THE DISTRIBUTION AND GROWTH OF THE FISH POPULATIONS ALONG THE WESTERN SHORE OF LAKE ERIE AT MONROE, MICHIGAN DURING 1970

Thesis for the Degree of M. S.

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BENJAMIN R. PARKHURST

1971

ABSTRACT

THE DISTRIBUTION AND GROWTH OF THE FISH POPULATIONS ALONG THE WESTERN SHORE OF LAKE ERIE AT MONROE, MICHIGAN DURING 1970

By

Benjamin R. Parkhurst

The fish populations along the western shore of Lake Erie at Monroe, Michigan were sampled from May, 1970 to November, 1970 to study the distribution of species, the growth rates of the more abundant species and the use of the area by young fish. This information will be used as a baseline in determining if any detrimental effects will occur from the forthcoming thermal discharge of a new steam electric plant being constructed on the lake shore.

Fish were collected by replicated trawling at two week intervals at five index stations and by seining along several shallow beach areas. Analysis of variance and Duncan's Multiple Range Test were used to analyze for differences in the species composition, numbers of species, numbers of individuals and the biomass of fish collected.

Significant differences were found between the stations and were related to the great extremes in the oxygen concentrations, to the relative protection from severe wave action and to differences in productivity at the stations.

Nine species comprised 97.5% of the numbers and 90.3% of the biomass of fish. These species could be divided into three categories on the basis of their habitat preferences: yellow

perch, white bass, emerald shiners, spottail shiners and alewifes were found in highest numbers in the open lake areas; carp, goldfish and sheepshead preferred areas sheltered from wave action; gizzard shad displayed the widest habitat preference being abundant at some time of the year in all the areas sampled.

Yellow perch growth in general was slightly less than that reported for other Great Lakes areas but this may be an artifact of the many different sampling methods used in other studies. The coefficient of condition (K) as calculated for the yellow perch followed a seasonal trend reaching a peak in August and then declining in the fall. This decline was caused by a continuation of growth in length after weight increases had ceased.

Age 0 carp exhibited abnormal growth, growing less in length during their first year of life than during their second. Carp growth in general was average when compared to other studies conducted in the northern United States.

The seasonal growth and abundance of young of the year indicated that this area was an important nursery for the young of five species.

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By

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A THESIS

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I wish to express my sincere thanks to Dr. Howard Johnson and Dr. Richard A. Cole for help in the initiation of this study and for their guidance in the development of results and preparation of this manuscript. Financial assistance from the Detroit Edison Company and the Institute of Water Research is most appreciated.

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INTRODUCTION

Lake Erie has gained the reputation of being a dead lake while continuing to maintain a high abundance of fish and other aquatic life. However, the increasing demand upon the use of Lake Erie water by industrial and dense urban centers poses a continuing threat to the quality of the lake and its ability to support a fishery. The near shore areas which are most accessible to sport and commercial fishermen are also those areas which are most threatened by the undesirable side effects of man's activities.

One of the major environmental concerns is the potential effects of thermal discharges from steam-electric stations. It is generally unknown if waste heat from these installations will cause significant changes in the aquatic environment of Lake Erie. The present study was undertaken to provide information specifically of value in determining the effects of a large fossil fuel power plant being constructed in Monroe, Michigan located on western Lake Erie at the mouth of the River Raisin. This study, completed before the plant began operating, will be followed by at least two years of study after operation begins.

The purpose of this study was to describe the general characteristics of the fish populations along the western shore of Lake Erie and to detect the more subtle variations in the distributions of species as they relate to some of the physical, chemical and biological characteristics of the lake. The specific parameters that were sampled included the numbers of species and individuals, the biomass of fish that inhabited the different sampling areas and how these factors changed with time. Yellow perch (*Perca flavescens*) and carp (*Cyprinus carpio*) because of their abundance were more intensively studied to provide information on growth rates, condition and year class strengths. The distribution, abundance and growth of juvenile fish were examined to determine the use of the area as a rearing ground.

DESCRIPTION OF THE STUDY AREA

The study area (Figure 1) included a variety of environmental conditions and a number of habitats that may potentially be affected by the heated effluents from the new Monroe power plant. The plant is being constructed immediately south of the mouth of the River Raisin at Monroe, Michigan. The plant will use river and lake water to cool its condensers and then release the heated effluent into a canal which empties into western Lake Erie 24 km south of the River Raisin's mouth.

The River Raisin has been reported to have a detrimental effect on this area (Carr and Hiltunen, 1965) because it carries municipal and industrial wastes into western Lake Erie. These wastes consist of effluents from several paper companies, an automobile manufacturing plant and a primary sewage treatment plant.

The chemical characteristics of the study area (Figure 2, Table 1) are typical of a lake undergoing rapid eutrophication. Beeton (1961) reported evidence of environmental changes in western Lake Erie that suggest accelerated eutrophication; *Hexagenia* sp. the dominant benthic organism have been replaced by chironomids and oligochaetes; during periods of thermal stratification severe oxygen depletions occur; and the concentrations of nitrogen and phosphorus have increased significantly. Drastic changes in the fish fauna have occurred but overfishing is thought to be at least partially responsible (Van Osten, 1948).

Figure 1. A map of the sampling area located along the near shore area of western Lake Erie at Monroe, Michigan. The locations of the power plant and five trawling stations are shown.

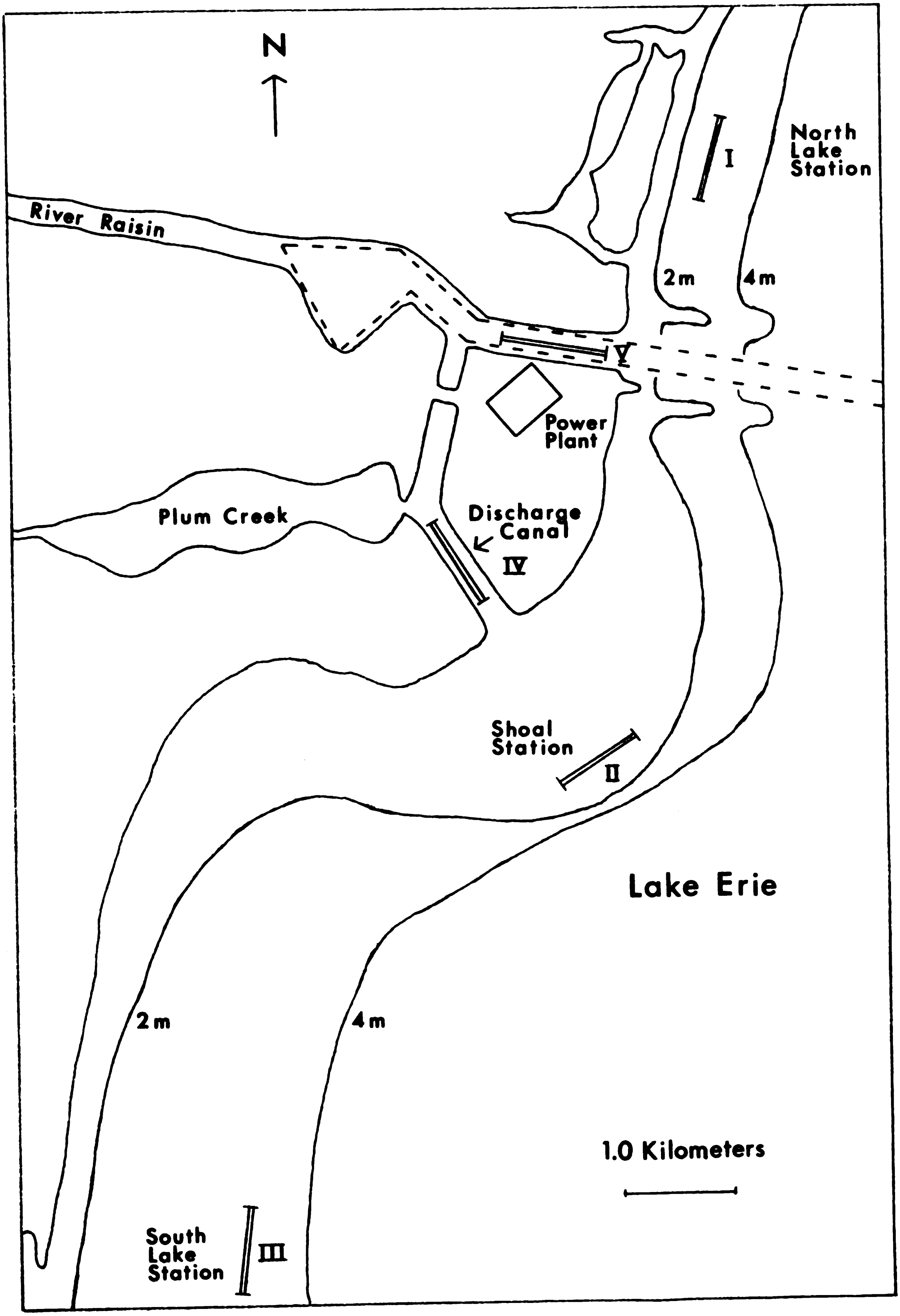

N
River Raisin
North
Lake
Station
I
2m
4m
V
Power
Plant
Plum Creek
Discharge
Canal
IV
Shoal
Station
II
Lake Erie
2m
4m
1.0 Kilometers
South
Lake
Station
III

Figure 2. The temperature and concentrations of oxygen in the River Raisin, discharge canal and near shore areas of western Lake Erie during 1970. Squares indicate temperature and circles indicate oxygen. Solid lines indicate surface values and broken lines indicate bottom values.

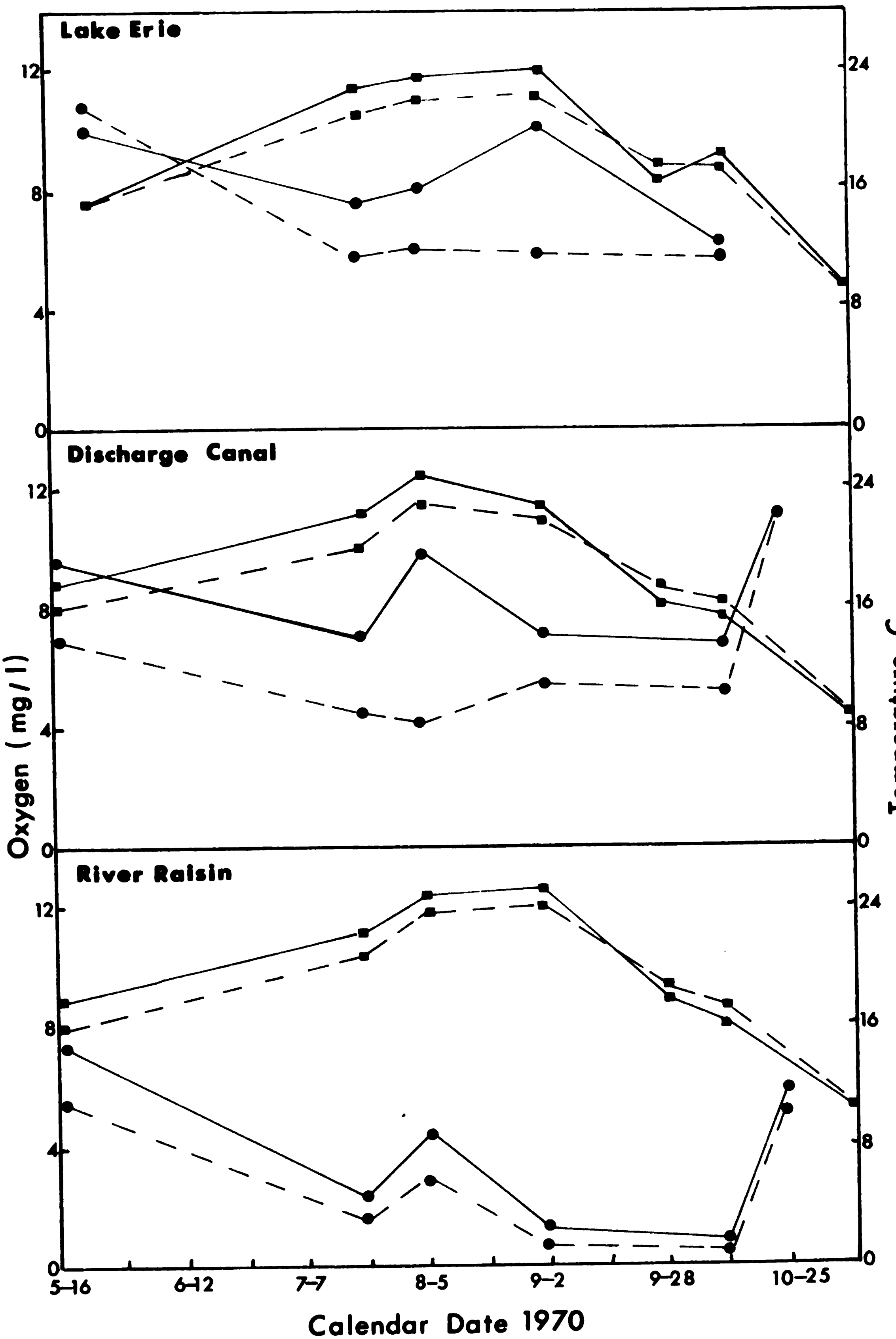

Lake Erie
Discharge Canal
River Raisin
Oxygen (mg / l)
Temperature C
12
8
4
0
24
16
8
0
5-16
6-12
7-7
8-5
9-2
9-28
10-25
Calendar Date 1970

Table 1. Concentrations (mg/l) of suspended solids, chloride, total organic carbon, total phosphorus, and total nitrogen in the near shore area of western Lake Erie, 1970.

	Suspended Solids		Total Chloride		Total Organic Carbon		Total Phosphorus		Total Nitrogen	
	Low	High	Low	High	Low	High	Low	High	Low	High
May										
River	26.0	52.0	27.3	30.6	38.0	52.0	.15	.25	1.0	1.7
Canal	52.0	94.0	22.0	34.0	37.0	94.0	.08	.16	.6	1.2
Lake	28.0	76.0	17.0	25.0	27.0	39.0	.05	.21	.1	1.2
June										
River	24.0	54.0	19.8	33.3	44.0	54.0	.11	.24	1.2	1.8
Canal	26.0	54.0	17.2	34.6	30.0	39.0	.09	.10	.9	1.8
Lake	22.0	42.0	18.0	21.5	25.0	32.0	.04	.09	.4	.8
July										
River	34.0	74.0	22.9	34.2	40.0	48.0	.22	.25	1.1	1.8
Canal	42.0	70.0	17.2	32.6	39.0	50.0	.12	.15	1.1	1.7
Lake	18.0	34.0	18.2	20.8	29.0	36.0	.06	.10	.4	.8
August										
River	52.0	80.0	34.1	37.6	40.0	47.0	.23	.30	1.0	1.3
Canal	46.0	62.0	29.4	33.9	38.0	44.0	.11	.14	1.0	1.5
Lake	26.0	34.0	26.5	31.4	23.0	26.0	.06	.14	.6	.7
September										
River	32.0	56.0	30.1	41.0	40.0	53.0	.29	.36	.8	1.5
Canal	18.0	46.0	27.1	30.8	38.0	50.0	.07	.23	.5	1.3
Lake	16.0	34.0	20.5	26.7	22.0	31.0	.05	.14	.3	.6
October										
River	32.0	40.0	24.1	41.0	41.0	56.0	.19	.30	1.0	1.5
Canal	16.0	28.0	17.5	29.8	42.0	47.0	.07	.14	.9	1.6
Lake	14.0	28.0	16.4	21.2	30.0	38.0	.06	.15	.3	.8
November										
River	26.0	36.0	27.1	31.9	17.0	56.0	.25	.35	1.0	1.5
Canal	24.0	42.0	15.4	24.5	40.0	49.0	.06	.11	.7	1.2
Lake	8.0	14.0	21.6	43.8	29.0	37.0	.08	.27	.4	.1

The study area included the off shore area of Lake Erie that extends 5 km north and 6.5 km south of the power plant discharge canal. Also included was the recently excavated discharge canal plus the last 1 km of the River Raisin. The lake bottom has a gentle slope to a miximum depth of 7 m in the study area. The River Raisin and the discharge canal are steep sided ditches maintained by periodic dredging. Maximum depth in both is 8 m. Dredging of the discharge canal was completed in July, 1970. The dredging resulted in highly turbid water in the canal and neareby areas of the lake until after its completion. Western Lake Erie is normally quite turbid because this shallow basin (maximum depth about 12 m) is continuously roiled by wind and high concentrations of plankton occur during the growing season. The prevailing winds are from the west though easterly winds are not uncommon in the spring and fall. Turbidity and wave action probably inhibit the growth of macrophytes which occurred only in shallows along the shore that were protected from rough water.

Commercial fishing was once very intensive in this area. The elimination of the high value species such as the cisco (*Coregonus artedii*) and whitefish (*Coregonus clupeaformis*), the decline of the walleye (*Stizostedion vitreum*) plus the recent discovery of high levels of mercury in Lake Erie fish had all but eliminated commercial fishing in this area by the summer of 1970. Sport fishing primarily for yellow perch and carp occurs in the study area, though the number of fishermen encountered throughout the sampling period was small.

Trawling was used as the primary method for monitoring the fish populations. Five stations were selected, each to include different environmental conditions in the area, both in relationship to the lake and to the forthcoming thermal discharge from the power plant.

Station I (north lake station) was located 2 km north of the discharge canal, and 100 m off Sterling State Park. The water depth ranged from 2 to 3 m over a muck and sand bottom. The bottom had a gentle slope with a slight dropoff 50 m from shore. The station was affected only by winds out of the east to northeast which could cause the area to become quite rough and roiled.

Station II (shoal station) was located 1.6 km out on the large sandy shoal which extended into the lake off of the power plant. Water depth was 1.5 to 2 m over a sandy bottom which had very little slope. This area was easily roiled by winds from the north, east and south quadrants. As a result, the sandy bottom was almost continuously disturbed.

Station IV (discharge canal station) was located in the last kilometer of the power plant discharge canal. The water depth ranged from 3 to 8 m over a peaty-muck bottom. A small stream (Plum Creek) entered the canal midway on its western side. Even though the canal was completely protected from rough wave action, the turbidity of the canal was as great as in the lake proper. This was caused by frequent fluctuations in the lake level (seiches) which results in lake water moving in and out of the canal. Erosion from the recent construction of the canal also contributed to the turbidity. The discharge canal will empty into the sandy shoal where station II was located.

Station III (south lake station) was located 6 km south of the discharge canal, 1.6 km off shore. The water depth ranged from 2 to 4 m over a muck bottom with a gentle slope. Due to its proximity to the south shore of the lake, this area was only subject to rough wave action when winds were out of the east. The south lake station is expected to be virtually unaffected by the thermal discharge and will thus serve as a control station in the subsequent years of sampling.

Station V (River Raisin station) was located in the last 1 km of the River Raisin. The water depth ranged from 6 to 8 m over a bottom composed of a pudding-like mixture of paper fiber and fine sediment. The river in addition to its heavy load of pollutants was markedly different from the other stations in that it was subject to severe oxygen depletion during the warmer months (Figure 2). At that time of the year, hydrogen sulfide gas continuously bubbles to the surface. Rafts of paper mill wastes drift down the river, break up and settle to the bottom. The river also differed from the other areas in the higher concentrations of organic carbon, nitrogen, phosphorus and suspended solids.

METHODS AND MATERIALS

To provide an index of change in the fish populations throughout the year, the trawling stations were sampled from May, 1970 to November, 1970 at two week intervals. Two hauls were made at each station on each sampling date to provide information on the variability of the trawl hauls. It was established through trial runs that a five minute haul at 1500 rpm provided an adequate sample. Longer hauls would at times completely fill the cod end thus allowing many fish to escape through the wings. The gear was a 5 meter otter trawl with 2.5 cm stretch mesh netting in the wings and 6 mm stretch mesh netting in the cod end. During a 5 minute tow the trawl moved over an area of bottom 5 m wide and approximately 1 km in length, or about 0.5 hectare. An unknown portion of the fish present were captured in the trawl, but in these shallow waters it was assumed that most fish remain near the bottom and were susceptible to the sampling technique.

In addition to the trawl, a 30 m seine with 1 inch (2.5 cm) stretch mesh was used to collect additional fish from the shallow areas of the lake between the mouth of the discharge canal and the mouth of the river. Data collected by seining was primarily used in the age and growth studies.

When samples were brought aboard the vessel the larger (greater than 1 kg) carp and goldfish (*Crassius auratus*) were immediately processed. All other fish were preserved for later analysis. No effort was made to distinguish between preserved and unpreserved samples in the analysis. All fish were measured and weighed and in addition scale samples were taken from carp and yellow perch. During the first four months of the study all the perch and carp captured were tagged with dart tags and released in an attempt to study the movement of these species. Tagged fish were never recovered and the perch and carp caught in subsequent sample periods were sexed.

Impressions of the scale samples were made on cellulose acetate (Smith, 1954) and age and growth were determined by measuring the distance from the origin of the scale to each annulus and to the margin. Annulus formation was assumed to occur on January 1 with all fish collected after January 1 and before the time of actual annulus formation being credited with an annulus. Length frequencies checked by random scale samples were used to determine the age and numbers of young of the year for species other than perch and carp.

The length-weight relationships, body-scale relationships, calculated lengths and calculated weights for perch and carp were determined using a computer program designed by Hogman, (1970). The program computed back-calculated lengths to each annulus using the Lee-Lea method:

$$L_1 = a + S_1/5 \ (L-a)$$

where L_1 is the total length of the fish at the time of annulus formation; a is the y intercept of the body-scale relationship; S_1 is the length of the scale radius at each annulus; S is the length of the fish at capture. Calculated weights at each annulus were computed by fitting the calculated lengths at each annulus to the length-weight relationship.

The coefficient of condition (K), an index of the relative "plumpness" of a fish, was computed for the perch and carp according to the relationship:

$$K = \frac{W \times 10^5}{L^3}$$

where W is the weight in grams and L is the total length at capture (Carlander, 1969).

Analysis of variance using a randomized block design was used to test for differences in numbers of fish and biomass of fish caught at the different trawling stations. Tests were run on each of the nine most abundant species and also on the total number of species caught, the total numbers of individuals of all species caught, and the total biomass of fish of all species caught. Duncan's Multiple Range Test (Steel and Torrie, 1960) was used to test for specific differences when significance was found with the analysis of variance. To meet certain of the assumptions of analysis of variance the data were transformed. The numbers of fish and numbers of species data were transformed using square roots while biomass data were transformed using common logarithms.

RESULTS

Species Composition and Distribution

A total of 8661 individual fish comprising 22 species (Table 2) were captured by trawling at the five sampling stations from May 24, 1970 to November 8, 1970. It was found that there was no significant difference ($p>.05$) in the numbers of fish caught in the two replicate sets of hauls made during each sampling period. There were definite descernible differences between the stations in the numbers of species, types of species, number of individuals and biomass of fish caught. The first two sampling dates were excluded from the analysis because sampling had not included all five trawling stations.

The results (Table 3) showed the River Raisin to have significantly lower values for all the parameters tested. Fish were caught at the river station on only three of the sampling dates. On one of these (July 7) the catch consisted of two yellow bullheads caught in only one of the two replicate hauls. The catches from the river on the last two sampling dates (October 25 and November 8) included eight species with 170 specimens and was comparable in composition to the catch at the other stations on those dates.

The north lake station had the highest mean numbers of species but was not significantly different from the discharge canal and south lake stations in this respect. The shoal station, while having significantly fewer species than the north lake station, did not differ

Table 2. The total numbers and biomass of fish species captured along the western shore of Lake Erie from June to November, 1970

	North Lake Station		Shoal Station		South Lake Station		Discharge Canal Station		River Raisin Station	
	No.	Wt. (Kg)	No.	Wt. (Kg)	No.	Wt. (Kg)	No.	Wt. (Kg)	No.	Wt. (Kg)
Perca flavescens (yellow perch)	813	31.9	63	2.7	1,472	17.4	101	3.6	2	0.2
Dorosoma cepedianum (gizzard shad)	83	1.3	208	2.9	213	4.6	1706	18.6	143	2.3
Roccus chrysops (white bass)	589	4.6	323	1.9	213	1.0	63	0.6	4	0.1
Notropis atheneroides (emerald shiner)	25	0.2	209	1.0	481	1.9	5	<.1	4	<.1
Notropis hudsonius (spottail shiner)	306	0.8	194	0.9	114	0.6	40	0.4	4	<.1
Crassius auratus (goldfish)	95	27.4	24	6.5	11	6.2	312	66.7	---	---
Alosa pseudoharengus (alewife)	215	2.9	55	0.7	54	0.9	1	0.1	---	---
Aplodinotus grunniens (sheepshead)	76	2.4	5	0.2	72	2.5	74	2.3	---	---
Cyprinus carpio (carp)	80	67.8	20	6.0	12	15.8	46	41.5	---	---
carp goldfish hybrid	27	18.8	5	4.6	2	1.3	6	5.6	---	---
Poxomis annularis (white crappie)	24	0.2	1	<.1	2	<.1	12	0.3	1	<.1
Ictalurus punctatus (channel catfish)	7	3.7	-----	----	9	1.3	17	1.3	---	---
Ictalurus natalis (yellow bullhead)	7	1.7	-----	----	-----	----	16	2.2	---	---
Stizostedion vitreum (walleye)	6	1.4	2	0.1	8	0.3	1	<.1	---	---
Hybopsis storeriana (silver chub)	1	<.1	9	0.2	2	<.1	1	<.1	---	---
Osmerus mordax (smelt)	5	0.1	4	<.1	3	<.1	-----	-----	12	0.2
Percina caprodes (log perch)	-----	-----	6	<.1	-----	----	7	<.1	---	---

Table 2 (con't.)

	North Lake Station		Shoal Station		South Lake Station		Discharge Canal Station		River Raisin Station	
	No.	Wt. (Kg)	No.	Wt. (Kg)	No.	Wt. (Kg)	No.	Wt. (Kg)	No.	Wt. (Kg)
<u>Carpiodes</u> <u>cyprinus</u> (quillback carpsucker)	3	2.6	1	1.3	-----	----	3	0.1	---	---
<u>Lepomis</u> <u>gibbossus</u> (pumpkinseed sunfish)	1	<.1	-----	----	-----	----	6	0.2	---	---
<u>Moxostoma</u> sp. (redhorse)	5	0.8	-----	----	-----	----	1	<.1	1	0.5
<u>Percopsis</u> <u>omiscomaycus</u> (troutperch)	6	0.1	1	<.1	-----	----	-----	-----	---	---
<u>Ambloplites</u> <u>rupestris</u> (rock bass)	1	0.1	-----	----	-----	----	-----	-----	---	---
<u>Ictalurus</u> <u>nebulosus</u> (brown bullhead)	-----	-----	-----	----	-----	----	1	0.1	---	---
TOTAL	2,376	168.8	1,130	28.8	2,668	57.4	2,423	143.6	173	3.3

Table 3. Duncans Multiple Range Test on the numbers of species, specimens and the biomass of fish caught at five trawling stations located in the near shore areas of western Lake Erie during 1970.

Numbers of Species

Stations[1]	V	II	III	IV	I
Means/date	0.95[2]	5.70	6.15	6.65	7.30

Numbers

Stations	V	II	IV	I	III
Means/date	8.5	50.6	121.1	134.6	138.6

Biomass (gm)

Stations	V	II	III	IV	I
Means/date	193.0	1390.3	2709.1	7108.1	7415.6

[1] I = north lake station; II = shoal station; III = south lake station; IV = discharge canal station; V = River Raisin station

[2] Means not underlined by the same line are significantly different (p>.05)

appreciably from the discharge canal or the south lake stations.

The highest number of specimens was caught at the south lake station though this station did not differ significantly from the north lake or discharge canal stations. The river and shoal stations had significantly fewer specimens than the other three stations.

In terms of the total biomass of fish caught the north lake station had the highest catch while the discharge canal had a slightly smaller but similar catch. The south lake and shoal stations had similar catches and both were significantly lower than the discharge canal and north lake stations.

The nine most abundant species comprised 97.5% of the total numbers of specimens and 90.3% of the total biomass of fish collected. The biweekly abundance of each of these nine species and the proportion of young of the year is presented in Figures 3 through 11.

These species can be divided into three categories on the basis of their habitat preferences within the study area as indicated by the Duncan's Multiple Range test (Table 4). The first category included yellow perch, white bass, emerald shiners, spottail shiners and alewifes. These five species showed a definite preference for the lake stations and tended to avoid the river and discharge canal. Yellow perch were most abundant at the south lake station though the catch consisted largely of young of the year caught during August. The north lake station had more consistent numbers and a greater biomass of yellow perch and young of the year were present almost continuously after June 24. Low but fairly consistent numbers of yellow perch were caught in the discharge canal and shoal stations. White bass catches were quite variable at all three lake stations.

Figure 3. Mean numbers and biomass of yellow perch caught at the five trawling stations in the near shore areas of western Lake Erie during 1970. Shaded areas denote proportion of young of the year in the catch. Dates marked by an asterisk were not sampled.

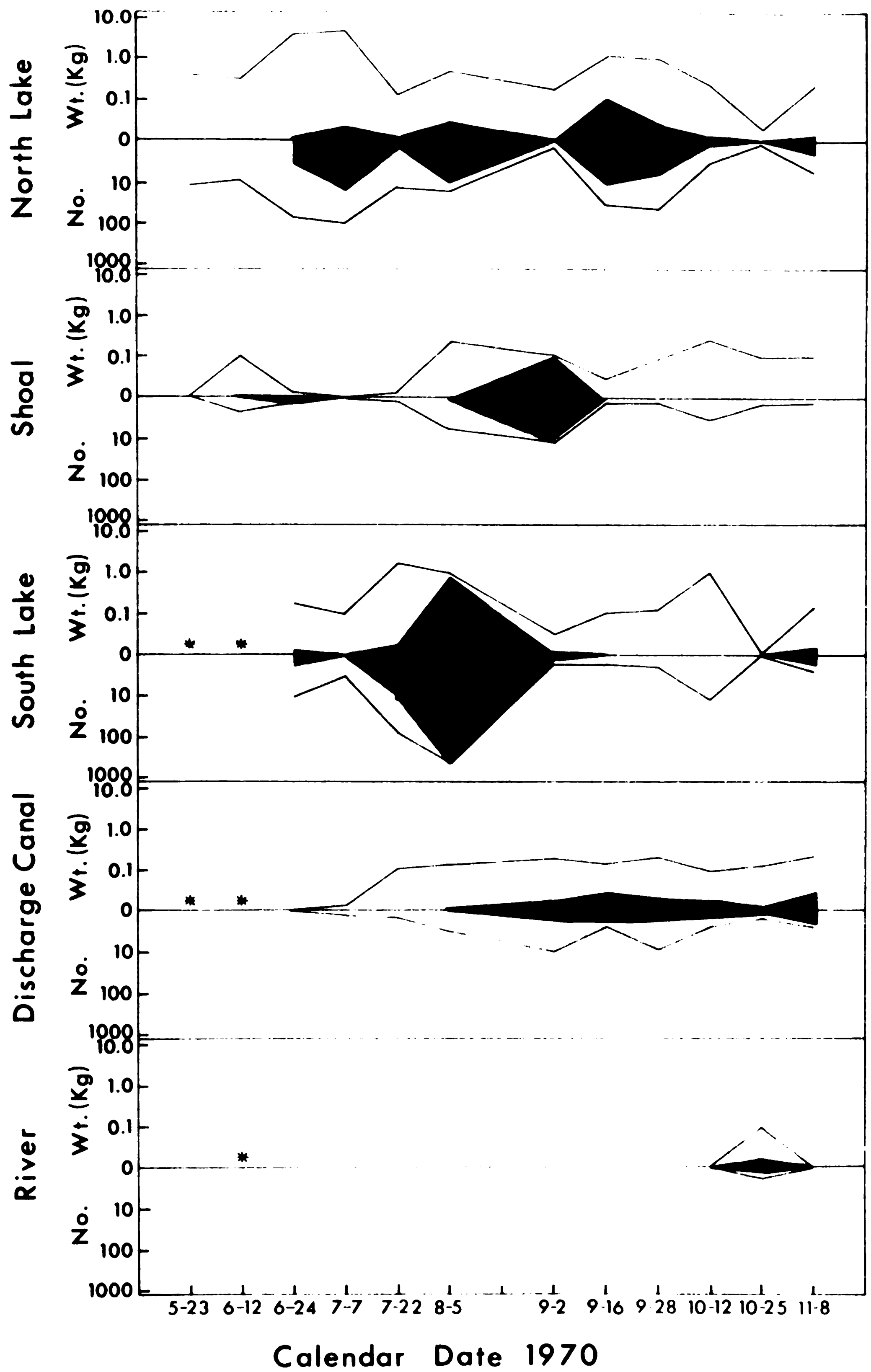

North Lake
Shoal
South Lake
Discharge Canal
River
Wt. (Kg)
No.
10.0
1.0
0.1
0
10
100
1000
5-23
6-12
6-24
7-7
7-22
8-5
9-2
9-16
9 28
10-12
10-25
11-8
Calendar Date 1970

Figure 4. Mean numbers and biomass of white bass caught at the five trawling stations in the near shore areas of western Lake Erie during 1970. Shaded areas denote proportion of young of the year in the catch. Dates marked by an asterisk were not sampled.

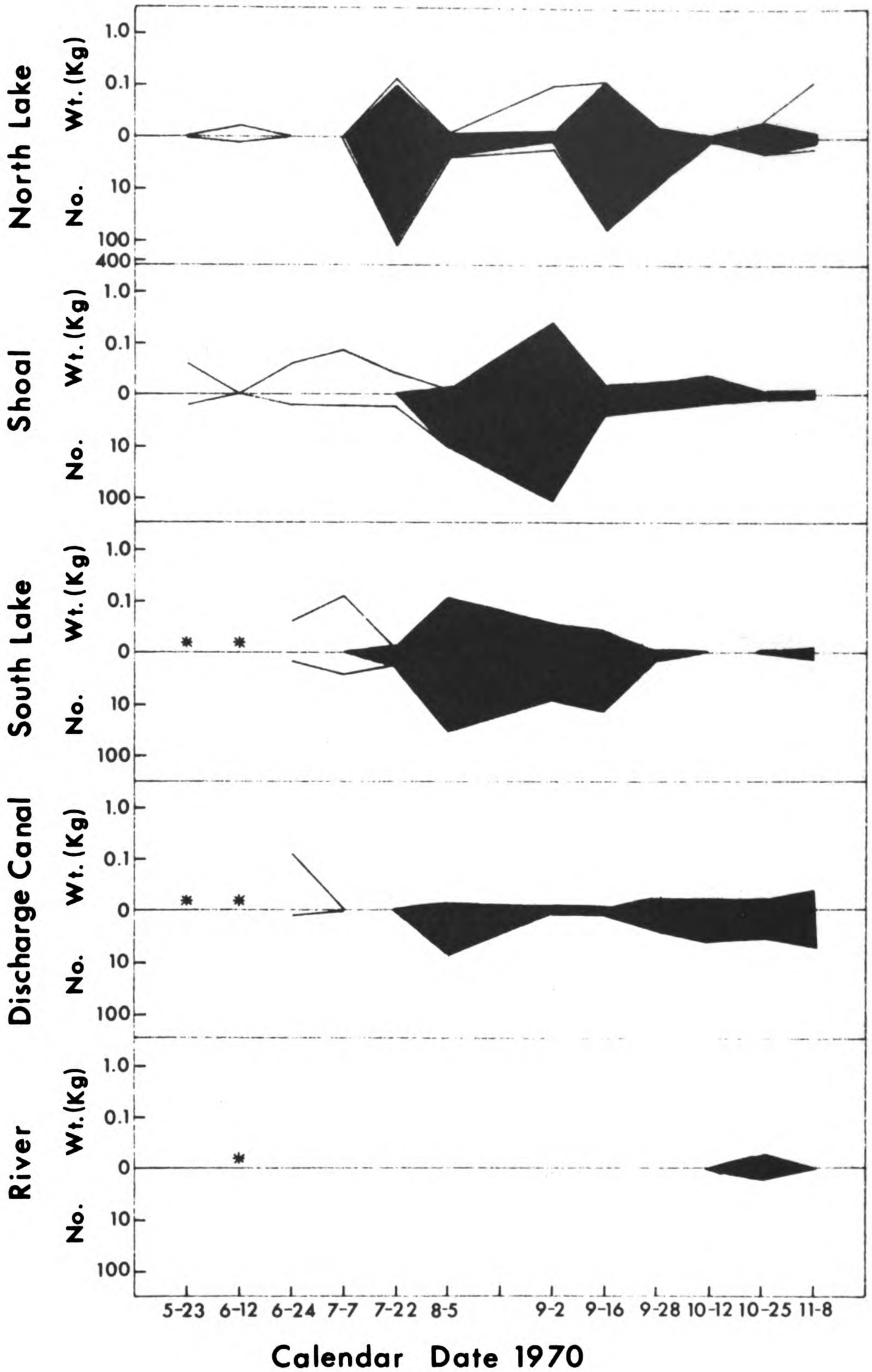

North Lake
Shoal
South Lake
Discharge Canal
River
Wt. (Kg)
No.
1.0
0.1
0
10
100
400
5-23 6-12 6-24 7-7 7-22 8-5 9-2 9-16 9-28 10-12 10-25 11-8
Calendar Date 1970

Figure 5. Mean numbers and biomass of emerald shiners caught at the five trawling stations in the near shore areas of western Lake Erie during 1970. Shaded areas denote proportion of young of the year in the catch. Dates marked by an asterisk were not sampled.

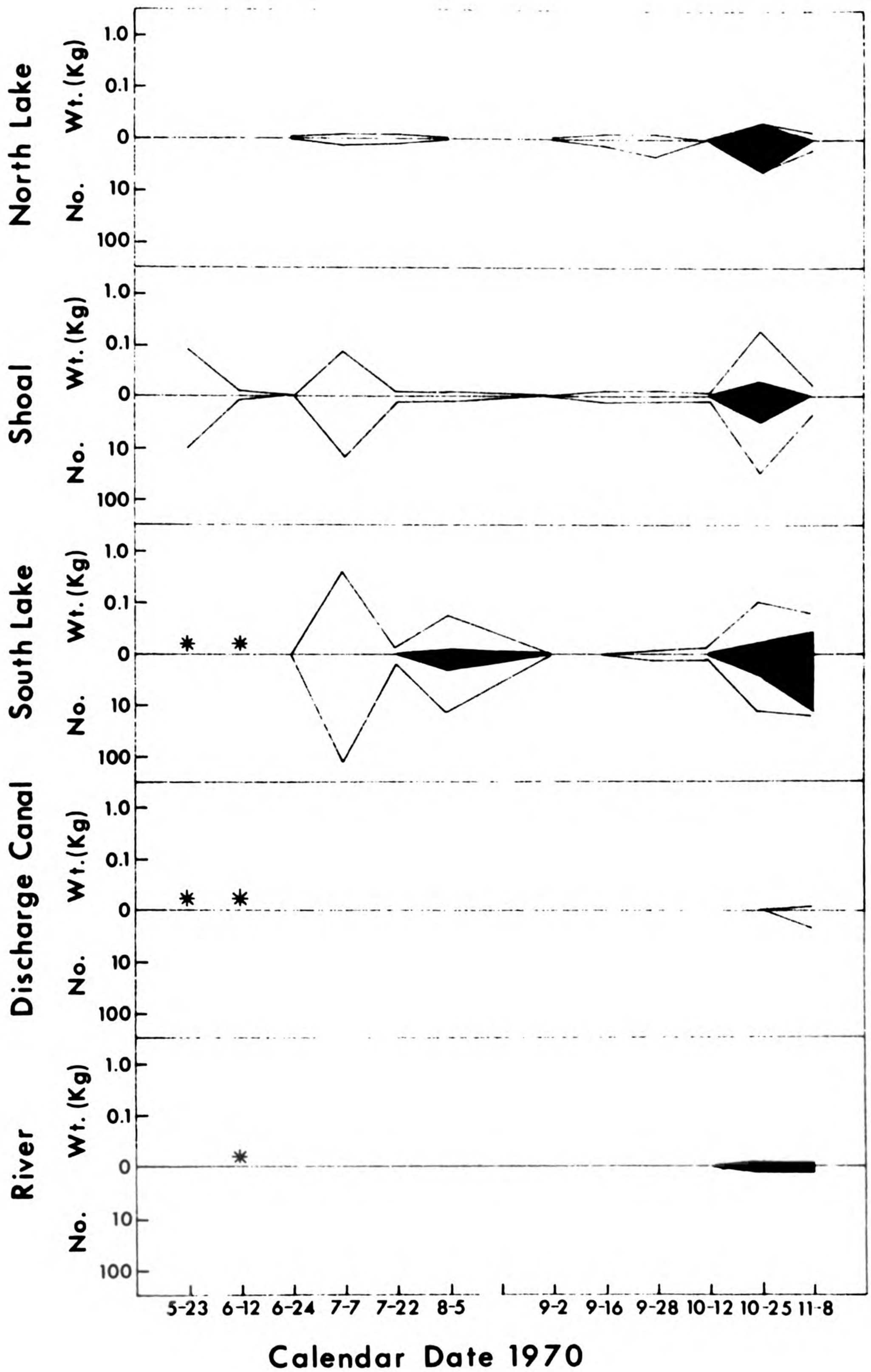

North Lake
Wt. (Kg)
No.
1.0
0.1
0
10
100
Shoal
Wt. (Kg)
No.
1.0
0.1
0
10
100
South Lake
Wt. (Kg)
No.
1.0
0.1
0
10
100
Discharge Canal
Wt. (Kg)
No.
1.0
0.1
0
10
100
River
Wt. (Kg)
No.
1.0
0.1
0
10
100
5-23 6-12 6-24 7-7 7-22 8-5 9-2 9-16 9-28 10-12 10-25 11-8
Calendar Date 1970

Figure 6. Mean numbers and biomass of spottail shiners caught at the five trawling stations in the near shore areas of western Lake Erie during 1970. Shaded areas denote proportion of young of the year in the catch. Dates marked with an asterisk were not sampled.

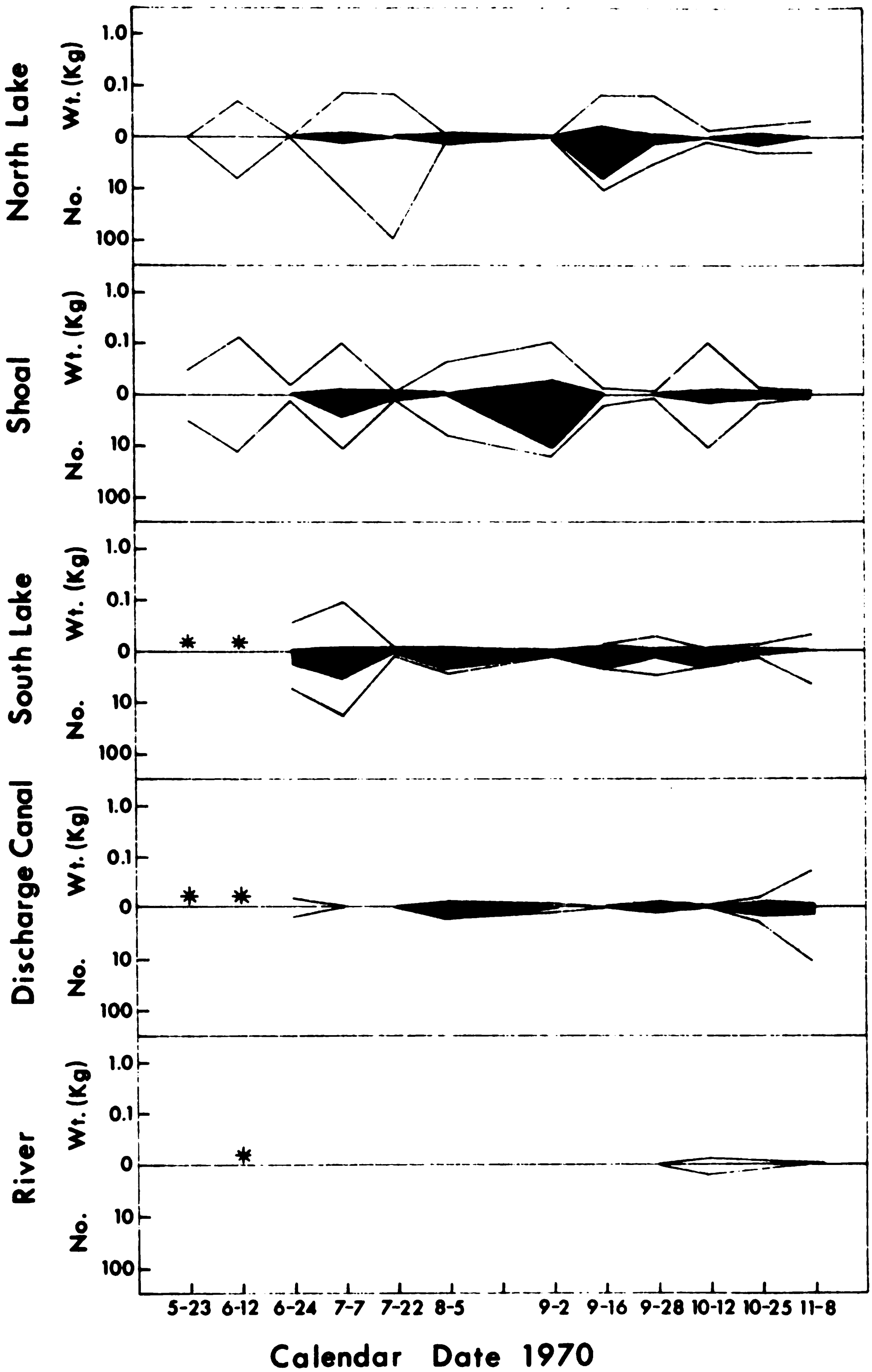

North Lake
Shoal
South Lake
Discharge Canal
River
Wt. (Kg)
No.
1.0
0.1
0
10
100
*
5-23
6-12
6-24
7-7
7-22
8-5
9-2
9-16
9-28
10-12
10-25
11-8
Calendar Date 1970

Figure 7. Mean numbers and biomass of alewives caught at the five trawling stations in the near shore areas of western Lake Erie during 1970. Shaded areas denote proportion of young of the year in the catch. Dates marked by an asterisk were not sampled.

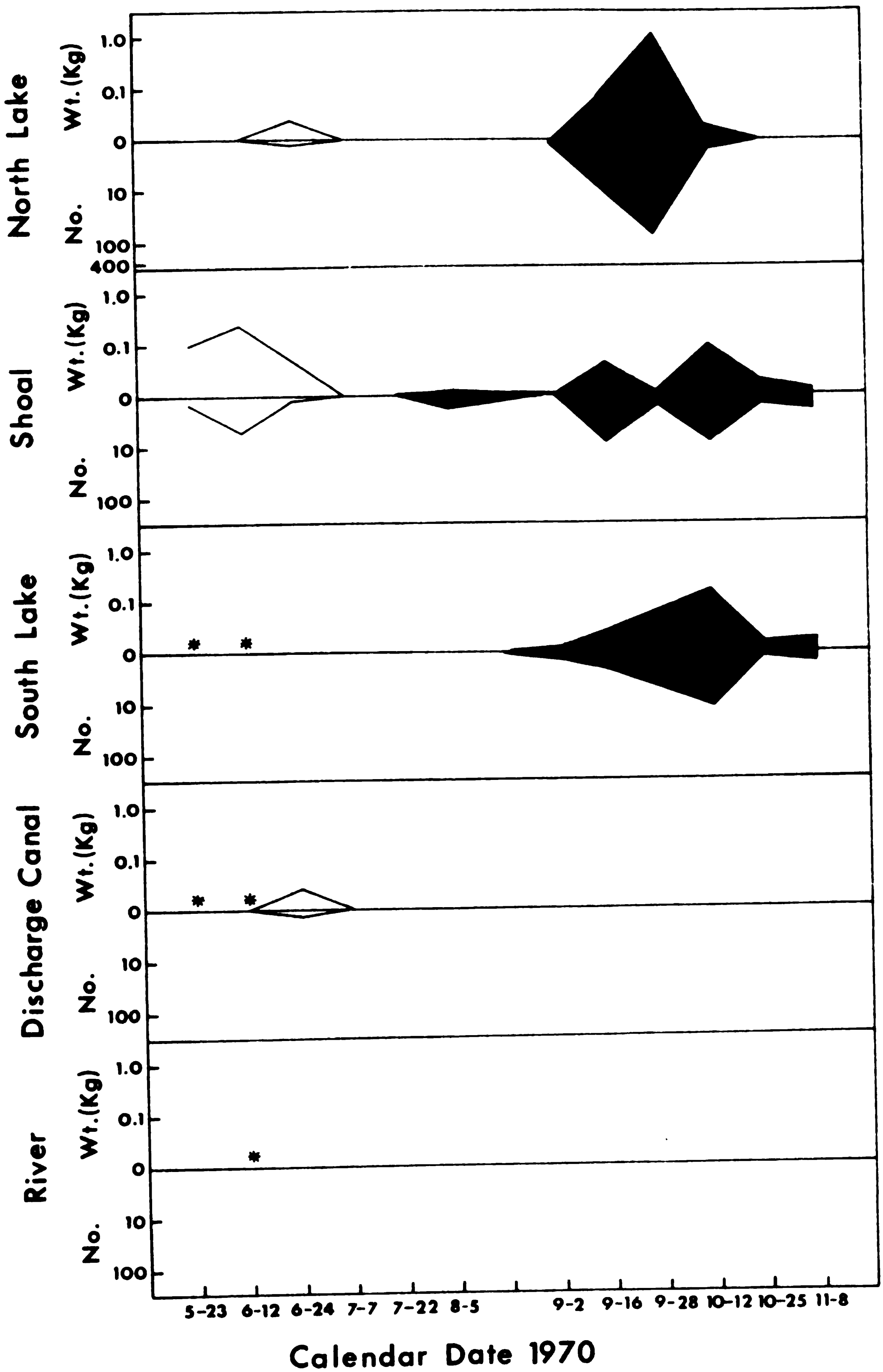

North Lake
Shoal
South Lake
Discharge Canal
River
Wt. (Kg)
No.
1.0
0.1
0
10
100
400
5-23
6-12
6-24
7-7
7-22
8-5
9-2
9-16
9-28
10-12
10-25
11-8
Calendar Date 1970

Figure 8. Mean numbers and biomass of carp caught at the five trawling stations in the near shore areas of western Lake Erie during 1970. Shaded areas denote proportion of young of the year in the catch. Dates marked by an asterisk were not sampled.

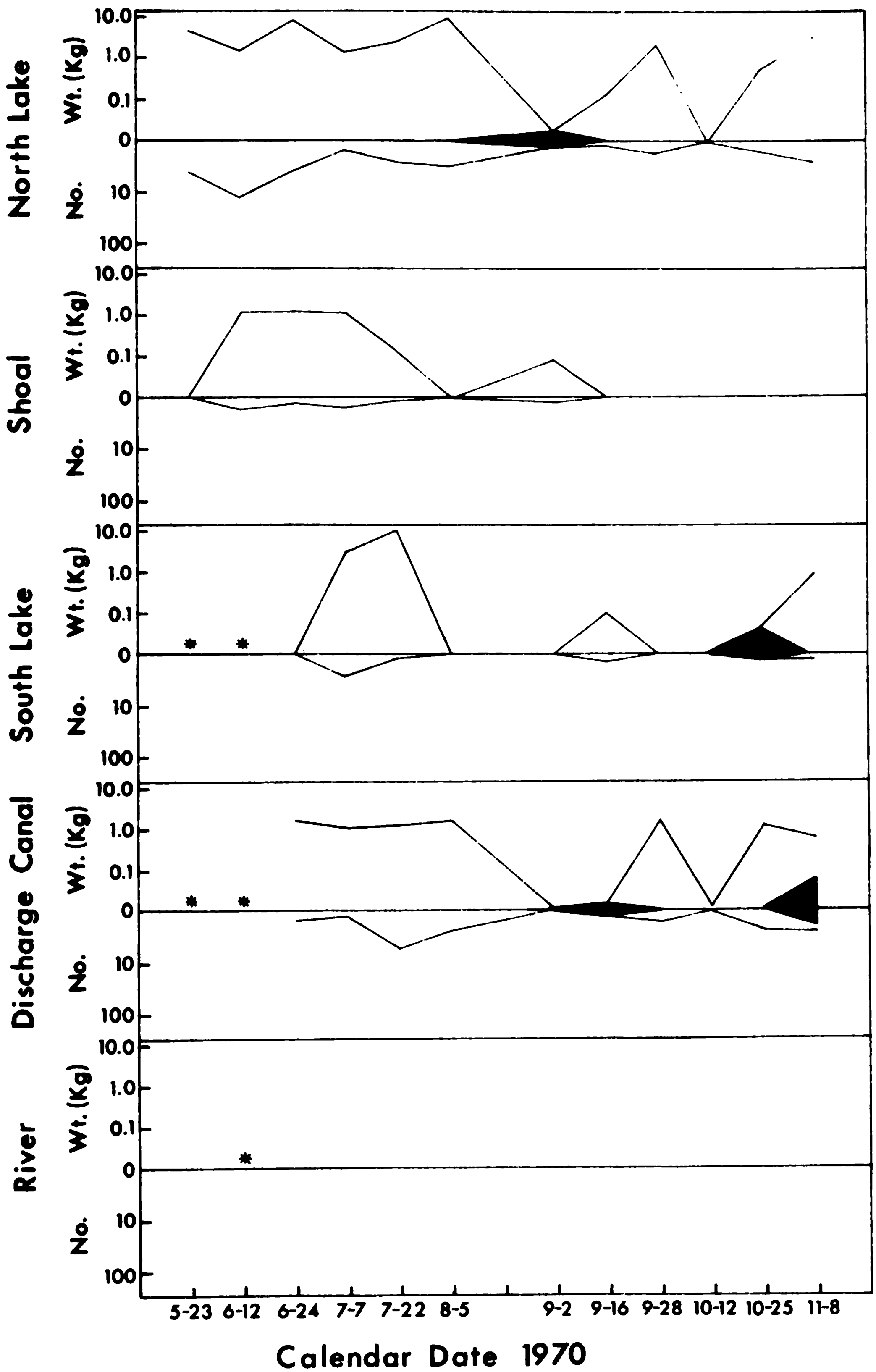

North Lake
Shoal
South Lake
Discharge Canal
River
Wt. (Kg)
No.
10.0
1.0
0.1
0
10
100
5-23
6-12
6-24
7-7
7-22
8-5
9-2
9-16
9-28
10-12
10-25
11-8
Calendar Date 1970

Figure 9. Mean numbers and biomass of goldfish caught at the five trawling stations in the near shore areas of western Lake Erie during 1970. Shaded areas denote proportion of young of the year in the catch. Dates marked by an asterisk were not sampled.

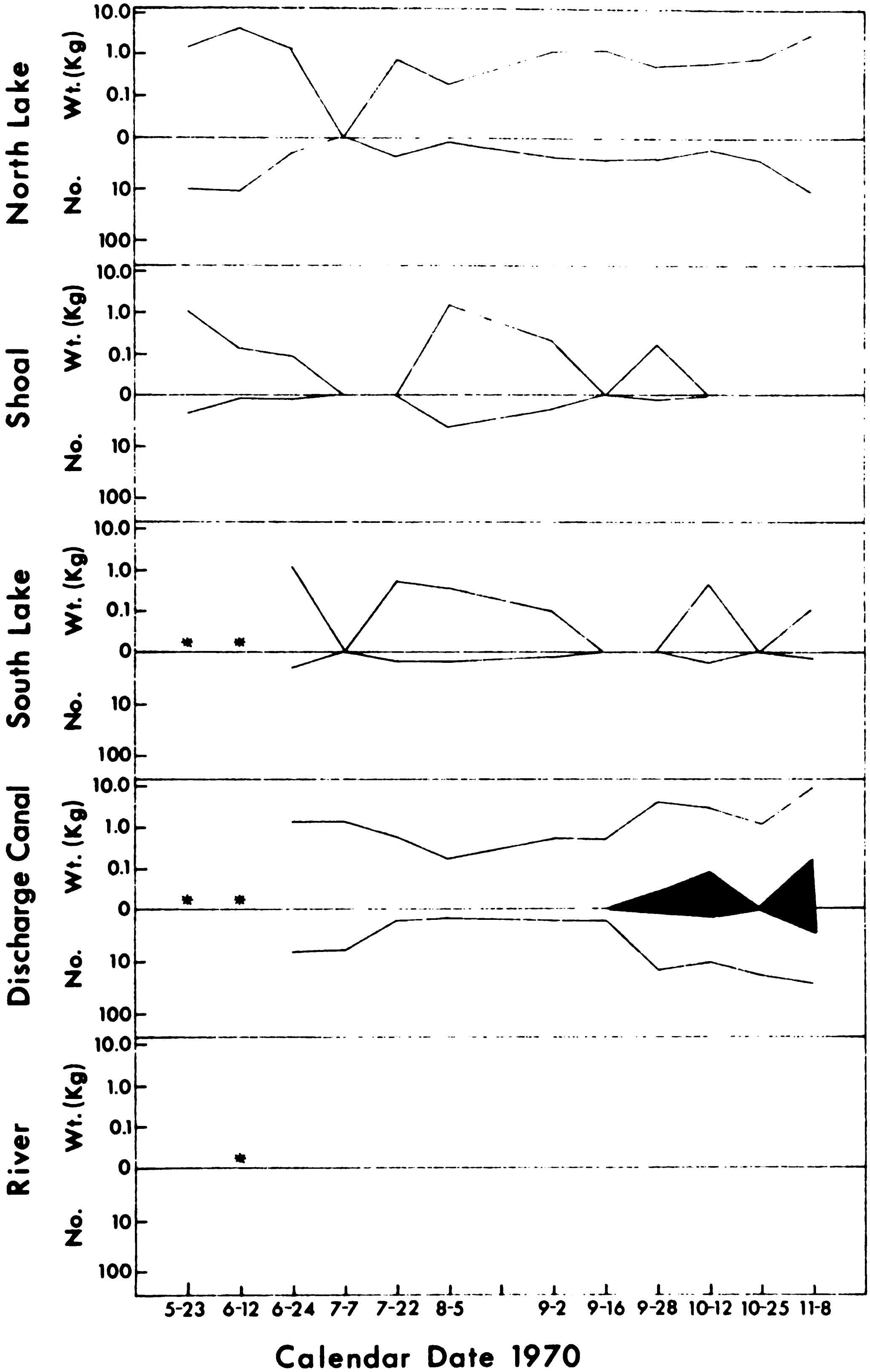

North Lake
Shoal
South Lake
Discharge Canal
River
Wt. (Kg)
No.
10.0
1.0
0.1
0
10
100
*
5-23
6-12
6-24
7-7
7-22
8-5
9-2
9-16
9-28
10-12
10-25
11-8
Calendar Date 1970

Figure 10. Mean numbers and biomass of sheepshead caught at the five trawling stations in the near shore areas of western Lake Erie during 1970. Shaded areas denote proportion of young of the year in the catch. Dates marked by an asterisk were not sampled.

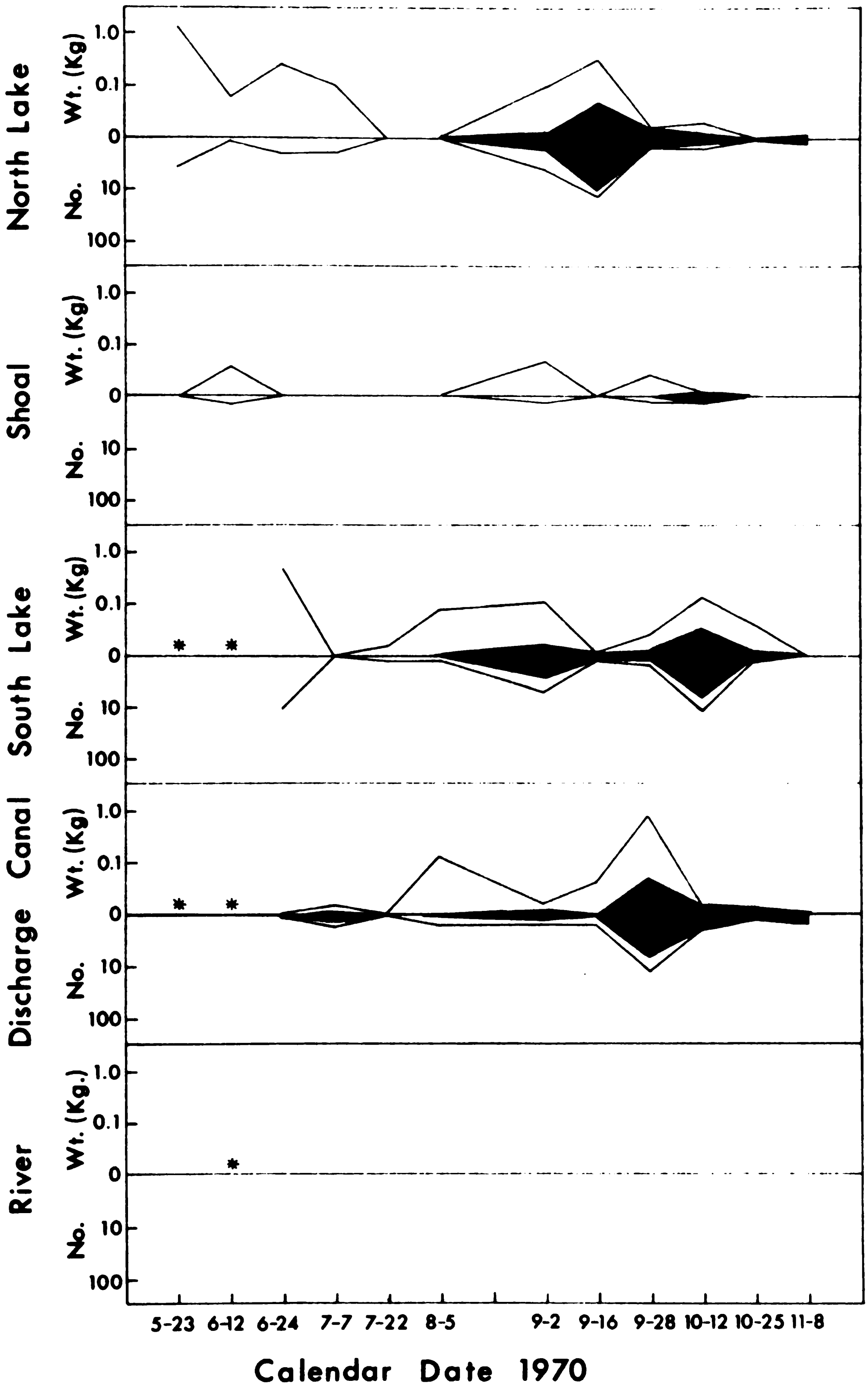

North Lake
Shoal
South Lake
Discharge Canal
River
Wt. (Kg)
No.
1.0
0.1
0
10
100
Wt. (Kg.)
*
5-23
6-12
6-24
7-7
7-22
8-5
9-2
9-16
9-28
10-12
10-25
11-8
Calendar Date 1970

Figure 11. Mean numbers and biomass of gizzard shad caught at the five trawling stations in the near shore areas of western Lake Erie during 1970. Shaded areas denote proportion of young of the year in the catch. Dates marked by an asterisk were not sampled.

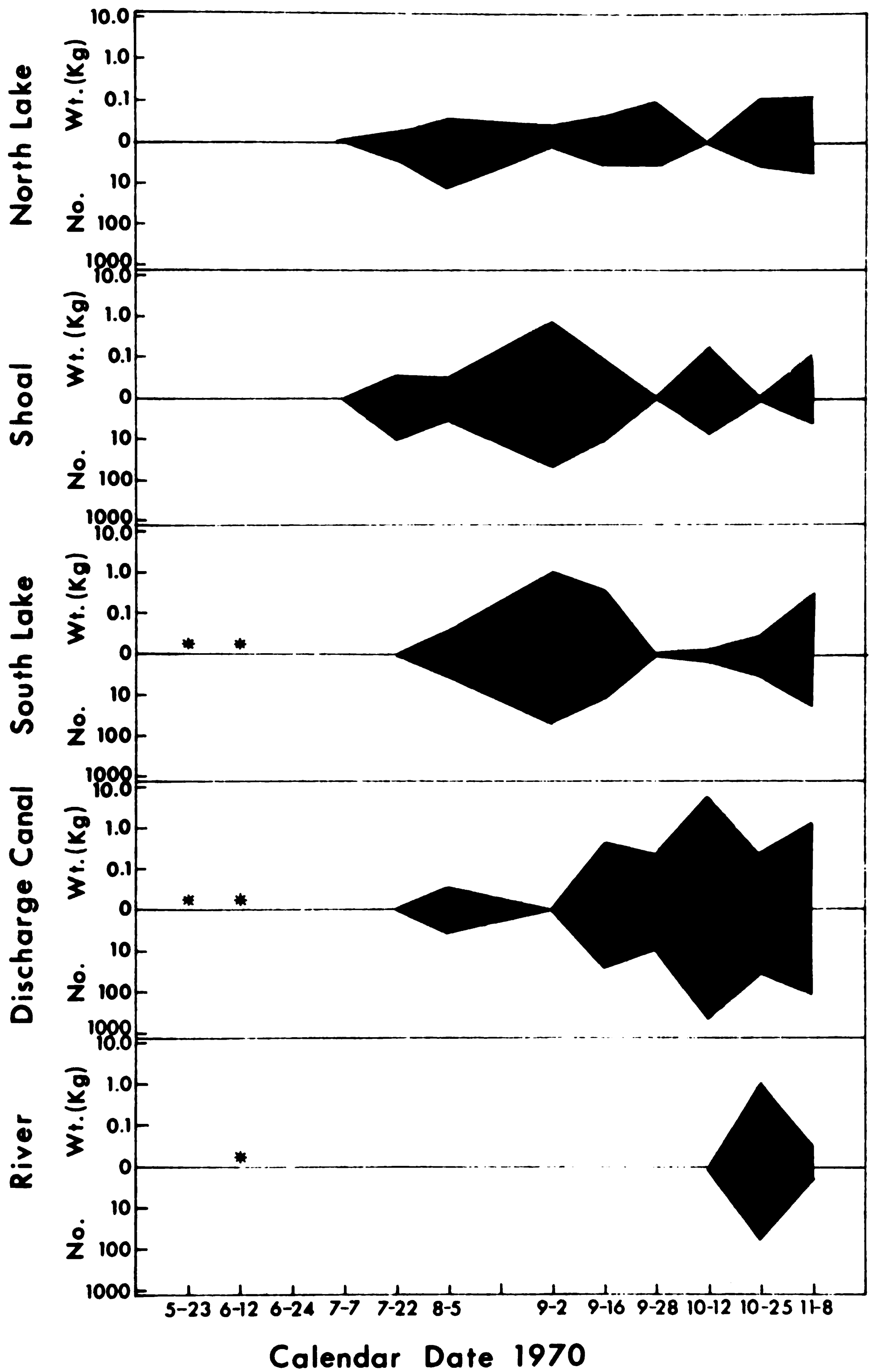

North Lake
Shoal
South Lake
Discharge Canal
River
Wt. (Kg)
No.
10.0
1.0
0.1
0
10
100
1000
5-23
6-12
6-24
7-7
7-22
8-5
9-2
9-16
9-28
10-12
10-25
11-8
Calendar Date 1970

Table 4. Duncan's Multiple Range test on the nine most abundant species of fish caught at five trawling stations in the near shore areas of western Lake Erie during 1970.

Species	Numbers					Biomass (gm)				
Yellow Perch										
Station[1]	V	II	IV	I	III	V	II	IV	III	I
Mean/date	0.1	3.0	4.1	32.2[2]	73.8	9.1	133.2	179.9	868.1	1595.8
Carp										
Station	V	II	III	I	IV	V	II	III	IV	I
Mean/date	0.0	3.0	0.6	2.4	4.7	0.0	297.8	789.3	2073.0	3390.8
Goldfish										
Station	V	II	III	I	IV	V	II	III	I	IV
Mean/date	0.0	0.7	0.9	3.3	15.6	0.0	308.1	326.7	1369.1	3334.0
Gizzard shad										
Station	I	III	II	V	IV	I	III	II	V	IV
Mean/date	4.2	7.2	10.4	10.7	85.3	67.3	116.0	143.8	229.0	930.8
Alewifes										
Station	V	IV	II	III	I	V	IV	II	III	I
Mean/date	0.0	0.1	2.6	2.7	10.0	0.0	4.5	33.4	44.6	146.1
Emerald shiners										
Station	V	IV	I	II	III	V	IV	I	II	III
Mean/date	0.1	0.3	1.9	8.8	23.8	0.3	2.1	8.3	48.5	96.5
Spottail shiners										
Station	V	IV	III	II	I	V	IV	III	I	II
Mean/date	0.2	3.6	5.8	6.5	14.6	1.2	18.1	30.0	39.4	44.3
White Bass										
Station	V	IV	III	II	I	V	IV	III	II	I
Mean/date	0.2	3.4	10.5	16.1	29.4	2.5	29.3	51.9	94.4	230.7
Sheepshead										
Station	V	II	III	IV	I	V	II	IV	I	III
Mean/date	0.0	0.2	3.6	3.7	3.8	0.0	11.4	115.1	121.2	125.5

[1]I = north lake station; II = shoal station; III = south lake station; IV = discharge canal station; V = River Raisin station.

[2]Means not underlined by the same line are significantly different (p>.05).

They were most abundant at the north lake station and were moderately abundant at the south lake and shoal stations especially in August and early September. The majority (95%) of bass collected after July 22 were young of the year. Only at the north lake station were older white bass caught after that date. Emerald shiners were most abundant at the south lake station while spottail shiners had a greater preference for the north lake station. There was no appreciable difference in the biomass of spottail shiners at the three lake stations. Similar numbers of both species were found at the shoal station. The emerald shiners showed much more variability in the catch than did the spottail shiners. Young of the year emerald shiners were only common in the catch during October and November while young of the year spottail shiners were common throughout most of the sampling period. The alewifes showed two peak periods of abundance, one in May when they were found at the north lake, shoal and discharge canal stations and the other coming after September 2 at all three lake stations. The first peak consisted of all adult alewifes while the second peak was all young of the year. Alewifes were caught in greatest numbers at the north lake station but were found more commonly during the sampling period at the shoal station. They were collected in fairly high numbers at the south lake station in the late summer and fall but were virtually absent from the discharge canal and completely absent from the river.

The second category of fish consisted of carp, goldfish, carp-goldfish hybrids and sheepshead, three species which showed a preference for the discharge canal and north lake stations though sheepshead were also found in quite large numbers at the south lake station. These three species were never collected in the river station and only occasionally were caught at the south lake and shoal stations. Carp were caught at the north lake and discharge canal stations in all months except September and the first sampling date in October. They dominated the biomass of the catch in the period before September 2. Goldfish were very abundant in the discharge canal, especially towards the end of the sampling period. Fairly consistent numbers of goldfish were caught at the north lake station but only occasionally were they found at the south lake and shoal stations. They became dominant in the biomass of the catch in the period after September 2. Only a few carp and goldfish young of the year were caught. Carp-goldfish hybrids were fairly common in the catch for the discharge canal and north lake station and seemed to have the same habitat preference as the carp and goldfish, thus the hybrids could also be included in the second category of fish. Sheepshead followed similar trends in abundance at all the stations where they were caught. There was no significant difference in the numbers of sheepshead at the north lake, discharge canal and south lake stations. Their abundance at the south lake stations showed a more diversified habitat preference than the carp and goldfish. Young of the year sheepshead numbers followed the same trends as the adults.

The third category included only one species, the gizzard shad. The gizzard shad showed the widest habitat preference of all the species being found at some time of the year in at least moderate abundance at all five stations. No gizzard shad were collected within the study area until July 22, when they were caught at the north lake and shoal stations. During the next sampling period they were found at the south lake and discharge canal but were not caught in the river until October 25. Gizzard shad indicated a tendency to rapidly colonize new habitats such as the freshly dug discharge canal and the river after tolerable oxygen concentrations returned in the fall. All the gizzard shad collected during the entire sampling period were young of the year.

Of the thirteen less abundant species collected, six contributed moderate numbers to the catch at certain times of the year. Channel catfish and yellow bullheads were commonly found in the discharge canal, north lake and south lake stations. Young of the year channel catfish were common in the discharge canal in the fall. White crappies were fairly common in the catch after July 7 and were most abundant in the discharge canal and north lake stations. Seventeen walleyes, fifteen of which were young of the year, were caught primarily from July through September at the north lake and south lake stations. Twelve adult smelt were caught in the river station on the last two sampling dates. A few young of the year smelt were caught at the lake stations during August.

Age and Growth

Yellow Perch

Annuli were complete on 72 per cent of the perch taken on the first sampling date, May 23, 1970. By June 12, 1970 annulus formation was complete in all perch samples. Of the 2,453 perch collected during the entire sampling period, 51 per cent were age 0, 7 per cent age I, 30 per cent age II, 6 per cent age III, 4 per cent age IV and 2 per cent age V.

A body-scale relationship was computed using a random subsample of 747 perch ranging in length from 30 to 250 millimeters and representing age groups 0 through VI. The body-scale relationship for the sexes combined was found to be linear with a correlation coefficient of 0.93. The equation was defined as:

$$L = 23.48 + 1.7351S$$

where L is the total length in millimeters at capture and S is the scale radius (32x) in millimeters. The length-weight relationship for the fish used in the body-scale relationship is defined as:

$$W = 5.35 \times 10^{-5} L^{2.6823}$$

where W is the weight in grams and L is the total length in millimeters.

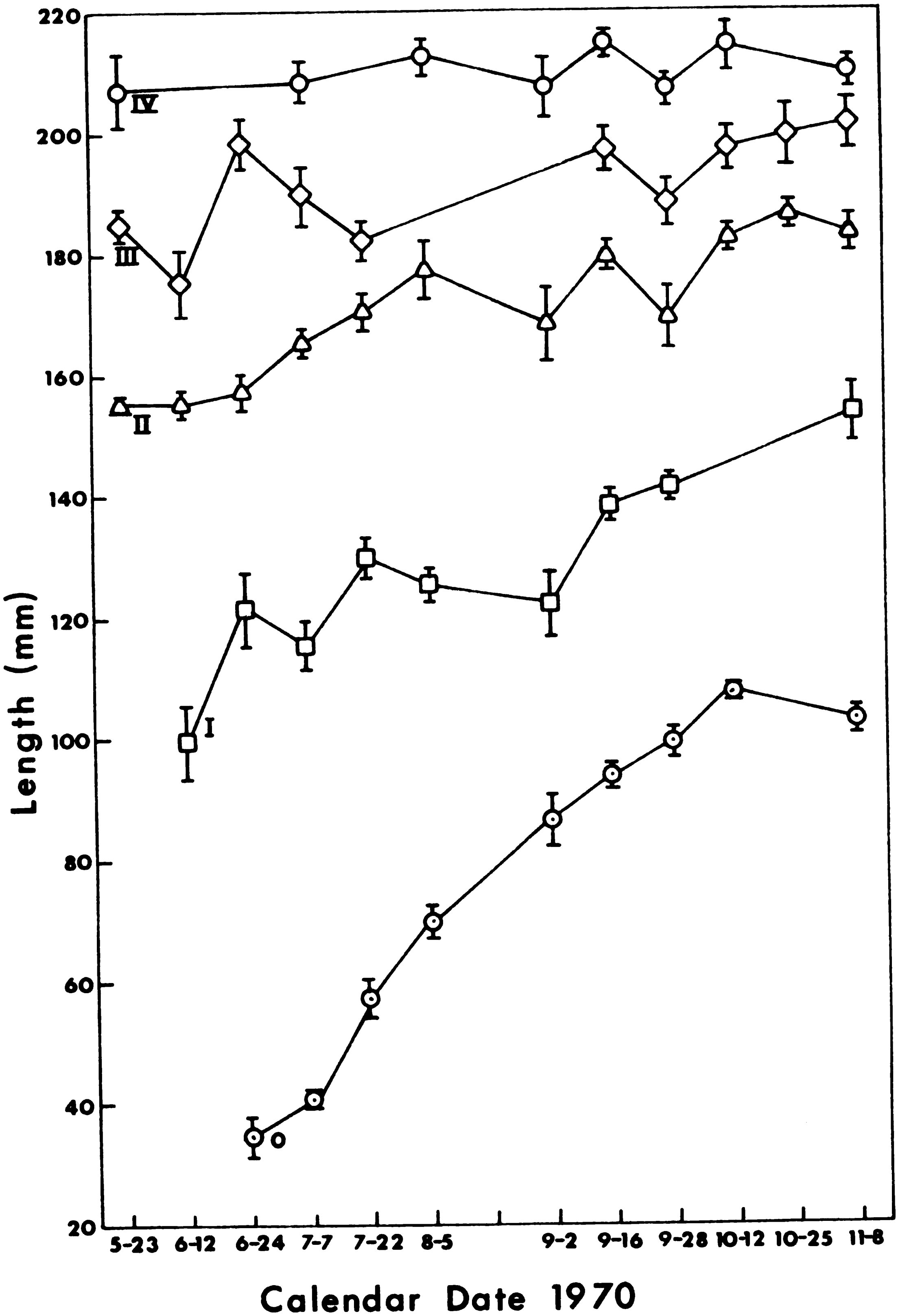
Table 5 presents the back-calculated lengths and weights for yellow perch collected in the study area. These Lake Erie perch grew most rapidly in length, 32.4% during their first year of life. Sixty per cent (134 mm) of their total length was attained during the second year, 79.5% (172 mm) the third year, 89.5% (194 mm) the fourth year and 94.5% (201 mm) the fifth year. The largest perch captured during the study period was an age VI fish 230 millimeters long, weighing 144 grams which had a calculated length at the end of five years of 212 millimeters. A significant difference ($p>.05$) was found between the back-calculated lengths of male and female perch. Male perch averaged 192 millimeters by age V while female perch were 204 millimeters. Because sex determinations were made on only 195 perch captured after September 2, 1970, no sexual distinctions were made in the analysis of the overall results.

Observed seasonal growth for the individual age groups of perch (Figure 12 and 13) indicate greater growth rates than the calculated growth rates. By November, 1970 age 0 perch were an average of 105 mm (9 grams), age I were 146 mm (31 grams), age II were 184 mm (70 grams), age III were 200 mm (90 grams) and age IV were 213 mm (120 grams).

Table 5. Calculated lengths to each annulus for yellow perch from the near shore area of western Lake Erie during 1970.

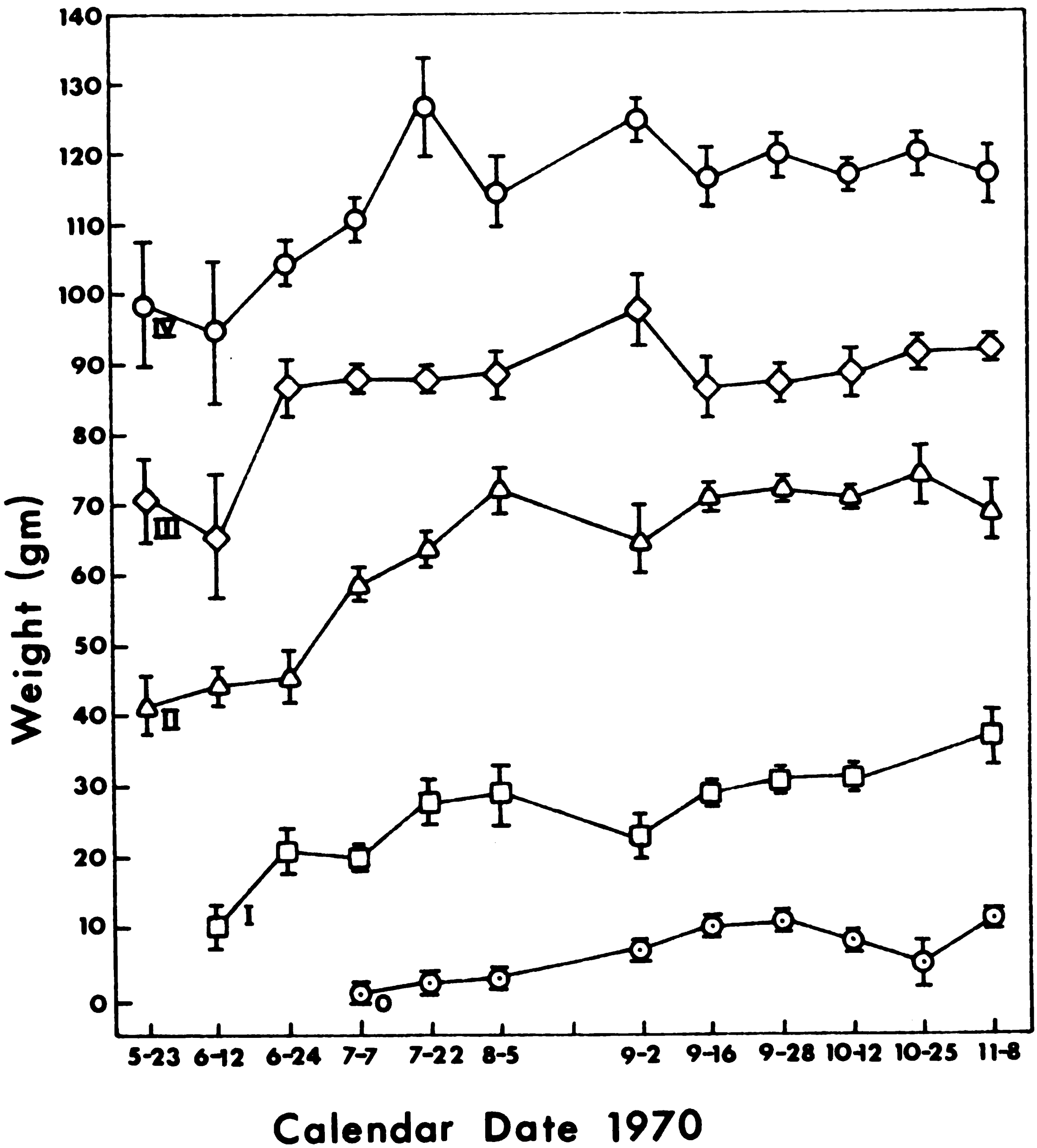
			Length (millimeters) at end of year					
Age	Number	Length at Capture	1	2	3	4	5	6
I	97	129	80					
II	367	169	77	136				
III	84	198	67	135	172			
IV	50	209	55	125	174	198		
V	13	214	48	116	171	187	201	
VI	1	230	77	90	153	190	202	212
Weighted Means								
Age		Length at Capture						
2.3		172	73	134	172	194	201	212
Increment			73	62	44	22	14	10
Percent of Growth			32	28	20	10	6	4
Calculated Weights (gm)			5	27	52	73	80	92

Figure 12. Seasonal growth in length (mean + one standard error) for age classes 0 - IV of yellow perch from the near shore areas of western Lake Erie during 1970.



220
200
180
160
140
120
100
80
60
40
20
Length (mm)
IV
III
II
I
0
5-23
6-12
6-24
7-7
7-22
8-5
9-2
9-16
9-28
10-12
10-25
11-8
Calendar Date 1970

Figure 13. Seasonal growth in weight (mean + one standard error) for age classes 0 - IV of yellow perch from the near shore areas of western Lake Erie during 1970.


Weight (gm)
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
IV
III
II
I
O
5-23
6-12
6-24
7-7
7-22
8-5
9-2
9-16
9-28
10-12
10-25
11-8
Calendar Date 1970

The coefficient of condition (K) computed for age classes I through IV (Figure 14) changed seasonally. There was no significant difference ($p<.05$) between the age groups over the entire sampling period. The mean K for all age groups was 1.04 on May 23, 1970. The mean K reached a high of 1.44 in August and then declined to 1.15 in September and to 1.08 by November. The season's growth in weight was completed by August and September while the growth in length was not completed until October. The continuation of growth in length without a corresponding increase in weight caused the perch to become longer for a given weight and reduced the K value.

Carp

Annulus formation for all age I carp collected within the study area was completed by May 23, 1970. In older fish annulus formation was not completed until July 22, 1970. The total collection of 298 carp ranged in size from 110 to 670 millimeters and represented age groups 0 through XI and XIII. Age 0 carp comprised 1.3% of the total catch, age I and II fish comprised 18.4%, ages III and IV comprised 58.1%, ages VII and VIII comprised 15.8% and fish older than age VIII comprised 6.4%. The two oldest carp collected were thirteen years old and had an average weight of 4208 grams. A linear body-scale relationship was computed from the data and was defined as:

$$L = 18.96 + 1.92185$$

and had a correlation coefficient of 0.937. The length-weight relationship for these carp was defined by the equation:

$$W = 1.44 + 10^{-5} \cdot L^{3.0042}$$

The calculated length and weights (Table 6) show slow growth (118 mm and 24 grams) during the first year of life. Growth in the second

Figure 14. The seasonal trend in the coefficient of condition (K) for age classes I-IV of yellow perch from the near shore area of western Lake Erie during 1970.

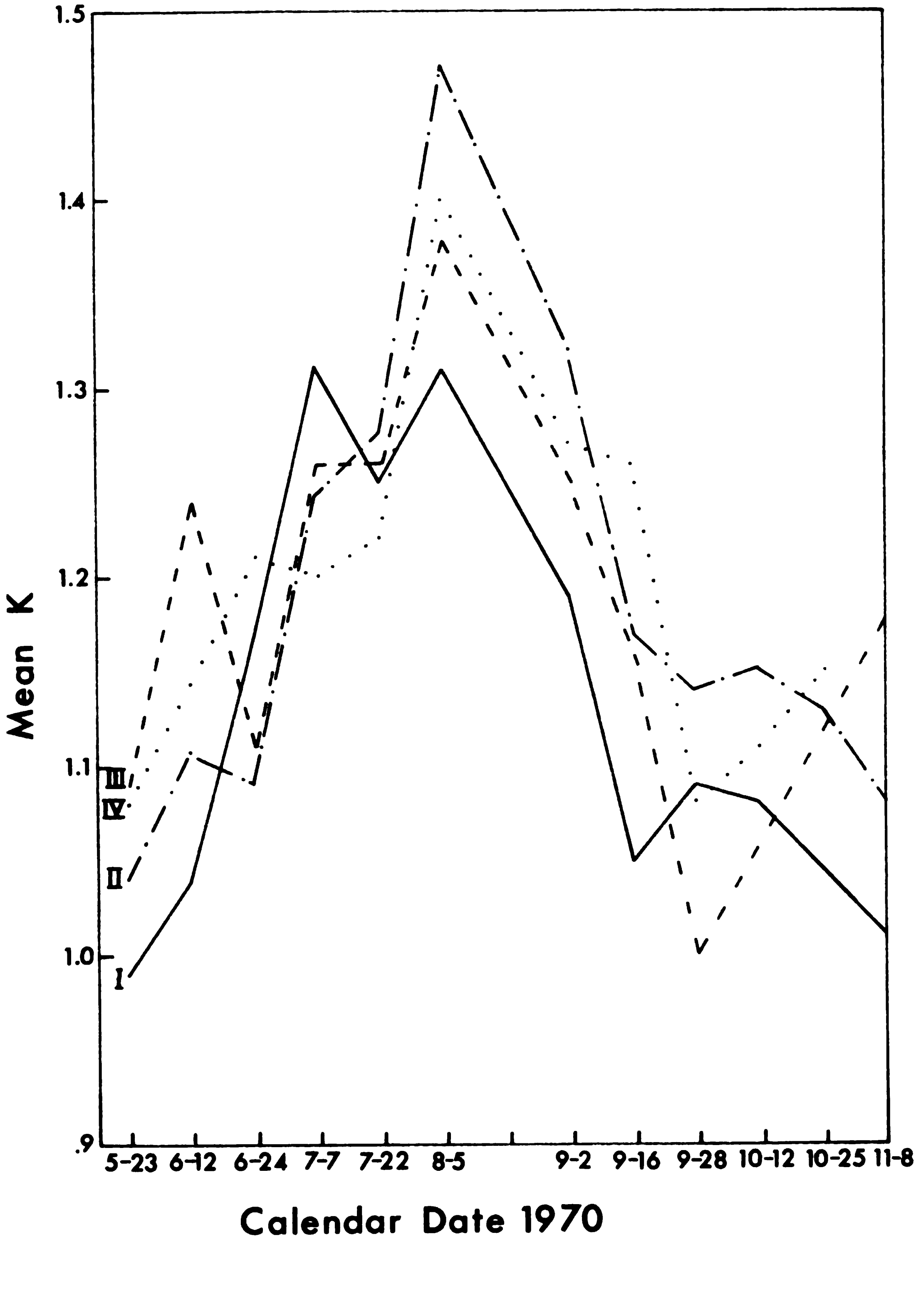

1.5
1.4
1.3
1.2
1.1
1.0
.9
Mean K
I
II
III
IV
V
5-23
6-12
6-24
7-7
7-22
8-5
9-2
9-16
9-28
10-12
10-25
11-8
Calendar Date 1970

Table 6. Calculated lengths to each annulus for carp from the near shore areas of western Lake Erie during 1970.

Age	Number	Length at Capture	1	2	3	4	5	6	7	8	9	10	11	12	13
I	29	249	129												
II	26	301	87	259											
III	41	336	111	239	315										
Iv	47	410	107	244	334	404									
V	42	454	126	279	364	417	451								
VI	43	491	119	277	372	423	460	487							
VII	23	510	121	291	383	429	464	488	508						
VIII	24	545	147	297	388	439	474	508	527	542					
IX	11	557	123	268	369	435	478	506	525	542	552				
X	4	618	141	321	421	472	504	531	560	578	593	610			
XI	2	638	127	278	416	456	478	528	555	568	583	613	625		
XIII	2	662	128	334	403	414	499	544	554	581	590	615	637	650	655
Weighted Means															
Age		Length at Capture													
4.8		423.0	118	268	358	423	464	498	525	550	573	612	631	650	655
Increment Percent of Growth			118	150	89	56	36	28	20	16	12	17	19	13	5
Calculated Weights (gm)			24	281	669	1108	1468	1805	2106	2409	2647	3364	3756	4024	4098

year was much accelerated with the carp reaching 268 mm and 281 gms, an increase of 226% and 833% respectively. After the second year the growth in length was progressively slower through the next four years and thereafter remained fairly constant. The numbers of carp collected within any one individual age group was insufficient to provide an estimation of their seasonal growth.

No seasonal trends were evident in the coefficient of condition for carp collected in the study area (Figure 15). However, there was a significant difference ($<.05$) in K between spawning carp collected by seining on May 23, 1970 and those collected by trawling throughout the rest of the sampling period. The carp collected on May 23 were heavy with eggs and milt and in "ripe" spawning condition. No significant differences in K were found between age classes.

Young of the Year

Sufficient numbers of age 0 fish were collected to establish the first years growth of six species found within the study area (Figures 11 and 16). Young of the year gizzard shad which are spawned during the month of June in Lake Erie (Bodda, 1964) had their greatest rate of growth from May until the beginning of September when a length of 120 mm had been attained. Through the rest of the season little additional growth was made. Young of the year Lake Erie yellow perch which are spawned in May (Jobes, 1952) also had their greatest growth rate during the same period but then continued to grow at a slower rate into the first part of October. Maximum mean length attained by the perch was 105 mm. Young of the year alewifes were not collected until September. Juvenile white bass spawned in June

Figure 15. Seasonal trend in the coefficient of condition, K (mean + one standard error), for carp from the near shore area of western Lake Erie during 1970. All age classes are combined.

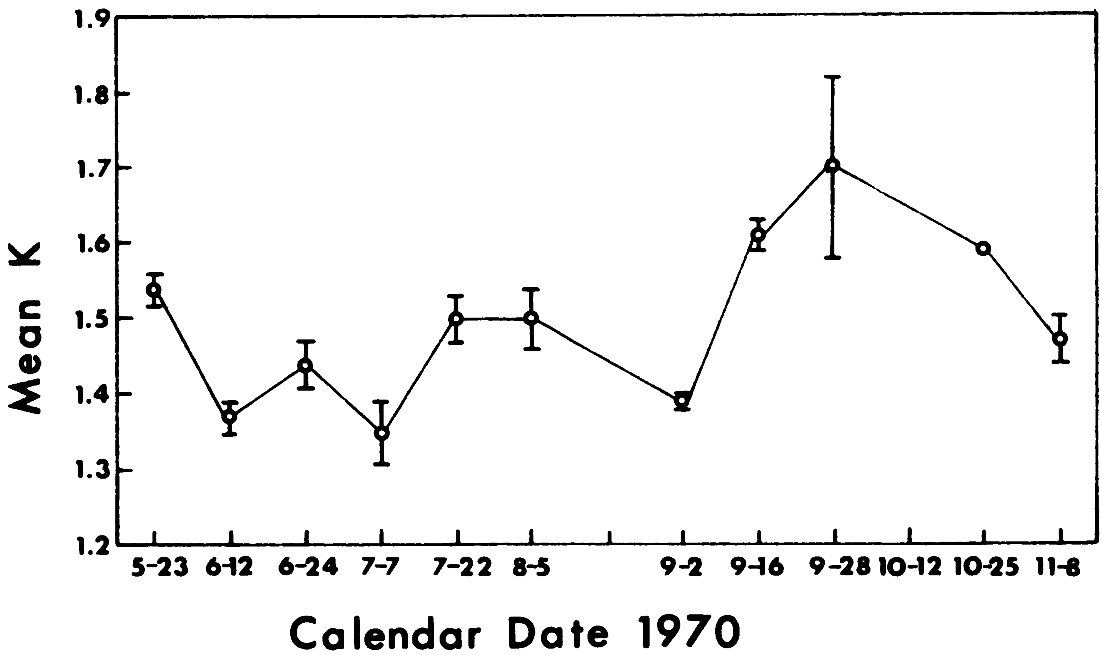
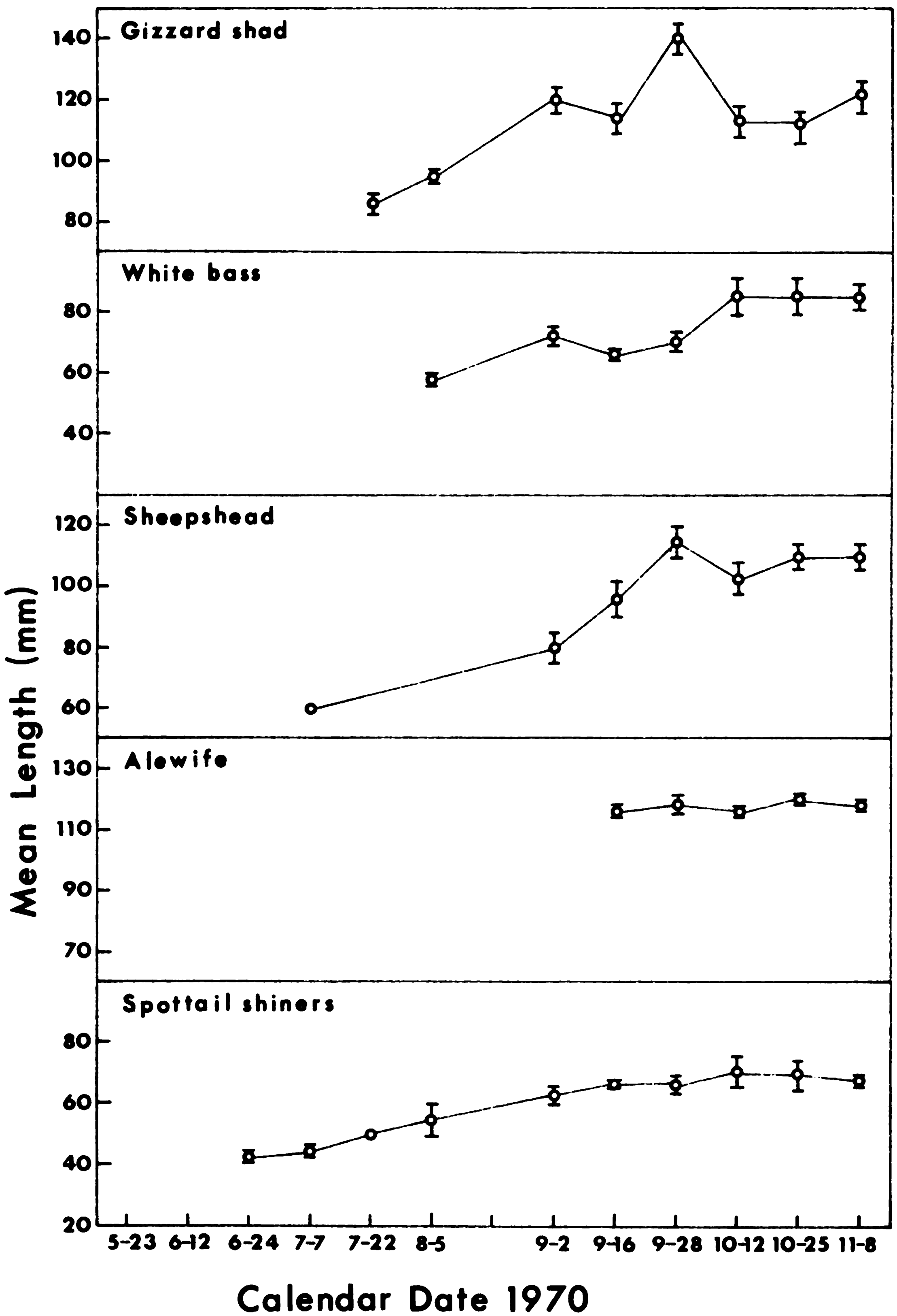

1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
Mean K
5-23
6-12
6-24
7-7
7-22
8-5
9-2
9-16
9-28
10-12
10-25
11-8
Calendar Date 1970

Figure 16. Seasonal growth in length (mean + one standard error) of young of the year gizzard shad, white bass, sheepshead, alewife, and spottail shiners from the near shore area of western Lake Erie during 1970.


Gizzard shad
White bass
Sheepshead
Alewife
Spottail shiners
Mean Length (mm)
140
120
100
80
80
60
40
120
100
80
60
130
110
90
70
80
60
40
20
5-23
6-12
6-24
7-7
7-22
8-5
9-2
9-16
9-28
10-12
10-25
11-8
Calendar Date 1970

(Van Oosten, 1942) reached 58 mm by August 5. A slower growth rate was continued until the beginning of October when a mean length of 85 mm was attained. Juvenile spottail shiners had their greatest growth rate from July 7 through September 16 when a mean length of 67 mm was attained. No appreciable growth was found after that date. The first young of the year sheepshead (2) were collected on July 7 when they were 60 mm long. The next group of juvenile sheepshead collected on September 2 were 80 mm. No appreciable growth was seen after September 28 when the average length of the juveniles was 106 mm.

DISCUSSION

Species Composition and Distribution

The discharge canal and north lake stations showed a number of similarities in the high abundance of fish and types of fish found. This was quite striking because of the physical differences between the stations; primarily the semi-isolation of the discharge canal from the lake and the discharge canal being a newly created environment. The large sandy shoal which extended out into the lake off the mouth of the discharge canal from the lake after the canal was dug. A period of progressively increased colonization followed completion of the canal in July, 1970. The mean catch rose from 12 fish per haul in June and July to 29 per haul in October and November. The seasonal trend of abundance was almost the opposite at the north lake station where the highest number of fish per haul was caught during the period from June 24 through September 28 (137 fish) while the lowest number per haul was caught from October 12 through November 8 (27 fish).

The primary reason for the high abundance and biomass of fish at the north lake and discharge canal stations may have been due to the relative richness of these areas. As shown in Table 1 the discharge canal had high concentrations of all the nutrients listed resulting in a high level of productivity. The richness of the north lake station is not indicated by Table 1 but the higher productivity may have been stimulated by the fertile discharge of the Raisin River. The river water, which had very high levels of most essential nutrients, was pushed into the north lake station area whenever there were southern winds. Although the river water had very low concentrations of oxygen, the wave action of the lake would quickly enrich it with oxygen. These two stations were also the least exposed to severe wave action. The discharge canal was protected from all wind action while the north lake station was protected from all but northeasterly winds.

Of the major species found at the discharge canal and north lake stations the differences in abundance of gizzard shad and alewifes was most apparent. Gizzard shad were found in their highest abundance in the discharge canal and in least abundance at the north lake station. Alewifes showed just the opposite relative abundance. Both of these species are primarily pelagic planktivores (Dendy, 1946, Odell, 1934), have similar morphologies and would be expected to prefer the same areas. The differences in abundances of these species may be due to a failure of the alewife to colonize the discharge canal or possibly different feeding habitats. The other major species found in the discharge canal were primarily bottom feeders. Gizzard shad do feed extensively on bottom fauna at certain times (Miller, 1960) and may have been able to exploit the discharge canal environment while the alewife could not.

The shoal and south lake stations were quite similar in the numbers and types of species found. The only species that had significantly different abundances were yellow perch and sheepshead, which showed a preference for the south lake station, perhaps because of its greater depth. The species collected at these two stations tended to be small planktivorous fish. There was a conspicuous scarcity of carp and goldfish which seemed to prefer the near shore areas.

The characteristics which distinguished the shoal station from the other was its shallow and sandy nature. This was probably responsible for the low numbers of fish caught in this area, as sand is not a very productive or stable substrate and the shallowness of the area made it very turbulent during times of easterly winds.

The river station was obviously different in many respects from the other stations. The factor which probably had the greatest affects on prohibiting fish from utilizing the river was the low levels of oxygen present during the warmer months (Figure 2). Oxygen levels were below 4 ppm during the entire summer and were less than 1 ppm during September. These measurements were taken during the day when the concentrations were most likely to be highest.

The large numbers of small young fish point to the study area as being an important nursery for yellow perch, white bass, gizzard shad and alewifes. Young of the year of all species comprised 65% of the total number of fish caught.

The conspicuous absence of large predators may be an important contributing factor for the large numbers of small fish. Only one large predator, the walleye, was caught and only in small numbers. The walleye is the only high value commercial species remaining in substantial numbers in Lake Erie. They were known to be common in the study area in the early spring and late fall when they were common in the commercial catch (Baldwin and Saalfield, 1962) but were absent, except for young of the year, during the remainder of the year.

The only medium quality commercial species common in the catch, white bass and yellow perch, accounted for 42% of the specimens and 12% of the biomass caught. Yellow perch of all ages and sizes were common but 48% of the white bass were young of the year. Adult white bass spawn in this area during the spring and are important in the commercial catch at that time. Two species considered as only low value commercial species, the carp and goldfish, made up 67% of the total biomass caught. The inshore areas, especially the north lake and discharge canal, seem to be very productive habitats for these species.

Age and Growth

Yellow Perch

The age distribution for the yellow perch was very similar to that reported by Baker and Scholl (1970) from their trawling survey in the Ohio waters of western Lake Erie. The age distribution has fluctuated widely in the past, the result of great differences in spawning success from year to year. Baker and Scholl (1970) reported the 1970 population of yearling and adult perch to be the lowest ever recorded and the numbers of young of the year to be the most abundant since 1965.

The calculated growth in length for the yellow perch during their first four years of life are similar to what has been previously reported throughout the Great Lakes. Age IV yellow perch from this study average 194 mm while those from the Ohio waters of western Lake Erie were 203 mm (Baker and Scholl, 1970); Saginaw Bay perch were 241 mm (Hile and Jobes, 1941); Green Bay perch were 201 mm and Lake Michigan perch were 180 mm (Hile and Jobes, 1942). Yellow perch greater than age IV from these other Great Lakes areas averaged substantially larger than the perch from this study. Different sampling methods probably account for most of this difference in length in the older fish. The other Great Lakes studies relied primarily on commercially caught yellow perch for their analysis which would tend to bias their results toward the larger, faster growing fish. Trap nets, the principle method used for commercial fishing for yellow perch in the Great Lakes have been found to be selective for the larger fish of a size class (Latta, 1959). The growth rates of yellow perch from waters other than the Great Lakes show the same range of variation as those from the Great Lakes (Carlander, 1953).

A definite Lee's Phenomenon was seen in the back-calculated lengths of the yellow perch. Lee's Phenomenon is the tendency of back-calculated lengths at a given age to become progressively smaller for older fish. Tesh (1968) gave four possible factors which might cause Lee's Phenomenon; incorrect procedure for back-calculation, non-random sampling of the stock, selective natural mortality, and selective fishing mortality. Among these, selective fishing mortality is probably the primary cause of Lee's Phenomenon in perch from this area but the sampling procedure and selective natural mortality may have contributed effects. Prior to the summer of 1970 commercial fishing with trap nets was quite intensive. These large mesh nets would tend to select for the larger, faster growing fish and allow greater survival of the smaller fish of a given age.

The overall mean coefficient of condition for the yellow perch was 1.14 which was as low as the lowest mean K reported for Great Lakes yellow perch (Hile and Jobes, 1942), (Jobes, 1952). The problem with comparing mean K's from these various studies is seen in the marked seasonal trend in K for the fish in the present study. A similar but less pronounced trend was previously reported in Lake Erie perch by Jobes, 1952, who showed for the year 1928 and 1929 that K increased from 1.12 in May to 1.23 in August and decreased to 1.16 in October.

If in this study only fish collected in the month of August had been used to calculate the mean K, this value would have been greater than that found in any other previous study on the Great Lakes.

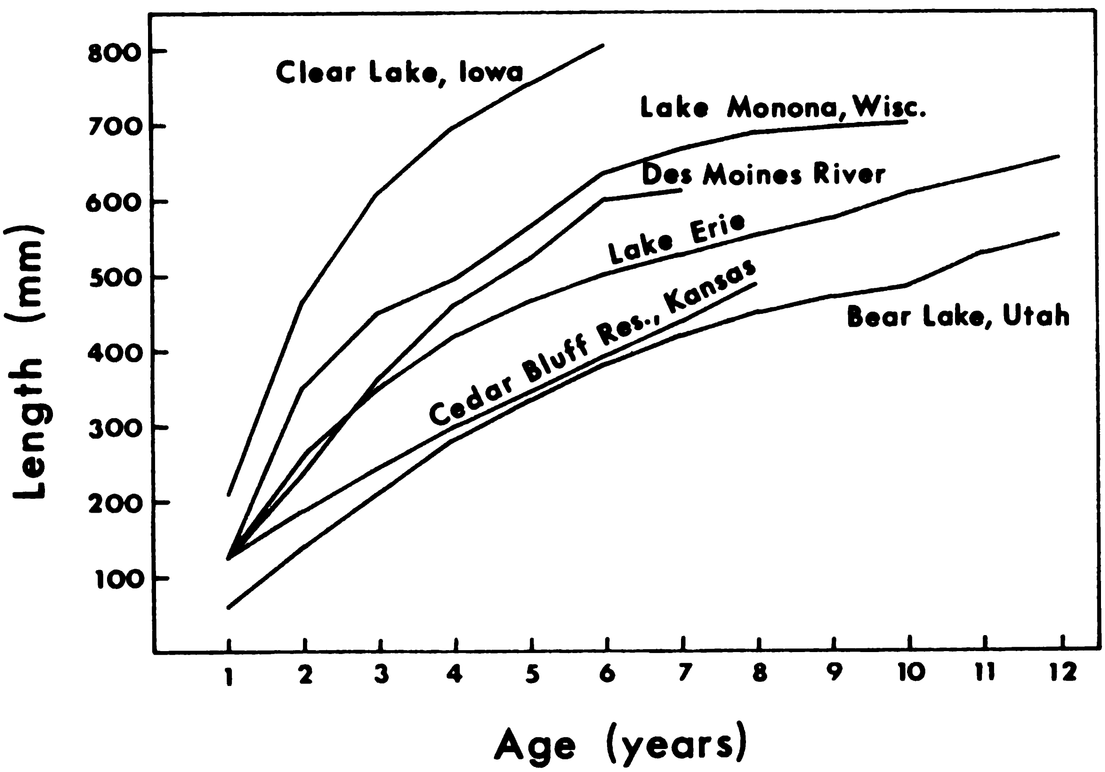
Carp

A pronounced reversed Lee's Phenomenon is seen in the back-calculated lengths of the carp. A reversed Lee's Phenomenon is thought to be caused by size selective mortality that bears more heavily on the smaller fish of an age group (Tesh, 1968), and favors survival of the faster growing fish.

The inhibited first year's growth in carp has also been reported in Utah, (Shields, 1958) and Wisconsin (Frey, 1940). The factors that inhibit growth in western Lake Erie are unknown but may result from high densities of juvenile carp and goldfish in the marshy carp spawning areas that abound along the shores of western Lake Erie. High densities have been found to inhibit carp growth even in areas of high food abundance (Robel, 1962). The competition between these species may be severe as juvenile carp and goldfish have similar feeding habits. This competition could result in a lower survival of smaller carp which would cause the reversed Lee's Phenomenon. The increased growth rate seen in the carp during the second year of growth is probably the result of migration of the carp into the open areas of the lake where density would be less of a problem. Adult carp feed primarily on bottom fauna (Moen, 1954) while goldfish feed on phyto-plankton (Shimodate et al, 1957) thus there is probably less competition between these species as adults.

The growth rate of Lake Erie carp was about average when compared to what has been reported from the northern United States (Figure 17).

Figure 17. Calculated growth of carp from several areas of the United States. Clear Lake, Iowa (English, 1952); Lake Monona, Wisconsin (Frey, 1940); Des Moines River (Rehder, 1959); Cedar Bluff Res., Kansas (Stucky and Klaassen, 1971); Bear Lake, Utah (Shields, 1958).


Clear Lake, Iowa
Lake Monona, Wisc.
Des Moines River
Lake Erie
Cedar Bluff Res., Kansas
Bear Lake, Utah
800
700
600
500
400
300
200
100
Length (mm)
1
2
3
4
5
6
7
8
9
10
11
12
Age (years)

Within the United States there is little evidence of regional differences in carp growth rates or in their length-weight relationships (Carlander, 1969). Though not enough fish were sexed to determine if there were differences in the growth of the sexes, Carlander, (1969) reported about half the studies in the United States showed no differences while the other half reported faster growth of females.

Most investigators reporting coefficient of condition (K) have not considered the many factors affecting this parameter. K may vary with season, sex, maturity, age and various other factors (Carlander, 1969). This has made it impossible to make reliable comparisons of the K calculated for Lake Erie carp with that calculated for other populations.

Young of the Year

The seasonal growth of the six species of young of the year collected in the study area was near or above that previously reported for these species in Lake Erie and reflects an adequate food supply for young fish in this area. Gizzard shad was the only species to show a much slower growth. Bodola (1964) reported that Lake Erie age 0 gizzard shad grew to 193 mm by October for the year 1952-1955. Bodola (1964) collected his fish from the Bass Islands of Lake Erie using a wide variety of methods, so his results are probably quite representative for those years. Baker and Scholl (1970) reported that an average of 4% of their trawling survey catch over the last ten years from the Ohio waters of Lake Erie was gizzard shad. In the present study, 26% of the catch was gizzard shad and this higher percentage may reflect a higher density of gizzard shad which may have resulted in the lower growth for gizzard shad in this area (125 mm).

The growth of age 0 Lake Erie gizzard shad in 1970 was near average when compared to other areas of the United States (Carlander, 1969).

Van Oosten (1942) reported a substantially higher seasonal growth for age 0 Lake Erie white bass. His use of fish from commercial trap nets probably biased his results toward the larger, faster growing fish (Latta, 1959). The growth of age 0 white bass reported by Baker and Scholl, 1970 was similar to that for the present study, and has not varied substantially over the last ten years. The seasonal growth of age 0 alewifes and spottail shiner (Baker and Scholl, 1970) were very similar to those from the study area and are near the mean values reported for the United States, (Carlander, 1969). Age 0 sheepshead growth was similar to that reported by Edsall (1967) but was lower than what has been reported throughout most of the United States. He thought that the high abundance of sheepshead now abundant in Lake Erie are responsible for this. Sheepshead have become much more abundant in the lake since the decline of all the major predator species.

SOME PROBABLE EFFECTS OF THE HEATED EFFLUENT ON THE STUDY AREA

The Monroe power plant may potentially affect the fish populations within the study area by the direct effects of the heated effluent and the rerouting of the discharge canal. The heating of the river water may cause a long period of severe oxygen depletion in the discharge canal during the warmer months of the year. This may severely limit the use of the discharge canal by most species.

The shoal station will become a mixing ground for the heated water. The heated water may attract fish during the colder months (Trembly, 1961) and will probably repulse them during the warmer months. The addition of the river water to this area will provide a richer environment which could result in higher numbers of fish.

The rerouting of the river water away from the north lake station may reduce the nutrient input to this area and could conceiveably reduce the carrying capacity for fish. The effects of the heated water may be only minimal at this station except possibly during temporary periods when the plume is pushed up along the shore by offshore winds.

The river station may be affected by lake water being pulled up the river channel and through the power plant for cooling purposes. The influx of oxygen rich lake water into the river channel would probably result in many lake species moving into and utilizing this area.

The south lake station, due to its greater distance from the source of heated water, will probably be unaffected.

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