Some Physical, Chemical and Biological Characteristics of the Chariton River Prior to Impoundment of Rathbun Reservoir

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THE PHYSICAL CHEMICAL AND BIOLOGICAL CHARACTERISTICS OF THE CHARITON RIVER PRIOR TO IMPOUNDMENT OF RATHBUN RESERVOIR

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FOREWORD

The Biology Section has been actively engaged in fisheries research in river areas where impoundment of the stream will ultimately occur. One flood control reservoir is already operational on the Iowa River in this state. Two additional reservoirs, Red Rock on the Des Moines River and Rathbun Reservoir, are in the final stages of construction and will become operational in 1969. Another is under construction on the Des Moines River near Saylorville with a projected closure date in 1973. Several other impoundments are in the planning stages by the Corps of Army Engineers. These storage reservoirs will have a profound influence upon the physical, chemical and biological characteristics of the stream they control. Pre-impoundment studies are the foundation for the determination of what changes occur and how they influence the river community.

Investigations such as this one are difficult to document and report because of their scope. It is impossible to present data of this magnitude in another form because of the interrelationship between all of the characteristics. Presentation of one part of this study without inclusion of other important segments would spoil the continuity of the research and reduce the value of having the results under a single cover. Jim Mayhew worked on this project for more than five years and has previously published certain portions of the results in Quarterly Biology Reports and other publications. However, with publication of this report the results of the information is assembled into a single reference. The report is the first of its kind by the Biology Section, and other projects of this size will undoubtedly be published in a similar manner.

Wise recreational use of reservoir complexes in Iowa will result from a thorough knowledge of the basic characteristics of these communities. The Chariton River project was originally designed so research can continue after impoundment. These investigations will allow evaluation of influence of the reservoir upon the stream.

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LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Rathbun Dam and Reservoir was authorized by the Flood Control Act of the United States Congress in 1954 as an integral part of the comprehensive Missouri River Basin Plan. The primary purpose of the project is to provide flood control to more than 90,000 square miles of land in the lower Chariton River Basin. Additional major benefits would also be realized through regulation of stream flow and recreation.

The damsite is located at mile 145 on the Chariton River in sections 25, 35 and 36, T 70 N, R 18 W in Appanoose county about six miles north of Centerville. The reservoir will extend into Lucas, Monroe and Wayne Counties.

Rathbun Dam will consist of two earthfill embankments, one approximately 8,100 ft long across the Chariton River valley; the other approximately 1,900 ft long across Buck Branch Creek. The Chariton River dam will rise about 86 ft above the valley floor, and the Buck Branch Creek dam will be about 76 ft high. Both dams will have the identical 946 msl crest elevation. One - 11 foot gated horseshoe conduit will serve as the outlet structure. The emergency overflow spillway will consist of an uncontrolled notch at 924 msl about 3,000 ft landward of the right abutment.

Rathbun Reservoir will impound 11,000 surface acres of water at conservation pool (904msl). With the reservoir at flood capacity the lake will contain more than 21,000 surface acres. Maximum depth at conservation pool level will be about 44 ft, which will increase to 66 ft at flood stage. The reservoir will vary from 500 to 8,000 ft wide and contain about 180 miles of shoreline. Construction began in 1965 with the estimated closure date in late summer or early autumn in 1969.

Impoundment of the Chariton River will result in immense alteration of the physical, chemical and biological characteristics of the stream. Much of the degree of this change from former characteristics will depend greatly upon the location of the stretch of stream prior to impoundment. The portion of stream located within the reservoir will obviously undergo immediate physical change. Waters that were previously flowing will assume the characteristics of impounded waters. The tailwaters section of the reservoir, which previously had been unaltered, will also undergo drastic change. Most of this change will be the direct result of stablization in discharge flow. Prior to impoundment this section of the stream was subject to rapid changes in natural flow from drought to flood. After impoundment, flow will be stabilized to a greater extent, without wide fluctuations in flow that occur naturally. Characteristics of the headwaters will likely remain, for the most part, unaltered unless there is advanced watershed stabilization by additional surface water storage.

Chemical composition of the water in the river will probably be altered gradually as the concentrating effects from impeding natural flow occurs. Concentrations of chemical constituents will also probably become more stable under impounded conditions. Chemical composition of the tailwaters will likely be similar to the reservoir. The headwaters are expected to remain unaltered from pre-impoundment quality.

Development of the reservoir biota will depend upon the degree of change in physical and chemical characteristics. Animal and plant life presently inhabiting the river will flourish in the reservoir only if the new habitat contains all their basic requirements of life. Species unable to tolerate the altered environment will either decline in abundance or perish.

The purpose of this investigation was to determine the physical, chemical and biological characteristics of the Chariton River prior to impoundment by Rathbun Dam and Reservoir. The study was designed so subsequent investigations can continue at identical sampling location after completion of the dam to measure the influence the reservoir has upon characteristics of the river basin and stream.

Investigations began in the summer of 1964 and continued until late autumn of 1968. Because of the magnitude of this study it became expedient to divide the project into smaller segments with the work concentrated on one segment until it was complete. The only exception was water sampling, which required only two days each month, but continued for 20 consecutive months. Several factors may have changed slightly during the study period, although for the purpose of this study it was assumed the characteristics of the river were relatively stable and without occurrences of major proportions that influenced the investigation to the extent of altering the results.

There are many people and agencies that gave information willingly throughout the study. Most of the physical characteristics of the river were obtained from records of the U. S. Corps of Army Engineers, U. S. Geological Survey, Soil Conservation Service and U. S. Weather Bureau. The physical description of the dam and reservoir were furnished by the Rathbun Office, U. S. Corps of Army Engineers and the Kansas City District Office of the organization. All chemical analyses of water samples were completed by the Des Moines Branch, State Hygienic Laboratory. Studies of surface water storage was made by using overflight photographs in county offices of the Agricultural Stabilization Conservation Service, U. S. Department of Agriculture. Farm pond datum was provided by county offices of the Soil Conservation Service. Investigations of the biological characteristics of the Chariton River were confined mostly to collections from fish populations by many personnel of the Biology Section. All of this assistance was greatly appreciated by the author.

DESCRIPTION AND LOCATION OF SAMPLING STATIONS

Five primary sampling stations were established within the Chariton River Basin. Two of these were located on the Chariton River below the confluence of the two main forks; two were located on the Chariton River in Lucas County; and one was located on the South

Chariton River in Wayne County. All five stations were strategically located so they would be in either the headwaters, reservoir or tailwaters after the dam was completed and the reservoir filled to conservation pool.

Sampling for physical and chemical attributes was made exclusively at these stations. Studies of fish population, including species composition and standing crop were also completed at these stations. Thirteen additional sub-stations were established in the basin for fish distribution studies.

Station I

Located at State Highway No. 60, 3.5 miles north of Centerville on the Chariton River. The station was approximately 2.5 miles downstream from the damsite. After impoundment of the reservoir this area will form the tailwaters. The stream was characterized by a series of short, deep, flowing pools with alternating short, swift flowing riffles. Maximum stream width was about 80 feet with very high, steep, barren banks. Depth of pools was generally less than 6 feet. There has been unimportant rechannelization of short stretches of the original channel in this region.

Station II

Located at Appanoose County Road R about 4 miles south of Iconium. The station was located about 2 miles downstream from the confluence of the Chariton and South Chariton Rivers. Honey Creek empties into the Chariton River immediately below the study area boundaries. This section of the river consisted of a series of short shallow pools alternating with long, swift, constricted riffles. Maximum pool depth was about 4 feet in late summer. This station was located in the middle of the reservoir after impoundment. Originally, the forest canopy formed a complete cover over the channel. Late in the study all trees were removed from the area completely exposing the stream. Much of the stream channel is unaltered.

Station III

The station was located adjacent to an unmarked Lucas County Road approximately 0.7 miles downstream from Brown's Slough. Several short riffles and pools alternating with long, sluggish pools were typical of this region. Average stream width was about 50 feet, with maximum pool depth of 5 feet. Dense forest canopy completely shaded the stream at this station. The station was located in the headwaters of the conservation pool, or in the upper reaches of the reservoir at flood pool elevation.

Station IV

Located at Lucas County Road J about 4.5 miles downstream from Chariton. The stream was extensively rechanneled in 1938-39. During the second year of the study an additional portion of the stream near the downstream boundary was rechanneled. The station consisted of a large, deep, sluggish pool which was isolated downstream by a very small, short riffle. Mean depth of the pool was about 7 feet. The stream was about 40 feet wide. Small grain cropland bordered the river banks at the station. This station was located in the upper headwaters of the reservoir at flood pool elevation. For the most part this station will remain unchanged because of its upstream location from the conservation pool.

Station V

The sampling station was located at Wayne County Road P approximately 5 miles north of Promise City on the South Chariton River. The original stream channel has been completely relocated and the stream might be classified as an agricultural drainage ditch. Long shallow pools alternating with wide, shallow riffles were typical of this station. Much of the stream bottom consisted of sand deposits. Mean depth in pools is less than 3 feet. The stream averaged 30 feet in width. Small grain cropland bordered the entire channel. The station was in the headwaters of the flood pool.

PHYSICAL CHARACTERISTICS

The Chariton River is a major tributary of the lower Missouri River.[1] Its source is located in the southwestern corner of Clarke County, then flows in a northeasterly direction through portions of Lucas and Monroe Counties, and southeasterly through Wayne and Appanoose Counties. The stream leaves Iowa and enters Missouri in the southeastern corner of the latter county. The Chariton River divides into two main branches in the northwestern corner of Appanoose County. The South Chariton River flows from the southeastern corner of Decatur County through Wayne and Appanoose Counties in an easterly direction (Figure 1).

For the most part stream flow is slow and sluggish, often choked by fallen trees and log drifts. Daily flow records at the Walnut Creek gaging station in Appanoose County revealed a mean discharge of 338 cfs since becoming operational in 1956. Maximum flow of 21,800 cfs was recorded on June 24, 1960. Low flow of 0.1 cfs was recorded on October 17, 1957 and October 11, 1966.

Prior to extensive rechannelization in the late 1930's the stream followed a tortious course through a broad alluvial valley in the six county area. Most of the original channel in Wayne and Appanoose Counties has been straightened to promote rapid drainage for agriculture. In Lucas and Clarke Counties much of the original channel remains. In the rechanneled region more than 100 cut-off oxbow overflow ponds presently exist. These ponds depend upon periodic flooding and limited storm run-off to maintain water levels. Without heavy precipitation many bayous are dry in late summer and autumn.

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1 A Plan for Recreational Development of Rathbun Dam and Reservoir. U. S. Army Engineer District, Kansas City.

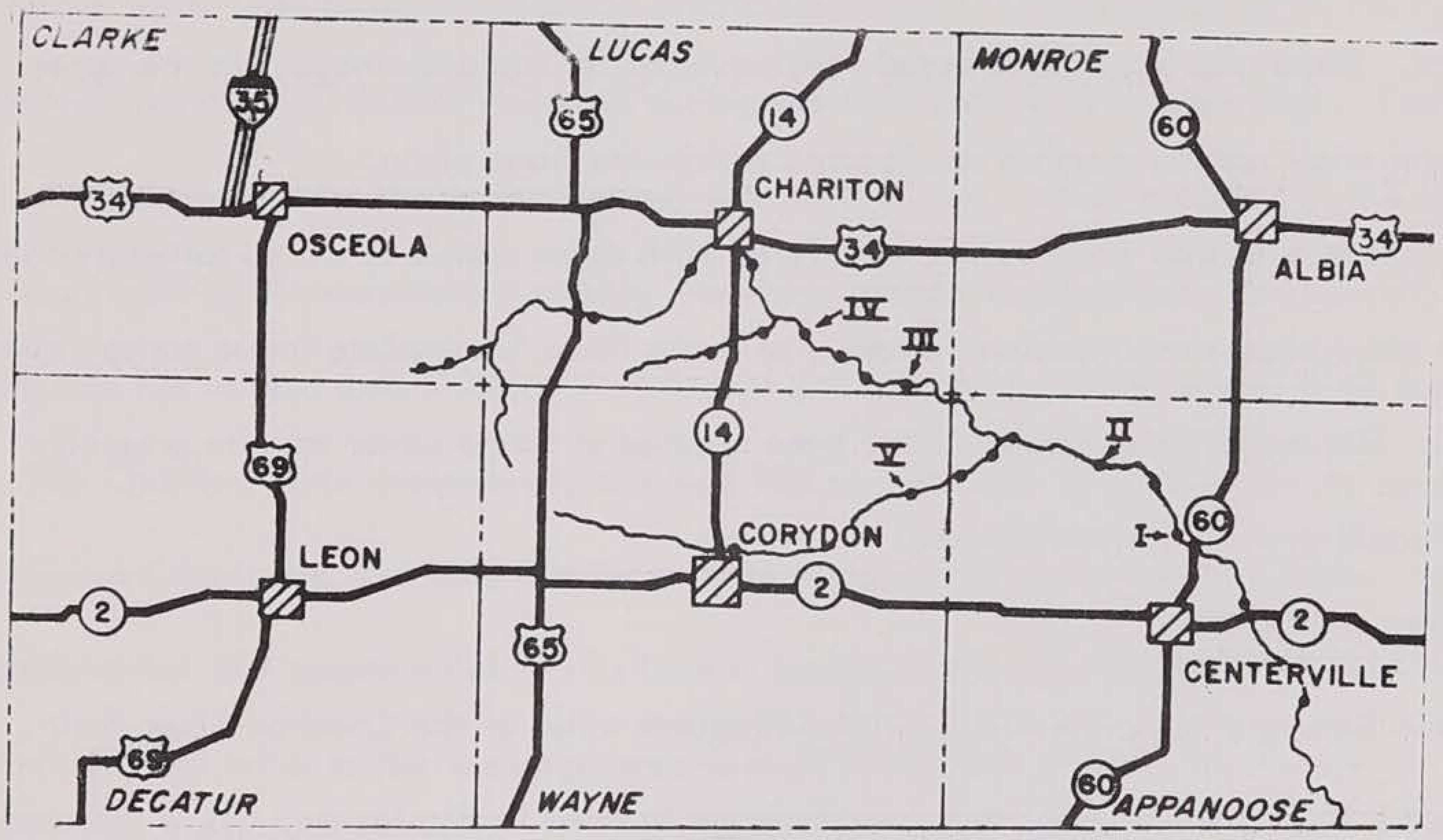

Figure 1. Map of the Chariton River Basin showing the location of sampling stations. The numbered stations represent the primary water sample collection sites. The dots represent the location of sub-stations where fish collections for distribution studies were made.

The river channel is characterized by very steep, barren banks varying from 5 feet high in the upper reaches of the basin to as much as 25 feet high in the lower basin. There are more than 70 small streams tributary to the Chariton and South Chariton Rivers upstream from the damsite. These also have been largely rechanneled for rapid drainage. In the upper basin several small natural marshes are located within the flood plain.

Much of the Chariton River valley is covered with dense stands of mixed soft-harwood forest. In many places the woodland cover is so dense there is complete forest canopy over the stream. The rechanneled regions have been cleared of forest cover and are presently farmed for small grain crops and pasture.

BASIN CHARACTERISTICS

Rathbun Dam and Reservoir will control 549 square miles of the Chariton River Basin. An additional 366 square miles of the river drainage in Iowa is also located below the damsite. However, this report will be concerned with only the portion of the river basin upstream from the dam and the immediate tailwaters of the structure.

This section of Iowa is located in the area covered by the Kansan glacial drift which was later covered by loessial deposits of more recent origin. In the eastern part of the basin, erosion has cut deeply into the face of the land and produced rugged terrain characterized by tributary streams of flat gradient in broad alluvial valleys. The alluvium is covered with a thick deposit of allochthonous loessial soil. The immediate slopes of the basin is composed of 5-30% Shelby soils. The upper basin soils, which are comparatively level uplands, is a mixture of 2-7% Grundy, 2-8% Weller, 7-30% Lindley and insignificant amounts of Haig and Edina soils[1].

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[1] Soil Survey, Lucas County. United States Department of Agriculture, Soil Conservation Service, 1960.

Limestone and coal outcropping occur in the lower basin on eroded banks and deep channel cuts. In the upper basin they are buried too deeply to appear at the surface.

Rainfall in the Chariton River valley has varied between relatively wide limits. Records available since 1881 revealed minimum precipitation of 22 inches occurred in 1921. Maximum recorded rainfall of 52 inches occurred during the first year records were kept. The mean annual precipitation for the entire periods was 33.3 inches. Over a period of the last 30 years, although individual years varied greatly, the long range trend has been downward[1]. The rate of decline has ranged from 0.05 to 0.12 inches per year with an average of 0.07 inches.

The Chariton River drains approximately 924 square miles of land in the six county area. Appanoose County has 415 square miles or 80% (Table 1) of the entire county area within the watershed; but 386 square miles of this land is located below the damsite. Wayne County contributes 325 miles to the drainage area with 62% of the county within the basin. Approximately 31% or 135 square miles of Lucas County is drained by the stream. Clarke, Decatur and Monroe Counties contribute a combined total of 49 square miles to the watershed.

TRIBUTARY STREAMS

According to the U.S. Geological Survey list of drainage areas of Iowa and plat maps of individual counties in the basin, 70 streams are tributary to the Chariton River. The most important tributary is the South Chariton River which contains 225 square miles or 41% of the river basin (Table 2). Other tributaries of the Chariton River are Wolf Creek in Lucas and Wayne Counties which drains 93.3 square miles, Goodwater Creek in Lucas County containing 19.8 square miles of drainage and Honey Creek in Appanoose County with 14.9 square miles in the watershed. Only the lower reaches of Wolf Creek maintains flow at all times.

[1] Rainfall of the Eastern United States. U. S. Weather Bureau. Dept. of Commerce 1965

Table 1. Chariton River Basin land area by county

County	Total square miles	Square miles in basin	% in basin	Square miles out of basin	% out of basin
Appanoose	522	415[1]	80.0	97	20.0
Clarke	428	28	6.5	400	93.5
Decatur	533	12	2.3	521	97.7
Lucas	432	135	31.3	297	68.7
Monroe	432	9	2.1	423	97.9
Wayne	524	325	62.0	199	38.0
Total	2,871	924		1,937	

[1] 386 square miles of this figure are located below the damsite

Major tributaries of the South Chariton River are Jackson Creek with 72.1 square miles of watershed; Jordan Creek with 26.3 square miles of drainage; and Walnut Creek which drains 18.1 square miles. All of these streams are located in Wayne County and are classed as intermittent without flow during periods of low precipitation. There is no gaging station on the South Chariton River, but the stream contains measureable flow during most periods in the lower reaches.

SURFACE WATER STORAGE

Within the Chariton River drainage basin approximately 1,130 surface acres of water are stored in 2,159 farm ponds (Table 3). Wayne County has more than 66% of these impoundments with a total of 1,365 ponds and a combined surface area of 682.5 acres. Inspection of over-flight photographs of all parts of counties in the river basin revealed the number of ponds

Table 2. Drainage area of streams tributary to the Chariton River

County	Stream	Tributary to	Drainage area (square miles)
Clarke	Chariton River	Chariton River	28.0
Lucas	Unnamed Creek	Chariton River	6.09
	Wolf Creek	Chariton River	65.5
	Honey Creek	Wolf Creek	5.3
	Five Mile Creek	Wolf Creek	13.7
	Lost Branch Creek	Chariton River	11.4
	Goodwater Creek	Chariton River	9.96
	Honey Creek	Chariton River	14.0
	Brush Creek	Chariton River	6.9
Appanoose	South Chariton River	Chariton River	225.0
	Sandy Branch Creek	South Chariton River	8.42
	Honey Creek	Chariton River	14.9
	Buck Branch Creek	Chariton River	18.45
Wayne	Wolf Creek	Chariton River	12.45
	Brush Creek	Wolf Creek	11.2
	Sugar Creek	Wolf Creek	6.16
	Goodwater Creek	Chariton River	9.76
	Dick Creek	South Chariton River	15.1
	Nine Mile Creek	South Chariton River	17.1
	Wild Cat Creek	South Chariton River	7.59
	Jordan Creek	South Chariton River	26.34

Table 2 (continued)

County	Stream	Tributary to	Drainage area (square miles)
Wayne	Duck Valley Creek	South Chariton River	5.2
	Jackson Creek	South Chariton River	44.3
	West Jackson Creek	Jackson Creek	28.8
	Walker Creek	South Chariton River	16.1
	South Walker Creek	Walker Creek	6.36
	Bollmar Creek	South Chariton River	7.63
	Walnut Creek	South Chariton River	18.1

proportional to the total area of the county within the watershed. Distribution of ponds is quite uniform throughout this region of the state. Lucas County was the second most important area of surface water storage followed in order by Appanoose, Clarke Decatur, and Monroe Counties, respectively. The average size of these ponds was 0.48 surface acres.

Table 3. Number and size of farm ponds located in the Chariton River Basin

County	Number of ponds	Total area in acres
Appanoose	122	61
Clarke	118	59
Decatur	50	25
Lucas	567	283.5
Monroe	37	18.5
Wayne	1,365	682.5
Total	2,159	1,129.5

The Honey Creek Watershed Stabilization Project is also located in the Chariton River watershed in the southeastern corner of Lucas County. This project is unique because it was a pilot project financed wholly by the Department of Agriculture for experimental stabilization of small watersheds. The project, which was completed in 1957, contains 21 ponds ranging in size from 1.15 to 6.5 surface acres. Collectively they impound 75 surface acres of water. All were constructed with earthen dikes and concrete drop-box outlet structures. Individual watersheds of these ponds have also been protected from erosion by additional use of soil conservation practices.

An additional 775 surface acres of water (Table 4) is also stored in 6 artificial lakes and reservoirs within the upper basin. These impoundments are Humeston Reservoir, Allerton Reservoir, West Lake, North Colyn, South Colyn and Brown's Slough.

Table 4. Artificial lakes and reservoirs within the Chariton River Basin

Lake	County	Surface area (acres)	Mean depth [1] (ft)	Storage capacity (acre/ft)
Humeston Reservoir	Wayne	37	6.7	248
Allerton Reservoir	Wayne	104	6.2	645
West Lake	Lucas	51	5.9	301
North Colyn	Lucas	199	2.6	517
South Colyn	Lucas	99	2.7	267
Brown's Slough	Lucas	285	2.8	798
Total		775		2,776

[1] $\text{Mean depth} = \frac{\text{Total volume}}{\text{Surface area}}$

Humeston Reservoir is a municipal water supply impoundment containing a surface area of 37 acres and a storage capacity of 149 acre/ft. The reservoir is located in the upper reaches of the Wolf Creek watershed in northwestern Wayne County. Construction of the lake was completed in 1928. The original reservoir contained 22 surface acres. In 1957 this was increased to the present size by increasing spillway elevation by 5 feet. Water supply for the reservoir comes wholly from storm run-off. The water level fluctuates frequently by as much as 4 feet.

Allerton Reservoir is located in Bob White State Park near Allerton in Wayne County. The lake contains 104 surface acres and has a total storage capacity of 645 acre/ft. It is located in the extreme upper basin of the South Chariton River and impounds water in the main stream channel of this stream. The reservoir was constructed in 1912. Water from the lake is used primarily for municipal and industrial purposes. There is considerable recreational use of the lake. During recent years siltation of the upper portion of the reservoir has become a serious problem with the water remaining turbid most of the year.

West Lake is a privately owned impoundment on an unnamed creek near Chariton in Lucas County. The lake contains a surface area of 51 acres and a storage capacity of 301 acre/ft at spillway elevation. Originally,the reservoir was constructed for industrial water supply to the Chicago, Burlington and Quincy Railroad Company. Later it was purchased by the Chariton Golf and Country Club as a source of irrigation water for the golf course. It is also used for recreation, but is closed to public use. The upper reaches of the lake are badly silted from severe bank erosion due to uncontrolled use of high speed boats. The water remains turbid throughout periods of high boating activity, mainly in the summer months.

North Colyn, South Colyn and Brown's Slough are man-made impoundments within 3 miles of each other in the southeastern corner of Lucas County. The impoundments were constructed in 1953 and 1955 with federal aid funds for waterfowl hunting and refuge. Brown's Slough is the largest lake containing 285 surface acres and 789 acre/ft of water. This lake was formed by constructing a long semi-circular dike adjacent to the river channel impounding water from storm run-off in the immediate river watershed. North Colyn has a surface area of 199 acres and a storage capacity of 517 acre/ft. South Colyn contains 99 surface acres and stores 267 acre/ft at spillway elevation. Both impoundments were formed by diking and rechanneling the Chariton River at a long, sweeping bend. The rechanneled portion of the river is located between the lakes in the barrow cut of the diking system. South Colyn is located on the downstream bend and was formed by semi-circle diking Goodwater Creek within the flood plain of the Chariton River near the confluence of the two streams. All three lakes are subject to severe fluctuation in water levels for waterfowl management. The Chariton River also periodically floods these lakes.

RIVER FLOW AND DISCHARGE

Two gauging stations are operated by the U. S. Geological Survey to measure flow in the Chariton River. The upstream station is located at Lucas County Road J at sampling station IV. The other is located immediately below the confluence of the Chariton River and Walnut Creek in Appanoose County. Only the lower station was used in this report because of the great influence the South Chariton River has upon flow in the lower basin.

Although this investigation covered a period of almost 4 years only the period from July 1, 1966 through June 30, 1967 was selected as representative of flow in the river so it would correspond with the period selected for water sampling. All natural forces affecting flow during this period were considered typical for the river.

Maximum discharge of 8,240 cfs was recorded on June 23 (Table 5). During this month discharge of $>$ 1,000 cfs was recorded on 21 days. Flow of this magnitude was also

Table 5. Mean daily discharge in cfs in the Chariton River from July 1966 through June 1967

Date	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
1	40	59	2.8	5.8	.9	1.6	1.2	28	6.8	774	123	2,350
2	35	53	2.5	5.5	1.2	1.7	1.2	26	7.4	869	69	1,940
3	27	37	2.9	4.6	1.2	1.4	1.2	25	8.2	596	56	1,020
4	20	38	3.1	3.7	1.3	1.2	1.2	27	9.0	392	50	634
5	15	32	3.4	2.8	1.6	15	1.2	30	7.0	255	51	587
6	13	23	4.1	.6	2.0	30	1.2	36	6.0	141	52	1,480
7	18	17	3.9	.3	1.7	20	1.2	45	6.5	96	55	1,540
8	16	13	3.1	.3	1.9	11	1.2	36	7.0	79	68	928
9	13	10	1.7	.2	1.9	7.6	1.2	32	7.5	132	71	603
10	10	8.5	1.1	.2	1.6	4.8	1.2	30	7.9	302	65	921
11	8.5	7.7	.7	.1	1.4	4.6	1.2	28	8.5	335	205	978
12	7.8	6.7	.7	.4	1.6	8.0	1.2	25	9.2	277	459	1,470
13	7.2	5.6	.9	5.4	1.9	12	1.2	30	10	1,080	430	2,930
14	6.1	4.9	5.4	2.0	1.9	8.0	1.2	35	11	1,380	397	3,440
15	7.7	4.8	4.5	3.7	1.3	5.4	1.2	20	10	1,070	355	4,410
16	6.4	4.0	10	1.1	1.3	4.4	1.2	15	9.8	811	253	5,550
17	8.4	3.1	8.1	.8	1.4	3.5	1.2	12	9.5	575	106	4,500
18	9.3	8.8	6.4	1.7	2.0	2.8	1.2	10	8.5	388	73	3,570
19	8.8	10	6.6	2.7	2.1	2.3	1.2	9.0	7.8	276	67	2,910
20	7.3	6.8	7.4	2.0	2.1	2.1	1.4	8.5	15	205	57	1,400
21	6.1	6.3	7.9	1.9	1.7	1.9	1.8	8.0	25	338	44	4,020
22	5.0	3.3	7.6	2.4	1.3	1.7	2.5	7.6	34	484	37	4,010
23	5.4	1.5	7.3	2.5	1.5	1.6	3.5	7.3	35	398	32	8,240
24	5.1	3.0	6.9	2.2	2.1	1.5	5.0	7.0	38	338	27	5,180
25	4.7	3.0	6.9	2.0	2.4	1.4	10	6.8	40	226	22	3,180
26	4.3	2.5	6.1	2.1	2.2	1.4	35	6.6	68	171	18	2,130
27	8.8	1.6	5.6	1.9	2.0	1.4	50	6.4	104	148	15	1,160
28	28	1.9	5.7	2.1	1.6	1.3	45	6.4	214	133	415	600
29	70	2.0	5.9	1.6	1.3	.9	35		140	129	531	253
30	78	2.5	5.5	.9	1.3	1.3	40		227	121	1,080	203
31	63	3.5		1.2		1.3	30		103		1,940	
Mean	18.2	12.4	4.8	2.1	1.7	5.3	9.1	20.1	38.7	417	233	2,422

recorded at the gauging station on 3 days in April and 2 days in May. The minimum flow of 0.1 cfs on October 11 equaled the low discharge record of October 17, 1957. November was the lowest in mean discharge with 25 days ≤2.0 cfs. Mean daily discharge for the year was 18.2 cfs compared to normal discharge of 33.3 cfs since the gauging station has operated in 1956.

Intense summer storms have a profound effect upon discharge in the Chariton River. Extremely high flow can be expected only from intense storms over the entire river basin. Minor flooding occurs from isolated heavy precipitation in small segments of the watershed. The maximum discharge on June 23 was the direct result of 5.2 inches of rainfall over the entire upper basin. Latent flooding can also be expected from snow cover in excess of 10 inches in the watershed particularly with rapid melting on frozen ground.

Intense storms occur frequently in southern Iowa. Of the 33 most intense storms in the northern United States from 1964 to 1967[1], five were so oriented to give maximum precipitation to Iowa. Four of these were located in southern Iowa. Rainfall in excess of 4.0 inches may be expected at a frequency of 1.21 years. Frequency of storms of this magnitude or greater are expressed by

$$\text{24-hour rainfall} = 3.8\ \text{frequency}^{0.23}$$

for a period of 20 years.

TOTAL SOLIDS AND TURBIDITY

Measurements of total solids were recorded monthly at the 5 primary sampling stations. The concentration of dissolved and suspended solids were used as an index of turbidity. Water samples were analyzed for both parameters at the Des Moines Branch, State Hygienic Laboratory. Total solids at the 5 primary stations are presented in Figure 2.

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[1] Storm Rainfall of the Eastern United States, Miami Conservancy District.

Differences in total solids between stations on identical sampling dates were caused, as in the previous case, mostly by isolated run-off with high concentrations of suspended material. The extreme upper range of total solids, 1,032 mg/l in the June samples, was made up of 829 mg/l suspended solids. Dissolved solids content of this sample was 210 mg/l, well within the range of dissolved solids at other stations on this date.

There was direct interrelationship of river discharge and total solids. During periods of high flow, total solids were high; when river flow was low, total solids were also low. Mean daily discharge was highest (2,422 cfs) in June. Total solids in the samples for this month at the combined stations was 611 mg/l. The lowest concentration of total solids occurred in September (sample range at the 5 stations - 290 to 342 mg/l) when the mean river discharge was <5 cfs the entire month.

WATER TEMPERATURE

Water temperature was routinely recorded with a Whitney Underwater thermometer during each sampling period at each station. Although this method of collecting temperatures does not achieve the accuracy of constant recording devises it does offer ranges in temperature for individual stations throughout the investigation. The mean temperature of the combined sampling stations and the maximum-minimum water temperature recorded on the sampling date are listed in Figure 3.

Water temperatures in the Chariton River were closely related to atmospheric temperatures. The highest mean temperature, 81.5° F, was recorded in the July samples. After this date mean water temperatures decline and the maximum-minimum ranges also became smaller. Under ice cover in January, February and March mean temperature was almost constant at 33-34°F. In early spring a very rapid increase in mean water temperature followed by a gradual increase

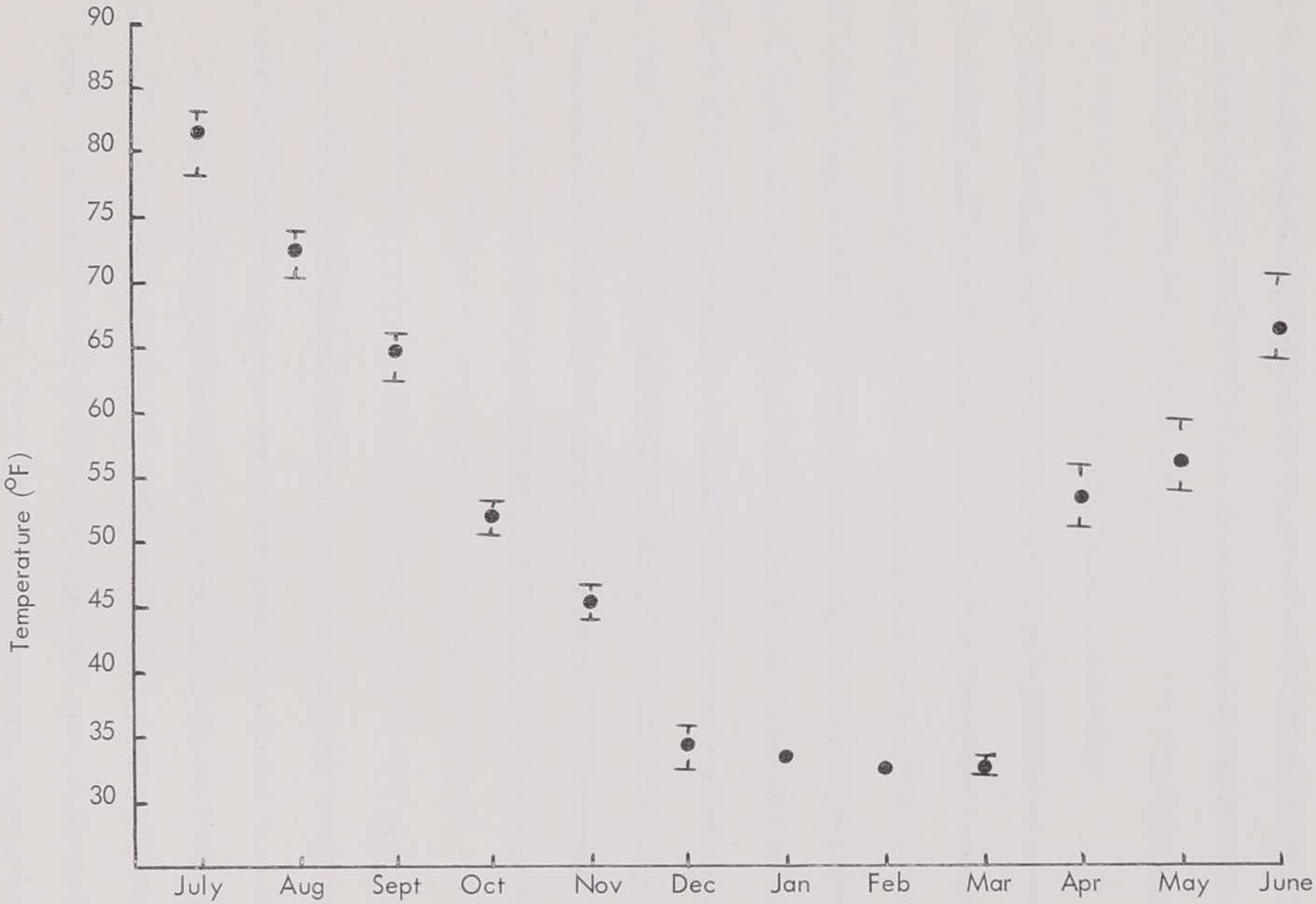

Figure 3. Mean monthly water temperature at the primary sampling stations. Dots represent mean temperature, and brackets represent temperature range.

in mean temperature occurred until the last sampling period in June.

The shading effect of heavy, complete forest canopy influenced water temperatures during the higher ranges. At Station III, where the stream was completely protected from direct sunlight by mature woodland mean water temperature was 3 to 5° F lower than other stations in the July and August samples.

CHEMICAL CHARACTERISTICS

Water samples were collected at monthly intervals at the primary sampling stations. These samples were transported immediately to the Des Moines Branch, State Hygienic Laboratory for analysis. Quantitative analyses were completed for dissolved oxygen, biochemical oxygen demand, total phosphates, organic nitrogen, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, alkalinity, pH and hardness. The laboratory used analytical procedures outlined in the Standard Methods for the Examination of Water, Sewage and Industrial Wastes, 12th Edition (1965). Water sampling was actually conducted from May 1966 through November 1967, but variation in samples repeated in the same month in consecutive years showed unimportant differences so only the 12 month period from July 1966 through June 1967 is included in this report.

Method of Data Analysis

Concentration of each chemical constituent in monthly samples was arranged in tabular form where the values at individual sampling stations were separated into columns and sampling dates into rows. In this array values between stations at monthly intervals could be directly compared at j^{th} sampling station on the i^{th} sampling date. Seasonal trends could also be compared by station by moving in the opposite axis in the table. Concentrations were graphically plotted for each sampling station.

Differences among samples was tested by using a one-way analysis of variance suggested by Snedecor and Cochran (1967). In this analysis it was assumed variance in samples approximated that in the river basin and approached a normal distribution. The basic reason for the analysis of variance was to express a measure of total variability of the data as a sum of terms, each of which could be attributed to a specific source, such as between sampling stations or within monthly sampling dates. Significant differences in variance was accepted at the 5% level of sampling probability.

The mean and ranges of concentrations of chemical substances were graphically plotted for the combined samples at each sampling station. Dispersion of values in monthly samples around the mean for the station was analyzed by computation of the standard error. As concentrations in monthly samples became abnormally high or low the magnitude of this deviation was reflected in the standard error. The 95% confidence intervals of sampling station means could also be computed by plotting to 2-standard-errors.

Inspection of all differences between pairs of mean values at sampling stations was completed by using a least significant difference (LSD) test for each parameter. This procedure involved calculation of the standard error between paired means in the usual fashion and multiplying the results by the 5% level of t (one-sided test) at the representative df. Hence, the differences between specific pairs of means was significant at the 5% level of sampling probability if it exceeded the calculated LSD value.

Dissolved Oxygen (DO)

DO concentrations ranged over relatively wide limits during the study. In general, levels were highest in early spring months with heavy runoff. There was a systematic decline in levels during summer months at all stations, reaching lowest levels in late autumn or early winter. DO concentrations were above the minimum requirements of fish life (3 to 5 mg/l) except during October and November at Stations III and IV. At Station III, October samples contained 2.0 mg/l and 0.9 mg/l in November (Figure 4). DO levels were 2.2 mg/l in October and 0.2 mg/l in November at Station IV. Neither of these values was greatly different from other stations during this period because DO was rather low at all sampling stations.

Both stations are located in the upper basin of the Chariton River within 12 miles of the Chariton Sewage Treatment Plant. Although this plant affords suitable treatment to most domestic and industrial wastes during most of the year it was obvious there was a breakdown in the efficiency of the process during this period. Recent studies of secondary and tertiary sewage treatment processess by Iowa State University (personal communication) showed loss of efficiency in the assimilation of organic wastes during periods of declining and low water temperatures. Lowest concentrations of DO during colder seasons always occurred at Station IV, which is nearest the treatment facility.

Mean DO levels ranged from 4.8 mg/l at Station IV to 9.0 mg/l at Station V (Figure 5). There was a progressive increase in mean DO levels as sampling moved toward the lower basin, thereby increasing the distance from the treatment plant. The standard errors of mean DO levels at individual sampling stations did not show great differences, but the least significant difference tested between paired means yielded significant differences between Station V and Stations III and IV. The mean DO level at Station I is also significantly different from Station IV. There was no significant difference between paired means at other sampling stations. Further evidence of the loss in treatment efficiency can also be observed for other parameters that are influenced by the degree of organic waste treatment.

Concentrations of DO on individual sampling dates ranged from 0.2 mg/l in November at Station IV to 15.8 mg/l at Station V in April. Analysis of variance (Table 7) among samples showed significant differences ($F = 3.25$; $P < 0.05$). Variation within sampling dates

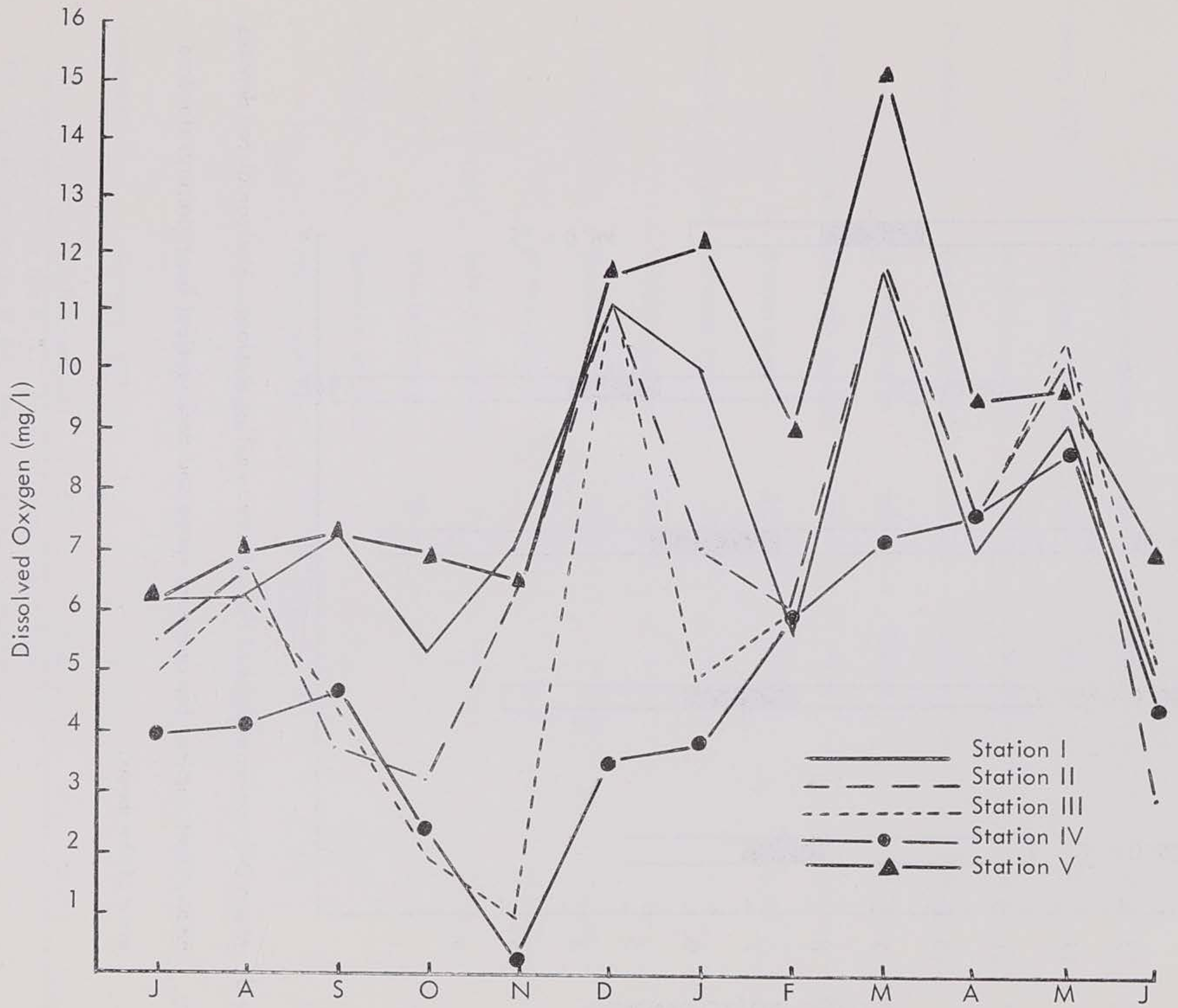

Figure 4. DO concentrations at monthly intervals at the primary sampling stations.

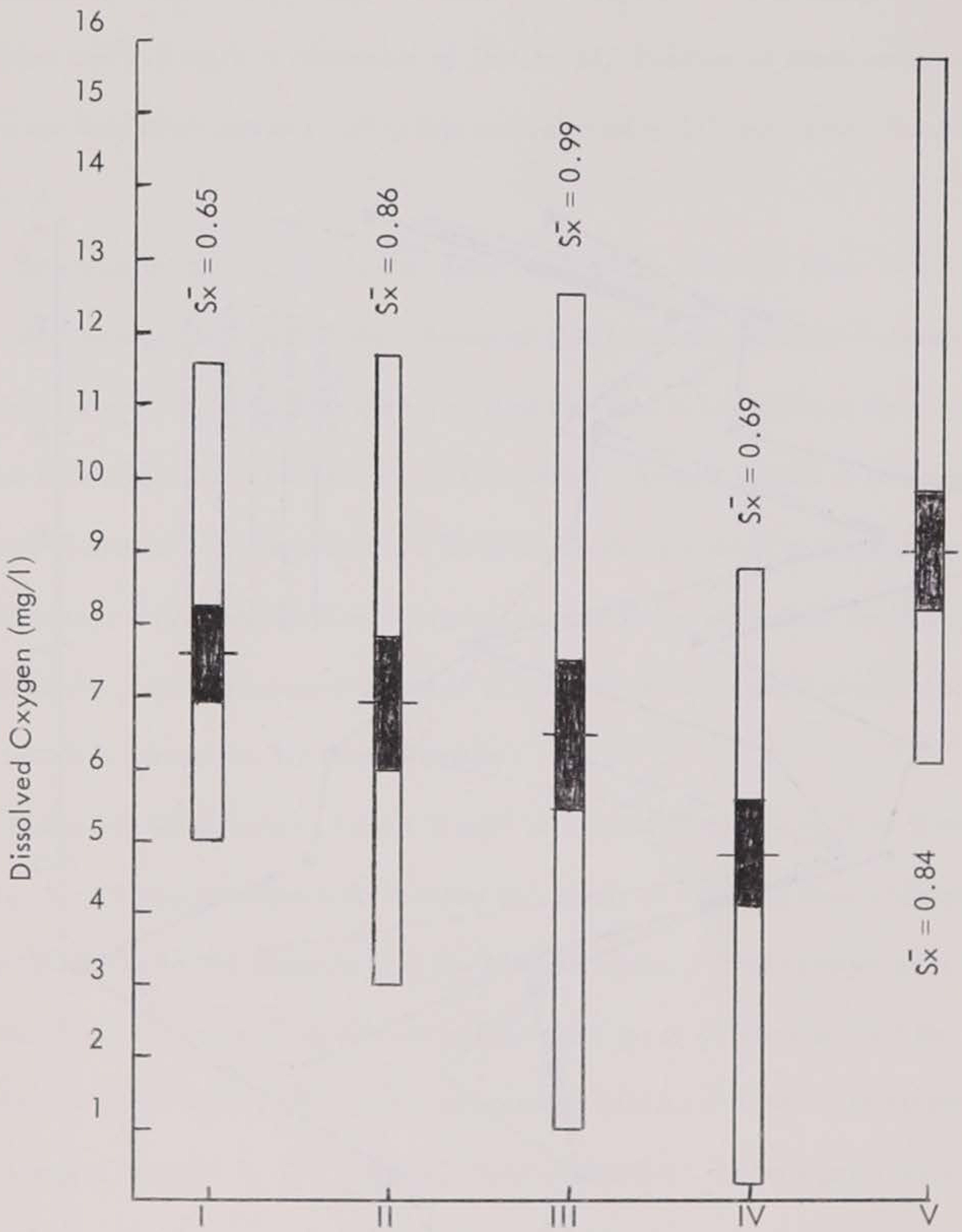

Figure 5. Mean DO concentrations at the primary sampling stations. Horizontal bar denotes mean, light vertical bar represent range and dark vertical bar represents standard error of the mean.

Table 7. Analyses of variance in the chemical composition of water samples from the Chariton River

Constituent	Source of variation	df	Sum of squares	Mean squares	F
Dissolved oxygen	Between stations	4	104.0	26.0	
	Within samples	55	440.2	8.0	3.25*
5-day BOD	Between stations	4	33.6	8.4	
	Within samples	55	358.0	8.5	1.29
Phosphate	Between stations	4	264.2	66.05	
	Within samples	55	852.8	15.5	4.25**
Organic nitrogen	Between stations	4	4.4	1.4	
	Within samples	55	12.6	0.2	5.50**
Ammonia nitrogen	Between stations	4	4.8	1.2	
	Within samples	55	1.2	0.21	6.02**
Nitrite nitrogen	Between stations	4	0.0144	0.0028	
	Within samples	55	0.069	0.0013	2.15
Nitrate nitrogen	Between stations	4	0.84	0.21	
	Within samples	55	9.2	0.17	1.24
Alkalinity	Between stations	4	9,540	2,385	
	Within samples	55	224,339	18,695	0.12
pH	Between stations	4	0.84	0.21	
	Within samples	55	3.4	0.061	3.44*
Hardness	Between stations	4	46.8	11.7	
	Within samples	55	535.5	9.73	1.20

* Significant at the 0.05 level of sampling probability

** Significant at the 0.01 level of sampling probability was the most important source of error accounting for approximately 65 % of the difference, indicating rather large seasonal differences in DO.

Biochemical Oxygen Demand (BOD)

BOD was not considered a true chemical substance of water chemistry because it possesses no identity as a specific chemical compound. However, it is important to water quality because of its profound depressing effect upon DO levels. BOD in this study, as expected, had an inverse relationship with DO. Where BOD levels were high, DO levels were low with the reverse also applicable.

Mean BOD levels ranged from 4.2 mg/l at Station I to 6.0 mg/l at Station V (Figure 6). Ranges in BOD levels were quite large, 1 to 18 mg/l, but the maximum range of standard errors was $\pm$ 1.10 mg/l, which indicated higher values of BOD were of rather short duration. There was no significant difference in levels of paired means.

Higher levels of BOD showed a tendency for progressive movement downstream from Station IV. The highest BOD value was recorded in November when the reading was 18 mg/l (Figure 7). The following month BOD was 10 mg/l at Station III, which was the highest recorded for that station. The next month BOD at Station II (the next downstream station) was greater than any other sampling station, but the level was not considered abnormally high. Analysis of variance revealed no significant difference ($F = 1.29$; $<0.10\ P <0.25$) between stations and within sampling dates. Most of the variation in sample means (76%) was attributed to differences in BOD levels between sampling stations.

Phosphates (PO_4)

Separate analyses were made for soluble and organic forms of phosphates by the laboratory, but were combined into total phosphates (PO_4) for this report. Soluble forms of phosphate were

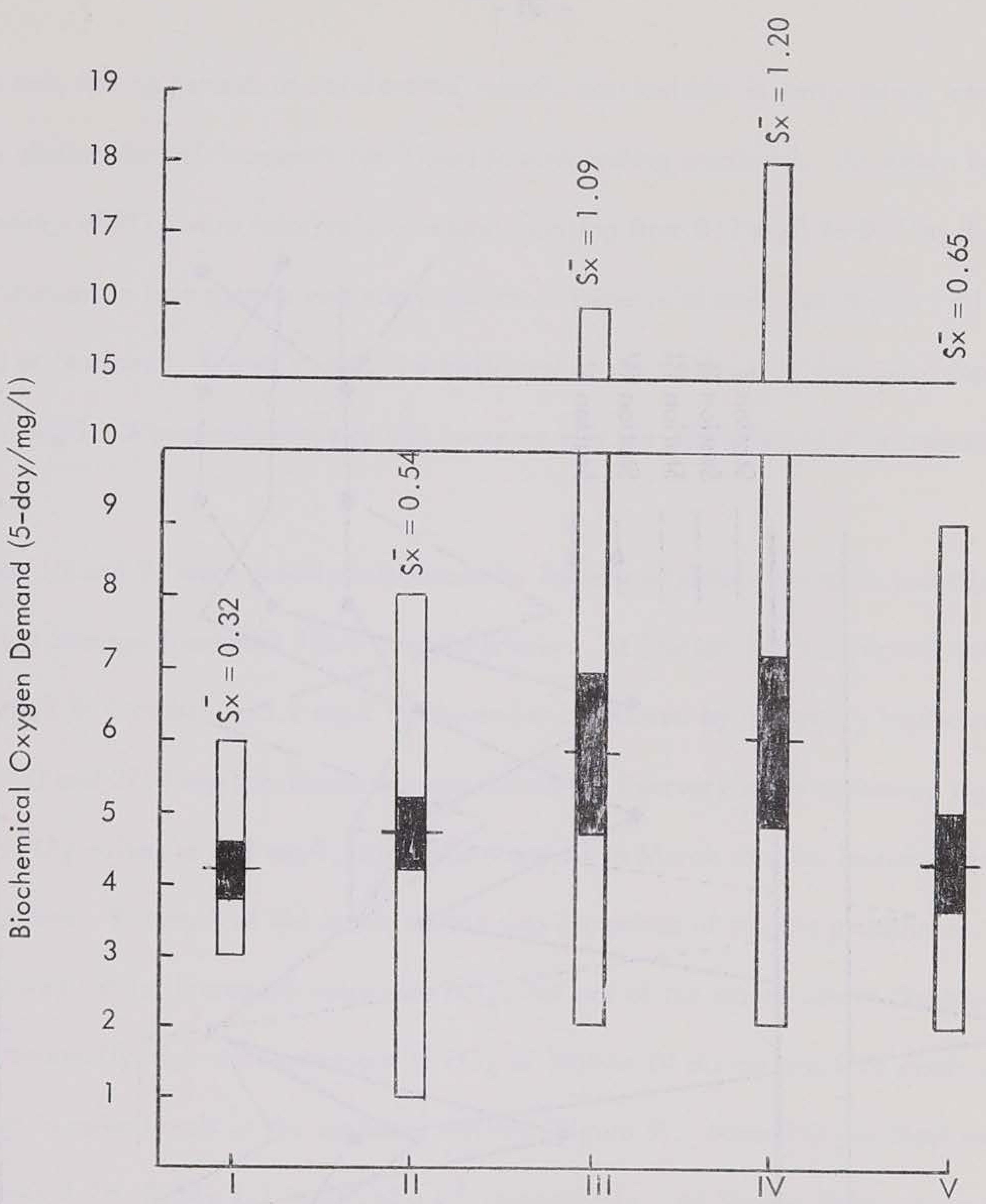

Figure 6. Mean 5-day BOD at the primary sampling stations. Horizontal bar denotes mean, light vertical bar represents range and dark vertical bar represents standard error of the mean.

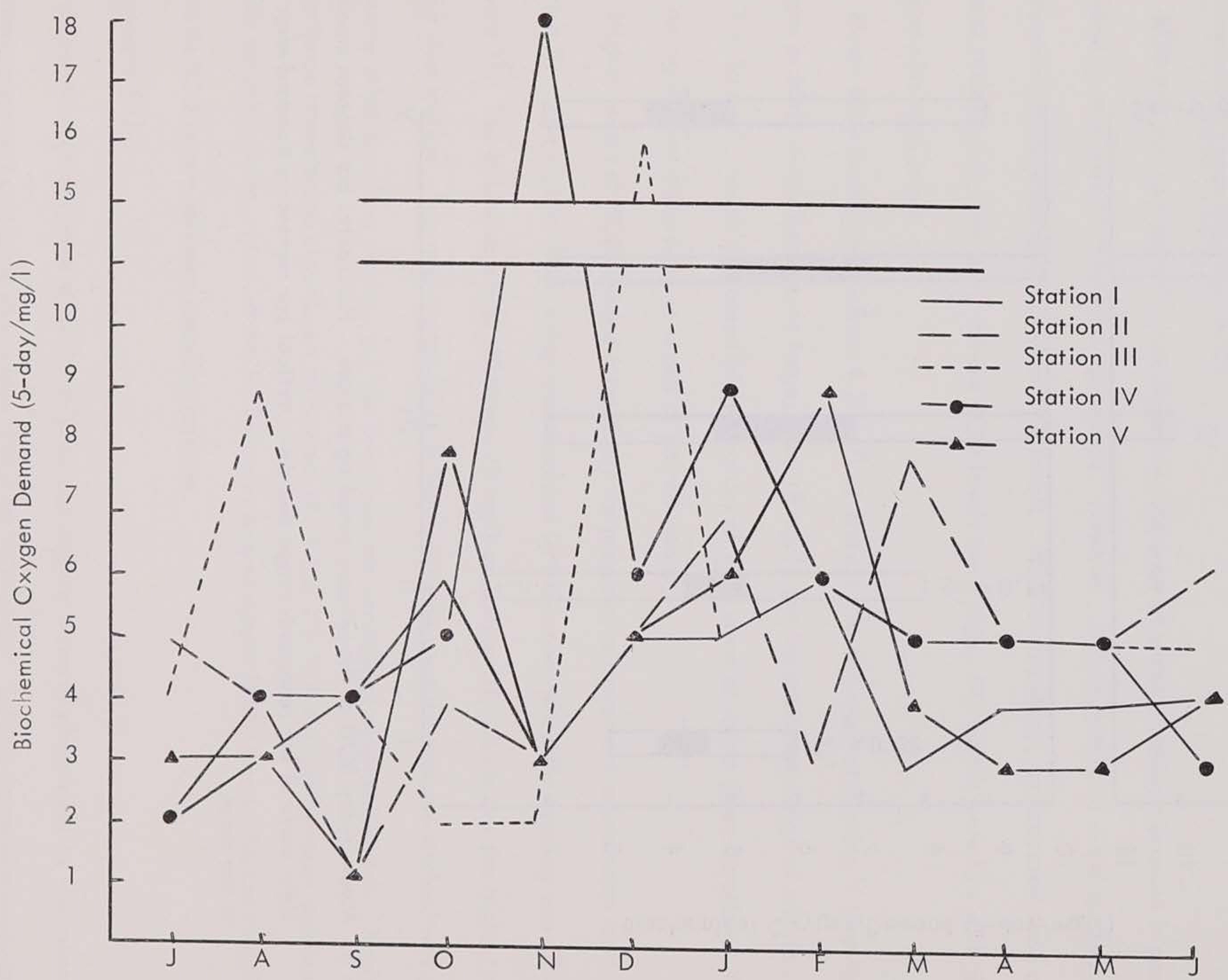

Figure 7. Five-day BOD at the monthly intervals at the primary sampling stations.

important only during periods of accelerated runoff, particularly in early spring immediately following applications of inorganic fertilizers to surrounding croplands. As shown by Figure 8, concentrations of PO_4 were relatively constant, ranging from 0.2 mg/l to 0.7 mg/l at all sampling stations in late summer and early autumn. These relatively low levels ($<$1 mg/l) continued at Stations I, II and V until the following spring, when they increased rapidly to 1.3 to 2.6 mg/l. A preponderance of this increase was the direct result of increased soluble phosphates.

Station III and IV were greatly influenced by large quantities of organic material from the Chariton Sewage Treatment Plant in early winter. At Station IV, PO_4 levels increased from 0.6 mg/l in October to 5.2 mg/l in November, followed by extremely high concentrations of 20.0 and 27.0 mg/l in December and January. February samples showed significant decline in PO_4 values to 3.1 mg/l, but concentrations in March samples increased to 10.0 mg/l. However, 9.2 mg/l of the latter sample was comprised of soluble phosphates. Station III also showed similar increased values for PO_4, but not of the magnitude at Station IV.

The abnormally high concentrations of PO_4 at Station IV during this five month period is reflected in mean levels at the sampling stations (Figure 9). Mean PO_4 at Stations I, II, III and V was 0.76, 0.92, 1.1 and 0.62 mg/l respectively. At Station IV the mean was 6.08 mg/l. Analysis of variance (Table 7) revealed differences in PO_4 concentrations between stations and within sampling dates were highly significant ($F = 4.25$; $P < 0.01$), and 71% of the variation was derived from differences between stations. Testing of least significant differences between all paired means showed the differences between Station IV and all other sampling stations was highly significant.

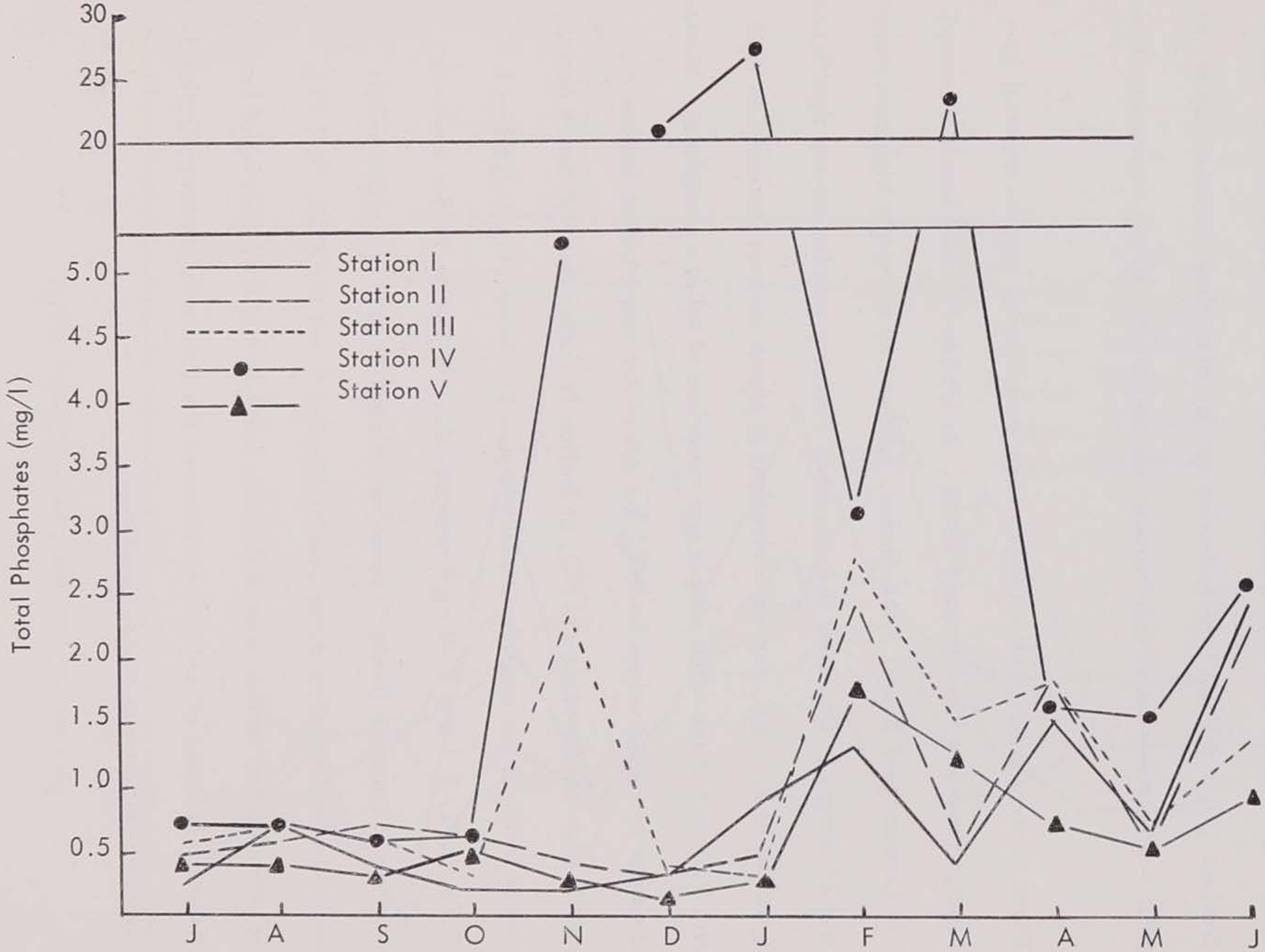

Figure 8. Total PO_4 concentrations at monthly intervals at the primary sampling stations.

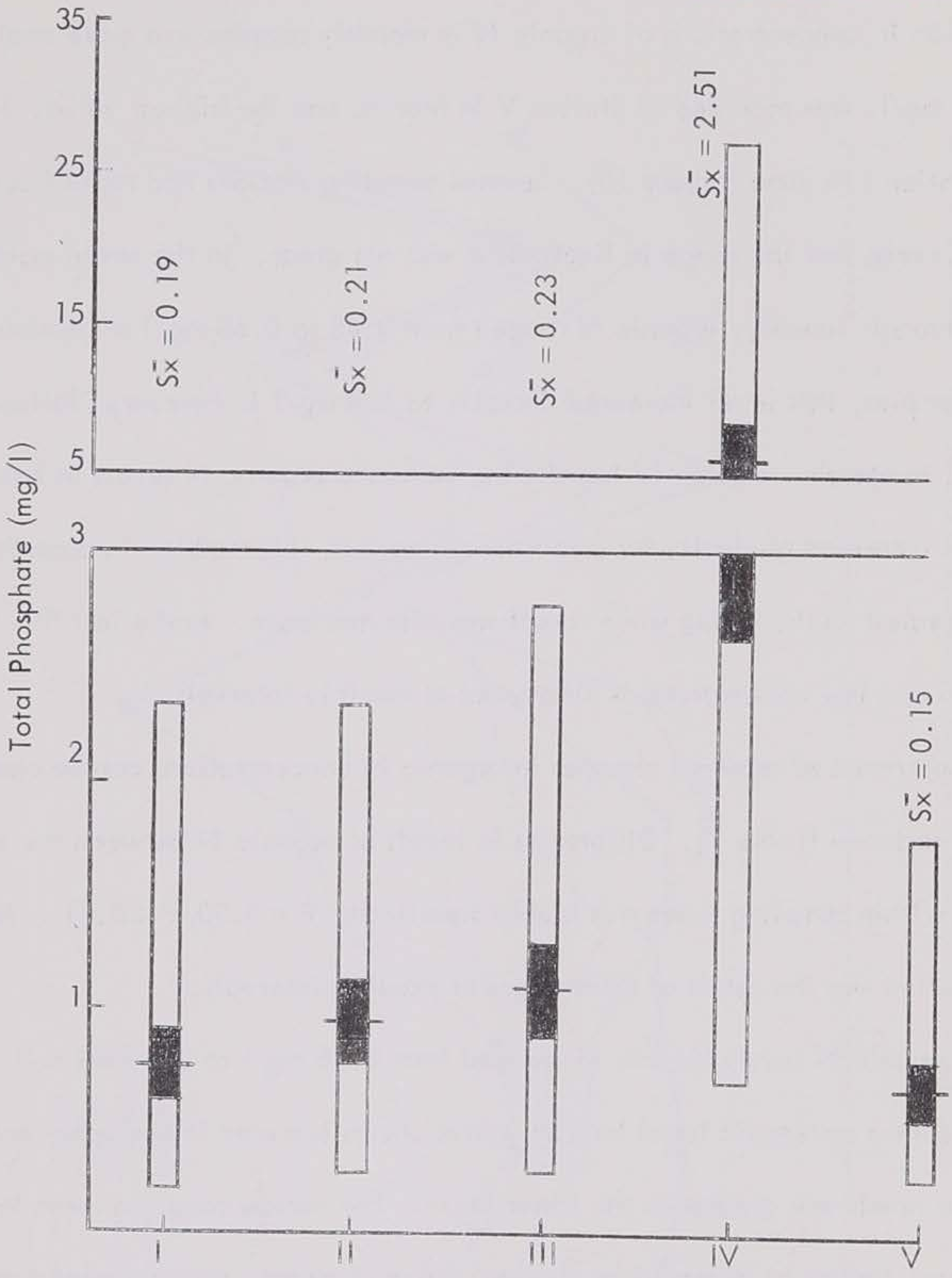

Figure 9. Mean PO_4 concentrations at the primary sampling stations. Horizontal bar denotes mean, light bar vertical bar represents range and dark vertical bar represents standard error of the mean.

Organic Nitrogen (N)

Variation in concentrations of organic N in monthly samples was quite small. The lowest value, 0.4 mg/l, was recorded at Station V in March; and the highest value, 3.0 mg/l, was found at Station I in June (Figure 10). Several sampling stations had rapid fluctuation in organic N levels, but the range in fluctuation was not great. In the seven monthly samples from July through January, organic N ranged from 0.45 to 0.68 mg/l at Station V. In the following samples, this level increased abruptly to 1.8 mg/l in February, followed by a decline to 0.4 mg/l in March. Station IV has similar increased organic N levels in February, but these levels increased gradually for a four month period. Fluctuation in organic N concentrations was greatest in the spring when runoff was also maximum. In the last five sampling periods high and low concentrations alternated at monthly intervals.

The importance of seasonal changes in organic N concentrations can be observed in the analysis of variance (Table 7). Difference in levels of organic N between the sampling station and within sampling dates was highly significant ($F = 5.50$; $P < 0.01$). More than 80% of this variation was the result of differences at monthly intervals.

Mean organic N levels (Figure 11) ranged from 0.76 mg/l at Station I to 1.55 mg/l at Station IV with a systematic trend for concentrations to increase in the upper basin region. Variation in levels was greater in the lower basin. The narrow range in mean levels of organic N can further be observed in standard errors of means, which ranged from only $\pm$ 0.19 to 0.28 mg/l. Analysis of the least significant difference between all means showed no significant difference at the 5% level of sampling probability.

Ammonia Nitrogen (NH_3)

In surface and ground waters NH_3, being a principle constituent of the nitrogen cycle, is one of the products of nitrogenous decomposition. With two major exceptions, NH_3

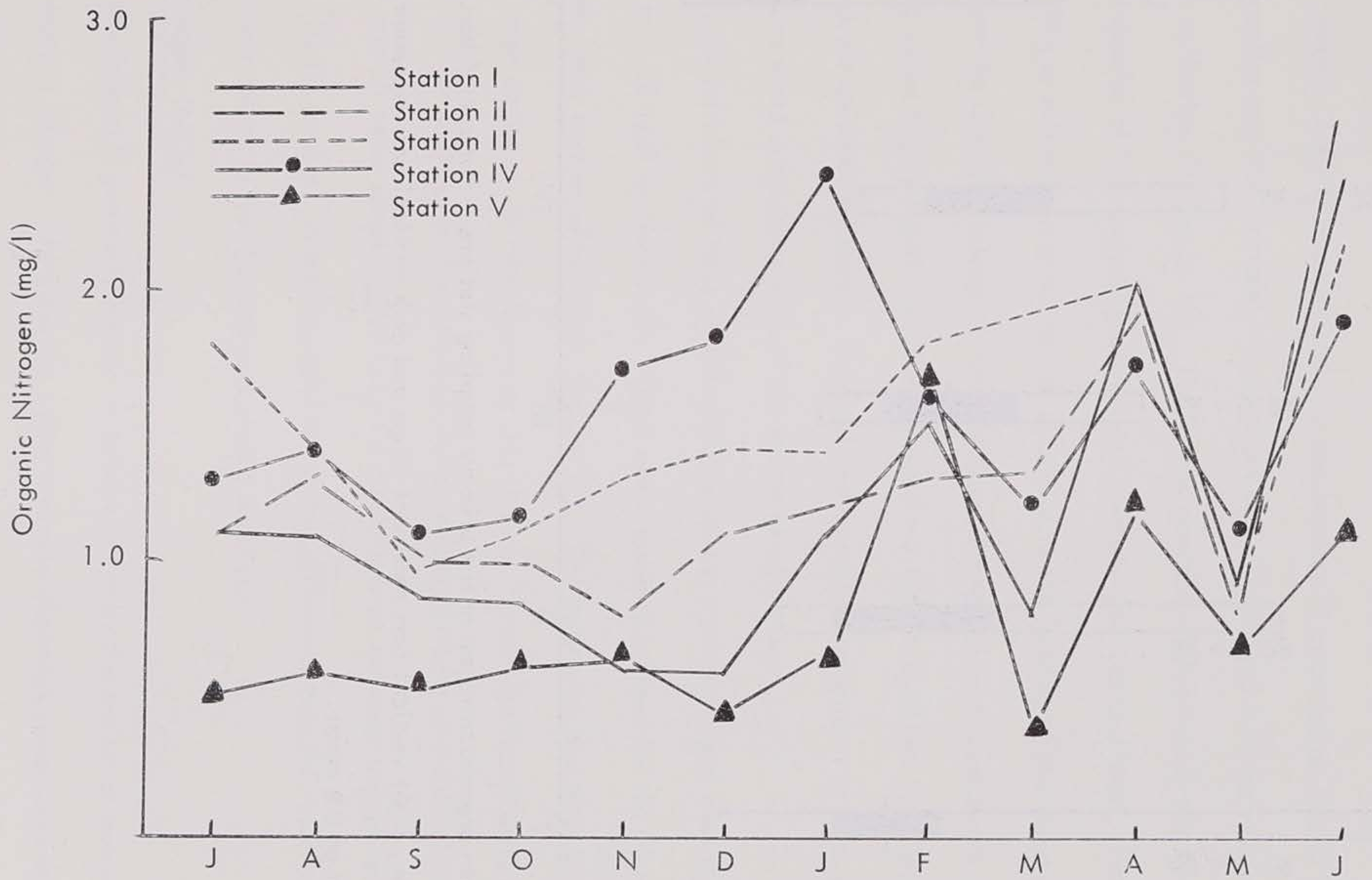

Figure 10. Organic nitrogen concentrations at monthly intervals at the primary sampling stations.

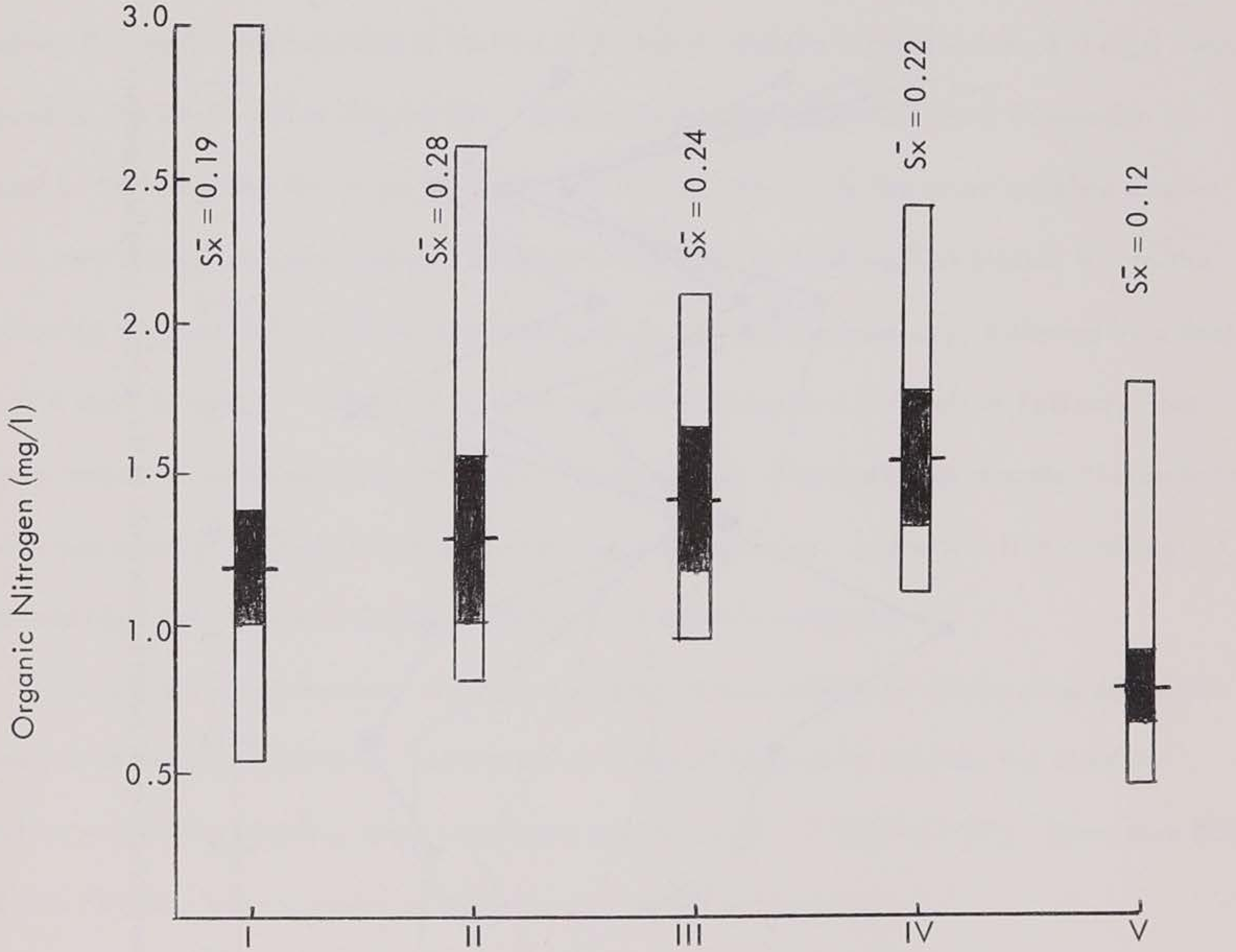

Figure 11. Mean organic nitrogen at the primary sampling stations. Horizontal bars denote mean, light vertical bars represent range and dark vertical bars represent standard error of the mean.

levels in the Chariton River were relatively low and constant. The first exception occurred in the February samples when NH_3 content increased 19 to 50 times the levels reported in previous months. Most of this was due to increased amounts of organic material washed into the river during accelerated runoff, and was compounded because it occurred on frozen terrain. The second exception was the extremely high values of 7.0 mg/l and 4.9 mg/l recorded in December and March at Station IV (Figure 12). The former concentration exceeds the 96-hour TL_m for several species of fish including sunfish and minnows (McKee and Wolf, 1963). High levels of NH_3 at this station gives further credence to the loading of the river with organic material from the Chariton Sewage Treatment Plant during colder temperatures. Analysis of variance revealed highly significant differences ($F= 6.02$; $P< 0.01$) in NH_3 levels between stations and within sampling dates. Seasonal and monthly fluctuations in NH_3 concentrations were very important comprising 92% of the source of variation.

Mean concentrations of NH_3 at individual sampling stations ranged from 0.6 mg/l at Station V to 1.28 mg/l at Station IV. There was a systematic trend for the higher values to occur in the upper portion of the basin (Figure 13). The large standard error at Station IV indicated large deviation in NH_3 levels at this station. Least significant difference between paired mean value of NH_3 at the sampling station was significant at the 5% level for Station IV and all other sampling stations, but no difference between the paired means of Stations I, II, III, and V. A great proportion of this difference was the result of the extraordinarily high values in the January and March samples.

Nitrite Nitrogen (NO_2)

Nitrite nitrogen is generally formed in surface water by the action of bacteria upon NH_3 and organic nitrogen. Nitrites are rather unstable chemical compounds because they are easily oxidized to nitrates (NO_3) and are seldom found in large concentrations. In

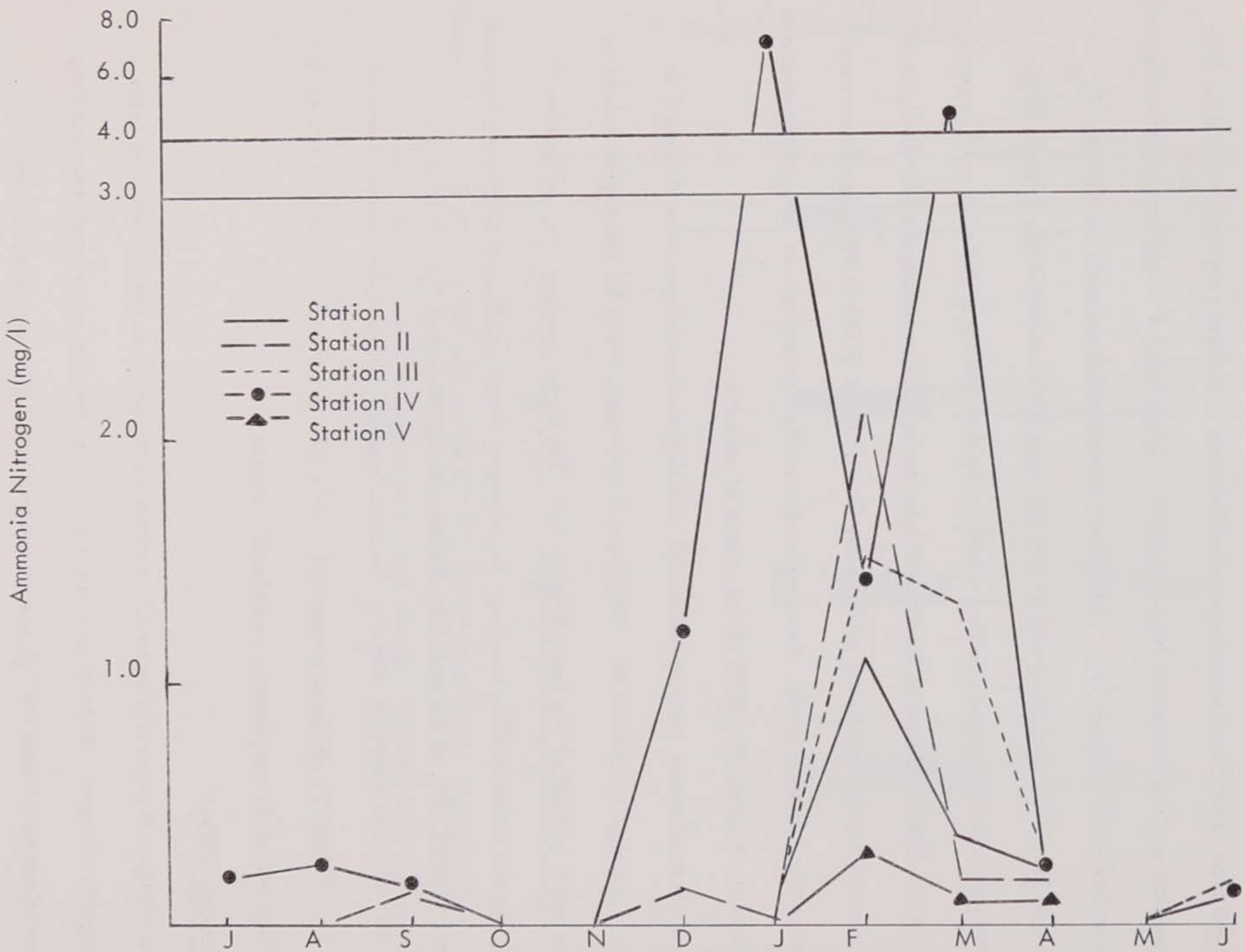

Figure 12. Ammonia nitrogen concentrations at monthly interval at the primary sampling stations.

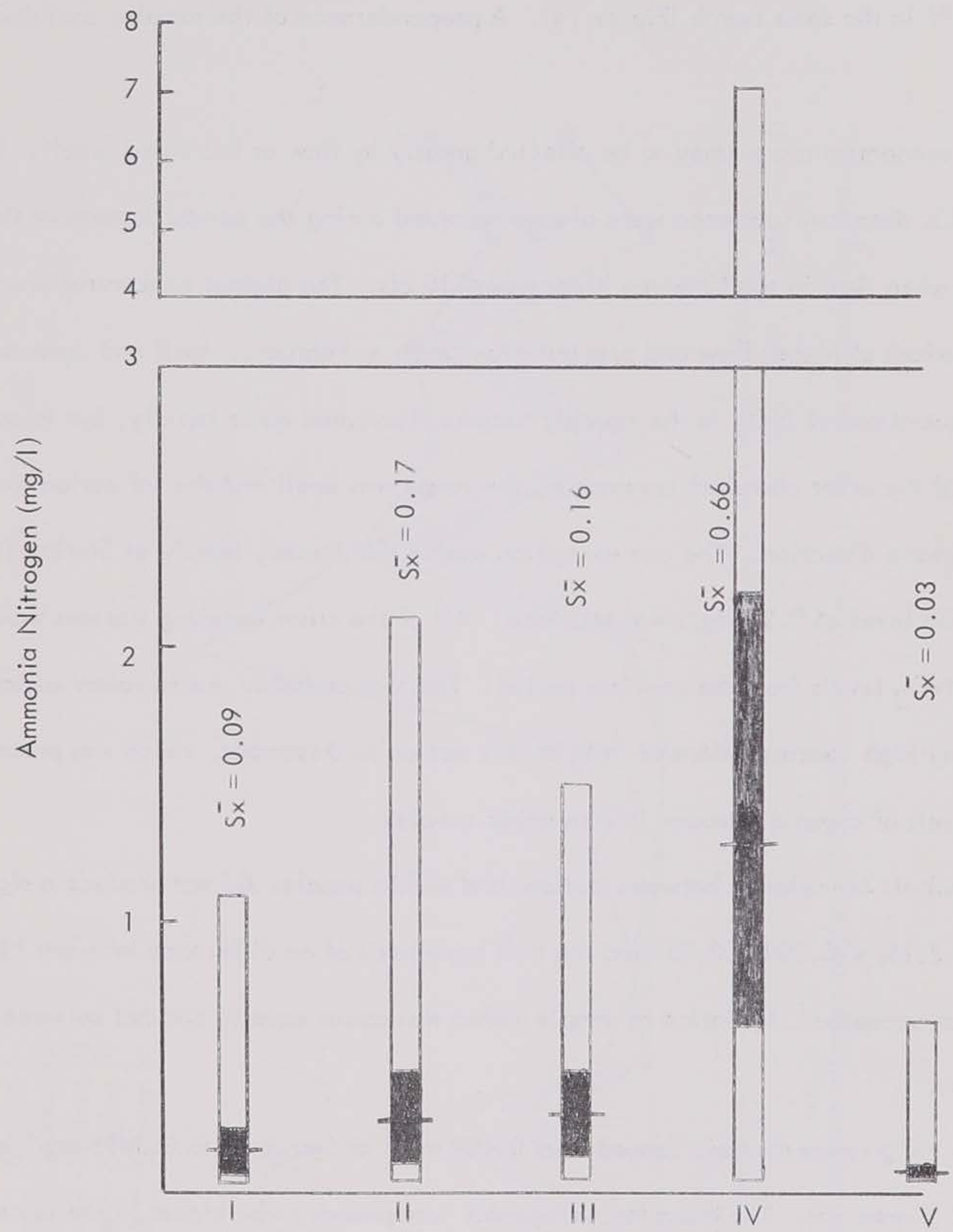

Figure 13. Mean NH_3 concentrations at the primary sampling stations. Horizontal bars denote mean, light vertical bars represent range and dark vertical bars represent standard error of the mean.

this investigation NO_2 levels ranged from < 0.001 mg/l at Station 1 in January to 0.25 mg/l at Station IV in the same month (Figure 14). A preponderance of the samples contained <0.005 mg/l.

NO_2 concentrations seemed to be effected greatly by flow or increased runoff. Lowest levels of this chemical substance were always recorded during the period September through November when flow in the Chariton River was < 10 cfs. The highest concentrations were found in periods of higher flow and precipitation, such as February, April and June samples.

Concentrations of NO_2 in the monthly samples fluctuated quite rapidly, but in contrast with most of the other chemical compounds, the range was small and the inflection was generally in the same direction. The one exception was in the January sample at Station IV when the maximum level of 0.25 mg/l was recorded. All of the other sampling stations showed declining NO_2 levels from the previous period. This was probably due to latent assimilation of extremely high concentrations of NH_3 at this station in December, which was preceeded by high levels of organic nitrogen in November samples.

An analysis of variance between stations and within samples did not produce a significant value ($F = 2.15$; $< 0.10\ P < 0.05$) and the null hypothesis of no difference between NO_2 samples was accepted. Variation of sample means was about equally divided between the two sources.

Mean NO_2 concentrations ranged from 0.009 mg/l at Station V to 0.0495 mg/l at Station IV (Figure 15). The trend for nitrogenous compounds to be higher in the upper portion of the Chariton River Basin and lowest in the South Chariton River Basin was also applicable for NO_2. There was significant difference in paired means at the 5% level with Station IV exceeding the least significant difference when paired with Station V, but not with the other stations.

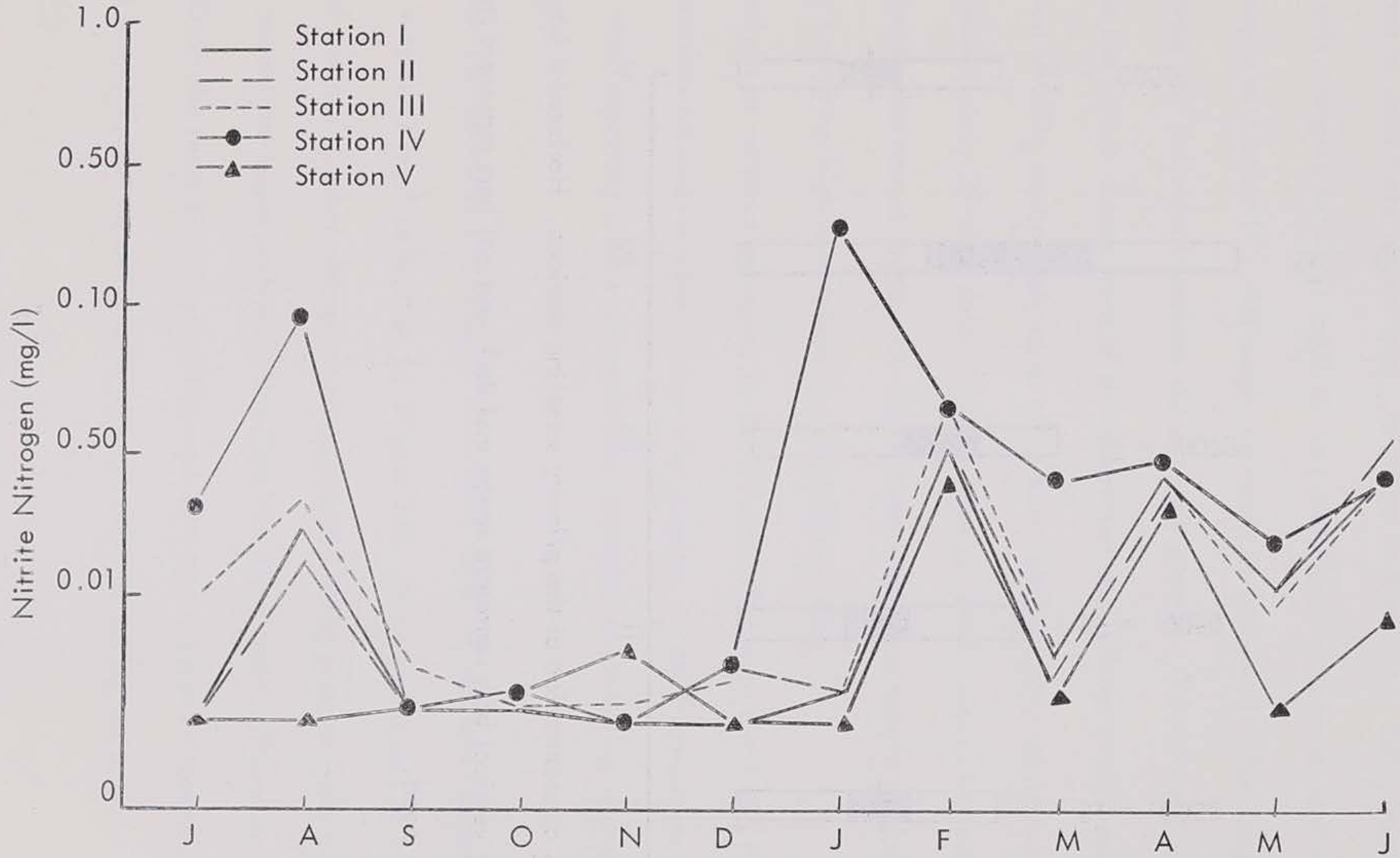

Figure 14. Nitrite nitrogen concentrations at monthly intervals at the primary sampling stations.

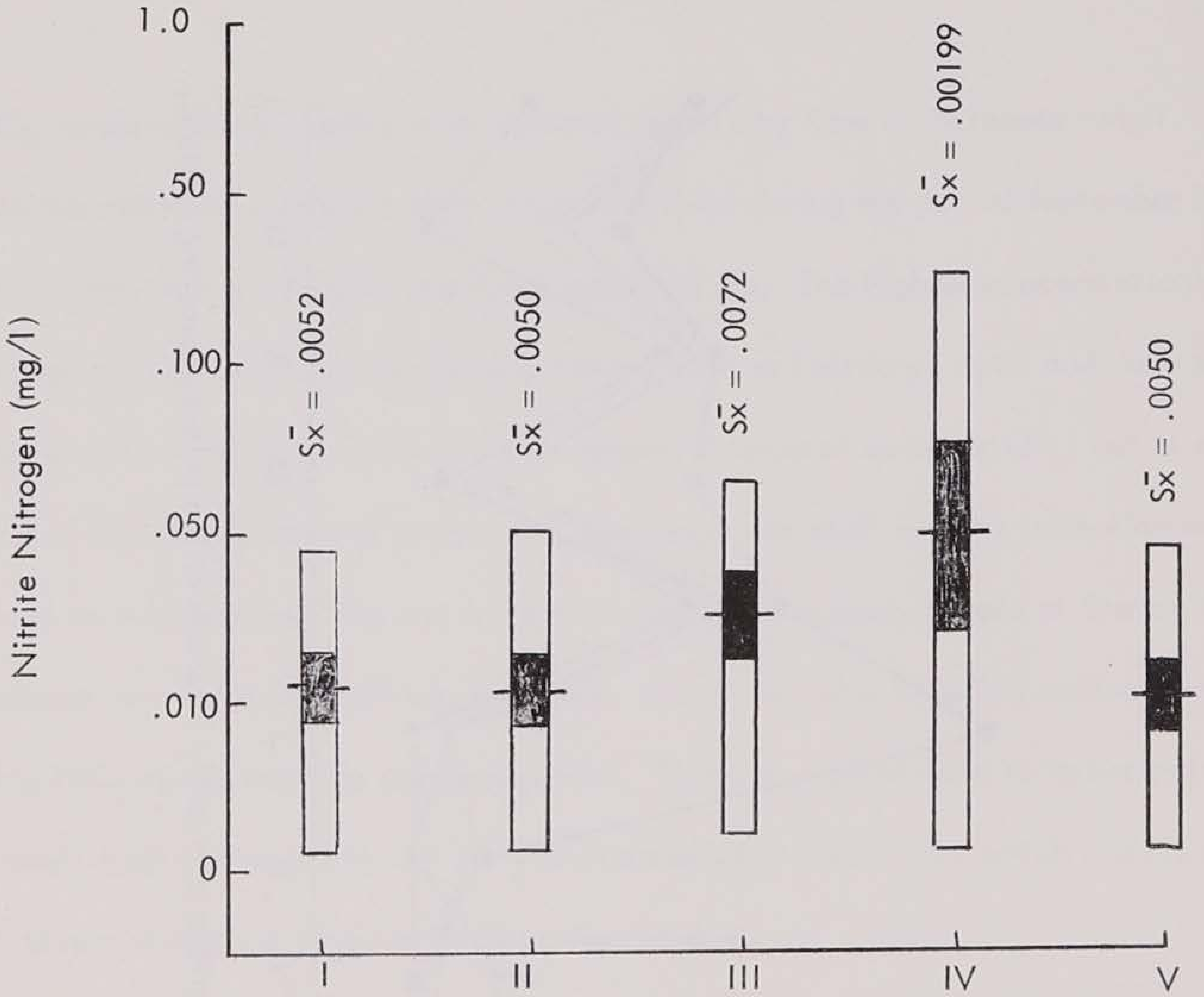

Figure 15. Mean NO_2 concentration at the primary sampling stations. Horizontal bars denote mean, light vertical bars represent range and dark vertical bars represent standard error of the mean.

Nitrate Nitrogen (NO_3)

Nitrate nitrogen is the end product of aerobic stabilization of organic nitrogen. Its level of concentration in surface waters may be greatly effected by excessive application of inorganic fertilizers to immediate watersheds. As shown in Figure 16, NO_3 fluctuated over relatively wide limits, ranging from 0.1 mg/l in July and March samples at Station V to 1.5 mg/l in the June sample at Station IV. Although the range of NO_3 was rather large, the standard error of the mean for individual stations did not vary greatly ($\pm$ 0.15 mg/l maximum). This would indicate the higher values were of short duration and did not occur frequently. In general, inflection in NO_3 concentrations at all stations were closely related and followed NO_2 levels with approximately 30-days delay in the higher or lower levels of concentration. The only exception to this was at Station IV where there was a two sample period interval in high values of NO_2 following high concentrations of NO_2 and NH_3.

Analysis of variance revealed no significant difference ($F = 1.27$; $P < 0.25$) in NO_3 concentrations between stations and within samples. Wide fluctuations in monthly samples was the most important source of variation in samples contributing approximately 80% of the variance.

Mean concentrations of NO_3 at individual sampling stations ranged from 0.35 mg/l at Station V to 0.71 mg/l at Station IV (Figure 17). The mean levels of NO_3 followed the identical pattern of other nitrogenous compounds, being progressively higher as sampling proceeded toward the upper portion of the Chariton River Basin. There was significant difference ($P < 0.05$) in the least significant difference between the paired means of Station IV and Stations II and V, but no difference between other sampling stations.

Alkalinity

Alkalinity is not a specific chemical compound, but rather a combined affect of several

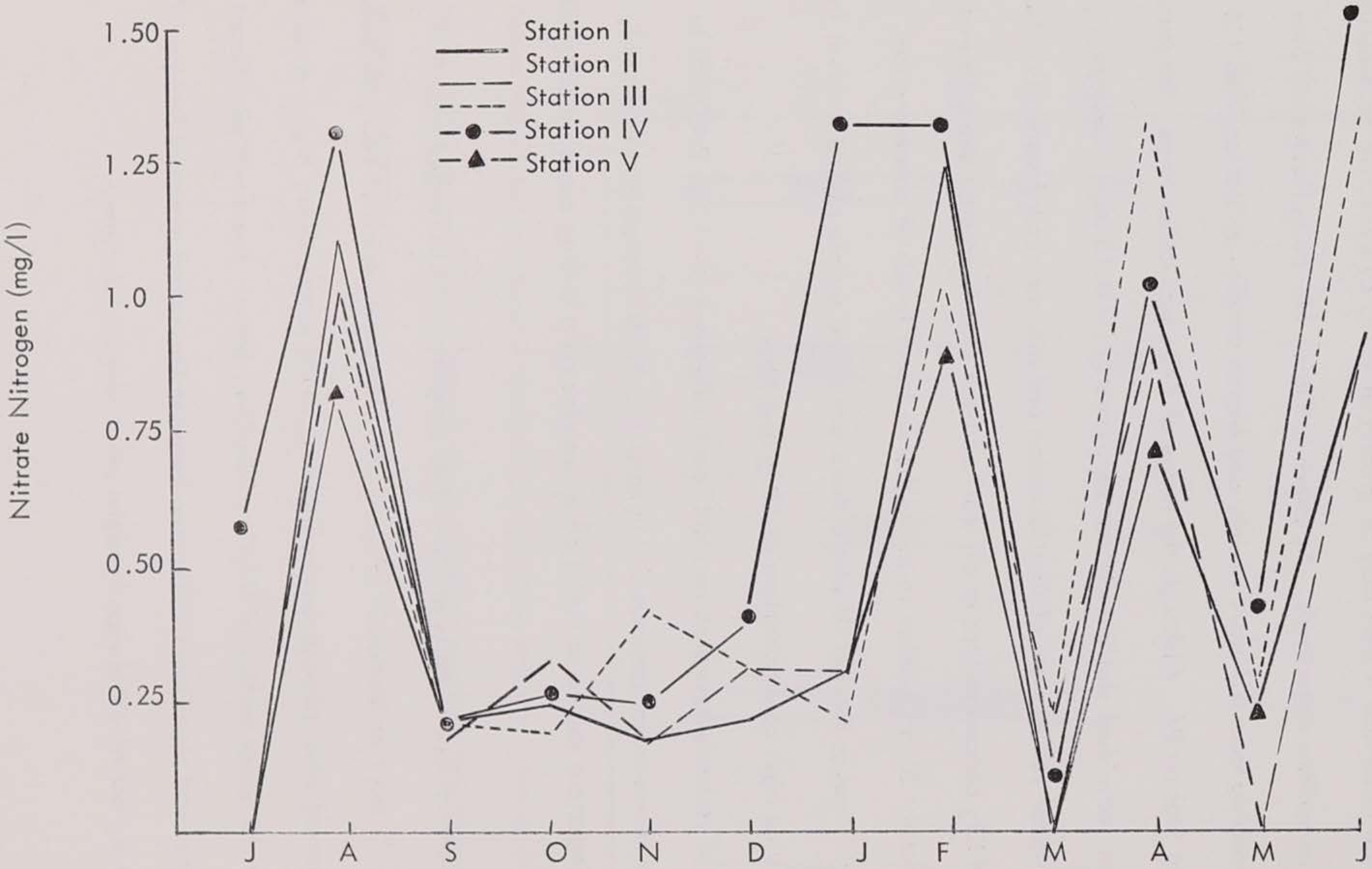

Figure 16. Nitrate nitrogen concentrations at monthly intervals at the primary sampling stations.

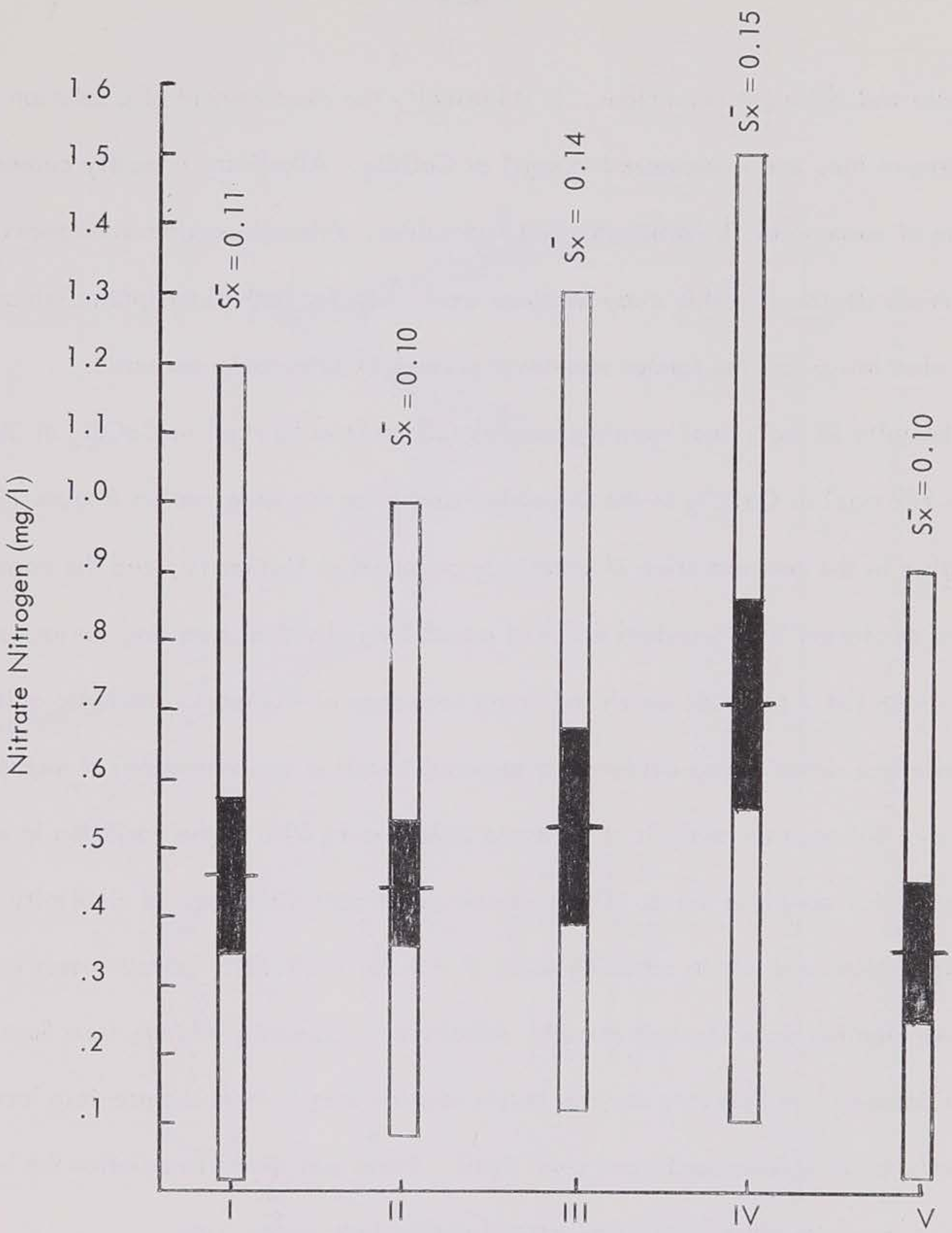

Figure 17. Mean NO_3 at the primary sampling station. Horizontal bar denotes mean, light vertical bar represents range and dark vertical bar represents standard error of the mean.

substances and chemical conditions. It is basically the measurement of a solution to neutralize the hydrogen ion, and is expressed in mg/l as $CaCO_3$. Alkalinity is mostly caused by the presence of carbonates, bicarbonates and hydroxides, although organic substances may affect it to a lesser degree. In this study analyses were made for both phenolphthalien and methyl orange alkalinity, but the former was never present in detectable amounts.

Alkalinity in individual monthly samples ranged from 53 mg/l as $CaCO_3$ at Station IV in June to 289 mg/l as $CaCO_3$ in the December sample at the same station (Figure 18). Greatest fluctuation in the concentration of alkalinity occurred at Station IV, and the narrowest range occurred at Station III. Standard errors of means for individual sampling stations showed a narrow range (14.7 to 21.6) which indicated the range of fluctuation was also quite small.

There was rather strong evidence of seasonal trends in concentrations of methyl orange alkalinity, although an analysis of variance showed only 60% of the variation in samples occurred within sampling dates. There was no significant difference in alkalinity between sampling stations and within sampling dates ($F = 0.25$; $P < 0.25$). Lowest levels were found in summer months, June through August. Alkalinity increased gradually from September through January. In February samples levels decline sharply from the previous interval, and continued in a downward trend until April. There was strong association for high alkalinity levels to occur during periods of reduced flow in the river.

Mean alkalinity at individual sampling stations showed relatively small variation, ranging from 168 mg/l as $CaCO_3$ at Station III to 194 mg/l as $CaCO_3$ at Station V (Figure 19). There was no significant difference in paired means.

Hydrogen Ion (pH)

pH is the common symbol used to designate concentrations of the hydrogen ion. It is

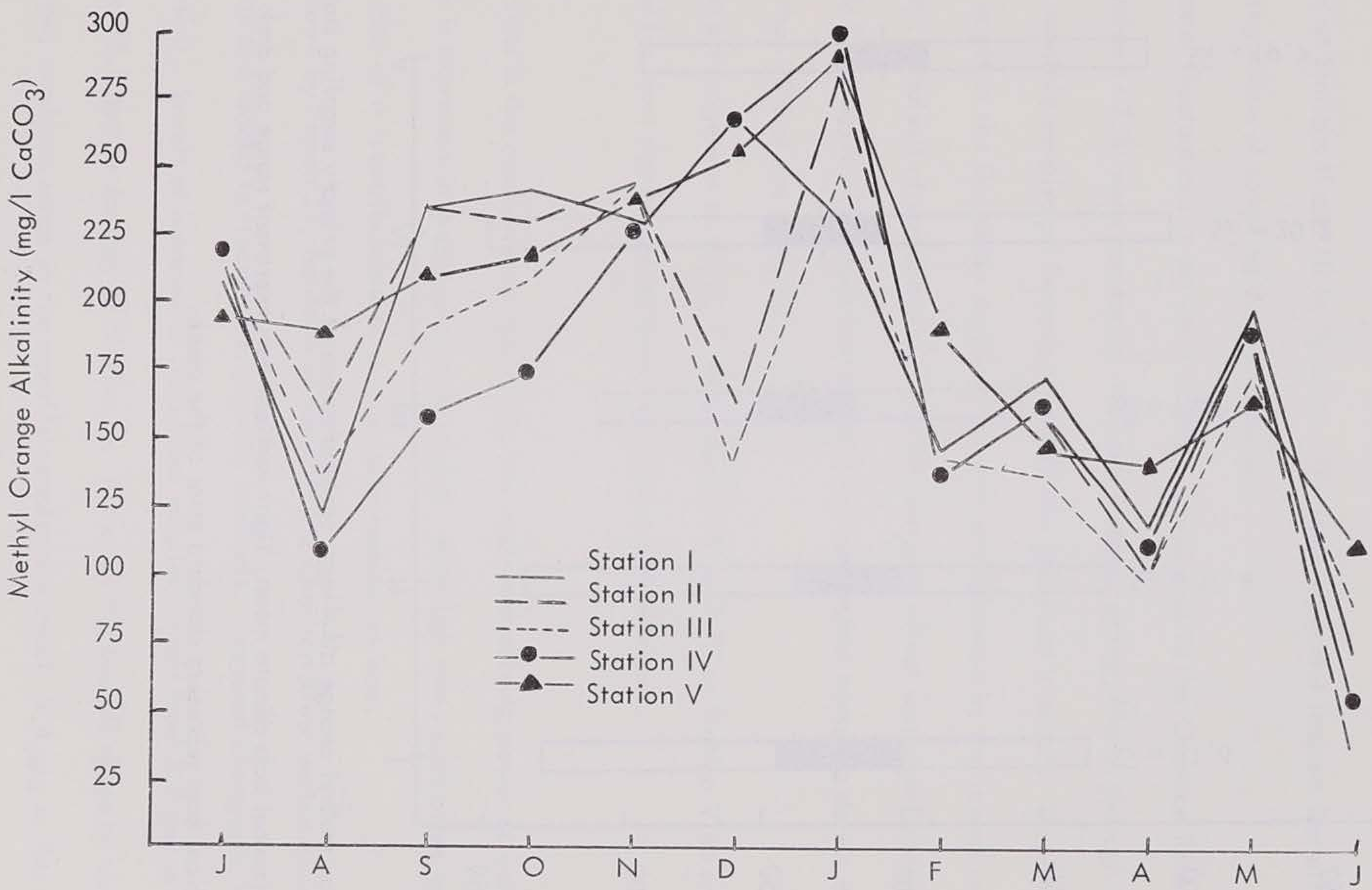

Figure 18. Methyl orange alkalinity at monthly intervals at the primary sampling stations.

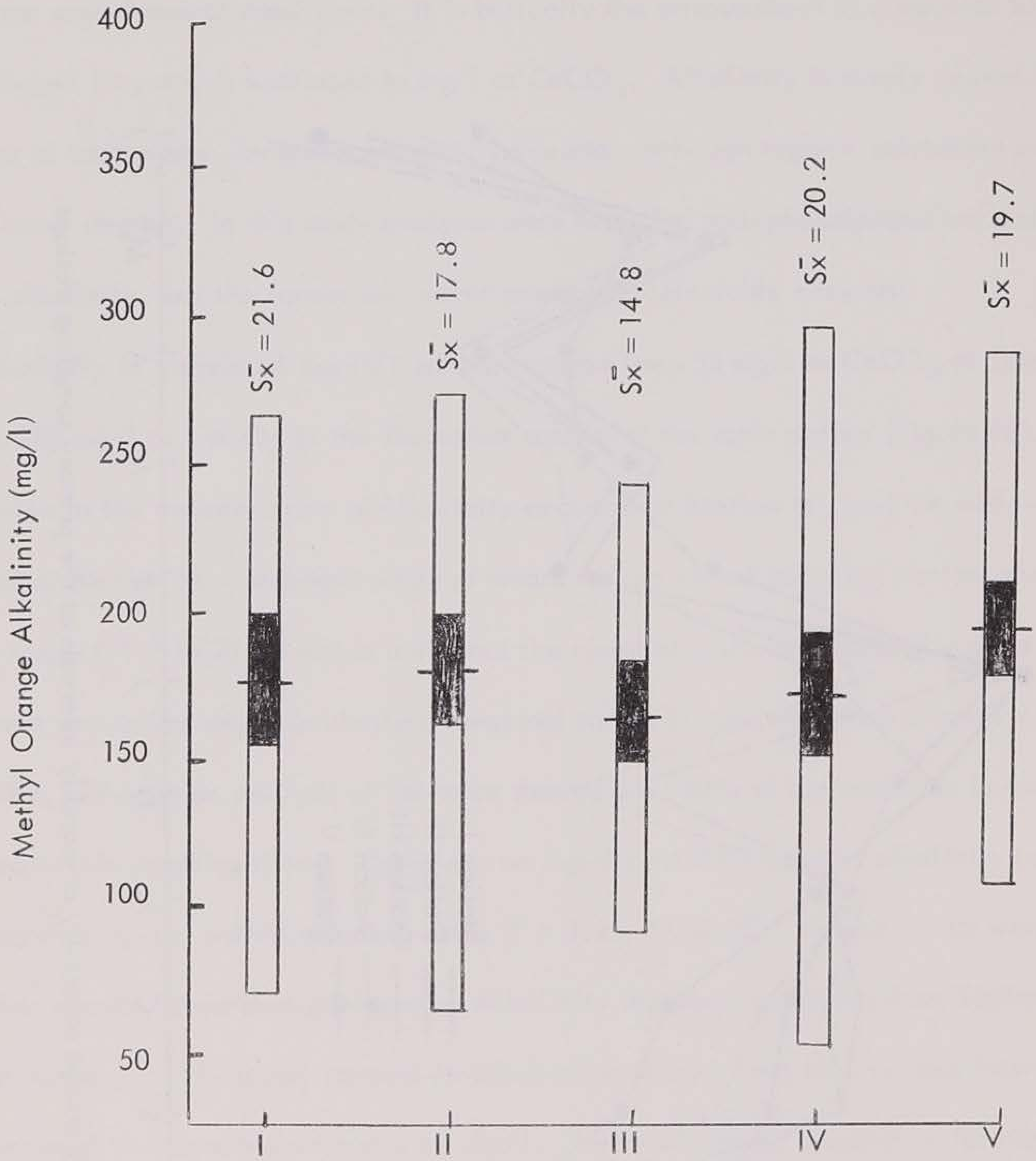

Figure 19. Mean methyl orange alkalinity concentrations at the primary sampling stations. Horizontal bars denote mean, light vertical bars represent range and dark vertical bars represent standard error of the mean.

intimately related to the concentrations of many chemical substances which control its level, whether acid or alkaline. In this study, the range of pH in individual sampling stations was very small. The maximum (8.2) was recorded at Station II in May, and the minimum (7.2) was found at Stations II and III in January. The most important feature was all samples were alkaline regardless of sampling date or location.

Seasonal fluctuations in pH were of major importance in the Chariton River (Figure 20). Highest value (+ 7.8) were constantly recorded in early spring, March through May. In the next five monthly samples pH became progressively less each interval. There was a slight increase in pH in the December samples, but this was followed by the lowest recorded levels in January. Analysis of variance revealed the temporal effect was significantly important ($F = 3.44$; $P < 0.05$) to pH values between stations and within sampling dates, and accounted for more than 70% of the variation.

Mean pH range was so small, 7.62 at Station IV to 7.72 at Station V no analysis was completed for least significant differences between paired means.

Hardness

Hardness is the common term applied to the soap-neutralizing power of water and in this study is expressed in grains-per-gallon (gpg). Although many substances contributed to hardness most of it is attributable to calcium and magnesium ions.

As shown by Figure 21, hardness of water in the Chariton River varied between relatively wide limits and tended to fluctuate at monthly intervals. Seasonal changes in hardness were not important. Levels of hardness in individual samples ranged from 3.9 gpg at Station IV in June to 18.9 gpg in January at Station V. Although the overall range of hardness was rather large, maximum range in the monthly samples was small, 3.8 gpg in December. In general, there was some difference in water hardness at individual sampling stations on separate

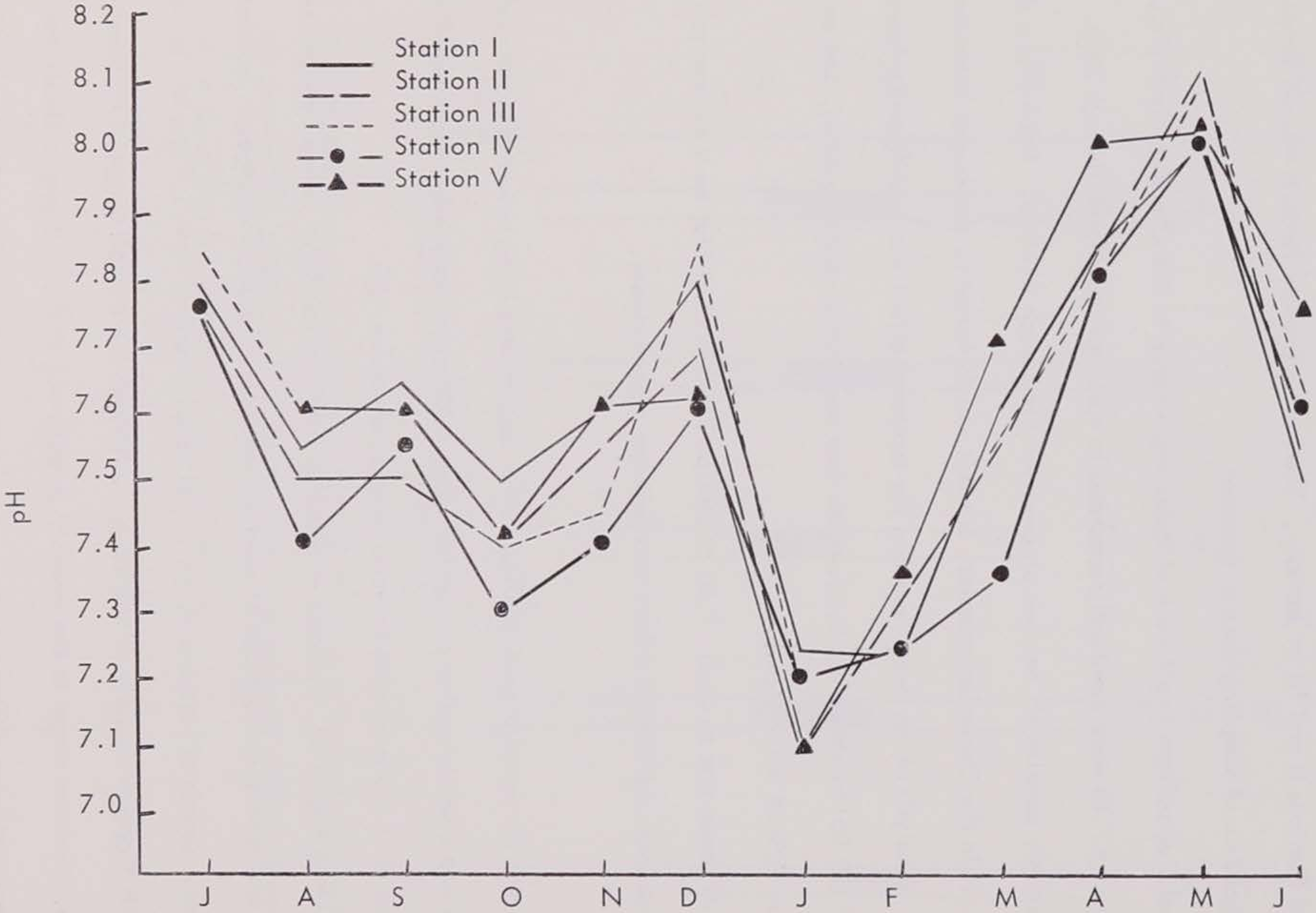

Figure 20. pH at monthly intervals at the primary sampling stations.

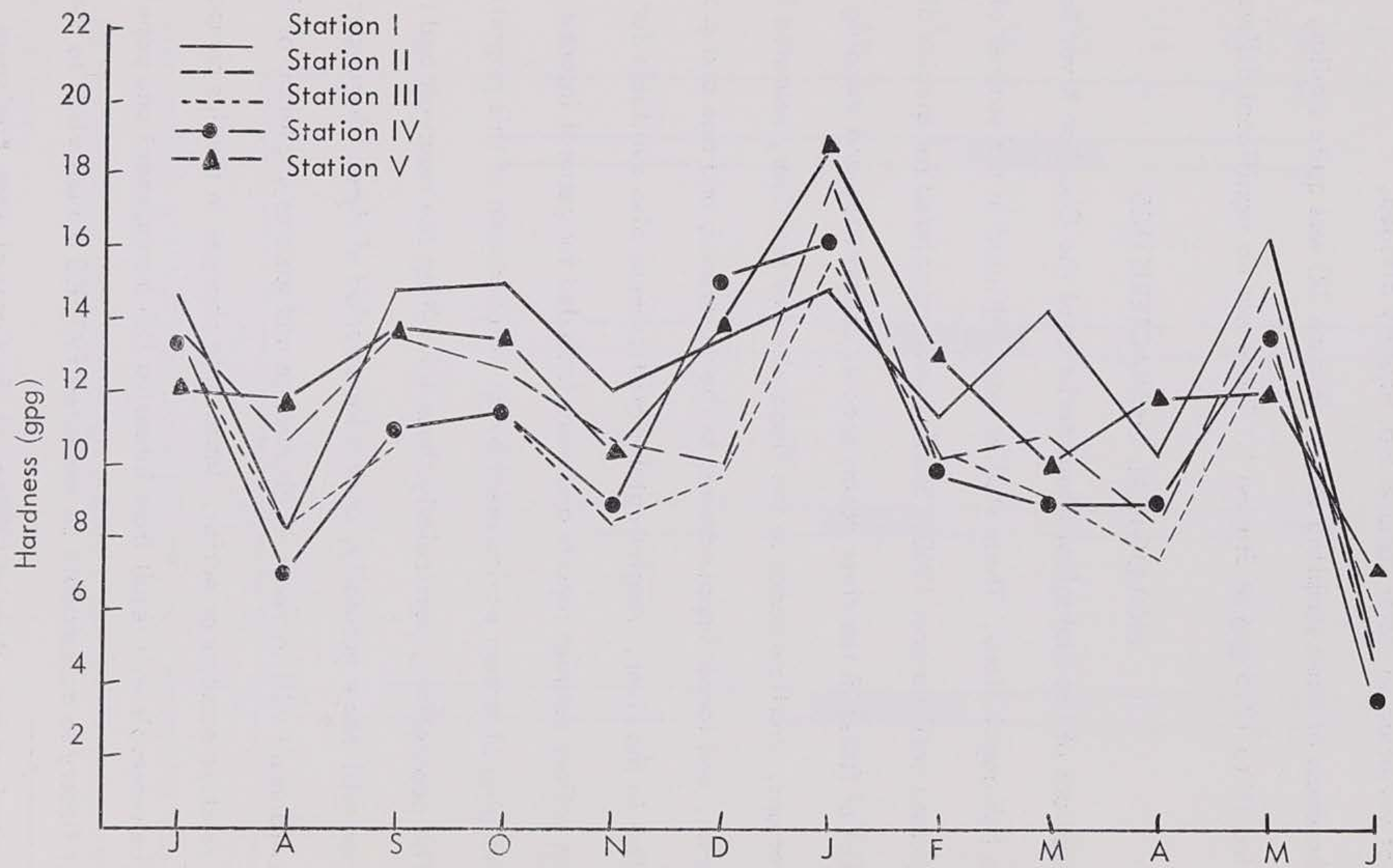

Figure 21. Water hardness at monthly intervals at the primary sampling stations.

sampling dates, but the inflection of these changes was nearly the same for all sampling dates.

An analysis of variance showed insignificant difference among samples ($F = 1.20$; $P < 0.25$). The source of variation in water samples was equally divided.

Mean hardness at each sampling station (Figure 22) was quite similar, ranging from 10.4 gpg at Station III to 12.5 gpg at Station I. There was no significant difference in paired means.

BIOLOGICAL CHARACTERISTICS

Investigations of the biological characteristics of the Chariton River Basin was confined primarily to fish populations. These studies were initiated in the summer of 1964 and continued in various phases until autumn 1968. Studies were completed for species distribution and an annotated list of fishes in the river basin; species composition and standing crop at the primary sampling stations, overflow ponds in the flood plain of the river, selected farm ponds within the river basin, and larger impoundments in the watershed; and age and growth of important species of fish in the river. Angler catch statistics were also available for several years from conservation officer contact reports and were included for general interest.

The changing of stream environment by an impoundment of this magnitude will profoundly influence fish populations, particularly those inhabiting the reservoir and tailwaters. Much of the change will occur naturally, over a long period of time, where species most tolerant of lotic environment will increase in abundance and species intolerant of this habitat will decline in relative numbers or perish. Immediate changes in species composition and abundance of fish in the reservoir will result from intensive fish management and population manipulation of the sport fishery to accomodate an expected 990,000 annual visits[1] to the reservoir. Stocking

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[1] Data obtained from District Office, U. S. Corps of Army Engineers, Kansas City, Missouri.

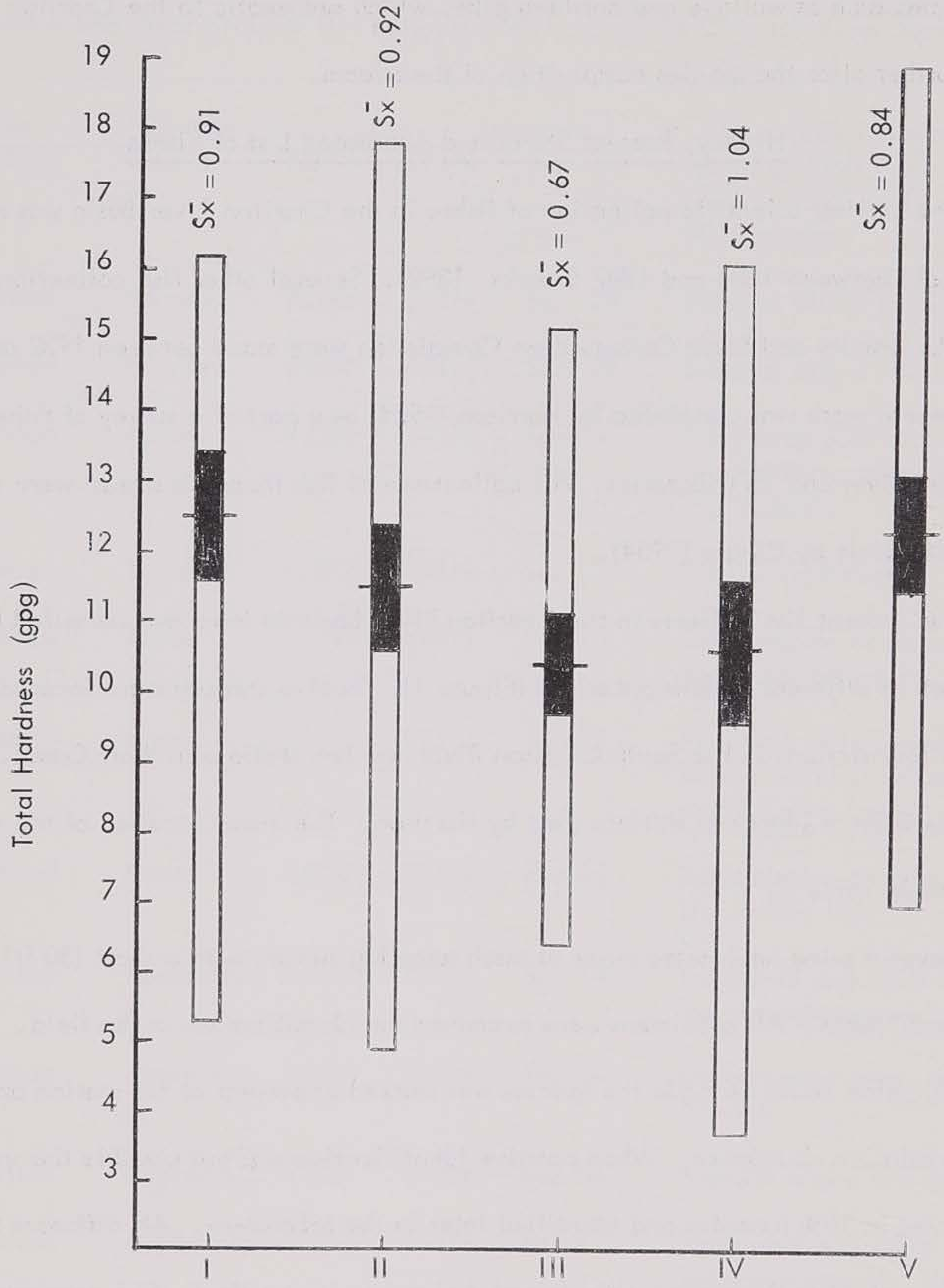

Figure 22. Mean water hardness at the primary sampling stations. Horizontal bars denotes mean, light vertical bars represent range and dark vertical bars represent standard error of the mean.

of species such as walleye and northern pike, which are exotic to the Chariton River Basin, will further alter the species composition of the stream.

History, Present Status and Annotated List of Fishes

The earliest scientific collection of fishes in the Chariton River Basin was made by Seth E. Meeks between 1884 and 1887 (Meeks, 1892). Several other fish collections by Iowa State University and State Conservation Commission were made between 1932 and 1946. The most recent work was completed by Harrison (1954) as a part of a survey of fishes in the Missouri River and its tributaries. All collections of fish from this stream were combined into a single report by Cleary (1954).

The present list of fishes in the Chariton River Basin in Iowa was compiled from seine hauls at 18 different sampling stations (Figure 1). Twelve stations were located in the Chariton River, four stations in the South Chariton River and two stations in Wolf Creek. Six of these stations were at identical stations used by Harrison. The exact location of the sampling stations is listed in Table 8.

Several seine hauls were made at each sampling station with a short (30 ft) drag seine with small mesh. All specimens were examined for identification in the field. If positive identification could be made the species was marked as present at the station and a note made for its relative abundance. When positive identification was not possible the specimen was preserved in 10% formalin and identified later in the laboratory. All different types of habitat present at the station were seined during low stream flow. Fish captured later in the summer while using fish toxicants for sampling total fish populations in small stretches of streams were also included.

The present list of fishes included 36 species representing 10 families. Other workers listed nine additional species that were not found in this survey. The present list included two species which were not previously reported.

Table 8. Location and description of fish collection stations in the Chariton River Basin

Station number	Stream	County	Location			Description of station
1	Chariton	Clarke	R25W	T71N	Sec 34	Series of short riffles and shallow short pools. Mud bottom.
2	Chariton	Clarke	R24W	T71N	Sec 29	Same as above station.
3	Chariton	Clarke	R24W	T71N	Sec 24	Same as above station.
4	Chariton	Lucas	R23W	T71N	Sec 14	Long deep pool separating short riffles. Most of sampling in pool.
5	Chariton	Lucas	R22W	T71N	Sec 2	Similar to station 1
6	Chariton	Lucas	R21W	T71N	Sec 15	Same station as primary sampling station IV
7	Chariton	Lucas	R21W	T71N	Sec 29	Pool and riffles immediately below outlet structures of N and S Colyn Lakes.
8	Chariton	Lucas	R20W	T71N	Sec 35	Same station as primary sampling station III.
9	Chariton	Appanoose	R19W	T70N	Sec 14	Long pool and swift riffles flowing through exposed bedrock.
10	Chariton	Appanoose	R18W	T70N	Sec 20	Rechanneled area, mostly swift flowing.
11	Chariton	Appanoose	R18W	T70N	Sec 36	Same as above station
12	Chariton	Appanoose	R17W	T69N	Sec 7	Short pool and riffle with sand bar development. Heavy coal stripping area on each side of stream.
13	S Chariton	Appanoose	R19W	T70N	Sec 28	Short pool and riffle with mud bottom.
14	S Chariton	Appanoose	R20W	T69W	Sec 10	Rechanneled.

15	S Chariton	Appanoose	R21W	T69N	Sec 1	Immediately below confluence of Chariton and S Chariton Rivers Some exposed bedrock with long deep pool.
16	S Chariton	Wayne	R21W	T71N	Sec 31	Rechanneled with some sand bar development at low flow.
17	Wolf Cr	Lucas	R21W	T71N	Sec 39	Small stream with low flow in late summer. Sandy stream bottom.
18	Wolf Cr	Lucas	R21W	T71N	Sec 15	Partly rechanneled, partly original channel. Sand bar development is pronounced in low flow.

Although records are not conclusive there has undoubtedly been change of immense proportions in the Chariton River since the collection of Meeks more than 80 years ago. Probably a great amount of this change has occured from rechannelization. The relative abundance of fishes has also changed with alteration of the habitat. Overflow stocking from the multitude of small ponds and lakes constructed during the past three decades has also influenced the abundance of several species, particularly the sunfishes.

Herring Family
(Clupeidae)

Dorsoma cepedianum (LeSueur). Gizzard shad. Common. Widely distributed throughout the entire steam. Becomes more abundant in the lower reaches of the river.

Mooneye Family
(Hiodontidae)

Hiodon alosides (Rafinesque). Goldeye. Rare. One specimen taken at station 10. Another specimen was known caught by an angler during the summer (1966) near Station 12. This species was not previously reported.

Ictiobus cyprinellus (Valenciennes). Bigmouth buffalo. Abundant. Species found at almost all sampling stations. Comprises a large proportion of the fish population by weight.

Ictiobus bubalus (Rafinesque). Smallmouth buffalo. Rare. Two specimens captured, both were in the headwaters region of the river. Also found in several overflow ponds. Harrison and Meeks also reported this species rare.

Carpoides carpio (Rafinesque). River carpsucker. Abundant. Found at all stations. One of the most abundant species of fish in the river.

Carpiodes cyprinus (LeSueur). Quillback carpsucker. Common. More numerous in the upper reaches of the river. Particularly abundant in Brown's Slough adjacent to the river at Station 8.

Moxostoma aureolum (LeSueur). Northern redhorse. Rare. Less than 5 individuals captured in the basin. Most of these were taken with fish toxicants. Three were captured at Station 9.

Catostomus commersoni commersoni (Lacepede). White sucker. Common. Found only at Station 6 in the Chariton River and Stations 15 and 16 in the South Chariton River. Rather abundant in early spring seine hauls in the headwaters region.

Minnow Family
(Cyprinidae)

Cyprinus carpio (Linnaeus). Carp. Abundant. Carp are generally distributed throughout the Chariton River Basin. Found in abundance at all sampling stations.

Notemigonus crysoleucas auratus (Rafinesque). Western golden shiner. Common. Found at all sampling stations. This species is common to abundant in all reservoirs and lakes in the watershed. More abundant in the lower portion of the river.

Semotilus atromaculatus atromaculatus (Mitchill). Northern creek chub. Common. Well distributed throughout the entire length of the stream. They were not concentrated in any particular area.

Hybopsis storeriana (Kirkland). Silver chub. Rare. One specimen captured at Station 17 in Wolf Creek. Harrison reported this species rare, but Meeks referred to it as quite common.

Phenacobius mirabilis (Girard). Plains suckermouth minnow. Common. Generally distributed throughout the entire basin in Iowa. Harrison reported this species common in the Missouri River Basin.

Notropis dorsalis dorsalis (Agassiz). Central bigmouth shiner. Common. Species found at almost all sampling stations, but showed distinct preference for the smaller, clear streams, such as Wolf Creek and the headwaters of the South Chariton River.

Notropis lutrensis (Baird and Girard). Plains red shiner. Common. Widely distributed throughout the entire river system. Particularly abundant at Stations 9 and 13 where flowage is through regions of exposed bedrock and gravel.

Notropis deliciousus (Cope). Plains sand shiner. Common. Found at nearly all sampling stations, but most numerous in Wolf Creek and South Chariton River.

Hybognathus nuchalis nuchalis (Agassiz). Silvery minnow. Common. Distributed throughout the Chariton River drainage. This species is quite tolerant of turbidity which may account for its abundance. Meeks and Harrison also reported it common.

Pimephales promelas promelas (Rafinesque). Fathead minnow. Abundant. Perhaps the most abundant species of fish in the Chariton River Basin. It is also numerous in small lakes and reservoirs in the watershed.

Catfish Family
(Ictaluridae)

Ictalurus punctatus (Walbaum). Channel catfish. Common. This species found at all stations in the Chariton River, but was found at only one station in the South Chariton River and absent in samples in Wolf Creek. Most abundant in regions where the original channel remains unaltered.

Ictalurus melas melas (Rafinesque). Northern black bullhead. Abundant. The most abundant species of fish in the samples. Found at all stations in large numbers.

Ictalurus natalis (LeSueur). Yellow bullhead. Rare. Species was rare to common. Distributed evenly throughout the river basin. More abundant in the lower reaches of the river.

Pylodictis olivaris (Rafinesque). Flathead catfish. Rare. Found only at Stations 6, 8 and 10 as young-of-the-year. No adults taken in seine hauls, but several were captured with fish toxicants.

Noturus flabus (Rafinesque). Stone cat. Rare. Nine specimens at sampling Station 8.

Noturus gyrinus (Mitchill). Tadpole madtom. Common. Species found quite commonly in the fish toxicant sampling, but rare in seine hauls.

Trout-Perch Family
(Percopsidae)

Percopsis omiscomaycus (Walbaum). Trout-perch. Rare. A few individuals captured in the lower reaches of the river. Several additional specimens taken in the fish toxicant samples at Station 12.

Bass Family
(Serranidae)

Roccus mississippiensis (Jones and Eigenmann). Yellow bass. Rare. Two specimens taken in the South Chariton River. This species is quite abundant in Allerton Reservoir, which forms the headwaters of this stream.

Sunfish Family
(Centrarchidae)

Micropterus salmoides (Lacepede). Largemouth bass. Common. Species is quite abundant below Brown's Slough-Colyn Lakes area, which was undoubtedly influenced the river population by overflow stocking. Not found in the South Chariton River or Wolf Creek.

Lepomis cynellus (Rafinesque). Green sunfish. Common. Generally distributed throughout this region. Found mostly in deep sluggish pools.

Lepomis macrochirus (Rafinesque). Bluegill. Common. Another species that is more numerous below the lakes adjacent to the river. Population density influenced considerably by overflow stocking.

Lepomis humilis (Girard). Orange-spotted sunfish. Common. Found commonly in deep pools at nearly all stations.

Pomoxis annularis (Rafinesque). White crappie. Common. Species was found evenly distributed in the river. Also abundant in lakes, but the contribution of these populations to the river is unknown. Some natural reproduction found in the river in late summer.

Pomoxis nigro-maculatus (Le Sueur). Black crappie. Rare. Cnly a few individuals captured. This species is generally intolerant of turbidity which may influence its abundance.

Perch Family
(Percidae)

Perca flavescens (Mitchill). Yellow perch. Rare. Only two specimens captured. Both of these were taken immediately below Brown's Slough, which indicated they might have been stocked during overflow.

Etheostoma nigrum (Rafinesque). Johnny darter. Rare. Reported rare in Harrison's collection. Meeks reported this species as common. They were rare in the present study.

Drum Family
(Sciaenidae)

Aplodinotus grunniens (Rafinesque). Freshwater drum. Rare. Two adult specimens caught at Station 12. Species not reported prior to this study in the Chariton River.

Species Composition and Standing Crop in the Primary Sampling Stations

Species composition and estimates of the standing crop of fish was completed for each of the primary sampling stations. Investigations on this phase of the project were initiated in August 1965, while flow in the river was low (<5 cfs). The four sampling stations in the Chariton River were finished within the next month, but flooding delayed sampling of fish populations in the South Chariton River until the following autumn (1966).

Effort was directed primarily toward estimating total fish populations and species composition in relation to different types of environmental characteristics of sampling stations. In regions where stream rechannelization was extensive, most sampling was conducted in this type of habitat. Likewise, where the original channel remained, this type environment made up the greater proportion of the sample. Regardless of the location both pool and riffle habitat was included in the survey.

Method of Fish Population Study

Fish populations were isolated by completely blocking a 600 ft section of the stream at both ends with wing nets (one-half inch chained mesh wings on 24-inch throated hoops). Several hauls were made with 50 ft of $\frac{1}{4}$ inch mesh drag seine inside the trapped area. Captured fish were marked by excision of the pectoral fin and immediately released into the enclosure. The following day the blocked section was treated with sufficient fish toxicant (1-3 mg/l $2\frac{1}{2}$% emulsified pro-noxfish) to kill all fish.

Mortality of downstream fish populations by toxic quantities of pro-noxfish drifting into lower pools was minimized by application of 2 mg/l sodium hyperchlorite at the lower net. Application of the detoxicant commenced when the downstream flow of the fish toxicant reached the lower boundary. Ordinarily loss of fish outside of the study area was unimportant because of low flow. Floating dead fish were collected continuously during the day of treatment and daily for the following three days. Total fish population estimates were computed by arithmetical expansion of the ratio of marked and unmarked fish captured. When expansion of the sample was impossible because no fish were previously captured due to low population densities only the number collected was recorded.

Length measurements, individual and aggregate weight and scale and spine samples were obtained from fish in the first day. After this,only visual counts were made for each species of fish as they were picked up and their collective weight estimated from the mean weight computed from the first collection. This was necessary because deterioration of flesh made handling of dead fish undesirable.

Species Composition

Nineteen of the 36 species of fish known to inhabit the Chartion River Basin were found important to species composition at the primary sampling stations. Carp, channel catfish, river carpsucker, black bullhead and gizzard shad were the most numerous species (Table 9). Less important species included bigmouth buffalo, yellow bullhead, northern redhorse, bluegill, freshwater drum, orangespotted sunfish, green sunfish, flathead catfish, tadpole madtom, common sucker, stonecat, largemouth bass and northern creek chub. Several additional species of small minnows were also collected, but were of minor importance to the overall fish population.

Black bullhead was the most abundant species comprising 25.5 % of the combined sample.

Table 9. Species composition of fish populations by number and weight at the primary sampling stations

Species	Number	%Occurrence	Weight	% Occurrence
Ch. catfish				
Station I	82	52.2	20.5	41.6
II	88	28.8	37.3	22.4
III	15	3.9	4.3	1.6
IV	6	1.4	5.2	2.6
V	24	9.2	6.0	4.4
Combined	215	14.1	73.3	9.1
Carp				
Station I	26	16.5	17.1	34.7
II	70	22.9	78.1	47.0
III	72	18.8	218.0	84.4
IV	46	10.8	32.2	16.1
V	82	31.5	106.6	78.4
Combined	296	19.9	452.0	55.9
Bigmouth buffalo				
Station I	1	0.6	1.5	3.0
II	5	1.6	1.6	0.9
III	9	2.3	4.5	1.7
IV	11	2.6	16.5	8.2
V	3	1.1	2.3	1.7
Combined	29	1.9	26.4	3.3
River carpsucker				
Station I	5	3.1	1.9	3.8
II	62	20.3	39.3	23.6
III	14	3.6	7.5	2.9
IV	5	1.1	2.8	0.6
V	30	11.5	15.8	11.6
Combined	116	7.6	67.3	8.3
White crappie				
Station I	15	9.5	1.3	2.6
II	4	1.3	0.1	0.1
III	11	2.8	1.1	0.4
IV	25	5.9	5.6	1.3
V	58	3.8	8.1	1.0

Table 9. continued

Species	Number	% Occurrence	Weight	% Occurrence
Black bullhead				
Station I	2	1.2	0.1	0.1
II	48	15.7	3.9	2.3
III	196	51.3	17.1	6.6
IV	102	24.1	10.1	5.0
V	42	16.1	4.2	3.1
Combined	390	25.5	35.4	4.4
Yellow bullhead				
Station II	4	1.3	0.1	0.1
III	27	7.0	3.2	1.2
IV	8	1.8	0.1	0.1
Combined	39	2.6	3.2	0.4
Northern redhorse				
Station I	2	1.2	1.3	2.6
Combined	2	0.1	1.3	0.2
Bluegill				
Station I	2	1.2	0.1	0.1
II	6	1.9	0.1	0.1
III	19	4.9	1.1	0.4
IV	5	1.1	0.1	0.1
Combined	32	2.1	1.2	0.2
Drum				
Station I	2	1.2	1.9	3.8
IV	1	0.2	0.1	0.1
Combined	3	0.2	1.9	0.2
Gizzard shad				
Station I	8	5.0	1.0	2.0
IV	178	42.0	111.3	55.9
Combined	186	12.2	112.3	13.9
Orangespotted sunfish				
Station I	7	4.4	0.1	0.1
V	10	3.8	0.1	0.1
Combined	17	1.1	0.1	0.1

Table 9. continued

Species	Number	% Occurrence	Weight	% Occurrence
Green sunfish				
Station I	1	0.6	0.1	0.1
III	9	2.3	0.1	0.1
IV	9	2.1	0.1	0.1
V	15	5.7	0.2	0.1
Combined	34	2.2	0.3	0.1
Flathead catfish				
Station I	2	1.2	2.5	5.0
II	3	0.9	3.3	1.9
Combined	5	0.3	5.8	0.7
Tadpole madtom				
Station I	2	1.2	0.1	0.1
Combined	2	0.1	0.1	0.1
Common sucker				
Station II	4	1.3	0.1	0.1
III	4	1.0	0.1	0.1
IV	25	5.9	12.5	6.2
Combined	33	2.2	12.6	1.6
Stonecat				
Station II	9	2.9	0.1	0.1
III	5	1.3	0.1	0.1
V	23	8.8	0.6	0.4
Combined	37	2.4	0.7	0.1
Largemouth bass				
Station II	2	0.6	2.4	1.4
III	1	0.2	1.2	0.4
IV	2	0.4	2.6	1.3
Combined	5	0.3	6.2	0.7
Creek chub				
Station V	28	10.7	0.2	0.1
Combined	28	1.8	0.2	0.1
Totals				
Station I	157		49.2	
II	305		166.0	
III	382		258.1	
IV	423		199.0	
V	260		136.0	
Grand total	1,527		808.3	

Carp made up 19.4%, followed in order of importance by channel catfish, 14.1%; gizzard shad, 12.2%; and river carpsucker, 7.6%. By weight, carp was the most important fish making up 55.9% of the population. This was followed by gizzard shad, 13.9%; channel catfish, 9.1%; river carpsucker, 8.3%; and black bullhead, 4.4%.

Species composition of individual sampling stations varied considerably. In general, channel catfish were most numerous in the lower reaches of the river with carp and bullhead abundant in the upper basin. River carpsucker, white crappie and bigmouth buffalo were evenly distributed throughout the river. Numerically, channel catfish ranked first at stations I and II, making up 52.2% and 28.8% of the population, respectively. Although black bullhead was the most numerous species of fish in the combined samples they ranked first only at Station III, where they comprised 51.3% of the sample. Carp were numerous throughout the entire river basin, but they dominated the numerical population structure only at Station V. Gizzard shad ranked fourth in overall abundance, and were absent from samples at three of the five stations. Their importance was the result of an extremely high population density of adults at Station IV. In general, there was considerable differences in the species composition of individual sampling stations, but three species, carp, black bullhead and channel catfish with only one exception ranked highest in numerical abundance.

By weight, carp was the most important species at three of the five sampling stations. Their abundance in the samples ranged from 16.1% at Station IV to 84.4% at Station III. Channel catfish ranked first at Station I, comprising 41.6% of the population weight. In overall importance channel catfish ranked third (9.1%). The large population of adult gizzard shad at Station IV, which comprised 55.9% of the sample weight, was sufficient to rank this species second in importance. River carpsucker was also important to the population weight comprising 8.3% of the total fish sample. At individual sampling stations they made up between 0.6% and 23.6% of the population weight.

The population density by both number and weight increased greatly as sampling progressed toward the upper basin. This is the opposite of what might be expected, because the stream increases in size in the lower portion of the basin. Part of this might be due to the extensive rechannelization that has occurred in the lower reaches of the Chariton River. In comparison, rechannelization has greatly reduced the number of large, deep pools, thereby proportionately reducing the amount of habitat even though the stream is wider. Also, deep pools are necessary for concentrations of species with large adult size, such as carp, channel catfish and river carpsucker.

Total weight of the fish populations in the sampling enclosures ranged from 48.8 lbs at Station I to 258 lbs at Station III (Table 10). Station III contained mostly original stream characteristics. When this poundage was converted into a more meaningful term, based on station samples of total fish populations, the standing crop of fish was estimated between 433 and 2,271 lbs per mile.

Differences in standing crop at individual sampling stations was highly significant ($P < 0.005$) by chi-square distribution. Some of this difference was primarily due to the influence of greater mean weight of fish at the different sampling stations. A preponderence of large, adult fish would greatly influence the gross weight of the population. Mean weight of fish ranged from 0.31 lbs at Station I to 0.67 lbs at Station III with a progressive increase toward the upper basin identical with the total weight of sampling stations. Fish were also more numerous at stations with higher mean weights. This trend in populations to become progressively greater in the upper basin is important, because the changes were progressive and not an isolated case of an unusually large fish population influencing the total sample.

Table 10. Standing crop of fish at the primary sampling station in the Chariton River

Station	Number in sample at station	Weight of sample	Estimated number per mile of stream	Estimated weight per mile of stream
I	157	49.2	1,382	433
II	305	166.0	2,684	1,461
III	382	258.1	3,362	2,271
IV	423	199.0	3,722	1,751
V	260	136.0	2,288	1,197

Fish Populations in Overflow Ponds

The flood plains of the Chariton and South Chariton Rivers contain more than 100 small overflow ponds. Most of these bayous are the result of rechannelization, where new channel diversions were constructed and the original channel remained open to the river during high water levels. Others were formed by natural relocation of the stream course and from barrow-fill for road grades and bridge ramps. Size of these ponds varies considerably depending upon the method which formed the basin. Rechanneled bayous range up to a maximum of approximately 2.5 surface acres. They are rather long, narrow bodies of water that follow the general shape of the original channel. Barrow cuts are usually smaller ranging up to a maximum of about one surface acre, but most are <0.25 acre in size. Depth of these ponds also varies considerably. Original channels are usually <5 feet deep, while the barrow cuts may contain as much as 10 ft of depth. All of these ponds are entirely dependent upon periodic overflow from the river to maintain water levels. Consequently, during periods of low precipitation many become completely dry.

Fish populations in overflow ponds originate from river populations that become trapped during flooding, and their density fluctuates greatly. Natural reproduction is almost nonexistant except for a few deep bayous where rough fish species, particularly gizzard shad, successfully reproduce at infrequent intervals. Marginal bayous, where winter kill and death from critical water temperatures are common, depend wholly upon periodic restocking from the river. All of the bayous are subject to extensive winter kill because of their shallow depth and high content of organic material.

Method of Estimating Species Composition and Standing Crop in Overflow Ponds

Six overflow ponds were selected for estimating species composition and standing crop. Three were located in Lucas County on the Chariton River, two were located in Appanoose County on the Chariton River and one was located in Wayne County on the South Chariton River. Size of the ponds ranged from 0.1 to 2.5 surface acres. The latter being the largest bayou known by the author on either stream. Maximum depth varied from 1.0 to 3.5 feet. Four of the bayous were formed by rechannelization of the river and two were the result of barrow for road grade fill. All investigations were conducted in late summer while water levels were somewhat reduced to facilitate counting and picking up dead fish.

Each pond was treated with sufficient fish toxicant to kill all fish. Several workers were stationed along the shoreline and as fish thrashed from the effects of the toxicant they were dipped up and placed in metal containers. After the initial activity from the toxicant ceased, these samples were separated by species, counted and weighed. Daily visits were made to the bayou during the following three days and all fish picked up and counted by species. Weight was estimated on these days by applying the mean weight recorded on the first day for each species to the total number recovered on each visit. Hence, values listed for total fish populations are minimum figures because fish that remained submerged or carried away by animals were never counted. Although with high water temperatures present at the time of treatment, it is doubtful great quantities of fish were missed.

Species Composition and Standing Crop in Overflow Ponds

Fish populations in overflow ponds, like the river populations, were dominated by rough fish species. Carp was the most abundant species, comprising 45.4% of the combined numerical population and 52.1% of the total weight of fish in overflow ponds. They ranked first by number and weight in four of the six ponds and never ranked lower than second in importance. At individual bayous carp made up from 9.1% to 82.1% of the numerical population and 16.4% to 87.6% of the weight. Gizzard shad ranked second in overall abundance although they were absent from two bayous. By number, they comprised 17.3% of the total sample and ranked third in importance by weight, occupying 12.1% of the sample. Much of their overall abundance was the result of an extremely high population density (78.6% by number and 55.6% by weight) of adults in Pond 1. Bigmouth buffalo ranked third in importance by weight (16.3%), but comprised only 8.7% of the combined sample number. Black bullhead made up 16.2% of the numerical population in bayous, but their small average size reduced their importance to fourth by weight with 8.4%. The overall importance of individual species and their abundance in individual overflow ponds is listed in Table 11.

Carp, black bullhead, crappie and green sunfish were found in all overflow ponds. Yellow bass, bluegill, river carpsucker, largemouth bass and freshwater drum were also recorded, but never comprised >2% of the population number or weight. Green sunfish and crappie were of general importance by number in Ponds 3 and 6 where they made up 17.2% and 15.3% of the fish population, respectively. One of the most noticable differences between river and overflow pond fish populations was the total lack of channel catfish in overflow ponds. Apparently they are not trapped during high water levels, or if they are mortality is complete and expeditious.

Table 11. Species composition by percent number and weight of the fish population in six overflow ponds

Species	1		2		3		4		5		6		Combined	
	N	Wgt	N	Wgt	N	Wgt	N	Wgt	N	Wgt	N	Wgt	N	Wgt
Carp	9.1	16.4	83.1	87.6	35.7	22.5	69.1	82.1	54.1	64.6	21.3	34.2	45.4	52.1
Bm buffalo	4.0	18.5			<1.0	<1.0	<1.0	<1.0	10.9	28.8	34.3	50.3	8.2	16.3
G shad	78.6	55.6			9.6	8.9	3.8	1.2			11.9	6.9	17.3	12.1
Bl bullhead	5.5	5.8	7.3	12.4	35.5	9.9	20.4	13.6	16.4	4.3	11.9	4.4	16.2	8.4
R carpsucker	<1.0	1.8	1.6	<1.0	<1.0	<1.0							<1.0	<1.0
Crappie	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	6.7	1.4	15.3	2.5	3.7	<1.0
Bluegill	<1.0	<1.0							4.2	<1.0	4.8	<1.0	1.5	<1.0
Gr sunfish	<1.0	<1.0	8.1	<1.0	17.2	4.6	6.1	2.5	<1.0	<1.0	<1.0	<1.0	5.2	1.2
Lm Bass	<1.0	<1.0			<1.0	<1.0			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Y bass									<1.0	<1.0			<1.0	<1.0
Fr drum											<1.0	<1.0	<1.0	<1.0

There was considerable difference in the standing crop of fish in overflow ponds. Standing crop ranged from 124 fish weighing 18.5 lbs in Pond 2 to 3,834 fish with a combined weight of 1,030 lbs in Pond 1. On a per acre basis standing crop was estimated at 122 to 982 lbs (Table 12) with a mean of 591. Much of this difference was due primarily to the quality of habitat in the bayou. Ponds in which habitat was marginal, such as rapidly fluctuating water levels, shallow depth and small area also had the lowest standing crop. Larger bayous with relatively deep water and stable water levels had the largest poundage.

Table 12. Standing crop of fish in overflow ponds of the Chariton River

Pond	Size (acres)	Total number	Total weight	Mean weight	Location	Maximum depth	Pounds per acre
1	1.1	3,834	1,030.2	0.27	Lucas	3.5	937
2	0.1	124	18.5	0.15	Lucas	1.5	185
3	0.1	563	98.2	0.17	Lucas	3.0	982
4	1.5	2,990	183.3	0.06	Appanoose	1.0	122
5	0.5	495	377.4	0.76	Wayne	2.0	755
6	2.5	1,879	1,408.7	0.74	Appanoose	3.5	564

Preliminary visual interpretation of the data indicated standing crop was linearly related to pond size and depth. Correlation between standing crop and pond size was not significant ($r = 0.638$; $P > 0.05$). Correlation between maximum depth and standing crop was significant ($r = 0.808$; $P < 0.05$). The coefficient of determination showed a rather large proportion (65%) of the variation in values of standing crop was related to maximum depth of bayous. The remainder can be attributed to experimental error. Mean weight of fish also was greater in ponds with more depth.

Fish Populations in Farm Ponds in the Chariton River Basin

More than 2,100 ponds for agricultural use have been constructed in the Chariton River Basin. All of these ponds have been privately financed except for governmental cost sharing programs. A vast majority of these impoundments contain a variety of fish. Both the State Conservation Commission and Soil Conservation Commission through facilities of the U. S. Fish and Wildlife Service offer fish for pond stocking upon application without cost to the owner. Many other ponds have received additional stocking from fishermen returning home and liberating fish. Except for occasional harvest by fishermen and periodic restocking because of winter kill most farm ponds in the region receive no active management for a fishery.

Four ponds ranging in size from 0.25 to 0.72 surface acres were selected for study. Age of the ponds ranged from 3 to 17 years. Maximum depth varied from 13 to 19 feet. In general, the ponds were typical for this region.

Three ponds had been stocked with fish received through governmental programs. The other pond, to the knowledge of the owner, had never been stocked with fish, although there was visible evidence of fish activity. In order farm ponds would not be confused with overflow ponds in this report the former were designated as alpha, beta, gamma and delta ponds for convenience.

Methods for determining species composition and standing crop in the farm ponds was identical with overflow ponds. Permission was obtained from the owner to treat the pond with sufficient fish toxicant to kill all fish. Estimates of standing crop and species composition were based upon the number and weight of fish picked up along the shoreline during four consecutive daily visits following treatment.

Species Composition and Standing Crop in Farm Ponds

Fish populations in farm ponds were, as expected, comprised mostly of species that had been stocked through governmental programs. The only exception was alpha pond, where the population was comprised wholly of black bullhead. Three of the 1,374 fish found in the pond were exceptionally large (mean weight 2.1 lbs) and the remainder small, stunted, mature fish. Alpha pond was constructed three years before this investigation. The three large fish were probably brood fish planted in the pond by a fisherman and succeeded in reproducing in the initial year. Evidence from length-frequency distribution of the smaller group of fish indicated only one year class was present.

Bluegill dominated the fish populations of the other ponds. Numerically they comprised 86.8%, 62.0% and 68.4% of the populations in beta, gamma and delta ponds, respectively. By weight, their abundance ranged from 55.8% to 71.4% of the population (Table 12). Largemouth bass were also found in these three impoundments. In the individual ponds their numerical abundance ranged from 3.0% in beta pond to 13.2% in delta pond; and by weight 17.9% in gamma pond to 31.2% in beta pond. Channel catfish were found in small numbers (0.7% of the numerical population) in delta pond. This also was undoubtedly the result of a channel catfish fingerling planting program by the Soil Conservation Service four years previously. Green sunfish were also found in three ponds, but were relatively unimportant to the population structure. A single flathead catfish was collected in delta pond. Numerous minnows were also found in gamma pond, but were not added into the species composition on standing crop.

The standing crop of fish in farm ponds ranged between relatively wide limits. Alpha pond, with a single species population, had the largest standing crop of 675 lbs per surface acre. Beta pond contained an estimated 308 lbs per acre; gamma pond, 470 lbs per acre;

Table 13. Species composition and standing crop of fish in farm ponds in the Chariton River Basin

Pond	Size (acres)	Species	Number	% Number	Weight	% Weight	Estimated lbs per acre
Alpha	0.25	Bullhead	1,374	100	168.8	100	675
Beta	0.25	Bluegill	774	86.8	43	55.8	172
		G sunfish	91	10.2	10	13.0	40
		Lm bass	27	3.0	24	31.2	96
		Total	892		77		308
Gamma	0.50	Bluegill	543	62.0	152	64.7	304
		G sunfish	75	8.6	9	3.8	18
		Lm Bass	90	10.3	42	17.9	84
		Bullhead	168	19.1	32	13.6	64
		Total	876		235		470
Delta	0.72	Bluegill	1,274	68.4	293	71.4	408
		G. sunfish	329	17.7	23	5.6	32
		Lm bass	246	13.2	75	18.2	104
		Ch catfish	13	0.7	17	4.1	23
		Fl catfish	1	0.1	3	0.7	4
		Total	1,863		411		571

and delta pond 571 lbs per acre. All of these poundage are within the limits found in other investigation of standing crop of fish in farm ponds in Iowa. By individual species, bluegill populations were estimated to range from 172 to 408 lbs per surface acre. Largemouth bass were second in importance ranging from 84 to 104 lbs per acre. Other species varied widely and are listed separately in Table 13.

Fish Populations in Lakes and Reservoirs

Six larger artificial lakes and reservoirs are located within the Chariton River Basin. Fisheries surveys have been conducted on all of these impoundments, except West Lake, for many years. Brown's Slough, North Colyn and South Colyn are owned by the State Conservation Commission and have secondary management for a sport fishery. These lakes were originally constructed for waterfowl hunting and refuge and management for this purpose receives first priority. Humeston Reservoir and Allerton Reservoir are municipal water supply impoundments that the State Conservation Commission has public fish management agreement, but all management practices must not interfere or jeopardize the primary purpose of supplying water to municipalities for human consumption and industrial use. West Lake is privately owned and receives no fish management. Fish population studies were completed after permission for a special survey was granted by the Lakeview Golf and Country Club.

Estimates of standing crop of fish in the lakes and reservoirs was impossible because of their size and other factors. Hence, only estimates of species composition are given in this report. These estimates were based upon special netting surveys using single-lead pound nets in Allerton Reservoir, Humeston Reservoir, Brown's Slough and West Lake. North Colyn and South Colyn are very difficult to net effectively because of standing trees and floating debris so surveys were made using electro-fishing gear. All surveys were made in May 1967.

Species composition of the fish population was determined for each impoundment both by number and weight. At the end of each net lift or shocker run all fish captured were counted by species and weighed aggregate. These values were summed at the conclusion of the survey to yield an estimate of species composition. Netting periods on the individual lakes lasted from two to seven days. Electro-fishing surveys were usually concluded in one day which consisted of four-30 minute shocker runs. No attempt was made to adjust species composition because of the selectivity of fishing gear. The original purpose of these inventories was to estimate species composition without estimating relative abundance or population density and should be considered only in this manner.

Species composition of the fish population in individual lakes and reservoirs varied considerably (Table 14). In general, crappie, carp, bluegill and largemouth bass dominated the populations by number or weight. Bluegill and bullhead were found in all of the impoundments, but their importance was rather low in most lakes. Bluegill comprised 3.5% of the numerical sample in West Lake and ranged up to a maximum of 19.7% of the sample in North Colyn. By weight, they varied from 0.5% in Brown's Slough to 8.7% in Humeston Reservoir. Bullhead ranged numerically from $<$0.1% of the sample in Allerton Reservoir to 30.3% in Humeston Reservoir. Their importance by weight varied from $<$ 0.1% to 48.6% in these reservoirs, respectively. Crappie were extremely abundant in the Allerton Reservoir survey making up 90.0% of the numerical sample and 58.3% of the sample by weight. Carp were most numerous in Brown's Slough, North Colyn and South Colyn where overflow from the Chariton River occurs frequently. In these impoundments carp comprised 62.7%, 50.1% and 26.8% of the numerical sample, respectively. Allerton Reservoir also has a carp population, but they accounted for only 0.8% of the sample number while comprising 27.5% of the sample weight. Much of the relative importance of the latter value was due to a sample consisting of large adult fish with a mean weight of 6.43 lbs. No carp were found in West Lake or Humeston Reservoir.

Bigmouth buffalo were collected only in the three impoundments subject to overflow from the Chariton River. By number this species comprised 4.2% in North Colyn and ranged up to a maximum of 15.9% in South Colyn. Because of their large individual size they ranked comparatively higher in the sample weight. Largemouth bass were found in all lakes except

Humeston Reservoir. Previous surveys indicated they are present in the lake, but were apparently missed in the netting survey. In other lakes their numerical abundance ranged from 0.6% of the sample in West Lake to 41.5% in South Colyn. By weight, they comprised 1.9% of the sample in Brown's Slough and 43.8% in South Colyn. Yellow bass were found in large numbers only in West Lake, where they made up 28.6% of the numerical sample and 26.4 % of the sample weight. Green sunfish, redear sunfish, warmouth and golden shiner were also captured in the lakes and reservoirs, but were usually of minor importance to species composition.

Table 14. Species composition by number and weight in artificial lakes and reservoirs in the Chariton River Basin

Lake	Species	Number	% Number	Weight	% Weight
Allerton Res	Lm bass	15	0.9	19.3	6.4
	Bluegill	127	7.7	19.2	6.3
	Crappie	1,479	90.0	177.1	58.3
	Bullhead	8	0.5	4.8	1.6
	Carp	13	0.8	83.6	27.5
Humeston Res	Crappie	196	39.0	31.4	31.4
	Bullhead	152	30.3	48.6	48.6
	G sunfish	68	13.5	8.8	8.8
	Bluegill	51	10.2	8.7	8.7
	Y bass	31	6.2	1.8	1.8
	Ch catfish	3	0.6	0.7	0.7
	Redear sunfish	1	0.2	0.1	0.1
West Lake	Crappie	854	63.3	108.9	51.7

Table 14. Continued

	Bullhead	53	2.4	21.4	10.2
	G sunfish	15	1.1	3.1	1.5
	Bluegill	47	3.5	7.4	3.5
	Y bass	386	28.6	55.7	26.4
	Ch catfish	1	0.1	0.9	0.4
	G shiner	5	0.5	0.1	0.1
	Lm bass	8	0.6	13.2	6.3
North Colyn	Lm bass	14	6.6	37.6	34.7
	Bluegill	42	19.7	8.4	7.8
	Crappie	24	11.3	3.7	3.4
	Bullhead	1	0.1	0.1	0.1
	Carp	107	50.1	53.7	49.6
	Bm buffalo	9	4.2	4.6	4.2
	G sunfish	15	7.0	0.1	0.1
	Warmouth	1	0.1	0.1	0.1
South Colyn	Lm bass	34	41.5	36.7	43.8
	Bluegill	9	11.0	1.3	1.6
	Bullhead	4	4.9	3.1	2.5
	Carp	22	26.8	22.4	26.8
	Bm buffalo	13	15.9	21.2	25.3
Brown's Slough	Lm bass	8	2.0	6.7	1.9
	Bluegill	26	6.3	2.1	0.5
	Carp	255	62.7	239.7	65.2
	Bm buffalo	16	4.0	89.6	24.4
	Bullhead	102	25.0	29.6	8.0

Age and Growth of Fishes in the Chariton River

Age and growth studies were completed for channel catfish, carp, river carpsucker and bigmouth buffalo. Data and scale samples for the determination of the age structure of crappie, gizzard shad, bluegill and green sunfish populations were also collected, but their number was usually less than 35 for each species and considered inadequate for reliable estimates of growth. Bullhead, the most numerically abundant fish in the river, were excluded from age and growth studies because methods used for processing spine samples of the very small fish characteristic of the Chariton River population are inaccurate. Scale and spine samples were also collected from fishes in overflow ponds, farm ponds and other artificial lakes and reservoirs in the basin, but growth analysis was not included in this report because the reservoir will have only minor effect upon fish populations in these waters.

Processing for ageing of fish from the spine and scale samples was identical with the methods recommended by Sneed (1951) for channel catfish and Lagler (1956) for scale fishes. Measurements of total body length were recorded to the nearest 0.1 inch and weight to the nearest 0.01 lbs. The samples were obtained exclusively during species composition and standing crop studies using a fish toxicant. Each sample was stored in a serially numbered coin envelope on which the sampling location and physical measurements of the specimen was recorded. Larger samples were obtained for determination of length-weight relationships and condition factors by measuring and weighing additional fish.

Age and Growth of Channel Catfish

Channel catfish is one of the most important species of fish in the Chariton River. They were particularly numerous in the lower sections of the stream, where they comprised up to 52% of the sample. Pectoral spine samples for age and growth studies were collected from 168 fish. Measurements of total body length and weight for computation of the length-weight relationship, length-frequency distribution and the ponderal index, C, were obtained from an additional 142 fish, for a total sample of 310 fish.

Length-frequency distribution of the sample by one-half inch size intervals (Figure 23) showed almost all lengths of fish from 3.5 to 20.5 inches were present. Highest modes in the polymodal histogram occurred at the 7.5-7.9 inch interval representing 13.9% of the sample and the 9.0-9.4 inch interval which comprised 9.0% of the sample. Associated value of 12.4% and 9.8% occurred on each side of the former mode. Length-frequency distribution of channel catfish of more than 13.0 inches made up $<1\%$ of the sample at each interval. Samples from the class marks 13.2, 16.2, 18.7 and 20.2 inches were missing from the sample.

Length-Weight Relationship

The fish were separated into one-half inch body length intervals and the mean length and weight computed for each group. These values were plotted in graphical form (Figure 24) with weight as the dependent variable. The length-weight relationship of channel catfish in this stream can best be described by the least squares equation $\log W = -2.7979 + 3.216 \log L$, where W = weight and L = total length.

Values for predicted weights based on the length-weight equation at each length interval are listed in Table 15. Difference in calculated weight and empirical weight was not significant ($P<0.800$). Greatest deviations in these values occurred at length intervals with fewer than four fish. Maximum difference in predicted and observed weights of -0.40 lbs occurred in the 20.5-20.9 inch length interval. There was a tendency for predicted weights in larger size groups to be less than observed values. When adequate samples of the two variables were available (10 or more) differences were generally ± 0.04 lbs.

A ponderal index of body condition was determined for each size group by using reciprocals of total length. The average C factor for the sample was 29 with a range of 24 to 44.

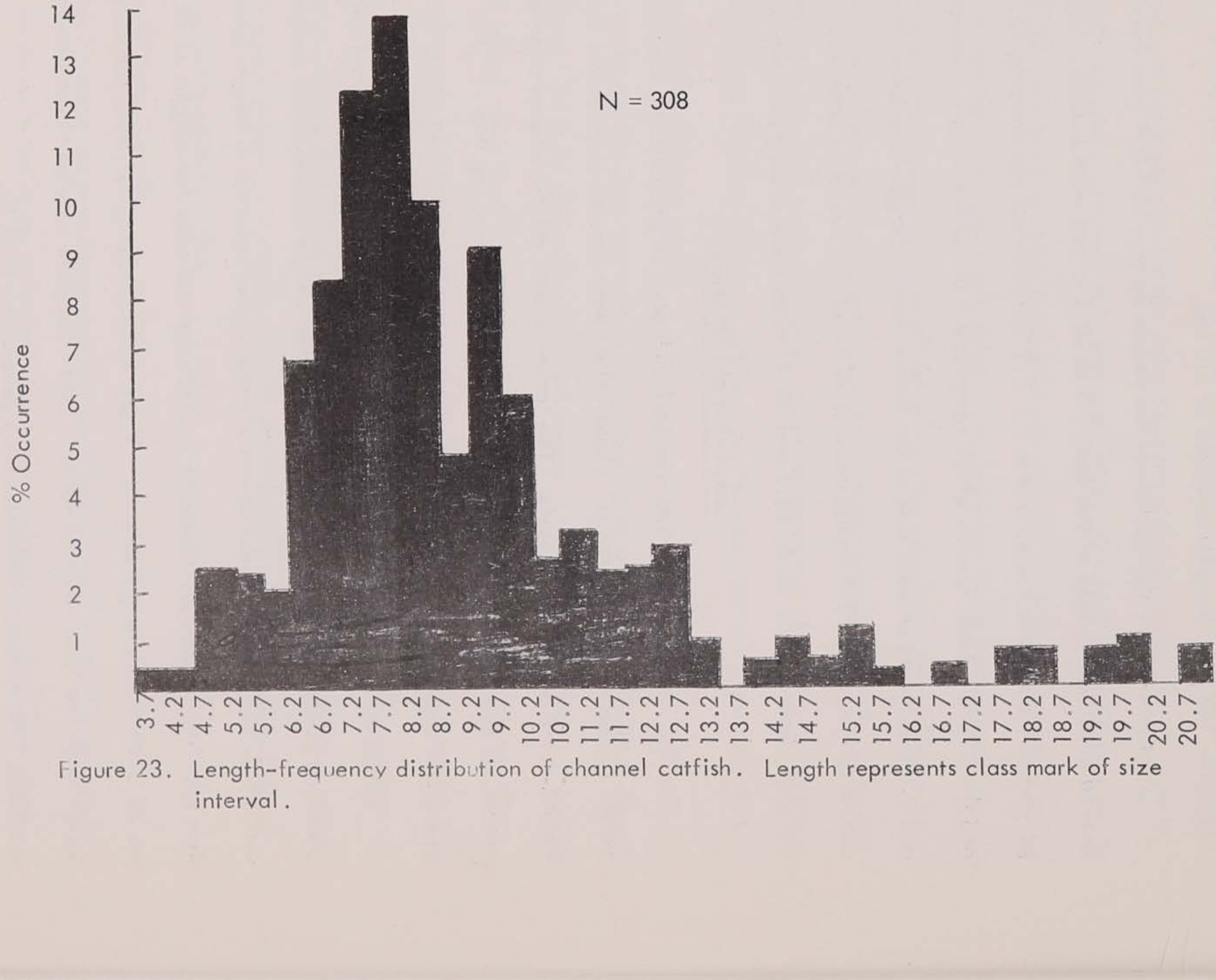

Figure 23. Length-frequency distribution of channel catfish. Length represents class mark of size interval.

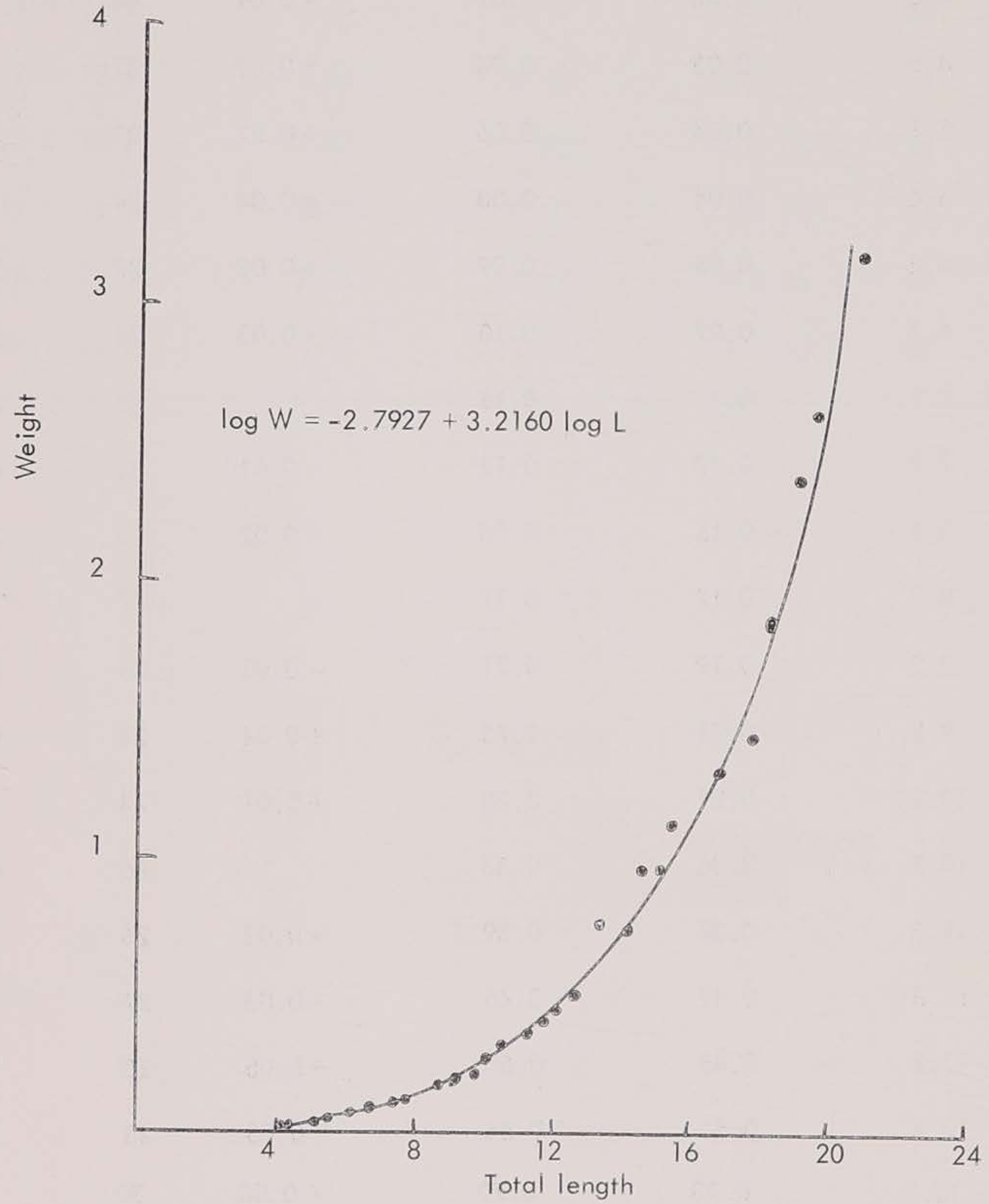

Figure 24. Total length-weight relationship of channel catfish.

Table 15. Observed and calculated weight of channel catfish

Size Group	Mean TL	Observed	Calculated	Deviation	C	N
4.0-4.4	4.2	0.03	0.02	- 0.01	44	1
4.5-4.9	4.6	0.03	0.04	+ 0.01	37	8
5.0-5.4	5.1	0.04	0.06	+ 0.02	31	7
5.5-5.9	5.6	0.04	0.08	+ 0.04	24	6
6.0-6.4	6.2	0.06	0.09	+ 0.03	27	21
6.5-6.9	6.7	0.07	0.10	+ 0.03	24	26
7.0-7.4	7.2	0.11	0.11		32	38
7.5-7.9	7.7	0.13	0.12	- 0.01	32	43
8.0-8.4	8.1	0.15	0.13	- 0.02	29	31
8.5-8.9	8.7	0.17	0.17		27	15
9.0-9.4	9.3	0.19	0.21	- 0.02	25	28
9.5-9.9	9.8	0.21	0.25	+ 0.04	24	18
10.0-10.4	10.2	0.27	0.28	+ 0.01	24	8
10.5-10.9	10.7	0.33	0.33		26	10
11.0-11.4	11.3	0.37	0.39	+ 0.02	26	7
11.5-11.9	11.8	0.42	0.45	+ 0.03	27	8
12.0-12.4	12.2	0.45	0.50	+ 0.05	25	9
12.5-12.9	12.7	0.51	0.56	+ 0.05	25	3
13.5-13.9	13.5	0.78	0.70	- 0.08	30	2
14.0-14.4	14.2	0.75	0.82	+ 0.07	26	3
14.5-14.9	14.5	0.91	0.88	- 0.03	30	1
15.0-15.4	15.2	0.92	1.02	+ 0.10	28	4

Table 15. Continued

15.5-15.9	15.5	1.13	1.09	- 0.04	31	1
16.5-16.9	16.8	1.31	1.41	+ 0.10	27	1
17.4-17.9	17.7	1.45	1.56	+ 0.11	26	2
18.0-18.4	18.2	1.87	1.82	- 0.05	28	2
19.0-19.4	19.0	2.37	2.09	- 0.28	34	2
19.5-19.9	19.5	2.62	2.27	- 0.35	35	3
20.5-20.9	20.8	3.19	2.79	- 0.40	36	2

Higher values of C occurred in the smaller size groups with rather small numbers of fish. Also, part of the incidence of higher C factors may have resulted from inaccurate weighing of very small fish on instruments with 0.01 lbs increments.

Average Length and Length Distribution by Age Group

Each of the 168 channel catfish from which a pectoral spine sample was collected was assigned to an age group. A general description of empirical growth was obtained by plotting mean length and the ranges of length for each age group (Figure 25). Because the samples were obtained in the autumn and almost one year of additional growth occurred after formation of the last annulus, total length at capture is somewhat greater than calculated lengths at the formation of the last annulus. If the spine sample showed two annuli the fish had attained nearly three years of growth.

Most of the fish in the sample were age IV or younger. Age group II contained the largest sample with 75 fish. Age groups III and IV followed with 43 and 22 samples, respectively. No fish were taken from age group VII. The paucity of this age fish in the population can be verified by the complete lack of fish of this size (16.0-16.4 inches TL) in the length-frequency distribution.

Overlapping of observed body length between age groups was common, particularly in the younger fish. Mean empirical length of age I fish was 5.2 inches at capture with a range of 4.0 to 7.2 inces. Mean body length of age II fish was 7.1 inches with a range of 4.6 to 7.3 inches. This means channel catfish separated by one year of age had common ranges of body length measurements of more than 2 inches. However, overlapping never extended more than one age group. As age increased and sample size became smaller the range of overlapping length became progressively smaller until at age V it was undetchable.

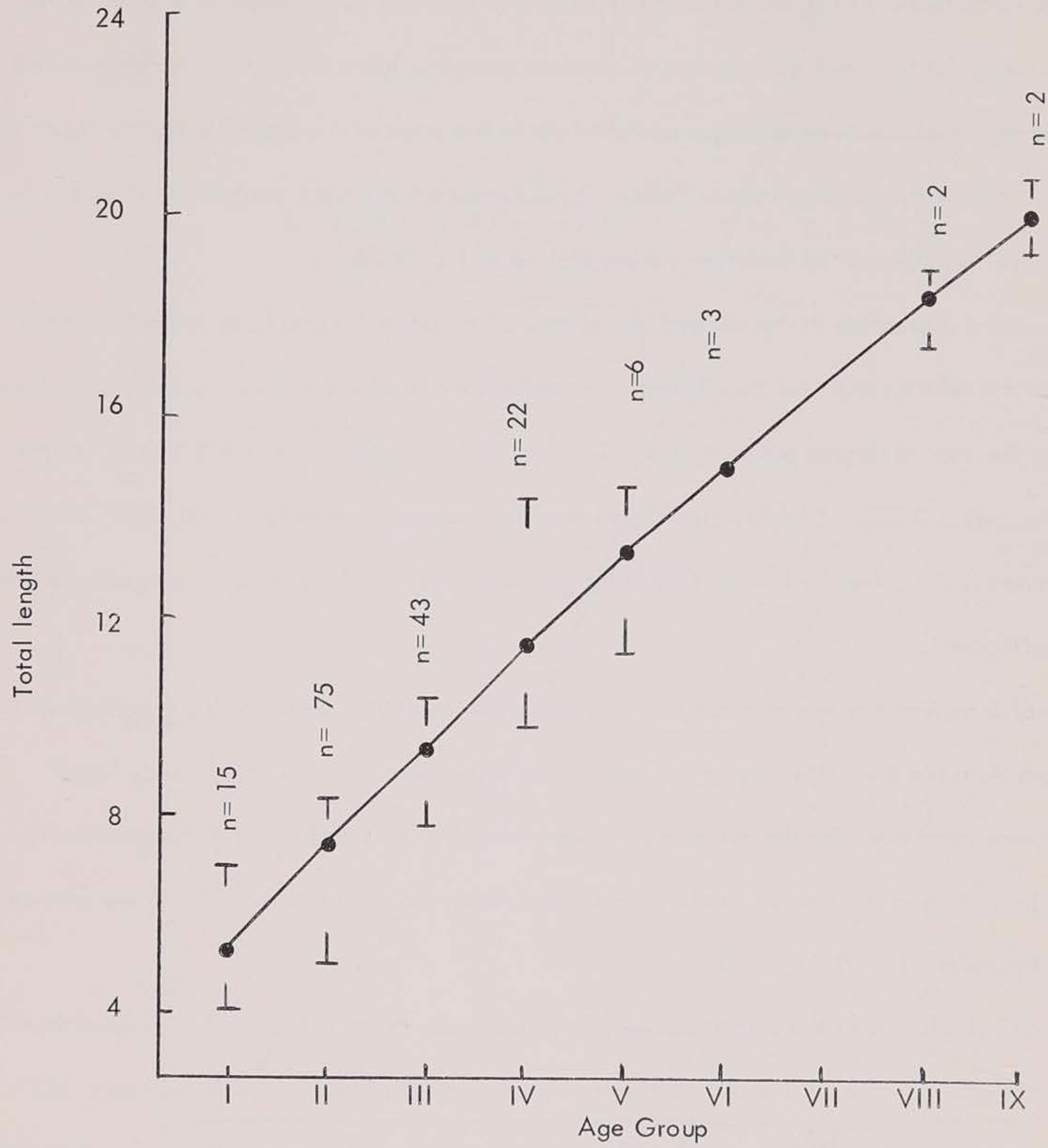

Figure 25. Mean observed length at each age group for channel catfish. Brackets represent maximum and minimum length within each age group.

Calculated Growth in Length

The establishment of a mathematical relationship between body length and spine radius was necessary for the back calculation of absolute growth. Spine X-sections were measured from the center of the lumen along a straight line to the edge of the magnified spine image in the right lobe of the postero-lateral field. These measurements were grouped by 2-inch intervals of total length and the resulting values plotted in Figure 26.

By visual inspection of the plotted variables, spine radius (R) and body length (L) it was apparent the relationship was curvilinear. A satisfactory fit of the regression line was achieved by using the second degree polynomial $L = 0.14 + 1.24 R - 1.34 R^2$, where L = total length and R = spine radius (X32). A highly significant product-moment correlation ($r = 0.997$), computed by the method described by Fruend (1967) for grouped data, resulted from the estimated regression coefficients.

Total length at the end of each year of life was computed by constructing a nomograph to accomodate the curvilinearity of the body-spine regression. In this device body length values were identical with the estimated regression coefficients and could be automatically shifted by adjusting the marked center of the spine image on the tagboard strip to the intercept of the regression (TL = 0.14, R=0).

Back calculation of the estimated total length at each annulus was easily accomplished for all age groups. Previous investigators of channel catfish growth in Iowa (Harrison, 1957; Mayhew and Mitzner, 1967) reported difficulty with accurate assignment of ages for older fish because of deterioration of the bony structure around the lumen and eventual erosion of the first and second annuli. In these studies, the first annulus usually disappeared at approximately age VI and the second annulus by age X. However, sample size of the latter was so small there was some question about the reliability of complete loss of the second annulus.

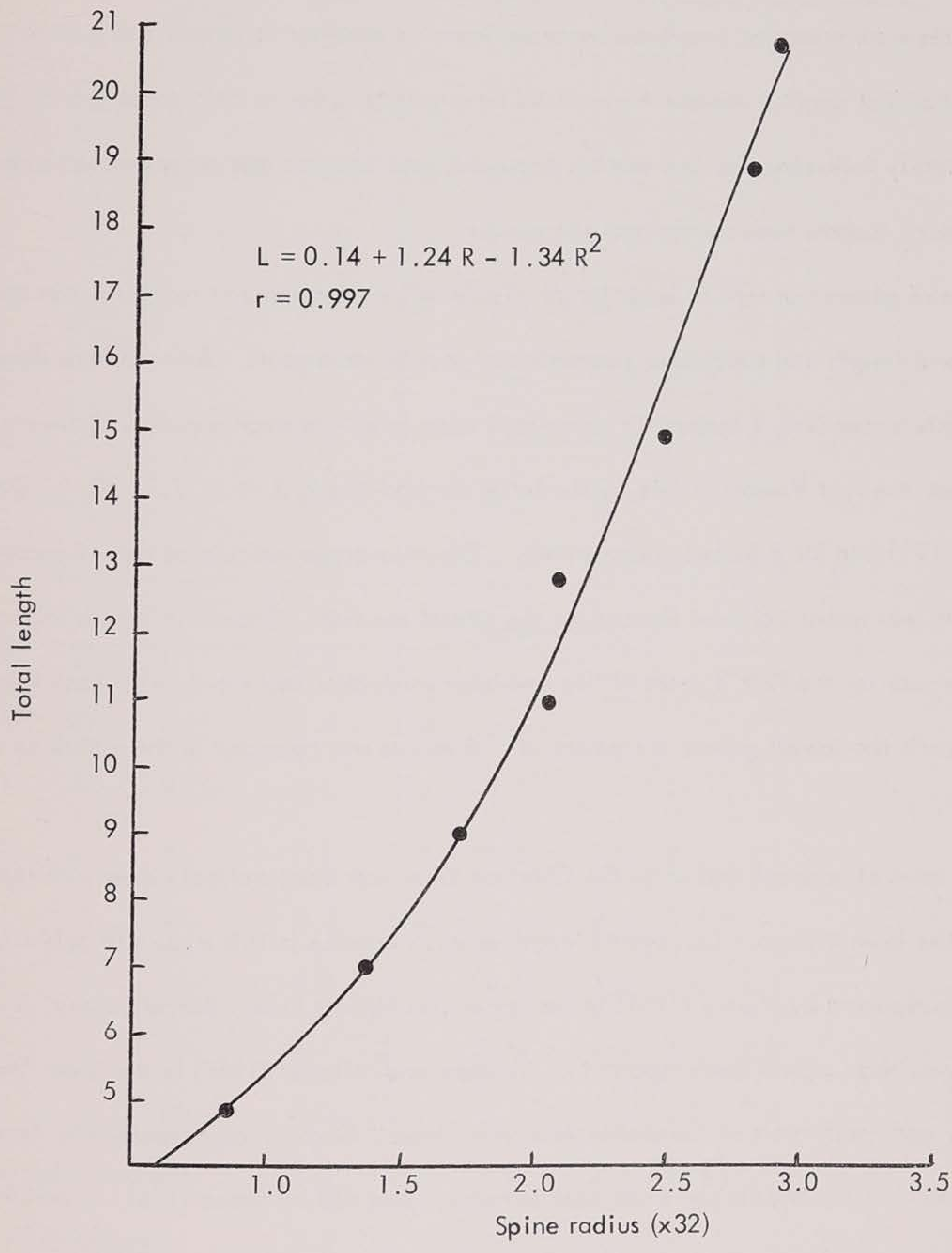

Figure 26. Body-spine relationship of channel catfish.

No evidence of this factor was evident in the samples of channel catfish from the Chariton River. Samples were arranged in successive order from the smallest to largest fish. In this procedure if the first annulus eroded there would be a reverse order in calculated growth increments immediately following the age erosion occurred, and younger age groups would contain larger calculated lengths than subsequent age groups.

Estimates of general growth in body length (Table 16) were computed by grand averages of calculated total length and successive summation of growth increments. Both methods showed only minor differences (± 0.7 inches) in calculated body length at each annulus. Estimated total length for the first 9 years of life by the latter method was 2.3, 4.9, 7.9, 10.4, 12.7, 14.8, 17.4, 19.3 and 20.9 inches, respectively. Grand average calculated growth increments showed growth was rather constant throughout the life of the fish. Growth in length increased slightly each year for the first 3 years of life and afterwards declined slowly with each successive year of life until the lowest growth increment of 1.6 inches was recorded in the eighth year of life.

Growth rates of channel catfish in the Chariton River was comparatively slow with reported growth in other Iowa streams. Calculated length at each annulus in this study was only slightly below lengths reported by Muncy (1957) in the upper Des Moines River, Boone County, Iowa, but much slower than growth rates reported by Mayhew and Mitzner (1967) in the lower Des Moines River and headwaters of Coralville Reservoir, Iowa. Growth rates reported by Appleget and Smith (1951) in the Mississippi River near Lansing, Iowa and by Sneed (1951) in an Oklahoma Reservoir were also much greater at each annulus. Finnell and Jenkins (1954) computed the state-wide growth of channel catfish in Oklahoma streams and reported total lengths about 25% greater in each age group than the Chariton River. Purkett (1958) found growth rates of channel catfish was slower in the Salt River, Missouri.

Table 16. Calculated total length and increments of length for channel catfish

Year class	N	Age group	1	2	3	4	5	6	7	8	9
			Growth								
			Year of Life								
1965	15	I	2.2								
1964	75	II	2.4	5.9							
1963	43	III	2.2	5.5	8.6						
1962	22	IV	2.2	5.0	7.9	10.6					
1961	6	V	3.2	5.0	8.0	10.9	13.3				
1960	3	VI	2.2	4.7	8.8	10.6	13.6	15.4			
1958	2	VIII	2.1	4.9	7.8	10.9	12.8	14.8	17.6	18.4	
1957	2	IX	2.3	4.4	6.5	8.9	11.1	13.7	16.1	19.1	20.7
Mean cal TL			2.3	5.1	7.9	10.4	12.7	14.6	16.7	18.8	20.7
			Increments								
1965	15	I	2.2								
1964	75	II	2.4	2.4							
1963	43	III	2.2	3.2	3.1						
1962	22	IV	2.2	2.8	2.9	2.9	2.7				
1961	6	V	3.2	1.8	3.0	2.9	2.4				
1960	3	VI	2.2	2.5	4.1	1.8	3.0	1.8			
1958	2	VIII	2.1	2.8	2.9	3.1	1.9	2.0	2.8	0.8	
1957	2	IX	2.3	2.1	2.1	2.4	2.2	2.6	2.4	3.0	1.6
Mean cal increment			2.3	2.6	3.0	2.5	2.3	2.1	2.6	1.9	1.6
Sum of increments			2.3	4.9	7.9	10.4	12.7	14.8	17.4	19.3	20.9
N in sample			168	153	78	35	13	7	3	2	2

Calculated Growth in Weight

Calculated growth in weight (Table 17) was determined by applying the sum of the average increments in each year of life in Table 16 to the length-weight equation. Annual increments of weight increased systematically from 0.01 lbs in the first year of life to 0.67 lbs in the seventh year. After this age weight increments were constant. Irregularity of weight increments in groups of fish VII or older was probably due to small samples of larger fish. In general, calculated weight became progressively greater with increased age.

Table 17. Calculated growth in weight of channel catfish

Year of life	Observed weight	Predicted weight	Increment of weight
1	0.04	0.01	0.01
2	0.10	0.03	0.02
3	0.21	0.13	0.11
4	0.39	0.33	0.20
5	0.68	0.63	0.30
6	0.91	1.02	0.39
7	[1]	1.69	0.67
8	1.92	2.35	0.66
9	3.51	3.00	0.65

[1] Age VII fish not present in observed sample

Age and Growth of Carp

Carp ranked second in numerical abundance in the Chariton River, and dominated the fish population by weight (See species composition section for exact numbers). Only bullhead were more numerous in the samples. Procedures for determination of the age and growth of carp were similar to the method used for channel catfish. A total of 501 samples including 215 scale samples and 286 measurements of total length and weight were collected simultaneously with species composition and standing crop studies using a fish toxicant.

The length-frequency distribution of the carp sample (Figure 27) by one-half inch size intervals showed the population was dominated by an extremely abundant year class with a modal length of 10.0-10.9 inch. This size group contained about 25% of the sample. Associated increase in the % occurrence of fish also occurred on either side (9.0-9.4 and 11.0-11.4) of this interval. Additional modes in the distribution occurred at 14.5-14.9, 17.0-17.4 and 18.0-18.4 inch size groups, but after the fish reached 13.0 inches in total length they never comprised more than 3% of the sample. All lengths between 5.5 and 21.5 inches were presented in the sample except the 19.0-19.4 and 21.4-inch groups.

Length-Weight Relationship

Length and weight data were collected from 501 fish. This sample was grouped into one-inch length intervals and the mean length and weight computed for each interval. A satisfactory straight line (Figure 28) was fitted to log-log transformed values of the two variables by the least squares equation $\log W = -2.3932 + 3.0449 \log L$, where W = weight and L = total length.

Deviation in residuals of empirical and predicted values of weight (Table 18) were small except in size groups with small sample size. In the smaller size intervals with 15 or more observations the difference between these values was a maximum of $\pm$ 0.13 lbs. When sample

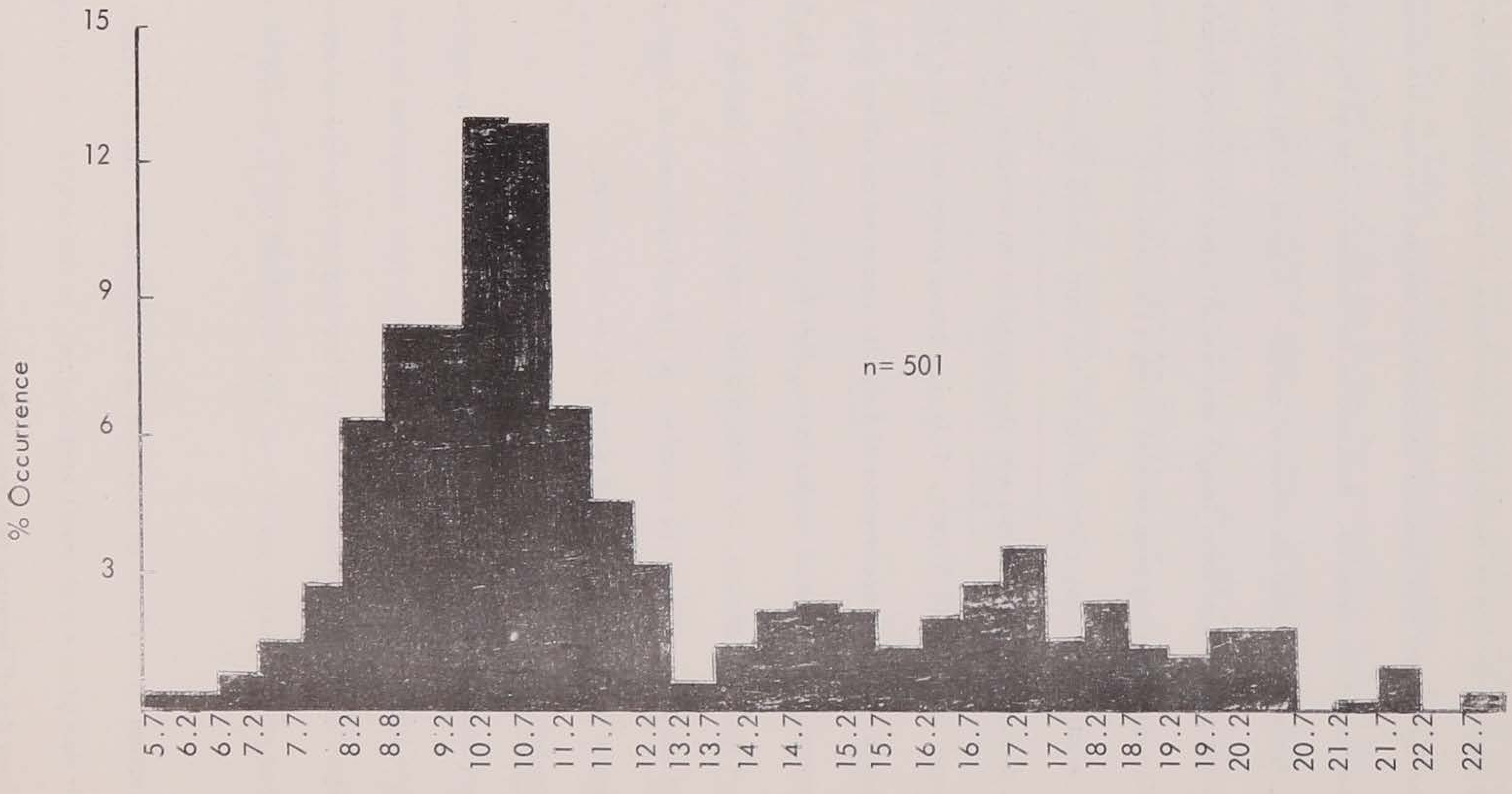

Figure 27. Total length-frequency distribution of carp. Length represents class mark of size interval.

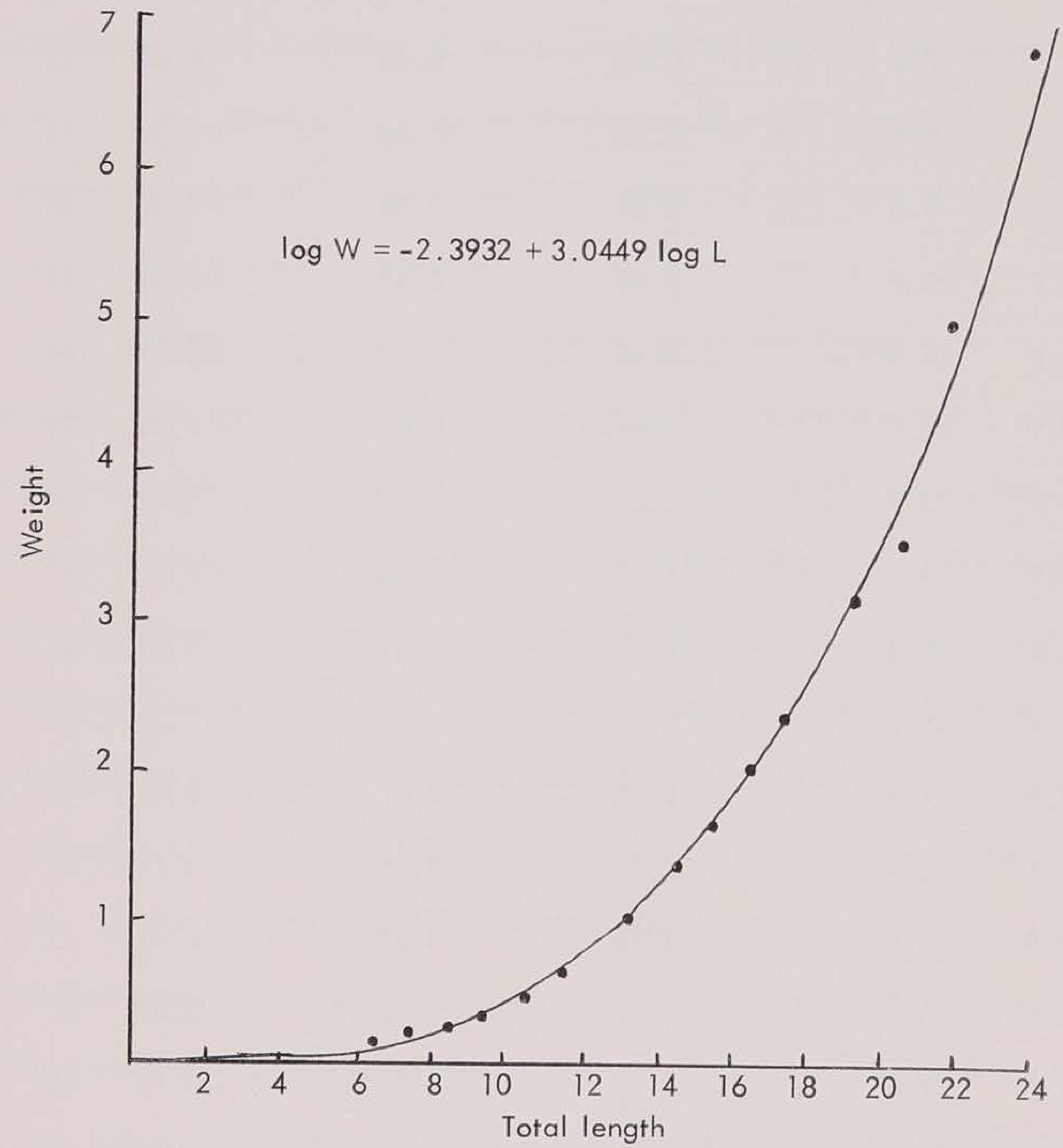

Figure 28. Total length-weight relationship of carp.

Table 18. Observed and calculated weight of carp

Size group	Total Length	Observed weight	Calculated weight	Deviation	C	N
6.0-6.9	6.5	0.15	0.12	- 0.03	56	6
7.0-7.9	7.4	0.20	0.18	- 0.02	52	21
8.0-8.9	8.4	0.25	0.26	+ 0.01	43	75
9.0-9.9	9.3	0.34	0.36	+ 0.02	43	108
10.0-10.9	10.4	0.49	0.55	+ 0.06	39	98
11.0-11.9	11.4	0.66	0.67	+ 0.01	44	40
12.0-12.9	12.1	0.82	0.81	- 0.01	45	10
13.0-13.9	13.9	1.02	1.09	+ 0.07	44	23
14.0-14.9	14.3	1.36	1.33	- 0.03	47	17
15.0-15.9	15.4	1.62	1.67	+ 0.05	46	24
16.0-16.9	16.3	2.05	1.98	- 0.07	47	26
17.0-17.9	17.4	2.35	2.42	+ 0.07	45	19
18.0-18.9	18.4	2.74	2.87	+ 0.13	45	15
19.0-19.9	19.2	3.16	3.27	+ 0.11	45	9
20.0-20.9	20.4	3.51	3.92	+ 0.41	47	6
21.0-21.9	21.8	5.00	4.81	- 0.19	48	2
23.0-23.9	23.8	6.81	6.23	- 0.58	51	2

size was small (6 or fewer observations) estimated regression residuals ranged up to a maximum of -0.58 lbs in the 23.0-23.9 inch group. A studentized test of the significants of the deviations in observed and calculated weight would have to exceed the 0.900 level of sampling probability before significant values would be expected.

Coefficients of body conditions, C, were computed for each size interval by using the reciprocal of length. Mean C factor for the sample was 46 with a range of 39 to 56. There was a tendency for values of C to be higher at the upper and lower ends of the sample. Most of this was attributed to small sample size.

Average Length and Length Distribution by Age Group

Age group I fish were most numerous in the sample with an average of 7.1 inches at capture and ranged from 5.8 to 10.9 inches (Figure 29). Carp were also collected in late autumn and almost one years growth occurred from the formation of the last annulus. As a result body length at capture was somewhat greater than calculated length for the same age group. Age II fish has a mean observed length of 10.3 inches and a range of 8.3 to 14.6 inches. Average observed length for age III was 14.2 inches with a range of 12.0 to 17.0 inches. Mean length for the following age groups was 17.1 inches at age IV, 19.8 inches at age V and 21.7 inches at age VII. No fish were captured from age group VI.

Empirical growth of carp in the Chariton River showed two general characteristics. First, as age increased the range in the distribution of length decreased. Length of age group II fish ranged from 8.3 to 14.6 inches. In comparison age V fish varied a maximum of 1.6 inches from 19.0 to 20.6 inches. Second, imbrication of empirical length in subsequent age groups was a common occurrence. Age I and II fish had common body lengths from 8.3 to 10.9 inches. Total length from carp in age groups II and III overlapped by 2.6 inches. However, as age increased the amount of imbrication became progressively less until age V overlapped lengths

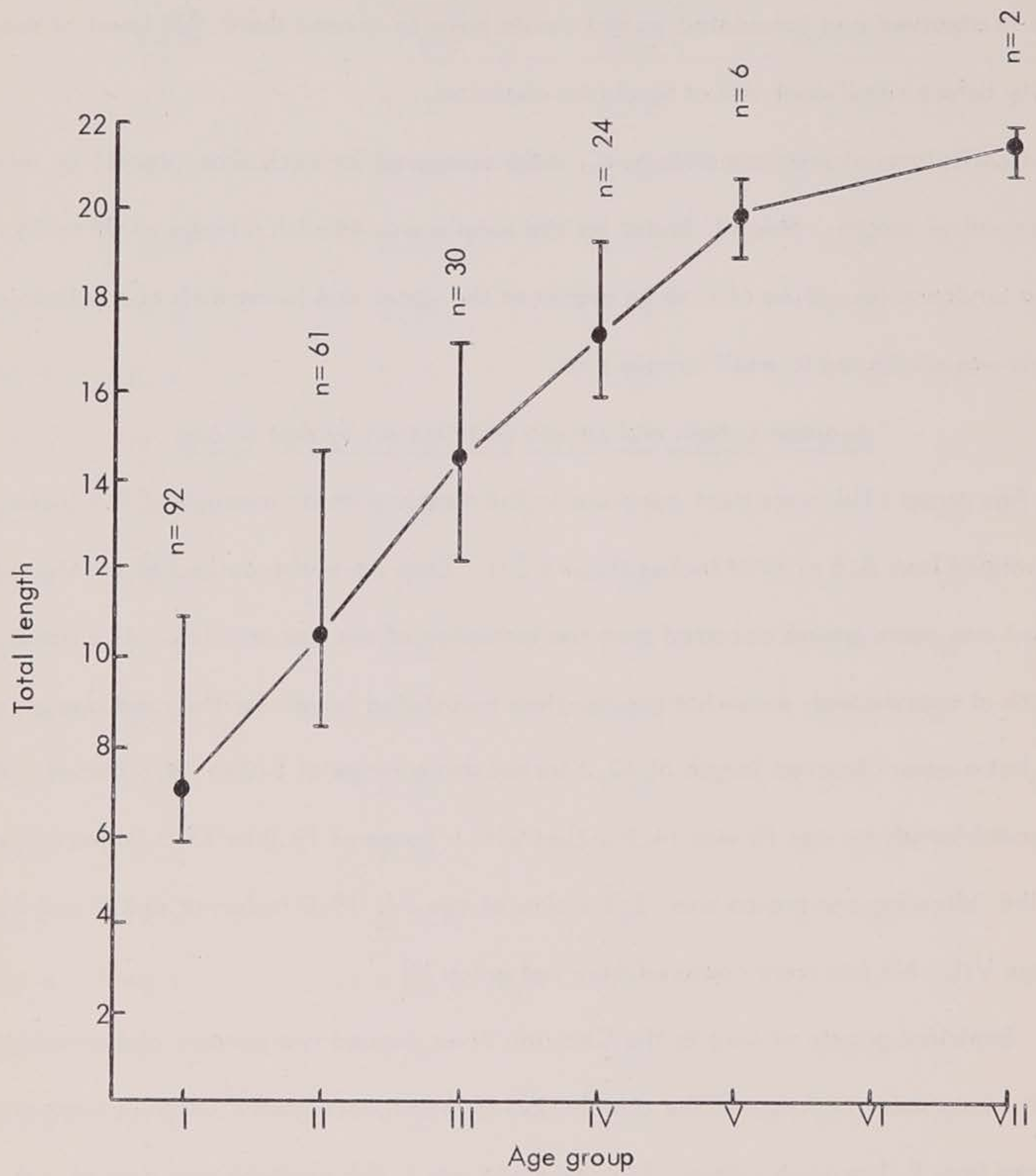

Figure 29. Mean observed length at each age group for carp. Brackets represent the maximum and minimum length within each age group.

in age IV by 0.5 inch.

Calculated Growth in Length

The body-scale regression for computation of body length at each annulus was based on 215 specimens ranging in length from 5.5 to 21.8 inches. Mean total length of fish at 2-inch intervals was plotted against the corresponding average scale radius (X 17). Visual inspection of this plot indicated this relationship was linear and could be estimated with a least squares regression (Figure 30). An adequate fit with a straight line was fitted to these data by the equation $L = 0.26 + 2.51 R$, where L = total length and R = scale radius. This regression yielded a highly significant product moment correlation coefficient ($r = 0.991$).

Back calculation of body length at the formation of each annulus was computed by using a direct proportion nomograph. The intercept used in this device (R=0) was 0.26 inches.

Estimates of general calculated growth was based on grand averages of calculated length and successive summation of growth increments (Table 19). Total length computed by the first method was consistently greater at the end of each year of life than the sum of increments. Differences between the two methods ranged from 0.0 inch in the first year of life to 0.6 inch at the sixth annulus. Much of the difference in the later years of life is probably the result of irregularities from successive elimination of age groups by the grand averages.

Growth was greatest in the first year of life and declined systematically with each successive year. Estimated total length of carp for the first seven annuli by summation of annual growth increments was 5.4, 9.4, 12.5, 14.7, 16.9, 18.9 and 19.9 inches respectively.

Comparison of carp growth in the Chariton River with other studies in Iowa waters revealed it was between extreme ranges. Rehder (1959), using scale methods for ageing fish, reported much faster growth in the upper Des Moines River, Boone County, Iowa. However, when he used opercle ageing methods calculated growth was quite similar to the present study. Mayhew and Mitzner (1967) found carp growth rates similar in the lower Des Moines River and Coralville

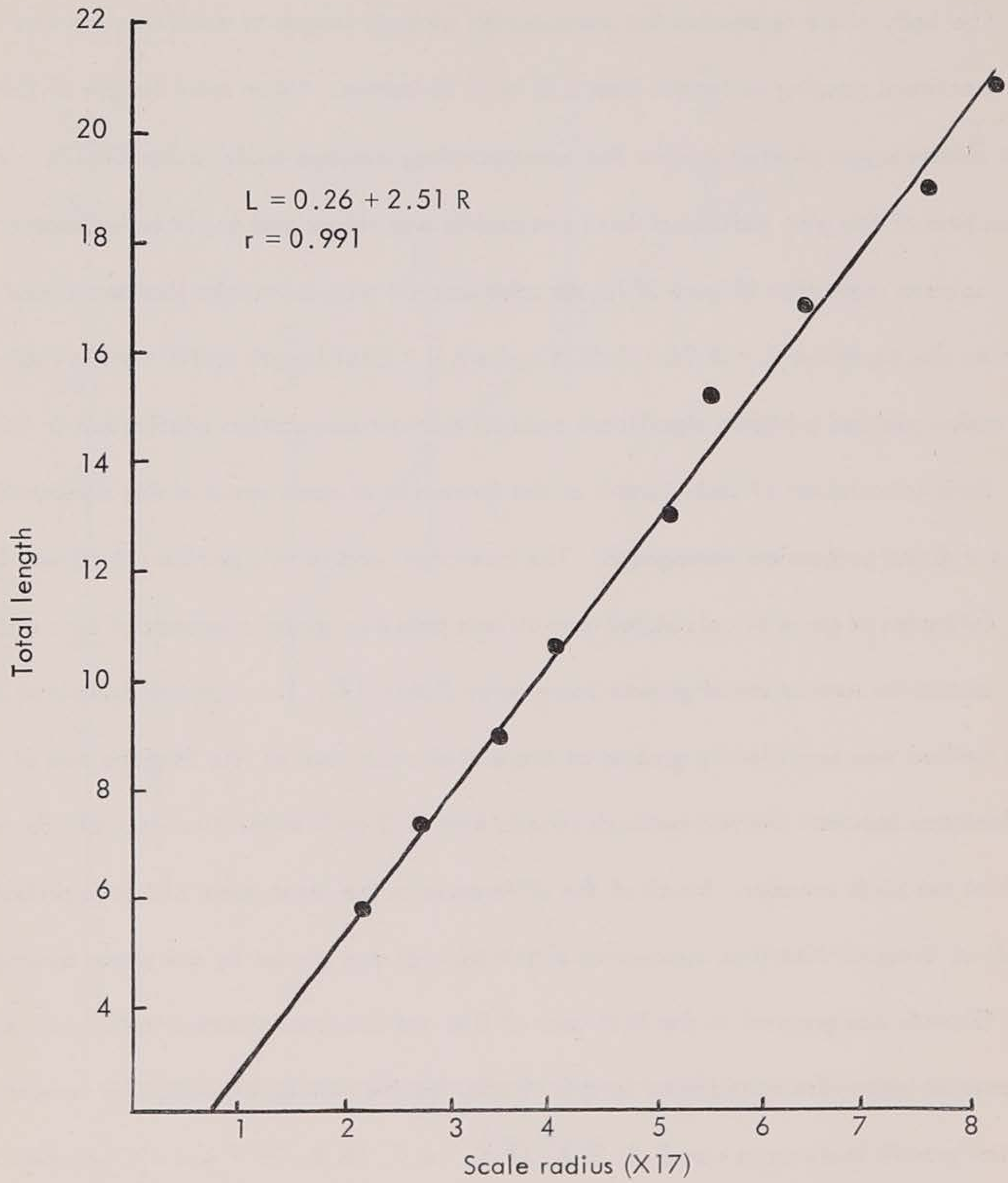

Figure 30. Body-scale relationship of carp in the Chariton River.

Table 19. Calculated total length and increments of length for carp

Year Class	N	Age group	Growth: Year of life 1	2	3	4	5	6	7
1965	92	I	5.5						
1964	61	II	5.1	8.6					
1963	30	III	5.6	9.4	12.3				
1962	24	IV	5.4	9.7	13.1	15.4			
1961	6	V	5.8	10.7	13.6	15.7	17.6		
1959	2	VII	5.2	9.0	12.4	14.5	17.1	19.1	20.1
Mean cal TL			5.4	9.5	12.9	15.2	17.4	19.1	20.1
Increments									
1965	92	I	5.5						
1964	61	II	5.1	3.5					
1963	30	III	5.6	3.5	2.9				
1962	24	IV	5.4	4.3	3.4	2.3			
1961	6	V	5.8	4.9	2.9	2.1	1.9		
1959	2	VII	5.2	3.8	3.4	2.1	2.6	2.0	1.0
Mean cal increment			5.4	4.0	3.1	2.2	2.2	2.0	1.0
Sum of increments			5.4	9.4	12.5	14.7	16.9	18.9	19.9
N in sample			215	123	62	32	8	8	2

Reservoir and their calculated length at each annulus was up to 2.3 inches greater at corresponding age groups for fish from age IV or younger. After this age calculated total length was quite similar regardless of location.

Calculated Growth in Weight

The calculated weight at the end of each year of life was determined by applying the length-weight regression coefficients to the estimated total length at each annulus in Table 19. Annual increments of calculated weight (Table 20) ranged from 0.02 lbs in the first year of life to 0.89 in the sixth year. Differences in empirical and predicted weight ranged from -0.05 lbs at age II to + 1.09 lbs at age VII. The latter is undoubtedly the results of only two observations.

Table 20. Calculated growth in weight of carp

Year of life	Observed weight	Calculated weight	Increment of weight
1	0.10	0.02	0.02
2	0.33	0.38	0.36
3	0.56	0.82	0.44
4	1.34	1.39	0.57
5	2.38	2.18	0.79
6	[1]	3.07	0.89
7	4.68	3.59	0.52

[1] Age VI fish not present in observed sample

Age and Growth of River Carpsucker

River carpsucker were generally distributed throughout the Chariton River Basin. Numerically, they comprised up to 20% of the fish population at individual primary sampling stations.

Overall, river carpsucker made up 7.6% of the population by number and 8.3% by weight, ranking fourth in abundance.

Scale samples for determination of age and growth of river, carpsucker were collected from all 116 fish captured by fish toxicant samples. An additional 127 measurements of total length and weight were obtained from fish during routine fish population inventories. Scale samples were processed identical to the methods used for carp.

A polymodal length-frequency distribution of river carpsucker at one-half inch total length intervals is exhibited in Figure 31. This distribution was based upon 127 individual length observations of river carpsucker ranging from 7.0 to 16.0 inches in body length. The most prominent mode, comprising 15.2% of the total sample, occurred at the 10.0-10.4 inch interval. The length interval preceeding this group also made up 13.6% of the total number of observations. Secondary modes in the distribution occurred at the 12.5-12.9 and 14.0-14.4 intervals. These groups made up 9.1% and 3.8% of the sample, respectively.

Length-Weight Relationship

The length-weight relationship for river carpsucker was calculated from a sample of 166 fish ranging in length from 7.2 to 16.0 inches. The sample was separated into one-half inch length groups and the mean length of each group plotted against mean weight. A straight line was fitted to these data by log-log transformation of the variables. This relationship can best be represented mathematically by the least squares equation $\log W = -2.2172 + 2.8813 \log L$, where L = total length and W = weight. In exponential form $W = aL^b$, where a and b are mathematically derived constants, this relationship assumes a curvilinear form (Figure 32). In general, all of the increases in weight for each size group follows an isometric relationship with linear dimensions of length.

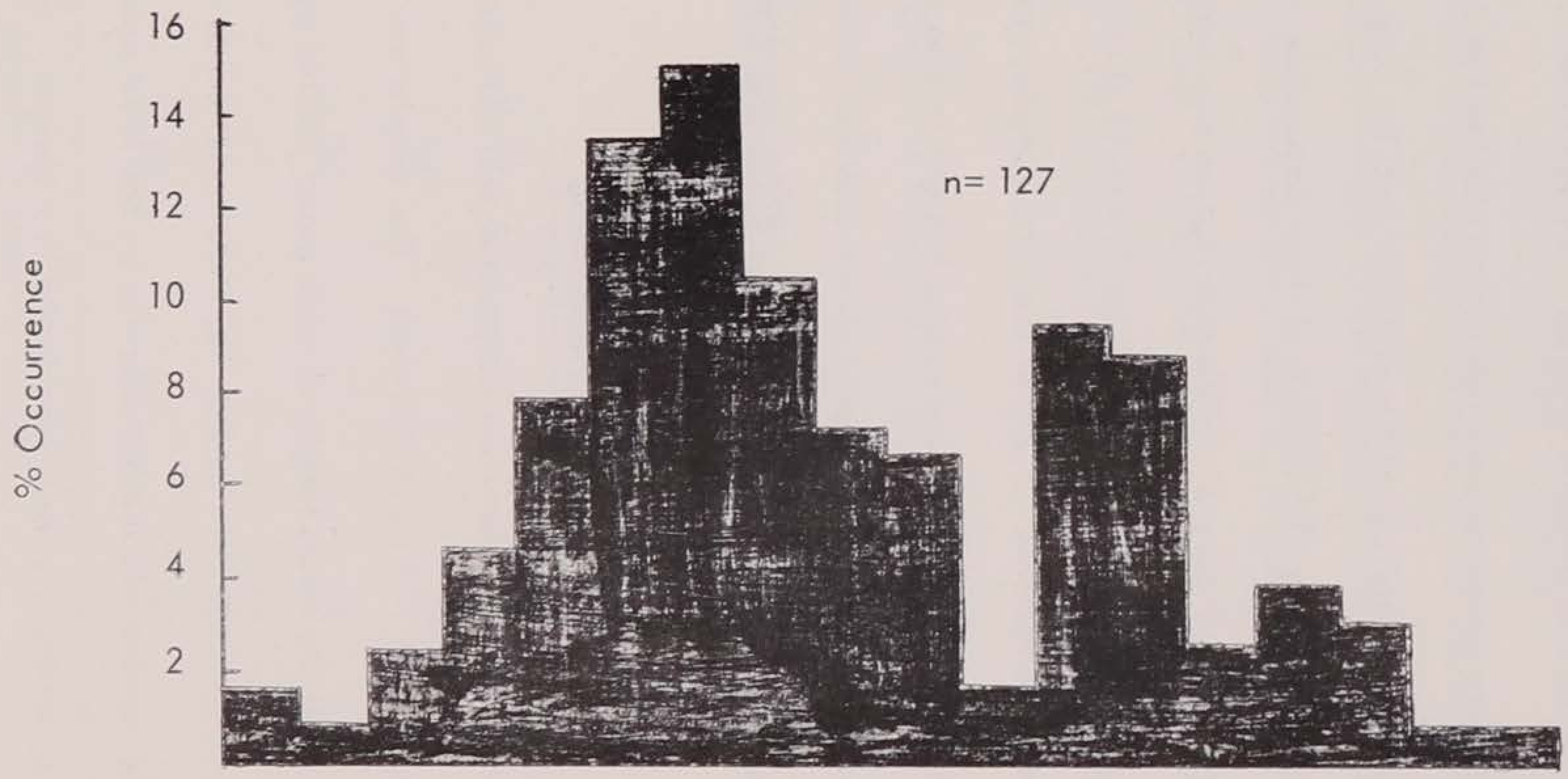

Figure 31. Total length-frequency distribution of river carpsucker in Chariton River. Length represents class mark of size interval.

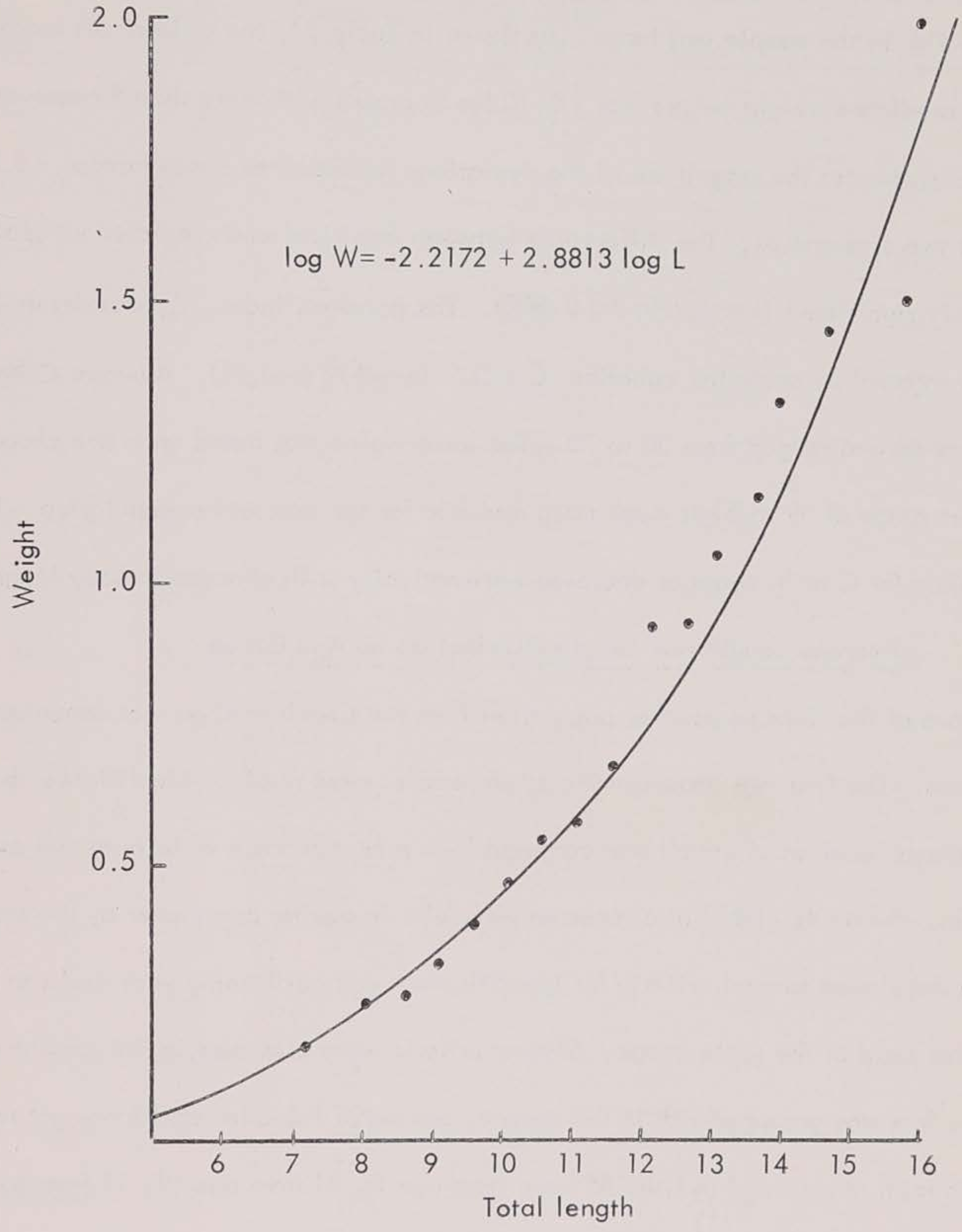

Figure 32. Total length-weight relationship of river carpsucker in the Chariton River.

Values of the residuals (W - W') from the length-weight equation were rather small when the number of fish in the sample was large. As shown in Table 21, the differences between observed and predicted weight values was $\pm$ 0.10 lbs in groups with more than 8 observations. Below this many samples the magnitude of the deviations increased to a maximum of + 0.22 lbs. in the largest two size groups. The differences between empirical and predicted weights was not statistically significant ($t = 0.270$; $P < 0.800$). The ponderal index, C, was determined for each size interval by using the equation $C = (1/\ \text{length})^3\ (\text{weight})$. Average C for river carpsucker was 46 and ranged from 30 to 70. The latter value was based upon one observation, and a C factor range of 39 to 51 is much more realistic for the carpsucker population. There was no tendency for C to increase or decrease systematically with changes in body length.

Average Length and Length Distribution by Age Group

The sample of the river carpsucker population from the Chariton River was comprised of four age groups. The first two annuli in the scale samples were readily identifiable, but after age II exact location of annuli was confused by a preponderance of false annuli and growth checks. Buchholz (1957) also reported difficulty in ageing carpsucker by the scale method. He developed several criteria for identification and positioning year marks in the postero-lateral field of the scale image. Similar criteria were also used in the present study, but with only four age groups of fish in the sample, ageing of fish over age II was not tedious.

From the total sample of 116 fish, 65 were from age II, 34 from age III, 11 from age I and 6 from age IV. Carpsucker were also sampled in late summer, so fish belonging to an age group would actually have attained almost one additional year's growth. Hence, considerable difference occurred between calculated length at the least annulus and the observed length at capture for fish belonging to the same age group.

Table 21. Observed and calculated weights of river carpsucker

Size group	Mean length	Observed weight	Calculated weight	Deviation	C	N
7.0-7.4	7.2	0.16	0.18	+ 0.02	45	3
7.5-7.9	7.8	0.37	0.23	- 0.14	70	1
8.0-8.4	8.1	0.24	0.25	+ 0.01	46	12
8.5-8.9	8.7	0.26	0.31	+ 0.05	41	22
9.0-9.4	9.1	0.31	0.35	+ 0.04	40	29
9.5-9.9	9.6	0.38	0.41	+ 0.03	39	15
10.0-10.4	10.1	0.47	0.48	- 0.01	43	33
10.5-10.9	10.6	0.54	0.55	+ 0.01	45	14
11.0-11.4	11.1	0.56	0.62	+ 0.06	40	16
11.5-11.9	11.6	0.66	0.71	+ 0.05	40	9
12.0-12.4	12.2	0.92	0.82	- 0.10	51	8
12.5-12.9	12.7	0.92	0.92		50	8
13.0-13.4	13.1	1.05	1.09	+ 0.04	47	10
13.5-13.9	13.7	1.14	1.14		44	9
14.0-14.4	14.0	1.32	1.22	- 0.10	49	7
14.5-14.9	14.7	1.43	1.40	- 0.03	45	6
15.5-15.9	15.8	1.50	1.72	+ 0.22	39	2
16.0-16.4	16.0	2.00	1.79	- 0.21	49	2

Average observed total length of age I fish was 8.6 inches and ranged from 7.3 to 9.3 inches (Figure 33). Age II fish had a mean length of 10.1 inches at capture and ranged from 7.3 to 11.8 inches. Age III fish averaged 13.0 inches and ranged from 11.0 to 14.8 inches. Mean total of age IV river carpsucker was 14.7 inches and ranged from 13.3 to 16.0 inches. There was close agreement between modes in the length-frequency distribution and observed modal lengths assigned to different age groups.

Overlapping of body length between different age groups was pronounced in river carpsuckers. Age I and II fish had common length measurements for 2.0 inches. Age II and III fish overlapped in body length by 4.5 inches. As age increased and sample size became smaller the magnitude of imbrication also decreased. Common body lengths did not exceed more than one subsequent age group. Starret (1948) and Behmer (1965) considered river carpsucker intermittent spawners with the main spawning period from May through July, but also observed spawning in August. Part of the large difference in body length within age groups might be attributal to the lengthy reproduction period, where fish hatched in May could easily attain lengths of 2.0 inches or more before later spawning commenced.

Calculated Growth in Length

An arithmetic plot of the two variables, scale radius (R) and total length (L) by 2- inch length intervals (Figure 34), was made to determine if scale growth and growth in body length were proportional. Visually this plot showed strong linear characteristics and a straight line was fitted to these data by the least squares method. Measurements of 116 fish were used to compute the equation $L = -0.35 + 3.47 R$,which satisfied mathematical description of this relationship. Product moment correlation of this regression was not high ($r = 0.809$), but remained slightly above the critical value for rejection of the null hypothesis at the 0.05 level.

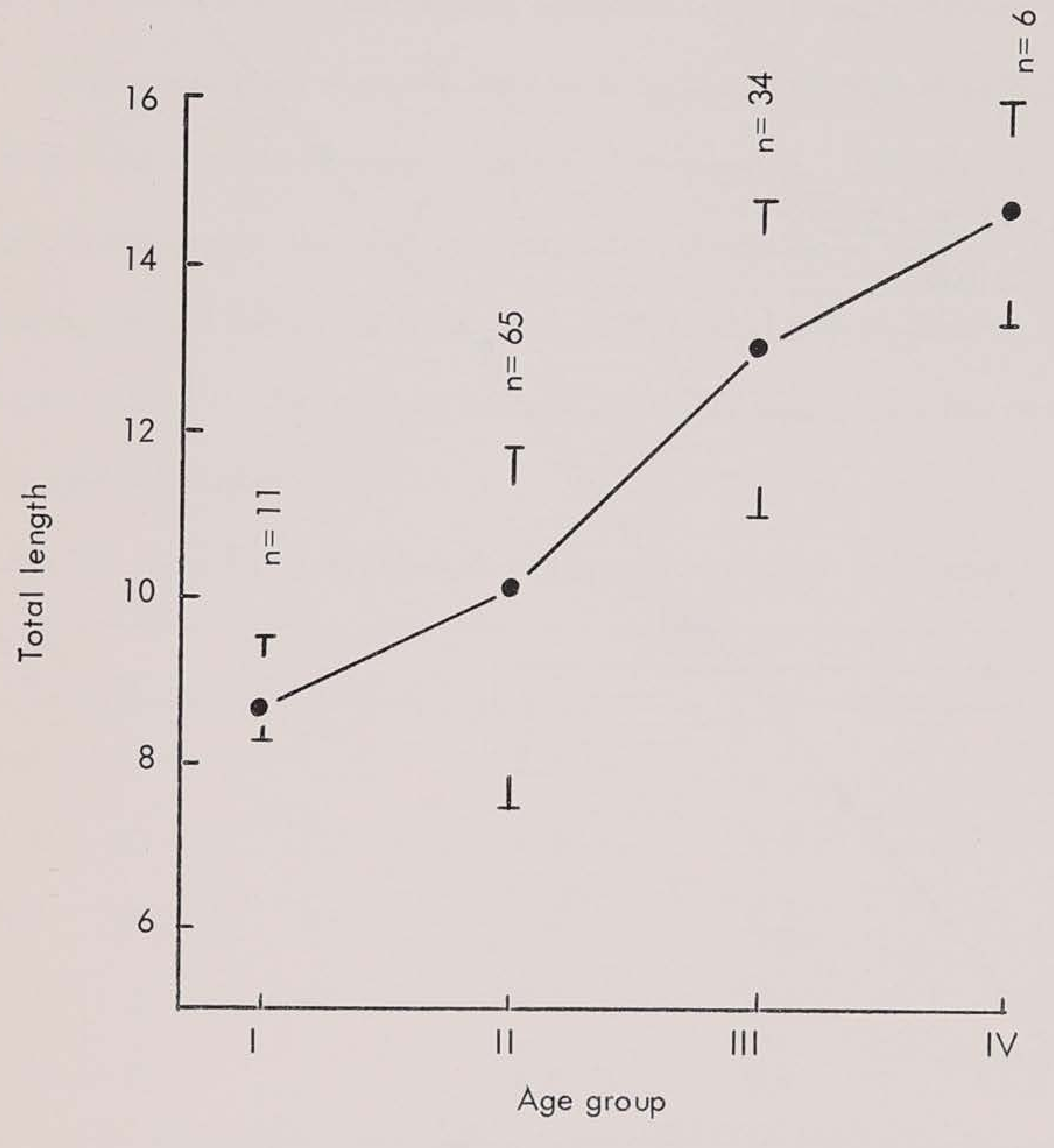

Figure 33. Mean observed length at each age group for river carpsucker in the Chariton River. Brackets represent the maximum and minimum of each age group.

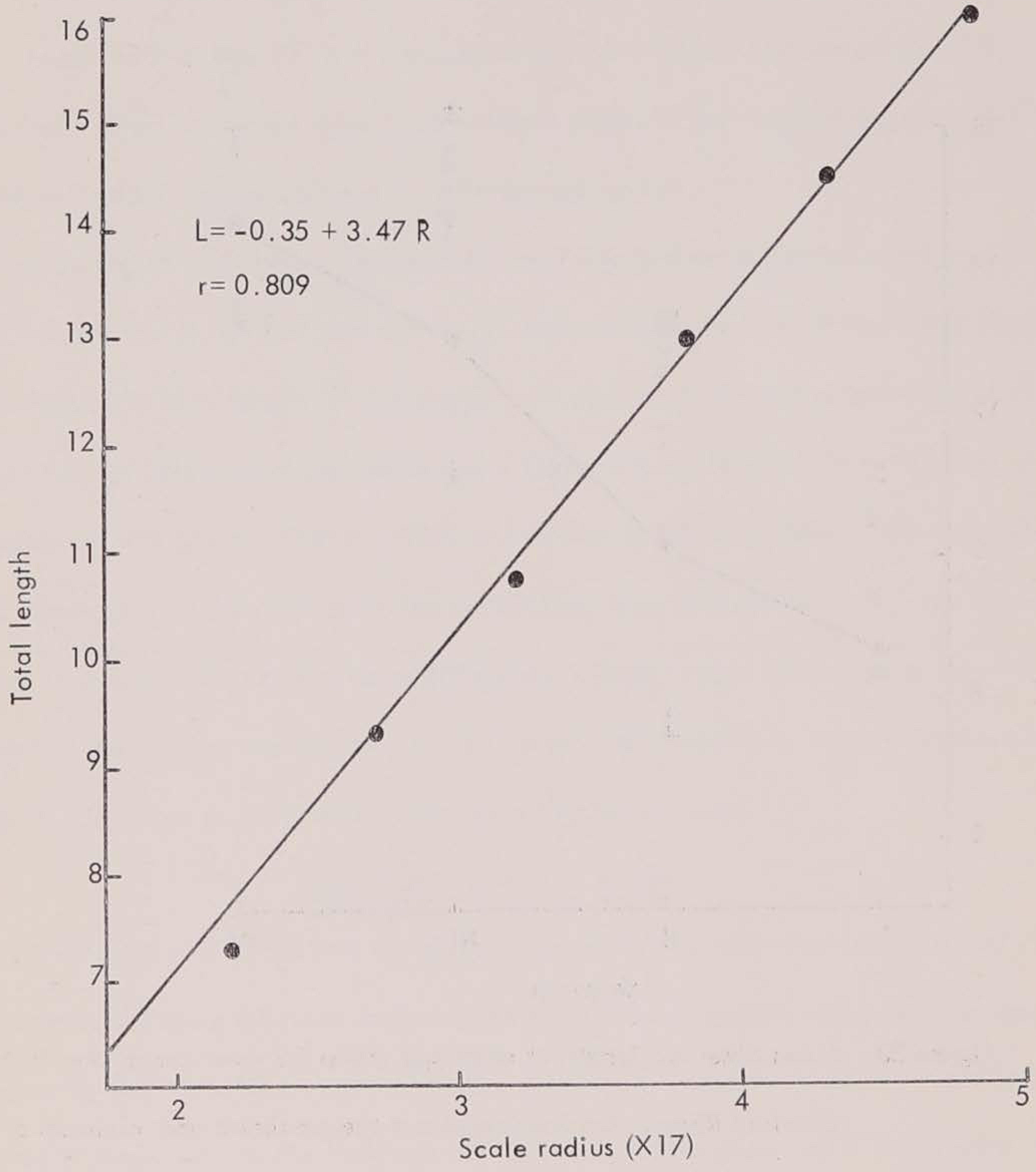

Figure 34. Body-scale relationship of river carpsucker in the Chariton River.

Back calculation of total length at each annulus was achieved by construction of a direct proportion nomograph to accomodate the body-scale regression. Body length values at each annulus were determined by shifting the center of the scale image to the computed intercept on L (TL = -0.13, R= 0) and reading estimated length directly from the nomograph.

Estimates of general growth were made by grand averages of calculated length at each annulus and successive summation of growth increments. Difference in length using both methods was small. The latter method, which is considered the most reliable estimate of growth, yielded calculated length of 4.6, 8.3, 11.1 and 13.3 inches for the first four years of life (Table 22). Growth was greatest in the first year of life and decreased systematically with each successive annulus.

Table 22. Calculated total length and growth increments for river carpsucker

Year class	N	Age group	Growth: Year of Life 1	2	3	4
1965	11	I	5.1			
1964	65	II	4.4	7.9		
1963	34	III	4.2	8.2	11.1	
1962	6	IV	4.7	8.1	10.8	13.0
Mean cal TL			4.6	8.1	11.0	13.0
Increment						
1965	11	I	5.1			
1964	65	II	4.4	3.5		
1963	34	III	4.2	4.0	2.9	
1962	6	IV	4.6	3.5	2.7	2.2
Mean cal increment			4.6	3.7	2.8	2.2
Sum of increments			4.6	8.3	11.1	13.3
N in sample			116	105	40	6

Comparison of growth of river carpsucker in the Chariton River with investigations in other Iowa waters revealed considerable differences. The calculated length attained at each annulus in a study of carpsucker age and growth by Buchholz (1957) in the upper Des Moines River, Boone County, Iowa was substantially less than the present study, particularly in the younger age groups. Growth in the lower Des Moines River and Coralville Reservoir (Mayhew and Mitzner, 1968) was also slower in the younger age groups, I and II, but at age III and IV exceeded total length in the Chariton River.

Calculated Growth in Weight

Estimated growth in weight at each annulus was computed by applying the length-weight regression coefficients to the mean calculated body length in Table 22. Predicted weight of river carpsucker at the formation of each annulus was 0.26, 0.61, 1.03 and 1.50 lbs, respectively (Table 23). Growth in weight became progressively greater with each successive annulus, reaching a maximum increment of 0.47 lbs at age IV.

Table 23. Calculated weight and weight increments for river carpsucker

Year of life	Observed weight	Calculated weight	Increment of weight
1	0.24	0.26	0.26
2	0.46	0.61	0.35
3	1.01	1.03	0.42
4	1.47	1.50	0.47

Age and Growth of Bigmouth Buffalo

Bigmouth buffalo was not prominent in fish population samples with the toxicant, but were common in routine fisheries surveys. Overall, they comprised 1.9% of the numerical sample and 3.3% of the population weight. They were found at all primary sampling stations and comprised up to a maximum of 8.2% of the sample by weight. Routine fishery surveys of the Chariton River produced a total sample of 121 fish. Scale samples were collected from 86 bigmouth buffalo and the remainder were measured for total length and weight.

Length-frequency distribution by one-half inch size groups revealed a typical polymodal structure (Figure 35). The highest mode occurred at the 9.5-9.9 inch interval and made up 11.5% of the sample. Other modes of importance were as follows: 10.0-10.4, 9.0%; 10.5-10.9, 9.0%; 12.5-12.9, 14.9%; 16.0-16.4, 4.1% and 21.5-21.9, 3.0%. Fish >17.0 inches made up less than 13 % of the total sample. Size intervals 16.5-16.9 and 21.0-21.4 inches were not represented in the distribution.

Length-Weight Relationship

The length-weight relationship for bigmouth buffalo in the Chariton River was determined by the method used for the other species of fish. The total sample of 121 fish was separated into 0.5 inch length intervals and the arithmetic mean of length and weight computed for each interval (Figure 36). A straight line was fitted to log-log transformed values of the two variable by the least squares method. The estimated length-weight wquation was $\log W = -2.3623 + 3.0779 \log L$, where W= weight and L= total length.

Differences in predicted and observed weight (Table 24) was small ($\pm$ 0.08 lbs) in groups of six or more observations. When sample size was small the residuals varied from -1.13 lbs to +0.73 lbs. There was no significant difference ($t = 0.230$; $P < 0.900$).

C factors, C, were computed for each size interval using the reciprocal of body length. Mean C was 54 with a range of 45 to 70. Variations in the value of C was randomly distributed throughout the sample with no inclination for C to change with increased length. Both the maximum and minimum of C occurred in size groups with one observation. A much more realistic range would be from 47 to 57.

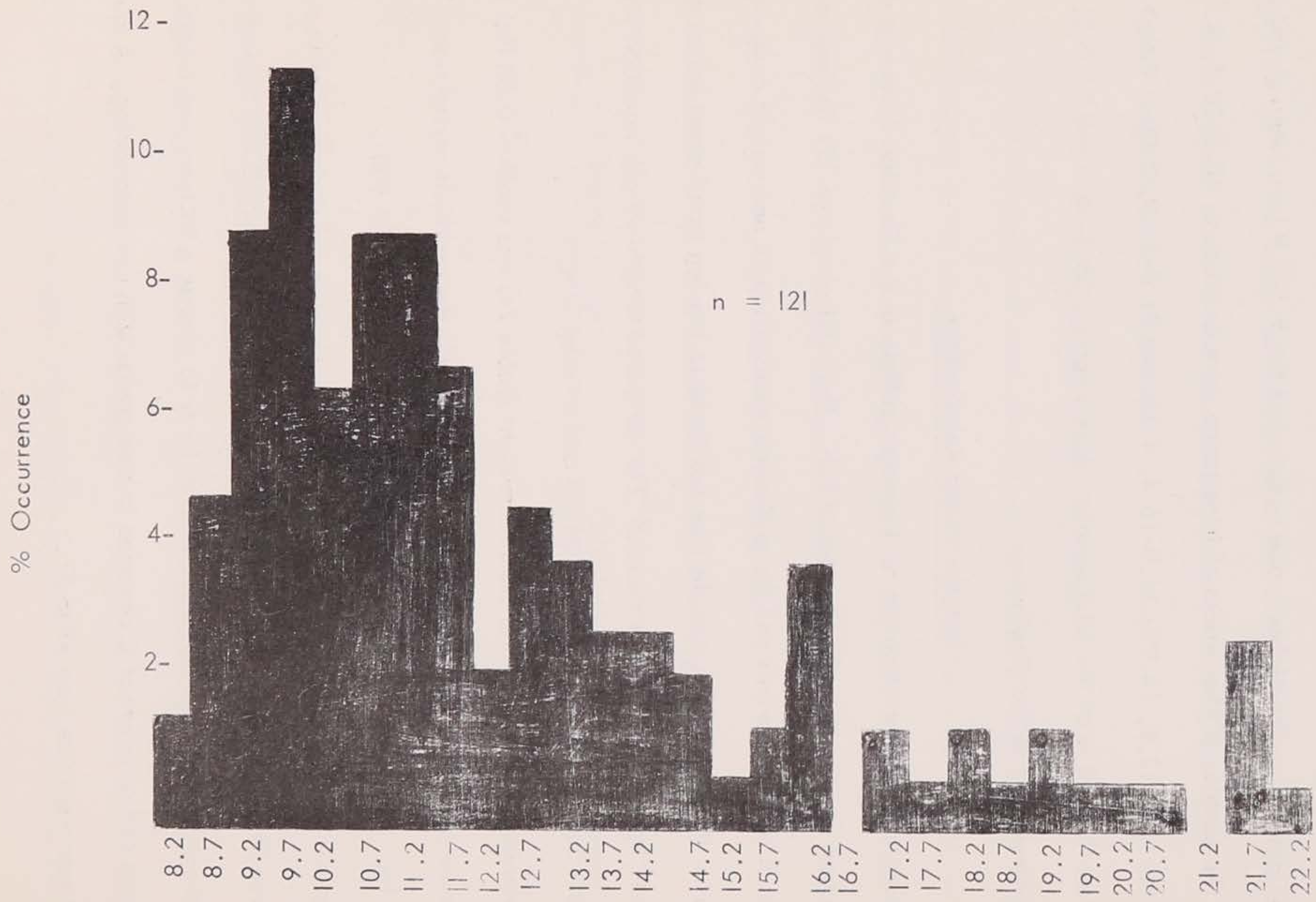

Figure 35. Length-frequency distribution of bigmouth buffalo in the Chariton River.

Length represents class mark of size intervals

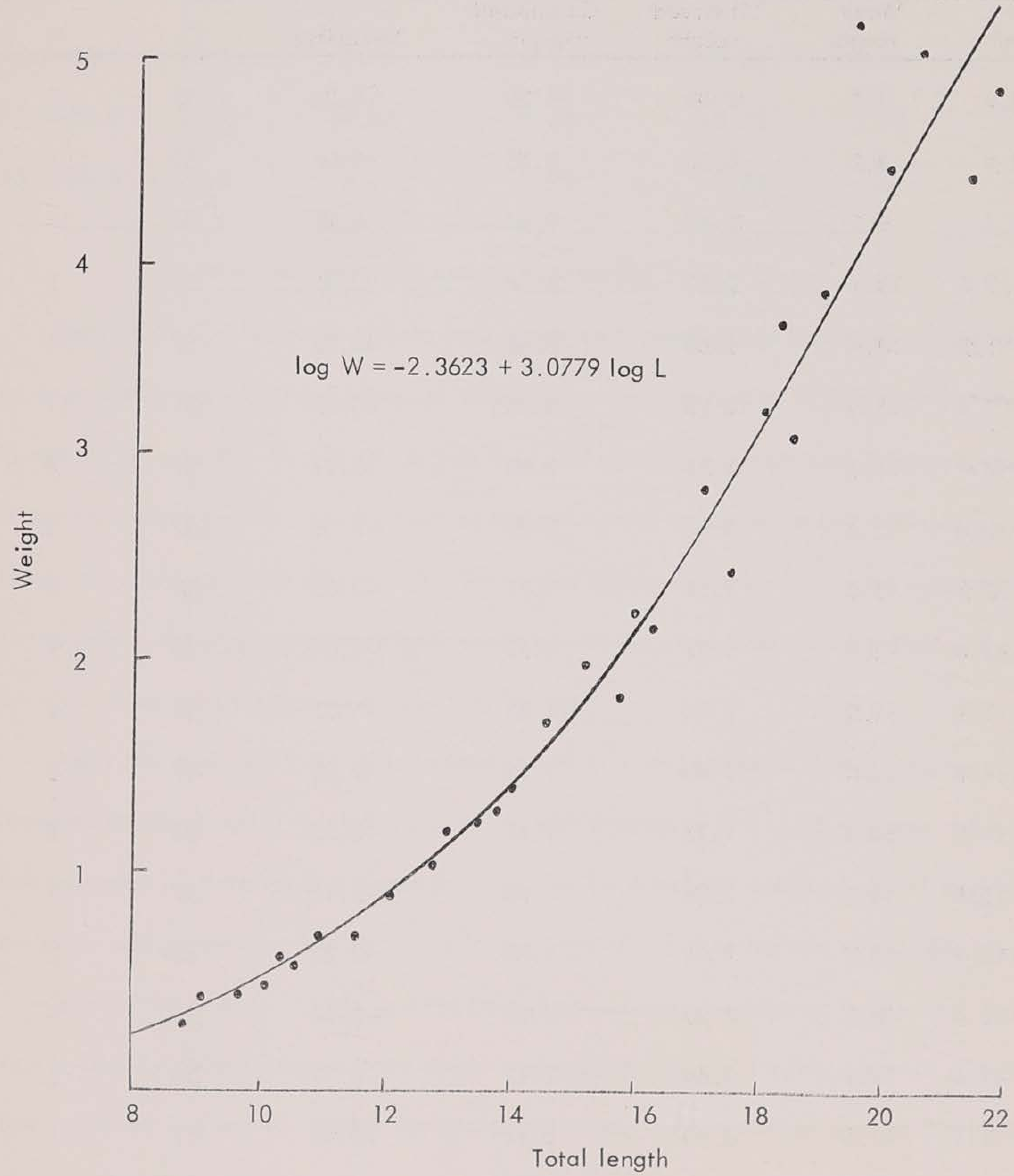

Figure 36. Total length-weight relationship of bigmouth buffalo in the Chariton River

Table 24. Observed and calculated weight of bigmouth buffalo

Size interval	Mean length	Observed weight	Calculated weight	Deviation	C	N
8.0-8.4	8.0	0.28	0.26	-0.02	55	2
8.5-8.9	8.8	0.34	0.35	+0.01	50	6
9.0-9.4	9.7	0.47	0.36	-0.05	52	11
10.0-10.4	10.1	0.52	0.54	+0.02	50	8
10.5-10.9	10.6	0.60	0.62	+0.02	50	11
11.0-11.4	11.0	0.75	0.70	-0.05	56	11
11.5-11.9	11.6	0.74	0.82	+0.08	47	9
12.0-12.4	12.2	0.95	0.92	-0.03	52	3
12.5-12.9	12.8	1.09	1.11	-0.02	52	6
13.0-13.4	13.0	1.19	1.15	-0.04	55	5
13.5-13.9	13.5	1.24	1.31	+0.07	57	4
14.0-14.4	14.0	1.43	1.46	+0.03	47	4
14.5-14.9	14.6	1.72	1.67	-0.05	55	3
15.0-15.4	15.2	2.00	1.88	-0.12	57	1
15.5-15.9	15.7	1.81	2.08	+0.23	45	2
16.0-16.4	16.0	2.25	2.21	-0.04	57	5
17.0-17.4	17.1	2.84	2.72	-0.12	50	2
17.5-17.9	17.5	2.44	2.91	+0.47	57	1
18.0-18.4	18.0	3.31	2.98	-0.33	50	1
18.5-18.9	18.5	3.19	3.47	+0.28	70	2
19.0-19.4	19.0	3.90	3.75	-0.15	56	1
19.5-19.9	19.5	5.19	4.38	-1.13	58	2

Table 24. Continued

20.0-29.4	20.0	4.50	4.38	-0.12	56	1
20.5-20.9	20.5	5.00	4.73	-0.27	48	1
21.5-21.9	21.7	4.89	5.64	+0.75	48	4
25.0-25.4	25.2	9.19	8.93	-0.26	57	1

Average Length and Length Distribution by Age Group

Each of the 139 bigmouth buffalo from which scale samples had been collected was assigned to an age group with Ages I through VI present. Age distribution of this sample was age I, 2; age II, 50; age III, 71; age IV, 6; age V, 7 and age VI, 3. A general description of empirical growth was obtained by plotting the mean total length at capture and the range in length for each age group (Figure 37). Samples of bigmouth buffalo were also obtained late in the season and almost one additional year's growth occurred from the formation of the last annulus. Most of the sample was age III or younger.

Age I fish averaged 8.6 inches in total length and ranged from 8.5 to 8.8 inches. Mean observed length of age II fish was 10.5 inches with a range of 8.8 to 12.8 inches. Age III fish averaged 13.3 inches and ranged from 11.2 to 14.8 inches. Mean empirical length of the other age groups was, age IV, 16.3 inches; age V, 18.3 inches and age VI, 21.3 inches.

Imbrication of body lengths in different age groups was also common in bigmouth buffalo. Age II and III fish had common body length measurements for 2.6 inches. Ages IV and V overlapped by 1.5 inches. Older age groups with small sample numbers did not overlap in observed length greatly.

Calculated Growth in Length

The body-scale relationship of the bigmouth buffalo sample was established by separating the two variables, total length and scale radius, into 2-inch length groups and plotting the

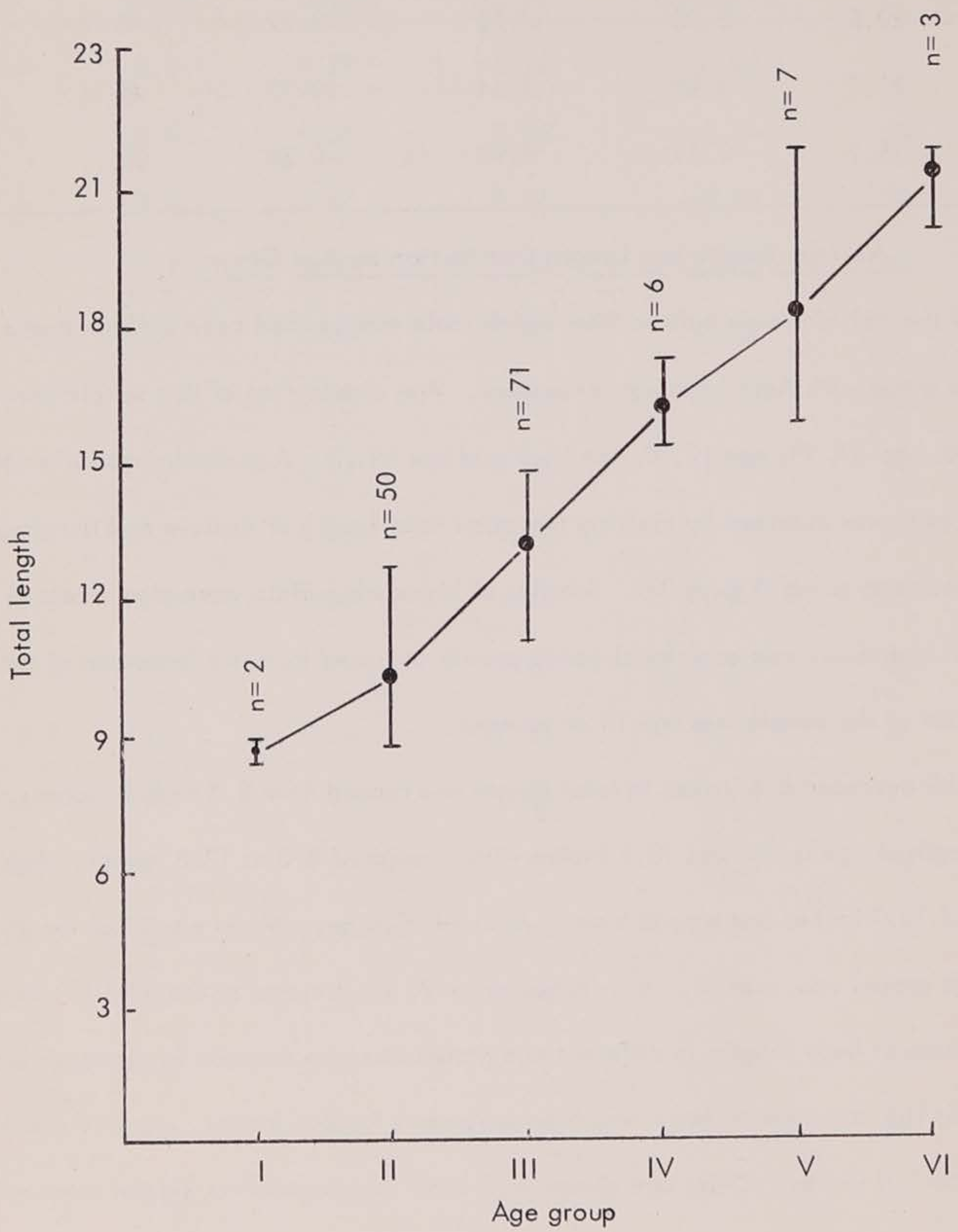

Figure 37. Mean observed length at each age group for bigmouth buffalo in the Chariton River. Brackets represent the maximum and minimum length within each age group.

arithmetic means of each interval in Figure 38. A straight line was fitted to these data by the least squares procedure. The resulting equation was L = 0.13 + 2.93 R, where L = length and R = scale radius (X17). Correlation was not high (r= 0.802) using these regression coefficients, but remained slightly above the critical value required for rejection of the null hypothesis at the 0.05 level, and the fit of this line was accepted.

Back calculation of total length at each annulus was accomplished by using a direct proportion nomograph. This devise was adjusted to accomodate the body-scale regression by shifting the center of the scale image to 0.13 inch in total length when R=0.

Estimates of general growth characteristics of bigmouth buffalo were made by grand averages of calculated total length and successive summation of growth increments. Both methods produced similar total length at the formation of each annulus which varied no more than ± 0.4 inch. The latter method showed total length at the end of each year of life was 6.5, 10.8, 14.2, 17.0, 19.0, and 20.1 inches for the first through the sixth year, respectively (Table 25). Growth was greatest (mean = 6.5 inches) in the first year of life and decreased gradually until the estimated increment for the sixth year was 1.8 inches.

Investigations of growth of bigmouth buffalo is rather scarce in the literature so comparison with other waters was limited. Schoppman (1943) reported growth rates of bigmouth buffalo in Tennessee far in excess of those in the Chariton River. Maximum difference in growth between the two regions was 6,8 inches at age I. Mayhew and Mitzner (1968) reported growth rate of bigmouth buffalo in Coralville Reservoir was about 20% greater in comparison to the Chariton River. Growth was slower in this study than any other reported.

<u>Calculated Growth in Weight</u>

Calculated growth of bigmouth buffalo in weight (Table 26) was computed by applying the length-weight regression coefficients to the sum of increments in Table 25. Mean

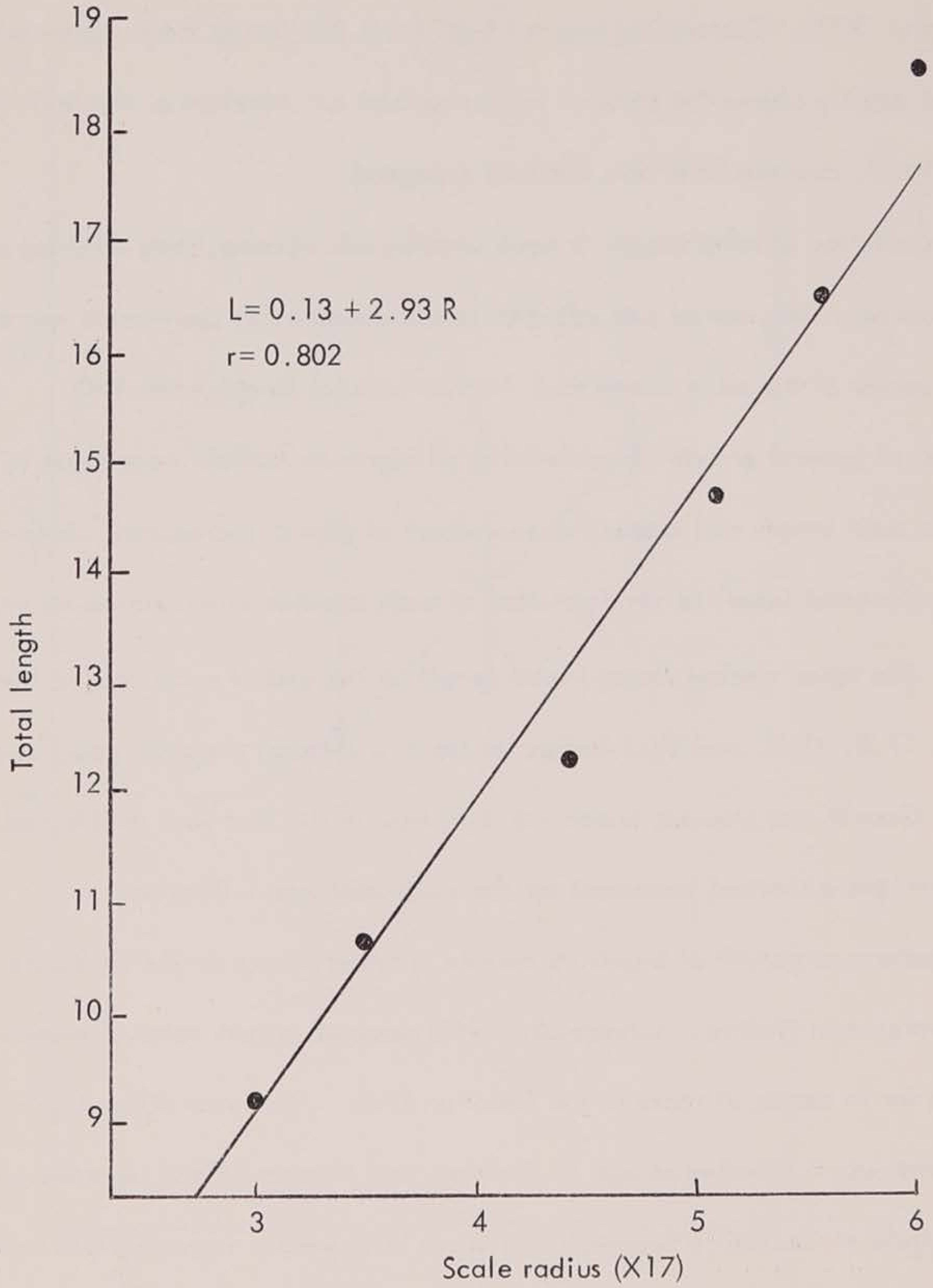

Figure 38. Body-scale relationship of bigmouth buffalo in the Chariton River.

Table 25. Calculated total length and increments of length for bigmouth buffalo

Year class	N	Growth group	Year of life 1	2	3	4	5	6
1965	2	I	8.6					
1964	50	II	6.3	10.5				
1963	17	III	5.4	10.2	13.3			
1962	6	IV	6.3	10.9	14.2	16.3		
1961	7	V	5.9	10.0	13.8	16.3	18.6	
1960	3	VI	6.6	10.6	14.0	17.7	19.5	21.3
Mean cal TL			6.5	10.4	13.8	16.8	19.1	21.3
Increment								
1965	2	I	8.6					
1964	50	II	6.3	4.2				
1963	17	III	5.4	4.8	3.1			
1962	6	IV	6.3	4.6	3.3	2.1		
1961	7	V	5.9	4.1	3.8	2.5	2.3	
1960	3	VI	6.6	4.0	3.4	3.7	1.8	1.8
Mean cal increment			6.5	4.3	3.4	2.8	2.1	1.8
Sum of increments			6.5	10.8	14.2	17.0	19.1	20.9
N in sample			85	83	33	16	10	3

calculated weight for the estimated length for age I through VI was 0.14, 0.66, 1.13, 2.66, 3.81 and 5.02 lbs. In general, weight increased progressively throughout the life of the fish.

Table 26. Calculated weight and weight increments for bigmouth buffalo

Year of life	Observed weight	Calculated weight	Increment of weight
1	0.35	0.14	0.14
2	0.63	0.66	0.52
3	1.29	1.13	0.47
4	2.17	2.66	1.53
5	3.74	3.80	1.15
6	4.50	5.02	1.21

Angler Harvest, Success and Use of the Chariton River

Information on the harvest of fish by anglers, fishing success and angler use of the Chariton River was compiled from conservation officer contacts and supplemental contacts of fishermen by persons assigned to the project. For several years, while this study was being conducted, conservation officers were requested to record information on the fishery during routine patrol. These instructions were for all waters of the state and it should not be misconstrued fishermen were contacted only on the Chariton River, rather the results of this census was from a wider program. Of most important interest was the number of hours fished, number of fishermen, and number and species of fish caught. Biology Section personnel assigned to the project were also instructed to contact all anglers they encountered while working on the river. Thus, all fishery statistics were collected incidental to primary duties with no effort to conduct a complete creel census for the river.

Conservation officers contacted 50 anglers in 1966 and 1967. These fishermen caught 202 fish after fishing 172 hours, for a catch rate of 1.2 fish/hr. Bullhead was the most important species making up 62.9% of the catch. Channel catfish comprised 35.6%; carp, 1% and gizzard shad, $<1\%$.

A total of 360 fishermen were contacted by project personnel in 1966 and 1967. These anglers fished 792 hours and caught 260 fish, for a catch rate of 0.3 fish/hr. Bullhead dominated the numerical catch making up 35.2% of the fishery. The catch of other species was carp, 20.5%; channel catfish, 20.5%; largemouth bass, 12%; common sucker, 6%; flathead catfish, 4%; and crappie, bluegill and sunfish comprising the remaining 1.8%.

The rather large disparity between the results of the two methods was the product of inconsistent contacts. All contacts made by conservation officers were completed in nine days of patrol. Each time fishermen were contacted by this method, fishing success was relatively high and was reflected in the 1.2 fish/hr catch rate. Biology Section contacts were made over a lengthy period of time when angling success varied widely. Many times no fishermen were observed on the river even though the work assignment, such as water sampling, required many miles of driving through the river basin. The only regions of angler concentration was immediately below the outlet channel of the Colyn Lakes and near sampling stations II and IV where there was easy access to large, deep pools.

SUMMARY

From the description of the Chariton River given by Seth E. Meeks during studies of fish distribution almost eight decades ago, it is apparent enormous changes have occurred in the river environment. Economic needs for the development of additional agricultural lands promoted vast rechannelization of the stream bed. By the early 1940's much of the original channel in Lucas, Wayne and Appanoose counties had been modified to facilitate rapid drainage of crop lands.

The Chariton River valley is rather wide, ranging up to a maximum of nearly three miles in the lower basin. However, the valley is almost straight, located in a northwest-southeasterly direction. Within this valley the original stream course meandered from bluff to bluff in a series of long, sweeping bends.

Large stands of dense, mature, mixed soft-hardwoods woodland covered much of the flood plain when Meeks conducted studies. Forest clearing and development of small grain croplands occurred with the advent of rechannelization in the upper basin. Much of the upper Chariton River and South Chariton River have cropland and pasture bordering the high, man-made channels. In the lower basin much of the forest still remains, forming a complete canopy over the stream. This factor had great influence upon water temperatures in summer months. Mean temperature at sampling stations with dense overhead protection was as much as 7° cooler than stations open to direct sunlight.

Erosion of soils has probably always been prevalent in the basin, even before man developed the land for agriculture. This fact is borne out by the vast deposits of allochthonous loessial soils found in the valley floor. The origin of these soils was from the surrounding terrain. Poor soil stabilization practises from farming in the lower basin accelerated erosion, and it has cut deeply into the face of the earth in this region.

Flow in the Chariton River was slow and sluggish due to the flat stream gradient. Large deposits of fallen trees, logs and other forest debris block the channel in many places further impeding flow. Another characteristics of the stream has undoubtedly always been extended periods of high turbidity. Large areas of colloidial type soils occur in the watershed which do not precipitate rapidly and generally compound the longevity of high turbidity.

Water quality in the Chariton River was rather high except for periodic heavy concentrations of sediment, natural organic debris and pollution of the upper basin from the Chariton Sewage Treatment Plant. This facility has a profound influence upon water chemistry extending from the outfall structure downstream for a distance of 12 miles. During periods of cold temperatures, especially in late autumn when atmospheric temperatures decline rapidly, the efficiency of treatment in the plant is lowered to the extent large quantities of partially treated industrial and municipal wastes enter the stream. BOD from this waste was sufficient to cause temporary severe depletion of DO below the TL_m of many species of fish. Additional quantities of nutrient material also entered the stream from application of inorganic fertilizers to surrounding croplands and were detected in water samples following rainfall.

Concentration of a chemical constituent in one portion of the river did not necessarily mean the level was the same in the entire basin. There are many factors that influenced water chemistry in one region which did not effect another region. DO, organic N, NH_3 and PO_4 were found at significantly different levels at the sampling stations on identical dates. pH also showed significant difference, but only on a seasonal basis. Concentrations of BOD, alkalinity, hardness and total solids were homogenous on identical sampling dates throughout the basin. Also, seasonal fluctuations of their concentrations were similar at each monthly interval.

The distribution of fishes in the Chariton River has changed greatly since Meeks' study. He found nine species that have apparently disappeared from the basin. Two new species, goldeye and freshwater drum, were added to the distribution list in this study. Several additional species found commonly by Meeks, such as silver chub, <u>Hybopsis storeriana</u>, and northern redhorse, <u>Moxostoma aureolum</u>, have declined in abundance until they are presently rarely captured. In general, Meeks found sunfishes, particularly largemouth bass, bluegill and green sunfish, rare in the river. Overflow stocking from farm ponds and recreational lakes has modified the distribution until these species are found commonly throughout the basin.

The fish population in the Chariton River was dominated by species statutorally classified as rough fish. Carp, buffalo, carpsucker, gizzard shad and sucker made up nearly 85% of the weight of samples. Individually, carp was the most prevalent species comprising over 50% of the population density by weight. Channel catfish and bullhead were the only game fish of importance.

Estimates of standing crop of fish in the river showed wide variation, depending upon the size of the stream, quality of the habitat and species composition. These estimates ranged from 413 to 2,100 lbs per mile of stream. Where game-fish were abundant, standing crop was lowest. Rough fish species contributed the greater proportion of standing crop in the samples that contained high population density. Overflow ponds in the flood plain had fish populations similar to the river except rough fish species were more important to the population structure. Standing crop of fish in bayous ranged up to nearly 1,000 lbs per surface acre.

Age and growth studies of the major species of fish in the river revealed about average growth rates in comparison to other Iowa streams. Age structure of channel catfish, carp, bigmouth buffalo and river carpsucker populations showed stable distribution. Only channel catfish and carp had missing year classes and these occurred in the older age groups. Fish populations were comprised mostly of younger age groups of fish.

Angler harvest of fish in the Chariton River was of minor importance. The stream is too small to attract fishermen from long distances. Consequently, fishing was of local interest and the origin of most anglers was within a few miles of the stream. Early in the summer most angling occurred in overflow ponds, later in the year the fishery was mostly in the river. Bullhead, channel catfish and carp were the most sought after and caught species of fish. The small size of the first species made its contribution to the overall fishery negligible.

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