THE BENTHIC MACROINVERTEBRATE POPULATIONS IN A NEW PUMPED STORAGE RESERVOIR AND THE ADJACENT COASTAL AREAS OF CENTRAL LAKE MICHIGAN

Thesis for the Degree of M. S.

MICHIGAN STATE UNIVERSITY
GREGORY R. OLSON

1974

THE BE
IN A

The purpose of
construction and oper
Plant would have on
adjacent coastal are
macroinvertebrate po
Michigan coastal are
and in 1973 during p
zation of the reser
impoundment in Octo

These benthic
grab and artificial
sampling used modif
samplers.

The seven ma
Lake Michigan were
midae; Gastropoda;
group in abundance

ABSTRACT

THE BENTHIC MACROINVERTEBRATE POPULATIONS
IN A NEW PUMPED STORAGE RESERVOIR AND
THE ADJACENT COASTAL AREAS OF
CENTRAL LAKE MICHIGAN

By

Gregory R. Olson

The purpose of this study was to determine what effects the construction and operation of the Ludington Pumped Storage Reservoir Plant would have on the benthic macroinvertebrate populations of the adjacent coastal areas of Lake Michigan and what type of benthic macroinvertebrate populations would develop in the reservoir. The Lake Michigan coastal areas were studied in 1972 before plant operation and in 1973 during plant operation. The benthic invertebrate colonization of the reservoir was examined from the initial filling of the impoundment in October, 1972 through one season operation in 1973.

These benthic populations were sampled by a combination of Ponar grab and artificial substrate sampling. The artificial substrate sampling used modified Hester-Dendy multiple plate and rock basket samplers.

The seven major benthic macroinvertebrate groups sampled from Lake Michigan were: Oligochaeta; Ostracoda; Amphipoda; Acari; Chironomidae; Gastropoda; and Pelecypoda. Chironomid larvae were the dominant group in abundance and regularity from the coastal Lake Michigan areas.

Macroinvertebrate grc

were: Nematoda; Hiru

and Trichoptera.

Single classifi

groups indicated that

pelecypod populations

certain sampling stat

least one group's cha

population comparison

indicated that shallo

June and July-August

were more variable be

reflected the great

major benthic group.

The Ludington

organisms from the a

pled were: Oligoch

Gastropoda. The oli

collected, and they

1973. Benthic group

Hirudinea; Collembol

Ceratopogonidae.

Physical and c

indicated the reservo

6 8086

Gregory R. Olson

Macroinvertebrate groups collected with less abundance and regularity were: Nematoda; Hirudinea; Mysidacea; Isopoda; Decapoda; Ephemeroptera; and Trichoptera.

Single classification analyses of variance of the major benthic groups indicated that oligochaete, ostracod, amphipod, water-mite and pelecypod populations differed significantly between 1972 and 1973 at certain sampling stations, with four of the six stations registering at least one group's change. The percentage composition of the benthic population comparisons using Spearman rank correlation coefficients, indicated that shallower Lake Michigan sampling stations, and the May-June and July-August sampling periods had benthic populations which were more variable between 1972 and 1973. An index of dispersion also reflected the great variation between seasons and stations for each major benthic group.

The Ludington Pumped Storage Reservoir was colonized by benthic organisms from the adjacent Lake Michigan area and the major taxa sampled were: Oligochaeta; Isopoda; Amphipoda; Acari; Chironomidae; and Gastropoda. The oligochaetes and chironomids were the first two taxa collected, and they became the dominant forms in the reservoir for 1973. Benthic groups found with less abundance and regularity were: Hirudinea; Collembola; Ephemeroptera; Trichoptera; Coleoptera; and Ceratopogonidae.

Physical and chemical parameters, recorded of the reservoir water, indicated the reservoir benthic organisms were affected by approximately the same water conditions as the adjacent Lake Michigan benthic populations. The chemical composition of the reservoir sediments was analyzed throughout 1973 and no significant changes in percentages of total carbon, hydrogen, and nitrogen on a dry weight basis were determined.

Detailed identification of the benthic taxa revealed specific distributions and relationships. A large number of immature oligochaetes at the sampling stations indicated either an unusual survival of the young or an unusual mortality of the adults. The protective jetties and breakwall area in Lake Michigan has provided microhabitats which have attracted macroinvertebrates not found at the other sampling areas. *Gammarus fasciatus* Say and *G. pseudolimnaeus* Bousfield amphipods were found only on the jetties and breakwall in Lake Michigan.

The constructional disturbance and operational effect of the Ludington Pumped Storage Plant on the Lake Michigan benthic macroinvertebrate populations could not be distinguished because this study was started after plant construction had begun. Following the construction and first season of operation, this plant has not had major detrimental effects on the adjacent Lake Michigan benthic macroinvertebrate communities.

THE BENTHIC MACROINVERTEBRATE POPULATIONS IN A NEW PUMPED STORAGE RESERVOIR AND THE ADJACENT COASTAL AREAS OF CENTRAL LAKE MICHIGAN

By

Gregory R. Olson

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Fisheries and Wildlife

1974

ACKNOWLEDGEMENTS

I wish to express great appreciation to Dr. P. I. Tack for providing me with this research opportunity, taking a sincere interest in my study, and assisting me in overcoming various obstacles. Appreciation is expressed to the members of my graduate committee, Drs. P. I. Tack (Chairman), R. C. Ball, W. H. Conley, and T. W. Porter for their support and constructive criticism. I thank Dr. T. W. Porter, for his special hints in the identification of the samples and his supportive attitude toward me.

I acknowledge Dr. C. R. Liston for designing this study's initial sampling scheme and I extend thanks for his beneficial suggestions in the organization of this manuscript. Special thanks are due my fellow graduate students, J. W. Armstrong, D. C. Brazo, T. L. Chiotti, L. A. Green, W. G. Duffy, F. R. Hauer, and D. J. Lechel, for helping collect the data. I am grateful to the late Russell Moran for his assistance in the construction of the samplers used in this study.

I thank Ms. C. Force for her expertise in preparing the graphics for this manuscript. Appreciation is expressed to Drs. E. L. Bousfield, G. A. Cole, D. R. Cook, K. W. Cummins, L. L. Curry, C. J. Goodnight, D. L. McGregor, R. E. Snyder, and M. G. Ward for their assistance and verification of the taxonomic identification of certain macroinvertebrates from my samples.

Acknowledgement is made to Consumers Power Company of Michigan for their funding of this research and to the Department of Fisheries and Wildlife of Michigan State University for providing me with a research assistantship.

Finally, I thank my wife, Joanne, for her encouragement, support, and understanding in the past two years; I feel truly fortunate.

TABLE OF CONTENTS

TABLE OF CON

TABLE OF CONTENTS--continued Page

LIST OF TABLES

LIST OF FIGURES

LIST OF F[illegible]

FIGURE

LIST OF FIG

FIGURE

The Depa

University, th

Consumers Powe

tal study to a

electric Plant

determine what

Physical param

transparency a

reservoir. Ch

dissolved soli

The aquatic or

periphyton, ph

fish.

Dr. Pet

State Univers

Charles R. Li

coordinator o

lected by an

captain.

INTRODUCTION

The Department of Fisheries and Wildlife of Michigan State University, through Dr. Peter I. Tack, contracted in 1971 with Consumers Power Company of Michigan to conduct a six-year environmental study to assess the impact of its Ludington Pumped Storage Hydroelectric Plant on the adjacent coastal Lake Michigan areas and to determine what aquatic populations would colonize the reservoir. Physical parameter studies of air and water temperatures, and water transparency and turbidity would be made in Lake Michigan and the reservoir. Chemical studies of pH, dissolved O_2, alkalinity, and dissolved solids would also be made in Lake Michigan and the reservoir. The aquatic organism population studies would include surveys of periphyton, phytoplankton, zooplankton, benthic invertebrates and fish.

Dr. Peter I. Tack, Fisheries and Wildlife Department of Michigan State University, is the supervisor of this research project and Dr. Charles R. Liston, also of Michigan State University, is the field coordinator of these environmental studies. The field data were collected by an average of four graduate research assistants with a boat captain.

The be

Pumped Stora

Michigan is

Food Source

Benthi

are an essen

organism pop

other aquati

Environmenta

The de

tion and pos

coastal area

the benthic

in and out o

istic enviro

in compositi

rather than

brates provi

aquatic area

changes in t

Wilhm, 1967).

Purpose of the Study

The benthic macroinvertebrate population study of the Ludington Pumped Storage Reservoir and the adjacent coastal areas of Lake Michigan is warranted for several reasons.

Food Source

Benthic macroinvertebrates, sometimes termed fish-food organisms, are an essential food source in aquatic ecosystems. The benthic organism population composition and abundance influence and support other aquatic populations.

Environmental Condition Indicator

The determination of the environmental effects of the construction and possibly the operation of the reservoir on the adjacent coastal areas of Lake Michigan can be evaluated most effectively by the benthic macroinvertebrate populations. Fish and plankton movement in and out of these areas makes them less reflective of the characteristic environmental conditions. The benthic organism population changes in composition and abundance in relation to the environmental conditions rather than by temporarily leaving the area. Benthic macroinvertebrates provide a good indicator of the environmental conditions of an aquatic area by their particular population composition and by the changes in their relative abundances (Simpson, 1949; Gaufin, 1956; Wilhm, 1967).

Lake Mic

Th

knowledg

research

investig

samples

to 117 m

vertebra

abundant

study wh

comprehe

brates.

collecte

the domi

Th

brates i

benthic

Powers,

dominate

Michigan

Herringt

abundanc

Michigan

We

bottom d

the night

Lake Michigan Research Opportunity

This study is also warranted because of the relatively meager knowledge of Great Lakes benthic populations. Most of this benthic research has been accomplished in the past several decades. An early investigation made by Stimpson (1870) reported findings from dredge samples taken in southern Lake Michigan near Chicago in water from 27 to 117 m depth. Eggleton (1936 and 1937) found the deep-water macro-vertebrates, Pontoporeia sp., Tubificidae, and Sphaeriidae, the most abundant benthic organisms from samples taken in 1931 and 1932. This study which used samples from many areas of Lake Michigan was the first comprehensive investigation of the Lake Michigan benthic macroinvertebrates. Merna (1960) studied Lake Michigan benthic invertebrates collected from 1951 to 1955, finding Pontoporeia affinis (Lindstrom) the dominant organism.

The effect of the St. Joseph River on the benthic macroinvertebrates in the adjoining area of Lake Michigan was compared with the benthic community off Little Sable Point south of Ludington (Cook and Powers, 1964). Powers and Robertson (1965) found that amphipods dominated the benthic macroinvertebrates in the northern part of Lake Michigan and oligochaetes dominated in the southern part. Henson and Herrington (1965) found relationships between the sediment type and abundance of different species of Sphaeriidae (Mollusca) of Lake Michigan in the Straits of Mackinac.

Wells (1968a and 1968b) concluded that P. affinis burrows into the bottom during the daytime and migrates into the water column during the night. Robertson and Alley (1966) investigated the deep-water macrobenthos using methods similar to those of Eggleton for comparative purposes. They found more Pontoporeia sp., oligochaetes, and Sphaeriidae in 1964 than Eggleton had 30 years earlier. The species diversity of sphaeriids decreases with increasing depth in Lake Michigan (Robertson, 1967). Hiltunen (1967) corrected the taxonomic identification of Lake Michigan oligochaetes which had been incorrectly grouped as Tubificidae in several previous studies.

Alley (1968) found P. affinis distributed on the bottom in relation to water depth with maximum concentration at 35 m. The zonation and distribution of benthic macroinvertebrates in the coastal zone of southeastern Lake Michigan were investigated by Mozley and Garcia (1972), who found a clear gradient in total abundance and species composition. Modlin and Gannon (1973) investigated the ecology and distribution of water-mites in the St. Lawrence Great Lakes. They found species of Lebertia and Hygrobates to predominate their samples.

Armstrong (1973), a fellow graduate research assistant on the Ludington Pumped Storage Plant research project, found chironomids were the major food item eaten by round whitefish, Proposium cylindraceum (Pallas), in the adjacent Lake Michigan areas. Snails, leeches, and crayfish were other food items. Brazo (1973), another fellow graduate assistant on this project, found amphipods were the major food item of the yellow perch, Perca flavescens (Mitchill), from 135-235 mm total length; and fish and crayfish were the major food items in larger perch.

Reservoir Research Opportunity

This benthic study also provides an opportunity to determine what benthic macroinvertebrates would colonize the reservoir from a large inland body of water like Lake Michigan. Most reservoir macroinvertebrate studies have dealt with colonization in newly constructed river reservoirs. The Russian research and literature have covered large river reservoirs with appreciable currents passing the length of the basin. Ozhegova (1962) studied the pattern of macroinvertebrate colonization in Kairak-Kumsk Reservoir, a Russian river reservoir, during the first year of its existence. Sokolova (1963) made a similar study of Mozhaisk Reservoir, during the first year of its existence. These two studies exemplify the macroinvertebrate reservoir research in the literature. Because the emphasis in the Russian literature has been on large river reservoirs with appreciable currents, direct comparison with a pumped storage reservoir is inappropriate.

Fragmentary information on the macroinvertebrate populations in North American reservoirs is available from studies of established older reservoirs. Nursall (1952) studied the development of the benthic fauna in a mountain reservoir in Alberta from May, 1947, shortly after the initial filling of the impoundment, through June, 1949. Later, Fillion (1967) studied the macroinvertebrate community of this same Alberta reservoir from 1960 to 1962 and compared his findings with those of Nursall's earlier study. Again, these two studies cannot be directly compared with pumped storage reservoirs which have a different flow pattern than river reservoirs.

Objective of the Study

The objectives of this study were to determine what effects the construction and operation of the Ludington Pumped Storage Plant would have on the adjacent Lake Michigan benthic populations and to determine the colonization rate of benthic macroinvertebrates in the new reservoir.

The Lake Michigan segment of this study will compare the data from May to October, 1972 (pre-operational), to data taken during the first year of plant operation, May to October, 1973. The macroinvertebrate colonization of the reservoir was studied from the initial filling of the reservoir in October, 1972, through November, 1973. The reservoir benthic communities that developed will be compared to the benthic populations sampled from the adjacent Lake Michigan study areas.

Limitations of the Study

The construction of this plant was started several years before these environmental studies began in the adjacent coastal Lake Michigan areas. Thus, the study was conducted in an altered or disturbed area. Because little baseline data is available on the pre-constructional environmental conditions of this area, changes in the benthic population from 1972 to 1973 may have resulted from the construction disturbance rather than plant operation. The distinction between construction and operation disturbance of the benthic populations is important. However, the lack of baseline data on the benthic macroinvertebrates before construction makes it difficult to assess whether the operation of the plant is affecting these populations.

Sampling Problems and Schedule

Lake Michigan is very difficult to sample because of recurrent high wind and wave conditions, and sampling sites were often inaccessible for field work. These wind and wave conditions particularly affected the macroinvertebrate sampling because relatively calm conditions are necessary to operate the Ponar grab-sampler and to collect the artificial substrate samplers. The resulting incomplete sampling schedules make comprehensive statistical evaluations of the benthic macroinvertebrate populations difficult.

The time table of the Lake Michigan and reservoir sampling of this study (Figure 1) shows the relationships and durations of the different sampling methods used in the two seasons.

Description of the Power Plant

The Ludington Pumped Storage Hydroelectric Plant was constructed jointly by the Consumers Power and Detroit Edison companies of Michigan for the purpose of assuring their clientele an adequate supply of electrical power at times of maximum energy demand. This plant, the largest of its kind in existence with the reservoir approximately 4.0 km long and averaging 1.2 km wide, is located on the shore of Lake Michigan 6.4 km south of Ludington, Michigan (Figure 2). The pumped storage reservoir plant functions by pumping water from Lake Michigan up into the reservoir which has a maximum water level of 106.7 m above the Lake Michigan water level. The reservoir is filled with water by pump-turbines, using electricity from existing electrical energy reserves for

Figure 1. Sampling schedule of Lake Michigan and Ludington Pumped Storage Reservoir for 1972 and 1973.

BENTHIC MACROINVERTEBRATE SAMPLING SCHEDULE

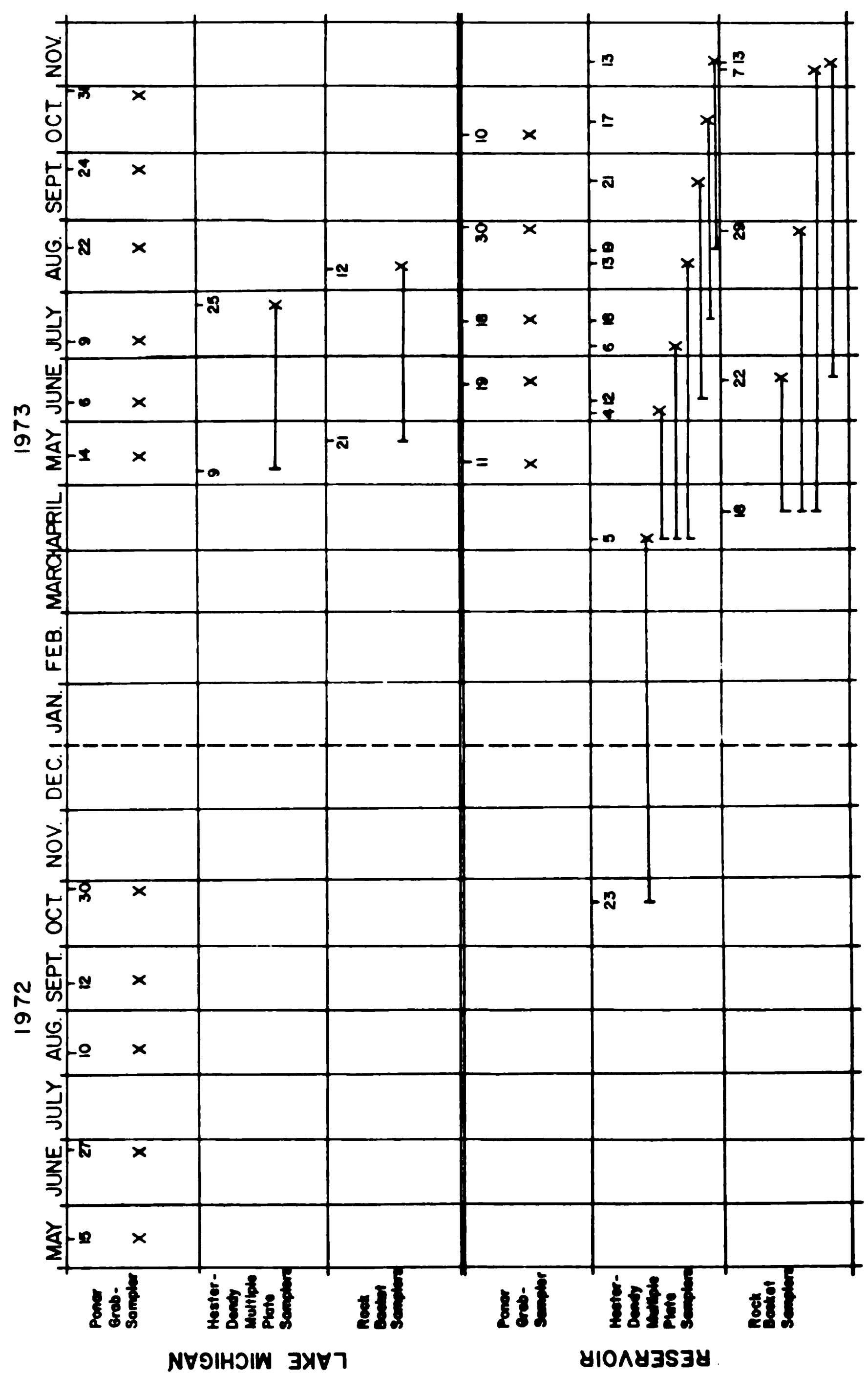


Figure 1

Figure 2. Diagram of the Ludington Pumped Storage Plant showing sampling stations (1-6), and offshore protective rock jetties and breakwall.

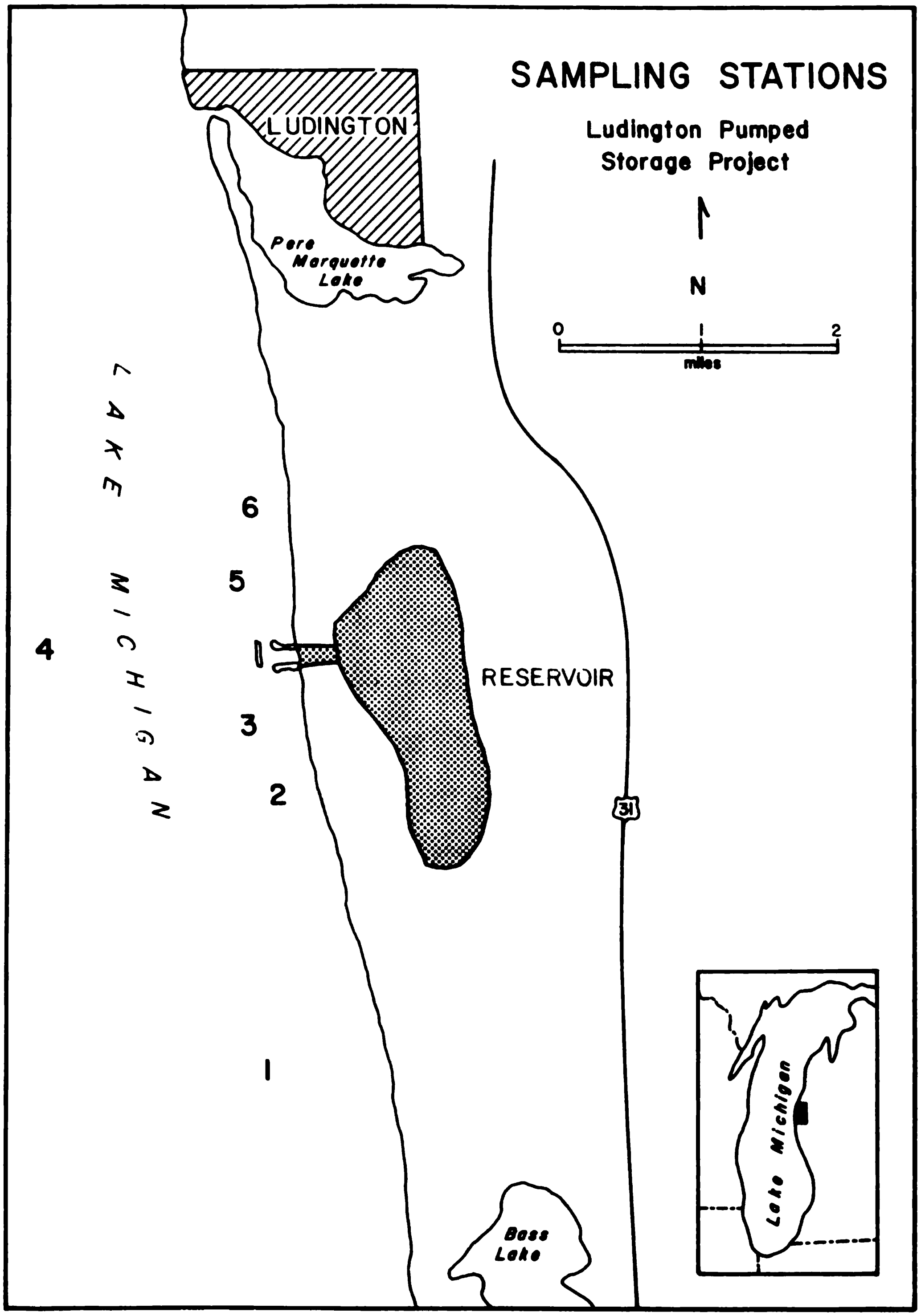

SAMPLING STATIONS
Ludington Pumped Storage Project
N
0
1
2
miles
LUDINGTON
Pere Marquette Lake
LAKE MICHIGAN
6
5
4
1
3
2
1
RESERVOIR
31
Bass Lake
Lake Michigan

Figure 2

pumping during low

by water flowing ba

peak demand periods

Six Francis-t

between Lake Michig

which are 8.7 m in

end. Two large roc

Michigan plant fac

compacted clay, ex

diameter limeston

voir has an aspha

in maximum depth

hectares when ful

meters of water.

power generation

m in one day. W

kw are produced,

non-industrial

pumping during low energy demand times. Electrical generation occurs by water flowing back down to Lake Michigan turning turbines during peak demand periods.

Six Francis-type reversible pump-turbines transfer the water between Lake Michigan and the reservoir through six large penstocks which are 8.7 m in diameter, tapering to 7.3 m at the Lake Michigan end. Two large rock jetties and a breakwall protect the onshore Lake Michigan plant facilities. The reservoir bottom consists mainly of compacted clay, except for a scour protection area composed of 0.3 m diameter limestone rocks in front of the intake structure. The reservoir has an asphalt-lined embankment averaging 32.9 m in height, varies in maximum depth from 32.0 to 34.1 m, has a surface area of 340.8 hectares when full, and has a maximum volume of 102 million cubic meters of water. Of this total volume, 64 million cu m are usable for power generation and the surface level may be lowered by 12.2 to 15.2 m in one day. When all six units are generating, a maximum of 1,872,000 kw are produced, enough to meet the needs of a 2.5 million population non-industrial city for eight hours.

The Lake Mi

page 11, and desc

The benthi

grab-sampler, mod

basket samplers

of Lake Michigan

monthly basis at

October in 1972

was placed at ea

two months. The

sampled by 16 ro

removed after th

storms. Samplin

Figure 3.

The multip

by Hester and De

board plates spa

area of 1.12 m^2 (

LAKE MICHIGAN STUDY

Sampling Stations

The Lake Michigan sampling stations are shown in Figure 2, on page 11, and described in Table 1, on the following page.

Methods and Materials

The benthic macroinvertebrate samples were collected by a Ponar grab-sampler, modified Hester-Dendy multiple plate samplers, and rock basket samplers to analyze the different habitats in the coastal areas of Lake Michigan. Triplicate Ponar grab samples were taken on a monthly basis at the six Lake Michigan stations from May through October in 1972 and 1973. On May 9, 1973, one multiple plate sampler was placed at each of the six Lake Michigan stations and sampled after two months. The offshore protective rock jetties and breakwall were sampled by 16 rock basket samplers placed May 21, 1973, and two were removed after three months. The other samplers were lost because of storms. Sampling sites on these offshore structures are shown in Figure 3.

The multiple plate samplers, a modification of the one described by Hester and Dendy (1962), were constructed of fourteen 20 cm^2 hard-board plates spaced vertically along a metal rod having a total surface area of 1.12 m^2 (Figure 4). Rock basket samplers were constructed of

Table 1. Description of Lake Michigan Sampling Stations

Stations	*Location*	*Depth*	Bottom Sediments
		12 m	fine sand and some gravel

Table 1. Description of Lake Michigan Sampling Stations

Stations	Location		Depth	Bottom Sediments
1 (control area)	43°51'00" N Lat.* 86°27'20" W Long.*	4.8 km S of plant breakwall	12 m	fine sand and some gravel
2	43°52'45" N Lat. 86°26'50" W Long.	1.6 km SSE of plant south jetty	8 m	fine sand with some large rocks and boulders
3	43°53'05" N Lat. 86°27'20" W Long.	0.8 km S of plant breakwall	14 m	sand to gravel with some rock beds
4	43°53'30" N Lat. 86°27'35" W Long.	2.4 km WSW of plant breakwall	24 m	fine clay to silt with some sand
5	43°54'20" N Lat. 86°27'35" W Long.	0.8 km NNW of plant breakwall	12 m	coarse sand and fine gravel with large boulders
6	43°54'50" N Lat. 86°27'10" W Long.	1.6 km N of plant north jetty	6 m	fine sand with a bed of rocks and some boulders

*Latitude and longitude values were determined from a location map reproduced from U. S. Lake Survey Chart #77 by Ebasco Engineering Corporation with the seconds being approximate.

Figure 3. Sampling stations in the Ludington Pumped Storage Reservoir, and on the protective rock jetties and breakwall in Lake Michigan (X's = rock basket samplers).

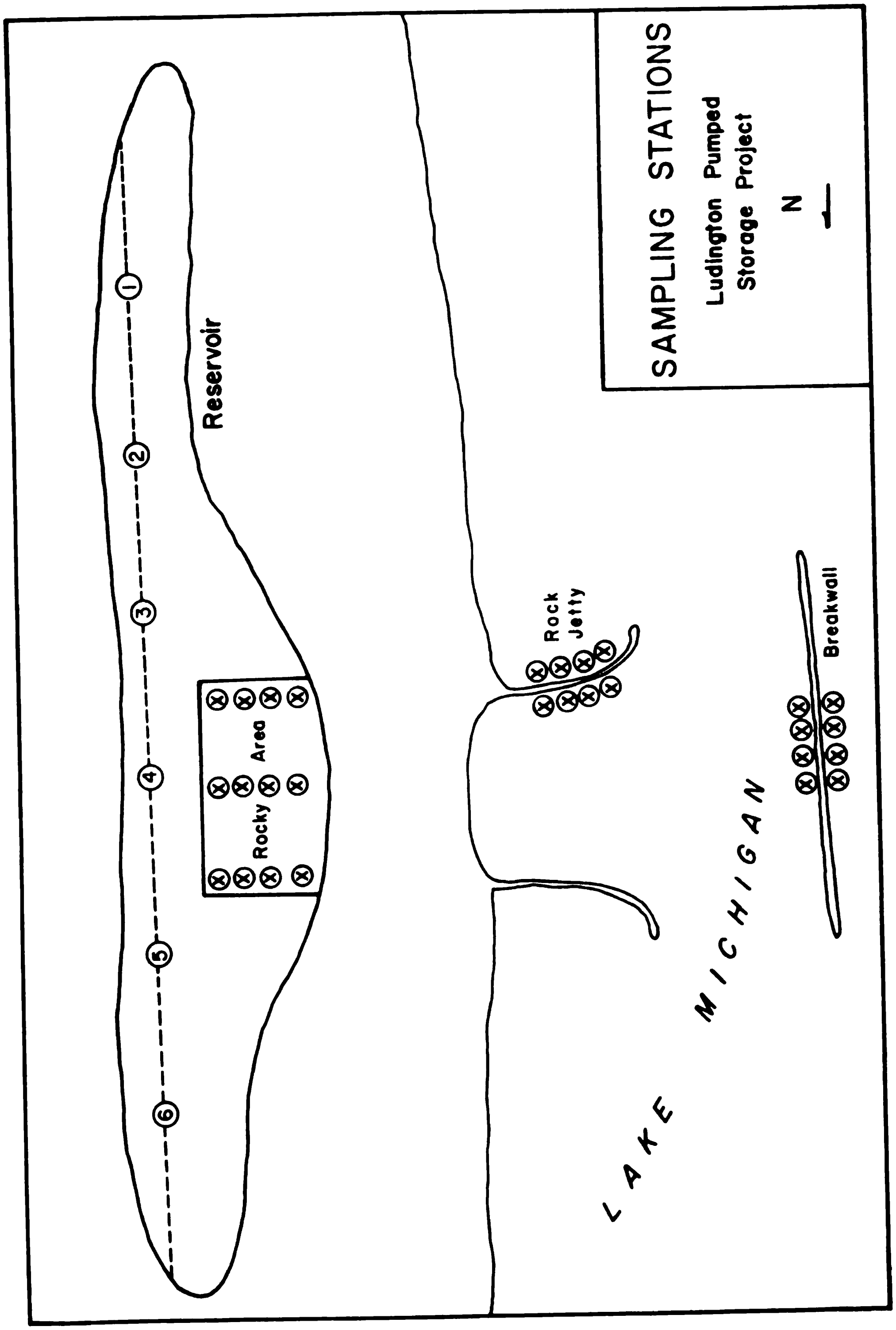

SAMPLING STATIONS
Ludington Pumped
Storage Project
N
Reservoir
1
2
3
4
5
6
Rocky Area
Rock Jetty
Breakwall
LAKE MICHIGAN

Figure 3

Figure 4. Modified Hester-Dendy multiple plate sampler and rock basket sampler.

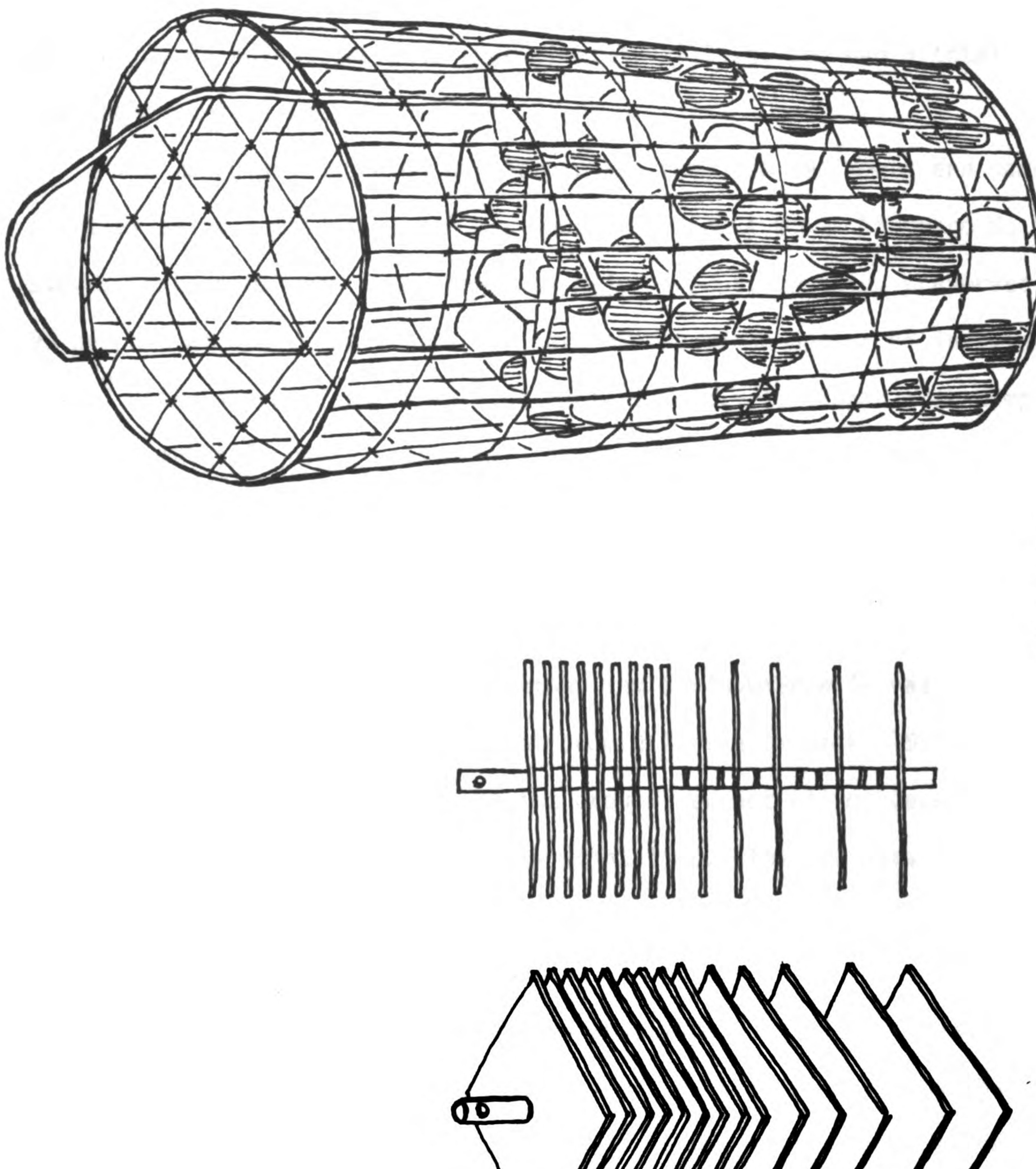


Figure 4

wire mesh shaped into cylinders supported by an iron rod frame, and were filled with concrete cylinders of two sizes: 9 cm tall, 7 cm diameter; 6 cm tall, 4 cm diameter (Figure 4). The basket samplers were 68 cm in height, weighed approximately 22.5 kg, and had a total substrate surface area of 0.76 m^2.

The macroinvertebrates were separated from the sediments and samplers by being washed in a tub and poured through a U. S. Standard No. 30 sieve. Organisms were separated into major groups, counted, preserved in 95 percent alcohol, identified and then expressed in number of individuals/m^2 using appropriate conversion factors: 18.9 for Ponar grab-sampler; 0.89 for multiple plate samplers; 1.32 for rock basket samplers.

Identifications were made using several taxonomic keys: oligochaetes (Hiltunen, 1973); ostracods, isopods, mysids, water-mites, gastropods and pelecypods (Pennak, 1953); amphipods (Pennak, 1953 and Bousfield, 1958); ephemeropteran nymphs and trichopteran larvae (Pennak, 1953; Day, 1971; Denning, 1971); chironomid larvae (Roback, 1957 and Mason, 1973). These benthic organism groups, except oligochaetes and chironomid larvae, were individually identified. The raw data from the Lake Michigan Ponar grab and artificial substrate sampling are appended.

The oligochaetes were subsampled when more than 30 individuals were present in one sample; the majority of the samples had less than 30 individuals/sample. A random subsample of one-half of each larger sample was identified, and the results were applied to the entire sample proportionately. The oligochaete specimens were processed, mounted and identified according to Hiltunen (1973).

Identification of the chironomid larvae involved grouping the specimens according to size, color and macroscopic morphological features. Representatives of each of the groupings were mounted and identified with the number of individuals in each group recorded on the slide. All the members of each grouping were given the same identification as the representative slide; more than one representative slide was made of a grouping to check the homogeneity of the grouping.

Precision of Figure Values

The organism group percentages on the figures have a 0.01 level of precision because of the conversion factors used for organisms/m^2. Incidental macroinvertebrates in the composition of the population would be eliminated in the figures if the percentages were rounded to the 0.1 level and these incidental organisms should be represented to accurately reflect the entire population composition.

Lake Michigan Physical and Chemical Studies

Water Temperature Results

Surface and bottom temperature readings made during 1972 and 1973 are shown in Figures 5, 6 and 7. Because temperatures at similar depth stations varied only slightly on all the 1972 sampling dates, data from stations one, three, and five (12-14 m depth) and from stations two and six (6-8 m depth) were combined and average values were calculated (Figure 5). Station four (24 m depth) water temperatures were plotted separately (Figure 5).

The 1973 Lake Michigan surface and bottom temperatures were plotted for each station (Figures 6 and 7).

Temperatures were homothermous and lowest April 3, 1972 (2.0-2.5 C) and April 13, 1973 (3.2 C). Water temperatures increased very irregularly to maximum values August 28, 1972 (20 C) and August 13, 1973 (23 C). The 1973 season had warmer minimum and maximum water temperatures with the rate of change more rapid. Bottom temperatures lagged behind surface temperatures especially at station four in both seasons. Temperatures at station four showed indications of varying independently from the other stations; temperatures increased from May 23 to June 2, 1972 at both surface and bottom depths at all stations except station four where the surface temperature decreased from 10.8 to 6.9 C (Figure 5).

The erratic water temperature data during the warming period of both seasons was caused mainly by the upwelling and displacement of colder, deeper water. The bottom temperatures in the Lake Michigan

Figure 5. Average surface and bottom water temperatures at Lake Michigan sampling stations during 1972.

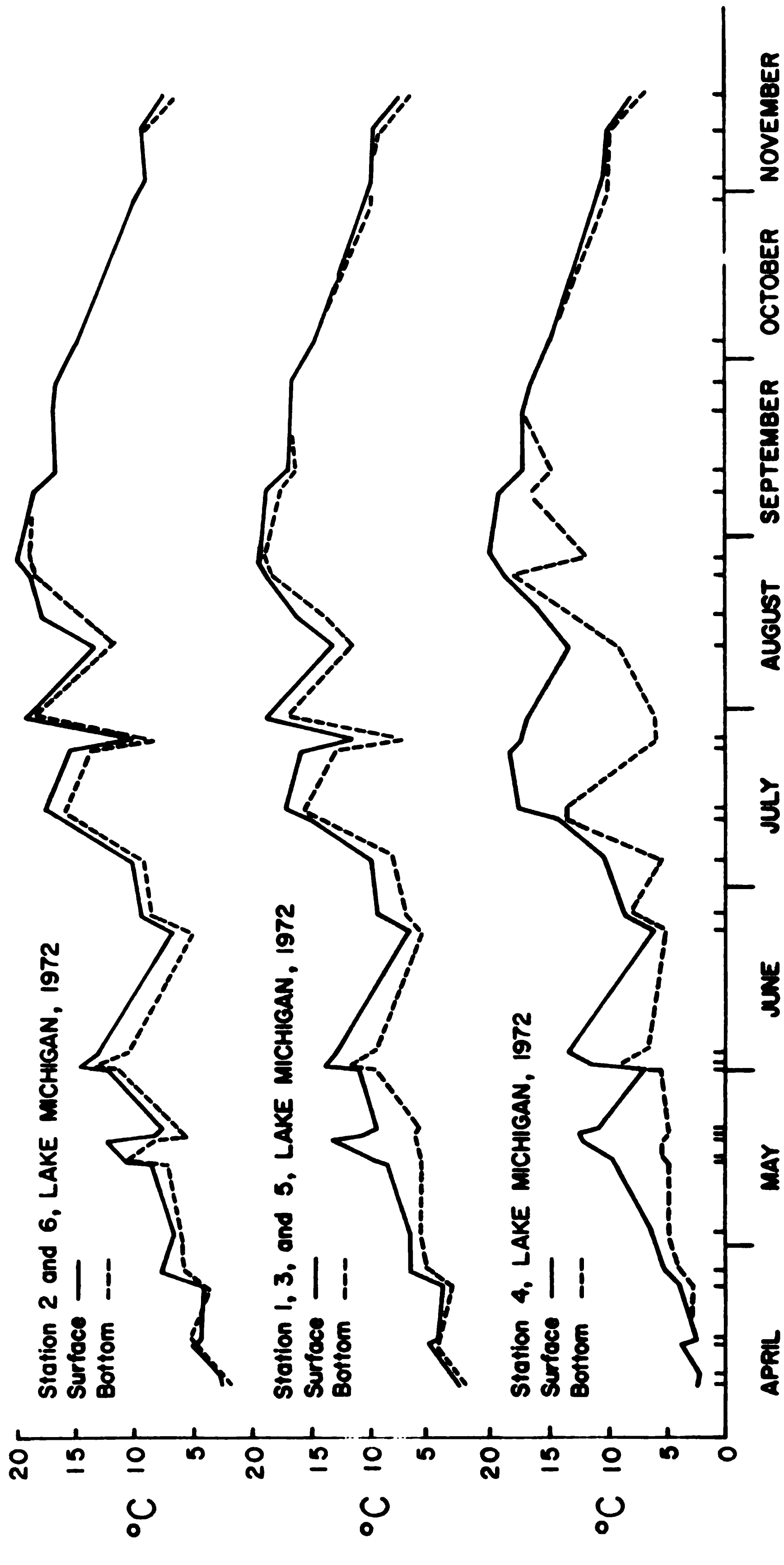
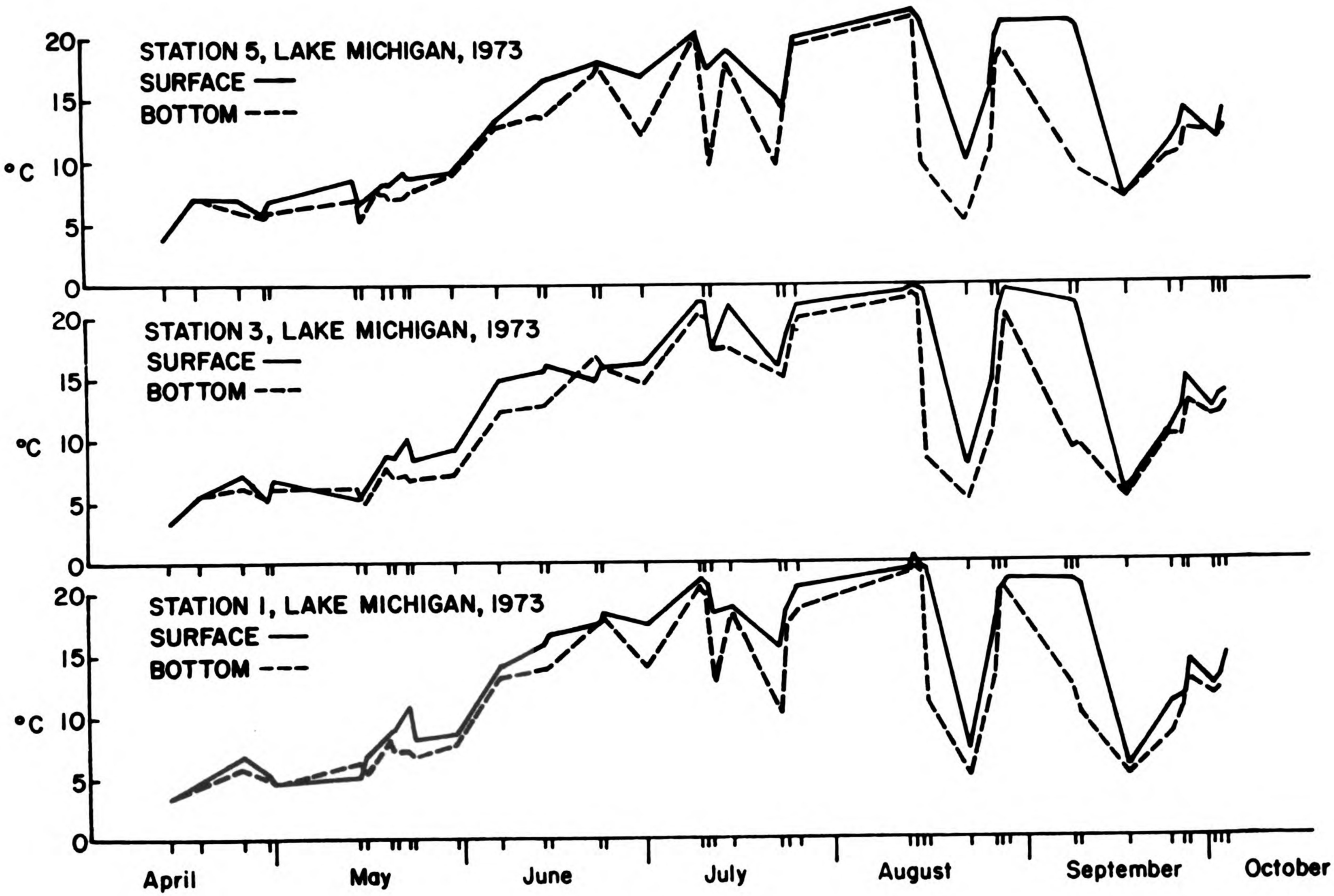

Station 2 and 6, LAKE MICHIGAN, 1972
Surface
Bottom
Station 1, 3, and 5, LAKE MICHIGAN, 1972
Surface
Bottom
Station 4, LAKE MICHIGAN, 1972
Surface
Bottom
°C
20
15
10
5
0
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER

Figure 5

Figure 6. Average surface and bottom water temperatures at Lake Michigan sampling stations one, three, and five during 1973.



STATION 5, LAKE MICHIGAN, 1973
SURFACE ——
BOTTOM ----
STATION 3, LAKE MICHIGAN, 1973
SURFACE ——
BOTTOM ----
STATION 1, LAKE MICHIGAN, 1973
SURFACE ——
BOTTOM ----
°C
0
5
10
15
20
April
May
June
July
August
September
October

Figure 6

Figure 7. Average surface and bottom water temperatures at Lake Michigan sampling stations two, four, and six during 1973.

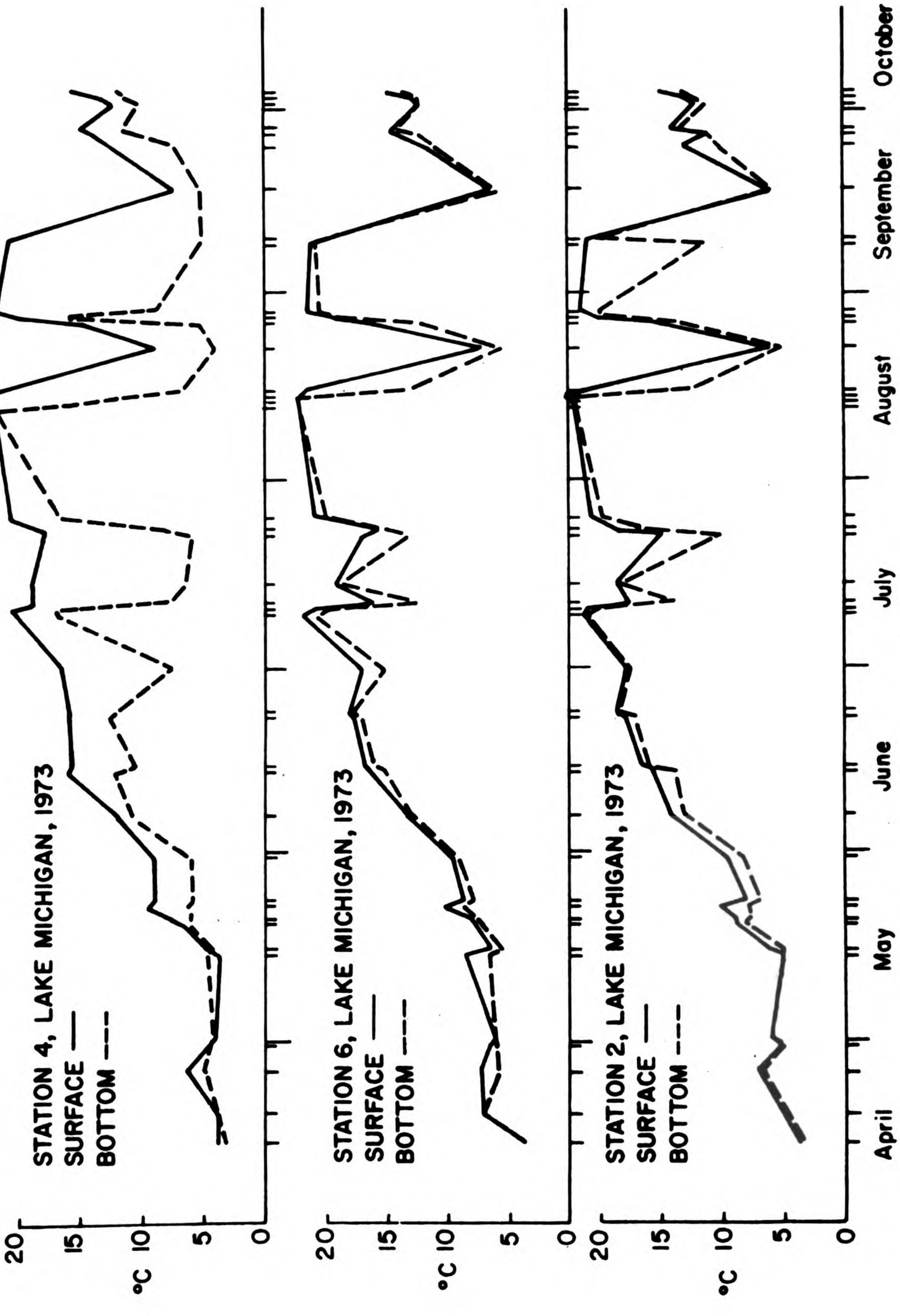

STATION 4, LAKE MICHIGAN, 1973
SURFACE ——
BOTTOM ---
STATION 6, LAKE MICHIGAN, 1973
SURFACE ——
BOTTOM ---
STATION 2, LAKE MICHIGAN, 1973
SURFACE ——
BOTTOM ---
°C
20
15
10
5
0
April
May
June
July
August
September
October

Figure 7

shallow c

were neve

cluded th

with onsh

winds ca

(1942 and

cycles i

Th

collecti

to appro

temperat

at all t

Water Tr

Se

and no t

Secchi d

in Table

Tr

est area

In 1972

stations

two sets

Dredging

caused v

depending

variation

shallow coastal waters (less than 22-27 m) near Saugatuck, Michigan, were never stable for any length of time (Wells, 1968). Wells concluded that winds were responsible for the erratic water temperatures with onshore winds increasing the depth of warm water and offshore winds causing colder water to enter the inshore coastal areas. Church (1942 and 1945) presents a comprehensive account of temperature cycles in Lake Michigan.

The 1972 water temperatures from September to the end of the collecting season in November decreased at a generally constant rate to approximately 7 C at all stations on November 15, 1972. The 1973 temperatures from this period of the year were erratic with an increase at all the stations in October.

Water Transparency Results

Secchi disc readings fluctuated at all stations in both seasons and no trends could be detected. The descriptive statistics of the secchi disc measurements at all stations for 1972 and 1973 are listed in Tables 2 and 3 respectively.

Transparency readings at stations two and six (6-8 m), the shallowest areas, ranged from 0.9 to 5.3 m in 1972 and 0.7 to 5.2 in 1973. In 1972 these stations had greater variation in the data than the other stations. However, there was no significant correlation between the two sets of data indicating that the variation was independent. Dredging of the area between the jetties during construction in 1972 caused visible amounts of turbid water to move either north or south depending on the water currents; this might explain the independent variation between the two stations.

Table 2. Secchi Disc Reading Descriptive Statistics from Lake Michigan Sampling Stations During 1972

Statistic	Station 1	2	3	4	5	6
Range	1.5-6.9	0.9-5.3	1.4-5.9	3.1-7.8	1.4-5.7	0.9-5.3
Mean	3.80	2.79	3.66	4.87	3.39	2.72
Variance	1.41	1.19	1.45	1.04	1.32	1.49
Standard deviation	1.18	1.09	1.20	1.02	1.15	1.22
Coefficient of variation	31.1%	39.1%	32.8%	20.9%	33.9%	44.9%

Table 3. Secchi Disc Reading Descriptive Statistics from Lake Michigan Sampling Stations During 1973

Table 3. Secchi Disc Reading Descriptive Statistics from Lake Michigan Sampling Stations During 1973

Statistic	Station 1	2	3	4	5	6
Number of readings	41	40	41	42	41	40
Range	1.0-5.9	1.0-5.2	1.3-5.5	2.2-7.6	0.9-5.0	0.7-5.0
Mean	3.3	3.1	3.2	4.1	2.8	2.7
Variance	1.43	1.08	1.44	1.48	1.17	1.35
Standard deviation	1.20	1.04	1.20	1.22	1.08	1.16
Coefficient of variation	36.7%	34.1%	37.5%	29.5%	38.6%	43.7%

At stations one, three, and five (12-14 m depth), secchi disc measurements ranged from 1.4 to 6.9 m in 1972 and from 0.9 to 5.9 m in 1972, indicating decreased transparency. Cook and Powers (1964) reported secchi disc measurements of 2.5 to 5.0 m in Lake Michigan near Benton Harbor at depths corresponding to stations one, three, and five.

Station 4 (24 m depth), the deep station, averaged 4.87 m in 1972 and 4.1 in 1973 with 3.1 to 7.8 m and 2.2 to 7.6 m ranges respectively. Station 4, approximately 2.4 km farther out into Lake Michigan than are any of the other stations, is the clearest water station being least influenced by shore erosion or the dredging activities although dredged materials from the plant were dumped near this station. Secchi disc readings of 4.5 to 7.0 m at a similar depth were measured in southern Lake Michigan (Cook and Powers, 1964).

Water Turbidity Results

Turbidity measurements were first taken on June 29, 1972 and were measured in formazin turbidity units. Turbidities ranged from 0.3 to 2.4 in 1972 (Table 4) and from 0.3 to 17.0 in 1973 for surface waters (Table 5).

Water Chemistry Results

Wind action caused extensive mixing in these coastal areas during 1972 and 1973, and the chemical parameters were within the following ranges at all stations: pH 7.4-8.8; dissolved O_2 8.7-15.0 ppm; alkalinity 98-136 ppm; dissolved solids 151-202 ppm (Liston and Tack, 1973; Liston, 1974). These measurements were determined by standard

Table 4. Surface Turbidity Measurement (Formazin Turbidity Units) Descriptive Statistics from Lake Michigan Sampling Stations During 1972

Statistic	Station 1	2	3	4	5	6
Number of readings	6*	6	6	6	6	6
Range	0.3-1.2	0.3-2.4	0.3-1.2	0.3-0.7	0.4-2.2	1.2-2.2
Mean	0.6	0.9	0.7	0.5	0.9	1.8

*Measurements taken on the following dates: June 29, July 14, August 1, August 18, September 8, and October 28, 1972.

Table 5. Surface Turbidity Measurement (Formazin Turbidity Units) Descriptive Statistics from Lake Michigan Sampling Stations During 1973

Statistic	Station					
	1	2	3	4	5	6
Number of readings	35*	35	36	36	36	36
Range	0.3-6.6	0.4-17.0	0.2-5.7	0.3-4.2	0.3-7.9	0.5-6.1
Mean	1.87	2.27	1.75	1.27	2.24	1.85
Variance	1.75	8.3	1.43	0.48	2.65	1.02
Standard deviation	1.32	2.89	1.20	0.69	1.63	1.01
Coefficient of variation	70.8%	127.3%	68.6%	54.3%	72.8%	54.6%

*Measurements taken from April 13th to October 20, 1973.

analytica

among sta

did not a

The

first sea

macroinve

areas of

Chironomi

larly in

The

larity fr

Mysidacea

The

numerical

brates of

Nematoda

Nem

stations,

sample th

Oligochae

Limn

nant oligo

small, imm

analytical methods. Because these chemical parameters were similar among stations and consistent throughout both seasons, they probably did not affect the benthic macroinvertebrates.

Lake Michigan Ponar Grab Samples

The study of the Lake Michigan coastal areas had 90 samples the first season and 102 samples the second season. Seven predominant macroinvertebrate groups were sampled from the Lake Michigan coastal areas of this study: Oligochaeta; Ostracoda; Amphipoda; Acari; Chironomidae; Gastropoda; and Pelecypoda. These groups were found regularly in the samples from both seasons.

The macroinvertebrate groups found in less abundance and regularity from the coastal sampling areas were: Nematoda; Hirudinea; Mysidacea; Isopoda; Decapoda; Ephemeroptera; and Trichoptera.

The Lake Michigan coastal sampling area study will compare the numerical abundance and taxonomic composition of the macroinvertebrates of the 1972 season with those of the 1973 season.

Nematoda

Nematodes were found occasionally at the Lake Michigan sampling stations, but the sampling methods used probably did not efficiently sample them because of their small size.

Oligochaeta

Limnodrilus sp., *Peloscolex* sp. and *Tubifex* sp. were the predominant oligochaetes found at the Lake Michigan sampling stations. Many small, immature forms were found in the samples along with eight

Table 6.

Relative A
macroinver

R (r
C (c

Nematoda

Annelida

Olig

Hiru

Arthropoda

Eucr

*"cf." mean

Table 6. Taxa and Relative Abundance of Lake Michigan Benthic Macroinvertebrates in 1972 and 1973 Ponar Grab Samples (192 Samples)

Relative Abundance: Numerical percentage of total number of benthic macroinvertebrates in all benthic groups.

R (rare) = 0-25% A (abundant) = 51-75%
C (common) = 26-50% VA (very abundant) = 76-100%

Nematoda	R
Annelida	
Oligochaeta	A
Plesiopora	
Naididae	
Stylaria sp.	
Tubificidae	
Limnodrilus sp.	
Peloscolex sp.	
Tubifex sp.	
Hirudinea	R
Arthropoda	
Eucrustacea	
Ostracoda	R
Podocopa	
Cypridae	
Candona rawsoni Tressler	
C. inopinata Furtos	
C. acuti Hoff	
C. cf.* *acutula* Delorme	

continued

*"cf." means "similar to"

Table 6--continued

Malacostraca	R
Mysidacea	
Mysidae	
Mysis oculata relicta (Loven)	
Amphipoda	C
Haustoriidae	
Pontoporeia affinis (Lindstrom)	
Decapoda	R
Arachnoidea	
Acari	C
Lebertiidae	
Lebertia sp.	
Hygrobatidae	
Hygrobates sp.	
Mideopsidae	
Mideopsis sp.	
Pionidae	
Forelia sp.	
Insecta	
Ephemeroptera	R
Heptageniidae	
Stenonema sp.	
Trichoptera	R

continued

Table 6--continued

Molannidae	
Molanna sp.	
Rhyacophilidae	
Rhyacophila sp.	
Hydropsychidae	
Hydropsyche sp.	
Diptera	C
Chironomidae	
Chironominae	
Chironomus sp.	
Cryptochironomus sp.	
Parachironomus sp.	
Polypedilum sp.	
Stictochironomus sp.	
Glyptotendipes sp.	
Tanypodinae	
Procladius sp.	
Conchapelopia sp.	
Thienemannimyia sp.	
Orthocladiinae	
Cricotopus sp.	
Mollusca	
Gastropoda	R
Pulmonata	

continued

Table 6--continued

Lymnaeidae	
Lymnaea sp.	
Planorbidae	
Gyraulus sp.	
Physidae	
Physa sp.	
Pelecypoda	R
Heterodonta	
Sphaeriidae	
Sphaerium sp.	
Pisidium sp.	

Stylaria sp. The oligochaete population at station two and six increased significantly (0.005 and 0.001 levels, respectively) in the 1973 season. Station five had the greatest combined seasons total abundance (Table 7). The oligochaete seasonal distribution for 1972 and 1973 at all the Lake Michigan sampling stations is presented in Figure 8.

Hirudinea

Leeches were found sporadically in samples from Lake Michigan which indicated either they were not abundant in these areas, or the sampling methods were not effectively collecting them.

Ostracoda

Ostracods from the genus Candona were sampled at the Lake Michigan stations and their population at station six increased significantly (0.05 level) in 1973 over 1972. The ostracods were most abundant at station five in 1972 and at station one in 1973 (Table 8). The seasonal distribution of the ostracods at all stations in the two seasons is presented in Figure 9. No ostracods were sampled from station two.

Mysidacea

At station four, one Mysis oculata relicta (Loven) was collected in August, 1972 and 18 were sampled in October, 1973.

Amphipoda

Pontoporeia affinis (Lindstrom) was the only amphipod collected from the coastal Lake Michigan sampling stations (Table 9).

Table 7. Taxa and Number of Oligochaeta in 1972 and 1973 Ponar Grab Samples from Lake Michigan Sampling Stations (Composition for Each Station on Each Sampling Day is a Three-Sample Total)

Stations	1972 5/18	6/27	8/10	9/12	10/30	Season Total	1973 5/14	6/6	7/9	8/22	9/24	10/31	Season Total	Combined Seasons Total
1														
Limnodrilus sp.	12	4	6	14	12	48	12	6	12	14	6	18	68	116
Peloscolex sp.	6	2	6	10	10	34	8	4	8	16	8	24	68	102
Tubifex sp.	4	0	4	8	6	22	2	2	2	8	0	12	26	48
Stylaria sp.	0	2	0	0	2	4	0	0	0	0	2	0	2	6
Immature forms	24	18	10	22	42	116	16	26	14	28	16	22	122	238
Undeterminable	54	14	14	36	26	144	8	28	32	20	8	34	130	274
2														
Limnodrilus sp.	0	0	0	0	0	0	1	0	3	4	1	4	13	13
Peloscolex sp.	0	0	0	0	0	0	0	0	4	6	2	2	14	14
Tubifex sp.	0	0	0	0	0	0	0	0	0	2	0	0	2	2
Immature forms	2	2	2	0	3	9	2	0	15	18	8	34	76	85
Undeterminable	0	0	0	0	2	2	2	0	6	24	13	22	67	69
3														
Limnodrilus sp.	8	48	10	48	14	138	2	0	4	20	30	2	58	196
Peloscolex sp.	2	36	6	56	10	110	3	0	8	16	12	2	41	151
Tubifex sp.	2	6	2	22	6	38	1	0	2	14	8	0	25	63
Immature forms	24	138	18	68	122	370	7	1	62	98	82	40	290	660
Undeterminable	18	52	56	110	24	260	5	0	28	74	20	10	137	397

4														
Limnodrilus sp.	28	12	2	4	18	64	1	4	6	4	4	8	27	91
Peloscolex sp.	20	8	4	8	14	54	4	2	6	2	6	22	42	96
Tubifex sp.	10	2	2	2	8	24	1	0	2	0	4	6	13	37
Immature forms	152	94	36	96	98	476	14	62	92	14	72	76	330	806
Undeterminable	50	48	50	145	30	323	19	32	40	32	18	31	172	495
5														
Limnodrilus sp.	20	32	20	18	30	120	12	14	12	10	32	--	80	200
Peloscolex sp.	2	26	18	12	22	80	8	12	14	18	28	--	80	160
Tubifex sp.	0	16	8	6	10	40	6	6	6	4	16	--	38	78
Immature forms	34	70	58	114	146	422	102	122	126	106	194	--	650	1072
Undeterminable	42	11	69	148	110	380	74	64	58	54	87	--	337	717
6														
Limnodrilus sp.	2	2	0	2	3	9	2	1	4	32	16	--	55	64
Peloscolex sp.	2	0	0	0	2	4	2	1	8	26	28	--	65	69
Tubifex sp.	0	0	0	0	0	0	0	0	0	12	2	--	14	14
Immature forms	3	5	0	1	6	15	15	5	48	72	42	--	182	197
Undeterminable	3	2	1	3	4	13	9	3	43	81	53	--	189	202

Figure 8. Oligochaeta seasonal distribution at Lake Michigan sampling stations for 1972 and 1973 (values are average of three Ponar grab samples taken at each station each sampling day).

ANNELIDA: OLIGOCHAETA

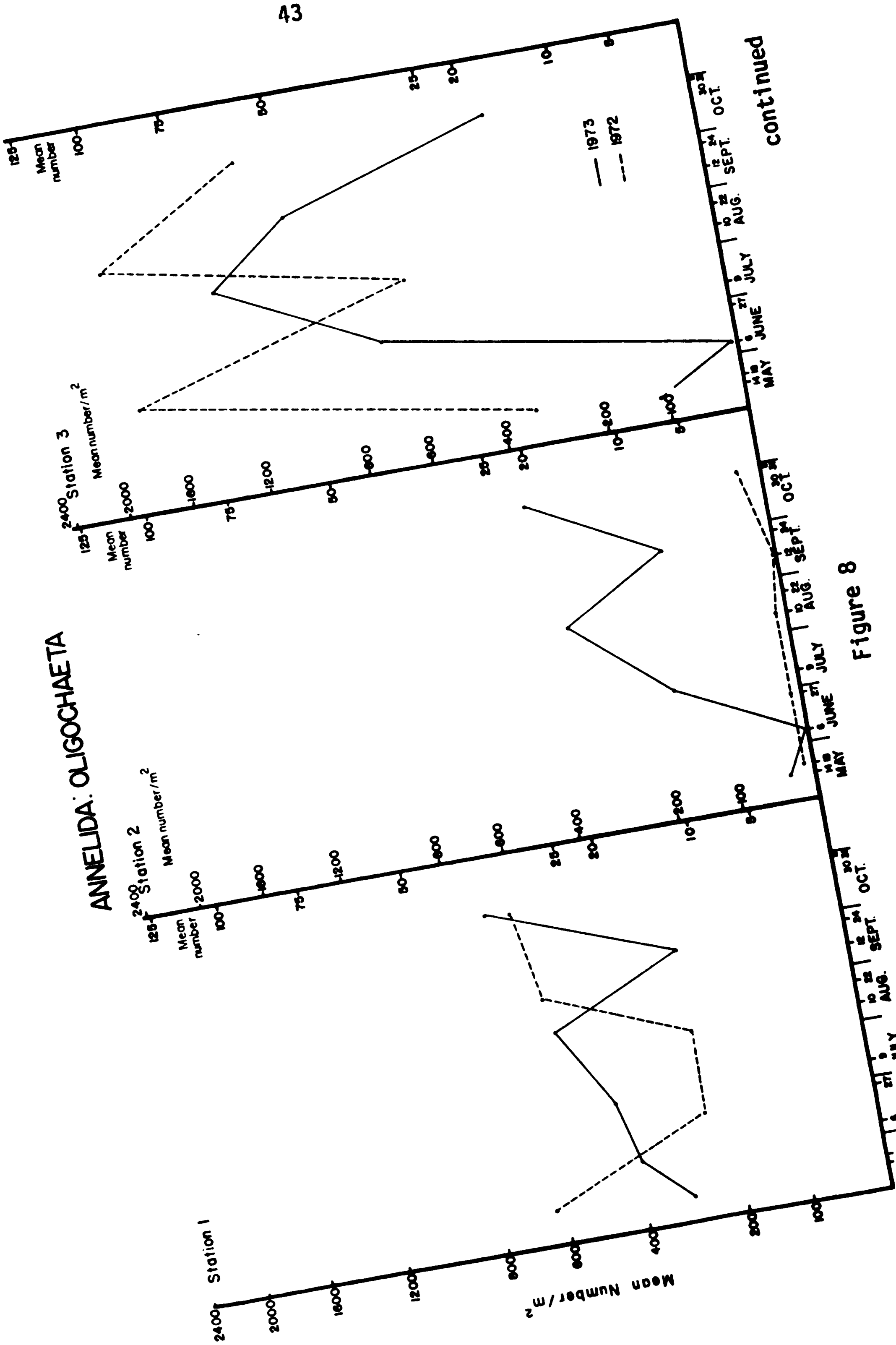
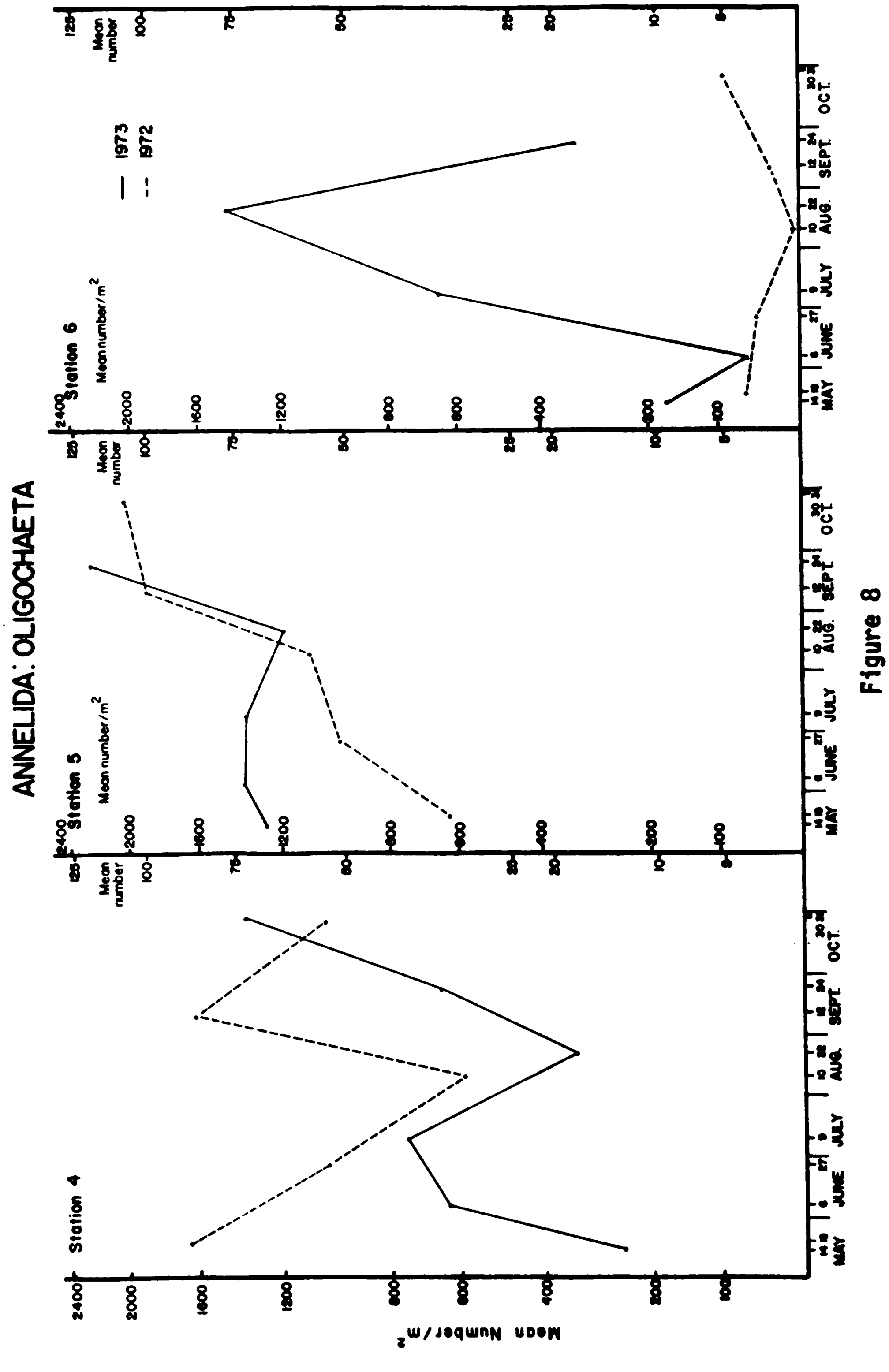


Figure 8

continued



ANNELIDA: OLIGOCHAETA
Station 4
Station 5
Station 6
Mean number/m²
Mean Number/m²
Mean number
— 1973
-- 1972
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
2400
2000
1600
1200
800
600
400
200
100
125
100
75
50
25
20
10
5

Figure 8

Table 8. Number of Ostracoda, Species of _Candona_, in the 1972 and 1973 Ponar Grab Samples from Lake Michigan Sampling Stations (Three-Sample Total for Each Station on Each Sampling Day)

	1972						1973							Combined
Stations	5/18	6/27	8/10	9/12	10/30	Season Total	5/14	6/6	7/9	8/22	9/24	10/31	Season Total	Seasons Total
1	0	0	45	1	0	46	17	68	5	0	0	0	90	136
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	68	9	0	77	32	1	1	0	0	0	34	111
4	0	0	2	0	0	2	0	4	0	0	0	4	8	10
5	0	0	78	2	0	80	2	73	0	0	0	-	75	155
6	0	0	0	0	0	0	0	7	3	0	1	-	11	11

Figure 9. Ostracoda seasonal distribution at Lake Michigan sampling stations for 1972 and 1973 (values are average of three Ponar grab samples taken at each station each sampling day).

OSTRACODA

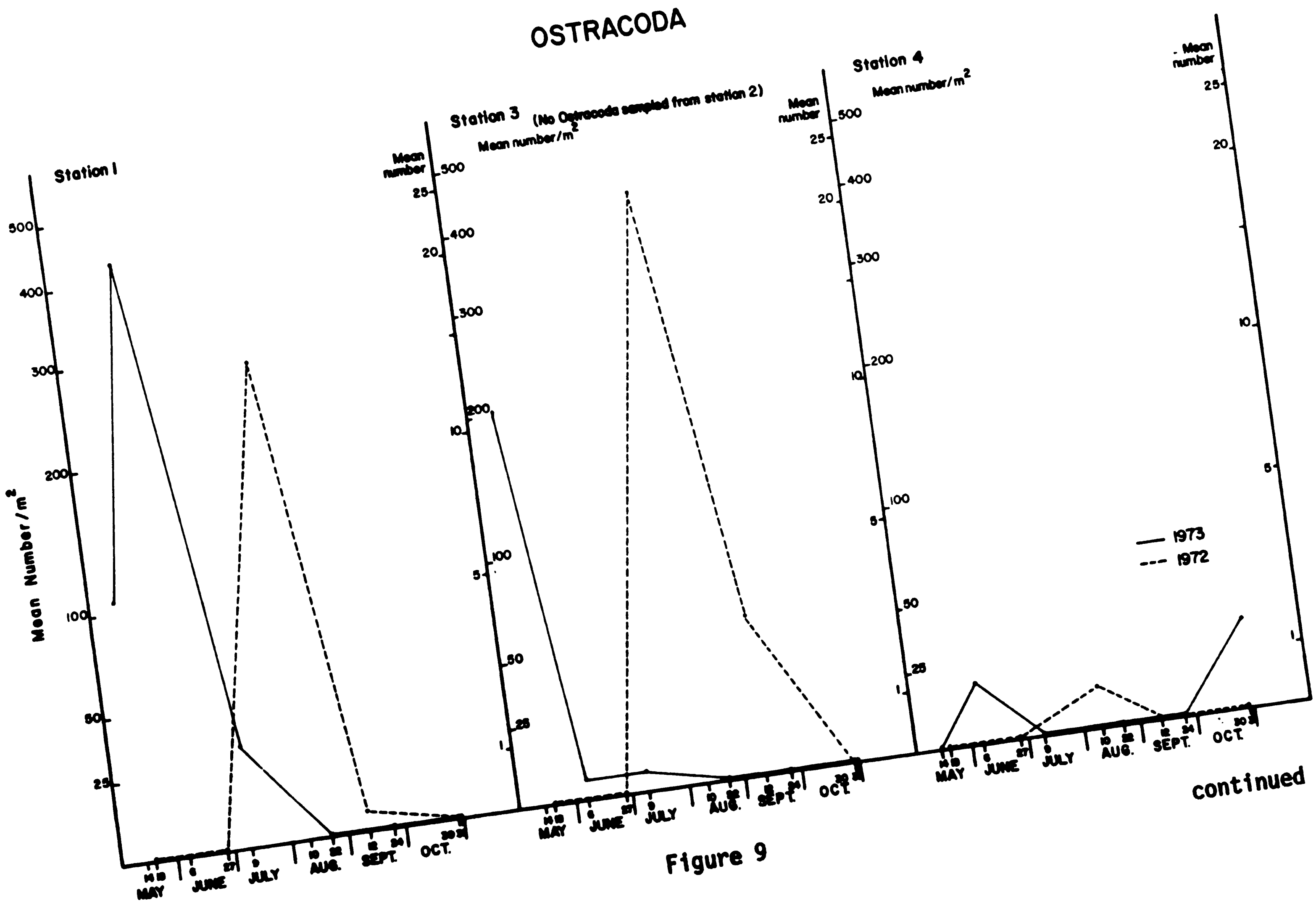


Figure 9

continued

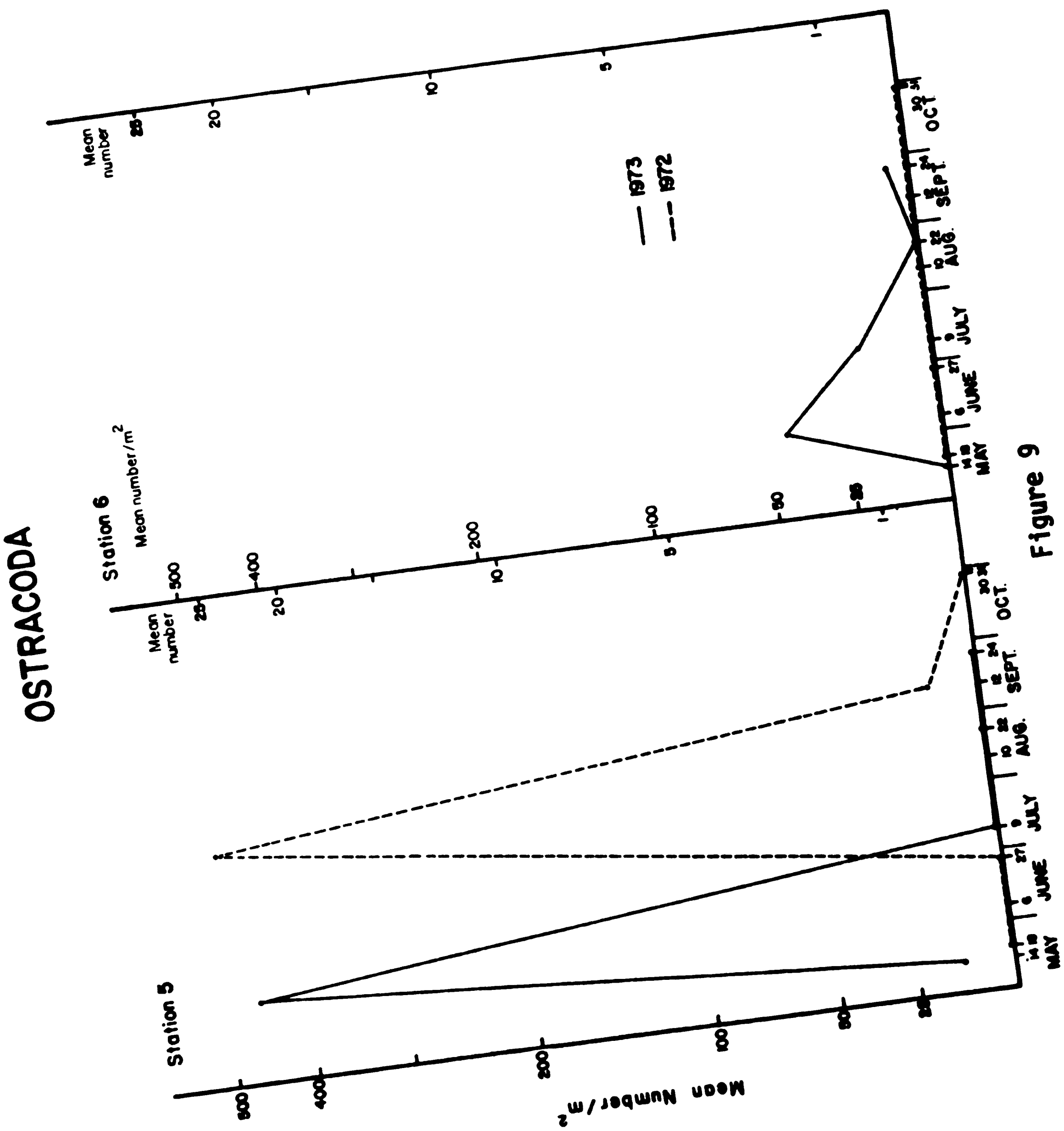

OSTRACODA
Station 6
Mean number/m²
Mean number
Station 5
Mean Number/m²
— 1973
--- 1972
MAY
JUNE
JULY
AUG.
SEPT.
OCT.

Figure 9

The amphipod, P. affinis, population at station five and six increased significantly (0.05 and 0.02 levels, respectively) in the 1973 season, being most abundant at station four (Table 9). The seasonal distribution of P. affinis in Lake Michigan for both seasons is shown in Figure 10.

Decapoda

Four crayfish were collected in a trawl sample taken near station five in August, 1972.

Acari

Hygrobates sp., Lebertia sp. and Mideopsis sp. were the major water-mites in the Lake Michigan samples with Forelia sp. occasionally present. Hygrobates longipalpis and Lebertia porosa were the most abundant and widely distributed species of aquatic Acari collected in the St. Lawrence Great Lakes comprising 37 percent and 13 percent, respectively, of the sample totals (Modlin and Gannon, 1973). The water-mite population (Table 10) had the greatest combined seasons total abundance at station three. The aquatic Acari population at stations two, five and six increased significantly (0.01, 0.005 and 0.001 levels, respectively) in the 1973 season. The 1972 and 1973 water-mite distribution at all Lake Michigan coastal sampling stations is presented in Figure 11.

Trichoptera

Molanna sp., Rhyacophila sp. and Hydropsyche sp. trichopteran larvae were collected from Lake Michigan in both seasons with a total of only four taken by the Ponar grab-sampler.

Table 9. Number of Amphipoda, Pontoporeia affinis (Lindstrom), in 1972 and 1973 Ponar Grab Samples from Lake Michigan Sampling Stations (Three-Sample Total for Each Station on Each Sampling Day)

Stations	1972 5/18	1972 6/27	1972 8/10	1972 9/12	1972 10/31	1972 Season Total	1973 5/14	1973 6/6	1973 7/9	1973 8/22	1973 9/24	1973 10/31	1973 Season Total	Combined Seasons Total
1	20	10	22	41	54	147	6	34	6	12	14	50	122	269
2	0	0	0	0	7	7	0	1	6	3	1	4	15	22
3	4	12	32	13	11	72	3	7	49	35	7	7	108	180
4	487	205	353	748	128	1921	5	718	350	131	262	181	1647	3568
5	10	6	40	22	12	90	2	13	9	2	7	-	33	123
6	0	0	1	0	0	1	0	0	6	7	2	-	15	16

Figure 10. Amphipoda, *Pontoporeia affinis* (Lindstrom), seasonal distribution at Lake Michigan sampling stations for 1972 and 1973 (values are average of three Ponar grab samples taken at each station each sampling day).

AMPHIPODA

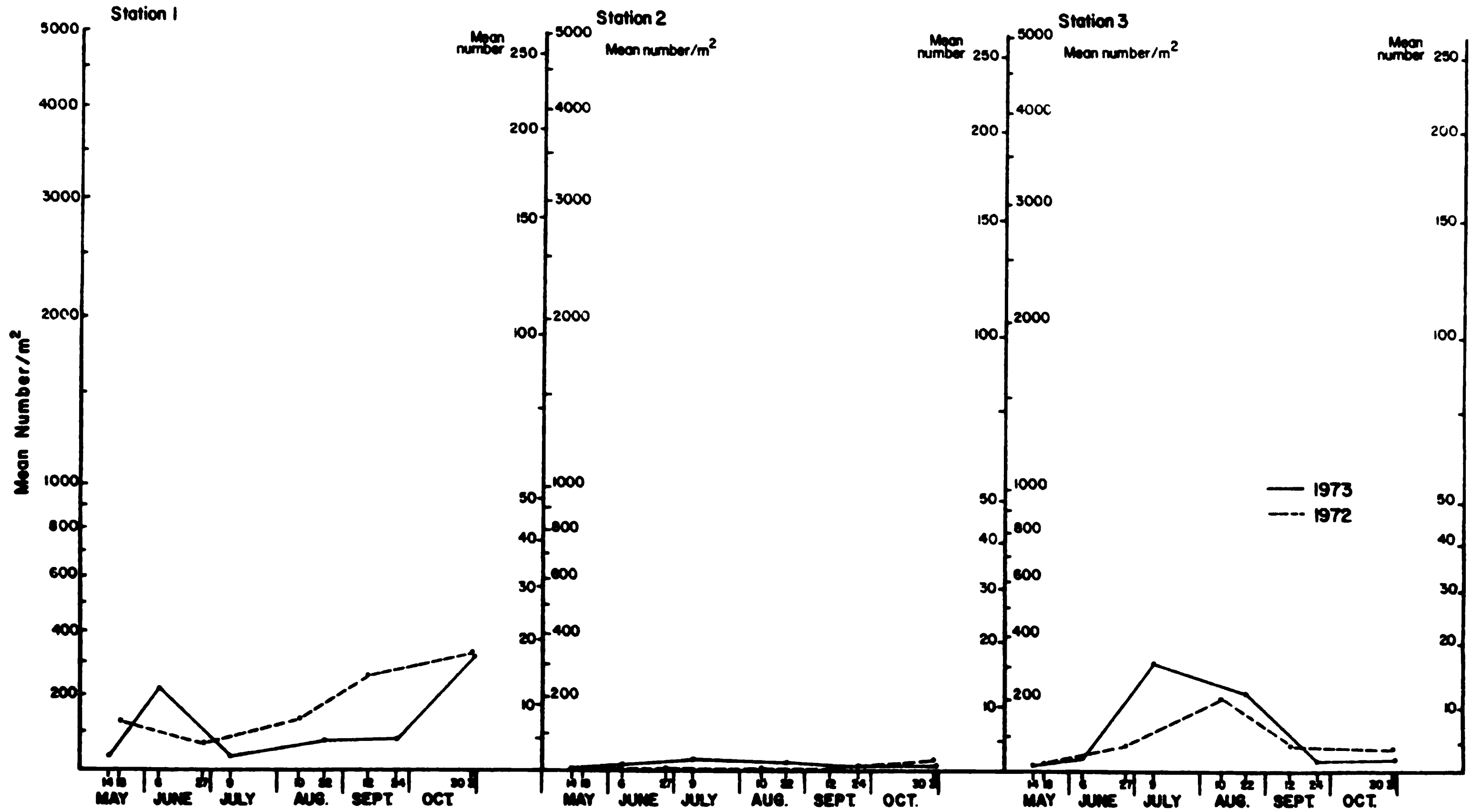


Figure 10

continued

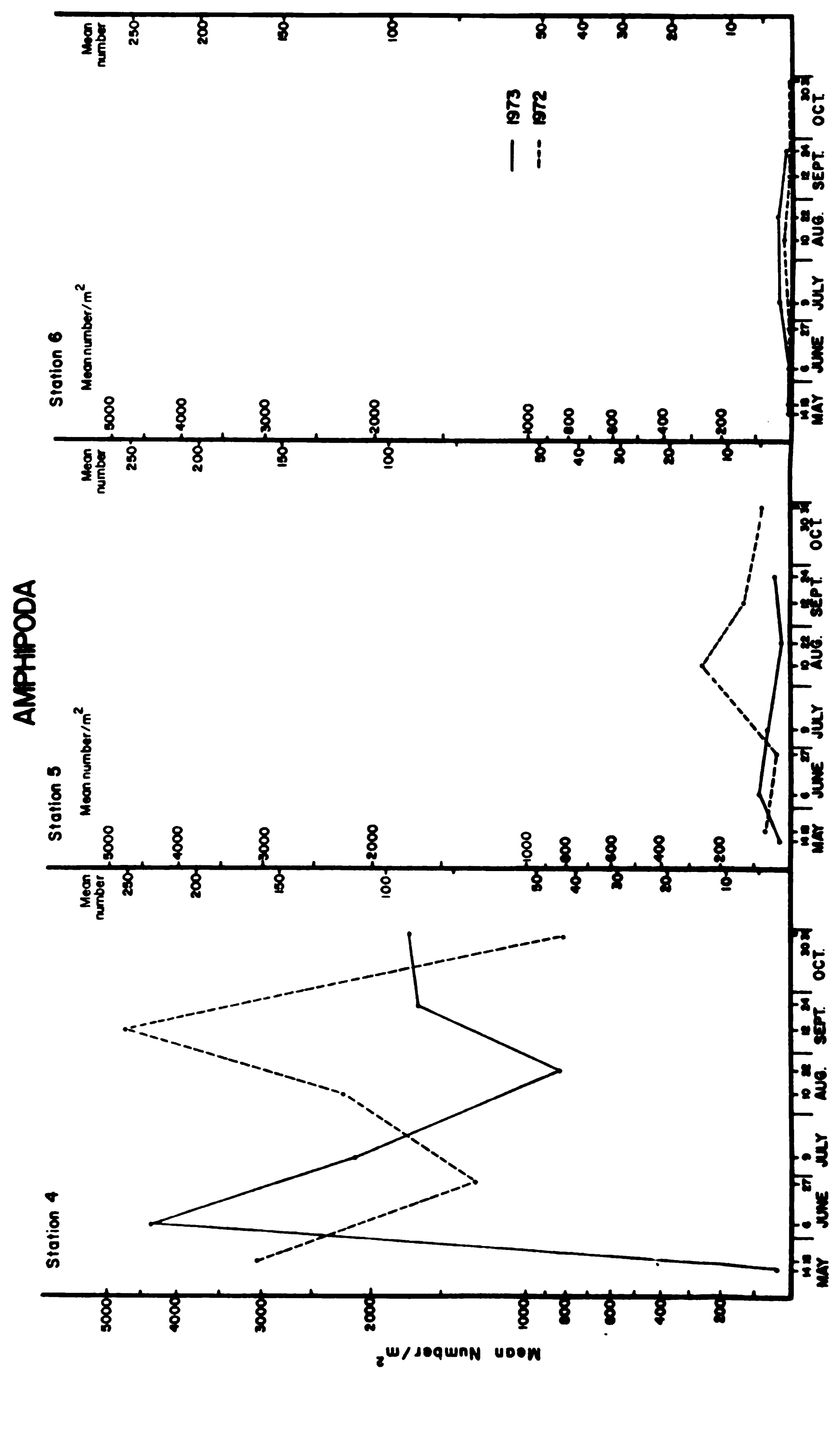

AMPHIPODA
Station 4
Station 5
Station 6
Mean number/m²
Mean number
Mean Number/m²
5000
4000
3000
2000
1000
800
600
400
200
250
200
150
100
50
40
30
20
10
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
1973
1972

Figure 10

Table 10. Taxa and Number of Acari in 1972 and 1973 Ponar Grab Samples from Lake Michigan Sampling Stations (Composition for Each Station on Each Sampling Day is a Three-Sample Total)

Stations	1972 5/18	1972 6/27	1972 8/10	1972 9/12	1972 10/30	1972 Season Total	1973 5/14	1973 6/6	1973 7/9	1973 8/22	1973 9/24	1973 10/31	1973 Season Total	Combined Seasons Total
1														
Hygrobates sp.	0	6	2	4	0	12	2	0	0	4	4	3	13	25
Lebertia sp.	0	0	3	7	0	10	0	1	0	7	7	6	21	31
Mideopsis sp.	0	0	0	0	0	0	0	0	0	2	0	0	2	2
2														
Hygrobates sp.	0	0	0	0	0	0	1	2	0	2	1	0	6	6
Lebertia sp.	0	0	0	1	0	1	1	4	1	6	1	0	13	14
Mideopsis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3														
Hygrobates sp.	2	3	6	2	0	13	4	0	0	5	4	7	20	33
Lebertia sp.	0	2	1	11	0	14	0	0	1	3	7	5	16	30
Mideopsis sp.	0	0	0	0	0	0	3	1	0	11	5	0	20	20

4														
Hygrobates sp.	0	0	2	7	0	9	0	0	0	0	1	11	12	21
Lebertia sp.	0	0	1	1	0	2	0	1	0	0	4	4	9	11
Mideopsis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5														
Hygrobates sp.	3	3	1	0	0	7	0	1	1	1	6	-	9	16
Lebertia sp.	0	1	1	2	0	4	2	3	3	3	2	-	13	17
Mideopsis sp.	0	0	0	0	0	0	1	0	0	0	5	-	6	6
Forelia sp.	0	0	0	0	0	0	0	0	1	1	0	-	2	2
6														
Hygrobates sp.	0	0	0	0	0	0	0	1	1	2	5	-	9	9
Lebertia sp.	0	1	0	0	0	1	1	0	0	6	1	-	8	9
Mideopsis sp.	0	0	0	0	0	0	0	0	0	0	4	-	4	4
Forelia sp.	0	0	0	0	0	0	0	1	0	0	0	-	1	1

Figure 11. Acari seasonal distribution at Lake Michigan sampling stations for 1972 and 1973 (values are average of three Ponar grab samples taken at each station each sampling day).

ACARI

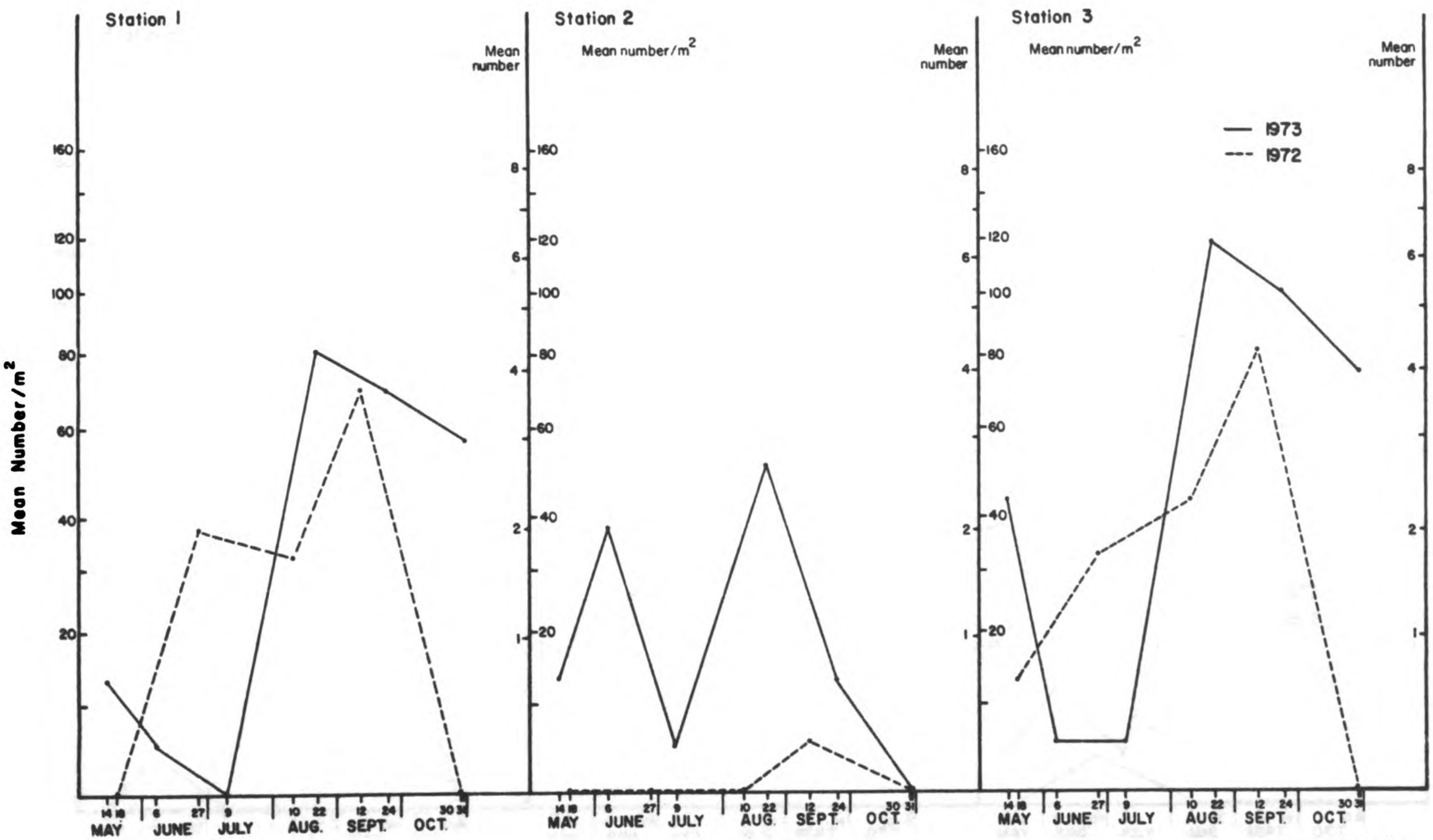


Figure 11 continued

ACARI

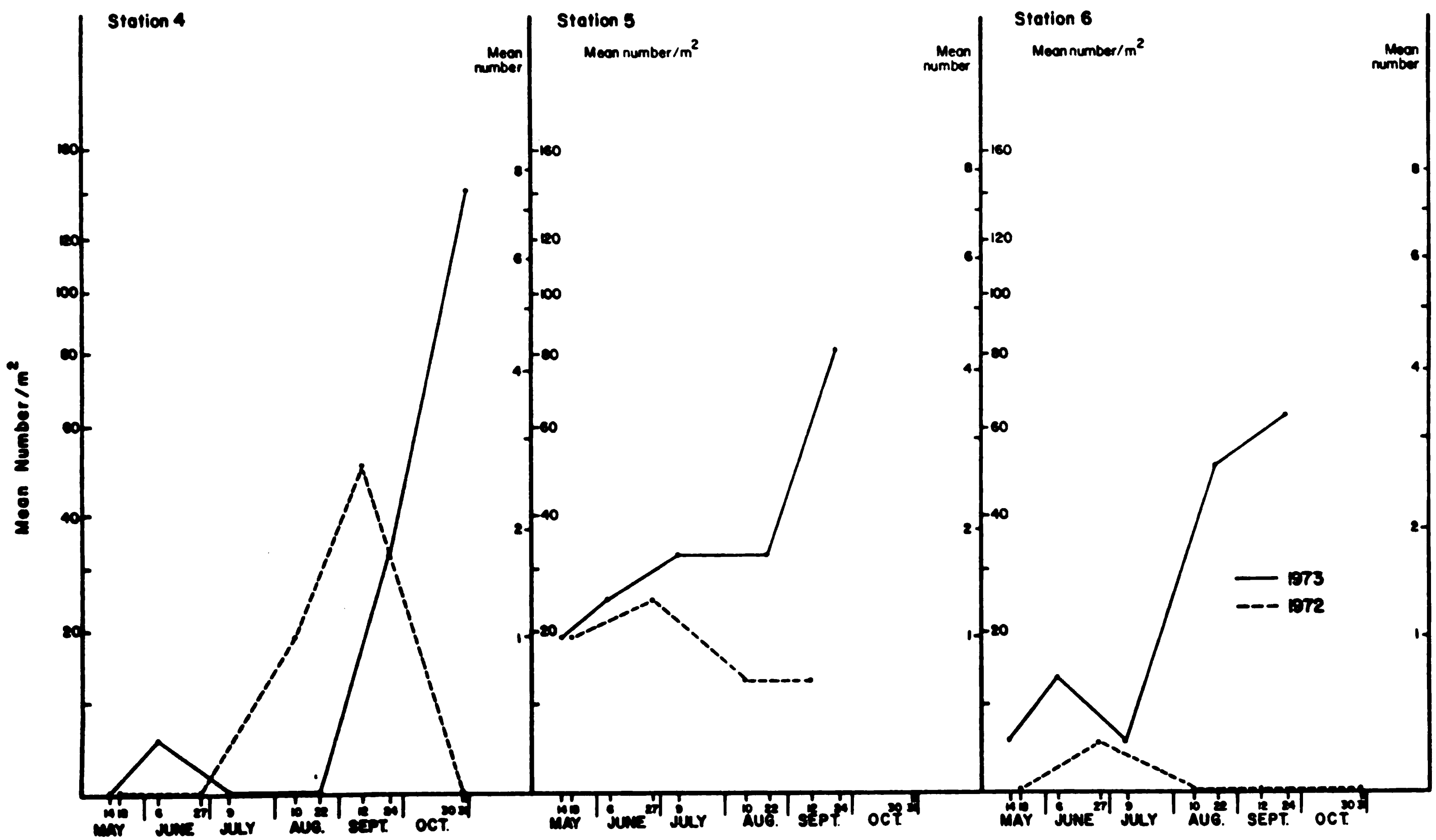


Figure 11

Chironomidae

The dominant chironomid larvae collected from Lake Michigan were from the tribe Chironomini of the subfamily Chironominae. *Chironomus* sp., *Cryptochironomus* sp., *Polypedilum* sp., *Parachironomus* sp., *Glyptotendipes* sp., and *Stictochironomus* sp. were the predominant genera (Table 11). *Procladius* sp., *Conchapelopia* sp. and *Thienemannimyia* sp., subfamily Tanypodinae, and *Cricotopus* sp., subfamily Orthocladiinae, were also collected (Table 11). There were no significant differences in the chironomid population at any of the six stations for the two seasons. The 1972 and 1973 seasonal distribution in Lake Michigan is presented in Figure 12. All of the stations had approximately the same size chironomid population.

Gastropoda

Gyraulus sp., *Physa* sp. and *Lymnaea* sp. were collected at the Lake Michigan stations with *Gyraulus* sp. the most abundant. Station one had the greatest combined seasons total abundance with 633 gastropods (Table 12). No statistical differences were found between the two seasons at any of the six Lake Michigan sampling stations. Six *Lymnaea* sp. were found in a trawl sample near station five in August, 1972. Seasonal distribution of gastropods for the two seasons at the six stations is shown in Figure 13. Station one in 1972 had the largest gastropod population.

Pelecypoda

Sphaerium sp. and *Pisidium* sp. were the two pelecypods sampled from Lake Michigan sampling stations. Station one had the greatest

Table 11. Taxa and Number of Chironomidae in 1972 and 1973 Ponar Grab Samples from Lake Michigan Sampling Stations (Composition for Each Station on Each Sampling Day is a Three-Sample Total)

Stations	1972					Season	1973						Season	Combined Seasons
	5/18	6/27	8/10	9/12	10/30	Total	5/14	6/6	6/9	8/22	9/24	10/31	Total	Total
1														
Chironomus sp.	10	9	172	24	12	227	14	3	75	23	16	22	153	380
Cryptochironomus sp.	7	3	49	19	33	111	7	24	21	13	12	17	94	205
Polypedilum sp.	0	1	0	3	1	5	0	0	38	2	0	0	40	45
Parachironomus sp.	7	4	0	8	3	22	1	0	0	1	2	4	8	30
Stictochironomus sp.	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Glyptotendipes sp.	17	0	2	15	5	39	2	1	84	18	14	8	127	166
Procladius sp.	2	4	7	0	6	19	1	6	15	4	2	3	31	50
Conchapelopia sp.	6	0	0	0	1	7	0	4	11	1	0	0	16	23
Thienemannimyia sp.	2	0	0	0	0	2	0	0	2	1	0	0	3	5
Cricotopus sp.	0	0	0	1	1	2	0	0	0	2	0	0	2	4
Pupae	3	0	2	2	2	9	0	4	1	2	2	3	12	21
2														
Chironomus sp.	4	2	13	51	7	77	9	4	93	18	44	39	207	284
Cryptochironomus sp.	12	4	27	54	12	109	6	1	11	14	5	45	82	191
Polypedilum sp.	0	0	3	0	0	3	0	0	0	0	0	0	0	3
Parachironomus sp.	2	1	4	0	0	7	0	1	0	3	0	10	14	21
Stictochironomus sp.	0	0	0	0	0	0	0	0	5	0	0	0	5	5
Glyptotendipes sp.	4	2	11	0	10	27	2	0	0	13	20	22	57	84
Procladius sp.	1	0	6	9	2	18	0	0	6	2	7	12	27	45
Conchapelopia sp.	0	0	0	4	2	6	1	0	0	5	0	0	6	12
Thienemannimyia sp.	0	0	0	0	0	0	0	0	0	0	0	2	2	2
Cricotopus sp.	0	0	0	0	0	0	0	0	0	7	0	0	7	7
Pupae	1	0	0	3	0	4	3	3	2	5	1	0	14	18

3														
Chironomus sp.	16	13	117	14	74	234	4	3	29	12	9	17	74	308
Cryptochironomus sp.	5	3	29	9	27	73	13	2	48	7	17	22	109	182
Polypedilum sp.	0	0	0	1	2	3	0	0	0	0	0	0	0	3
Parachironomus sp.	0	2	5	1	0	8	2	0	16	0	2	18	38	46
Glyptotendipes sp.	0	6	54	4	5	69	3	0	28	11	0	3	45	114
Procladius sp.	0	2	14	3	9	28	1	0	7	2	6	11	27	55
Conchapelopia sp.	3	0	0	0	3	6	0	0	0	4	0	0	4	10
Thienemannimyia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cricotopus sp.	0	0	0	0	0	0	0	2	0	0	0	0	2	2
Pupae	2	2	9	1	4	18	1	0	2	3	2	4	12	30
4														
Chironomus sp.	11	6	9	5	3	34	11	8	4	0	5	4	32	66
Cryptochironomus sp.	1	1	13	11	9	35	4	5	15	0	3	7	34	69
Polypedilum sp.	2	0	1	0	0	3	0	3	0	0	0	0	3	6
Parachironomus sp.	0	0	0	0	1	1	0	2	6	0	1	0	9	10
Glyptotendipes sp.	11	0	3	0	4	18	2	6	7	0	1	0	16	34
Procladius sp.	1	0	2	3	0	6	4	1	7	0	1	0	13	19
Conchapelopia sp.	0	0	0	2	0	2	0	0	0	0	0	0	0	2
Thienemannimyia sp.	1	0	0	0	0	1	0	1	0	0	0	0	1	2
Cricotopus sp.	2	0	0	0	0	2	0	0	9	0	0	0	9	11
Pupae	1	0	0	0	0	1	2	0	3	0	0	2	7	8
5														
Chironomus sp.	19	39	63	23	89	233	2	42	12	4	23	-	83	316
Cryptochironomus sp.	15	12	72	0	24	123	16	15	25	19	15	-	90	213
Polypedilum sp.	0	0	4	0	0	4	0	0	0	0	0	-	0	4
Parachironomus sp.	4	1	18	0	1	24	0	5	0	0	3	-	8	32
Glyptotendipes sp.	15	1	5	10	14	45	0	22	11	52	10	-	95	140
Procladius sp.	3	2	7	1	4	17	0	4	5	10	2	-	21	38
Conchapelopia sp.	0	0	3	2	4	9	0	1	0	3	0	-	4	13
Thienemannimyia sp.	0	0	1	0	0	1	0	0	0	0	0	-	0	1
Cricotopus sp.	0	0	0	0	0	0	0	1	10	0	0	-	11	11
Pupae	0	5	7	1	2	15	0	0	1	0	4	-	5	20

continued

Table 11--continued

Stations	1972 5/18	6/27	8/10	9/12	10/30	Season Total	1973 5/14	6/6	6/9	8/22	9/24	10/31	Season Total	Combined Seasons Total
6														
Chironomus sp.	3	5	6	10	20	44	7	9	8	37	63	-	124	168
Cryptochironomus sp.	24	16	2	8	15	65	2	18	43	21	15	-	99	164
Polypedilum sp.	0	0	0	0	1	1	0	0	3	0	0	-	3	4
Parachironomus sp.	2	4	0	2	3	11	0	3	0	10	0	-	13	24
Stictochironomus sp.	0	0	0	0	0	0	0	0	18	0	0	-	18	18
Glyptotendipes sp.	0	0	43	2	3	48	2	6	26	12	6	-	52	100
Procladius sp.	2	1	6	0	3	12	0	4	11	8	2	-	25	37
Conchapelopia sp.	1	0	0	0	3	4	0	2	0	0	0	-	2	6
Thienemannimyia sp.	0	1	1	0	0	2	0	0	0	1	0	-	1	3
Cricotopus sp.	0	0	2	0	0	2	0	0	0	1	0	-	1	3
Pupae	0	1	2	0	3	6	3	0	2	5	0	-	10	16

Figure 12. Chironomidae seasonal distribution at Lake Michigan sampling stations for 1972 and 1973 (values are average of three Ponar grab samples taken at each station each sampling day).

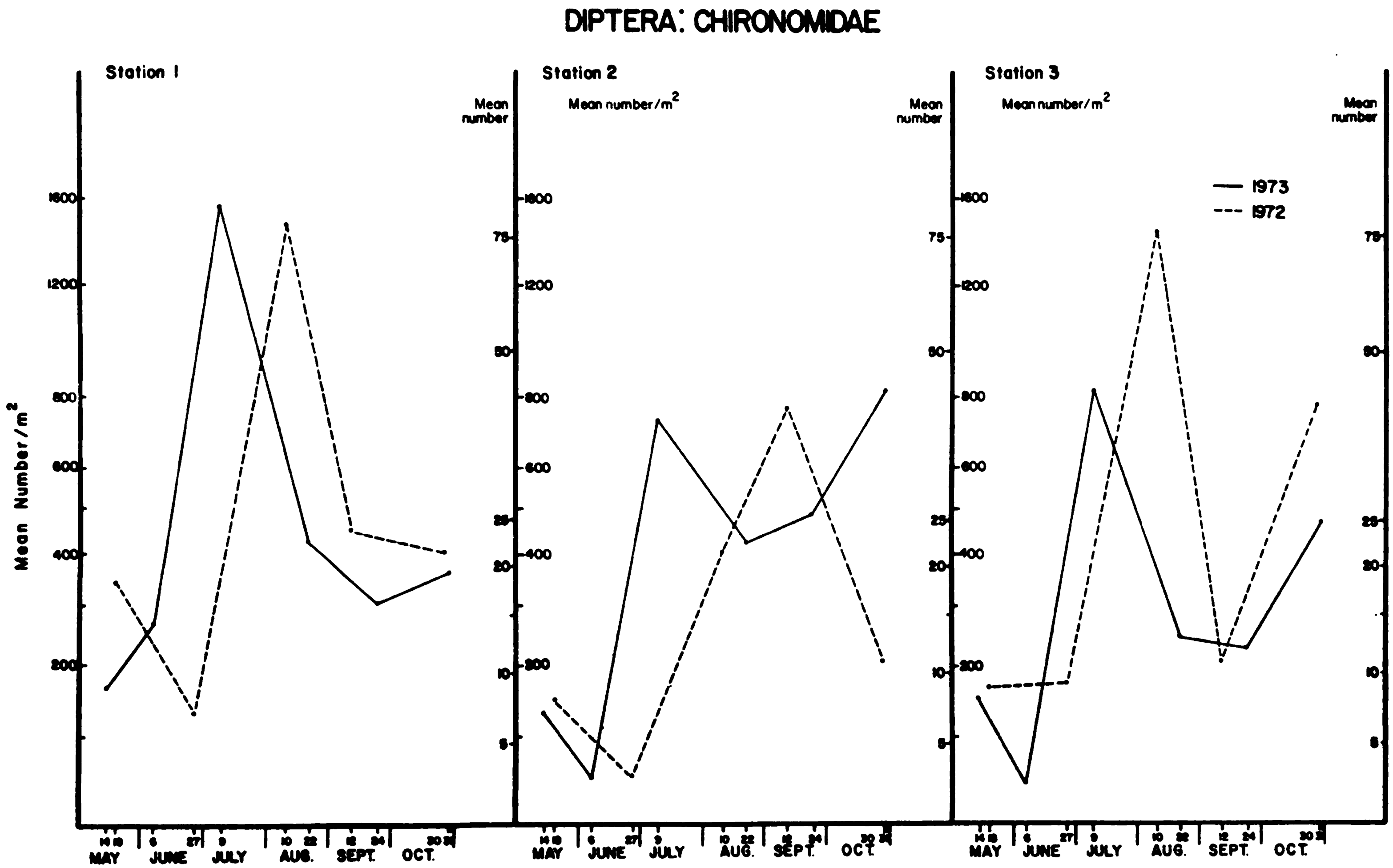


Figure 12 continued

DIPTERA: CHIRONOMIDAE

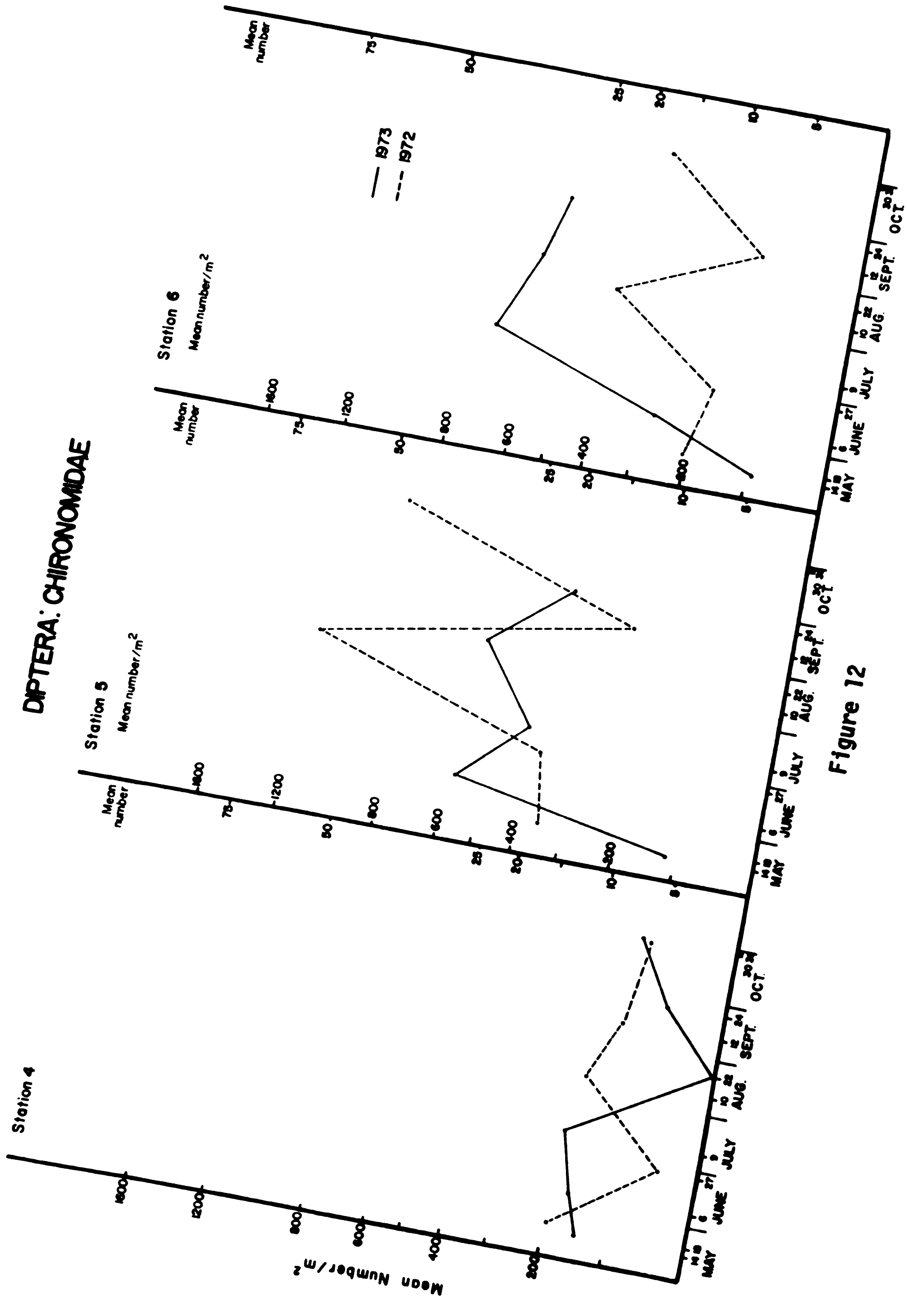


Figure 12

Table 12. Taxa and Number of Gastropoda in 1972 and 1973 Ponar Grab Samples from Lake Michigan Sampling Stations (Composition for Each Station on Each Sampling Day is a Three-Sample Total)

Stations	1972 5/18	1972 6/27	1972 8/10	1972 9/12	1972 10/30	1972 Season Total	1973 5/14	1973 6/6	1973 7/9	1973 8/22	1973 9/24	1973 10/31	1973 Season Total	Combined Seasons Total
1														
Gyraulus sp.	31	28	31	31	24	145	13	9	5	13	67	281	388	533
Physa sp.	8	10	12	8	5	43	1	0	0	1	18	37	57	100
2														
Gyraulus sp.	0	0	0	0	0	0	0	0	3	0	4	0	7	7
Physa sp.	0	0	0	0	1	1	0	0	1	0	0	0	1	2
3														
Gyraulus sp.	1	2	2	3	10	18	1	2	26	0	7	5	41	59
Physa sp.	0	1	0	0	0	1	0	0	1	0	1	1	3	4
4														
Gyraulus sp.	10	20	1	26	2	59	0	9	2	15	2	5	33	92
Physa sp.	5	8	0	2	0	15	0	2	0	0	0	1	3	18
5														
Gyraulus sp.	0	0	2	0	3	5	0	0	0	0	7	-	7	12
Physa sp.	1	0	3	0	0	4	0	0	0	0	2	-	2	6
Lymnaea sp.	0	0	6	0	0	6	0	0	0	0	0	-	0	6
6														
Gyraulus sp.	0	0	0	0	0	0	0	0	0	0	0	-	0	0
Physa sp.	0	0	0	0	0	0	0	0	1	1	0	-	2	2

Figure 13. Gastropoda seasonal distribution at Lake Michigan sampling stations for 1972 and 1973 (values are average of three Ponar grab samples taken at each station each sampling day).

GASTROPODA

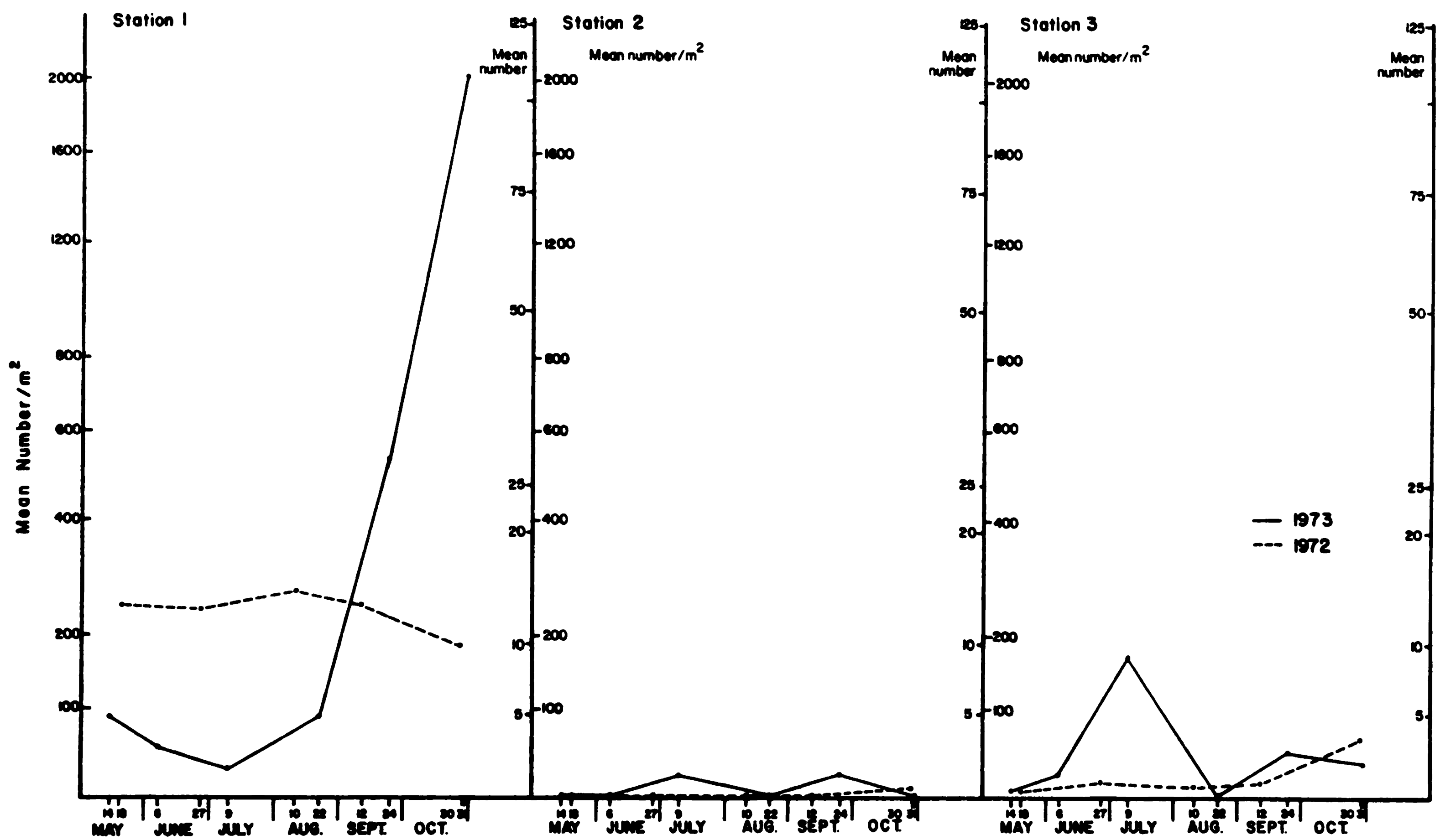


Figure 13

continued

GASTROPODA

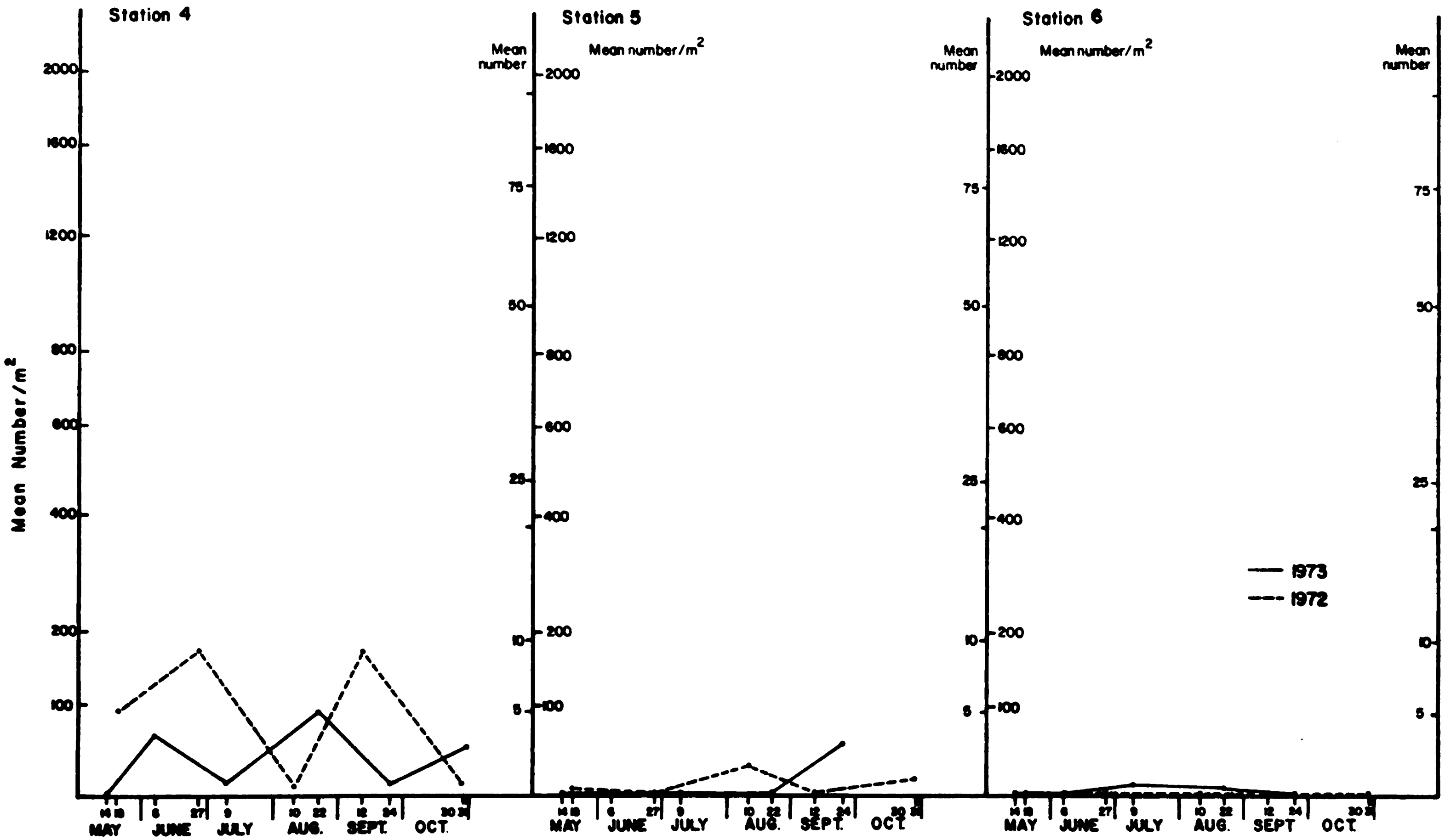


Figure 13

combined seasons total abundance of 557 pelecypods (Table 13). The pelecypod population at station one decreased significantly (0.025 level) in the 1973 season. Sphaerium sp. was in greatest abundance at all the stations. The seasonal distribution of pelecypods in the 1972 and 1973 seasons is presented in Figure 14. Stations one and four had the greatest populations with rapid and variable changes in their abundances.

Percentage Composition of Benthic Macroinvertebrate Populations

The percentage composition of the benthic macroinvertebrate groups in the population at each station for two-month periods, May-June, July-August, and September-October, was determined, and the population group percentages of the two seasons were paired. Comparisons of these pairs of the same two-month sampling period at the same station were completed statistically and graphically.

Spearman rank correlation coefficients (Siegel, 1956) were calculated for the paired percentages of the benthic organism groups (Table 14). The r_s (Spearman rank correlation coefficient) is a measure of the association between two variables whose individuals or observations are ranked in two-ordered series. The differences between the two-ordered series of variables is an indication of the disparity between these two rankings. If there is an association between the two rankings, in this case the two-percentage compositions, the disparity is not great enough to be judged statistically significant. The r_s equation for ties in the ranks and the critical r_s value table in Siegel (1956) were used due to the many ties in the paired ranks and the low number of ranks ($n < 10$).

Table 13. Taxa and Number of Pelecypoda in 1972 and 1973 Ponar Grab Samples from Lake Michigan Sampling Stations (Composition for Each Station on Each Sampling Day is a Three-Sample Total)

Stations	5/18	6/27	8/10	9/12	10/30	Season Total	5/14	6/6	7/9	8/22	9/24	10/31	Season Total	Combined Seasons Total
1														
Sphaerium sp.	54	29	51	72	22	228	8	13	9	15	28	130	203	431
Pisidium sp.	26	13	23	11	4	77	6	3	3	5	9	23	49	126
2														
Sphaerium sp.	4	0	0	0	0	4	0	0	6	0	0	0	6	10
Pisidium sp.	0	0	0	0	0	0	0	0	1	0	0	0	1	1
3														
Sphaerium sp.	3	6	6	9	10	34	0	0	18	18	15	3	54	88
Pisidium sp.	0	1	2	0	1	4	0	0	3	6	4	0	13	17
4														
Sphaerium sp.	97	49	14	71	7	238	0	39	9	8	6	28	90	328
Pisidium sp.	41	11	6	11	0	69	0	0	0	0	0	0	0	69
5														
Sphaerium sp.	8	10	8	2	1	29	0	3	0	4	18	-	25	54
Pisidium sp.	2	9	6	1	1	19	0	1	0	0	7	-	8	27
6														
Sphaerium sp.	0	2	0	0	0	2	0	2	0	4	1	-	7	9
Pisidium sp.	0	0	0	0	0	0	0	0	0	3	0	-	3	3

Figure 14. Pelecypoda seasonal distribution at Lake Michigan sampling stations for 1972 and 1973 (values are average of three Ponar grab samples taken at each station each sampling day).

PELECYPODA

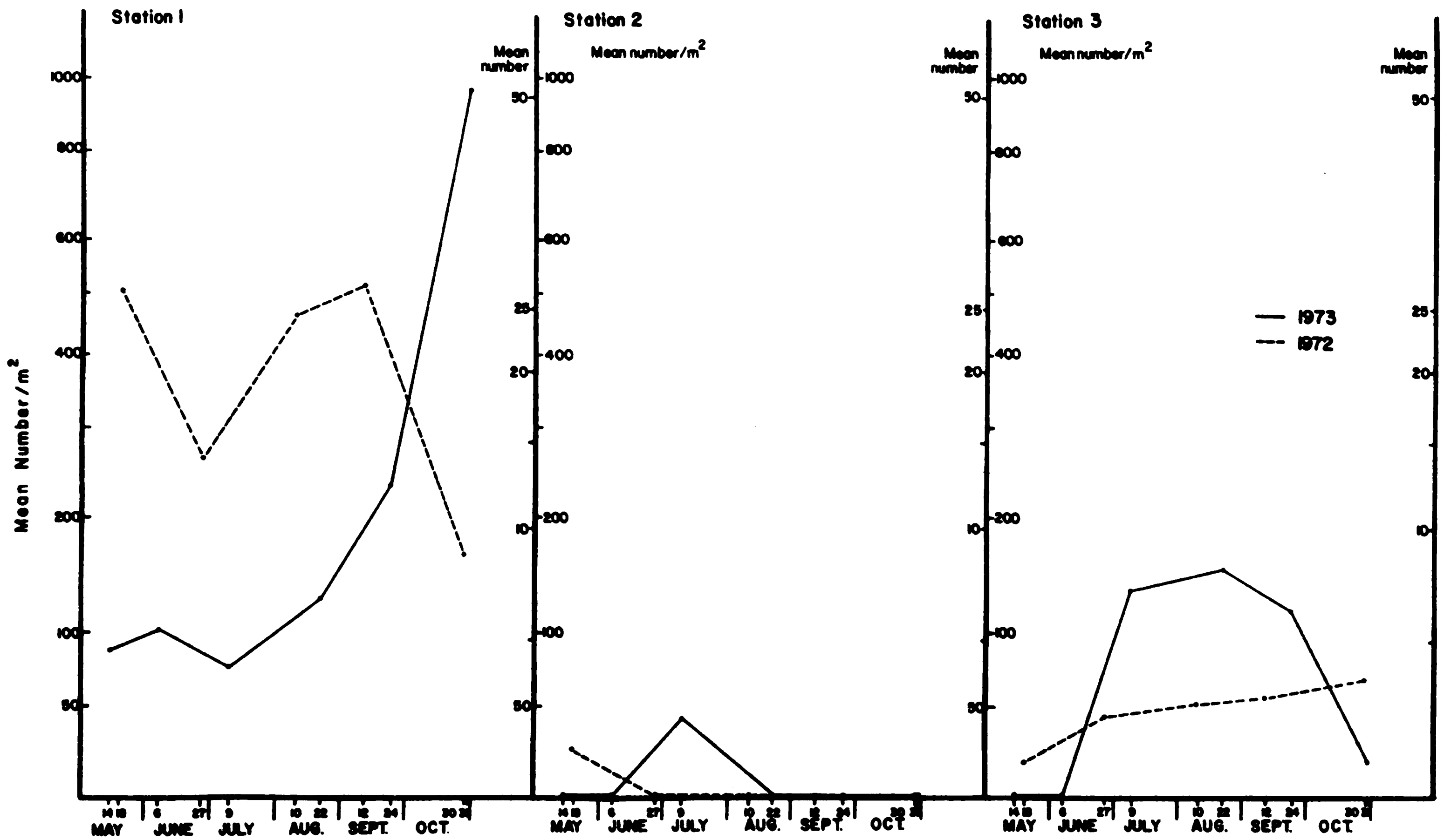


Figure 14 continued

PELECYPODA

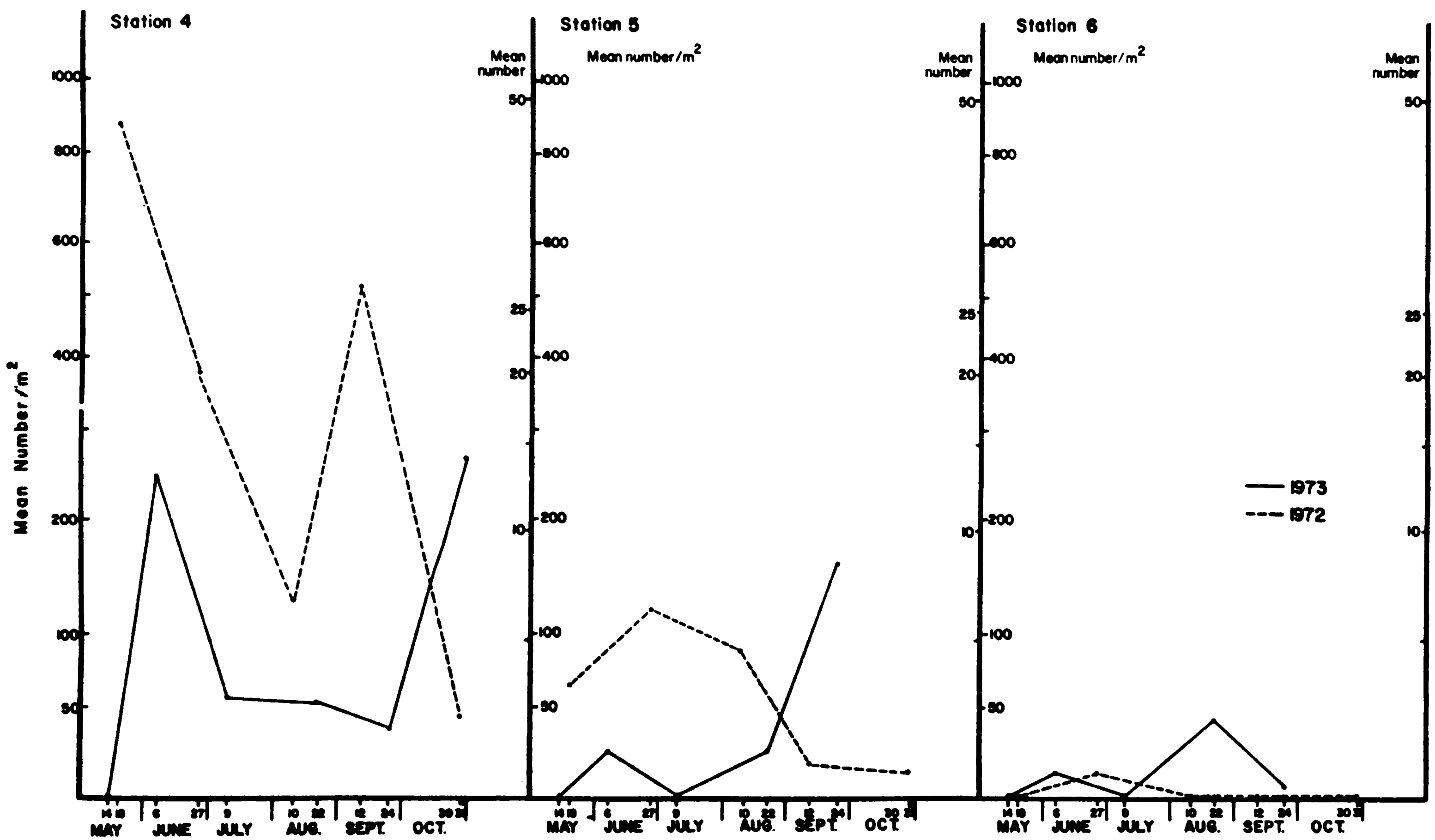


Figure 14

Table 14. Spearman Rank Correlation Coefficients for Comparison of Lake Michigan Benthic Macroinvertebrate Groups' Percentage Composition of Population Between 1972 and 1973

Stations	May-June			July-August			September-October			Total	
	Associated	Not Associated	Figure Number	Associated	Not Associated	Figure Number	Associated	Not Associated	Figure Number	Associated	Not Associated
1		X .31 n = 8	15	X .67 n = 8		16	X .64 n = 9		17	2	1
2		X .32 n = 5	15		X .60 n = 6	16	X .88 n = 6		17	1	2
3		X .20 n = 8	18		X .60 n = 8	19	X .77 n = 7		20	1	2
4	X .90 n = 5		18	X .77 n = 8		19	X .96 n = 7		20	3	0
5		X .54 n = 7	21		X .54 n = 9	23		X .70 n = 7	22	0	3
6		X .60 n = 5	21	X .83 n = 8		23		X .83 n = 6	22	1	2
Total Associated	1			3			4			8	
Total Not Associated		5			3			2			10

In testing the association for significance using r_s, the null hypothesis (H_0) is that the two-ranked series of percentages are unrelated or not associated in the population; the 1972 and 1973 population percentage composition at each station is not related or associated. If calculated r_s < tabulated critical value of r_s (0.05 significance level), then retain H_0; if calculated $r_s \geq$ tabulated critical value of r_s (0.05 significance level), then reject H_0 and accept H_1 which states that the two-ranked series of percentages are related or associated.

Station one benthic macroinvertebrate population comparison for the May-June sampling period (Figure 15) was not associated; the appearance and development of organisms in the spring at different times is probably responsible for this difference. The July-August (Figure 16) and September-October (Figure 17) sampling periods had r_s values greater than the critical value indicating that these two comparisons had populations which were associated or related.

The May-June (Figure 15) and July-August (Figure 16) population composition comparisons at station two were not associated which was primarily due to the greater diversity of groups in the 1973 season. September-October comparison (Figure 17) indicated that the two season population percentages were associated.

Station three May-June (Figure 18) and July-August (Figure 19) comparisons were not associated or related. This lack of association between the populations is probably caused by the greater number of organisms/m^2 and the predominance of oligochates in May-June 1972, and the fewer samples in July-August 1972. The September-October comparison (Figure 20) had populations which were associated.

Figure 15. Comparison of May-June benthic macroinvertebrate populations of 1972 and 1973 Ponar grab samples from stations one and two.

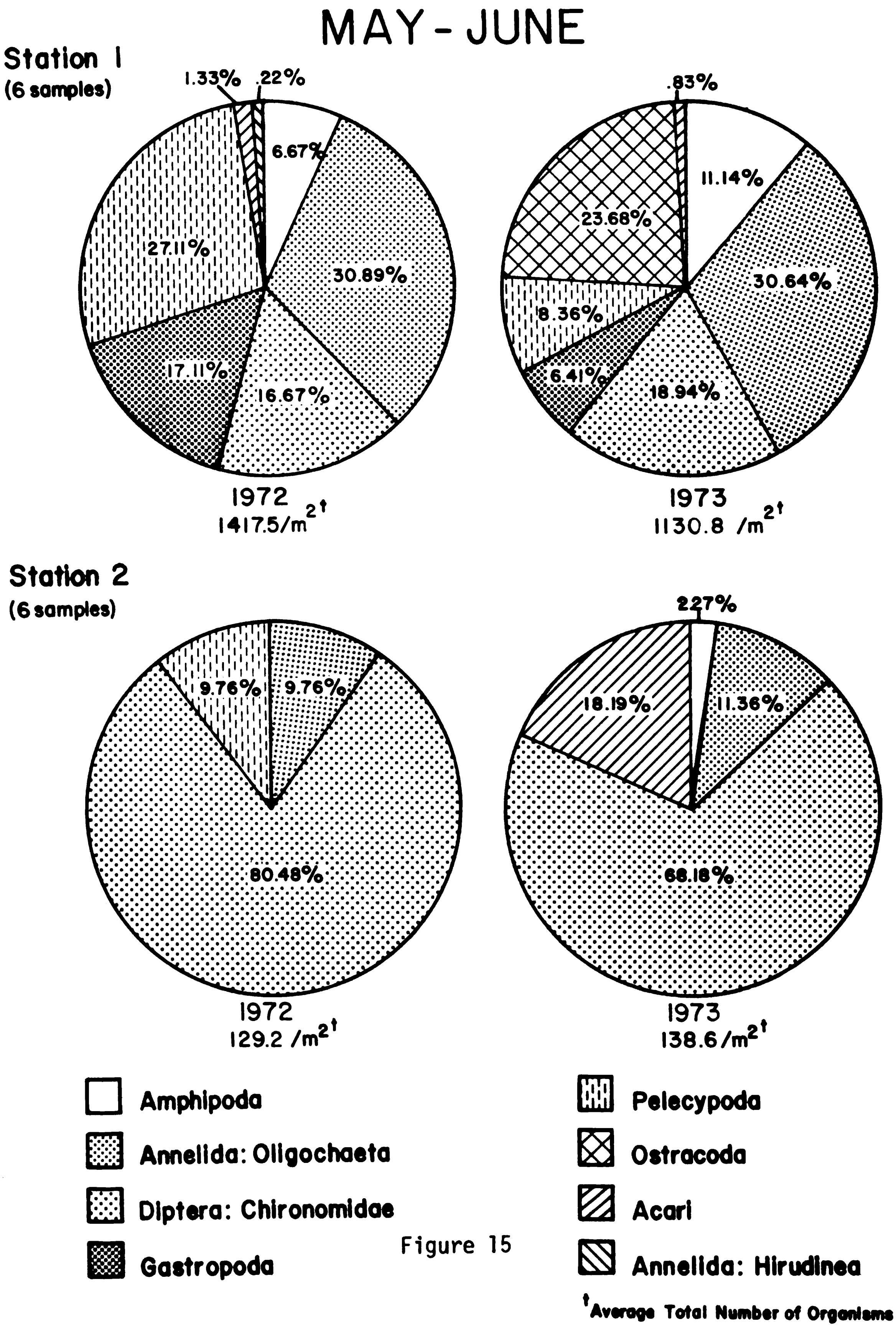

MAY - JUNE
Station 1
(6 samples)
1.33%
.22%
6.67%
30.89%
16.67%
17.11%
27.11%
1972
1417.5/m2†
.83%
11.14%
30.64%
18.94%
6.41%
8.36%
23.68%
1973
1130.8 /m2†
Station 2
(6 samples)
9.76%
9.76%
80.48%
1972
129.2 /m2†
2.27%
11.36%
68.18%
18.19%
1973
138.6/m2†
Amphipoda
Annelida: Oligochaeta
Diptera: Chironomidae
Gastropoda
Pelecypoda
Ostracoda
Acari
Annelida: Hirudinea
†Average Total Number of Organisms

Figure 15

Figure 16. Comparison of July-August benthic macroinvertebrate populations of 1972 and 1973 Ponar grab samples from stations one and two.

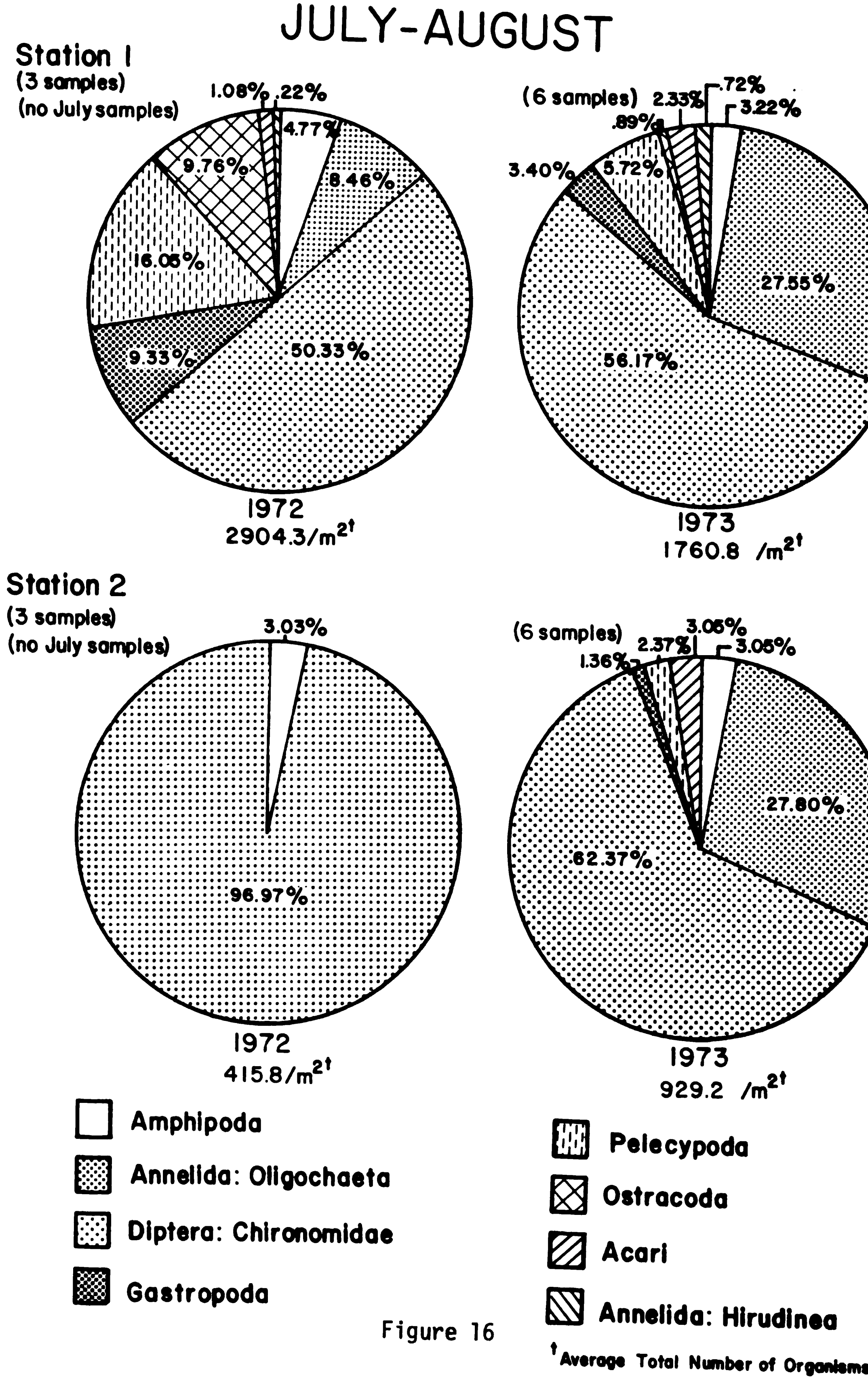

JULY-AUGUST
Station 1
(3 samples)
(no July samples)
1.08%
.22%
4.77%
9.76%
8.46%
16.05%
9.33%
50.33%
1972
2904.3/m²†
(6 samples)
2.33%
.72%
3.22%
.89%
3.40%
5.72%
27.55%
56.17%
1973
1760.8 /m²†
Station 2
(3 samples)
(no July samples)
3.03%
96.97%
1972
415.8/m²†
(6 samples)
3.06%
2.37%
3.06%
1.36%
27.80%
62.37%
1973
929.2 /m²†
Amphipoda
Annelida: Oligochaeta
Diptera: Chironomidae
Gastropoda
Pelecypoda
Ostracoda
Acari
Annelida: Hirudinea
† Average Total Number of Organisms

Figure 16

Figure 17. Comparison of September-October benthic macroinvertebrate populations of 1972 and 1973 Ponar grab samples from stations one and two.

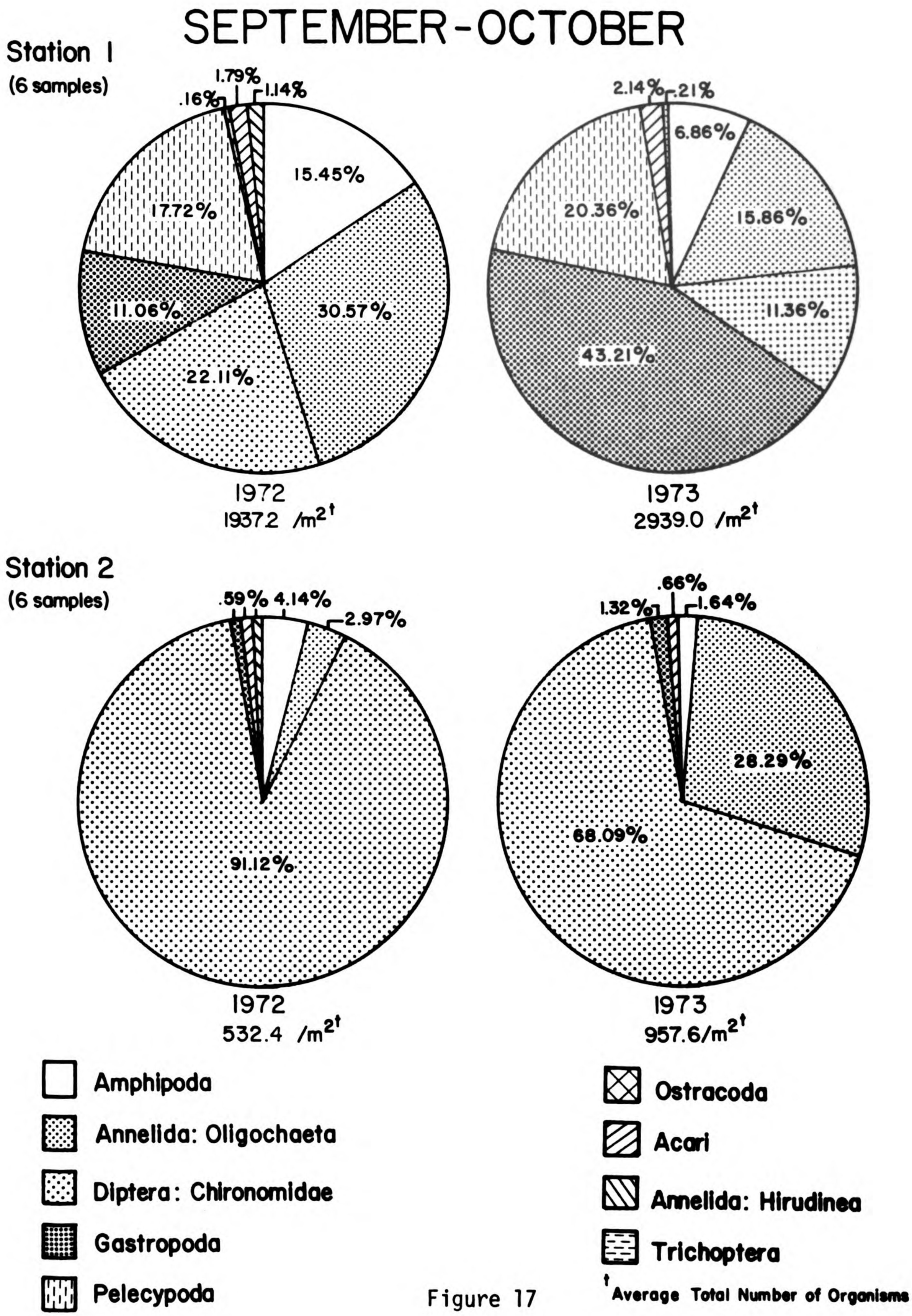

SEPTEMBER-OCTOBER
Station 1
(6 samples)
.16%
1.79%
1.14%
15.45%
17.72%
11.06%
30.57%
22.11%
1972
1937.2 /m²†
2.14%
.21%
6.86%
20.36%
15.86%
11.36%
43.21%
1973
2939.0 /m²†
Station 2
(6 samples)
.59%
4.14%
2.97%
91.12%
1972
532.4 /m²†
.66%
1.32%
1.64%
28.29%
68.09%
1973
957.6/m²†
Amphipoda
Annelida: Oligochaeta
Diptera: Chironomidae
Gastropoda
Pelecypoda
Ostracoda
Acari
Annelida: Hirudinea
Trichoptera
† Average Total Number of Organisms

Figure 17

Figure 18. Comparison of May-June benthic macroinvertebrate populations of 1972 and 1973 Ponar grab samples from stations three and four.

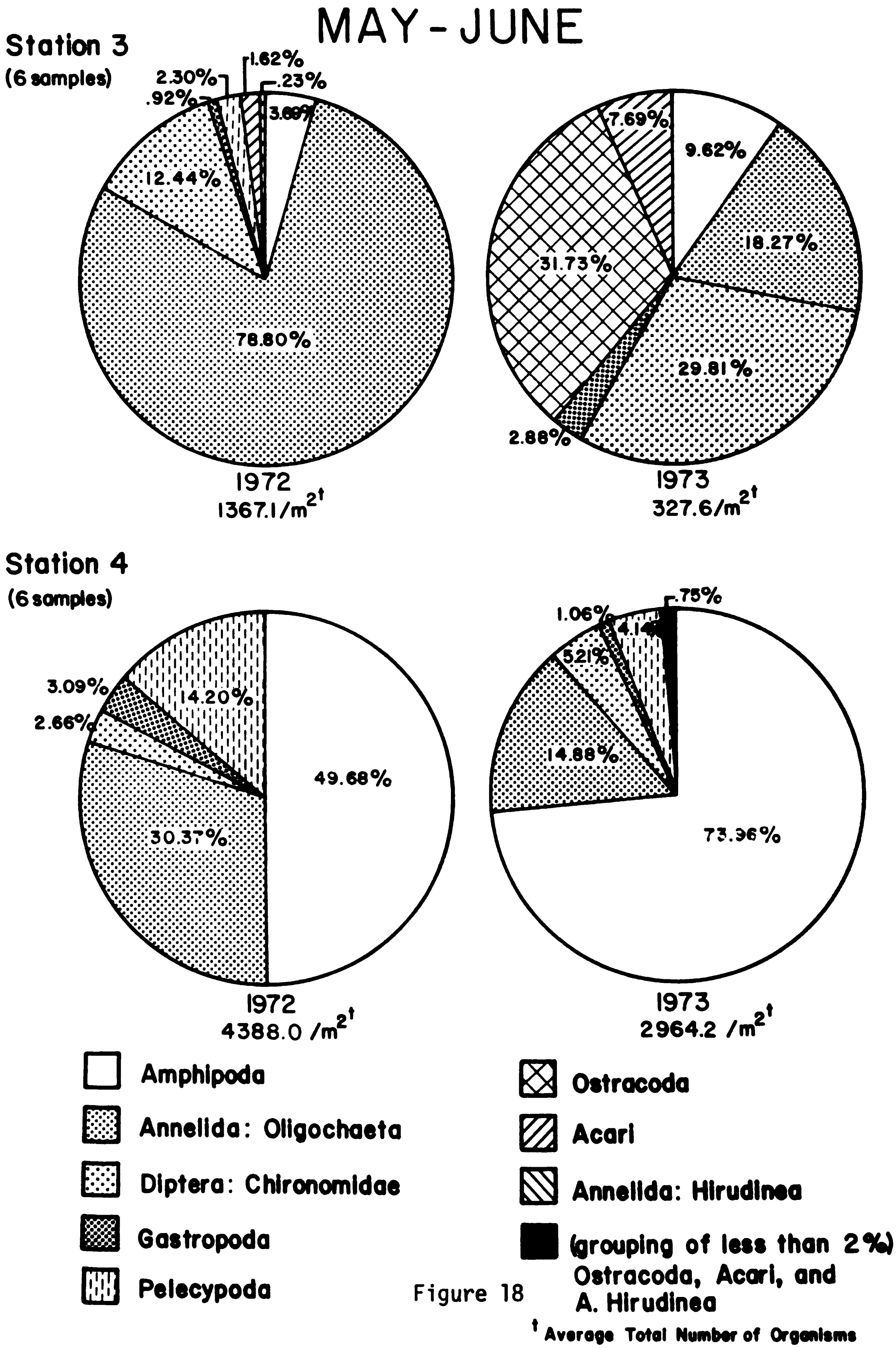

MAY - JUNE
Station 3
(6 samples)
1.62%
2.30%
.23%
.92%
3.69%
12.44%
78.80%
1972
1367.1/m²†
7.69%
9.62%
18.27%
31.73%
29.81%
2.88%
1973
327.6/m²†
Station 4
(6 samples)
3.09%
2.66%
14.20%
49.68%
30.37%
1972
4388.0 /m²†
.75%
1.06%
4.14%
5.21%
14.88%
73.96%
1973
2964.2 /m²†
Amphipoda
Annelida: Oligochaeta
Diptera: Chironomidae
Gastropoda
Pelecypoda
Ostracoda
Acari
Annelida: Hirudinea
(grouping of less than 2%)
Ostracoda, Acari, and
A. Hirudinea
† Average Total Number of Organisms

Figure 18

Figure 19. Comparison of July-August benthic macroinvertebrate populations of 1972 and 1973 Ponar grab samples from stations three and four.

JULY-AUGUST

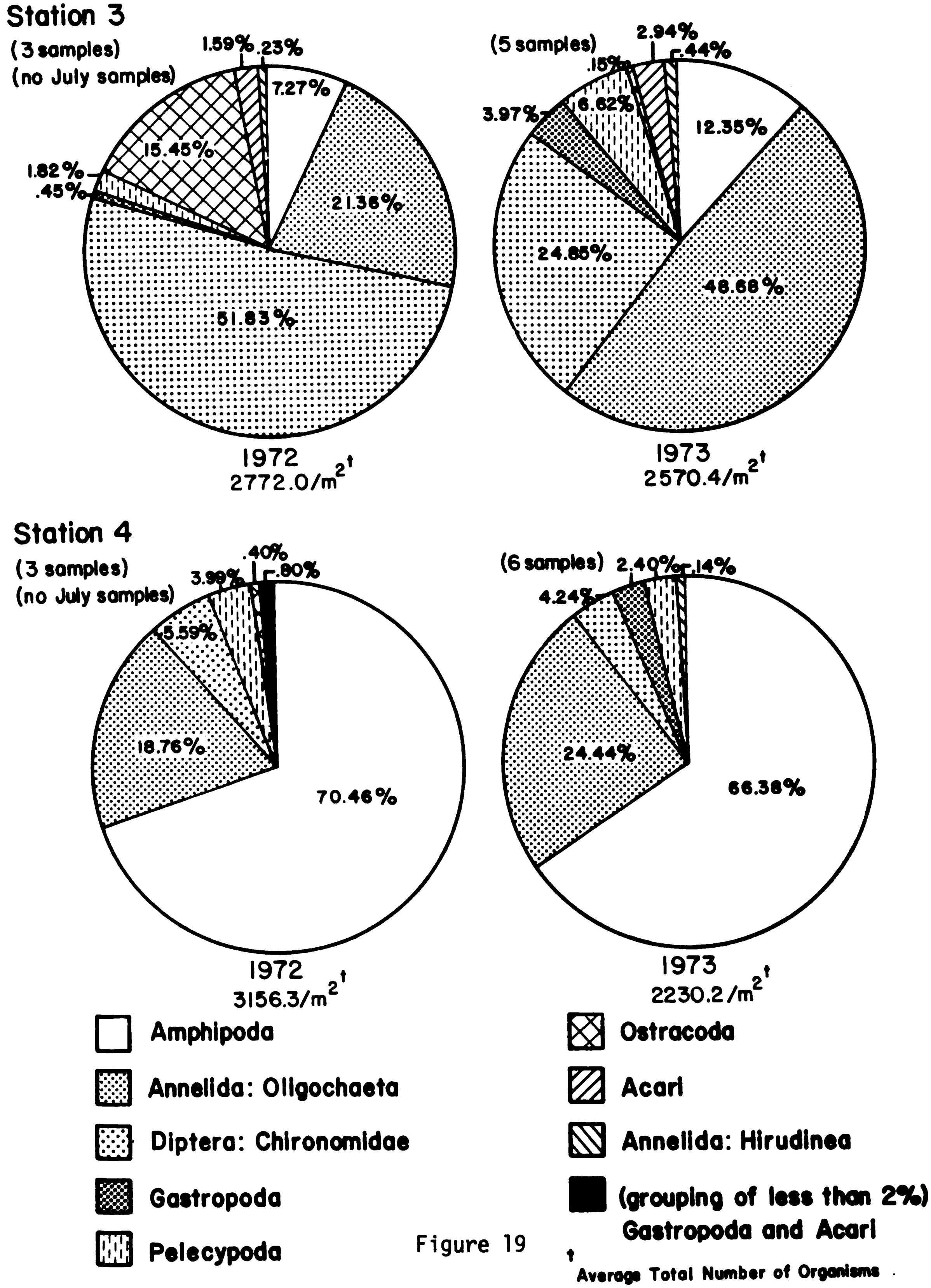


Figure 19

Figure 20. Comparison of September-October benthic macroinvertebrate populations of 1972 and 1973 Ponar grab samples from stations three and four.

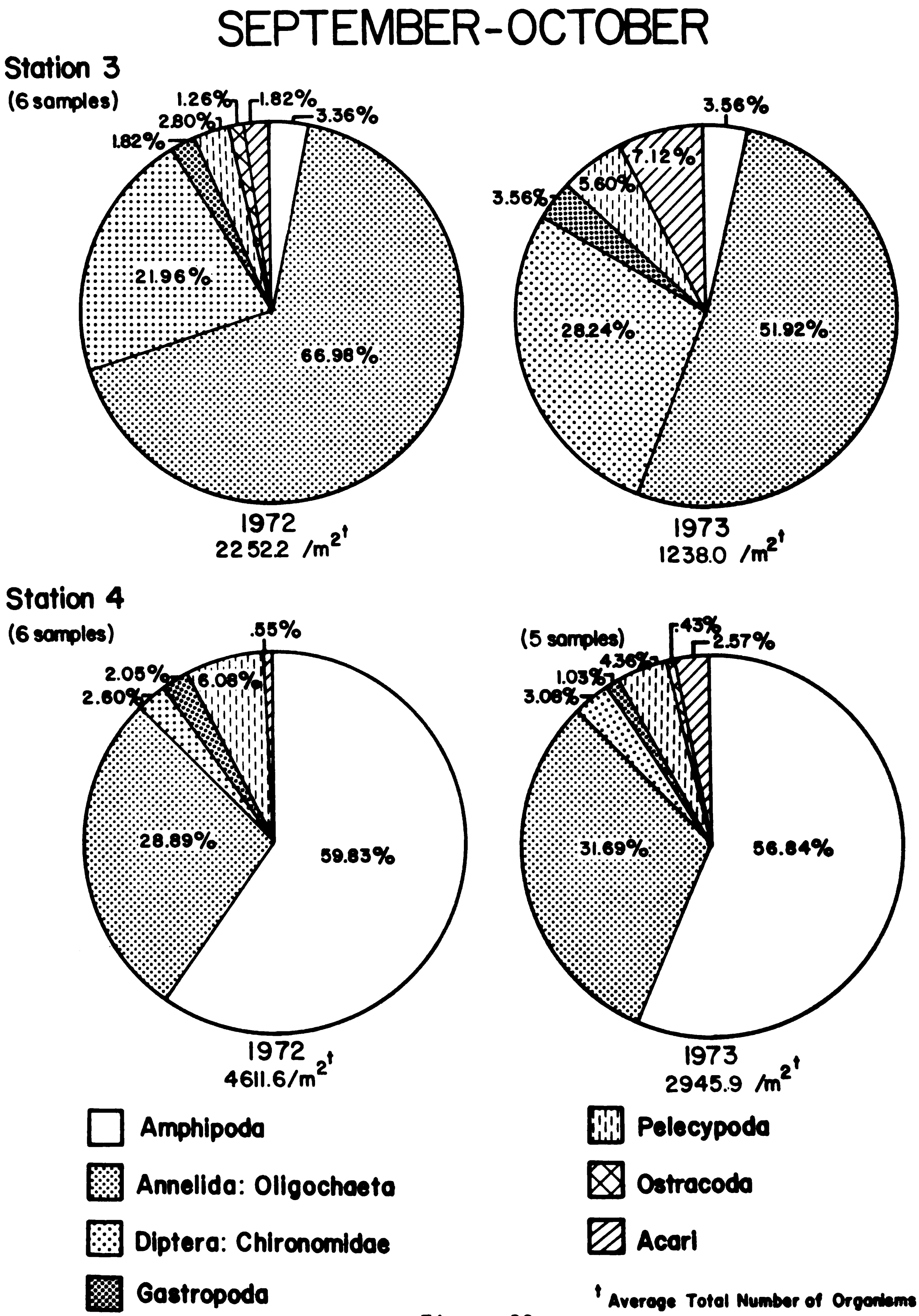

SEPTEMBER-OCTOBER
Station 3
(6 samples)
1.26%
1.82%
2.80%
3.36%
1.82%
21.96%
66.98%
1972
2252.2 /m²†
3.56%
7.12%
5.60%
3.56%
28.24%
51.92%
1973
1238.0 /m²†
Station 4
(6 samples)
.55%
2.05%
6.08%
2.60%
28.89%
59.83%
1972
4611.6/m²†
(5 samples)
.43%
2.57%
4.36%
1.03%
3.08%
31.69%
56.84%
1973
2945.9 /m²†
Amphipoda
Annelida: Oligochaeta
Diptera: Chironomidae
Gastropoda
Pelecypoda
Ostracoda
Acari
† Average Total Number of Organisms

Figure 20

Station four population comparisons (Figures 18, 19, and 20) indicated each paired population was associated. There is less variation in the abundance and distribution of the benthic groups at this deep water station.

Station five population comparisons (Figures 21, 22, and 23) were all unrelated indicating the Lake Michigan area immediately adjacent to the plant is most variable.

The May-June (Figure 21) and September-October (Figure 22) comparisons at station six were not associated due to greater group diversity and number of organisms/m^2 in 1973. The July-August (Figure 23) comparison indicated that the two populations were associated.

The Spearman rank correlation coefficient is only an indication of whether two populations are "similar or different" due to the disparity between their paired series of organism groups. It should be viewed as an indicator in making conclusions on the relationship between the populations. The number of ties resulting from the absence of groups from pairs and the small number of samples may have adjusted the r_s values, indicating a greater disparity than actually exists.

The important trends in these comparisons are that the shallower stations have populations which are more variable, and the May-June and July-August sampling periods show greater variation.

Figure 21. Comparison of May-June benthic macroinvertebrate populations of 1972 and 1973 Ponar grab samples from stations five and six.

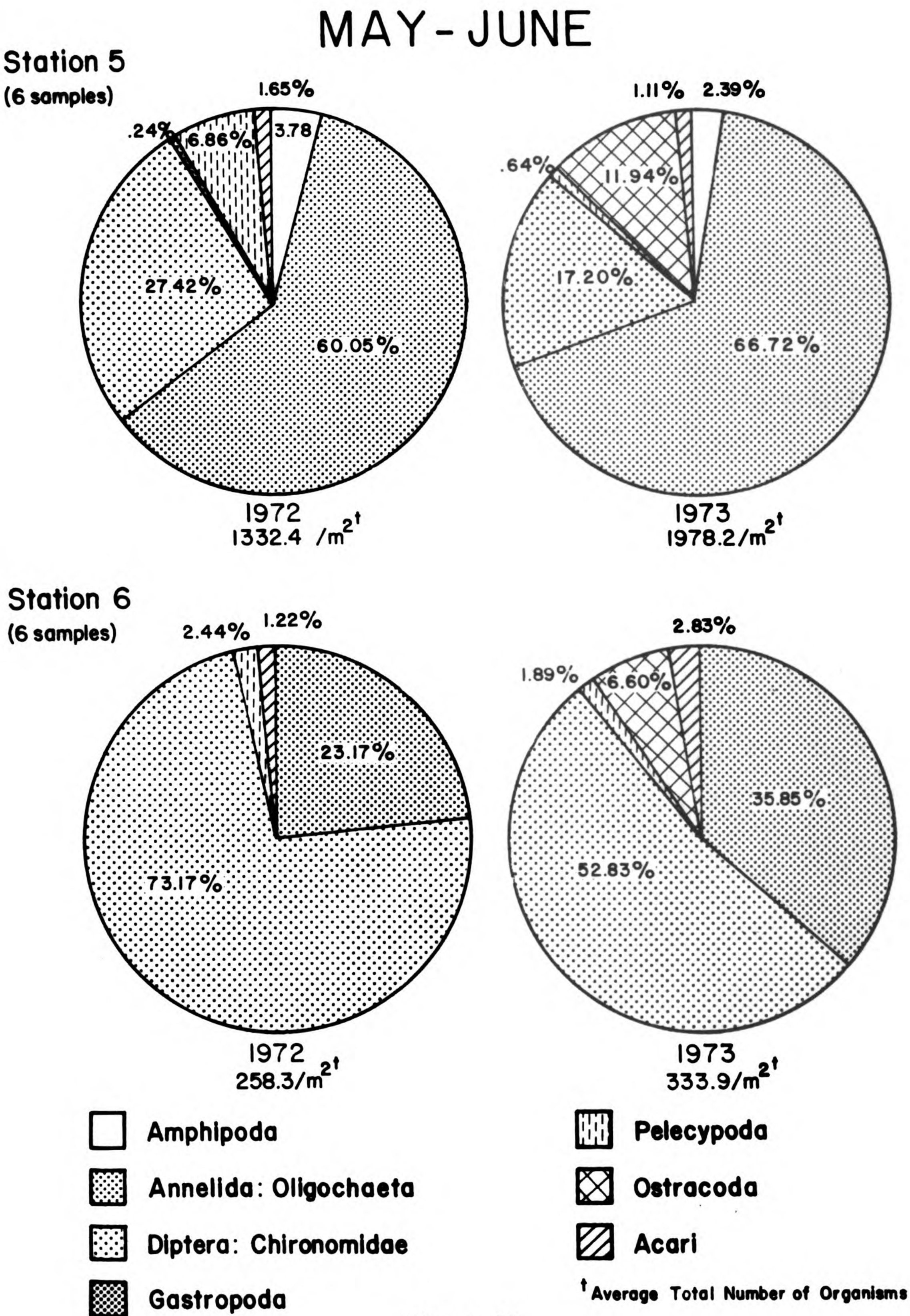

MAY-JUNE
Station 5
(6 samples)
1.65%
.24%
6.86%
3.78
27.42%
60.05%
1972
1332.4 /m²†
1.11% 2.39%
.64%
11.94%
17.20%
66.72%
1973
1978.2/m²†
Station 6
(6 samples)
2.44%
1.22%
23.17%
73.17%
1972
258.3/m²†
2.83%
1.89%
6.60%
35.85%
52.83%
1973
333.9/m²†
Amphipoda
Annelida: Oligochaeta
Diptera: Chironomidae
Gastropoda
Pelecypoda
Ostracoda
Acari
†Average Total Number of Organisms

Figure 21

Figure 22. Comparison of September-October benthic macroinvertebrate populations of 1972 and 1973 Ponar grab samples from stations five and six.

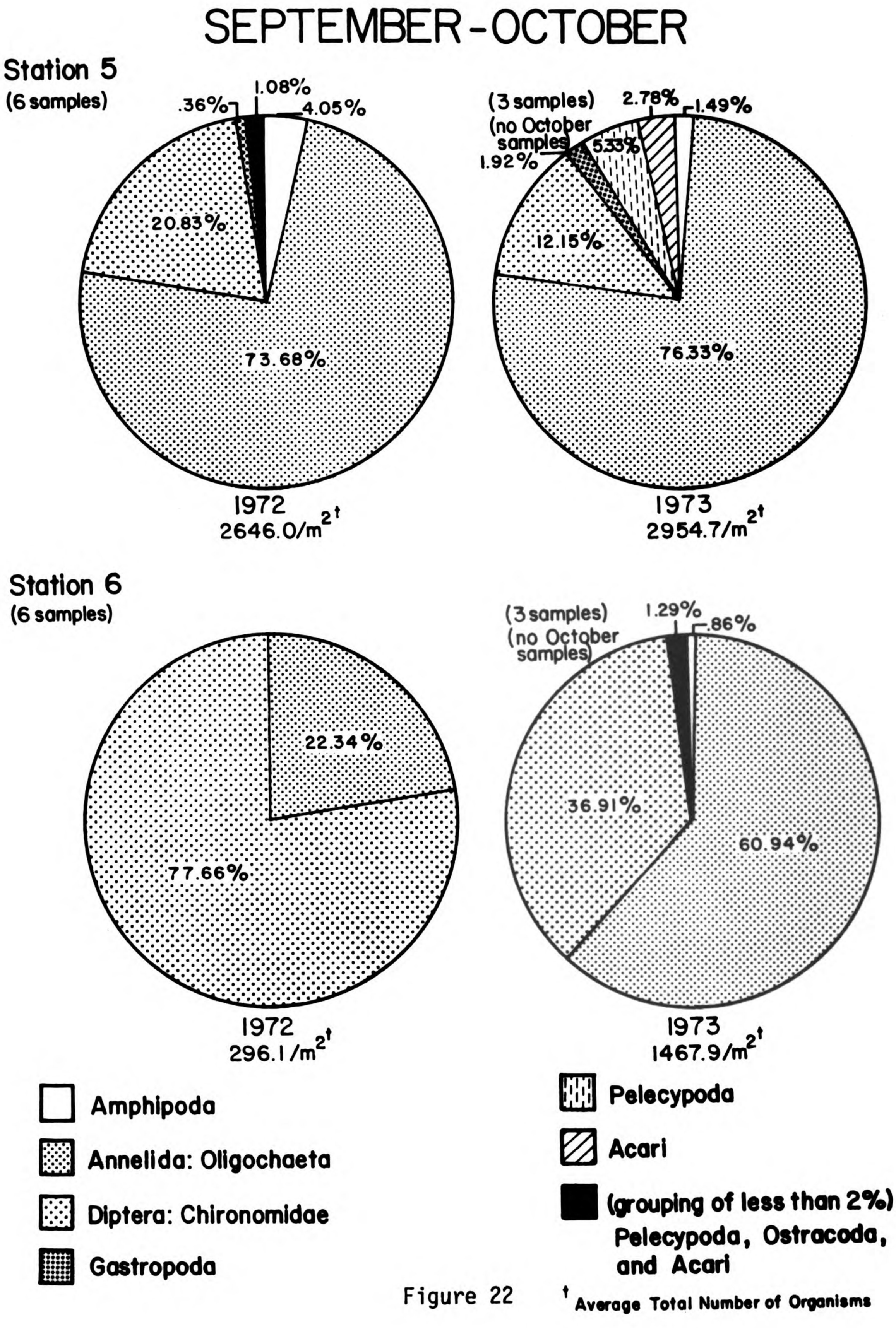

SEPTEMBER-OCTOBER
Station 5
(6 samples)
.36%
1.08%
4.05%
20.83%
73.68%
1972
2646.0/m2†
(3 samples)
(no October samples)
2.78%
1.49%
5.33%
1.92%
12.15%
76.33%
1973
2954.7/m2†
Station 6
(6 samples)
22.34%
77.66%
1972
296.1/m2†
(3 samples)
(no October samples)
1.29%
.86%
36.91%
60.94%
1973
1467.9/m2†
Amphipoda
Annelida: Oligochaeta
Diptera: Chironomidae
Gastropoda
Pelecypoda
Acari
(grouping of less than 2%) Pelecypoda, Ostracoda, and Acari
† Average Total Number of Organisms

Figure 22

Figure 23. Comparison of July-August benthic macroinvertebrate populations of 1972 and 1973 Ponar grab samples from stations five and six.

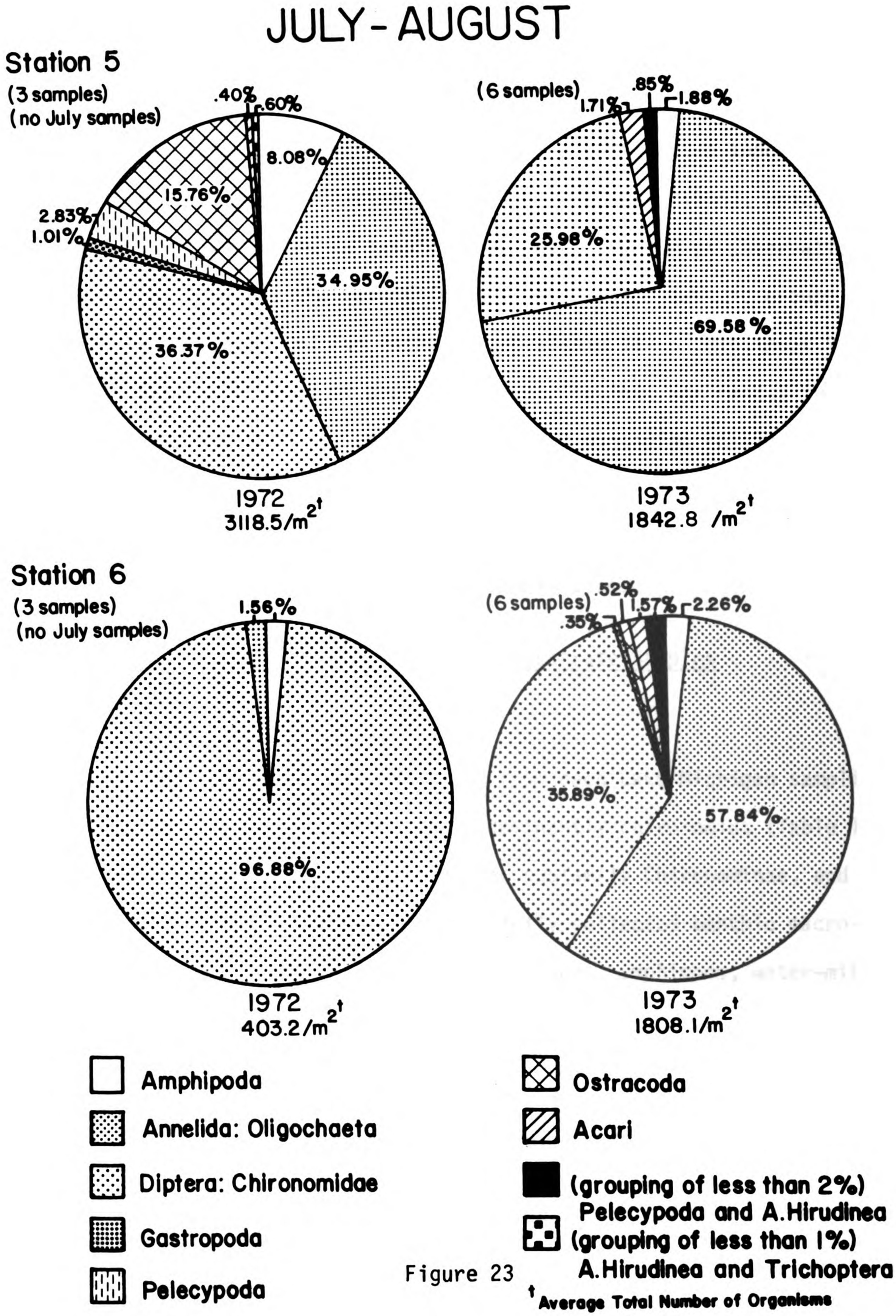

JULY - AUGUST
Station 5
(3 samples)
(no July samples)
.40%
.60%
8.08%
15.76%
2.83%
1.01%
34.95%
36.37%
1972
3118.5/m2†
(6 samples)
.85%
1.71%
1.88%
25.98%
69.58%
1973
1842.8 /m2†
Station 6
(3 samples)
(no July samples)
1.56%
96.88%
1972
403.2/m2†
(6 samples)
.52%
.35%
1.57%
2.26%
35.89%
57.84%
1973
1808.1/m2†
Amphipoda
Annelida: Oligochaeta
Diptera: Chironomidae
Gastropoda
Pelecypoda
Ostracoda
Acari
(grouping of less than 2%)
Pelecypoda and A.Hirudinea
(grouping of less than 1%)
A.Hirudinea and Trichoptera
† Average Total Number of Organisms

Figure 23

Dispersion Index of Major Benthic Macroinvertebrate Groups

The variance to mean ratio is used as a comparative index of dispersion. Green's coefficient, $\frac{(s^2/\bar{x}) - 1}{\Sigma x - 1}$ (Green, 1966), which is independent of variation in sample size, mean, and sum of observations, was used to calculate the values for the seven major benthic groups at each of the six stations for both seasons (Table 15). This index is suitable for comparisons of contagious distribution, and ranges from zero for random dispersion to one for maximum contagion (Elliott, 1971).

These values from the dispersion index should be considered as indicators of the variance to mean ratio, rather than a precise measurement because of the small and unequal sample sizes.

Lake Michigan Artificial Substrate Samples

Multiple Plate Samples

The multiple plate samples taken from each Lake Michigan sampling station after two months collected predominantly chironomids (Table 16), mainly from the tribe Chironomini of the subfamily Chironominae, and water-mites. These plate samplers primarily collected benthic macroinvertebrates which are <u>on</u> the bottom: isopods, amphipods, water-mites, chironomids and gastropods.

Asellus sp. isopods were sampled in greater abundance on the multiple plate samplers than in the Ponar grab samples.

Ten ephemeropteran nymphs, *Stenonema* sp., were sampled on the multiple plate samplers while none were collected in the Ponar grab samples.

Table 15 Dispersion Index for Major Benthic Macroinvertebrate Taxa from Lake Michigan 1972 and 1973 Ponar Grab Samples

Stations	Oligochaeta		Ostracoda		Amphipoda		Acari		Chironomidae		Gastropoda		Pelecypoda	
	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973
1	$.62^{*}$	$.02^{\#}$	$.27^{*}$	$.21^{\#}$	$.02^{*}$	$.07^{\#}$	$.08^{*}$	$.07^{\#}$	$.06^{*}$	$.12^{\#}$	$.01^{*}$	$.14^{\#}$	$.02^{*}$	$.11^{\#}$
2	$.03^{*}$	$.04^{\#}$	$.00^{*}$	$.00^{\#}$	$.27^{*}$	$.09^{\#}$	$.00^{*}$	$.04^{\#}$	$.05^{*}$	$.04^{\#}$	$.00^{*}$	$.31^{\#}$	$.23^{*}$	$.97^{\#}$
3	$.05^{*}$	$.09^{+}$	$.24^{*}$	$.88^{+}$	$.03^{*}$	$.28^{+}$	$.11^{*}$	$.05^{+}$	$.08^{*}$	$.04^{+}$	$.07^{*}$	$.25^{+}$	$.00^{*}$	$.10^{+}$
4	$.04^{*}$	$.06^{-}$	$.00^{*}$	$.08^{-}$	$.61^{*}$	$.05^{-}$	$.17^{*}$	$.42^{-}$	$.02^{*}$	$.04^{-}$	$.23^{*}$	$.07^{-}$	$.13^{*}$	$.20^{-}$
5	$.03^{*}$	$.01^{*}$	$.32^{*}$	$.33^{*}$	$.03^{*}$	$.03^{*}$	$.10^{*}$	$.02^{*}$	$.03^{*}$	$.03^{*}$	$.15^{*}$	$.40^{*}$	$.13^{*}$	$.26^{*}$
6	$.09^{*}$	$.07^{*}$	$.00^{*}$	$.43^{*}$	$.00^{*}$	$.07^{*}$	$.00^{*}$	$.07^{*}$	$.01^{*}$	$.06^{*}$	$.00^{*}$	$.00^{*}$	$.00^{*}$	$.54^{*}$

Sample size: $^{*}n = 15$; $^{\#}n = 18$; $^{+}n = 17$; $^{-}n = 19$

Table 16. Taxa and Relative Abundance of Lake Michigan Benthic Macroinvertebrates in 1972 and 1973 Multiple Plate Samples (6 Samples)

Relative Abundance: Numerical percentage of total number of benthic macroinvertebrates in all benthic groups.
R (rare) = 0-25% A (abundant) = 51-75%
C (common) = 26-50% VA (very abundant) = 76-100%

Nematoda	R
Annelida	R
Oligochaeta	
Plesiopora	
Tubificidae	
Limnodrilus sp.	
Peloscolex sp.	
Tubifex sp.	
Arthropoda	
Eucrustacea	
Malacostraca	
Isopoda	R
Asellidae	
Asellus sp.	
Amphipoda	R
Haustoriidae	
Pontoporeia affinis (Lindstrom)	
Decapoda	R

continued

Table 16--continued

Arachnoidea	
Acari	C
Lebertiidae	
Lebertia sp.	
Hygrobatidae	
Hygrobates sp.	
Mideopsidae	
Mideopsis sp.	
Insecta	
Ephemeroptera	R
Heptageniidae	
Stenonema sp.	
Trichoptera	R
Rhyacophilidae	
Rhyacophila sp.	
Hydropsychidae	
Hydropsyche sp.	
Diptera	C
Chironomidae	
Chironominae	
Chironomus sp.	
Cryptochironomus sp.	
Polypedilum sp.	
Glyptotendipes sp.	

continued

Table 16--continued

Tanypodinae	
Procladius sp.	
Conchapelopia sp.	
Mollusca	
Gastropoda	R
Pulmonata	
Planorbidae	
Gyraulus sp.	
Physidae	
Physa sp.	

Five trichopteran larvae, Rhyacophila sp. and Hydropsyche sp., were collected on these multiple plate samplers in Lake Michigan.

Physa sp. gastropods appeared to be selectively collected by the multiple plate samplers.

The multiple plate samplers collected benthic organisms which presented a different composition compared to the Ponar grab samples. However, weather conditions and vandalism made it difficult to keep many plate samplers in Lake Michigan for any length of time.

Rock Basket Samples

The rock basket samples from the protective rock jetties and breakwall area indicated that this area had attracted benthic macro-invertebrates by providing many new habitats (Table 17). Gammarus fasciatus and G. pseudolimnaeus amphipods, which dominated these samples, were found in Lake Michigan only on the rock baskets. These amphipods move about on the surface of rocks and plants (Bousfield, 1974), and the rock jetties and breakwall provide this habitat.

Trichopteran larvae, Rhyacophila sp. and Hydropsyche sp., were found abundantly in the rock basket samples. These trichopteran larvae are net-spinners found usually in a lotic habitat (Denning, 1971). The great amounts of water passing between the jetties constitute a lotic environment to which the benthic organisms are responding. Trichopteran larvae were sampled in greatest abundance in this entire study on the jetties and breakwall.

Water-mites, chironomids, gastropods, oligochaetes, leeches, and isopods were also collected from the rock baskets.

Table 17. Taxa and Relative Abundance of Lake Michigan Benthic Macroinvertebrates in 1972 and 1973 Rock Basket Samples (2 Samples)

Relative Abundance: Numerical percentage of total number of benthic macroinvertebrates in all benthic groups.
R (rare) = 0-25% A (abundant) = 51-75%
C (common) = 26-50% VA (very abundant) = 76-100%

Annelida	
Oligochaeta	R
Plesiopora	
Tubificidae	
Limnodrilus sp.	
Tubifex sp.	
Hirudinea	R
Arthropoda	
Eucrustacea	
Malacostraca	
Isopoda	R
Asellidae	
Asellus sp.	
Amphipoda	C
Gammaridae	
Gammarus fasciatus Say	
G. pseudolimnaeus Bousfield	
Arachnoidea	
Acari	R

continued

Table 17--continued

Hygrobatidae	
Hygrobates sp.	
Insecta	
Trichoptera	C
Hydropsychidae	
Hydropsyche sp.	
Diptera	R
Chironomidae	
Chironominae	
Chironomus sp.	
Cryptochironomus sp.	
Polypedilum sp.	
Glyptotendipes sp.	
Tanypodinae	
Procladius sp.	
Conchapelopia sp.	
Mollusca	
Gastropoda	R
Pulmonata	
Physidae	
Physa sp.	

DISCUSSION OF LAKE MICHIGAN STUDY

Statistical Analyses of Lake Michigan Benthic Macroinvertebrates

The Lake Michigan coastal area study compared the 1972 and 1973 benthic macroinvertebrates at each sampling station. A comparison between the two seasons was difficult because of the great variability in the benthic macroinvertebrate populations.

Many statistical analyses of benthic macroinvertebrate populations have been done to determine patterns and changes, ranging from basic statistical tests to diversity indices and multivariate data analyses. Wilhm (1967) compared diversity indices and their application to macroinvertebrates in streams for detecting pollution. Multivariate analysis was used to identify functional components of the benthos in a Nova Scotian bay (Hughes, Peer and Mann, 1972).

Statistical testing should determine differences and trends in data which can be interpreted biologically. Single classification analysis of variance, approximate t-test, Spearman rank correlation coefficients, and a dispersion index were used in the evaluation of the Lake Michigan benthic macroinvertebrate populations.

Negative Binomial Distribution of Benthic Macroinvertebrate Population

The spatial distribution of the bottom fauna is very important in estimating the total population. Benthic macroinvertebrates generally group or clump together on the bottom. Because they are not randomly distributed, most statistical tests cannot be directly applied to the data.

The negative binomial distribution has often been considered the appropriate model for macroinvertebrate populations (Anscombe, 1949; Bliss and Fisher, 1953; Debauche, 1962; Elliott, 1971). The parameters of this distribution are the arithmetic mean u and exponent k. The k statistic is related to the spatial distribution of the benthic macroinvertebrates with 1/k a measure of the excessive variance or clumping of the bottom organisms.

The calculation of k is:

$$k = \frac{\bar{x}^2}{s^2 - \bar{x}}$$

Because k is small in extremely clumped populations and the mean is usually small due to zero counts, the benthic organism counts must be transformed to normalize the frequency distribution, eliminate the dependence of the variance on the mean, and guarantee that components of the analysis of variance are additive (Elliott, 1971). The appropriate transformation of the benthic macroinvertebrate counts is determined by the calculation of the k statistic which is dependent on the original frequency distribution of the counts.

Transformation of Original Data

The k factor for the combined two seasons was calculated for the oligochaetes, ostracods, amphipods, water-mites, chironomids, gastropods, and pelecypods (Table 18). The k values for these seven groups were all less than 1.0 and the variances were all greater than the means. The log (x + 1) transformation was chosen (Elliott, 1971), and performed on all the individual counts from the seven groups.

Homogeneity of Variances

One assumption of the analysis of variance is that the samples come from populations which have the same or equal variances. The variances of the seven major benthic macroinvertebrate group comparisons for each two-month sampling period at each Lake Michigan station were tested to determine whether they were significantly different, using the F-test in Sokal and Rohlf (1969) and Elliott (1971).

$$F = \frac{\text{variance}_1}{\text{variance}_2} \qquad \text{(largest variance always in the numerator)} \qquad v_1 = n_1 - 1 \text{ df} \qquad v_2 = n_2 - 1 \text{ df}$$

Single Classification Analysis of Variance

A single classification was performed on the comparisons whose groups had homogeneous variances. This analysis of variance for two groups is the same as the t-test of the differences between two means which is the traditional method of determining a difference (Sokal and Rohlf, 1969); they feel that there is no advantage to the t-test in terms of ease of computation or understanding. In the single

Table 18. Mean ($\bar{x}$), Variance (s^2), and Excessive Variance or "Clumping" (k) of Lake Michigan Benthic Macroinvertebrate Major Taxa from the Combined Six Stations and Two Seasons (Ponar Grab Samples)

Benthic Macroinvertebrate Groups (192 Samples)	$\bar{x}$	s^2	k
Oligochaeta	663.7	572,747.06	.770
Ostracoda	41.5	17,352.84	.100
Amphipoda	411.3	1,082,718.42	.156
Acari	23.9	1,495.15	.390
Chironomidae	385.0	184,276.85	.806
Gastropoda	82.2	73,240.43	.092
Pelecypoda	114.5	62,443.24	.210

classification analysis of variance for two groups, the null hypothesis is that the two samples are taken from the same population or populations with the same means and variances. Small samples ($n < 60$) require the population also to be normally distributed.

When the variances were not equal, the approximate t-test for two samples whose variances are assumed to be unequal (Sokal and Rohlf, 1969) was performed on the data.

Spearman Rank Correlation Coefficient (r_s)

The Spearman rank correlation coefficient is a non-parametric test which measures the degree of association between two ranked series of observations. The percentages of the different macroinvertebrate groups for each station during the two-month period are ranked and paired between the two seasons. The r_s results indicated that 10 of the 18 comparisons were not significantly associated. These results should be interpreted with the understanding that the r_s method must have paired groups or ranks. Because unpaired percentages occurred, these values would be paired with zeros which produced a number of ties in several instances. This most probably affected the r_s value even when the equation for ties was being used. The small and unbalanced sample sizes at stations five and six in September-October, 1973, may have offset the r_s values. The r_s determination should be viewed cautiously and used primarily to illustrate major trends because the r_s values may indicate a greater disparity than actually exists.

Index of Dispersion

An index of dispersion was calculated for the seven major macroinvertebrate groups at each station comparing between season differences. These 84 values are presented in Table 15 and show the great variation in the samples. A difficulty with a dispersion index is determining significant differences between the values and then interpreting these differences biologically.

Green's coefficient of the variance to mean ratio (Green, 1966) was used because it is independent of variation in sample size, arithmetic mean and sum of observations. Green felt that indices of dispersion were inaccurate when $n < 50$ and should not be calculated. However, these values are good for relative comparisons of the benthic macroinvertebrates between stations and between seasons.

Lake Michigan Samples

The round whitefish (Armstrong, 1973) and yellow perch (Brazo, 1973) population studies in the adjacent Lake Michigan areas of the Ludington Pumped Storage Plant indicated benthic macroinvertebrates were major food items in their diets. However, some of these benthic organisms were not collected in the Ponar grab samples from the Lake Michigan stations. This fact initiated an evaluation of the benthic sampling effectiveness and influenced the implementation of artificial substrate sampling in 1973.

Oligochaeta

The oligochaetes found at the coastal Lake Michigan stations were primarily Limnodrilus sp., Peloscolex sp. and Tubifex sp. with a great number of immature forms. The oligochaetes were preserved in Bouin's solution; many of the samples had begun to decompose and some were stained a dark yellow. This dark yellow stain made it difficult and many times impossible to see the taxonomic structures even after the samples were rinsed in lactophenol or alcohol. Hiltunen's (1973) key was used for their identification. Dr. C. J. Goodnight provided valuable assistance in the identification, verification and interpretation of the oligochaetes in Lake Michigan and reservoir samples.

The stations and seasonal abundances of Lake Michigan oligochaetes are presented in Table 7. In addition to the three genera of Tubificidae which dominate the samples, one genus of Naididae, Stylaria sp., was found in the samples. The presence of numbers of immature forms indicates either an unusual survival of the young or an unusual mortality of the adults. The number of immature oligochaetes present in the samples indicates that these sampling areas probably had been disturbed (Goodnight, 1974).

The U. S. Standard No. 30 sieve used in processing the samples also probably allowed many of the immature Tubificidae and Naididae to be lost. Hiltunen (1967) found Lake Michigan oligochaete abundances significantly higher at depths less than 40 m. A decline in sexual activity before the fall overturn of Lake Michigan might be the reason for the decline of adult L. hoffmeisteri and T. tubifex in late summer and fall (Hiltunen, 1967). Peloscolex multisetosus, Limnodrilus hoffmeisteri, Ilyodrilus templetoni, Tubifex tubifex, and Potamothrix spp. would become established and dominate in the inshore areas (depth less than 40 m) of Lake Michigan if gradual organic enrichment occurred, as has happened in bays and harbors (Hiltunen, 1967). The presence of Limnodrilus sp., Peloscolex sp. and Tubifex sp. in the Lake Michigan sampling stations around the Ludington Pumped Storage Reservoir does not necessarily indicate eutrophication is occurring in this area.

Ostracoda

Species of Candona were the only ostracods found in the samples, with C. rawsoni Tressler found at all the stations and C. inopinata Furtos, tentatively identified by Dr. D. L. McGregor, also at all the stations. Dr. McGregor also tentatively identified C. acuti Hoff as the ostracod found primarily at the shallow stations and C. cf. acutula Delorma as the deep station ostracod ("cf." means "similar to").

This ostracod genus is non-swimming and usually found in the top sediment layers (Pennak, 1953). It feeds on benthic algae. Ostracods have a one year life cycle and most are mature during January to June (McGregor, 1972). As soon as ostracods reach maturity, they start reproducing after which they die. Due to their relatively small size and the sampling methods used in this study, ostracods were lost in the collecting and processing of the samples.

Isopoda

Asellus sp. isopods were found primarily on the multiple plate samplers at the six Lake Michigan sampling stations. Merna (1960) reported Lirceus lineatus as the shallow water isopod from Lake Michigan shoal areas with bottom types ranging from a mixture of sand and clay to sand, silt and gravel.

Amphipoda

Pontoporeia affinis was the only amphipod species collected in the coastal Lake Michigan bottom sampling. Table 9 lists the relative abundance of Pontoporeia affinis among stations and between the two seasons. The high individual sample level reached by P. affinis was in June, 1973 with 6255.9 individuals/m^2. Gammarus fasciatus Say and G. pseudolimnaeus Bousfield were sampled from the protective jetties and breakwall area by the rock basket samplers.

A significant decrease in the amphipod population at station five in the 1973 season might indicate an effect of the reservoir operation. P. affinis is a bottom-dwelling amphipod whose individuals migrate up and down in the water column primarily at night (Alley, 1968). P. affinis is an active swimmer, but its locomotion pattern involves periods of drifting; it could be affected by currents of an area. One possible explanation for the decrease in the amphipod population at station five would be that the reservoir currents are generally removing amphipods from the area. These currents might also be selectively removing only the larger mature P. affinis which are more susceptible because they are distributed throughout the water column. This could affect the amphipod reproductive potential of that area and reduce the population. Water temperature differences between 1972 and 1973 may have changed the amphipod distribution at the Lake Michigan stations decreasing their abundance in the Ponar grab samples.

Acari

Water-mites were sampled from the six Lake Michigan sampling stations in both seasons with the number of individuals/m^2 being the greatest in September. Hygrobates sp. and Lebertia sp. were the two dominant water-mites in the Lake Michigan sampling areas using the Ponar grab-sampler with Mideopsis sp. becoming subdominant the second season at the stations nearest the jetties and breakwall area. Forelia sp. was collected in several samples (Table 10).

The majority of these Lake Michigan water-mites, Hygrobates sp. and Lebertia sp., was from the genera which Modlin and Gannon (1973) found to dominate their samples of the St. Lawrence Great Lakes water-mites.

Water-mites are parasitic in their larval stage and predaceous as adults. Modlin (1971) found that hygrobatid larvae parasitize chironomid larvae. Crowell (1960) concluded that larvae of Lebertia porosa parasitize trichopteran larvae. Most water-mites parasitize dipteran larvae (Cook, 1974). Adults are predaceous in their food habits and Paterson (1970) concluded that certain aquatic mites feed on chironomids. Modlin (1971) observed Hygrobates sp. feeding on Gammarus sp. eggs.

Less than two percent of the alewife alimentary tracts sampled from Lake Michigan (Modlin and Gannon, 1973) had water-mites present. The ingested water-mites in the alewife alimentary tracts were not digested and it is questionable whether any aquatic insects or fish actively feed on water-mites (Modlin and Gannon, 1973).

Hygrobates longipalpis was reported on homogeneous sand substrates and Lebertia porosa was found from areas of homogeneous silt by

Modlin and Gannon (1973) with both species present in mixed sand and silt. They found the greatest numbers of individuals and species in Lake Michigan were in less than the 20 m depth with *H. longipalpis* and *L. porosa* the most abundant genera in these areas.

Ephemeroptera

Several *Stenonema* sp. nymphs were taken by the multiple plate samplers in Lake Michigan.

Trichoptera

Molanna sp. larvae were collected from the Lake Michigan sampling stations, and *Hydropsyche* sp. and *Rhyacophila* sp. were found in the rock basket samples from the jetty and breakwall.

Chironomidae

The chironomids from the five inshore Lake Michigan stations had similar seasonal distributions with approximately the same ranges (Figure 12). Station four had a different chironomid seasonal distribution with a lower range. *Chironomus* sp., *Cryptochironomus* sp., *Glypototendipes* sp., and *Procladius* sp. dominated the chironomid larvae (Table 11). Dr. L. L. Curry provided valuable assistance in the identification, verification and interpretation of the chironomids. The chironomid forms present in these Lake Michigan areas indicate an essentially oligotrophic environment (Curry, 1974). A large number of benthic macroinvertebrate taxa, each with relatively low abundances, are representative of an oligotrophic environment.

Mozley and Garcia (1972) found chironomid larvae, primarily forms of Chironomus, Cryptochironomus and Procladius, in the coastal zone of southeastern Lake Michigan. These chironomid forms were also in the samples from the coastal area of central Lake Michigan near Ludington. Differences in the minor chironomid forms existed between these two Lake Michigan studies, but the dominant forms were the same.

Chironomid larvae were the dominant or characteristic organism in southeastern Lake Michigan coastal waters of less than 20 m (Mozley and Garcia, 1972). The chironomid larvae near Ludington were also numerically the dominant benthic organism group in the coastal areas.

As the chironomid larvae from the coastal area of central Lake Michigan near Ludington occupy several trophic levels, they appear to be a stable resident population. Tanypodinae larvae, Procladius sp., are predaceous, feeding on small invertebrates and other chironomid larvae (Bryce and Hobart, 1972). Chironominae larvae are generally non-carnivorous and have a wide range of feeding methods. Many forms use their labial plate for scraping algae or detritus off surfaces. Forms of Chironomus are detritus feeders and forms of Glyptotendipes are filter feeders (Bryce and Hobart, 1972). Cryptochironomus sp. are bottom-dwelling detritivores (Ward, 1974). Orthocladiinae larvae feed by typically scraping algae off the surfaces of stones and vegetation (Bryce and Hobart, 1972). The chironomid larvae present in this study occupy different trophic levels in the ecosystem, making them a firmly established aquatic population.

Chironomids are an important food source in the aquatic ecosystem, being hosts and a major food item for water-mites. Chironomid larvae are also a major item in the diets of round whitefish (Armstrong, 1973) and yellow perch (Brazo, 1973) of these Lake Michigan areas.

Gastropoda

Gyraulus sp. and *Physa* sp. were the major gastropods found in the Lake Michigan samples. Lenat and Weiss (1973) reported these genera were primarily periphyton feeders. *Lymnaea* sp. was collected in a trawl sample in August, 1972 near station five. *Physa* sp. reproduces easily throughout the year with temperature, light, and food changes stimulating egg depositing (Pennak, 1953).

Pelecypoda

The pelecypod population, *Sphaerium* sp. and *Pisidium* sp., was largest at stations one and four (Figure 14). Station one pelecypod population decreased significantly in 1973. This decline was probably due to seasonal variation, because the pelecypod populations at the sampling stations near the reservoir did not change significantly.

RESERVOIR STUDY

Methods and Materials

The colonization of the reservoir by benthic macroinvertebrates has been monitored since the initial filling of the impoundment in October, 1972. Sampling was done along a north-south transect in the reservoir, with multiple plate samples collected at stations one, two, three, four, five, and six, and grab samples at stations one, four, and six (Figure 3). Three multiple plate samplers were placed in the reservoir immediately following the initial reservoir filling in October, 1972, and remained in the reservoir over the winter; they were lifted and analyzed in April, 1973. Eighteen more plate samplers were then placed in the reservoir with three samplers at each of the six stations; they were removed and analyzed one sampler per station after being in the reservoir for two, three, and four months periods. After processing the multiple plate samplers each sampling time, they were returned to the reservoir to recolonize with benthic invertebrates, and again removed and analyzed in two months. Ponar grab sampling in the reservoir was done on a monthly basis from May through October, 1973, with triplicate samples taken on the clay bottom at each of the three stations.

Twelve rock baskets were placed on the scour protection area in front of the intake structure on April 18, 1973, with four samplers in three rows perpendicular to the intake structure (Figure 3). One row of rock baskets was lifted and analyzed on June 22, August 29, and November 7, during 1973. One row of rock baskets, replaced on June 22, was lifted and analyzed on November 13, 1973.

The reservoir water was lowered to a depth of approximately 4 m on September 1, 1973 to inspect and repair the embankment. The asphalt surfacing of the inside of the reservoir embankment stops approximately 6 m from the bottom and compacted clay comprises the remaining surface. When the reservoir water was drawn down, core samples were taken as the water receded on the clay rim near the reservoir bottom (Figure 24).

The macroinvertebrates taken by these four sampling methods were processed and analyzed the same as the Lake Michigan samples (Methods and Materials, page 19). Identifications of benthic invertebrates found only in the reservoir were made using several taxonomic keys: Collembola (Salmon, 1964); Coleoptera and Diptera (Pennak, 1953). The raw data from the reservoir Ponar grab and artificial substrate sampling are appended.

Reservoir sediment chemical tests were run on samples taken by the Ponar grab-sampler on May 11, July 18, August 30, September 1, and October 10, during 1973. The two three-sample profiles of the compact of clay portion of the reservoir inside embankment at the north and south ends were taken during the September 1, 1973 draw-down period. These 36 sediment samples were homogenized, subsampled, and dried at 40 C for 24 hours. The sediment subsamples were ground and analyzed for percentages of total carbon, hydrogen, and nitrogen on a dry weight basis using

Figure 24. Reservoir core sampling locations on the clay rim near the bottom of the embankment.

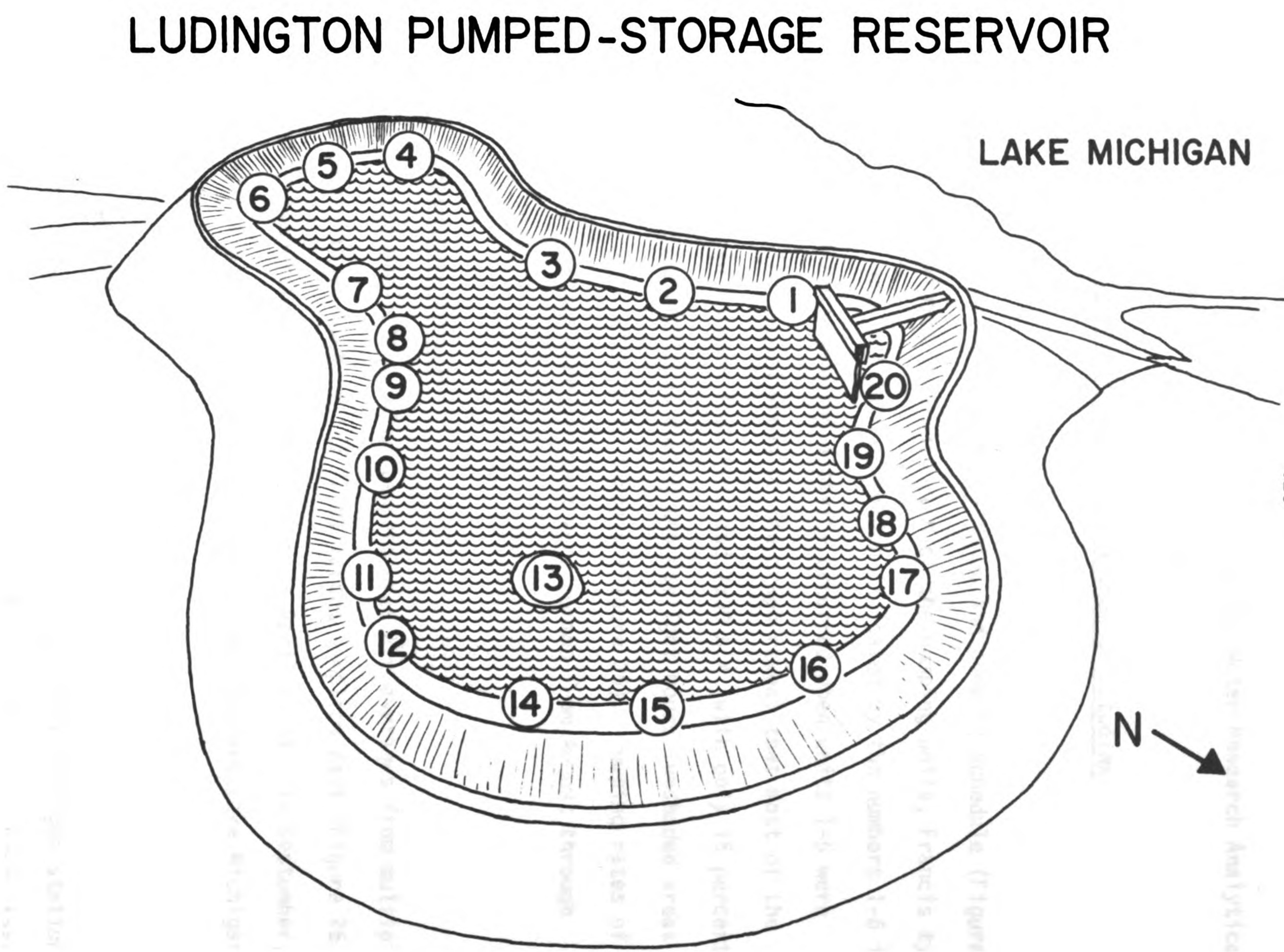

LUDINGTON PUMPED-STORAGE RESERVOIR
LAKE MICHIGAN
N
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Figure 24

a Perkin-Elmer 240 Elemental Analyzer by the Water Research Analytical Laboratory of Michigan State University.

Reservoir Physical and Chemical Studies

Weekly Pumping Rates

The reservoir water exchange rates and pumping schedule (Figure 25) shows the approximate time when each of the pumping units, Francis type pump-turbines, was put into operation indicated by the numbers 1-6 in the figure. Maximum pumping activity occurred when units 1-5 were operational. The shaded areas of the graph reveal that most of the pumping occurred between 7:00 P.M. and 7:00 A.M. with only 15 percent of weekly volume accomplished during the daylight hours (unshaded areas of graph), which were usually on Sundays (Figure 25). Pumping rates of 200,000 acre-feet or more per week were common from August through December, 1973.

Water Temperature Results

Surface and bottom water temperatures are averages from multiple measurements taken each of the 77 different sampling days (Figure 26). Reservoir temperatures ranged from 3 C in April to 24 C in September, 1973, reflecting the thermal conditions in the adjacent Lake Michigan coastal areas.

Water Transparency Results

Secchi disc values from the reservoir and Lake Michigan stations three and five (Figure 27) are averages of multiple measurements taken each sampling day. Reservoir transparencies ranged from 0.6 m in April

Figure 25. Water volume pumping capability of the Ludington Pumped Storage Reservoir for each week in 1973 (numbers 1-6 indicate the first operational date of each pump-turbine unit).

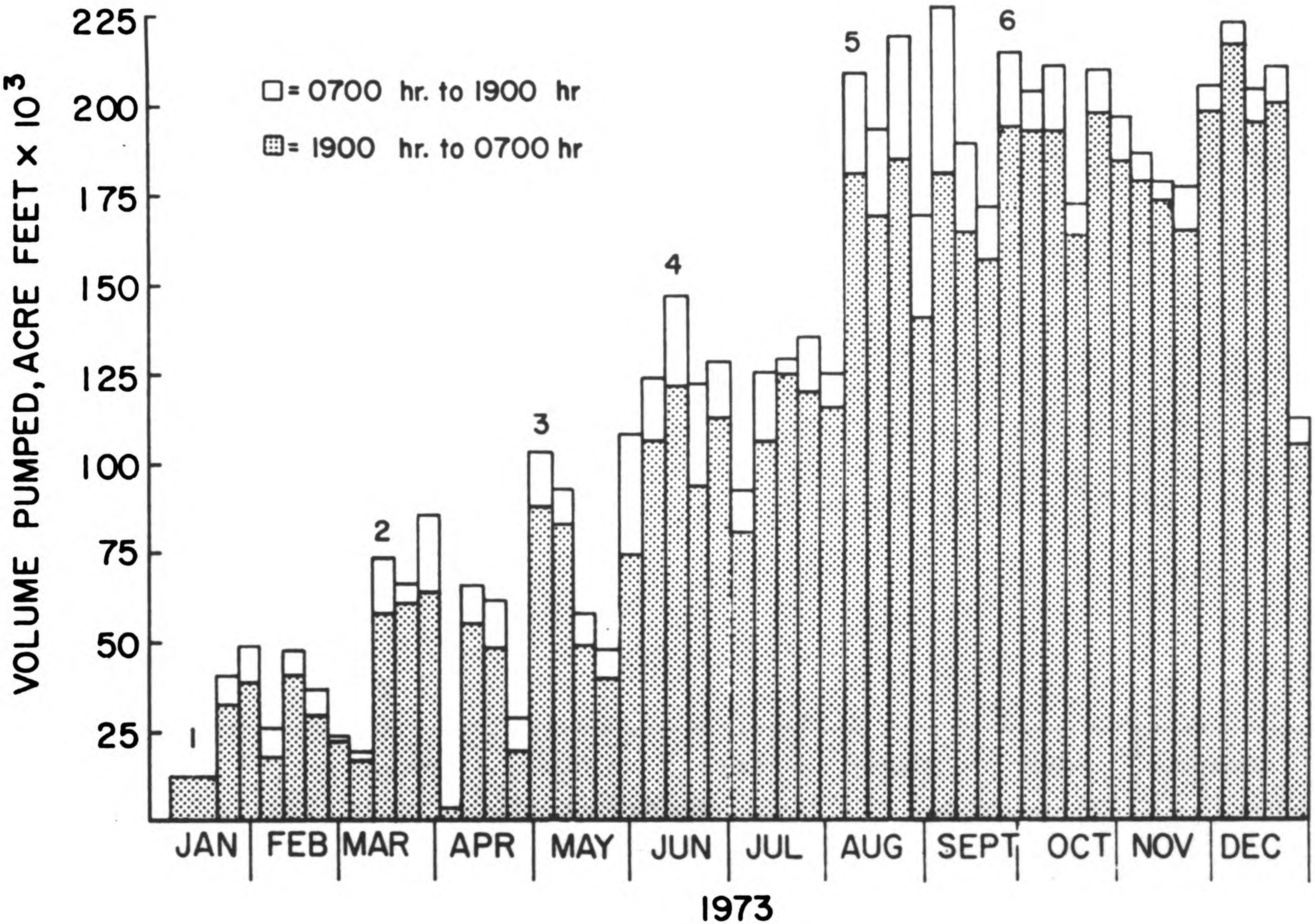

VOLUME PUMPED, ACRE FEET × 10³
225
200
175
150
125
100
75
50
25
□ = 0700 hr. to 1900 hr
▦ = 1900 hr. to 0700 hr
1
2
3
4
5
6
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC
1973

Figure 25

Figure 26. Average surface and bottom water temperatures at reservoir sampling stations during 1973.

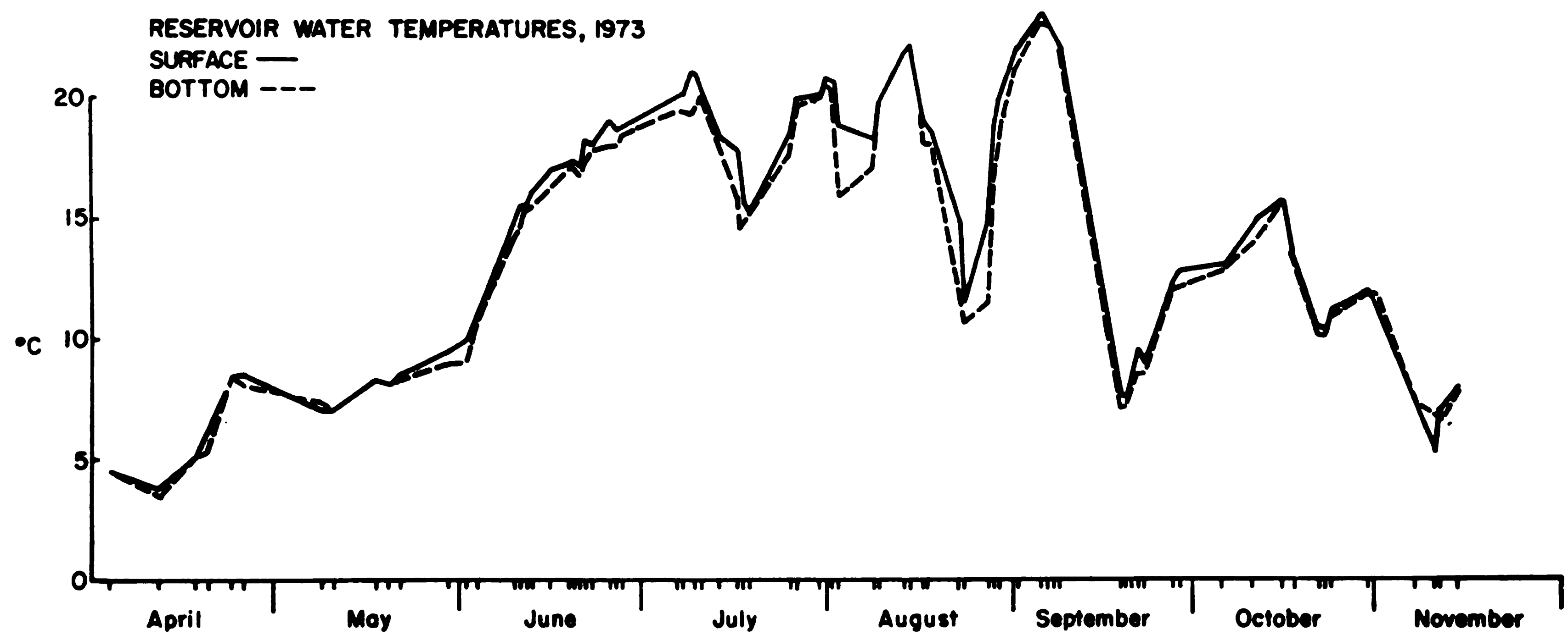

RESERVOIR WATER TEMPERATURES, 1973
SURFACE ——
BOTTOM ---
°C
20
15
10
5
0
April
May
June
July
August
September
October
November

Figure 26

Figure 27. Average secchi disc readings at Lake Michigan sampling stations three and five, and at reservoir sampling stations during 1973.

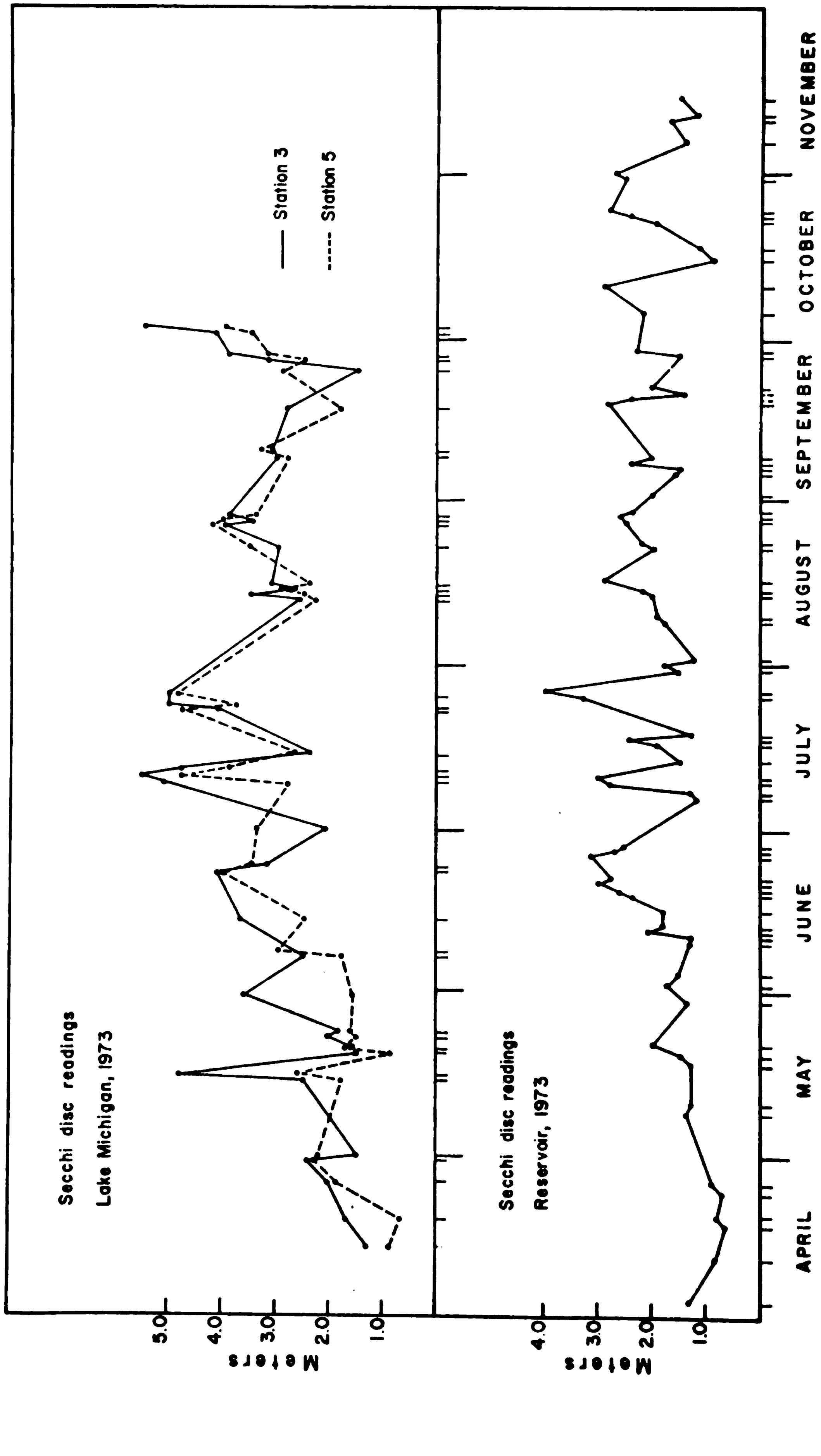

Secchi disc readings
Lake Michigan, 1973
Station 3
Station 5
Secchi disc readings
Reservoir, 1973
Meters
5.0
4.0
3.0
2.0
1.0
Meters
4.0
3.0
2.0
1.0
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER

Figure 27

to 4.1 in July, 1973. Lake Michigan stations three and five transparencies ranged from 0.6 in April to 5.6 in July, 1973. The reservoir transparency was consistently lower than the adjacent Lake Michigan areas.

Water Turbidity Results

Turbidity measurements were made in formazin turbidity units, ranging from 0.4 to 12.0 (Table 19). In general, the reservoir turbidities were similar to the adjacent Lake Michigan sampling areas (Figure 28) with the highest reservoir values in April, 1973.

Water Chemistry Results

The chemical parameters were within the following ranges throughout the reservoir: pH 8.2-8.5; dissolved O_2 9-12 ppm; alkalinity 102-122 ppm; dissolved solids 159-190 ppm (Liston, 1974).

The physical and chemical conditions of the reservoir were within the same ranges as those from the adjacent Lake Michigan areas. The benthic macroinvertebrates were affected by the same water quality conditions in the reservoir as in the adjacent Lake Michigan areas.

Sediment Chemistry Results

Percentages of total carbon, hydrogen, and nitrogen on a dry weight basis were determined on reservoir sediments taken by the Ponar grab-sampler. The ranges of the percentages of these elements in the sediments were: carbon 1.12-5.43; hydrogen 0.07-0.31; nitrogen 0.02-0.13. No significant trends or patterns were detected in the chemical content of these sediment samples. These analyses are generally

Table 19. Surface Turbidity Measurement (Formazin Turbidity Units) Descriptive Statistics from Reservoir Sampling Stations During 1973

	Station		
	1	4	6
Number of readings	55	46	54
Range	0.5-11.5	0.5-11.0	0.4-11.5
Mean	2.79	3.00	3.20
Variance	2.42	4.02	4.84
Standard deviation	1.56	2.01	2.20
Coefficient of variation	55.8%	67.0%	68.8%

Figure 28. Average surface turbidity measurements at Lake Michigan sampling stations three and five, and at reservoir sampling stations during 1973.

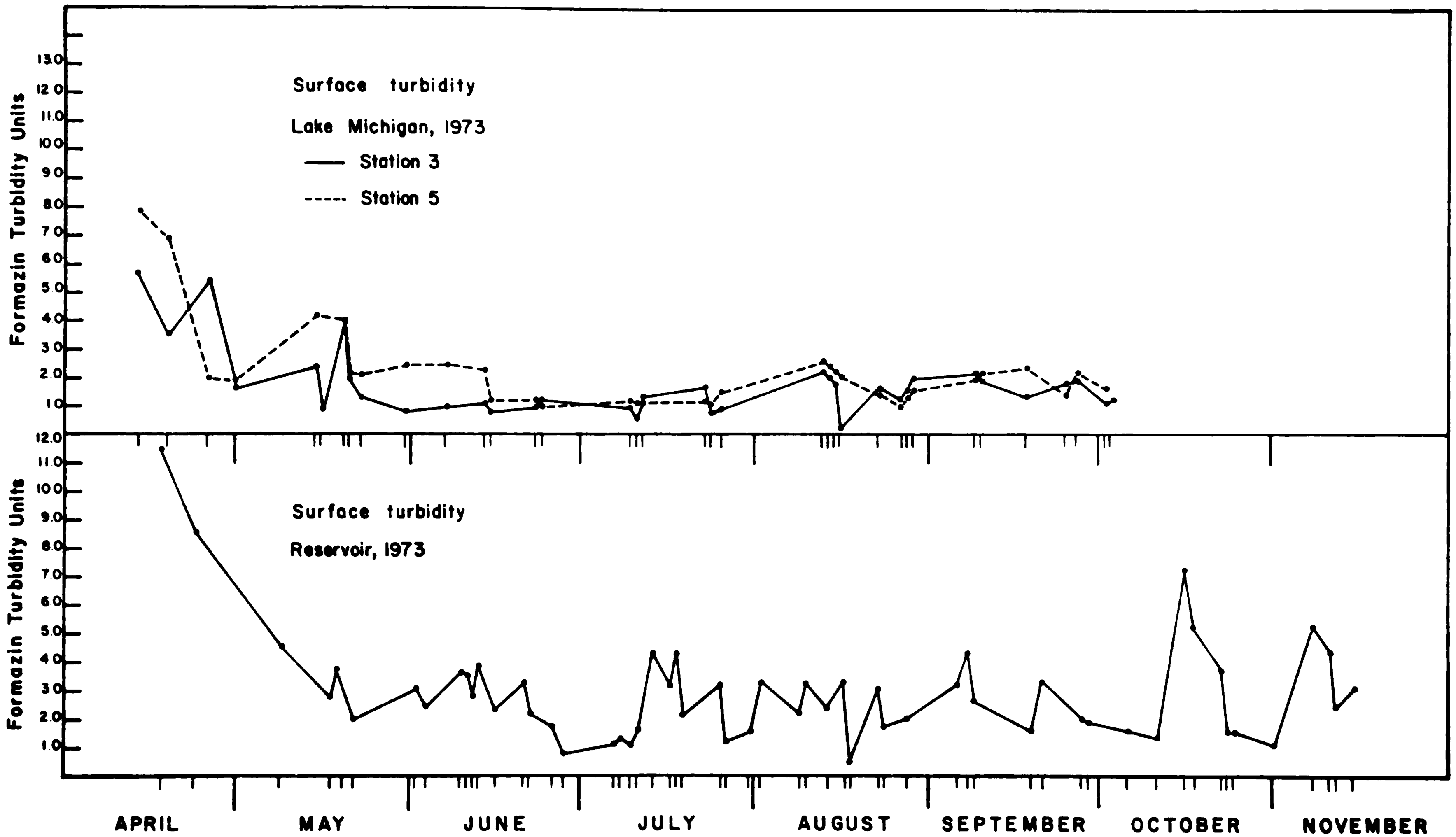

Surface turbidity
Lake Michigan, 1973
Station 3
Station 5
Formazin Turbidity Units
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
Surface turbidity
Reservoir, 1973
Formazin Turbidity Units
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER

Figure 28

accurate to 0.05 percent, however, obtaining a homogeneous subsample was the major difficulty with an average 0.07 difference between duplicate subsample percentages.

Reservoir Ponar Grab Samples

The oligochaetes and chironomids dominated the 42 Ponar grab samples taken from the reservoir on May 11, June 19, July 18, August 30, and October 10 during 1973 (Table 20).

Oligochaeta

Oligochaetes showed a rapid increase and sustained high level in the Ponar grab samples in the first season of reservoir operation (Figure 29). *Limnodrilus* sp., *Peloscolex* sp. and *Tubifex* sp. were the genera of Tubificidae found in the reservoir (Table 21); these three genera also were found in the Lake Michigan samples. Many immature and unidentifiable oligochaetes were present in these samples (Table 21).

Hirudinea

Two leaches were sampled in June, 1973 from the north end of the reservoir.

Amphipoda

Amphipods colonized the reservoir and increased throughout the entire season (Figure 30). *Gammarus fasciatus* was eight times more abundant than *G. pseudolimnaeus* until August, 1973. *Pontoporeia affinis* was first sampled from the reservoir in August and increased through the end of the season (Table 22).

Table 20. Taxa and Relative Abundance of Reservoir Benthic Macroinvertebrates in 1973 Ponar Grab Samples (42 Samples)

Relative Abundance: Numerical percentage of total number of benthic macroinvertebrates in all benthic groups.
R (rare) = 0-25% A (abundant) = 51-75%
C (common) = 26-50% VA (very abundant) = 76-100%

Annelida	
Oligochaeta	C
Plesiopora	
Tubificidae	
Limnodrilus sp.	
Peloscolex sp.	
Tubifex sp.	
Hirudinea	R
Arthropoda	
Eucrustacea	
Malacostraca	
Amphipoda	R
Haustoriidae	
Pontoporeia affinis (Lindstrom)	
Gammaridae	
Gammarus fasciatus Say	
G. pseudolimnaeus Bousfield	
Arachnoidea	R
Acari	
Lebertiidae	
Lebertia sp.	

continued

Table 20--continued

Hygrobatidae	
Hygrobates sp.	
Mideopsidae	
Mideopsis sp.	
Pionidae	
Forelia sp.	
Unionicolidae	
Neumania sp.	
Insecta	
Ephemeroptera	R
Heptageniidae	
Stenonema sp.	
Diptera	C
Chironomidae	
Chironominae	
Chironomus sp.	
Cryptochironomus sp.	
Parachironomus sp.	
Polypedilum sp.	
Glyptotendipes sp.	
Tanypodinae	
Procladius sp.	
Conchapelopia sp.	
Ceratopogonidae	R
Palpomyia sp.	

Figure 29. Oligochaeta and Chironomidae seasonal distribution in the reservoir for 1973 (values are average of the total nine Ponar grab samples taken each sampling day).

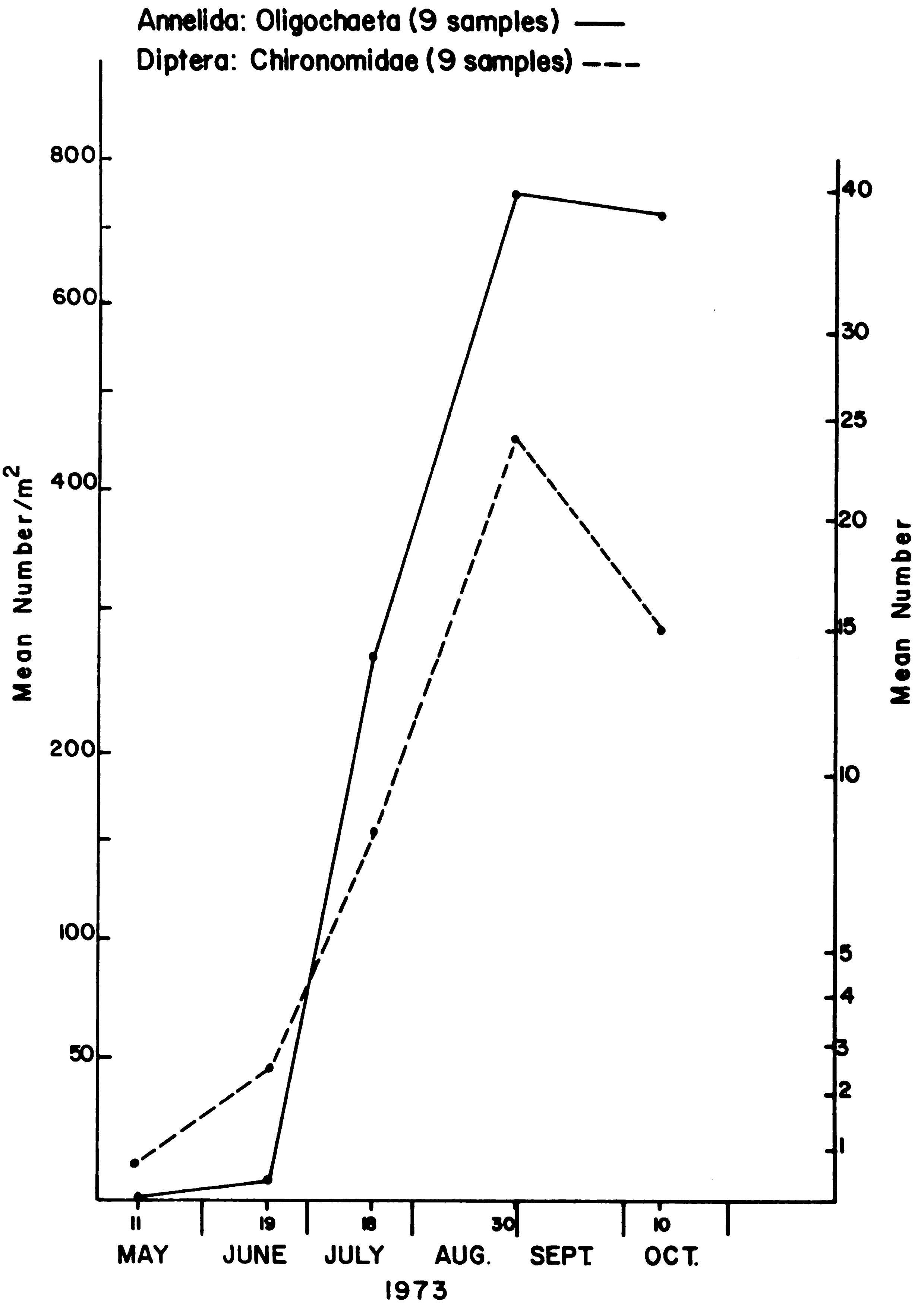

Annelida: Oligochaeta (9 samples) ——
Diptera: Chironomidae (9 samples) ---
Mean Number/m^2
800
600
400
200
100
50
Mean Number
40
30
25
20
15
10
5
4
3
2
1
11
19
18
30
10
MAY
JUNE
JULY
AUG.
SEPT
OCT.
1973

Figure 29

Table 21. Taxa and Number of Oligochaeta in Reservoir Ponar Grab Samples for 1973 (Composition for Each Station on Each Sampling Day is a Three Sample Total)

Stations	1973 5/11	6/19	7/18	8/30	10/10	Season Total
1						
Limnodrilus sp.	0	0	16	26	44	86
Peloscolex sp.	0	0	2	2	18	22
Tubifex sp.	0	0	8	8	26	42
Immature forms	0	0	8	10	48	66
Undeterminable	0	0	18	20	37	75
4						
Limnodrilus sp.	0	1	10	56	18	85
Peloscolex sp.	0	0	6	18	2	26
Tubifex sp.	0	0	14	34	14	62
Immature forms	0	1	12	32	10	55
Undeterminable	0	0	13	38	6	57
6						
Limnodrilus sp.	0	0	0	3	28	31
Peloscolex sp.	0	0	0	4	10	14
Tubifex sp.	0	0	1	1	36	38
Immature forms	0	1	0	4	22	27
Undeterminable	0	0	0	1	32	33

Figure 30. Amphipoda and Acari seasonal distribution in the reservoir for 1973 (values are average of the total nine Ponar grab samples taken each sampling day).

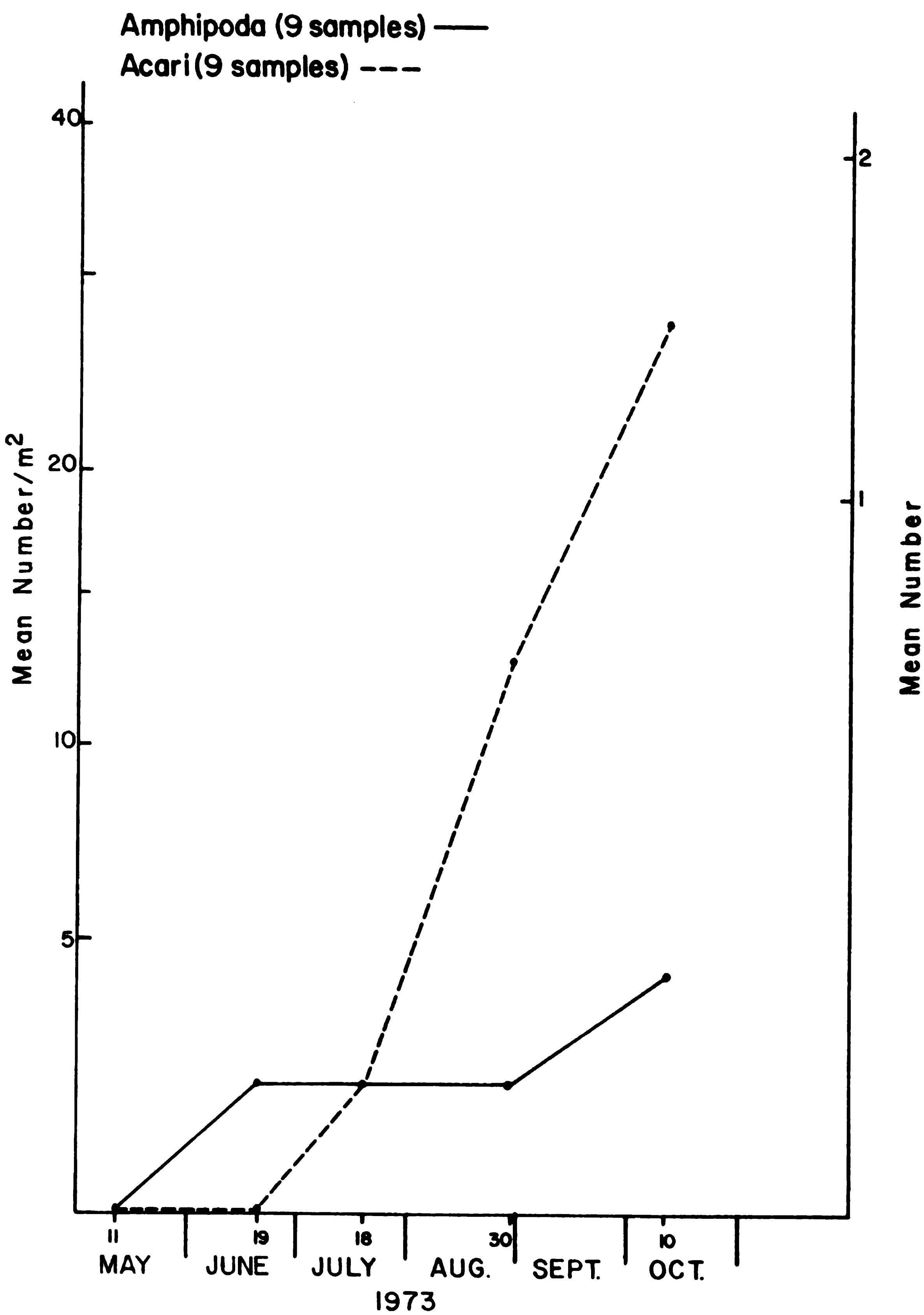

Amphipoda (9 samples)
Acari(9 samples)
Mean Number/m2
Mean Number
40
20
10
5
2
1
11
19
18
30
10
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
1973

Figure 30

Table 22. Taxa and Number of Amphipoda in Reservoir Ponar Grab and Multiple Plate Samples for 1973 (Ponar Grab Composition for Each Station on Each Sampling Day is a Three Sample Total)

Stations	Ponar 5/11	Mult. Plate 6/4	Ponar 6/19	Mult. Plate 7/6	Ponar 7/18	Mult. Plate 8/13	Ponar 8/30	Mult. Plate 9/21	Ponar 10/10	Mult. Plate 10/17	Mult. Plate 11/13	Total Ponar	Total Mult. Plate
1													
G. fasciatus	0	3	0	24	0	1	0	3	0	2	0	0	33
G. pseudolimnaeus	0	2	0	4	0	0	0	0	0	0	0	0	6
P. affinis	0	0	0	0	0	0	0	0	1	1	1	1	2
2													
G. fasciatus		0		5		4		5		2	0		16
G. pseudolimnaeus		0		0		1		2		3	0		6
P. affinis		0		0		0		0		0	0		0
3													
G. fasciatus		1		12		20		0		0	0		33
G. pseudolimnaeus		2		0		4		1		0	0		7
P. affinis		0		0		0		0		0	1		1
4													
G. fasciatus	0	2	1	0	0	7	0	0	0	0	0	1	9
G. pseudolimnaeus	0	0	0	0	0	1	0	0	0	0	0	0	1
P. affinis	0	0	0	0	0	0	1	0	0	2	2	1	4
5													
G. fasciatus		0		0		30		0		0	0		30
G. pseudolimnaeus		0		0		3		1		0	0		4
P. affinis		0		0		0		0		2	0		2
6													
G. fasciatus	0	0	0	0	1	20	0	0	0	0	0	1	20
G. pseudolimnaeus	0	0	0	1	0	0	0	0	0	0	0	0	1
P. affinis	0	0	0	0	0	0	0	0	1	1	6	1	7

Acari

Water-mites increased toward the end of the first season (Figure 30) with Lebertia sp., Hygrobates sp., Mideopsis sp., Forelia sp. and Neumania sp. in the Ponar grab samples. Lebertia sp., Hygrobates sp. and Mideopsis sp were the predominant forms found in the reservoir (Table 23).

Ephemeroptera

One ephemeropteran nymph, Stenonema sp., was collected in June from the south end of the reservoir.

Chironomidae

Chironomids collected in the Ponar grab samples increased throughout the first season (Figure 29). Chironomus sp. and Cryptochironomus sp. dominated the samples (Table 24).

Ceratopogonidae

One Palpomyia sp. larva was collected in the first series of Ponar grab samples on May 11, 1973. This incidental organism had probably been blown into the reservoir.

Reservoir Multiple Plate Samples
October, 1972 to April, 1973

Oligochaeta and Chironomidae

Oligochates and chironomids were the first two groups taken after filling of the reservoir on October 23, 1972, by three multiple plate samplers on April 5, 1973 (Table 25). One Limnodrilus sp. and an immature oligochaete, along with one Chironomus sp. were collected in

Table 23. Taxa and Number of Acari in Reservoir Ponar Grab Samples for 1973 (Composition for Each Station on Each Sampling Day is a Three Sample Total)

Stations	1973 5/11	6/19	7/18	8/30	10/10	Season Total
1						
Hygrobates sp.	0	0	0	1	2	3
Lebertia sp.	0	0	0	0	1	1
Mideopsis sp.	0	0	0	2	0	2
Forelia sp.	0	0	0	0	1	1
Neumania sp.	0	0	0	0	1	1
4						
Hygrobates sp.	0	0	0	1	0	1
Lebertia sp.	0	0	0	0	0	0
Mideopsis sp.	0	0	0	0	1	1
Forelia sp.	0	0	0	0	0	0
Neumania sp.	0	0	0	0	0	0
6						
Hygrobates sp.	0	0	1	1	1	3
Lebertia sp.	0	0	0	1	2	3
Mideopsis sp.	0	0	0	0	2	2
Forelia sp.	0	0	0	0	1	1
Neumania sp.	0	0	0	0	0	0

Table 24. Taxa and Number of Chironomidae in Reservoir Ponar Grab Samples for 1973 (Composition for Each Station on Each Sampling Day is a Three Sample Total)

Stations	1973 5/11	6/19	7/18	8/30	10/10	Season Total
1						
Chironomus sp.	0	2	15	11	31	59
Cryptochironomus sp.	0	1	4	30	53	88
Polypedilum sp.	0	0	2	5	14	21
Parachironomus sp.	0	1	0	2	16	19
Glyptotendipes sp.	0	0	0	7	20	27
Procladius sp.	0	1	6	9	17	33
Conchapelopia sp.	0	0	4	2	14	20
4						
Chironomus sp.	1	2	7	58	12	80
Cryptochironomus sp.	2	3	8	95	27	135
Polypedilum sp.	0	1	10	25	0	36
Parachironomus sp.	0	0	0	33	0	33
Glyptotendipes sp.	0	0	6	39	9	54
Procladius sp.	0	1	1	20	2	24
Conchapelopia sp.	0	1	0	8	0	9
6						
Chironomus sp.	2	3	6	4	39	54
Cryptochironomus sp.	0	1	5	5	23	34
Polypedilum sp.	0	1	2	1	13	17
Parachironomus sp.	0	0	0	0	9	9
Glyptotendipes sp.	0	1	4	2	15	22
Procladius sp.	0	1	1	1	21	24
Conchapelopia sp.	0	0	1	0	8	9

Table 25. Taxa and Relative Abundance of Reservoir Benthic Macroinvertebrates in October, 1972 to April, 1973 Multiple Plate Samples (3 Samples)

Relative Abundance: Numerical percentage of total number of benthic macroinvertebrates in all benthic groups.
R (rare) = 0-25% A (abundant) = 51-75%
C (common) = 26-50% VA (very abundant) = 76-100%

Annelida	
Oligochaeta	C
Plesiopora	
Tubificidae	
Limnodrilus sp.	
Arthropoda	
Insecta	C
Diptera	
Chironomidae	
Chironominae	
Chironomus sp.	

the multiple plate sample from the north end of the reservoir. One Chironomus sp. was sampled from the multiple plate sampler in the middle of the reservoir. These four organisms were the only specimens collected from the reservoir for the first months of water impoundment and reservoir operation.

Reservoir Multiple Plate Samples
April to August, 1973

Eighteen multiple plate samplers were placed in the reservoir on April 10, 1973, with three at each of the six reservoir stations. One sampler was removed from each station on June 4, July 6, and August 13 during 1973. The benthic organisms collected on these samplers reflect the colonization of the reservoir during two, three and four month periods (Table 26).

Oligochaeta

Oligochaetes increased to their highest level in July with substantially lower numbers than the Ponar grab samples indicating that these organisms are primarily in the sediments (Figure 31). The oligochaete population composition in the reservoir was similar to the Lake Michigan samples with Limnodrilus sp., Peloscolex sp., Tubifex sp., and immature forms (Table 27). Many oligochaetes were undeterminable in these samples due to decomposition and staining.

Hirudinea

Two leeches were collected in the June samples from the south end of the reservoir.

Table 26. Taxa and Relative Abundance of Reservoir Benthic Macroinvertebrates in April to August, 1973 Multiple Plate Samples (18 Samples)

Relative Abundance: Numerical percentage of total number of benthic macroinvertebrates in all benthic groups.

R (rare) = 0-25% A (abundant) = 51-75%

C (common) = 26-50% VA (very abundant) = 76-100%

Annelida	
Oligochaeta	C
Plesiopora	
Tubificidae	
Limnodrilus sp.	
Peloscolex sp.	
Tubifex sp.	
Hirudinea	R
Arthropoda	
Eucrustacea	
Malacostraca	
Isopoda	R
Asellidae	
Asellus sp.	
Amphipoda	R
Gammaridae	
Gammarus fasciatus Say	
G. pseudolimnaeus Bousfield	
Arachnoidea	C
Acari	

continued

Table 26--continued

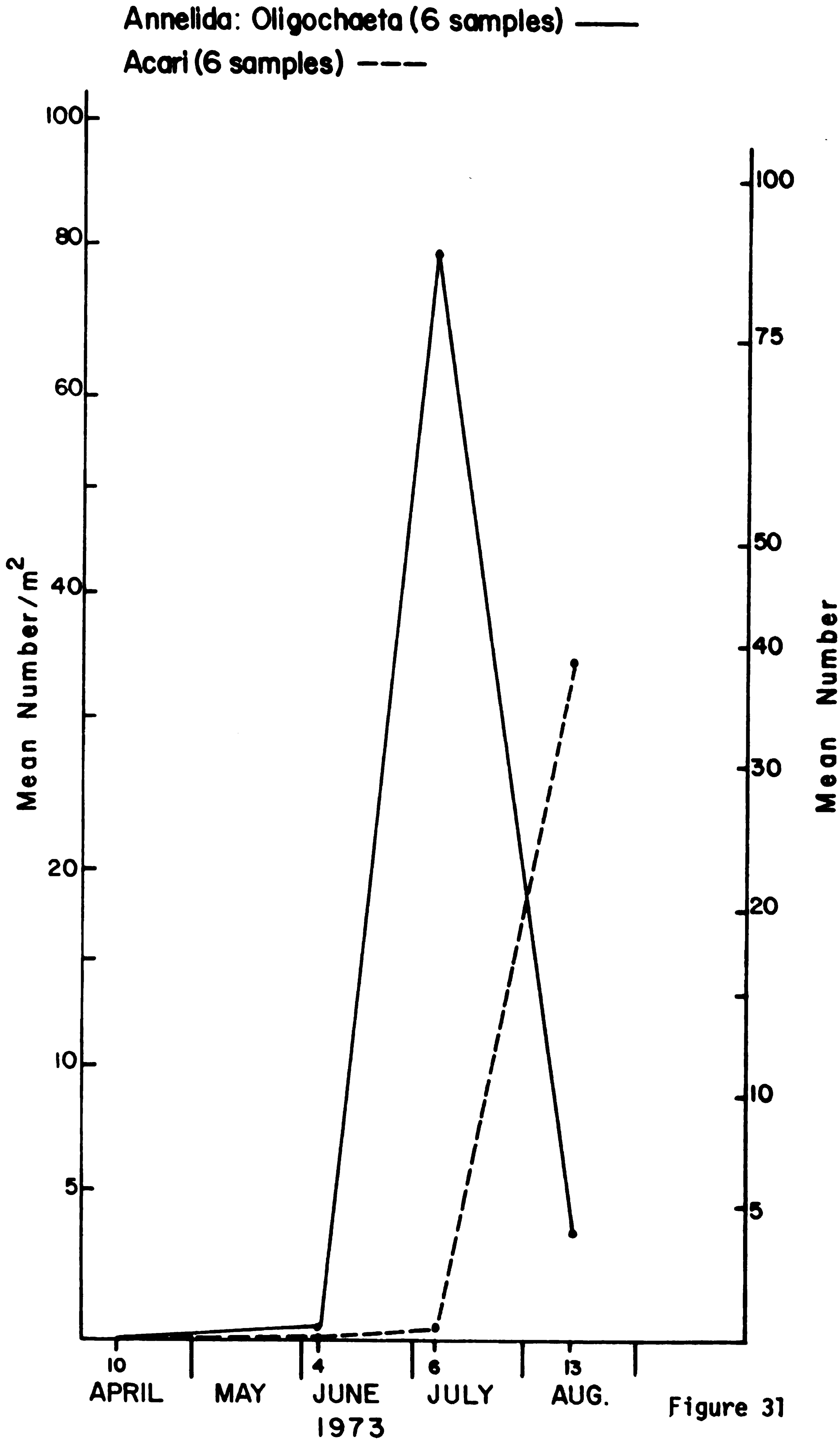
Lebertiidae	
Lebertia sp.	
Hygrobatidae	
Hygrobates sp.	
Mideopsidae	
Mideopsis sp.	
Pionidae	
Forelia sp.	
Unionicolidae	
Neumania sp.	
Insecta	
Collembola	R
Entomobryidae	
Ephemeroptera	R
Heptageniidae	
Stenonema sp.	
Trichoptera	R
Rhyacophilidae	
Rhyacophila sp.	
Hydropsychidae	
Hydropsyche sp.	
Coleoptera	R
Dytiscidae	

continued

Table 26--continued

Diptera	R
Chironomidae	
Chironominae	
Chironomus sp.	
Cryptochironomus sp.	
Parachironomus sp.	
Polypedilum sp.	
Glyptotendipes sp.	
Tanypodinae	
Procladius sp.	
Conchapelopia sp.	
Mollusca	
Gastropoda	R
Pulmonata	
Physidae	
Physa sp.	

Figure 31. Oligochaeta and Acari seasonal distribution in the reservoir for 1973 (values are average of the total six multiple plate samples taken each sampling day).



Annelida: Oligochaeta (6 samples) ——
Acari (6 samples) ---
Mean Number/m2
Mean Number
100
80
60
40
20
10
5
100
75
50
40
30
20
10
5
10
APRIL
MAY
4
JUNE
6
JULY
13
AUG.
1973

Figure 31

Table 27. Taxa and Number of Oligochaeta in 1973 Multiple Plate Samples from Reservoir Sampling Stations

Stations	1973 4/5	6/4	7/6	8/13	9/21	10/17	11/13	Season Total
1								
Limnodrilus sp.	0	0	5	4	32	0	0	41
Peloscolex sp.	0	0	3	2	12	0	0	17
Tubifex sp.	0	0	4	2	34	0	0	40
Immature forms	0	0	15	6	108	1	0	130
Undeterminable	0	0	5	2	44	0	0	51
2								
Limnodrilus sp.	-	0	14	0	0	1	0	15
Peloscolex sp.	-	0	8	0	0	0	0	8
Tubifex sp.	-	0	10	0	0	3	0	13
Immature forms	-	0	36	0	0	2	0	38
Undeterminable	-	0	12	0	0	0	0	12
3								
Limnodrilus sp.	-	0	2	0	1	1	2	6
Peloscolex sp.	-	0	1	0	1	0	1	3
Tubifex sp.	-	0	1	0	3	0	1	5
Immature forms	-	0	4	2	2	0	2	10
Undeterminable	-	0	5	1	1	0	3	10
4								
Limnodrilus sp.	0	0	1	0	12	0	1	14
Peloscolex sp.	0	0	2	0	6	0	0	8
Tubifex sp.	0	0	2	0	8	1	0	11
Immature forms	0	0	6	0	18	0	2	26
Undeterminable	0	0	4	0	4	0	1	9
5								
Limnodrilus sp.	-	0	32	1	10	7	-	50
Peloscolex sp.	-	0	26	0	2	3	-	31
Tubifex sp.	-	0	34	1	14	8	-	57
Immature forms	-	1	104	2	6	5	-	118
Undeterminable	-	0	48	1	1	7	-	57
6								
Limnodrilus sp.	1	0	22	0	7	6	2	38
Peloscolex sp.	0	0	10	0	6	1	0	17
Tubifex sp.	0	0	18	0	5	5	3	31
Immature forms	1	0	62	0	5	7	2	77
Undeterminable	0	0	31	0	7	17	1	56

Isopoda

Isopods increased to their highest level in August after four months colonization of the samplers (Figure 32). *Asellus* sp. were the only isopods found in the samples and the rapid increase indicates their establishment in the reservoir.

Amphipoda

Amphipods showed a rapid increase with the highest level also in August (Figure 32). *Gammarus fasciatus* and *G. pseudolimnaeus* were the two forms present with *G. fasciatus* approximately eight times more abundant (Table 22).

Acari

The water-mites increased to an average number of 34 in August (Figure 31). *Lebertia* sp., *Hygrobates* sp. and *Mideopsis* sp. were the major forms with *Forelia* sp. and *Neumania* sp. present in less abundance (Table 28).

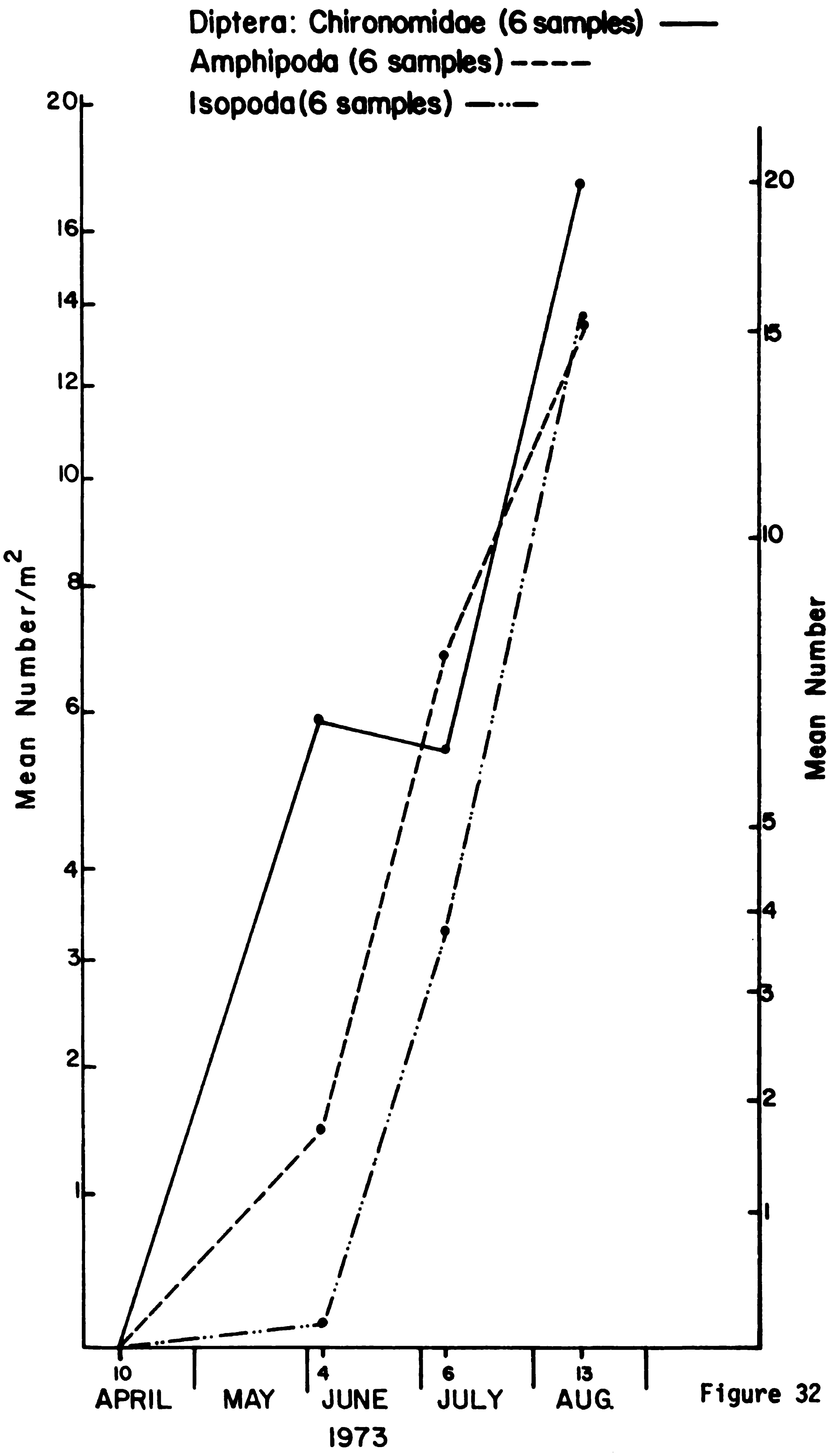
Collembola

Twenty-nine Entomobryidae were collected by the multiple plate samplers. Entomobryidae are terrestrial usually found in dead bark or decaying wood, and secondarily in the upper soil layers. They probably blew into the reservoir and were on the water surface when the multiple plate samplers were pulled out of the water.

Ephemeroptera

Three ephemeropteran nymphs, *Stenonema* sp., were collected by the plate samplers from the reservoir.

Figure 32. Chironomidae, Amphipoda and Isopoda seasonal distribution in the reservoir for 1973 (values are average of the total six multiple plate samples taken each sampling day).



Diptera: Chironomidae (6 samples)
Amphipoda (6 samples)
Isopoda(6 samples)
Mean Number/m^2
Mean Number
20
16
14
12
10
8
6
4
3
2
1
20
15
10
5
4
3
2
1
10
APRIL
MAY
4
JUNE
6
JULY
13
AUG.
1973

Figure 32

Table 28. Taxa and Number of Acari in 1973 Multiple Plate Samples from Reservoir Sampling Stations

Stations	1973 4/5	6/4	7/6	8/13	9/21	10/17	11/13	Season Total
1								
Hygrobates sp.	0	0	1	9	0	2	1	13
Lebertia sp.	0	0	0	4	0	0	1	5
Mideopsis sp.	0	0	0	7	0	2	0	9
Forelia sp.	0	0	0	2	0	1	1	4
Neumania sp.	0	0	0	0	0	0	1	1
2								
Hygrobates sp.	0	0	0	0	3	3	2	8
Lebertia sp.	0	0	0	0	1	2	4	7
Mideopsis sp.	0	0	0	0	2	1	2	5
Forelia sp.	0	0	0	0	1	0	1	2
Neumania sp.	0	0	0	0	0	1	0	1
3								
Hygrobates sp.	0	0	0	3	0	4	2	9
Lebertia sp.	0	0	0	11	0	7	3	21
Mideopsis sp.	0	0	0	6	0	3	0	9
Forelia sp.	0	0	0	1	0	1	1	3
Neumania sp.	0	0	0	1	0	0	0	1
4								
Hygrobates sp.	0	0	0	31	1	0	5	37
Lebertia sp.	0	0	0	22	0	0	3	25
Mideopsis sp.	0	0	0	17	0	0	8	25
Forelia sp.	0	0	0	6	0	0	0	6
Neumania sp.	0	0	0	1	0	0	0	1
5								
Hygrobates sp.	0	0	0	18	0	1	-	19
Lebertia sp.	0	0	0	9	0	0	-	9
Mideopsis sp.	0	0	0	21	1	3	-	25
Forelia sp.	0	0	0	9	0	0	-	9
6								
Hygrobates sp.	0	0	0	10	3	6	4	23
Lebertia sp.	0	0	0	18	2	8	16	44
Mideopsis sp.	0	0	0	15	1	3	12	31
Forelia sp.	0	0	0	5	2	2	7	16
Neumania sp.	0	0	0	4	1	0	2	7

Table 29. Taxa and Number of Chironomidae in 1973 Multiple Plate Samples from Reservoir Sampling Stations

Stations	4/5	6/4	7/6	8/13	9/21	10/17	11/13	Season Total
1								
Chironomus sp.	0	2	0	12	2	0	0	16
Cryptochironomus sp.	0	1	2	9	5	0	1	18
Polypedilum sp.	0	0	0	1	0	0	0	1
Parachironomus sp.	0	0	0	2	0	0	0	2
Glyptotendipes sp.	0	1	0	0	2	0	0	3
Procladius sp.	0	1	0	2	1	0	0	4
Conchapelopia sp.	0	0	0	1	2	0	0	3
2								
Chironomus sp.	-	1	1	6	7	0	1	16
Cryptochironomus sp.	-	3	0	9	1	0	3	16
Polypedilum sp.	-	0	0	0	1	0	1	2
Parachironomus sp.	-	0	1	0	0	0	0	1
Glyptotendipes sp.	-	0	0	4	1	0	1	6
Procladius sp.	-	1	0	1	4	0	0	6
Conchapelopia sp.	-	1	0	0	1	0	0	2
3								
Chironomus sp.	-	1	0	12	8	2	1	24
Cryptochironomus sp.	-	2	0	7	5	0	1	15
Polypedilum sp.	-	0	0	1	0	0	0	1
Parachironomus sp.	-	0	0	0	2	0	0	2
Glyptotendipes sp.	-	0	0	4	0	0	0	4
Procladius sp.	-	0	0	2	2	0	2	6
Conchapelopia sp.	-	0	1	2	2	0	0	5
4								
Chironomus sp.	1	6	2	17	3	0	0	29
Cryptochironomus sp.	0	4	1	2	0	0	0	7
Parachironomus sp.	0	0	1	0	0	0	0	1
Glyptotendipes sp.	0	1	3	0	0	0	0	4
Procladius sp.	0	3	2	1	0	0	0	6
5								
Chironomus sp.	-	0	4	2	0	0	-	6
Cryptochironomus sp.	-	5	2	9	1	1	-	18
Polypedilum sp.	-	0	1	0	0	0	-	1
Parachironomus sp.	-	0	0	2	0	0	-	2
Glyptotendipes sp.	-	0	2	0	0	0	-	2
Procladius sp.	-	0	1	0	1	0	-	2

continued

Table 29--continued

Stations	1973 4/5	6/4	7/6	8/13	9/21	10/17	11/13	Season Total
6								
Chironomus sp.	1	2	7	1	2	2	0	15
Cryptochironomus sp.	0	1	0	7	1	1	0	10
Polypedilum sp.	0	1	0	0	0	0	0	1
Parachironomus sp.	0	0	1	0	0	0	0	1
Glyptotendipes sp.	0	2	0	0	0	1	0	3
Procladius sp.	0	0	2	2	2	1	0	7
Conchapelopia sp.	0	1	0	0	0	0	0	1

Trichoptera

Ten trichopteran larvae were collected with *Rhyacophila* sp. and *Hydropsyche* sp. the two genera present in the samples.

Coleoptera

One adult Dytiscidae was taken from the reservoir by the multiple plate samplers. This aquatic beetle, approximately 40 mm in length, probably flew into the reservoir from one of the surrounding lakes.

Chironomidae

The chironomid larvae increased to an average number of $17/m^2$ in August (Figure 32). These chironomids were dominated by Chironomini genera, similar to the reservoir Ponar grab samples (Table 29).

Gastropoda

Nine gastropods, *Physa* sp., were taken from the reservoir in August after four months colonization of the samplers. The multiple plate samplers either selectively collected *Physa* sp., or there were no other gastropods in the reservoir.

Reservoir Multiple Plate Samples
June to September, 1973

The six multiple plate samplers, placed one at each station in June, were allowed to colonize for three months and were lifted in September (Table 30).

Oligochaeta

The oligochaetes dominated the samples with the majority found in the south end of the reservoir. Many immature and undeterminable forms

Table 30. Taxa and Relative Abundance of Reservoir Benthic Macroinvertebrates in June to September, 1973 Multiple Plate Samples (6 Samples)

Relative Abundance: Numerical percentages of total number of benthic macroinvertebrates in all benthic groups.

R (rare) = o-25% A (abundant) = 51-75%
C (common) = 26-50% VA (very abundant) = 76-100%

Annelida	
Oligochaeta	A
Plesiopora	
Tubificidae	
Limnodrilus sp.	
Peloscolex sp.	
Tubifex sp.	
Arthropoda	
Eucrustacea	
Malacostraca	
Isopoda	R
Asellidae	
Asellus sp.	
Amphipoda	R
Gammaridae	
Gammarus fasciatus Say	
G. pseudolimnaeus Bousfield	
Arachnoidea	R
Acari	
Lebertiidae	

continued

Table 30--continued

Lebertia sp.	
Hygrobatidae	
Hygrobates sp.	
Mideopsidae	
Mideopsis sp.	
Insecta	
Ephemeroptera	R
Heptageniidae	
Stenonema sp.	
Trichoptera	R
Rhyacophilidae	
Rhyacophila sp.	
Hydropsychidae	
Hydropsyche sp.	
Diptera	R
Chironomidae	
Chironominae	
Chironomus sp.	
Cryptochironomus sp.	
Parachironomus sp.	
Polypedilum sp.	
Glyptotendipes sp.	

continued

Table 30.--continued

Tanypodinae	
Procladius sp.	
Conchapelopia sp.	
Mollusca	
Gastropoda	C
Pulmonata	
Physidae	
Physa sp.	

along with Limnodrilus sp., Peloscolex sp. and Tubifex sp. were found in these samples.

Isopoda

The majority of the isopods, Asellus sp., was collected at the north end of the reservoir.

Gastropoda

The majority of the gastropods, Physa sp., was sampled at the north end of the reservoir.

Reservoir Multiple Plate Samples July to October, 1973

The six multiple plate samplers, placed one at each station in July, were allowed to colonize for three months and were lifted in October (Table 31).

Oligochaeta

The oligochates sampled during this period came almost entirely from the north end of the reservoir with Limnodrilus sp., Peloscolex sp. and Tubifex sp. along with immature and undeterminable forms present in these samples.

Isopoda

Asellus sp. were most abundant at the north end of the reservoir.

Gastropoda

Gastropoda, Physa sp., was the most abundant benthic macroinvertebrate group in these samples.

Table 31. Taxa and Relative Abundance of Reservoir Benthic Macroinvertebrates in July to October, 1973 Multiple Plate Samples (6 Samples)

Relative Abundance: Numerical percentage of total number of benthic macroinvertebrates in all benthic groups.
R (rare) = 0-25% A (abundant) = 51-75%
C (common) = 26-50% VA (very abundant) = 76-100%

Annelida	
Oligochaeta	C
Plesiopora	
Tubificidae	
Limnodrilus sp.	
Peloscolex sp.	
Tubifex sp.	
Arthropoda	
Eucrustacea	
Malacostraca	
Isopoda	C
Asellidae	
Asellus sp.	
Amphipoda	R
Haustoriidae	
Pontoporeia affinis (Lindstrom)	
Gammaridae	
Gammarus fasciatus Say	
G. pseudolimnaeus Bousfield	

continued

Table 31--continued

Arachnoidea	R
Acari	
Lebertiidae	
Lebertia sp.	
Hygrobatidae	
Hygrobates sp.	
Mideopsidae	
Mideopsis sp.	
Pionidae	
Forelia ap.	
Insecta	
Ephemeroptera	R
Heptageniidae	
Stenonema sp.	
Trichoptera	R
Rhyacophilidae	
Rhyacophila sp.	
Diptera	R
Chironomidae	
Chironominae	
Chironomus sp.	
Cryptochironomus sp.	

continued

Table 31--continued

Parachironomus sp.	
Polypedilum sp.	
Glyptotendipes sp.	
Tanypodinae	
Procladius sp.	
Conchapelopia sp.	
Mollusca	
Gastropoda	C
Pulmonata	
Physidae	
Physa sp.	

Reservoir Multiple Plate Samples August to November, 1973

The six multiple plate samplers, placed one at each station in August, were allowed to colonize for three months and were lifted in November (Table 32). Only five samplers were available to be lifted and analyzed.

Isopoda

Asellus sp. were the only isopods collected, being most abundant at the north end of the reservoir.

Amphipoda

Pontoporeia affinis was the only amphipod in these samples; *Gammarus fasciatus* and *G. pseudolimnaeus* had dominated the multiple plate samples earlier in the season.

Acari

The water-mites, *Lebertia* sp., *Hygrobates* sp., and *Mideopsis* sp., were the most abundant benthic macroinvertebrates in these samples. They were concentrated at the north end of the reservoir.

Gastropoda

Physa sp. were also concentrated at the reservoir's north end.

Table 32. Taxa and Relative Abundance of Reservoir Benthic Macroinvertebrates in August to November, 1973 Multiple Plate Samples (5 Samples)

Relative Abundance: Numerical percentage of total number of benthic macroinvertebrates in all benthic groups.

R (rare) = 0-25% A (abundant) = 51-75%

C (common) = 26-50% VA (very abundant) = 76-100%

Annelida	
Oligochaeta	R
Plesiopora	
Tubificidae	
Limnodrilus sp.	
Peloscolex sp.	
Tubifex sp.	
Arthropoda	
Eucrustacea	
Malacostraca	
Isopoda	R
Asellidae	
Asellus sp.	
Amphipoda	R
Haustoriidae	
Pontoporeia affinis (Lindstrom)	
Arachnoidea	C
Acari	
Lebertiidae	
Lebertia sp.	

continued

Table 32--continued

Hygrobatidae	
Hygrobates sp.	
Mideopsidae	
Mideopsis sp.	
Insecta	
Ephemeroptera	R
Heptageniidae	
Stenonema sp.	
Trichoptera	R
Rhyacophilidae	
Rhyacophila sp.	
Hydropsychidae	
Hydropsyche sp.	
Diptera	R
Chironomidae	
Chironominae	
Chironomus sp.	
Cryptochironomus sp.	
Polypedilum sp.	
Glyptotendipes sp.	
Tanypodinae	
Procladius sp.	

continued

Table 32--continued

Mollusca	
Gastropoda	R
Pulmonata	
Physidae	
Physa sp.	

Reservoir Rock Basket Samples on Scour Protection Area

The rock baskets on the scour protection in the reservoir were sparsely colonized (Table 33) compared to the rock baskets on the jetty and breakwall in Lake Michigan. On the scour protection, chironomid larvae reached an average of $15/m^2$.

Oligochaetes, gastropods, and water-mites were found occasionally in the rock basket samples (Figure 33).

Reservoir Benthic Macroinvertebrate Colonization and Development

The reservoir population composition of three selected months June, August, and October, indicated the direction the macroinvertebrate population was developing.

In June, chironomids dominated the population although the average total number of individuals was relatively low (Figure 34). The oligochaetes were the next most abundant group in the Ponar grab samples and amphipods the second most abundant on the plate samplers.

The August population composition in the Ponar grab samples was dominated by oligochaetes and chironomids with the average total number of individuals reaching approximately $1,200/m^2$ (Figure 34). The multiple plate samples presented a population which was more diverse in the number of different invertebrate groups with the water-mites the most abundant followed by the chironomids, isopods, and amphipods. The total number of individuals in the multiple plate samples was substantially less than in the grab samples.

Table 33. Taxa and Relative Abundance of Reservoir Benthic Macro-invertebrates in 1973 Rock Basket Samples (15 Samples)

Relative Abundance: Numerical percentage of total number of benthic macroinvertebrates in all benthic groups.
R (rare) = 0-25% A (abundant) = 51-75%
C (common) = 26-50% VA (very abundant) = 76-100%

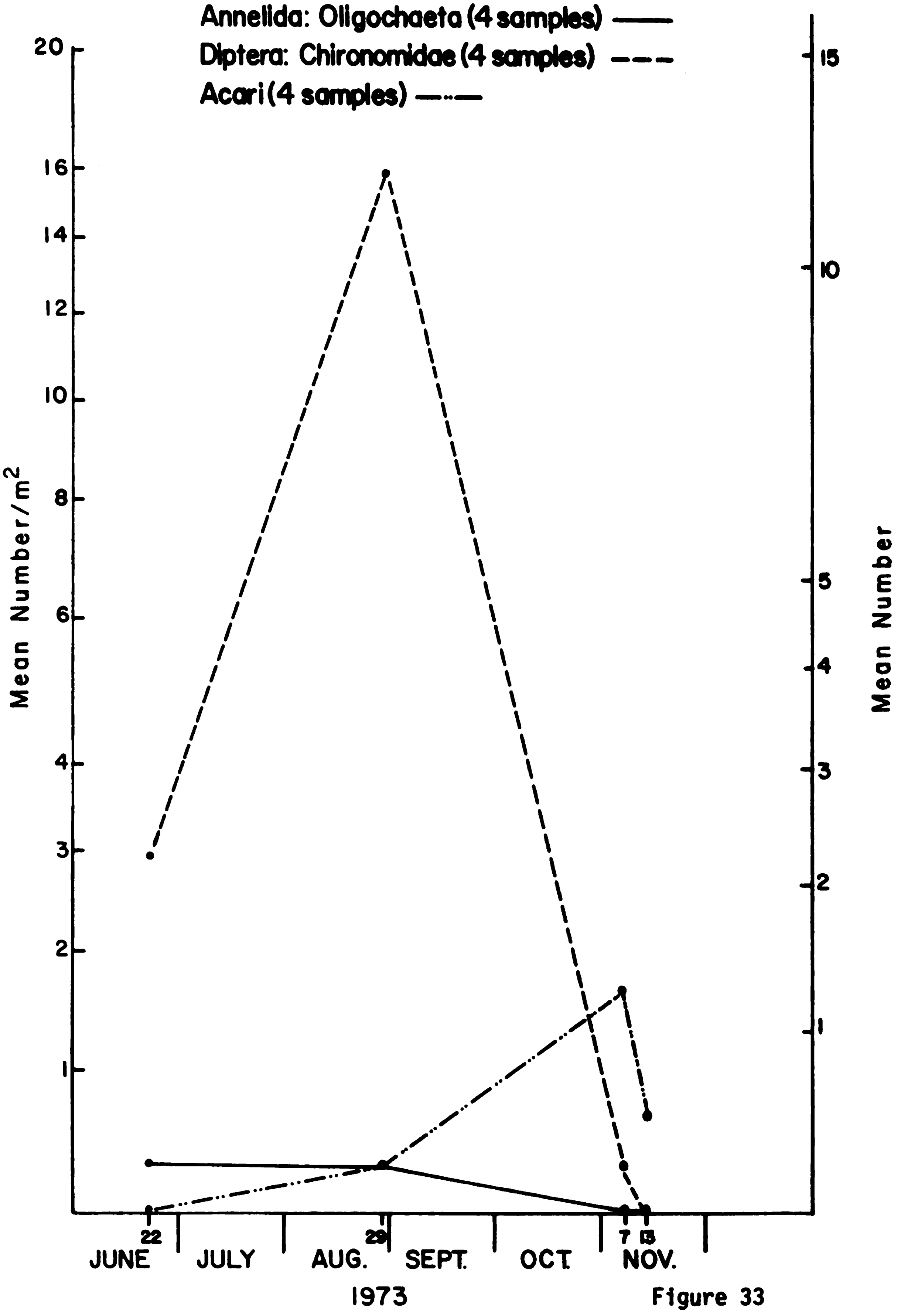
Annelida	
Oligochaeta	R
Plesiopora	
Tubificidae	
Limnodrilus sp.	
Tubifex sp.	
Hirudinea	R
Arthropoda	
Arachnoidea	R
Acari	
Libertiidae	
Lebertia sp.	
Hygrobatidae	
Hygrobates sp.	
Mideopsidae	
Mideopsis sp.	
Insecta	A
Diptera	
Chironomidae	

continued

Table 33--continued

Chironominae	
Chironomus sp.	
Cryptochironomus sp.	
Polypedilum sp.	
Glyptotendipes sp.	
Tanypodinae	
Procladius sp.	
Conchapelopia sp.	
Mollusca	
Gastropoda	R
Pulmonata	
Physidae	
Physa sp.	

Figure 33. Oligochaeta, Chironomidae and Acari seasonal distribution in the reservoir for 1973 (values are average of the total four rock basket samples taken each sampling day).



Annelida: Oligochaeta (4 samples)
Diptera: Chironomidae (4 samples)
Acari (4 samples)
Mean Number/m²
Mean Number
20
16
14
12
10
8
6
4
3
2
1
15
10
5
4
3
2
1
22
29
7
13
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
1973

Figure 33

Figure 34. Percentage composition seasonal trends of reservoir benthic macroinvertebrates from three months in 1973 Ponar grab and multiple plate samples (number/m^2 is the average total number organisms each sampling day).

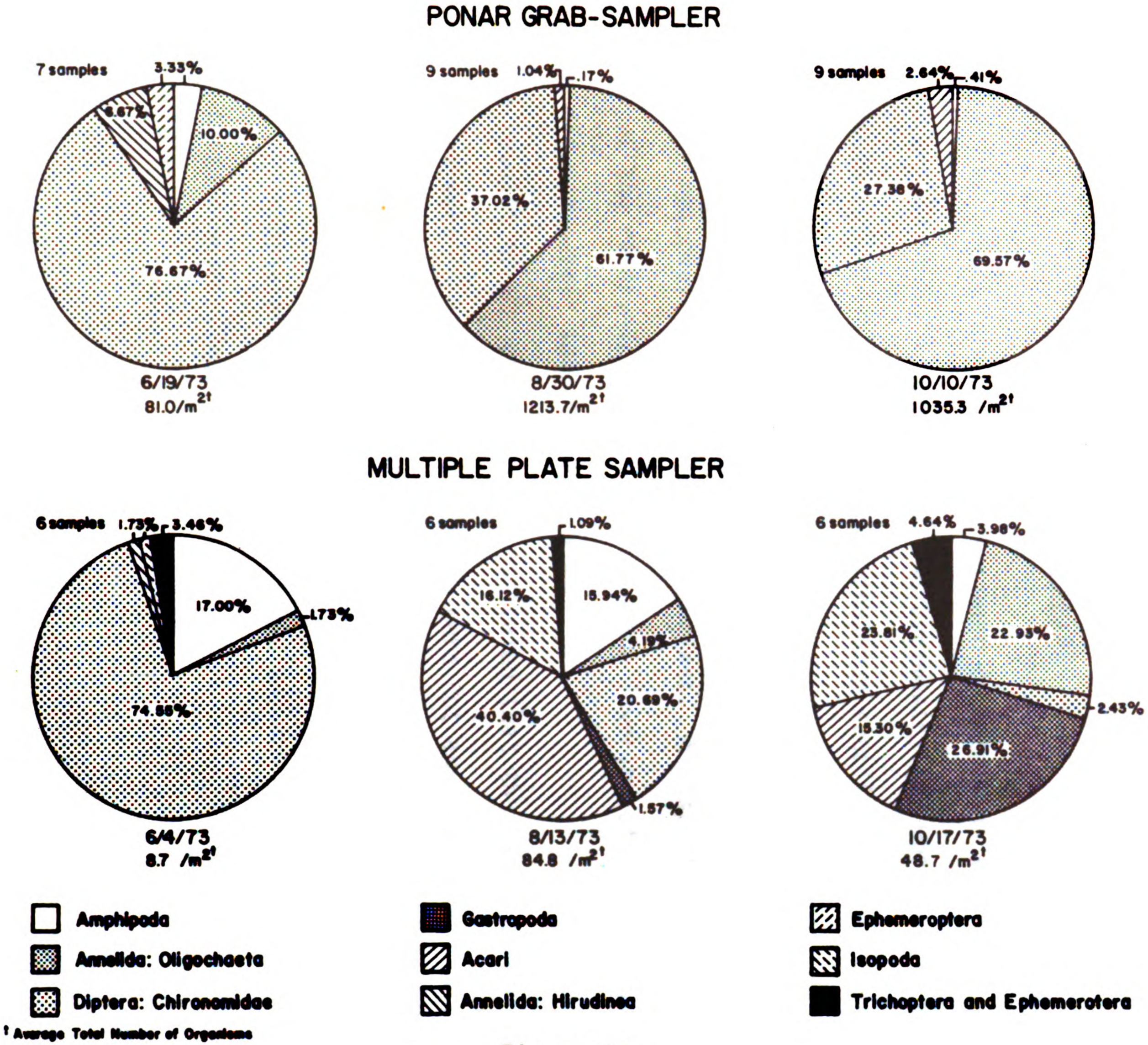

PONAR GRAB-SAMPLER
7 samples
3.33%
6.67%
10.00%
76.67%
6/19/73
81.0/m²†
9 samples
1.04%
.17%
37.02%
61.77%
8/30/73
1213.7/m²†
9 samples
2.64%
.41%
27.38%
69.57%
10/10/73
1035.3 /m²†
MULTIPLE PLATE SAMPLER
6 samples
1.73%
3.46%
17.00%
1.73%
74.88%
6/4/73
8.7 /m²†
6 samples
1.09%
16.12%
15.94%
4.19%
20.69%
40.40%
1.57%
8/13/73
84.8 /m²†
6 samples
4.64%
3.98%
23.81%
22.93%
2.43%
15.30%
26.91%
10/17/73
48.7 /m²†
Amphipoda
Annelida: Oligochaeta
Diptera: Chironomidae
† Average Total Number of Organisms
Gastropoda
Acari
Annelida: Hirudinea
Ephemeroptera
Isopoda
Trichoptera and Ephemerotera

Figure 34

The October population composition (Figure 34) in the grab samples reflected the dominance of oligochaetes and chironomids. The multiple plate samples again showed greater diversity in macroinvertebrate groups with lower average total number of individuals.

Reservoir Core Samples

The objectives of the core sampling were to determine whether benthic invertebrate had burrowed into the sediments, and whether there was any concentration of benthic populations in a specific area of the reservoir.

Core sampling was done along the clay rim (Figure 24) near the bottom of the reservoir inside embankment surface. A clay island in the north end of the reservoir was exposed with the lowering of the water, but time did not permit sampling this area.

The results of the core sampling indicated that the benthic macroinvertebrates were in the sediments, there were not any new organisms found on the exposed reservoir bottom, and the greatest numerical abundance of benthic invertebrates sampled was in the south end of the reservoir. Oligochaetes, chironomids, water-mites and amphipods were found in these samples (Table 34).

Table 34. Taxa and Number of Reservoir Benthic Macroinvertebrates in Core Samples from September 1, 1973

Sample 1

1 *Chironomous* sp.

Sample 2

1 *Chironomus* sp.

Sample 3

1 *Cryptochironomus* sp.

Sample 4

10 *Limnodrilus* sp.
4 *Tubifex* sp.
7 Immature Oligochaeta
4 *Chironomus* sp.
2 *Cryptochironomus* sp.
3 *Procladius* sp.
1 *Glyptotendipes* sp.
1 *Gammarus fasciatus*
1 *Lebertia* sp.
2 *Hygrobates* sp.
1 *Mideopsis* sp.

Sample 5

1 *Limnodrilus* sp.
3 Immature Oligochaeta
3 *Chironomus* sp.
4 *Cryptochironomus* sp.
3 *Procladius* sp.

Sample 7, Sample 8, Sample 9, Sample 10, Sample 11 } no organisms

Sample 6

1 *Cryptochironomus* sp.

Sample 12

1 *Chironomus* sp.
1 *G. fasciatus*

Sample 13

Not sampled

Sample 14

1 *Chironomus* sp.
1 *Procladius* sp.

Sample 15, Sample 16, Sample 18 } no organisms

Sample 17

1 *Cryptochironomus* sp.

Sample 19

2 *Chironomus* sp.

Sample 20

1 *Chironomus* sp.
2 *Cryptochironomus* sp.
1 *Procladius* sp.

DISCUSSION OF RESERVOIR STUDY

Reservoir Benthic Macroinvertebrate Colonization

Macroinvertebrates have colonized the Ludington Pumped Storage Reservoir after one season of operation and it appears that they have become a resident population. Only four benthic macroinvertebrates were collected April 5, 1973 on the multiple plate samplers which had been placed in the reservoir October 23, 1972 following water impoundment. The probable reason for this low number of organisms after six months was that most of the benthic invertebrates are in the larval stage by late October with only limited recruitment and colonization after this time of the year. Therefore, the two oligochaetes and two chironomids were probably immediately underneath the samplers and colonized them in the early spring. The first season showed a net increase in the number of benthic macroinvertebrates/m^2 with the greatest abundance in August, 1973.

Oligochaeta and Chironomidae

The dominance of two benthic groups, oligochaetes and chironomids, in the reservoir is consistent with the findings of the other reservoir studies of Mundie (1957), Ozhegova (1962), Sokolova (1963), Fillion (1967), and Paterson and Fernando (1970). The decrease in the chironomid larvae in the bottom sediments toward late summer and fall in the reservoir is mainly the result of their emergence as adults. Oliver's discussion (1971) of the life history and environmental requirements of chironomids supports this explanation of their decrease in the reservoir during late summer and fall. Paterson and Fernando (1970) found the peak chironomid density in July in Laural Creek Reservoir.

Chironomid larvae are the most numerous taxa in Lake Michigan to a depth of approximately 20 m, especially in summer, and oligochaetes are numerically subdominant from 8 to 20 m (Mozley and Garcia, 1972). The same oligochaete and chironomid forms sampled from Lake Michigan were collected from the reservoir. The major oligochaete found in the reservoir was Limnodrilus sp. This is consistent with the findings of Paterson and Fernando (1970) who also found that the chironomid forms hierarchy changes throughout the season. No hierarchy changes were found in the chironomid forms present in the Ludington Pumped Storage Reservoir (Tables 24 and 29).

Isopoda

Asellus sp. isopods were sampled from the reservoir only in the multiple plate samples. These isopods crawl about on the bottom and would readily colonize these samplers. Because Asellus sp. are detritivores (Lenat and Weiss, 1973), this may help them in adapting to the reservoir environment. Organic matter appears to be accumulating on the reservoir bottom, but the sediment chemical composition has not significantly changed.

Amphipoda

Operation of the plant may attract macroinvertebrates from the surrounding Lake Michigan areas, and could pull them toward the plant depositing them on the jetties and breakwall. The colonization of the reservoir by Gammarus fasciatus and G. pseudolimnaeus demonstrates that the jetties and breakwall in Lake Michigan have attracted macroinvertebrates. The three amphipod species found in this study show a seasonal succession in their occurrence in the reservoir. G. pseudolimnaeus, a cold water form first present in the spring, reproduces once a year and grows slowly. G. fasciatus, a warmer water form found in largest numbers in the summer, reproduces all summer giving more than two generations per year with the young first appearing in the fall (Bousfield, 1974). G. fasciatus is a very fast growing and breeding amphipod. It was approximately eight times more abundant than G. pseudolimnaeus in the reservoir (Table 22), reflecting its growth and reproductive potential (Bousfield, 1974). These two gammarid amphipods are plant feeders which move about upon submerged rock and plant surfaces during the summer. In the winter months, they migrate down to the bottom and burrow into the sediments.

Pontoporeia affinis, the amphipod which became the dominant form in the reservoir after September, breed and hatch in the winter living primarily on the bottom. In the fall when the Lake Michigan waters cool to below 12 C, the young P. affinis come into shallower waters close to shore. They can then be drawn up into the reservoir at a time which corresponds with G. fasciatus and G. pseudolimnaeus burrowing down into the sediments and becoming inactive. This explains why *P. affinis* became the dominant amphipod in the reservoir in the fall.

Acari

The water-mites appear to be a subdominant group in the reservoir following the oligochaetes and chironomids. *Lebertia* sp., *Hygrobates* sp., and *Mideopsis* sp. were dominant forms (Tables 23 and 28). The water-mites increased toward the end of the first season demonstrating that they are firmly established in the reservoir; they were found primarily on the plate samplers. The water-mites feed on dipteran larvae and the reservoir chironomid population supplies this food source.

Gastropoda

Physa sp. was the only gastropod found in the reservoir and they were collected primarily on the multiple plate samplers. *Physa* sp. is able to adapt to many conditions and to survive in a wide range of habitats; it is a scavenger being omnivorous, and reproduces throughout the year (Pennak, 1953).

Pelecypoda

The absence of pelecypods from the reservoir indicates either they were not sampled in the reservoir or they could not survive under the reservoir conditions.

SUMMARY AND CONCLUSIONS

Lake Michigan

The seven major benthic macroinvertebrate groups sampled from Lake Michigan were: Oligochaeta; Ostracoda; Amphipoda; Acari; Chironomidae; Gastropoda; and Pelecypoda. Chironomid larvae were the dominant group in abundance and regularity sampled from the coastal Lake Michigan areas.

Single classification analyses of variance of the major benthic groups indicated that oligochaete, ostracod, amphipod, water-mite and pelecypod populations differed significantly between 1972 and 1973 at certain sampling stations, with four of the six stations registering at least one group's change.

Benthic invertebrate populations north of the plant appeared to be displaced from station five to station six, farther north, in 1973. Station five amphipod population decreased and station six oligochaete, ostracod, amphipod and water-mite populations increased. The water from the plant was observed to pass out of the jetties toward the north the majority of the time. No documented current measurements were successfully taken to substantiate this observation.

The percentage composition of the benthic population comparisons using Spearman rank correlation coefficients (Table 14) indicated the shallower Lake Michigan sampling stations, and the May-June and

July-August sampling periods had benthic populations which were more variable between 1972 and 1973. An index of dispersion also reflected the great variation between seasons and stations for each major benthic group (Table 15).

Detailed identification of the benthic taxa indicated specific distributions and relationships. The large number of immature oligochaetes at the Lake Michigan stations (Table 7) indicated either an unusual survival of the young or an unusual mortality of the adults. The protective jetties and breakwall area in Lake Michigan has provided microhabitats which have attracted macroinvertebrates not found at the coastal sampling stations. *Gammarus fasciatus* Say and *G. pseudolimnaeus* Bousfield amphipods were found only on the jetties and breakwall. This area constitutes a lotic environment, which benthic organisms like amphipods and trichopteran larvae have colonized. The water-mite population increase at station five in 1973 may have been influenced by the gammarid amphipods on the jetties and breakwall. Hygrobatid watermites feed on gammarid eggs (Modlin, 1971).

Reservoir

The Ludington Pumped Storage Reservoir has been colonized by benthic macroinvertebrates from the adjacent Lake Michigan area and the major taxa sampled were: Oligochaeta; Isopoda; Amphipoda; Acari; Chironomidae; and Gastropoda. The oligochaetes and chironomids were the first two taxa collected, and they became the dominant forms in the reservoir for 1973 (Figures 29, 31, and 32). These benthic organisms were collected by Ponar grab and multiple plate sampling. Relatively few organisms were found in the rock basket samples from the scour protection area (Figure 33). The great water volume passing over this area may not have allowed many benthic invertebrates to colonize. No documented current measurements were successfully taken from the scour protection area to substantiate this conclusion.

The oligochaete and chironomid populations declined slightly in late summer. The numerical abundance of a population decreases as the biomass of the individual organisms increase, with maximum numbers immediately after reproduction (Tack, 1974). The emergence of the chironomid larvae as adults in late summer also explains this decrease (Oliver, 1971).

Physical and chemical parameters, recorded of the reservoir water, indicated the reservoir benthic organisms were affected by approximately the same water conditions as the adjacent Lake Michigan benthic populations. The chemical composition of the reservoir sediments was analyzed throughout 1973 and no significant changes in percentage of total carbon, hydrogen and nitrogen on a dry weight basis were determined.

Reservoir Impact on Lake Michigan Benthic Macroinvertebrates

The constructional disturbance and operational effect of the Ludington Pumped Storage Plant on the Lake Michigan benthic macroinvertebrate populations could not be distinguished because this study was started after the plant construction had begun. Following the construction and first season of operation, this plant has not had major detrimental effects on the adjacent Lake Michigan benthic macroinvertebrate communities.

APPENDIX

LAKE MICHIGAN PONAR GRAB SAMPLES 5/18/72

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m^2	OSTRACODA n	OSTRACODA N/m^2	AMPHIPODA n	AMPHIPODA N/m^2	ACARI n	ACARI N/m^2	CHIRONOMIDAE n	CHIRONOMIDAE N/m^2	GASTROPODA n	GASTROPODA N/m^2	PELECYPODA n	PELECYPODA N/m^2	OTHERS n
	42	793.8	0	0	8	151.2	0	0	25	472.5	8	151.2	14	264.6	Hir. 1
1	39	737.1	0	0	5	94.5	0	0	18	340.2	17	321.3	52	982.8	
	18	340.2	0	0	7	132.3	0	0	11	207.9	14	264.6	14	264.6	
	0	0	0	0	0	0	0	0	6	113.4	0	0	2	37.8	
2	0	0	0	0	0	0	0	0	10	189.0	0	0	0	0	
	2	37.8	0	0	0	0	0	0	8	151.2	0	0	2	37.8	
	0	0	0	0	2	37.8	0	0	5	94.5	0	0	0	0	
3	1	18.9	0	0	2	37.8	2	37.8	8	151.2	0	0	0	0	
	52	982.8	0	0	0	0	0	0	13	245.7	1	18.9	3	56.7	
	76	1436.4	0	0	154	2910.6	0	0	16	302.4	7	132.3	75	1417.5	
4	68	1285.2	0	0	174	3288.6	0	0	5	94.5	0	0	13	245.7	
	116	2192.4	0	0	159	3005.1	0	0	9	170.1	8	151.2	50	945.0	
	8	151.2	0	0	1	18.9	0	0	12	226.8	0	0	0	0	
5	20	378.0	0	0	3	56.7	3	56.7	19	359.1	0	0	1	18.9	
	71	1341.9	0	0	6	113.4	0	0	25	472.5	1	18.9	9	170.1	
	1	18.9	0	0	0	0	0	0	15	283.5	0	0	0	0	
6	9	170.1	0	0	0	0	0	0	15	283.5	0	0	0	0	
	0	0	0	0	0	0	0	0	2	37.8	0	0	0	0	

Hir. = Hirudinea; n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 18.9

LAKE MICHIGAN PONAR GRAB SAMPLES 6/27/72

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m^2	OSTRACODA n	OSTRACODA N/m^2	AMPHIPODA n	AMPHIPODA N/m^2	ACARI n	ACARI N/m^2	CHIRONOMIDAE n	CHIRONOMIDAE N/m^2	GASTROPODA n	GASTROPODA N/m^2	PELECYPODA n	PELECYPODA N/m^2	OTHERS n
	12	226.8	0	0	0	0	0	0	8	151.2	7	132.3	6	113.4	
1	4	75.6	0	0	1	18.9	2	37.8	7	132.3	17	321.3	13	245.7	
	24	453.6	0	0	9	170.1	4	75.6	6	113.4	14	264.6	23	434.7	
	2	37.8	0	0	0	0	0	0	5	94.5	0	0	0	0	
2	0	0	0	0	0	0	0	0	3	56.7	0	0	0	0	
	0	0	0	0	0	0	0	0	1	18.9	0	0	0	0	
	12	226.8	0	0	2	37.8	1	18.9	12	226.8	2	37.8	4	75.6	Hir. 1
3	142	2683.8	0	0	6	113.4	4	75.6	15	283.5	0	0	0	0	
	135	2551.5	0	0	4	75.6	0	0	1	18.9	1	18.9	3	56.7	
	18	340.2	0	0	14	264.6	0	0	0	0	0	0	2	37.8	
4	0	0	0	0	9	170.1	0	0	4	75.6	0	0	1	18.9	
	145	2740.5	0	0	182	3439.8	0	0	3	56.7	28	529.2	57	1077.3	
	120	2268.0	0	0	5	94.5	0	0	16	302.4	0	0	17	321.3	
5	0	0	0	0	0	0	1	18.9	10	189.0	0	0	0	0	
	35	661.5	0	0	1	18.9	3	56.7	34	642.6	0	0	2	37.8	
	2	37.8	0	0	0	0	1	18.9	4	75.6	0	0	0	0	
6	4	75.6	0	0	0	0	0	0	17	321.3	0	0	0	0	
	3	56.7	0	0	0	0	0	0	7	132.3	0	0	2	37.8	

Hir. = Hirudinea; n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrate/sq m; Conversion factor for N/m^2 = 18.9

LAKE MICHIGAN PONAR GRAB SAMPLES 8/10/72

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m^2	OSTRACODA n	OSTRACODA N/m^2	AMPHIPODA n	AMPHIPODA N/m^2	ACARI n	ACARI N/m^2	CHIRONOMIDAE n	CHIRONOMIDAE N/m^2	GASTROPODA n	GASTROPODA N/m^2	PELECYPODA n	PELECYPODA N/m^2	OTHERS n
	13	245.7	11	207.9	10	189.0	1	18.9	107	2022.3	25	472.5	33	623.7	Nem.6;Hir.1
1	20	378.0	20	378.0	6	113.4	1	18.9	46	869.4	7	132.3	17	321.3	
	6	113.4	14	264.6	6	113.4	3	56.7	79	1493.1	11	207.9	24	453.6	Nem.5
	0	0	0	0	0	0	0	0	33	623.7	0	0	0	0	
2	2	37.8	0	0	0	0	0	0	23	434.7	0	0	0	0	
	0	0	0	0	0	0	0	0	8	151.2	0	0	0	0	
	24	453.6	32	604.8	12	226.8	1	18.9	39	737.1	0	0	2	37.8	Nem.1;Hir.1
3	70	1323.0	23	434.7	9	170.1	6	113.4	62	1171.8	1	18.9	4	75.6	Nem.4
	0	0	13	245.7	11	207.9	0	0	127	2400.3	1	18.9	2	37.8	Nem.2
	51	963.9	0	0	245	4630.5	3	56.7	10	189.0	1	18.9	19	359.1	
4	17	321.3	2	37.8	77	1455.3	0	0	6	113.4	0	0	0	0	Mys.1
	26	491.4	0	0	31	585.9	0	0	12	226.8	0	0	1	18.9	
	34	642.6	12	226.8	12	226.8	0	0	50	945.0	4	75.6	8	151.2	Nem.5;Tric.2
5	81	1530.9	36	680.4	15	283.5	2	37.8	78	1474.2	0	0	3	56.7	Nem.4
	58	1096.2	30	567.0	13	245.7	0	0	52	982.8	1	18.9	3	56.7	Hir.1
	0	0	0	0	0	0	0	0	28	529.2	0	0	0	0	
6	1	18.9	0	0	1	18.9	0	0	17	321.3	0	0	0	0	
	0	0	0	0	0	0	0	0	17	321.3	0	0	0	0	

Nem. = Nematoda; Hir. = Hirudinea; Mys. = Mysidacea; Tric. = Trichoptera; n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 18.9

LAKE MICHIGAN PONAR GRAB SAMPLES 9/12/72

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m²	OSTRACODA n	OSTRACODA N/m²	AMPHIPODA n	AMPHIPODA N/m²	ACARI n	ACARI N/m²	CHIRONOMIDAE n	CHIRONOMIDAE N/m²	GASTROPODA n	GASTROPODA N/m²	PELECYPODA n	PELECYPODA N/m²	OTHERS n
	42	793.8	0	0	10	189.0	2	37.8	34	642.6	20	378.0	26	491.4	Hir.4
1	25	472.5	1	18.9	9	170.1	7	132.3	19	359.1	10	189.0	32	604.8	Nem.12;Hir.3
	23	434.7	0	0	22	415.8	2	37.8	19	359.1	9	170.1	25	472.5	Nem.4
	0	0	0	0	0	0	1	18.9	45	850.5	0	0	0	0	
2	0	0	0	0	0	0	0	0	37	699.3	0	0	0	0	
	0	0	0	0	0	0	0	0	39	737.1	0	0	0	0	
	123	2324.7	0	0	2	37.8	2	37.8	16	302.4	0	0	4	75.6	
3	39	737.1	7	132.3	4	75.6	9	170.1	7	132.3	3	56.7	1	18.9	Nem.1
	141	2664.9	2	37.8	7	132.3	2	37.8	10	189.0	0	0	4	75.6	Nem.1
	144	2721.6	0	0	324	6123.6	4	75.6	6	113.4	1	18.9	4	75.6	Nem.4
4	49	926.1	0	0	182	3439.8	1	18.9	5	75.6	1	18.9	3	56.7	
	62	1171.8	0	0	242	4573.8	3	56.7	11	207.9	26	491.4	75	1417.5	
	76	1436.4	0	0	11	207.9	0	0	13	245.7	0	0	0	0	Nem.7
5	179	3383.1	0	0	6	113.4	2	37.8	9	170.1	0	0	2	37.8	Nem.2
	44	831.6	2	37.8	5	94.5	0	0	15	283.5	0	0	1	18.9	Nem.2
	3	56.7	0	0	0	0	0	0	9	170.1	0	0	0	0	
6	1	18.9	0	0	0	0	0	0	4	75.6	0	0	0	0	
	2	37.8	0	0	0	0	0	0	9	170.1	0	0	0	0	

Nem. = Nematoda; Hir. = Hirudinea; n = number of macroinvertebrates in sample; N/m² = converted number of macroinvertebrates/sq m; Conversion factor for N/m² = 18.9

LAKE MICHIGAN PONAR GRAB SAMPLES 10/30/72

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m²	OSTRACODA n	OSTRACODA N/m²	AMPHIPODA n	AMPHIPODA N/m²	ACARI n	ACARI N/m²	CHIRONOMIDAE n	CHIRONOMIDAE N/m²	GASTROPODA n	GASTROPODA N/m²	PELECYPODA n	PELECYPODA N/m²	OTHERS n
	36	680.4	0	0	17	321.3	0	0	26	491.4	18	340.2	11	207.9	
1	26	491.4	0	0	23	434.7	0	0	21	396.9	5	94.5	14	264.6	
	36	680.4	0	0	14	264.6	0	0	17	321.3	6	113.4	1	18.9	Hir. 1
	1	18.9	0	0	1	18.9	0	0	6	113.4	0	0	0	0	
2	2	37.8	0	0	4	75.6	0	0	17	321.3	0	0	0	0	
	2	37.8	0	0	2	37.8	0	0	10	189.0	1	18.9	0	0	
	62	1171.8	0	0	3	56.7	0	0	36	680.4	2	37.8	3	56.7	
3	48	907.2	0	0	1	18.9	0	0	42	793.8	2	37.8	3	56.7	
	66	1247.4	0	0	7	132.3	0	0	46	869.4	6	113.4	5	94.5	
	108	2041.2	0	0	102	1927.8	0	0	13	245.7	2	37.8	7	132.2	
4	2	37.8	0	0	6	113.4	0	0	0	0	0	0	0	0	
	58	1096.2	0	0	20	378.0	0	0	4	75.6	0	0	0	0	
	88	1663.2	0	0	6	113.4	0	0	52	982.8	0	0	0	0	
5	120	2268.0	0	0	4	75.6	0	0	48	907.2	2	37.8	2	37.8	
	112	2116.8	0	0	2	37.8	0	0	38	718.2	1	18.9	0	0	
	3	56.7	0	0	0	0	0	0	17	321.3	0	0	0	0	
6	12	226.8	0	0	0	0	0	0	21	396.9	0	0	0	0	
	0	0	0	0	0	0	0	0	13	245.7	0	0	0	0	

Hir. = Hirudinea; n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 18.9

LAKE MICHIGAN PONAR GRAB SAMPLES 5/14/73

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m^2	OSTRACODA n	OSTRACODA N/m^2	AMPHIPODA n	AMPHIPODA N/m^2	ACARI n	ACARI N/m^2	CHIRONOMIDAE n	CHIRONOMIDAE N/m^2	GASTROPODA n	GASTROPODA N/m^2	PELECYPODA n	PELECYPODA N/m^2	OTHERS n
	12	226.8	2	37.8	2	37.8	0	0	8	151.2	1	18.9	6	113.4	
1	10	189.0	1	18.9	0	0	0	0	6	113.4	7	132.3	5	94.5	
	25	472.5	14	264.6	4	75.6	2	37.8	12	226.8	6	113.4	3	56.7	Nem. 6
	0	0	0	0	0	0	0	0	5	94.5	0	0	0	0	
2	5	94.5	0	0	0	0	0	0	7	132.3	0	0	0	0	
	0	0	0	0	0	0	2	37.8	9	170.1	0	0	0	0	
	8	151.2	32	604.8	0	0	5	94.5	4	75.6	1	18.9	0	0	
3	0	0	0	0	1	18.9	1	18.9	8	151.2	0	0	0	0	
	10	189.0	0	0	2	37.8	1	18.9	12	226.8	0	0	0	0	
	0	0	0	0	1	18.9	0	0	7	132.3	0	0	0	0	
4	1	18.9	0	0	0	0	0	0	1	18.9	0	0	0	0	
	38	718.2	0	0	4	75.6	0	0	15	283.5	0	0	0	0	
	77	1455.3	2	37.8	0	0	1	18.9	5	94.5	0	0	0	0	Nem. 7
5	66	1247.4	0	0	1	18.9	1	18.9	10	189.0	0	0	0	0	
	58	1096.2	0	0	1	18.9	1	18.9	3	56.7	0	0	0	0	
	7	132.3	0	0	0	0	0	0	2	37.8	0	0	0	0	
6	8	151.2	0	0	0	0	1	18.9	5	94.5	0	0	0	0	Tric. 1
	13	245.7	0	0	0	0	0	0	7	132.3	0	0	0	0	Nem. 1

Nem. = Nematoda; Tric. = Trichoptera; n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 18.9

LAKE MICHIGAN PONAR GRAB SAMPLES 6/6/73

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m^2	OSTRACODA n	OSTRACODA N/m^2	AMPHIPODA n	AMPHIPODA N/m^2	ACARI n	ACARI N/m^2	CHIRONOMIDAE n	CHIRONOMIDAE N/m^2	GASTROPODA n	GASTROPODA N/m^2	PELECYPODA n	PELECYPODA N/m^2	OTHERS n
	10	189.0	7	132.3	24	453.6	0	0	11	207.9	2	37.8	5	94.5	Nem.7
1	31	585.9	31	585.9	10	189.0	1	18.9	6	113.4	4	75.6	6	113.4	Nem.5
	22	415.8	30	567.0	0	0	0	0	25	472.5	3	56.7	5	94.5	Nem.6
	0	0	0	0	1	18.9	4	75.6	4	75.6	0	0	0	0	
2	0	0	0	0	0	0	0	0	2	37.8	0	0	0	0	
	0	0	0	0	0	0	2	37.8	3	56.7	0	0	0	0	
	0	0	0	0	4	75.6	0	0	5	94.5	1	18.9	0	0	
3	1	18.9	1	18.9	3	56.7	0	0	1	18.9	1	18.9	0	0	
	0	0	0	0	0	0	1	18.9	1	18.9	0	0	0	0	
	66	1247.4	1	18.9	331	6255.9	1	18.9	12	226.8	8	151.2	35	661.5	Nem.2;Hir.2
4	12	226.8	1	18.9	134	2532.6	0	0	8	151.2	1	18.9	2	37.8	
	23	434.7	1	18.9	226	4271.4	0	0	6	113.4	1	18.9	2	37.8	Hir.1
(clay)	0	0	1	18.9	27	510.3	0	0	0	0	1	18.9	0	0	
	67	1266.3	21	396.9	3	56.7	0	0	37	699.3	0	0	3	56.7	Nem.2
5	73	1379.7	39	737.1	5	94.5	3	56.7	32	604.8	0	0	1	18.9	Nem.11;Tric.1
	78	1474.2	13	245.7	5	94.5	1	18.9	21	396.9	0	0	0	0	Nem.6
	1	18.9	0	0	0	0	0	0	8	151.2	0	0	0	0	
6	9	170.1	7	132.3	0	0	2	37.8	29	548.1	0	0	2	37.8	
	0	0	0	0	0	0	0	0	5	94.5	0	0	0	0	

Nem. = Nematoda; Hir. = Hirudinea; Tric. = Trichoptera; n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 18.9

LAKE MICHIGAN PONAR GRAB SAMPLES 7/9/73

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m2	OSTRACODA n	OSTRACODA N/m2	AMPHIPODA n	AMPHIPODA N/m2	ACARI n	ACARI N/m2	CHIRONOMIDAE n	CHIRONOMIDAE N/m2	GASTROPODA n	GASTROPODA N/M2	PELECYPODA n	PELECYPODA N/m2	OTHERS n
	53	1001.7	0	0	2	37.8	0	0	180	3402.0	2	37.8	2	37.8	Nem.21;Hir.2
1	9	170.1	5	94.5	4	75.6	0	0	53	1001.7	3	56.7	10	189.0	Nem.12;Hir.1
	6	113.4	0	0	0	0	0	0	14	264.6	0	0	0	0	Nem.11;Hir.1
	2	37.8	0	0	0	0	0	0	18	340.2	0	0	0	0	
2	7	132.3	0	0	1	18.9	1	18.9	20	378.0	1	18.9	0	0	
	19	359.1	0	0	5	94.5	0	0	79	1493.1	3	56.7	7	132.3	Nem.5
	78	1474.2	0	0	35	661.5	1	18.9	63	1190.7	2	37.8	15	283.5	Nem.21
3	4	75.6	0	0	1	18.9	0	0	46	869.4	23	434.7	0	0	Nem.5
	27	510.3	1	18.9	13	245.7	0	0	21	396.9	2	37.8	6	113.4	Nem.20
	0	0	0	0	107	2022.3	0	0	0	0	0	0	0	0	Nem.1
4	8	151.2	0	0	152	2872.8	0	0	14	264.6	1	18.9	9	170.1	
	112	2116.8	0	0	80	1512.0	0	0	16	302.4	1	18.9	0	0	Hir.1
(clay)	28	529.2	0	0	11	207.9	0	0	21	396.9	0	0	0	0	
	22	415.8	0	0	3	56.7	2	37.8	28	529.2	0	0	0	0	Nem.1
5	85	1606.5	0	0	6	113.4	0	0	21	396.9	0	0	0	0	Nem.4
	110	2079.0	0	0	0	0	3	56.7	15	283.5	0	0	0	0	Hir.1
	13	245.7	0	0	0	0	0	0	7	132.3	1	18.9	0	0	Nem.1
6	59	1115.1	2	37.8	2	37.8	1	18.9	77	1455.3	0	0	0	0	Nem.2;Hir.1
	31	585.9	1	18.9	4	75.6	0	0	27	510.3	0	0	0	0	Nem.2

Nem. = Nematoda; Hir. = Hirudinea; n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 18.9

LAKE MICHIGAN PONAR GRAB SAMPLES 8/22/73

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m^2	OSTRACODA n	OSTRACODA N/m^2	AMPHIPODA n	AMPHIPODA N/m^2	ACARI n	ACARI N/m^2	CHIRONOMIDAE n	CHIRONOMIDAE N/m^2	GASTROPODA n	GASTROPODA N/m^2	PELECYPODA n	PELECYPODA N/m^2	OTHERS n
	30	567.0	0	0	5	94.5	9	170.1	35	661.5	10	189.0	11	207.9	Nem.7
1	32	604.8	0	0	4	75.6	2	37.8	17	321.3	4	75.6	5	94.5	Nem.3
	24	453.6	0	0	3	56.7	2	37.8	15	283.5	0	0	4	75.6	
	17	321.3	0	0	0	0	1	18.9	14	264.6	0	0	0	0	
2	17	321.3	0	0	0	0	3	56.7	27	510.3	0	0	0	0	
	20	378.0	0	0	3	56.7	4	75.6	26	491.4	0	0	0	0	
	147	2778.3	0	0	21	396.9	8	151.2	27	510.3	0	0	15	283.5	Nem.5
3	75	1417.5	0	0	14	264.6	11	207.9	12	226.8	0	0	9	170.1	Nem.3;Hir.3
	-	-	0	0	-	-	-	-	-	-	-	-	-	-	
	21	396.9	0	0	29	548.1	0	0	0	0	6	113.4	0	0	
4	10	189.0	0	0	71	1341.9	0	0	0	0	7	132.3	6	113.4	Nem.1
	22	415.8	0	0	31	585.9	0	0	0	0	2	37.8	2	37.8	
	10	189.0	0	0	0	0	3	56.7	5	94.5	0	0	0	0	
5	108	2041.2	0	0	1	18.9	1	18.9	64	1209.6	0	0	3	56.7	
	72	1360.8	0	0	1	18.9	1	18.9	19	359.1	0	0	1	18.9	
	71	1341.9	0	0	2	37.8	3	56.7	30	567.0	0	0	0	0	
6	114	2.54.6	0	0	4	75.6	5	94.5	54	1020.6	1	18.9	7	132.3	Nem.2
	44	831.6	0	0	1	18.9	0	0	11	207.9	0	0	0	0	Nem.1;Hir.1

Nem. = Nematoda; Hir. = Hirudinea; n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 18.9

LAKE MICHIGAN PONAR GRAB SAMPLES 9/24/73

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m^2	OSTRACODA n	OSTRACODA N/m^2	AMPHIPODA n	AMPHIPODA N/m^2	ACARI n	ACARI N/m^2	CHIRONOMIDAE n	CHIRONOMIDAE N/m^2	GASTROPODA n	GASTROPODA N/m^2	PELECYPODA n	PELECYPODA N/m^2	OTHERS n
1	20	378.0	0	0	5	94.5	3	56.7	18	340.2	30	567.0	6	113.4	Nem. 1
	12	226.8	0	0	8	151.2	5	94.5	15	283.5	31	585.9	14	264.6	Nem. 2
	7	132.3	0	0	1	18.9	3	56.7	15	283.5	24	453.6	17	321.3	
2	9	170.1	0	0	1	18.9	1	18.9	42	793.8	0	0	0	0	
	10	189.0	0	0	0	0	1	18.9	21	396.9	0	0	0	0	
	5	94.5	0	0	0	0	0	0	14	264.6	4	75.6	0	0	
3	32	604.8	0	0	4	75.6	8	151.2	11	207.9	2	37.8	10	189.0	
	58	1096.2	0	0	1	18.9	4	75.6	16	302.4	1	18.9	2	37.8	
	61	1152.9	0	0	2	37.8	4	75.6	9	170.1	5	94.5	7	132.3	
4	44	831.6	0	0	133	2513.7	2	37.8	3	56.7	1	18.9	1	18.9	Nem. 1
	37	699.3	0	0	88	1663.2	1	18.9	3	56.7	1	18.9	1	18.9	Nem. 1
	23	434.7	0	0	41	774.9	2	37.8	5	94.5	0	0	4	75.6	
5	107	2022.3	0	0	5	94.5	5	94.5	13	254.7	6	113.4	17	321.3	
	109	2060.1	0	0	0	0	6	113.4	26	491.4	2	37.8	1	18.9	
	142	2683.8	0	0	2	37.8	2	37.8	18	340.2	1	18.9	7	132.3	
6	91	1719.9	0	0	1	18.9	5	94.5	45	850.5	0	0	0	0	
	17	321.3	1	18.9	0	0	4	75.6	13	245.7	0	0	1	18.9	Nem. 1
	34	642.6	0	0	1	18.9	1	18.9	28	529.2	0	0	0	0	

Nem. = Nematoda; n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 18.9

LAKE MICHIGAN PONAR GRAB SAMPLES 10/31/73

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m^2	OSTRACODA n	OSTRACODA N/m^2	AMPHIPODA n	AMPHIPODA N/m^2	ACARI n	ACARI N/m^2	CHIRONOMIDAE n	CHIRONOMIDAE N/m^2	GASTROPODA n	GASTROPODA N/m^2	PELECYPODA n	PELECYPODA N/m^2	OTHERS n
	47	888.3	0	0	27	510.3	1	18.9	17	321.3	131	2475.9	86	1625.4	Tric. 1
1	39	737.1	0	0	15	283.5	7	132.3	16	302.4	101	1908.9	32	604.8	Tric. 1
	23	434.7	0	0	8	151.2	1	18.9	25	472.5	86	1625.4	35	661.5	
	26	491.4	0	0	1	18.9	0	0	37	699.3	0	0	0	0	
2	16	302.4	0	0	2	37.8	0	0	30	567.0	0	0	0	0	
	20	378.0	0	0	1	18.9	0	0	63	1190.7	0	0	0	0	
	20	378.0	0	0	2	37.8	5	94.5	25	472.5	5	94.5	3	56.7	
3	8	151.2	0	0	3	56.7	6	113.4	19	359.1	0	0	0	0	
	25	472.5	0	0	2	37.8	1	18.9	31	585.9	1	18.9	0	0	
	42	793.8	1	18.9	44	831.6	1	18.9	5	94.5	2	37.8	3	56.7	Mys. 3
4	101	1908.9	3	56.7	137	2589.3	14	264.6	8	151.2	4	75.6	25	472.5	Mys. 15
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

Mys. = Mysidacea; Tric. = Trichoptera; n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 18.9

LAKE MICHIGAN MULTIPLE PLATE SAMPLES 7/25/73

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m^2	AMPHIPODA n	AMPHIPODA N/m^2	ACARI n	ACARI N/m^2	EPHEMEROPTERA n	EPHEMEROPTERA N/m^2	TRICHOPTERA n	TRICHOPTERA N/m^2	CHIRONOMIDAE n	CHIRONOMIDAE N/m^2	GASTROPODA n	GASTROPODA N/m^2	OTHERS n
1	2	1.8	1	0.9	184	163.8	0	0	0	0	348	309.7	4	3.6	Nem. 1; Dec. 1
2	0	0	9	8.0	118	105.0	1	0.9	1	0.9	158	140.6	10	8.9	
3	8	7.1	17	15.1	483	429.1	1	0.9	3	2.8	392	348.9	10	8.9	Iso. 1
4	1	0.9	4	3.6	0	0	0	0	0	0	1	0.9	0	0	
6	11	9.8	15	13.4	1	0.9	8	7.1	1	0.9	47	41.8	51	45.4	

Nem. = Nematoda; Iso. = Isopoda; Dec. = Decapoda; n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 0.89

LAKE MICHIGAN ROCK BASKET SAMPLES 8/12/73

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m^2	HIRUDINEA n	HIRUDINEA N/m^2	ISOPODA n	ISOPODA N/m^2	AMPHIPODA n	AMPHIPODA N/m^2	ACARI n	ACARI N/m^2	TRICHOPTERA n	TRICHOPTERA N/M^2	CHIRONOMIDAE n	CHIRONOMIDAE N/m^2	GASTROPODA n	GASTROPODA N/m^2
Outside South Jetty	2	2.6	1	1.3	1	1.3	36	47.5	0	0	24	31.7	7	9.2	1	1.3
Outside Break-wall	2	2.6	1	1.3	1	1.3	85	112.2	3	3.9	65	85.8	4	5.3	0	0

n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m;
Conversion factor for N/m^2 = 1.32

RESERVOIR PONAR GRAB SAMPLES 5/11/73

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m^2	AMPHIPODA n	AMPHIPODA N/m^2	ACARI n	ACARI N/m^2	CHIRONOMIDAE n	CHIRONOMIDAE N/m^2	OTHERS n
	0	0	0	0	0	0	0	0	
1	0	0	0	0	0	0	0	0	
	-	-	-	-	-	-	-	-	
	0	0	0	0	0	0	2	37.8	Cer. 1
4	0	0	0	0	0	0	1	18.9	
	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	1	18.9	
6	0	0	0	0	0	0	1	18.9	
	0	0	0	0	0	0	0	0	

Cer. = Ceratopogonidae; n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 18.9

RESERVOIR PONAR GRAB SAMPLES 6/19/73

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m^2	AMPHIPODA n	AMPHIPODA N/m^2	ACARI n	ACARI N/m^2	CHIRONOMIDAE n	CHIRONOMIDAE N/m^2	OTHERS n
	0	0	0	0	0	0	2	37.8	
1	0	0	0	0	0	0	3	56.7	Eph. 1
	0	0	0	0	0	0	0	0	
	2	37.8	1	18.9	0	0	5	94.5	Hir. 1
4	0	0	0	0	0	0	5	94.5	
	-	-	-	-	-	-	-	-	
	1	18.9	0	0	0	0	7	132.3	Hir. 1
6	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	

Hir. = Hirudinea; Eph. = Ephemeroptera; n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 18.9

RESERVOIR PONAR GRAB SAMPLES 7/18/73

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m^2	AMPHIPODA n	AMPHIPODA N/m^2	ACARI n	ACARI N/m^2	CHIRONOMIDAE n	CHIRONOMIDAE N/m^2	OTHERS n
	37	699.3	0	0	0	0	20	378.0	
1	13	245.7	0	0	0	0	4	75.6	
	0	0	0	0	0	0	7	132.3	
	29	548.1	0	0	0	0	15	283.5	
4	20	378.0	0	0	0	0	16	302.4	
	4	75.6	0	0	0	0	1	18.9	
	11	207.9	0	0	0	0	9	170.1	
6	12	226.8	1	18.9	1	18.9	8	151.2	
	0	0	0	0	0	0	2	37.8	

n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 18.9

RESERVOIR PONAR GRAB SAMPLES 8/30/73

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m²	AMPHIPODA n	AMPHIPODA N/m²	ACARI n	ACARI N/m²	CHIRONOMIDAE n	CHIRONOMIDAE N/m²	OTHERS n
	21	396.9	0	0	3	56.7	32	604.8	
1	37	699.3	0	0	0	0	18	340.2	
	8	151.2	0	0	0	0	64	1209.6	
	113	2135.7	0	0	0	0	8	151.2	
4	72	1360.8	0	0	0	0	3	56.7	
	93	1757.7	1	18.9	1	18.9	9	170.1	
	8	151.2	0	0	0	0	35	661.5	
6	2	37.8	0	0	0	0	45	850.5	
	3	56.7	0	0	2	37.8	0	0	

n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 18.9

RESERVOIR PONAR GRAB SAMPLES 10/10/73

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m^2	AMPHIPODA n	AMPHIPODA N/m^2	ACARI n	ACARI N/m^2	CHIRONOMIDAE n	CHIRONOMIDAE N/m^2	OTHERS n
	88	1663.2	0	0	5	94.5	14	264.6	
1	24	453.6	0	0	1	18.9	7	132.3	
	53	1001.7	1	18.9	0	0	15	283.5	
	32	604.8	0	0	1	18.9	27	510.3	
4	2	37.8	0	0	0	0	0	0	
	16	302.4	0	0	0	0	12	226.8	
	50	945.0	1	18.9	6	113.4	23	434.7	
6	44	831.6	0	0	0	0	19	359.1	
	34	642.6	0	0	0	0	18	340.2	

n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 18.9

RESERVOIR MULTIPLE PLATE SAMPLES 4/5/73

STATIONS	OLIGOCHAETA		ISOPODA		AMPHIPODA		ACARI		TRICHOPTERA		CHIRONOMIDAE		GASTROPODA		OTHERS
	n	N/m^2	n	N/m^2	n	N/m^2	n	N/m^2	n	N/m^2	n	N/m^2	n	N/m^2	n
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	0	0	1	0.9	0	0	
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	2	1.8	0	0	0	0	0	0	0	0	1	0.9	0	0	

n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m;
Conversion factor for N/m^2 = 0.89

RESERVOIR MULTIPLE PLATE SAMPLES 6/4/73

STATIONS	OLIGOCHAETA		ISOPODA		AMPHIPODA		ACARI		TRICHOPTERA		CHIRONOMIDAE		GASTROPODA		OTHERS
	n	N/m^2	n	N/m^2	n	N/m^2	n	N/m^2	n	N/m^2	n	N/m^2	n	N/m^2	n
1	0	0	0	0	5	4.4	0	0	0	0	5	4.4	0	0	
2	0	0	0	0	0	0	0	0	0	0	6	5.3	0	0	
3	0	0	1	0.9	3	2.7	0	0	0	0	3	2.7	0	0	Hir. 1
4	0	0	0	0	2	1.8	0	0	0	0	14	12.5	0	0	Hir. 1; Eph. 1
5	1	0.9	0	0	0	0	0	0	0	0	5	4.4	0	0	
6	0	0	0	0	0	0	0	0	0	0	7	6.2	0	0	

Hir. = Hirudinea; Eph. = Ephemeroptera; n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 0.89

RESERVOIR MULTIPLE PLATE SAMPLES 7/6/73

STATIONS	OLIGOCHAETA		ISOPODA		AMPHIPODA		ACARI		TRICHOPTERA		CHIRONOMIDAE		GASTROPODA		OTHERS
	n	N/m^2	n	N/m^2	n	N/m^2	n	N/m^2	n	N/m^2	n	N/m^2	n	N/m^2	n
1	32	28.5	0	0	28	24.9	1	0.9	0	0	2	1.8	0	0	Col. 3
2	80	71.2	0	0	5	4.4	0	0	1	0.9	2	1.8	0	0	Eph. 1
3	13	11.6	3	2.7	12	10.7	0	0	0	0	1	0.9	0	0	Col. 21
4	15	13.4	16	14.2	0	0	0	0	1	0.9	9	8.0	0	0	
5	244	217.2	9	8.0	0	0	0	0	0	0	10	8.9	0	0	
6	143	127.3	1	0.9	1	0.9	0	0	1	0.9	10	8.9	0	0	Col. 5

Col. = Collembola; Eph. = Ephemeroptera; n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 0.89

RESERVOIR MULTIPLE PLATE SAMPLES 8/13/73

STATIONS	OLIGOCHAETA		ISOPODA		AMPHIPODA		ACARI		TRICHOPTERA		CHIRONOMIDAE		GASTROPODA		OTHERS
	n	N/m²	n	N/m²	n	N/m²	n	N/m²	n	N/m²	n	N/m²	n	N/m²	n
1	16	14.2	11	9.8	1	0.9	22	19.6	5	4.4	27	24.0	1	0.9	
2	0	0	8	7.1	5	4.4	0	0	1	0.9	20	17.8	1	0.9	
3	3	2.7	39	34.7	24	21.4	22	19.6	0	0	28	24.9	6	5.3	
4	0	0	28	24.9	8	7.1	77	68.5	1	0.9	20	17.8	1	0.9	
5	5	4.4	2	1.8	33	29.4	57	50.7	0	0	13	11.6	0	0	
6	0	0	4	3.6	20	17.8	52	46.3	0	0	10	8.9	0	0	Eph. 1

Eph. = Ephemeroptera; n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 0.89

RESERVOIR MULTIPLE PLATE SAMPLES 9/21/73

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m^2	ISOPODA n	ISOPODA N/m^2	AMPHIPODA n	AMPHIPODA N/m^2	ACARI n	ACARI N/m^2	TRICHOPTERA n	TRICHOPTERA N/m^2	CHIRONOMIDAE n	CHIRONOMIDAE N/m^2	GASTROPODA n	GASTROPODA N/m^2	OTHERS n
1	230	204.7	5	4.45	3	2.67	0	0	0	0	12	10.68	0	0	
2	0	0	16	14.24	7	6.23	7	6.23	0	0	15	13.35	2	1.78	
3	8	7.12	8	7.12	1	0.89	0	0	0	0	19	16.91	32	28.48	
4	48	42.72	5	4.45	0	0	1	0.89	1	0.89	3	2.67	9	8.01	
5	33	29.37	0	0	1	0.89	1	0.89	1	0.89	2	1.78	7	6.23	
6	30	26.70	47	41.83	0	0	9	8.01	1	0.89	5	4.45	68	60.52	

n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 0.89

RESERVOIR MULTIPLE PLATE SAMPLES 10/17/73

STATIONS	OLIGOCHAETA		ISOPODA		AMPHIPODA		ACARI		TRICHOPTERA		CHIRONOMIDAE		GASTROPODA		OTHERS
	n	N/m²	n	N/m²	n	N/m²	n	N/m²	n	N/m²	n	N/m²	n	N/m²	n
1	1	0.89	2	1.78	3	2 67	5	4.45	2	1.78	0	0	7	6.23	
2	6	5.34	13	11.57	5	4.45	7	6.23	3	2.67	0	0	2	1.78	
3	1	0.89	14	12.46	0	0	15	13.35	2	1.78	2	1.78	23	20.47	
4	1	0.89	6	5.34	2	1.78	0	0	2	1.78	0	0	20	17.80	
5	30	26.70	28	24.92	2	1.78	4	3.56	3	2.67	1	0.89	17	15.13	Eph. 1
6	36	32.04	15	13.35	1	0.89	19	16.91	3	2.67	5	4.45	19	16.91	

Eph. = Ephemeroptera; n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 0.89

RESERVOIR MULTIPLE PLATE SAMPLES 11/13/73

STATIONS	OLIGOCHAETA		ISOPODA		AMPHIPODA		ACARI		TRICHOPTERA		CHIRONOMIDAE		GASTROPODA		OTHERS
	n	N/m^2	n	N/m^2	n	N/m^2	n	N/m^2	n	N/m^2	n	N/m^2	n	N/m^2	n
1	0	0	1	0.89	1	0.89	4	3.56	1	0.89	1	0.89	1	0.88	
2	0	0	3	2.67	0	0	9	8.01	0	0	6	5.34	2	1.78	
3	9	8.01	5	4.45	1	0.89	6	5.34	1	0.89	4	3.56	11	9.79	
4	4	3.56	10	8.9	2	1.78	16	14.24	0	0	0	0	1	0.89	
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
6	8	7.12	22	19.58	3	2.67	41	36.49	3	2.67	0	0	16	14.24	Eph. 1

Eph. = Ephemeroptera; n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 0.89

RESERVOIR ROCK BASKET SAMPLES 6/22/73

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m^2	HIRUDINEA n	HIRUDINEA N/m^2	ACARI n	ACARI N/m^2	CHIRONOMIDAE n	CHIRONOMIDAE N/m^2	GASTROPODA n	GASTROPODA N/m^2
South Row										
1 (nearest intake)	0	0	0	0	0	0	1	1.3	0	0
2	0	0	0	0	0	0	1	1.3	0	0
3	0	0	0	0	0	0	4	5.3	0	0
4	1	1.3	0	0	0	0	3	4.0	0	0

n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 1.32

RESERVOIR ROCK BASKET SAMPLES 8/29/73

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m^2	HIRUDINEA n	HIRUDINEA N/m^2	ACARI n	ACARI N/m^2	CHIRONOMIDAE n	CHIRONOMIDAE N/m^2	GASTROPODA n	GASTROPODA N/m^2
North Row										
1 (nearest intake)	0	0	0	0	0	0	11.	14.5	0	0
2	0	0	0	0	1	1.3	15	19.8	0	0
3	1	1.3	0	0	0	0	12	15.8	0	0
4	0	0	0	0	0	0	10	13.2	0	0

n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 1.32

RESERVOIR ROCK BASKET SAMPLES 11/7/73

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m^2	HIRUDINEA n	HIRUDINEA N/m^2	ACARI n	ACARI N/m^2	CHIRONOMIDAE n	CHIRONOMIDAE N/m^2	GASTROPODA n	GASTROPODA N/m^2
Middle										
1 (nearest intake)	0	0	0	0	3	4.0	1	1.3	0	0
2	0	0	1	1.3	0	0	0	0	2	2.6
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	2	2.6	0	0	0	0

n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 1.32

RESERVOIR ROCK BASKET SAMPLES 11/13/73

STATIONS	OLIGOCHAETA n	OLIGOCHAETA N/m^2	HIRUDINEA n	HIRUDINEA N/m^2	ACARI n	ACARI N/m^2	CHIRONOMIDAE n	CHIRONOMIDAE N/m^2	GASTROPODA n	GASTROPODA N/m^2
South 1 (nearest intake)	0	0	0	0	2	2.64	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0

n = number of macroinvertebrates in sample; N/m^2 = converted number of macroinvertebrates/sq m; Conversion factor for N/m^2 = 1.32

LITERATURE CITED

LITERATURE CITED

Alley, W. P. 1968. Ecology of the burrowing amphipod Pontoporeia affinis in Lake Michigan. Great Lakes Res. Div., Univ. Michigan Spec. Rpt. No. 36, 131 pp.

Anscombe, F. J. 1949. The statistical analysis of insect counts based on the negative binomial distribution. Biometrics, 5: 165-173.

Armstrong, J. W. 1973. Age, growth, and food habits of the round whitefish, Prosopium cylindraceum (Pallas), in central Lake Michigan. M. S. Thesis, Michigan State Univ., 76 pp.

Bliss, C. I. and R. A. Fisher. 1953. Fitting the binomial distribution to biological data and a note on the efficient fitting of the negative binomial. Biometrics, 9: 176-200.

Bousfield, E. L. 1958. Fresh-water amphipod crustaceans of glaciated North America. Can. Field Nat., 72:55-113.

Brazo, D. C. 1973. Fecundity, food habits and certain allometric features of the yellow perch Perca flavescens (Mitchill) before operation of a pumped storage project on Lake Michigan. M. S. Thesis, Michigan State Univ., 75 pp.

Bryce, D. and A. Hobart. 1972. The biology and identification of the larvae of the Chironomidae (Diptera). Entomologist's Gazette, 23:175-217.

Church, P. E. 1942. The annual temperature cycle of Lake Michigan. I. Cooling from late autumn to the terminal point, 1941-42. Univ. Chicago Inst. Meteorol., Misc. Rpt. 4, 48 pp.

________. 1945. The annual temperature cycle of Lake Michigan. II. Spring warming and summer stationary periods, 1942. Univ. Chicago Inst. Meteorol., Misc. Rpt. 18, 100 pp.

Cook, D. R. 1974. Personal communication.

Cook, G. W. and R. E. Powers. 1964. The benthic fauna of Lake Michigan as affected by the St. Joseph River. Proc. 7th Conf. Great Lakes Res., Great Lakes Res. Div., Univ. Michigan, 68-76.

Crowell, R. M. 1960. The taxonomy, distribution and developmental stages of Ohio water mites. Bull. Ohio Biol. Surv., N. S., 1(2): 1-77.

Curry, L. L. 1974. Personal communication.

Day, W. C. 1971. Ephemeroptera, pp. 237-270. In R. L. Usinger (Ed.) Aquatic insects of California with keys to North American genera and California species. Univ. California Press, Los Angeles, 508 pp.

Debauche, H. R. 1962. The structural analysis of animal communities in the soil. In P. W. Murphy (Ed.) Progress in Soil Zoology. London, 10-25.

Denning, D. G. 1971. Trichoptera, pp. 237-270. In R. L. Usinger (Ed.) Aquatic insects of California with keys to North American genera and California species. Univ. California Press, Los Angeles, 508 pp.

Eggleton, F. E. 1936. The deep-water fauna of Lake Michigan. Papers Michigan Acad. Sci., Arts and Letters, 21: 599-612.

________. 1937. Productivity of the profundal benthic zone in Lake Michigan. Papers Michigan Acad. Sci., Arts and Letters, 22: 593-611.

Elliott, J. M. 1971. Some methods for the statistical analysis of samples of benthic invertebrates. Freshwater Biol. Assoc., Scientific Publ. No. 25, 144 pp.

Fillion, D. B. 1967. The abundance and distribution of benthic fauna of three mountain reservoirs on the Kananaskis River in Alberta. J. Appl. Ecol., 4: 1-11.

Gaufin, A. R. and C. M. Tarzwell. 1956. Aquatic macroinvertebrate communities as indicators of organic pollution in Lytle Creek. Sewage and Industrial Wastes, 28: 906-924.

Goodnight, C. J. 1974. Personal communication.

Green, R. H. 1966. Measurement of non-randomness in spatial distributions. Researches Popul. Ecol. Kyoto Univ. (1), 8, 1-7.

Hensen, E. B. and H. B. Herrington. 1965. Sphaeriidae (Mollusca: Pelecypoda) of Lakes Huron and Michigan in the vicinity of the straits of Mackinac. Proc. 8th Conf. Great Lakes Res., Great Lakes Res. Div., Univ. Michigan, 77-95.

Hester, F. E. and J. S. Dendy. 1962. A multiple-plate sampler for aquatic macroinvertebrates. Trans. Amer. Fish. Soc., 91: 420-421.

Hiltunen, J. K. 1967. Some oligochaetes from Lake Michigan. Trans. Amer. Microsc. Soc., 86(4): 433-454.

Hiltunen, J. K. 1973. A laboratory guide, keys to the tubificid and naidid Oligochaeta of the Great Lakes region. 2nd ed. April 1, 1973. Not a publication.

Hughes, R. N., D. L. Peer and K. H. Mann. 1972. Use of multivariate analysis to identify functional components of the benthos in St. Margaret's Bay, Nova Scotia. Limnol. Oceanog., 17: 111-121.

Lenat, D. R. and C. M. Weiss. 1973. Distribution of benthic macroinvertebrates in Lake Wylie North Carolina-South Carolina. Dept. Environmental Sci. and Engineering, Univ. North Carolina, Chapel Hill. 75 pp.

Liston, C. R. 1974. Personal communication.

Liston, C. R. and P. I. Tack. 1973. A study of the effects of installing and operating a large pumped storage project on the shores of Lake Michigan near Ludington, Michigan. Final Rpt., Phase I Studies, to Consumers Power Co. of Michigan. 113 pp.

Mason, W. T. 1973. An introduction to the identification of chironomid larvae. U. S. Environmental Protection Agency, 90 pp.

McGregor, D. L. 1972. The Ostracoda of Gull Lake, Michigan: selected aspects of their ecology. Ph. D. Thesis, Michigan State Univ., 187 pp.

McGregor, D. L. 1974. Personal communication.

Merna, J. W. 1960. A benthological investigation of Lake Michigan. M. S. Thesis, Michigan State Univ., 74 pp.

Modlin, R. F. 1971. Contributions to the life cycle and ecology of the water mites, Hygrobates neooctoporus Marshall 1924 (Hygrobatidae, Acari). Am. Midland Naturalist, 85(1), 54-62.

Modlin, R. F. and J. E. Gannon. 1973. A contribution to the ecology and distribution of aquatic Acari in the St. Lawrence Great Lakes. Trans. Amer. Microsc. Soc., 92(2): 217-224.

Mozley, S. C. and L. C. Garcia. 1972. Benthic macrofauna in the coastal zone of southeastern Lake Michigan. Proc. 15th Conf. Great Lakes Res., Internat. Assoc. Great Lakes Res., 102-116.

Mundie, J. H. 1957. The ecology of Chironomidae in storage reservoirs. Trans. Roy. Entomol. Soc. London, 109: 149-232.

Nursall, J. R. 1952. The early development of a bottom fauna in a new power reservoir in the Rocky Mountains of Alberta. Can. J. Zool., 30: 387-409.

Oliver, D. R. 1971. Life history of the Chironomidae. Annu. Rev. Entomol. 16:211-230.

Ozhegova, V. E. 1962. (Facts relating to the hydrobiological characteristics of the Kairak-Kumsk Reservoir during the first year of its existence.) Tr. Zonal. Sov. po Tipol. i Biol. Obzn. ryb. ispol. Vnut. Vod. Yuzhn. Zony SSSR: 172-177. (In Russian; Transl. by Nat. Lending Libr. Sci. Technol., Boston Spa, Yorkshire, England.)

Paterson, C. G. 1970. Water mites (Hydracarina) as predators of chironomid larvae (Insecta: Diptera). Can. J. Zool., 48: 610-614.

Paterson, C. G. and C. H. Fernando. 1970. Benthic fauna colonization of a new reservoir with particular reference to the Chironomidae. J. Fish. Res. Bd. Can., 27: 213-232.

Pennak, R. W. 1953. Freshwater invertebrates of the United States. Ronald Press, New York. 769 pp.

Powers, C. F. and A. Robertson. 1965. Some quantitative aspects of the macrobenthos of Lake Michigan. Proc. 8th Conf. Great Lakes Res., Great Lakes Res. Div., Univ. Michigan, 153-159.

Roback, S. S. 1957. The immature tendipedids of the Philadelphia area. Acad. Nat. Sci. Phila. Monog. 9, 152 pp.

Robertson, A. and W. P. Alley. 1966. A comparative study of Lake Michigan macrobenthos. Limnol. Oceanog., 11: 576-583.

Robertson, A. 1967. A note on the Sphaeriidae of Lake Michigan, pp. 132-135. In J. C. Ayers and D. C. Chandler (Eds.), Studies on the environment and eutrophication of Lake Michigan, Great Lakes Res. Div., Univ. Michigan Spec. Rpt. No. 30, 415 pp.

Salmon, J. T. 1964. An index to the Collembola. Royal Soc. New Zealand. Parts I and II (Bull. 7) 644 pp.

Siegel, S. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Co., New York, New York, 312 pp.

Simpson, E. H. 1949. Measurement of diversity. Nature, 163: 688.

Stimpson, W. 1870. On the deep-water fauna of Lake Michigan. Am. Naturalist 4: 403-405.

Sokal, R. R. and J. J. Rohlf. 1969. Biometry: the principles and practice of statistics in biological research. W. H. Freeman and Co., San Francisco, 776 pp.

Sokolova, N. I. 1963. (The benthic fauna of the Mozhaisk Reservoir during the first year of its existence.) Uchin. i. Mozh. Vod. Gilro Biol.-Pod. Fak. M.G.U. Mosk Univ.: 355-374. (In Russian: Transl. by Nat. Lending Libr. Sci. Technol., Boston Spa, Yorkshire, England.)

Tack, P. I. 1974. Personal communication.

Ward, M. G. 1974. Personal communication.

Wells, L. 1968a. Daytime distribution of Pontoporeia affinis off bottom in Lake Michigan. Limnol. Oceanog., 703-705.

________. 1968b. Seasonal depth distribution of fish in southeastern Lake Michigan. U. S. Fish and Wildl. Serv., Fishery Bull. 67(1): 1-15.

Wilhm, J. L. 1967. Comparison of some diversity indices applied to populations of benthic macroinvertebrates in stream receiving organic wastes. J. Water Pollut. Control Fed. 39: 1673-1683.