

INTRODUCTION

In future years, as stream pollution abatement regulations become more strict and lakes and reservoirs receive increasing usage, stream fisheries must ultimately play a more pronounced role in offsetting pressure from increasing numbers of fishermen. It is reasonable to foresee comprehensive management plans being applied to many of Kentucky's more productive streams. Already, put-and-take trout fisheries have been established in many of the cooler, less-polluted streams, and redbreast sunfish are being evaluated for possible stocking in those streams which have been degraded by acid waters. Regardless of the validity of the assumption that management plans are forthcoming for stream fisheries, vital information is needed concerning the present state of stream fish populations, their community structure, their interactions, seasonal changes, relative abundance, and their movement patterns.

Information such as the above is very limited for stream fish populations, particularly information dealing with these parameters on an annual basis. It has been shown that fishes repopulate decimated areas of streams and seem to do so at increased rates during certain periods of the year (Larimore *et al*., 1959; Berra and Gunning, 1970). Harrel, *et al*. (1967) reported that intermittent streams could be invaded by most species after only two or three days of flow. Funk (1957), in a study on the movement of stream fishes, concluded that for most species there seems to be a mobile and a sedentary component. Gerking (1953) had previously reported that in some populations of stream fishes there existed definite home ranges. He felt that in streams with riffle-pool development, the fish populations may be considered a series of discrete, natural units rather than a single homogeneous, freely-mixing group. Smith and Powell (1971) also feel that inter-species relationships among fishes are predictable and that fish assemblages are biocoenoses of ecologically interacting forms; i.e., they are true communities and not merely fortuitous associations.

Kuehne (1962), on the other hand, feels that the exclusiveness of pool and riffle communities has been exaggerated probably in a subjective desire to fit the classifications making use of these two habitats. Sheldon (1968) also feels the fish fauna of a single pool cannot be considered completely independent of adjoining riffle areas.

In recent years, the use of various diversity indices has gained wide acceptance as means of summarizing large amounts of information about numbers and kinds of organisms. These indices have been applied, to some extent, to studies concerning fish community structure. In this regard, Smith and Powell (1971) have stated that the faunal composition, although frequently the only kind of information available, conveys a minimum of information about the community structure.

Previous studies concerning species diversity in stream fish assemblages have generally involved comparisons of stream order (Whiteside and McNatt, 1972; Harrel et al., 1967), or longitudinal succession (Sheldon, 1968). Smith and Powell (1971) used species diversity indices to describe the summer fish communities of a stream in Oklahoma. Recently, Harima and Mundy (1974) used diversity indices to study the numerical and biomass structures of the fish biofacies from a small stream in Alabama. Except for the latter study, these studies were all of short duration, involving periods of less than twelve months. The study of Harima and

Mundy (1974), although on an annual basis, involved a single, localized area and, due to frequent sampling and the removal of all collected fish from the area populations, may have been affected by decimation of the natural populations.

The present study was concerned with evaluating the community structure of the fishes in three areas (upper reaches, mid-reaches, and lower reaches) of the Middle Fork of Drake's Creek, on an annual basis. This evaluation included studies on the relative abundance of species and individuals throughout the year, seasonal fluctuations in populations, diversity indices and any observable fluctuations, the relative contribution of each species to the overall diversity, and any observed movement of these stream fishes.

MATERIALS & METHODS

Fish were collected from three stations on the Middle Fork of Drake's Creek during the period January, 1972 - January, 1973. Monthly collections were made at each of these stations, except at Stations 2 and 3 during January, 1972, and Stations 1 and 2 during November and December, 1973, when water conditions were such that collecting was impossible.

Fish were collected using standard electroshocking and seining techniques. Electrofishing gear consisted of a portable "Tiny Tiger" generator (O & R Manufacturing Co.) with home-made stainless steel electrodes. The generator supplied 110 volts alternating current and 250 continuous watts, with maximum surges of 350 watts. Power was supplied to the generator by a 1 horsepower, 2-cycle, gasoline engine. Stunned fish were retrieved with large, fine-mesh dip-nets and placed in live-tanks. Ice was added to these holding tanks in the warmer months to enhance fish survival. All fish were held in the holding tanks until the collection at a given station was completed.

Sampling time at each station varied according to stream conditions but generally approximated one hour. However, in all cases a predetermined area of stream (as given in station descriptions) was sampled at each station.

Fish were identified to species, measured for total length, and returned to the stream as quickly as possible. Fish that could not be identified in the field, or which died during the course of collecting and/or holding, were fixed and returned to the laboratory. These fish, in addition to one or two specimens of all other species collected, were used to develop a reference collection of Drake's Creek fishes. Nomenclature follows that recommended by Bailey et al. (1970). All fish returned to the laboratory were fixed in a 10% formaldehyde solution followed by preservation in 70% ethanol.

Water chemistry determinations, including pH, total hardness, total alkalinity, and dissolved oxygen were performed with a Hach chemical kit, Model AL-36-WR. Temperatures in the Middle Fork were measured with a standard mercury Celsius thermometer. Determinations were made at each station at the end of each collecting period, except at Station 1 during January and February, 1972, when no determinations were made. Discharge, in liters per second, was estimated using methods described by Embody (1927). Determinations were made at each station at the end of each collecting period, except at Stations I-III during January and February, 1972, and Stations I and III during March, 1972. These determinations represent discharge at the time of collection only; they are not mean monthly discharge values.

Total numbers of individuals (N), number of individuals per species (n_1) and number of species present (s) were used to calculate an estimate of the average diversity ($\overline{D}$) according to the following equation, as variously used by Pielou, 1966; Wilhm and Dorris, 1968; Cairns, et al., 1971; McIntosh, 1967; and Whiteside and McNatt, 1972:

$$\overline{D} = -\sum_{i=1}^{s} ni/N \log_2 ni/N$$

Computations were performed at Western Kentucky University on a PDP-8 data processing machine.

Individual species information units, referred to as "bits" when logarithms to base 2 are used (Pielou, 1966; McIntosh, 1967), were used in attempts to evaluate the relative contribution individual species made to the overall community diversity. These contributions were expressed as percentages of the total community diversity (%CD). The January, 1972, collection at Station I is given below as an example of the procedures used:

Number of Species (s) = 11

Number of individuals (N) = 42

Species	Number Collected	"bits" $= (\frac{ni}{N} \log_2 \frac{ni}{N})$	%CD- $(\frac{\text{"bits"}}{\bar{D}})$
N. hog sucker	5	-0.366	12.0%
Stoneroller minnow	5	-0.366	12.0%
Greenside darter	1	-0.128	4.2%
Bluntnose minnow	1	-0.128	4.2%
Rock bass	2	-0.209	6.9%
Longear sunfish	5	-0.366	12.0%
Orangefin darter	3	-0.272	8.9%
"Ulocentra" darter	1	-0.128	4.2%
Rainbow darter	9	-0.476	15.6%
Spotfin shiner	1	-0.128	4.2%
Banded sculpin	9	-0.476	15.6%
	42	$\bar{D} = -\Sigma \frac{ni}{N} \log_2 \frac{ni}{N} = 3.043$	99.8%

This method was felt to be superior to the use of absolute numbers or relative abundance computations as absolute numbers may fluctuate widely in a given species without the relative contribution of this species to the community changing to similar degrees. In addition, %CD values are affected by the number of species present, the number of individuals per species, and the total number of individuals present. Relative abundance values would not reflect all of these parameters.

Averages were obtained from %CD values for each species during each collection. These averages were used to compare average-monthly-contributions to diversity (AMCD) and average-seasonal-contributions to diversity (ASCD).

Based upon frequency of occurrence at each station, fish were categorized as permanent residents, seasonal residents, or transients. The criterion for permanent resident classification was presence in a total of 8 or more collections at a given station. Seasonal residents were collected 3 to 7 times at a given station; transients were collected 2 or fewer times. The total number of collections at each station varied from 11 at Stations I and III to 10 at Station II.

Attempts were made to detect movement of stream fishes by mark-and-recapture techniques. Fast Turquoise KS Liquid (Allied Chemical Corporation, National Aniline Division; Cincinnati, Ohio) was injected subcutaneously in several species (Many species' body size precluded practical efforts at injecting them) using disposable hypodermic syringes. Areas of the body which were marked included the lower jaw, caudal peduncle, base of the dorsal fin and base of the anal fin. Differing body marks were used to distinguish specific stations and to separate dates of marking.

STUDY AREA

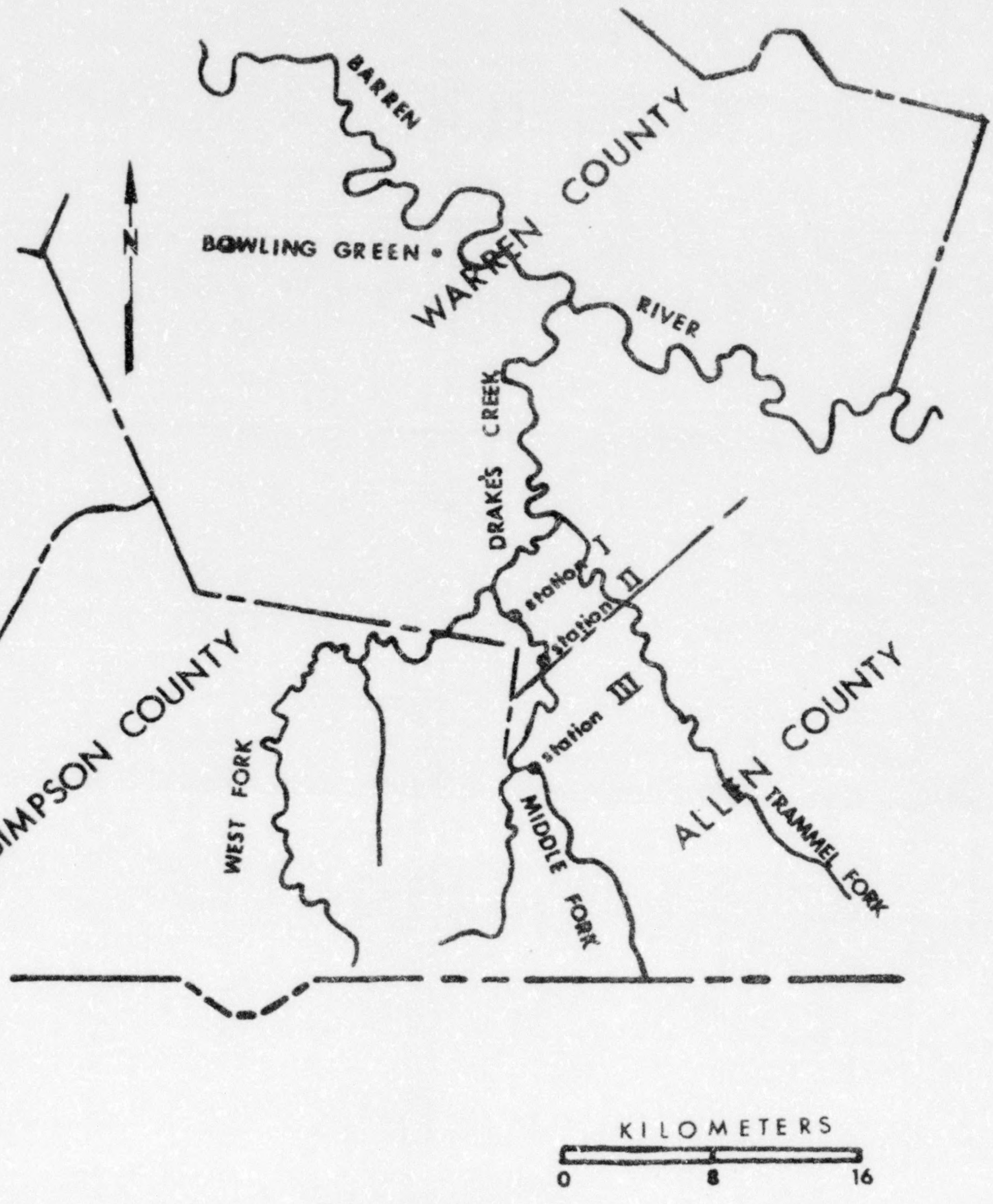
The study area consisted of three stations located on the Middle Fork of Drake's Creek, Warren and Allen counties, Kentucky (Figure 1).

The Middle Fork of Drake's Creek originates in northcentral Tennessee and courses 33.8 kilometers (km) through portions of Allen, Simpson and Warren counties, Kentucky. The convergence of the Middle Fork, West Fork and Trammel Fork forms Drake's Creek which courses through the southeastern portion of Warren County, Kentucky, emptying into Barren River approximately 6.4 km east of Bowling Green, Kentucky.

Middle Fork Creek has characteristics which are typical of the karst topography of southcentral Kentucky having a bedrock or coarse rubble substrate with alternating pool and riffle areas. The stream flows over a layer of Fort Wayne limestone, siltstone and shale. Areas surrounding the gravel, sand and clay alluvial floodplain are overlain by Salem and Warsaw limestone formations with various thicknesses of alluvial covering. This alluvium consists of poorly sorted, unconsolidated clay, silt, sand and rock fragments. Higher elevations of the watershed are capped by St. Louis limestone which is covered in most areas by reddish-brown soil that contains much chert [U.S.G.S. - Hickory Flat (1965) and Adolphus (1964) quadrangles]. The Middle Fork is canopied in most areas by a riparian forest of varying depth, composed chiefly of sycamore, beech, oak, and hickory species. Nonforested areas along the stream are used for agricultural purposes, both as cropland and cattle pasture.

The creek descends from an elevation of 186 meters (m) above mean sea level (msl) at the Kentucky-Tennessee boundary in Allen County to an elevation of 146 m msl at its mouth, with an average gradient of 3.0 m/km.

Figure 1. Map of Middle Fork of Drake's Creek showing general drainage area and locations of study sites.


BARREN
RIVER
WARREN COUNTY
BOWLING GREEN
N
DRAKES CREEK
station I
station II
station III
SIMPSON COUNTY
ALLEN COUNTY
WEST FORK
MIDDLE FORK
TRAMMEL FORK
KILOMETERS
0
8
16

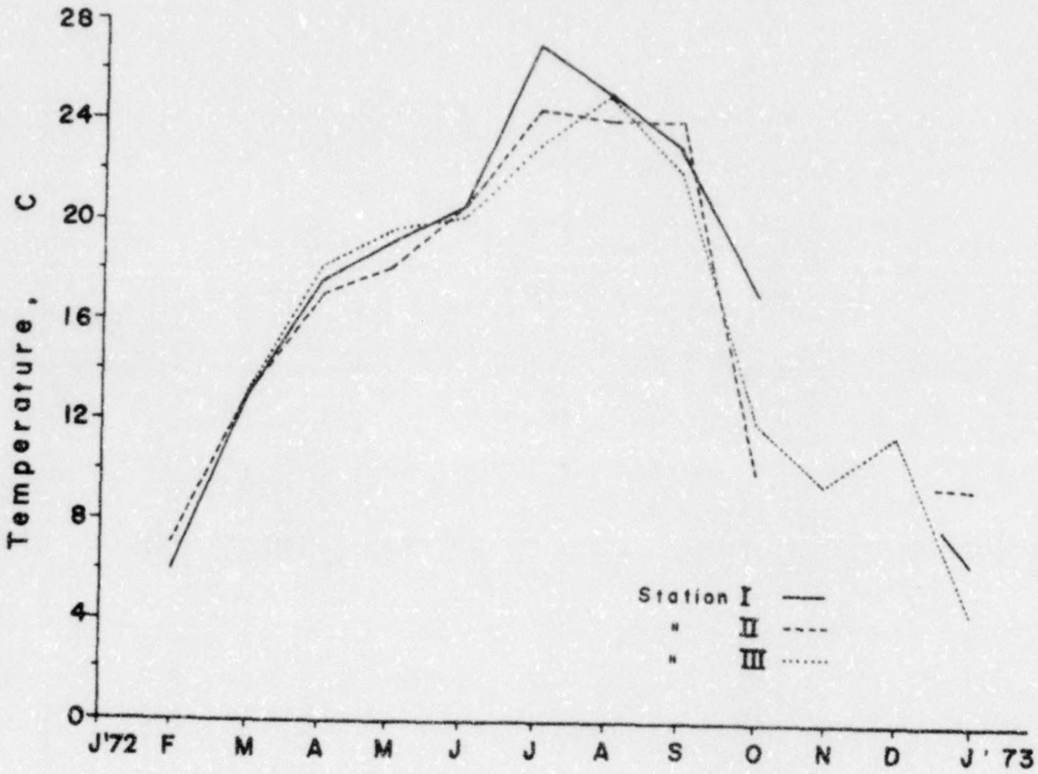
Station I: Station I was located 3.6 km upstream from the mouth of Middle Fork Creek. The downstream boundary of Station I was formed by a gravel ford which received limited use from area residents. The upstream station boundary was formed by a shoal area (average depth = 16 centimeter (cm), average width = 11 m, length = 20 m) which was located at the head of a long, shallow pool (average depth = 19 cm, average width = 13 m, length = 36 m). This pool was bordered on the east by a steep mud and clay bank with overhanging trees and on the west by limestone outcroppings at and under the surface. Proceeding downstream, the pool ended abruptly at a bedrock and broken rubble area (average depth = 8 cm, average width = 15 m, length = 3 m) followed by a shallow pool (average depth = 14 cm, average width = 13 m, length = 17 m) and gravel and rubble riffle area (average depth = 5 cm, average width = 8 m, length = 48 m) which formed the basis, at its lower end, for the fordable portion of the stream. The average gradient at Station I was 1.2 m/km.

Temperatures at Station I ranged from 6.5 C in January, 1973, to 27 C in July, 1972 (Figure 2). Dissolved oxygen (D.O.) varied from 7 milligrams per liter (mg/l) in September, 1972, to 13 mg/l in January, 1973 (Figure 3). Total alkalinity, as $CaCO_3$, ranged from 180 mg/l in September, 1972, to 128 mg/l in January, 1973 (Figure 4); total hardness, as $CaCO_3$, ranged from 205 mg/l in September, 1972, to 137 mg/l in July, 1972 (Figure 5). The pH of Middle Fork at Station I varied from 8.8 during August, 1972, to 7.6 during October, 1972 (Figure 6). Discharge at Station I ranged from 4,309 liters per second in April, 1972, to 71 liters per second in September, 1972 (Figure 7).

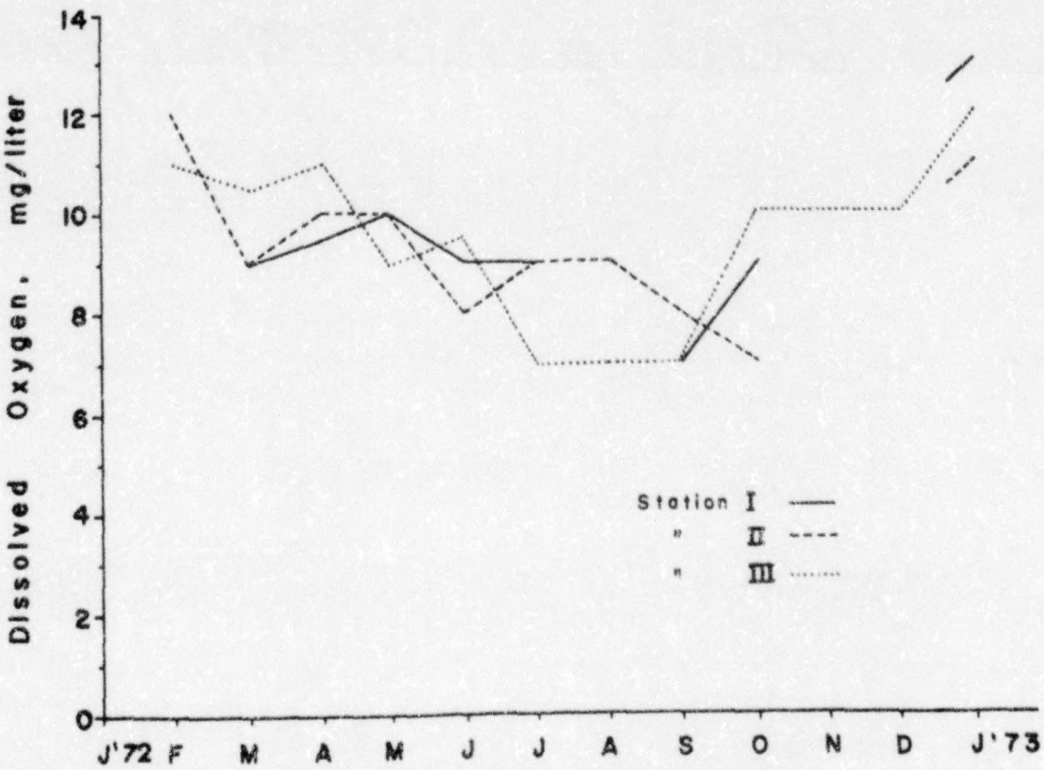
Station II: Station II was located 5.8 km upstream from Station I. The upstream boundary of Station II consisted of the lower portion of a large, rather uniformly deep pool (average depth = 18 cm, average

Figure 2. Water temperatures, in degrees Celsius, for each station during the period February, 1972, through January, 1973.

Figure 3. Dissolved oxygen concentrations, in milligrams per liter, for each station during the period February, 1972, through January, 1973.



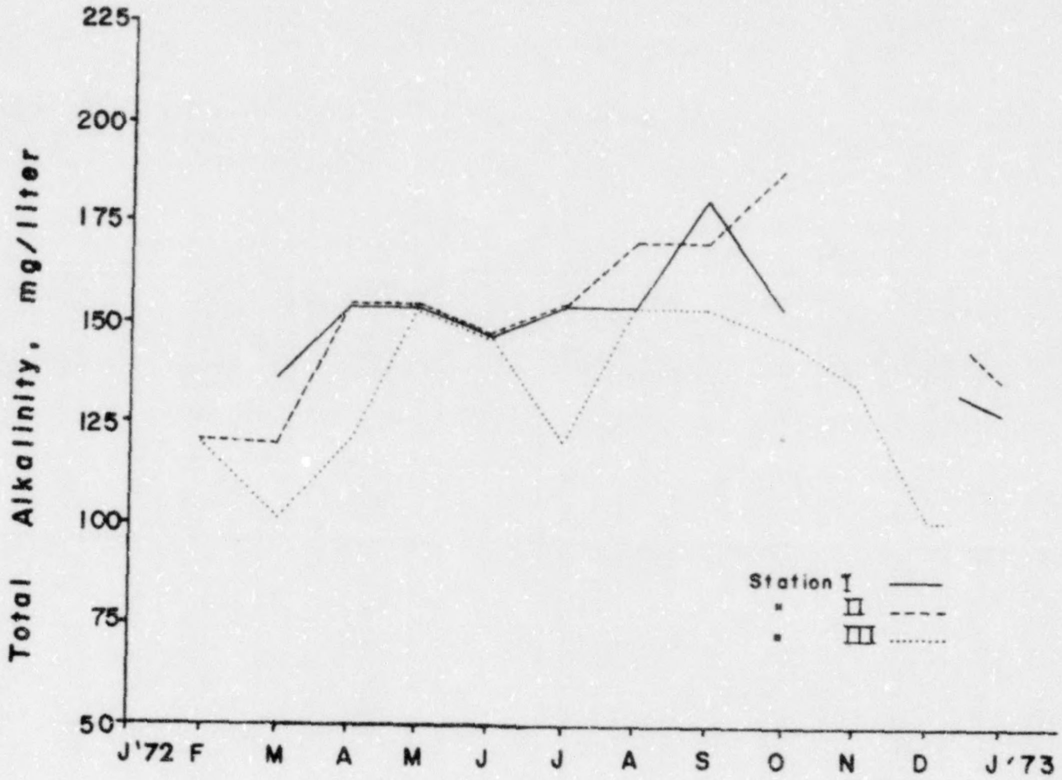
Temperature, C
28
24
20
16
12
8
4
0
J'72 F M A M J J A S O N D J'73
Station I
" II
" III



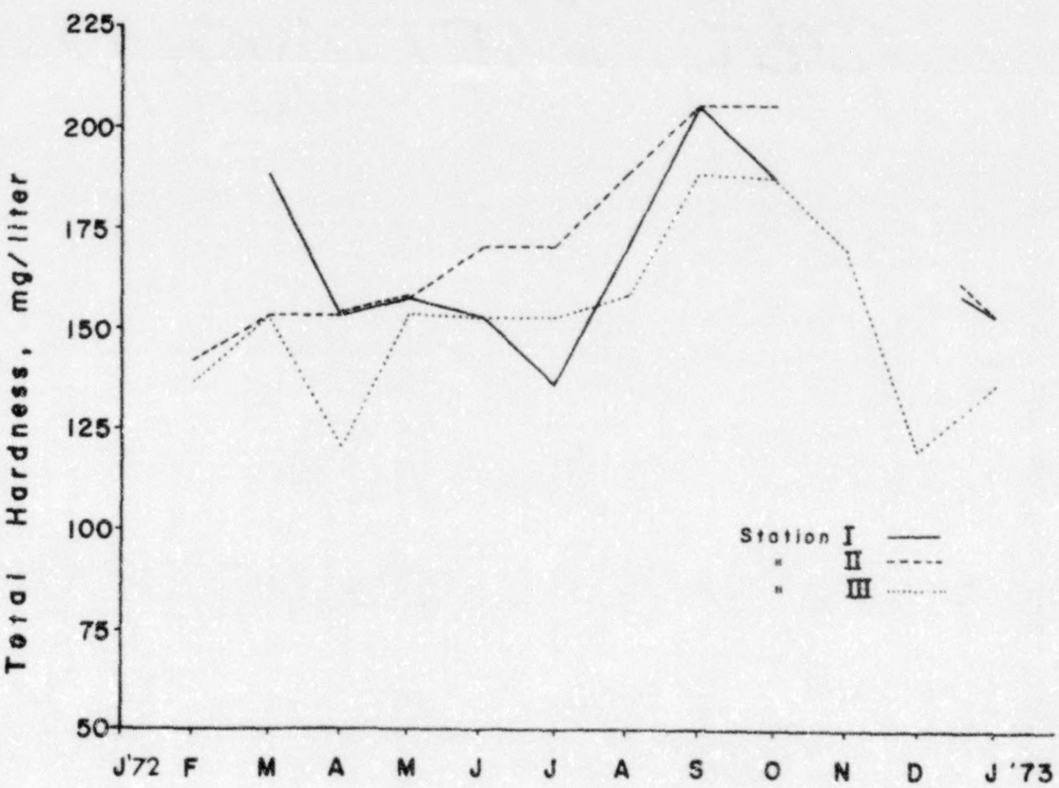
Dissolved Oxygen, mg/liter
14
12
10
8
6
4
2
0
J'72 F M A M J J A S O N D J'73
Station I
" II
" III

Figure 4. Total alkalinity, in milligrams per liter, for each station during the period February, 1972, through January, 1973.

Figure 5. Total hardness, in milligrams per liter, for each station during the period February, 1972, through January, 1973.



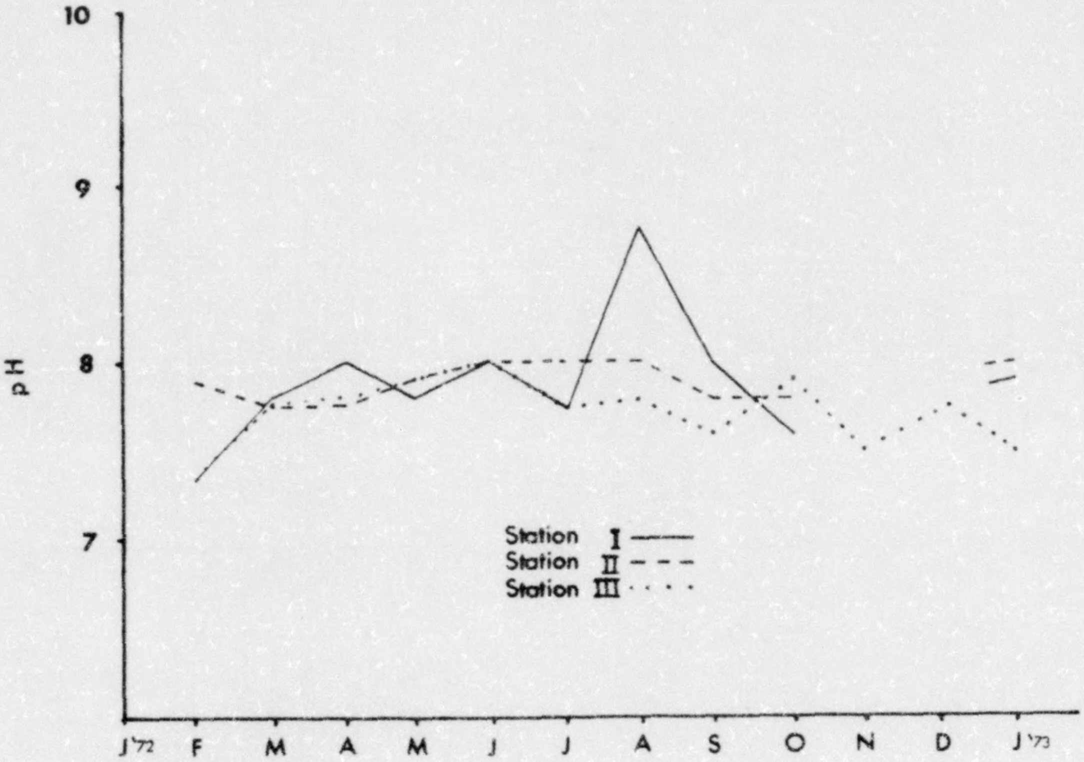
Total Alkalinity, mg/liter
225
200
175
150
125
100
75
50
J'72
F
M
A
M
J
J
A
S
O
N
D
J'73
Station I
" II
" III

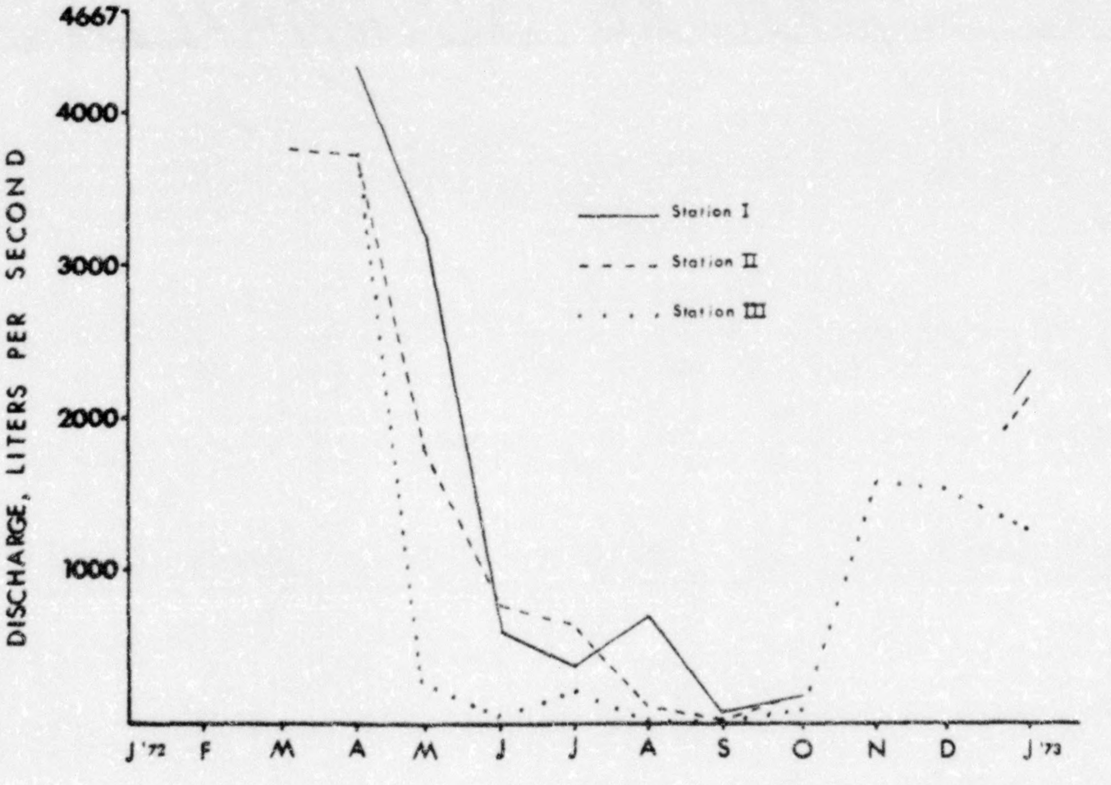


Total Hardness, mg/liter
225
200
175
150
125
100
75
50
J'72
F
M
A
M
J
J
A
S
O
N
D
J'73
Station I
" II
" III

Figure 6. Hydrogen ion concentration (pH) for each station during the period February, 1972, through January, 1973.

Figure 7. Discharge, in liters per second, during the period February, 1972, through January, 1973.


10
9
8
7
pH
Station I
Station II
Station III
J'72
F
M
A
M
J
J
A
S
O
N
D
J'73


4667
4000
3000
2000
1000
DISCHARGE, LITERS PER SECOND
Station I
Station II
Station III
J'72
F
M
A
M
J
J
A
S
O
N
D
J'73

width = 14 m, length = 31 m). This pool emptied into a narrow chute (average depth = 6 cm, average width = 7 m, length = 60 m) then emptied into another large pool (average depth = 13 cm, average width = 14 m). The upper, shallow portion of this pool (approximately 20 m long during normal flow periods) constituted the lower limits of Station II. The substrate was primarily gravel and exposed clay. The east bank was steep and eroded, exposing clay and gravel while the west bank was heavily vegetated with willow and various understory species. The average gradient at Station II was 2.5 m/km.

Temperatures at Station II ranged from 7 C in February, 1972, to 24.5 C in July, 1972 (Figure 2). D.O. varied from 12 mg/l in February, 1972, to 7 mg/l in October, 1972 (Figure 3). Total alkalinity ranged from 188 mg/l in October, 1972, to 120 mg/l in February and March, 1972 (Figure 4); total hardness ranged from 205 mg/l in September and October, 1972, to 142 mg/l in February, 1972 (Figure 5). The pH varied only slightly (7.8 - 8.0) during all collections at Station II (Figure 6). Discharge at Station II ranged from 3,775 liters per second in March, 1972, to 19 liters per second in September, 1972 (Figure 7).

Station III: Station III was located 10 km upstream from Station II. The upper limits of Station III consisted of an area immediately upstream from a low-water, culvert-type concrete bridge. This area was a wide shoal-like expanse (average depth = 8 cm, average width = 16 m, length = 23 m) which was bordered on the north side by a deeper chute (average depth = 18 cm, average width = 2 m). Below the low-water bridge Station III contained a large, deep pool (average depth = 1 m, average width = 21 m, length = 8 m). Proceeding downstream, Station III included shallow riffle and intermittent shoal areas surrounded by gravel bars (approximate average depth = 4 cm, width = 8 m, length = 91 m).

This area contained two large holes formed by water-action around submerged tree trunks and root structures. These holes each had approximate depths of 1 m. The substrate at Station III was primarily gravel except for broken concrete which was piled below the low-water bridge, apparently to prevent undercutting of the bridge by water-action. The average gradient at Station III was 4.9 m/km. The banks on each side contained a narrow band of mature riparian vegetation.

Temperatures at Station III ranged from 4.5 C in January, 1973, to 25 C in August, 1972 (Figure 2). D.O. varied from 7 mg/l in July, August and September, 1972, to 12 mg/l in January, 1973 (Figure 3). Total alkalinity ranged from 103 mg/l to 154 mg/l (figure 4); total hardness ranged from 188 mg/l in September and October, 1972, to 120 mg/l in April and December, 1972 (Figure 5). The pH varied from 7.3 to 8.0 (Figure 6). Discharge at Station III ranged from 3,718 liters per second in April, 1972, to 0 liters per second in September, 1972 (Figure 7).

RESULTS

A total of 7,485 fish, representing 49 species, 25 genera, and 11 families, were collected from the three stations during the study period (Table 1). Station I provided 28 species totaling 1,964 specimens (Table 2); Station II, 34 species and 2,318 specimens (Table 3); and Station III, 39 species and 3,203 specimens (Table 4). The number of species per collection averaged 15.1 at Station I, 14.8 at Station II and 17.8 at Station III. At all stations, the number of species per collection was at its highest during September, with marked decreases in the following months (Figure 8).

Twenty-one species were common to all three stations at some time during the collecting period (Table 1). Three species were unique to Station I (Table 1), however, these species were not abundant (Table 2). Six species were collected only at Station II (Table 1) of which only one occurred in more than one monthly collection (Table 3). Nine species were taken only at Station III (Table 1); five of these were represented only by single occurrences, the remaining four occurring in multiple collections (Table 4).

Several species occurred at combinations of two stations but not at all three. The brook silverside was taken only at Stations I and II. Six species, southern redbelly dace, northern studfish, blackstripe topminnow, smallmouth bass, logperch, and johnny darter, were collected only at Stations II and III. Three species, carp, bigeye chub, and green sunfish, were taken at Stations I and III, but not at Station II.

TABLE I

SPECIES LIST AND NUMBERS OF INDIVIDUALS OF EACH SPECIES COLLECTED AT EACH STATION.

Scientific Name	Common Name	Station I	Station II	Station III	Total
Family Petromyzontidae					
Lampetra aepyptera (Abbott)	Least brook lamprey			6	6
Family Lepisosteidae					
Lepisosteus osseus (Linnaeus)	Longnose gar		3		3
Family Cyprinidae					
Campostoma anomalum (Rafinesque)	Stoneroller	1024	760	1000	2784
Cyprinus carpio Linnaeus	Carp	3		1	4
Hybopsis amblops (Rafinesque)	Bigeye chub	1		1	2
Nocomis micropogon (Cope)	River chub		1		1
Notemigonus crysoleucas (Mitchill)	Golden shiner	1			1
Notropis ardens (Cope)	Rosefin shiner	88	259	468	815
Notropis boops Gilbert	Bigeye shiner			2	2
Notropis cornutus (Mitchill)	Common shiner	53	248	238	539
Notropis photogenis (Cope)	Silver shiner			3	3
Notropis rubellus (Agassiz)	Rosyface shiner	2	5	3	10
Notropis spilopterus (Cope)	Spotfin shiner	11	15	15	41
Notropis stramineus (Cope)	Sand shiner	4	32	5	41
Notropis venustus (Girard)	Blacktail shiner		1		1
Phoxinus erythrogaster (Rafinesque)	Southern redbelly dace		1	1	2
Pimephales notatus (Rafinesque)	Bluntnose minnow	56	373	435	864
Semotilus atromaculatus (Mitchill)	Creek chub	15	4	28	47

TABLE I (continued).

Scientific Name	Common Name	Station I	Station II	Station III	Total
Family Catostomidae					
Catostomus commersoni (Lacepede)	White sucker			1	1
Hypentelium nigricans (Lesueur)	Northern hog sucker	64	145	80	289
Minytrema melanops (Rafinesque)	Spotted sucker		1		1
Moxostoma duquesnei (Lesueur)	Black redhorse			3	3
Moxostoma erythrurum (Rafinesque)	Golden redhorse	8	22	53	83
Family Ictaluridae					
Ictalurus melas (Rafinesque)	Black bullhead	1			1
Ictalurus natalis (Lesueur)	Yellow bullhead			1	1
Ictalurus nebulosus (Lesueur)	Brown bullhead			1	1
Pylodictis olivaris (Rafinesque)	Flathead catfish	2			2
Family Cyprinodontidae					
Fundulus catenatus (Storer)	Northern studfish		22	19	41
Fundulus notatus (Rafinesque)	Blackstripe topminnow		8	2	10
Fundulus olivaceus (Storer)	Blackspotted topminnow		2		2
Family Poeciliidae					
Gambusia affinis (Baird and Girard)	Mosquitofish			1	1
Family Atherinidae					
Labidesthes sicculus (Cope)	Brook silverside		13		13

TABLE I (continued)

Scientific Name	Common Name	Station I	Station II	Station III	Total
Family Centrarchidae					
Ambloplites rupestris (Rafinesque)	Rock bass	77	36	74	187
Lepomis cyanellus Rafinesque	Green sunfish	3		5	8
Lepomis macrochirus Rafinesque	Bluegill	4	8	21	33
Lepomis megalotis (Rafinesque)	Longear sunfish	78	109	348	535
Micropterus dolomieui Lacepede	Smallmouth bass		4	8	12
Micropterus punctulatus (Rafinesque)	Spotted bass	24	25	42	91
Family Percidae					
Etheostoma bellum Zorach	Orangefin darter	42	23	28	93
Etheostoma blennioides Rafinesque	Greenside darter	79	27	25	131
Etheostoma caeruleum Storer	Rainbow darter	203	60	140	403
Etheostoma flabellare Rafinesque	Fantail darter	8	5	2	15
Etheostoma nigrum Rafinesque	Johnny darter		1	8	9
Etheostoma (Ulocentra) sp.		31	13	56	100
Etheostoma zonale (Cope)	Banded darter	3	9	4	16
Percina caprodes (Rafinesque)	Logperch		3	3	6
Percina maculata (Girard)	Blackside darter		2		2
Percina sp. (*melanoptera*)				1	1
Family Cottidae					
Cottus carolinae (Gill)	Banded sculpin	78	78	64	220

TABLE LI

SPECIES LIST, NUMBER OF INDIVIDUALS PER COLLECTION, AND DIVERSITY PER COLLECTION AT STATION I DURING THE PERIOD JANUARY, 1972, THROUGH JANUARY, 1973.

Common Name	Jan '72	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Jan '73	Total
Stoneroller	5	20	15	42	7	100	77	143	354	237			24	1024
Carp							3							3
Bigeye chub								1						1
Golden shiner							1							1
Rosefin shiner		12			2	11	18	8	19	9			9	88
Common shiner		2	6	5	5	11	8	3	6	6			1	53
Rosyface shiner		1							1					2
Spotfin shiner	1	3		1	2		3	1						11
Sand shiner						2	1		1					4
Bluntnose minnow	1	3	3		2	4		2	29	5			7	56
Creek chub			1	1			1	5	6	1				15
Northern hog sucker	5	6	1			1	2	9	13	22			5	64
Golden redhorse			1		1	2			1	3				8
Black bullhead						1								1
Flathead catfish							1			1				2
Brook silverside							1							1
Rock bass	2	5	6	6	13	14	6	9	9	3			4	77
Green sunfish								3						3
Bluefill			1					1	2					4
Longear sunfish	5	15	7	6	5	9	9	7	11	3			1	78
Spotted bass			1			1	4	6	3	8			1	24
Orangefin darter	3	13	8	4	6		1		5	1			1	42
Greenside darter	1	10	5	7	5	9	8	12	10	10			2	79
Rainbow darter	9	36	43	28	24	11	10	12	7	12			11	203
Fantail darter		1	6					1						8
Etheostoma (*Ulocentra*) sp.	1	3	8	3			1	2	9	2			2	31
Banded darter								1	1				1	3
Banded sculpin	9	6	6	5	2	6	7	13	9	13			2	78
Total species	11	15	16	11	12	14	19	19	19	16			14	1964
Total individuals	42	136	118	108	74	182	162	239	496	336			71	
Diversity	3.04	3.31	3.17	2.61	3.02	2.47	2.88	2.46	1.91	1.88			3.03	

TABLE III

SPECIES LIST, NUMBER OF INDIVIDUALS PER COLLECTION, AND DIVERSITY PER COLLECTION AT STATION II DURING THE PERIOD JANUARY, 1972, THROUGH JANUARY, 1973.

Common Name	Jan '72	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan '73	Total
Longnose gar					3									3
Stoneroller			10	6	6	66	130	112	218	210			2	760
River chub						1								1
Rosefin shiner				5	1	6	47	120	58	22				259
Common shiner		1	11	14	23	16	21	57	50	39			16	248
Rosyface shiner							1	4						5
Spotfin shiner						3	7	4	1					15
Sand shiner							22	3	7					32
Blacktail shiner									1					1
Southern redbelly dace							1							1
Bluntnose minnow			10	1	6	59	36	70	137	53			1	373
Creek chub							2		2					4
Northern hog sucker		9	3	15	1	17	11	26	35	25			3	145
Spotted sucker		1												1
Golden redhorse			2	3		2	7	3	4	1				22
Northern studfish				1				1	13	7				22
Blackstripe topminnow								3	5					8
Blackspotted topminnow									2					2
Brook silverside								7	6					13
Rock bass		2	1		4	4	7	2	11	5				36
Bluegill			3						5					8
Longear sunfish			15	4	8	25	9	15	23	7			3	109
Smallmouth bass						4								4
Spotted bass			1		1	2	4	7	9	1				25
Orangefin darter		3		6				6	7				1	23
Greenside darter		4		2		1	1	9	9	1			1	27

TABLE III (continued)

Common Name	Jan '72	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Jan '73	Total
Rainbow darter		3	6	6	5	4	3	7	12	11			3	60
Fantail darter		4							1					5
Johnny darter		1												1
<u>Etheostoma</u> (<u>Ulocentra</u>) sp.							2	6	5					13
Banded darter								5	4					9
Logperch							1	2						3
Blackside darter			1				1							2
Banded sculpin		6	12	6	3	5	4	6	20	13			3	78
Total species		10	12	12	11	14	21	22	25	13			8	2318
Total individuals		34	75	69	61	214	318	475	645	395			32	
Diversity		2.98	3.12	3.21	2.85	2.81	2.97	3.18	3.20	2.35			2.34	

TABLE IV

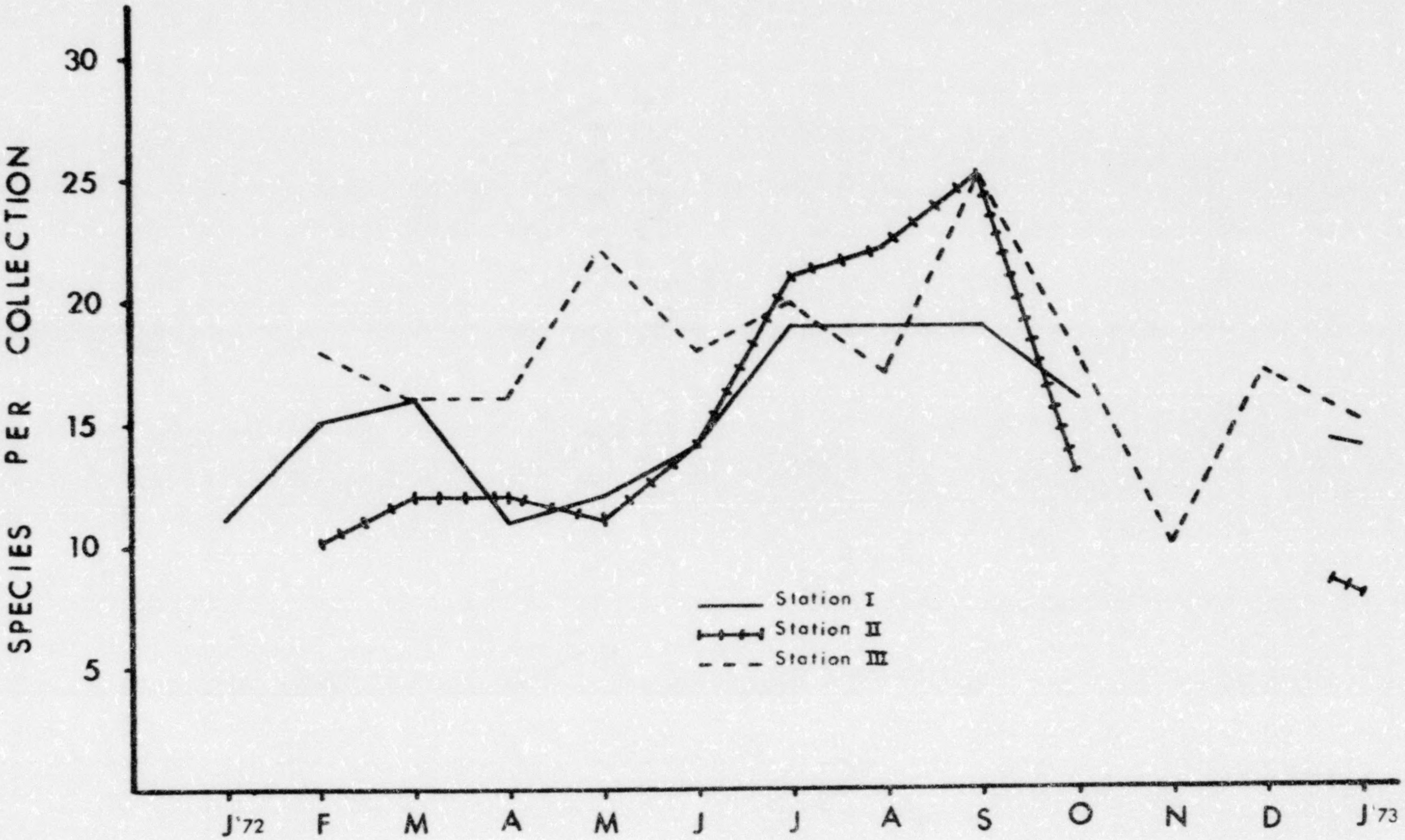
SPECIES LIST, NUMBER OF INDIVIDUALS PER COLLECTION, AND DIVERSITY PER COLLECTION AT STATION III DURING THE PERIOD JANUARY, 1972, THROUGH JANUARY, 1973.

Common Name	Jan '72	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Jan '73	Total
Least brook lamprey								1	1			2	2	6
Stoneroller		4	35	19	20	244	283	78	116	186	2	10	3	1,000
Carp				1										1
Bigeye chub					1									1
Rosefin shiner		15	35	10	10	17	18	3	5	33	43	38	241	468
Bigeye shiner					1				1					2
Common shiner		7	25	8	4	32	23	4	56	44	2	26	7	238
Silver shiner									1			3	6	10
Rosyface shiner					1				1				1	3
Spotfin shiner			4				5			2		2	2	15
Sand shiner					2		3							5
Southern redbelly dace			1											1
Bluntnose minnow		3	148	36	38	37	48	6	41	36	8	2	32	435
Creek chub			4		1	1	8	4	10					28
White sucker												1		1
Northern hog sucker		7	3	3	7	15	19	4	11	9		1	1	80
Black redhorse		1				2								3
Golden redhorse		1	3	1	3	16	11	1	7	7	1	1	1	53
Yellow bullhead		1												1
Brown bullhead							1							1
Northern studfish		1	2					2	6	3	2	3		19
Blackstripe topminnow						1					1			2
Mosquitofish									1					1
Rock bass			8	18	8	12	12	3	7	4		2		74
Green sunfish		1		1	2	1								5
Bluegill		1				5	10		2		1		2	21
Longear sunfish		7	22	25	57	65	50	31	61	22	2	2	4	348

TABLE IV (continued)

Common Name	Jan '72	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Jan '73	Total
Smallmouth bass					3	1	2	2						8
Spotted bass			2	12	4	6	8	5	2	3				42
Orangefin darter		1		1	2		17	1	6					28
Greenside darter		1	1	1			11	1	6	2			2	25
Rainbow darter		19	24	12	15	1	17	4	30	9		4	5	140
Fantail darter		1			1									2
Johnny darter				1					3	2		2		8
Etheostoma (_Ulocentra_) sp.		7	8		2	2	2		19	11		5		56
Banded darter									2	2				4
Logperch					1				2					3
Percina sp. (_melanoptera_)										1				1
Banded sculpin		6	10	8	6	3	9	4	5	5	1	6	1	64
Total species		18	17	16	22	18	20	17	25	18	10	17	15	3,203
Total individuals		84	335	157	189	461	557	154	402	381	63	110	310	
Diversity		3.46	2.83	3.27	3.32	2.45	2.83	2.56	3.37	2.68	1.76	3.04	1.39	

Figure 8. Number of species for each collection.



SPECIES PER COLLECTION
30
25
20
15
10
5
J'72
F
M
A
M
J
J
A
S
O
N
D
J'73
Station I
Station II
Station III

The family Cyprinidae, represented by a total of 5,157 specimens, was the predominant family taken in the study. The majority of the minnow total was provided by one species, the stoneroller, with a total of 2,784 specimens, by far the most abundant representative in the stream. Other major species included bluntnose minnows (864), the second most abundant species in the stream; rosefin shiners (815), third numerically; and common shiners (539), fourth numerically.

The family Centrarchidae, with 866 specimens, represented the second largest family in the study. Predominant members of this family included longear sunfish (535), the fifth most abundant species of the study, and rock bass (187), ninth numerically.

The family Percidae, with 766 specimens, represented the third largest of the study. Predominant species of this total included the rainbow darter (403), sixth numerically; the greenside darter (131), tenth numerically; and *Etheostoma* (*Ulocentra*) sp. (100), eleventh numerically.

The sucker family, Catostomidae, and sculpin family, Cottidae, represented the next most common families with 377 and 220 representatives, respectively. The chief sucker species present was the northern hog sucker, with 289 specimens, seventh numerically. The sculpin family was represented by a single species, the banded sculpin, with a total of 220 specimens, eighth numerically in the study.

The remaining six families had a combined total of only 73 specimens. Eleven of the forty-nine species collected during the course of this study had totals of 100 or more specimens. These eleven species, in order of decreasing abundance, are as follows:

Stoneroller---------------------*Campostoma anomalum*

Bluntnose minnow----------------*Pimephales notatus*

Rosefin shiner------------------*Notropis ardens*

Common shiner-------------------*Notropis cornutus*

Longear sunfish-----------------*Lepomis megalotis*

Rainbow darter------------------*Etheostoma caeruleum*

Northern hog sucker-------------*Hypentelium nigricans*

Banded sculpin------------------*Cottus carolinae*

Rock bass-----------------------*Ambloplites rupestris*

Greenside darter----------------*Etheostoma blennioides*

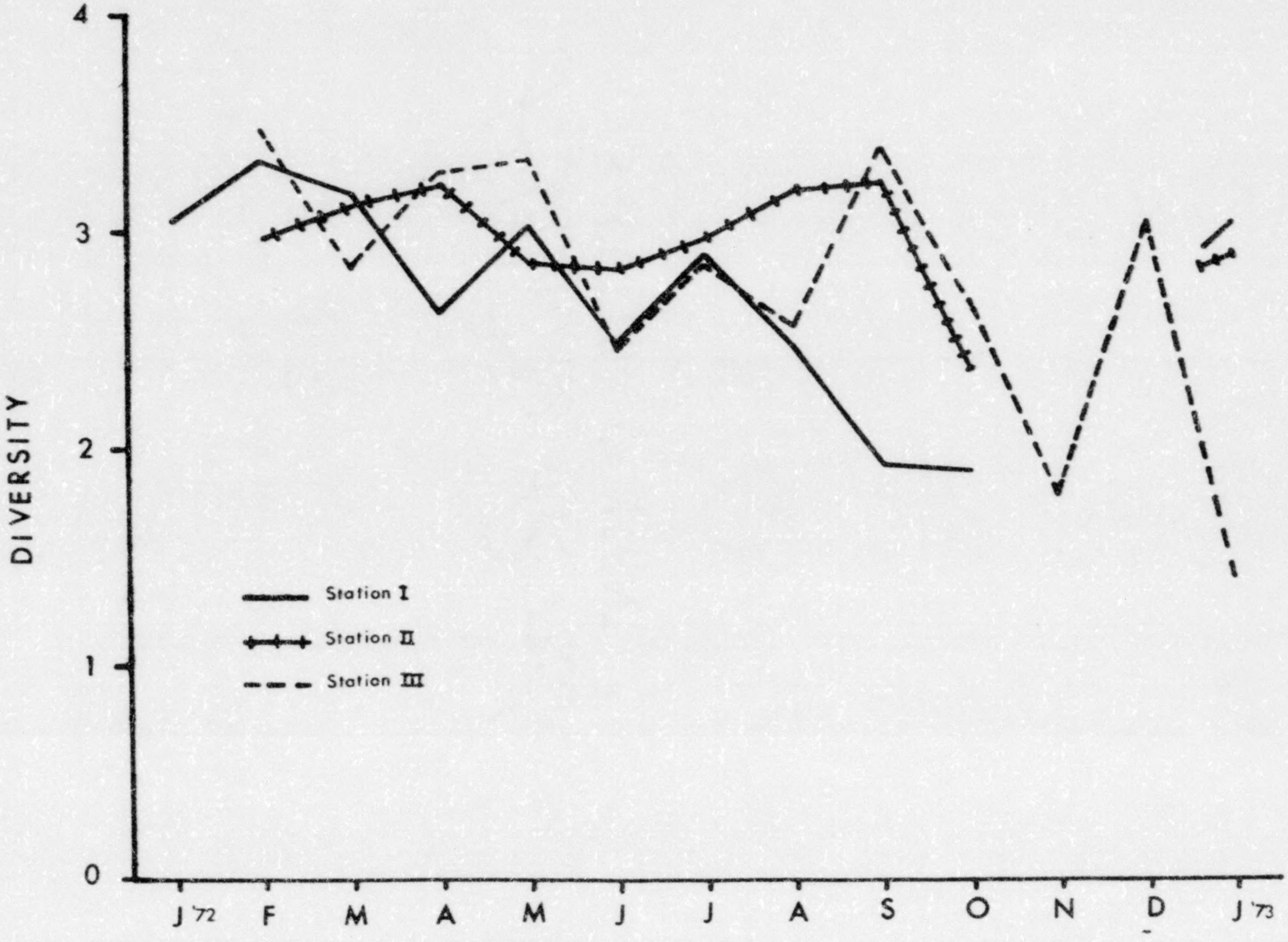
Etheostoma (*Ulocentra*) sp.------undescribed

These same eleven species comprised 6,867 specimens, 91.8% of the total number collected during the study.

Diversity ($\overline{D}$) values at Station I ranged from a high of 3.31 in February to a low of 1.88 in October, with a monthly average of 2.67 (Table 2, Figure 9). Station II had diversity values which ranged from 3.21 in April to 2.34 in January, 1973, with an average of 2.90 (Table 3, Figure 9). Station III was unique in providing the highest and lowest diversity values in the study, 3.46 in February and 1.39 in January, 1973 (Table 4, Figure 9). The average monthly diversity for Station III was 2.75.

Station II showed the most stable diversity pattern (Figure 9) of the three stations. The pattern at Station III was somewhat erratic, with intermittent high and low values (Figure 9). Station I also exhibited an unstable pattern, but with a general decreasing trend from February to October (Figure 9). The January, 1973, collection at Station I ($\overline{D}$ = 3.03) correlated well with the January, 1972, collection ($\overline{D}$ = 3.04).

Figure 9. Diversity ($\overline{D}$) values for each collection.


4
3
2
1
0
DIVERSITY
Station I
Station II
Station III
J '72
F
M
A
M
J
J
A
S
O
N
D
J '73

Those species considered permanent residents and their occurrence at each of the three stations are listed in Table 5. Station I had the greatest proportion of permanent residents as 12 of 28 collected species (43%) were classified in this category. Station II, with 34 total species, had only 8 (24%) permanents, the lowest percentage of the three stations. Thirteen of 39 species (33%) collected at Station III were considered permanent residents.

The major contributors to monthly diversity among permanent residents at Station I, as determined by % AMCD values, were the stoneroller, rainbow darter, banded sculpin, longear sunfish, and rock bass, in decreasing order (Table 5).

The stoneroller was also the greatest contributor to diversity at Stations II and III, followed at Station II by the common shiner, bluntnose minnow, northern hog sucker, and longear sunfish; and at Station III by the bluntnose minnow, longear sunfish, rosefin shiner and common shiner (Table 5).

Eight species, northern hog sucker, stoneroller, rosefin shiner, common shiner, bluntnose minnow, longear sunfish, rainbow darter and banded sculpin were unique in that they each represented one of the ten highest averages at all stations. The stoneroller was the most dominant species at all stations; however, % AMCD values for the stoneroller decreased toward the more upstream areas. The same trend was evident for four other common representatives, rainbow darter, banded sculpin, greenside darter and orangefin darter. The reverse trend, *i.e.*, an increase in % AMCD values toward the more upstream stations, was evident in regard to the golden redhorse, rosefin shiner, bluntnose minnow, and longear sunfish (Table 5).

TABLE V

A LIST OF SPECIES REGARDED AS PERMANENT RESIDENTS AND THEIR OCCURRENCE AT EACH STATION. NUMBERS IN PARENTHESES DENOTE AVERAGE MONTHLY CONTRIBUTIONS TO DIVERSITY.

Common Name	Station I	Station II	Station III
Stoneroller	X (15.9%)	X (13.3%)	X (12.9%)
Rosefin shiner	X (6.0%)	Seasonal	X (10.8%)
Common shiner	X (5.1%)	X (12.6%)	X (9.2%)
Bluntnose minnow	X (4.2%)	X (3.5%)	X (3.7%)
Northern hog sucker	X (5.2%)	X (9.6%	X (4.2%)
Golden redhorse	Seasonal	Seasonal	X (3.1%)
Rock bass	X (7.6%)	X (3.5%)	X (3.7%)
Longear sunfish	X (8.0%)	X (8.2%)	X (10.9%)
Spotted bass	Seasonal	Seasonal	X (2.4%)
Orangefin darter	X (5.0%)	Seasonal	Seasonal
Greenside darter	X (7.6%)	Seasonal	X (1.5%)
Rainbow darter	X (12.6%)	X (7.2%)	X (6.5%)
Etheostoma (*Ulocentra*) sp.	X (3.4%)	Seasonal	X (3.0%)
Banded sculpin	X (8.1%)	X (8.0%)	X (4.6%)

The spotted bass had relatively unchanged % AMCD values at each of the three stations. The rosefin shiner, longear sunfish, and banded sculpin had little change from Station I to Station II. The stoneroller, rock bass, and rainbow darter had little change from Station II to Station III (Table 5).

Diversity values computed incorporating only that proportion that permanent resident species contribute versus the total numerical diversity values are compared in Figures 10 - 12. Station II was most affected by seasonal and transient components, particularly during the early spring and summer months. Stations I and III were constantly influenced by other than permanent components; however, this influence was of no great magnitude and showed little seasonal variation.

Seasonal trends in contributions to diversity (%CD) were evident among several permanent resident species.

The northern hog sucker contributed more to diversity during the fall and winter periods at Station I and II than it did at other periods. A slight spring-summer prevalence of the hog sucker was evident at Station III (Figure 13).

The stoneroller was generally most dominant during the summer period at all stations (Figure 14).

The rosefin shiner was most prominent during the late spring and summer periods at Station I; the summer period at Station II; and the fall-winter period at Station III (Figure 15).

The common shiner was more prevalent at Station I during the late winter-summer periods; no seasonal trends were readily apparent at Stations II and III. However, increases in contributions at Station I seemed to be correlated in some instances (particularly during the spring) with decreased contributions at Station III (Figure 16).

Figure 10. Comparison of diversity ($\bar{D}$) values at Station I for permanent, seasonal, and transient species. Solid line represents total diversity. Dashed line represents that proportion of the total diversity which was contributed by permanent resident species. Vertical distance between solid and dashed lines represents transient and seasonal species' contribution to total diversity.

Figure 11. Comparison of diversity ($\bar{D}$) values at Station II for permanent, seasonal, and transient species. Solid line represents total diversity. Dashed line represents that proportion of the total which was contributed by permanent resident species. Vertical distance between solid and dashed lines represents transient and seasonal species' contribution to total diversity.

Figure 12. Comparison of diversity ($\bar{D}$) values at Station III for permanent, seasonal, and transient species. Solid line represents total diversity. Dashed line represents that proportion of the total diversity which was contributed by permanent resident species. Vertical distance between solid and dashed lines represents transient and seasonal species' contribution to total diversity.

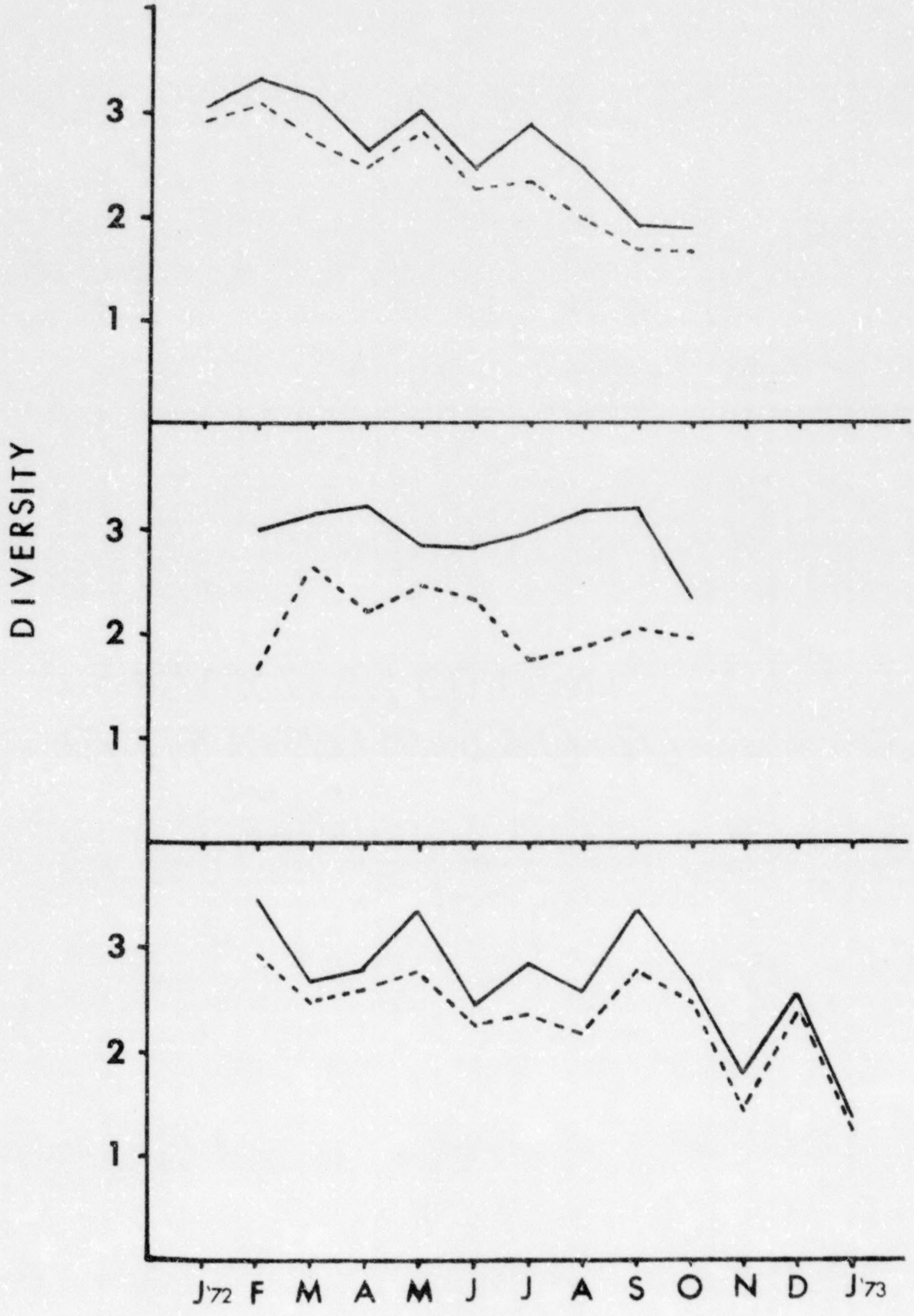
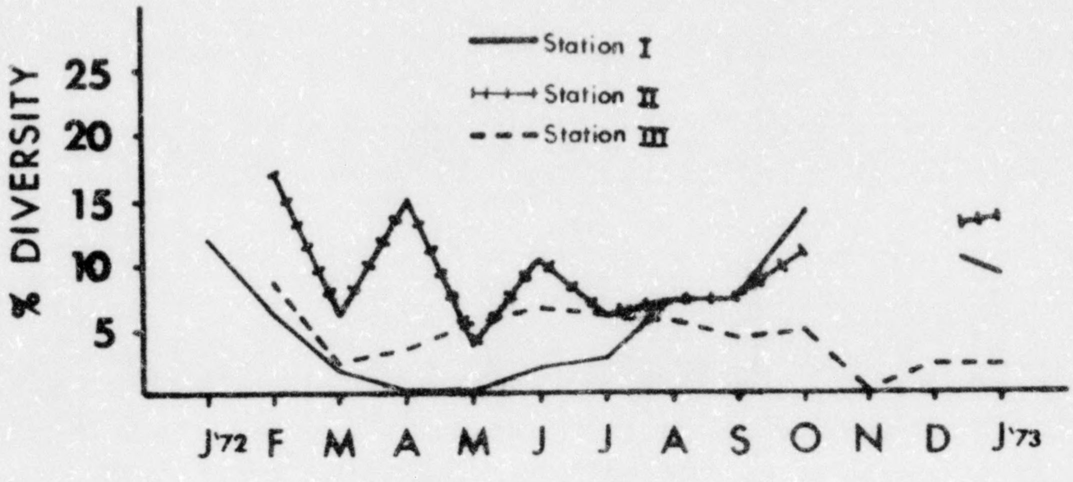
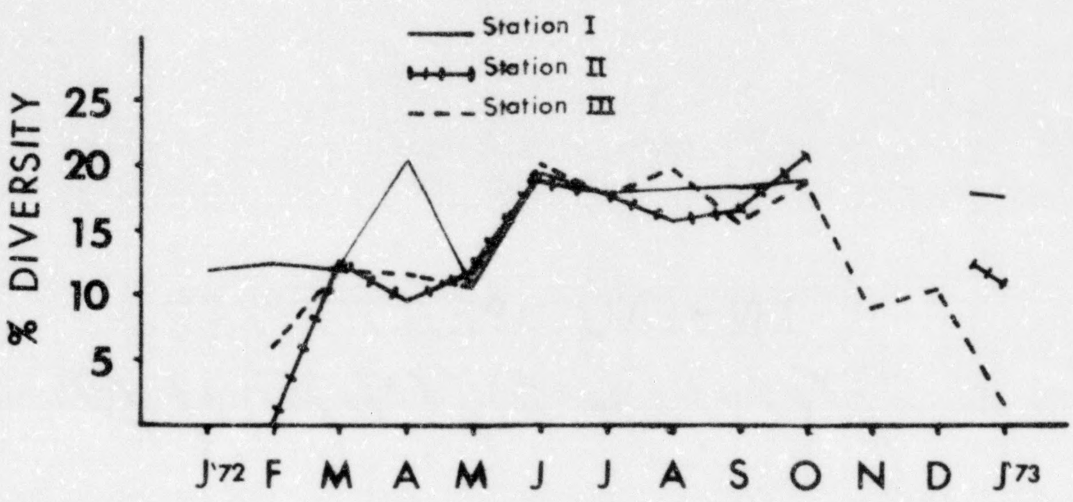

DIVERSITY
3
2
1
3
2
1
3
2
1
J'72 F M A M J J A S O N D J'73

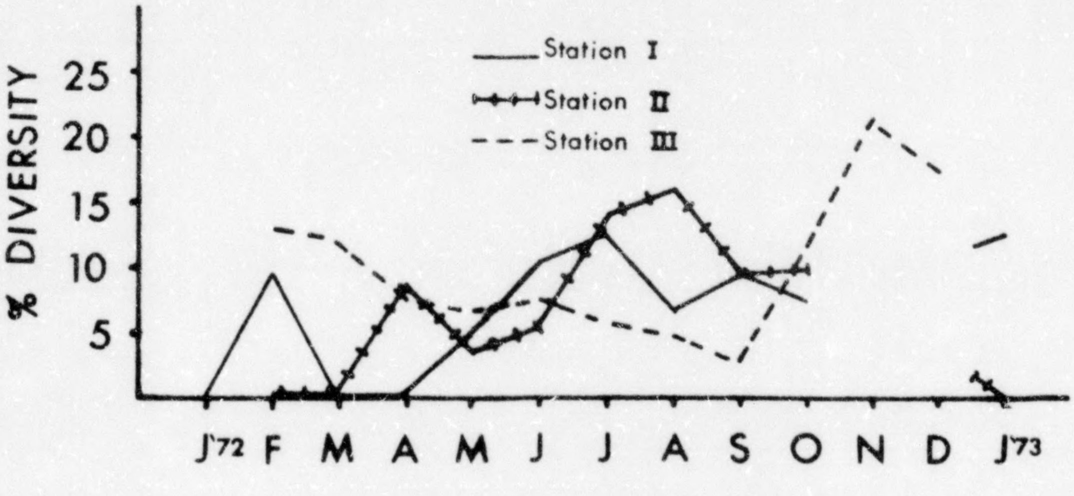
Figure 13. Monthly diversity contributions by the northern hog sucker, expressed as a percentage of the total diversity ($\bar{D}$), for all collections.

Figure 14. Monthly diversity contributions by the stoneroller, expressed as a percentage of the total diversity ($\bar{D}$), for all collections.

Figure 15. Monthly diversity contributions by the rosefin shiner, expressed as a percentage of the total diversity ($\bar{D}$), for all collections.


Station I
Station II
Station III
% DIVERSITY
25
20
15
10
5
J'72 F M A M J J A S O N D J'73


Station I
Station II
Station III
% DIVERSITY
25
20
15
10
5
J'72 F M A M J J A S O N D J'73


Station I
Station II
Station III
% DIVERSITY
25
20
15
10
5
J'72 F M A M J J A S O N D J'73

The bluntnose minnow fluctuated widely in its contributions to diversity (Figure 17); however, a trend of increasing presence appeared evident at Station II throughout the spring to fall periods. Rock bass were most contributory during the spring collections at all stations (Figure 18).

Longear sunfish exhibited a decreasing trend at Station I throughout the collecting period; Station II showed a prominent increase during the late winter and spring periods; at Station III this increase was delayed until the mid-spring period, but was of longer duration, extending throughout the summer period (Figure 19).

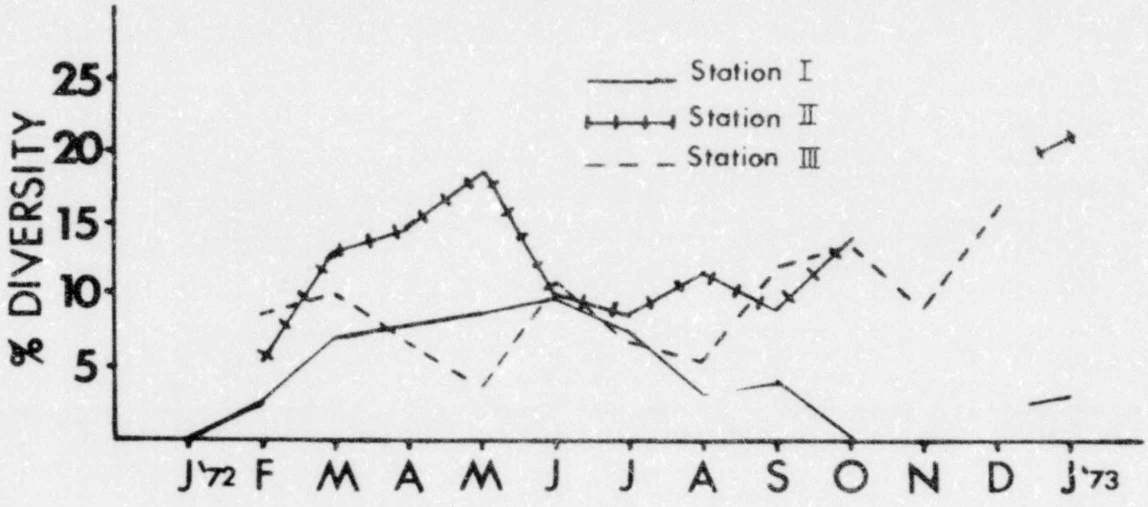
The orangefin darter exhibited a winter-early spring predominance at Station I (Figure 20). Two other darters exhibited seasonal trends of contribution: the rainbow darter, at all stations, was most prominent during the winter-spring period with signs of additional dominance at Station III throughout the summer and early fall periods (Figure 21); Etheostoma (Ulocentra) species illustrated peak concentrations during the summer collections at Station II (Figure 22).

Banded sculpins showed a marked decreasing trend from the winter to the summer periods at Station II; however, no trends were evident at the remaining stations (Figure 23).

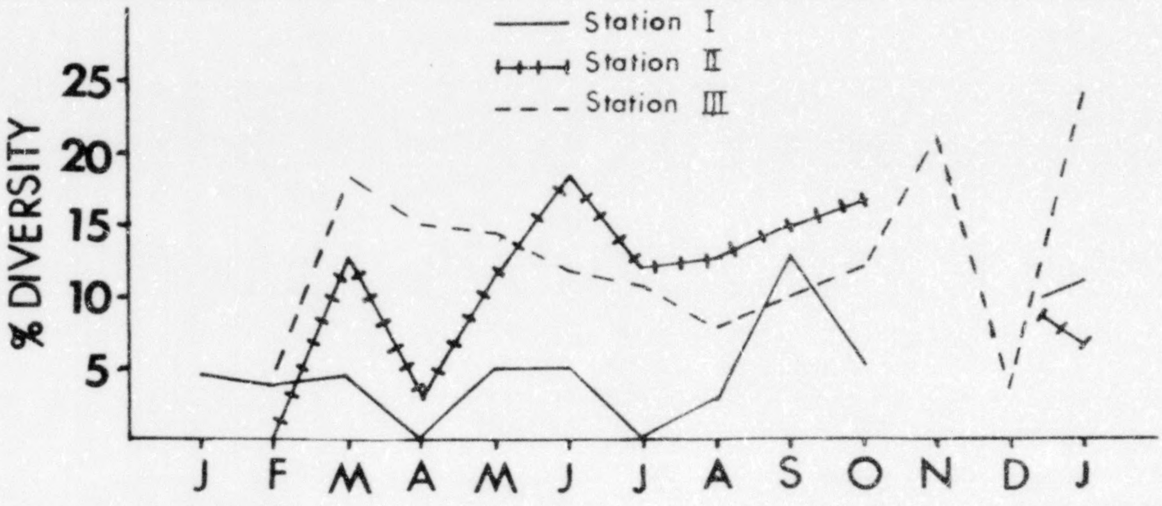
The spring collections (April-June) at Station I showed the dominant permanent residents for this period, as determined by % average-seasonal-contributions to diversity (% ASCD) values, to be the stoneroller, rainbow darter, rock bass, greenside darter, longear sunfish and common shiner. In the summer (July-September) the stoneroller was again the dominant species followed by the rosefin shiner, banded sculpin, greenside darter, and rainbow darter. The fall period, which at Station I consisted

Figure 16. Monthly diversity contributions by the common shiner, expressed as a percentage of the total diversity ($\overline{D}$), for all collections.

Figure 17. Monthly diversity contributions by the bluntnose minnow, expressed as a percentage of the total diversity ($\overline{D}$), for all collections.



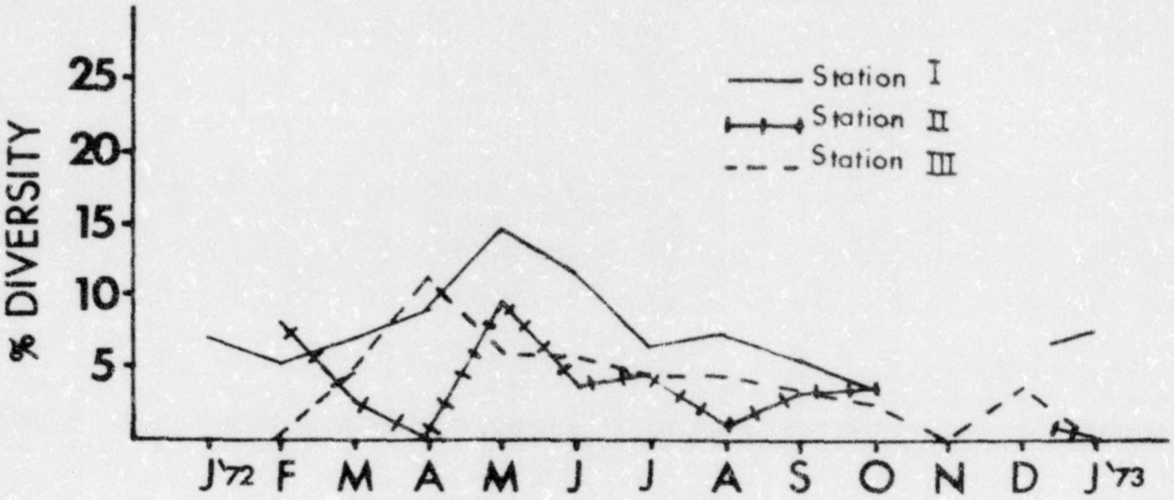
Station I
Station II
Station III
% DIVERSITY
25
20
15
10
5
J'72 F M A M J J A S O N D J'73



Station I
Station II
Station III
% DIVERSITY
25
20
15
10
5
J F M A M J J A S O N D J

Figure 18. Monthly diversity contributions by the rock bass, expressed as a percentage of the total diversity ($\overline{D}$), for all collections.

Figure 19. Monthly diversity contributions by the longear sunfish, expressed as a percentage of the total diversity ($\overline{D}$), for all collections.


Station I
Station II
Station III
25
20
15
10
5
% DIVERSITY
J'72 F M A M J J A S O N D J'73

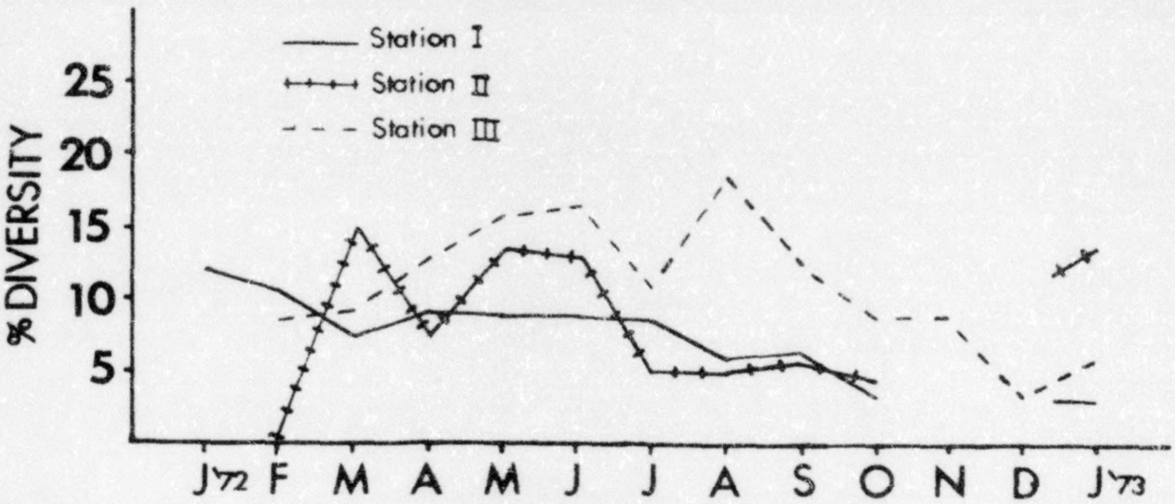
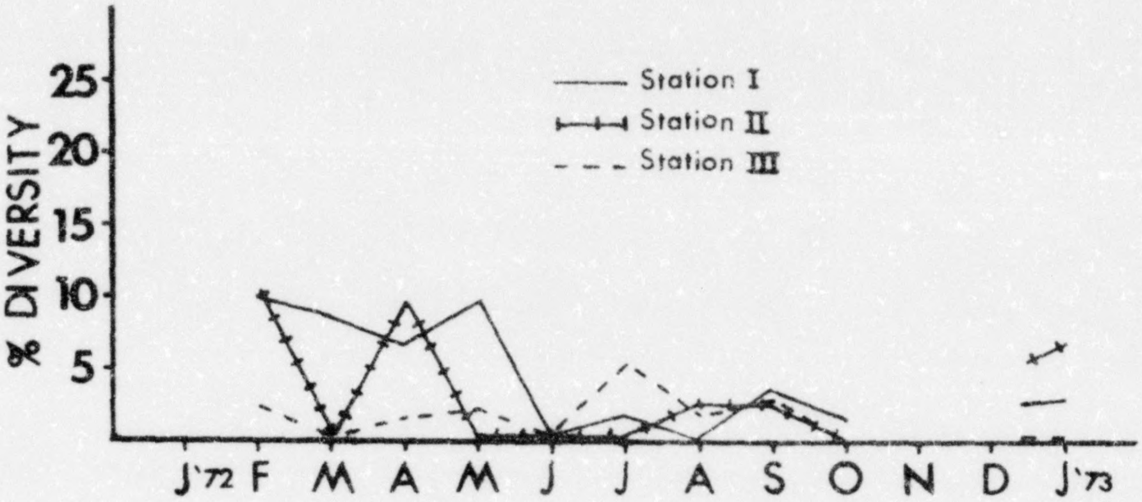

Station I
Station II
Station III
25
20
15
10
5
% DIVERSITY
J'72 F M A M J J A S O N D J'73

Figure 20. Monthly diversity contributions by the orangefin darter, expressed as a percentage of the total diversity ($\bar{D}$), for all collections.

Figure 21. Monthly diversity contributions by the rainbow darter, expressed as a percentage of the total diversity ($\bar{D}$), for all collections.


% DIVERSITY
25
20
15
10
5
Station I
Station II
Station III
J'72 F M A M J J A S O N D J'73

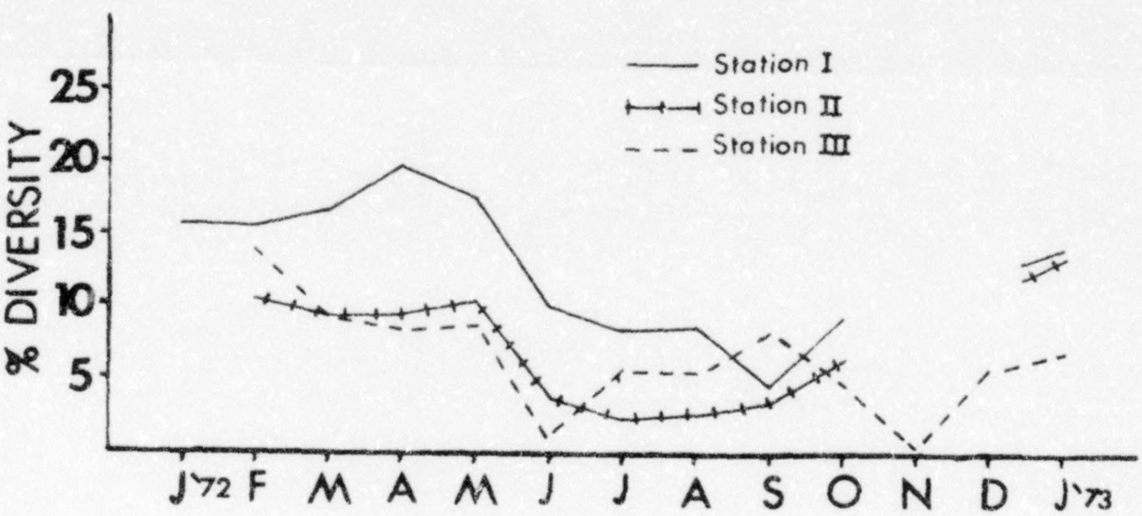
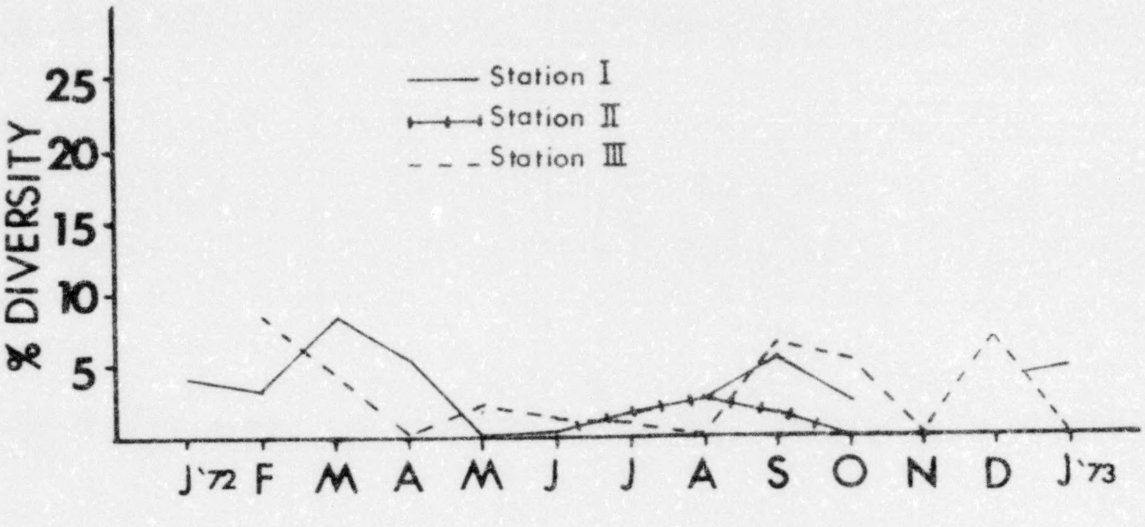
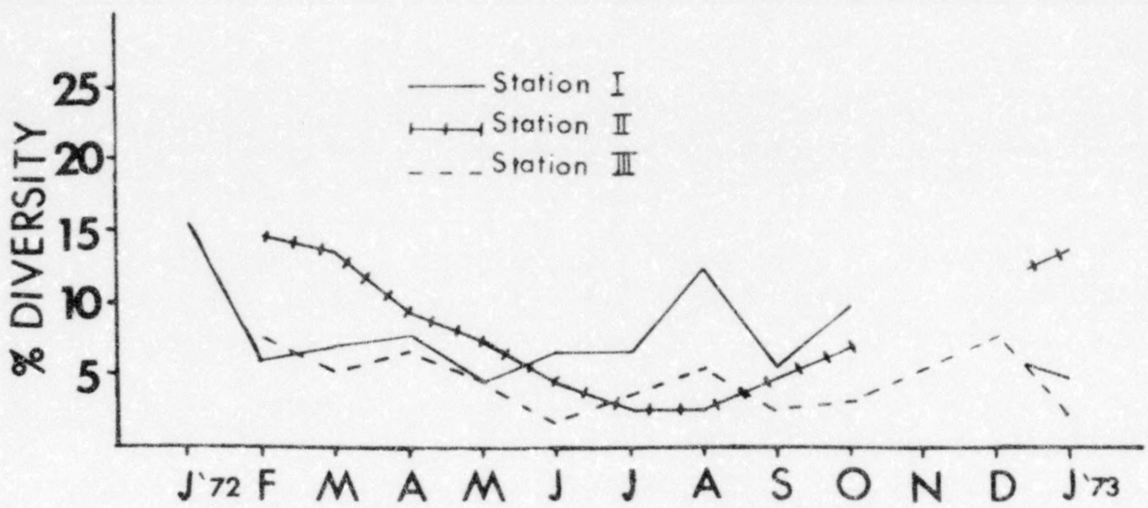

% DIVERSITY
25
20
15
10
5
Station I
Station II
Station III
J'72 F M A M J J A S O N D J'73

Figure 22. Monthly diversity contributions by the Etheostoma (Ulocentra) species, expressed as a percentage of the total diversity ($\bar{D}$), for all collections.

Figure 23. Monthly diversity contributions by the banded sculpin, expressed as a percentage of the total diversity ($\bar{D}$), for all collections.


Station I
Station II
Station III
% DIVERSITY
25
20
15
10
5
J'72 F M A M J J A S O N D J'73


Station I
Station II
Station III
% DIVERSITY
25
20
15
10
5
J'72 F M A M J J A S O N D J'73

of only the October collection, was again dominated by the stoneroller. Less numerous members were the northern hog sucker, banded sculpin, rainbow darter and greenside darter. The winter collections (January-March) at Station I showed the dominant permanent species for this period to be the rainbow darter, stoneroller, longear sunfish, banded sculpin, and the orangefin darter.

Spring collections at Station II were influenced most by the following permanent species: common shiner, stoneroller, longear sunfish, bluntnose minnow, and northern hog sucker. The stoneroller was again one of the major permanent species during the summer collection followed by the bluntnose minnow, rosefin shiner, common shiner, and northern hog sucker. Fall collections were again dominated by the stoneroller followed by the bluntnose minnow, common shiner, northern hog sucker, and rosefin shiner. Winter collections were influenced most by the banded sculpin, common shiner, northern hog sucker, rainbow darter, and longear sunfish.

Spring collections at Station III were dominated by the longear sunfish, followed by the stoneroller, longear sunfish, bluntnose minnow, common shiner and rainbow darter. During the summer the dominants included the stoneroller, longear sunfish, bluntnose minnow, common shiner, and rainbow darter. The rosefin shiner was the major species of the fall period followed by the common shiner, stoneroller, bluntnose minnow, and longear sunfish. Winter at Station III was dominated by the bluntnose minnow, rosefin shiner, rainbow darter, common shiner, and longear sunfish.

Of 28 species at Station I, 8 were considered seasonal giving this station the highest percentage (29%) of the three stations (Table 6). Stations II and III had equal proportions of seasonal residents as both stations had 26% of the collected species in the seasonal category; however,

TABLE 6

A LIST OF SPECIES REGARDED AS SEASONAL RESIDENTS AND THEIR OCCURRENCE AT EACH STATION. NUMBERS IN PARENTHESES DENOTE AVERAGE MONTHLY CONTRIBUTIONS TO DIVERSITY

Common Name	Station I	Station II	Station III
Rosefin shiner	Permanent	X (6.6%)	Permanent
Silver shiner	---------	---------	X (1.1%)
Rosyface shiner	Transient	Transient	X (0.3%)
Spotfin shiner	X (2.0%)	X (1.0%)	X (1.1%)
Sand shiner	X (0.5%)	X (1.2%)	Transient
Creek chub	X (1.6%)	Transient	X (1.4%)
Golden redhorse	X (1.2%)	X (2.1%)	Permanent
Northern studfish	---------	X (1.1%)	X (2.1%)
Green sunfish	Transient	---------	X (0.6%)
Bluegill	X (0.5%)	Transient	X (1.6%)
Smallmouth bass	---------	Transient	X (0.6%)
Spotted bass	X (2.3%)	X (1.7%)	Permanent
Orangefin darter	Permanent	X (3.1%)	X (1.3%)
Greenside darter	Permanent	X (2.6%)	Permanent
Fantail darter	X (1.0%)	Transient	Transient
Johnny darter	---------	Transient	X (0.6%)
Etheostoma (*Ulocentra*) sp.	Permanent	X (0.6%)	Permanent
Banded darter	X (0.2%)	Transient	Transient

Station III had a higher absolute number of seasonal residents with 10 of 39 species in this category compared to 9 of 34 for Station II.

The major contributors to diversity, according to % AMCD values, among those species considered seasonal residents at Station I included the spotted bass, spotfin shiner, creek chub, golden redhorse, and fantail darter (Table 6). At Station II the major seasonal contributors were the rosefin shiner, orangefin shiner, greenside darter, golden redhorse, and spotted bass (Table 6). Station III was dominated by the northern studfish, bluegill, creek chub, orangefin darter, silver shiner, and spotfin shiner (Table 6).

Many species which qualified as seasonal residents at a given station were either permanent residents or transients at other stations (Table 6). Also, many species denoted as seasonal residents by their frequency of occurrence did not exhibit true seasonal occurrence as they were taken randomly throughout the collecting period (Tables 2-4). Species which did show some prevalence for a specific season or seasons are as follows: At Station I; sand shiner (spring and summer), creek chub (summer), spotted bass (summer and early fall), fantail darter (winter), and banded darter (summer); at Station II; rosefin shiner (summer), spotfin shiner (summer), northern studfish (summer-early fall), spotted bass (spring and summer), and *Etheostoma* (*Ulocentra*) sp. (summer); at Station III; silver shiner (late fall and early winter), northern studfish (late summer thru winter), green sunfish (winter and spring), and smallmouth bass (spring and summer) (Tables 2-4).

Those species considered to be transients and their occurrence at each of the three stations are listed in Table 7. Station I was represented by 8 transients or 29% of its 28 collected species. One-half

TABLE 7

A LIST OF SPECIES REGARDED AS TRANSIENT MEMBERS AND THEIR OCCURRENCE AT EACH STATION. NUMBERS IN PARENTHESES DENOTE AVERAGE MONTHLY CONTRIBUTIONS TO DIVERSITY.

Common Name	Station I	Station II	Station III
Least brook lamprey	---------	---------	X (0.8%)
Longnose gar	---------	X (0.8%)	---------
Carp	X (0.4%)	---------	---------
Bigeye chub	X (0.1%)	---------	X (0.1%)
River chub	---------	X (0.1%)	---------
Golden shiner	X (0.2%)	---------	---------
Bigeye shiner	---------	---------	X (0.2%)
Rosyface shiner	X (0.8%)	X (0.3%)	Seasonal
Sand shiner	Seasonal	Seasonal	X (0.3%)
Blacktail shiner	---------	X (0.1%)	---------
Southern redbelly dace	---------	X (0.1%)	X (0.1%)
Creek chub	Seasonal	X (0.2%)	Seasonal
White sucker	---------	---------	X (0.2%)
Spotted sucker	---------	X (0.5%)	---------
Black redhorse	---------	---------	X (0.3%)
Black bullhead	X (0.2%)	---------	---------
Yellow bullhead	---------	---------	X (0.2%)
Brown bullhead	---------	---------	X (0.1%)
Flathead catfish	X (0.3%)	---------	---------
Blackstripe topminnow	---------	X (0.3%)	X (0.5%)
Blackspotted topminnow	---------	X (0.1%)	---------
Mosquitofish	---------	---------	X (0.1%)
Brook silverside	X (0.2%)	X (0.5%)	---------
Green sunfish	X (0.3%)	---------	Seasonal
Bluegill	Seasonal	X (0.7%)	Seasonal
Smallmouth bass	---------	X (0.4%)	Seasonal
Fantail darter	Seasonal	X (1.3%)	X (0.3%)
Johnny darter	---------	X (0.5%)	Seasonal
Logperch	---------	X (0.2%)	X (0.2%)
Blackside darter	---------	X (0.4%)	---------
Percina sp. (*melanoptera*)	---------	---------	X (0.1%)
Banded darter	Seasonal	X (0.4%)	X (0.2%)

of the species (17 of 34) collected at Station II were considered transient as they were collected in fewer than 3 collections. Station III had the second highest proportion of transients with 16 of 39 species (41%) placed into this category.

Of the 8 transients at Station I, 6 were collected only during the period June, July, and August (Table 2). A similar trend was evident at Station II as 11 of 14 transient species were collected only during the period of June, July, August and September (Table 3). At Station III this trend was disrupted as only 2 of 16 transients were specifically collected only during this same period (Table 4).

Fish were marked on four occasions: March 13, 1972, at all stations; June 24, 1972, at Stations II and III; July 13, 1972, at Station II; and September 15, 1972, at Station II. The recapture of marked fish represented a return of 10.9%, as 16 of 146 marked fish were recaptured. Those species marked at each station, their lengths (TL) when marked, and their lengths (TL) and date upon subsequent recapture are listed in Table 8.

Of the sixteen recaptured fish, fifteen were captured at the same station as their point of release. The one exception was a rock bass marked March 13, 1972 at Station III which was recaptured April 20, 1972, at Station I, a distance of 15.8 km from its point of release. This same fish was again recaptured on July 14, 1972, this time back at its point of release, Station III (Table 8). Another rock bass was involved in an instance of multiple recapture; a fish marked at Station II on June 24, 1972, was recaptured at the station on three occasions; July 13, 1972, September 15, 1972, and October 18, 1972 (Table 8). A northern hog sucker marked June 24, 1972, was recaptured at the same station twice, August 29, 1972, and October 18, 1972 (Table 8).

TABLE 8 A

DATA FOR MARKING EXPERIMENTS, SHOWING DATES OF MARKING, SPECIES MARKED, TOTAL LENGTH WHEN MARKED, AND DATES AND TOTAL LENGTHS OF RECAPTURED INDIVIDUALS.

Mark Number 1, March 13, 1972:
Station I;

Common Name	Total Length When marked	Recaptured Station	Recaptured Total Length	Recaptured Date
Stoneroller minnow	81 mm			
	70 mm			
	79 mm			
	70 mm			
	65 mm			
Common shiner	60 mm			
	57 mm			
	68 mm			
Northern hog sucker	147 mm			
Golden redhorse	280 mm			
Longear sunfish	157 mm	Station I	161 mm	05/17/72
	104 mm			
	104 mm			
	120 mm			

Station II;

Common Name	Total Length When marked	Recaptured Station	Recaptured Total Length	Recaptured Date
Common shiner	200 mm			
	120 mm			
Northern hog sucker	240 mm			
	220 mm			
Golden redhorse	315 mm			
	260 mm			
Longear sunfish	135 mm			
	130 mm			
	110 mm			
	95 mm			
	90 mm			
Spotted bass	170 mm	Station II	190 mm	06/24/72

Table 8 A (continued)

Station III;

Creek chub	145 mm			
Golden redhorse	175 mm			
	160 mm			
Rock bass	170 mm			
	170 mm			
	173 mm			
	190 mm			
	150 mm			
	120 mm	Station I	125 mm	04/20/72
		Station III	130 mm	07/14/72
Longear sunfish	130 mm	Station III	125 mm*	04/20/72
	120 mm			
	123 mm			
	120 mm			
	110 mm			
	112 mm			
	110 mm			
	115 mm			
Spotted bass	230 mm			
	250 mm			

TABLE 8 B

Mark Number 2, June 24, 1972:
Station II;

Stoneroller minnow	145 mm			
	130 mm			
	122 mm			
	118 mm			
	105 mm			
Northern hog sucker	245 mm	Station II	251 mm	08/29/72
		Station II	280 mm	10/18/72
	154 mm	Station II	160 mm	07/13/72
	220 mm			
	230 mm			
Golden redhorse	180 mm			
Rock bass	201 mm	Station II	150 mm	07/13/72
	250 mm			
	150 mm	Station II	150 mm	07/13/72
		Station II	157 mm	09/15/72
		Station II	170 mm	10/18/72
Longear sunfish	152 mm	Station II	96 mm*	09/15/72
	94 mm			
	75 mm			
	72 mm			
	80 mm			
	72 mm			
	113 mm			
	120 mm			
	116 mm			
	80 mm			
	86 mm			
	69 mm			
	121 mm			
	80 mm			
Spotted bass	172 mm	Station II	178 mm	07/13/72

Table 8 B (continued)

	Station III			
Stoneroller minnow	122 mm	Station III	130 mm*	07/14/72
	133 mm			
	115 mm			
	130 mm			
	112 mm			
	127 mm			
	140 mm			
Common shiner	200 mm			
	130 mm			
	125 mm			
	124 mm			
Northern hog sucker	180 mm			
Golden redhorse	190 mm			
	148 mm			
	155 mm			
	333 mm			
Rock bass	133 mm	Station III	140 mm*	07/14/72
	134 mm			
	84 mm			
	116 mm			
	167 mm			
Bluegill	148 mm			
	170 mm			
Longear sunfish	150 mm			
	135 mm			
	108 mm			
	92 mm			
	135 mm			
	120 mm			
	142 mm			
	143 mm			
	140 mm			
	140 mm			
	113 mm			
	150 mm			
	117 mm			
Spotted bass	242 mm			

TABLE 8 C

Mark Number 3, July 13, 1972
Station II

Stoneroller minnow	121 mm
	110 mm
Bluntnose minnow	45 mm
Northern hog sucker	205 mm
Golden redhorse	335 mm
	189 mm
Rock bass	145 mm
	95 mm
	195 mm
	140 mm
	125 mm
	117 mm
Longear sunfish	88 mm
	137 mm
	125 mm
Spotted bass	115 mm
	167 mm
	187 mm

TABLE 8 D

Mark Number 4, September, 15, 1972
Station II

Common shiner	124 mm
	96 mm
	89 mm
	90 mm
	105 mm
	110 mm
	97 mm
	85 mm
	108 mm
Northern hog sucker	270 mm
Golden redhorse	335 mm
	220 mm
Rock bass	169 mm
	190 mm
	158 mm
	90 mm
Longear sunfish	153 mm
	90 mm
	104 mm

* Indicates size when marked is not discernible.

The longest duration between marking and subsequent recapture was approximately four months. At Station II a rock bass marked June 24, 1972, was recaptured October 18, 1972 (Table 8) and at Station I a rock bass marked March 13, 1972, was recaptured July 14, 1972 (Table 8). In another instance a northern hog sucker marked at Station II June 24, 1972, was recaptured October 18, 1972 (Table 8).

DISCUSSION

The ichthyofauna of Middle Fork Creek may generally be categorized as rich in both variety of species and number of individuals. The 49 species which were collected during the course of this study include the majority of the fish fauna known to occur in this drainage; species known to occur in the stream but not taken in this study were the gizzard shad (Dorosoma cepedianum), gravel chub (Hybopsis x-punctata) and warmouth (Chaenobryttus gulosus) (from a catalogue of collected fishes, Biology Department, Western Kentucky University, Bowling Green, Kentucky).

The total number of species and individuals collected at each station progressively increased toward the upstream areas. The number of species per collection was consistently highest and most stable at the most upstream station, Station III. However, obvious increases in the number of species were noted in the downstream areas during the period June-September. These increases were primarily due to influxes of transient species. Harima and Mundy (1974) found similar increases to occur earlier (May thru mid-July) in a stream in Alabama. Whether such influxes, and resulting increases in the number of species/collection, were primarily upstream or downstream in origin was not easily discernible, however, greater numbers of transient species at the more upstream stations (16 at Station III versus 8 at Station I) indicated a downstream immigration. This probably resulted from lowered water levels in the headwater areas during the period June-September. The number of species per collection decreased during the late fall and winter periods at all stations, possibly, in part, due to increased water levels and subsequent reinvasion of headwater areas previously abandoned. In this regard, Smith and Powell (1971) feel that stream fishes must frequently redistribute themselves due to drying of upstream areas and periodic flooding of lower reaches. Hall (1972) found increased upstream migration during spring, summer and fall following any substantial rise in water levels.

The theory of longitudinal succession of stream fishes, as variously reported by Smith and Powell (1971), Sheldon (1968), Kuehne (1962), Whiteside and McNatt (1972) and Harrel, et al. (1967), was not supported by this study. These workers found increasing numbers of species as they progressed from the headwater sections to the more downstream areas. The opposite was true in this study, as the number of species consistently increased at the more upstream stations. Upon close inspection of the above studies, it is most plausible that this apparent inconsistency has as its foundation the duration of the studies: 1) With the exception of the study of Whiteside and McNatt (1972) all of these studies were conducted during the period June-September, corresponding with the period when maximum number of species were taken from the downstream stations during this study. In short, longitudinal succession would be most obvious during this period, particularly in regard to the low water levels encountered by all the previously named workers in the headwater areas during their respective studies: 2) Whiteside and McNatt's study was conducted during the period January-April and exhibited a decreasing number of species between IV and V order streams. This corresponds with the results of the present study as Stations I and II are located on an Order IV (Kuehne, 1962) stream; 3) Year-long studies might have yielded different results for the above authors, particularly in view of the wide fluctuations in water levels encountered in stream systems and seasonal variations and migrations known to exist in some stream populations (Hall, 1972; Gunning and Berra, 1969; Funk, 1957; Berra and Gunning, 1970; Larimore, et al., 1959). This is not to say that longitudinal succession may not be a viable theory in characterizing overall stream systems; however, it does appear to be relative to the stream sections involved, seasonally influenced, and may be less impressive when annual species per collections are involved. Habitat availability, structural features of the habitat (Sheldon, 1968), and environmental conditions would seem to be more of a delineating factor in the distribution of stream fishes than would artificial systems of stream classification.

The expected influx, particularly at the uppermost stations, of both species and individuals during the spring and early summer spawning period, as observed by Hall (1972) for both mass and numbers of fish in a North Carolina stream, did not materialize. This is not to say that many indications of spawning activity were not encountered, as both gravid females and secondary sexual characteristics were numerous during the spring and early summer collections. However, these conditions were generally found among species commonly collected at these stations. The Middle Fork of Drake's Creek is apparently minimally affected by spawning runs from lower stream areas. The one notable exception was an obviously spawn-induced immigration of longnose gar into the general area of Station II during the May collection. Many gar eluded capture during this collection; however, the three specimens that were collected included two males which emitted milt upon their capture. No gar were collected or observed during the remainder of the study. The least brook lamprey was also a unique species, as ammoecytes were collected at Station III during the August and September collections, however, adults were not captured until December and January.

The twenty-one species which were found at all three stations indicated total stream use by those species. In this regard Smith and Powell (1971) hypothesized, from a study of a stream in Oklahoma, that it was likely that every species at times occurred throughout that stream system. The several species which were found to occur only at specific stations during the present study were generally in such low abundance as to make unwarrented any claims of specificity for particular stream areas; however, the distribution of these unique species toward the upstream areas (three at Station I, six at Station II, and nine at Station III) tends to be nonsupportive of the theory of longitudinal succession, as does the hypothesis expressed by Smith and Powell above.

The habitat of Middle Fork Creek, with its numerous riffle-pool assemblages, is particularly suited to the requirements of several members of the minnow, sunfish, darter, sucker, and sculpin families. Members of these five families constituted 99.3% of the fishes collected from the Middle Fork. Eleven species within these five families contributed 91.8% of the collected fish. The majority of these abundant species are generally components of riffle assemblages and/or fast-flowing, shallow waters. These species also, with the possible exception of the longear sunfish, banded sculpin, northern hog sucker, and rock bass, feed upon organisms of the lower trophic levels. A distinctly piscivorous predator is absent from the list of eleven most abundant species. The rigors of maintaining position in swiftly-flowing waters possibly necessitates feeding upon the more efficient food items in regard to energy conversion. The darters, sculpins, and northern hog sucker, generally regarded as carnivorous, have adapted body forms which allow them to maintain position with little expenditure of energy, this contributing to their ability to utilize the higher trophic levels in a normally stressful riffle environment.

Monthly diversity values at all stations were erratic and showed no seasonal trends. Erratic fluctuations in diversity values were evidenced in studies by other workers (Smith and Powell, 1971; Dahlberg and Odum, 1970) and have been attributed by Harima and Mundy (1974) to be indicative of the temporal variations in the composition of populations. The decreasing trend in $\bar{D}$ values at Station I was felt to be the result of unequal distribution or "equitability" among species due, primarily, to increasing numbers of stonerollers. Smith and Powell (1971) noted similar results in Oklahoma due to increases in numbers of bigeye shiners at one station and threadfin shad at another station. The relative stability and high mean $\bar{D}$ values at Station II were largely due to the greater availability of habitats at this station. Although all stations were selected for their riffle-pool structure, Station II had submerged trees and brush at both ends of the riffle area. During this study such areas were generally found to be second in production only to riffle areas. Station III, with only a slightly lower $\bar{D}$ value than Station II (2.89 versus 2.75), also contained submerged vegetation but to a lesser extent. Station I contained little submerged vegetation and supported the least diverse populations; however, as has been stated earlier, this may be attributed, in part, to a dominant population of stonerollers. The exposed root structure of a sycamore tree near the confluence of the riffle and pool areas generally harbored the most diverse ichthyofauna at Station I. Harrel, *et al*. (1967) attributed increases in diversity with increases in stream order to an increase in available habitat and decrease in environmental fluctuations. Sheldon (1968) also found slight but observable increases in species diversity when cover, such as roots and logs, were present.

The stoneroller provided the greatest contribution to total diversity at all stations. The stoneroller was normally found in fast-flowing riffles or gravelly shoal areas. Few dominant species occupied the total habitat that was available to them, the majority being components of riffle assemblages. The longear sunfish, rock bass, and common shiner were prominent species which showed a preference for pool areas. Of these, the longear sunfish and rock bass were virtually always associated with cover, while the common shiner normally was not. The northern hog sucker and rosefin shiner were found frequently in both pool and the deeper riffle areas, indicating an adaptability to either habitat.

Decreased % AMCD values toward the headwater areas observed in some dominant species, i.e., stoneroller, rainbow darter, banded sculpin, greenside darter, and orangefin darter, was probably due to a combination of decreasing numbers of these species toward the upstream areas and increasing numbers and kinds of other species. The reverse trend (increased % AMCD values toward headwater areas) observed among golden redhorse, rosefin shiner, and longear sunfish seemed to be a result of optimum habitat availability for these particular species in the upstream areas. The buffering effect of increasing numbers and kinds of other species was overridden by prominent increases in numbers of these species, which contributed to increased % AMCD values.

The position of Station II, coupled with its position in what could be considered a "midstream" area, was felt to be responsible for the high incidence of seasonal and transient species at this station. Both upstream and downstream movement of fishes appear to be most prominent, and thus rare or uncommon species most detectable, at such a station.

Seasonal and transient species, although, taken as a whole, contributed heavily to diversity, did not appear to be responsible for the erratic fluctuations observed in diversity values. It was also apparent that movement of transient species, particularly into the larger areas of the stream, was most pronounced during June-September.

The mark-and-recapture study supported, in many instances, the home range concept of some stream species as proposed by Gerking (1953). This was particularly true in regard to the longear sunfish, rock bass, northern hog sucker, and spotted bass, as these species appeared to remain in the areas where they were marked and thus showed relatively high rates of return. In Gerking's study he found these same species to exhibit limited movement and to normally occupy a home range of less than 400 feet in stream length. The very nature of the mark-and-recapture experiments was such that movement from the area of initial marking was difficult to document. No attempts were made to recapture marked specimens from areas outside the individual station boundaries. Low or nonexistent returns for marked specimens of some species can be expected under the conditions of the study as streams are open systems which do not lend themselves readily to marking studies. Despite these limitations, a rock bass which was marked at Station I was recaptured at Station III and then again at its original point of release, Station I. This is indicative of extensive movement among individuals of a species normally considered to move very little. The theory proposed by Funk (1957) that some populations consist of both sedentary and mobile components is supported by such occurrences.

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