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Spatial and Seasonal Structure of Rotifer Communities in Lake Huron

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SPATIAL AND SEASONAL STRUCTURE OF ROTIFER COMMUNITIES IN LAKE HURON

by

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FOREWORD

Effective preservation of high water quality in the Laurentian Great Lakes requires a knowledge of the effects of stressed ecosystems on aquatic communities. Studies have therefore been initiated to assess the responses of organisms to various environmental conditions, particularly those associated with cultural eutrophication.

This report on the distribution of rotifers in southern Lake Huron relates this planktonic community to environmental differences in the lake and demonstrates the value of these organisms in water quality assessment studies. A more thorough understanding of the responses of biological components to ecosystem disturbances can lead to improved management of the Great Lakes.

Donald I. Mount, Ph.D.
Director
Environmental Research Laboratory

ABSTRACT

This report presents comprehensive data on species composition and distribution of planktonic rotifers in Saginaw Bay and southern Lake Huron from April to November, 1974. Rotifer species composition and abundance differed greatly between Saginaw Bay and open Lake Huron waters. Through cluster analyses, these differences were empirically related to the physicochemical environment. The results of these analyses suggest that rotifers are valuable organisms in water quality assessment studies. Several species which displayed distribution limited to eutrophic Saginaw Bay stations or to oligotrophic offshore Lake Huron stations were potentially useful as environmental indicators. Based on rotifer data, the greatest impact of Saginaw Bay waters on Lake Huron occurred along the western shore of southern Lake Huron below the mouth of the bay. In general, inshore stations of southern Lake Huron displayed greater rotifer abundance than mid-lake stations.

Certain rotifers displayed distinct epilimnetic or hypolimnetic vertical distributions. However, maxima of total rotifer abundance usually occurred in the vicinity of the metalimnion. Wind-generated turbulence often distributed rotifers more evenly in the epilimnion.

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CONTENTS

FIGURES

Number		Page

TABLES

APPENDIX FIGURES

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SECTION 1

INTRODUCTION

This report is part of the Upper Lakes Reference Study which was designed to provide data pertinent to future water quality management decisions (International Joint Commission 1977). It presents comprehensive data on species composition and distribution of planktonic Rotifera in Lake Huron waters.

Previous investigations of zooplankton in Lake Huron have dealt primarily with crustacean plankton (Davis 1966; Watson 1974). Rotifer studies were more limited in scope. Williams (1962, 1966) studied abundance of predominant rotifer genera in water intake samples collected near Port Huron, Michigan during 1961 and 1962. Nauwerck (1972) briefly discussed species composition and abundance of approximately 30 rotifer species in samples collected throughout Lake Huron in 1971. Schelske and Roth (1973) provided some data on the distribution of *Asplanchna* during 1970.

Our report is based on data collected from April to November 1974 at 94 stations in southern Lake Huron and Saginaw Bay. This study represents the first comprehensive taxonomic survey of Lake Huron rotifers and attempts to relate rotifer community composition to water quality assessment efforts.

SECTION 2

CONCLUSIONS

Seventy-five species of rotifers occurred in Saginaw Bay and southern Lake Huron during the study period. *Keratella*, *Polyarthra*, *Synchaeta*, *Notholca*, *Filinia*, and *Conochilus* were the predominant planktonic genera.

The data revealed distinct differences in the composition and abundance of rotifers between the Saginaw Bay and southern Lake Huron stations. These differences were qualitatively related to differences in trophic conditions, through cluster analysis, suggesting a strong relationship between community composition and the environment. Cluster analysis was a useful technique to simplify a large multivariate data base into basic elemental groups that could be readily described and interpreted. Based on rotifer data alone, the greatest impact of Saginaw Bay waters on Lake Huron occurred along the western shore of southern Lake Huron immediately below the mouth of the Bay.

Certain rotifer species showed a distinct epilimnetic or hypolimnetic vertical distribution. The maxima of rotifer abundance usually occurred in the vicinity of the metalimnion. Wind-generated turbulence distributed rotifers more evenly in the epilimnion.

Several species, such as *Anuraeopsis fissa*, *Brachionus* spp., *Conochiloides dossuarius*, and *Keratella cochlearis* f. *tecta*, which occurred only at stations in or near the Saginaw River are potentially valuable eutrophic indicators. Certain cold stenothermal species, such as *Notholca laurentiae* and *Synchaeta asymmetrica*, are useful as oligotrophic indicators only during periods of thermal stratification.

Greatest abundance of rotifers and development of indicator species occurred during late spring and early summer. Therefore, as few as two surveys for rotifers during this period should yield maximum information for biomonitoring studies.

SECTION 3

METHODS

Plankton samples were collected at 44 stations in southern Lake Huron on eight cruises from April to November 1974. In addition, as part of EPA Grant R802780-02-02, samples for rotifers were collected at 50 stations in Saginaw Bay. Because of weather conditions, not all stations could be sampled on every cruise. Overlapping cruise schedules allowed data from six Saginaw Bay cruises to be combined with data from southern Lake Huron (Figure 1).

In southern Lake Huron, aboard the R/V Simons, samples were taken with 8-liter Niskin bottles at 5-m intervals from surface level to 20 m deep, and at 10-m intervals below that. After collection, the water samples were immediately pooled and concentrated with a filtering funnel that was covered with 54-μm Nitex nylon screening. Vertical distribution was studied at stations 43, 21, and 60 (Figure 1) to determine if sampling at discrete depths would seriously bias total rotifer abundance, especially at deep stations. Station 43 (29 m), located in outer Saginaw Bay, was sampled during all cruises. Station 21 (98 m), situated in the central portion of the lake, was sampled only in June, July and August (cruises 3, 4, 5, and 6) because of rough seas. Stations 60 (43 m) and an alternate station, 60A (30 m), in the southern portion of the lake, were sampled opportunistically depending on weather conditions. Station 60A was sampled during cruise 1 and station 60 was sampled during cruises 2-7. Neither station was sampled during cruise 8 because of rough seas.

In Saginaw Bay, aboard the R/V Johnson, deep water stations were sampled at 5-m intervals down to 15 m deep and at 10-m intervals below that with a Jabsco model 11810 pump fitted with a 1.5 cm I.D. intake hose. Water samples from inshore stations were collected at 5-m intervals with transparent 7- or 8.1-liter Van Dorn bottles from a 5.5-m outboard patrol boat. Depending on the density of organisms, 7 to 90 liters of water were filtered through the Nitex-fitted plankton funnel.

The plankton funnel and screen were thoroughly washed with the filtrate and samples were carefully transferred to 0.12- or 0.24-liter (4 or 8 oz.) screw cap jars. Carbonated water was promptly added as a narcotizing agent (Gannon and Gannon 1975) and samples were preserved with 5% buffered formalin. Physicochemical data collected concurrently with the rotifer samples was provided for Saginaw Bay by the Cranbrook Institute of Science and for southern Lake Huron by the Great Lakes Research Division, The University of Michigan.

In preparation for rotifer counts, all samples were concentrated to 50 ml. Each sample was thoroughly mixed with a calibrated automatic pipette

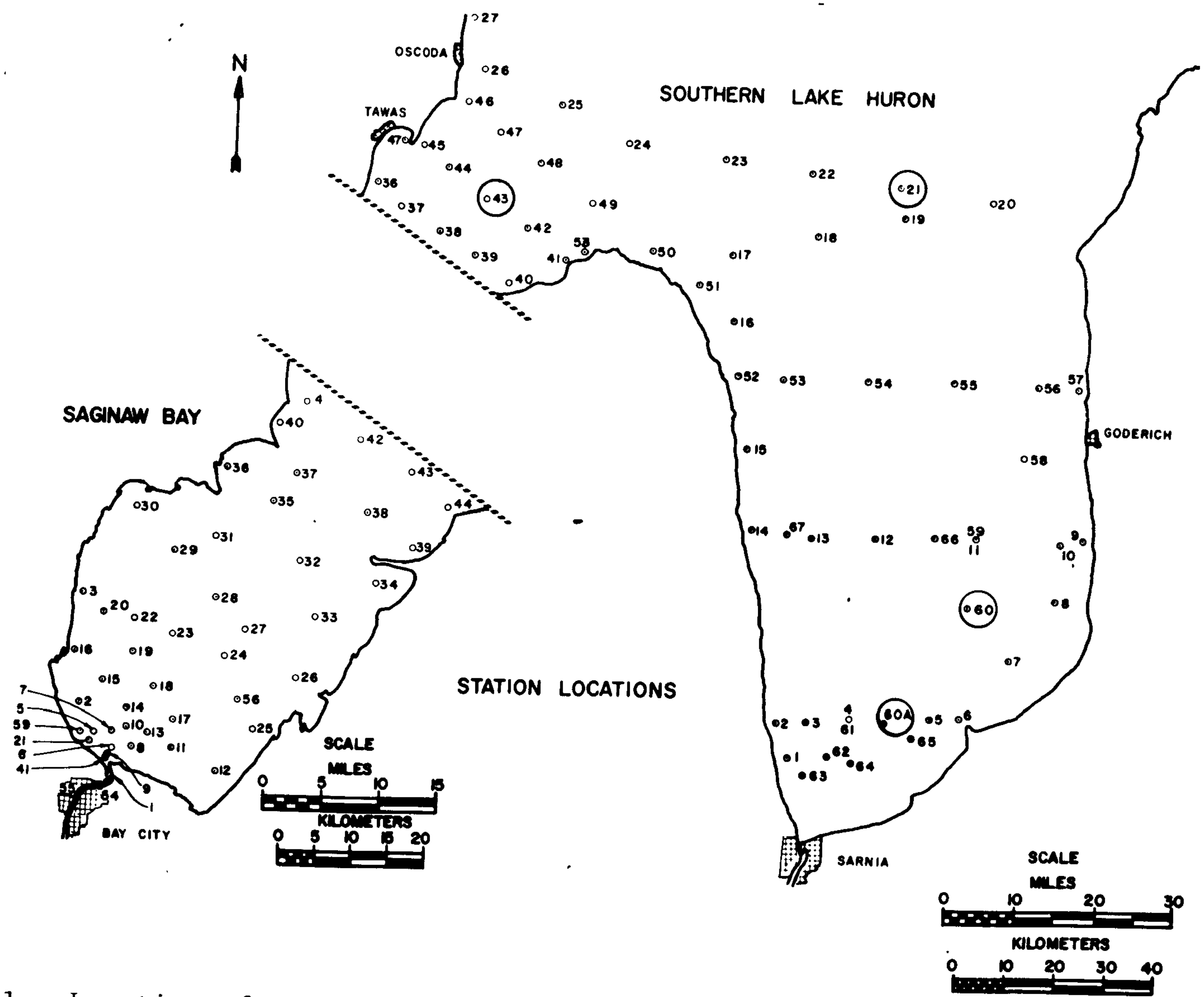

Figure 1. Location of sampling stations in Saginaw Bay (left) and southern Lake Huron (right). Rotifer vertical distribution was investigated at encircled stations.

immediately before taking a subsample with the pipette from the center of the jar. Subsamples of 1 ml, 3 ml, or 5 ml were taken, depending on the density of organisms, so that the concentration of rotifers in each subsample included 100 to 300 individuals. Subsamples were transferred to a 2- or 5-ml plexiglas counting cell and all rotifers were enumerated under an American Optical compound microscope at 100 x. Each subsample was then replaced in the jar, a second subsample was taken and enumerated, and the two counts were averaged. A minimum of 200 rotifers per sample were routinely counted.

To assess the reproducibility of subsampling methods, one sample was repetitively subsampled 10 times. A least squares regression of raw counts against percent error indicated that a minimum count of 15 individuals achieved an estimated error of 20% at the 95% confidence level.

Identification was made to species in most instances through direct observation under the microscope. Species of the genus Synchaeta were indistinguishable because of their contracted state. Identification of these species was determined by configurations of the mouthparts after chlorox bleach was used as a clearing agent (Stemberger 1973). The primary references used in identifying the rotifers were Ahlstrom (1940, 1943), Voigt (1957), Ruttner-Kolisko (1974), and Stemberger (1976).

Diversity indices were calculated for rotifers at each station based on the Shannon-Wiener function (Pielou 1975). Base 10 logarithms were used for calculations. Although calculations were performed for all cruises, index values are presented for only three cruises representing spring, summer, and fall.

Cluster analyses were performed on the rotifer data base to asssess the similarities and differences in the rotifer communities among stations and to provide an aid for interpreting large-scale distributional data. Stations were clustered by the complete linkage method (Sneath and Sokal 1973) based on the abundance of rotifers at each station. Euclidean distance was the proximity measure employed to determine the similarities among the stations.

On the July data, cluster analyses were conducted on manipulations of the rotifer data base to determine how the data should be utilized to achieve maximum information. These manipulations included cluster analyses based on log-transformed and non-transformed data, which included all species in one set of analyses and selected species in another. Selected species included cold stenotherms, eutrophic indicator species, and most predominant species. Stations were also clustered based on presence-absence data for all rotifer species, with Jaccard coefficients as measures of intra-lake similarity. All cluster analyses yielded fairly similar results. However, cluster analyses based on raw data for all species and for selected species resulted in the highest cophenetic correlations (.94 and .95, respectively). Analysis of presence-absence data provided little information (Cophenetic correlation = 0.63), although the method delineated extremes of community types such as Saginaw River stations and offshore stations in Lake Huron. All subsequent cluster analyses were based on the abundance of all species.

A cluster analysis was also performed based on the physicochemical variables at each station for the July data only. This analysis was based on standardized data from 99 stations for surface values of pH, specific conductance, chloride, chlorophyll *a*, phaeophytin, ammonia nitrogen, soluble phosphorus, and silica. Secchi disc depth was also included.

Station groups were determined tentatively by examining a printer plot dendrogram. A computer printout of the Euclidean distance matrix was then used to evaluate the strength of the similarities between stations. This was accomplished by connecting adjacent stations on a station map with a line depicting the actual Euclidean distance. This procedure was followed for every station, thus forming a network of lines which indicated the Euclidean relationship among stations. When a disparity or large distance occurred between adjacent stations, a separation was made. Initial groups were formed by evaluating the distances in this way. Distances between stations in groups separated geographically were also evaluated for similarity, and similar groups were combined.

SECTION 4

RESULTS

During the study period 68 rotifer species were collected from Saginaw Bay stations and 60 from southern Lake Huron stations (TABLE 1). Major results for horizontal distribution are presented separately for each cruise, whereas the results for vertical distribution are based on data from combined cruises. Species which comprised at least 10% of total abundance were arbitrarily defined as predominant. Species regarded as eutrophic indicators or cold stenotherms were considered significant even though they may have contributed <10% of the total abundance. Data from all cruises was also computer-plotted to display horizontal distribution of total rotifers and individual species (Appendix A, Figures A-1 through A-48).

HORIZONTAL DISTRIBUTION

Cruise One

Thirty stations in Saginaw Bay (28-30 April) and 36 stations in southern Lake Huron (28 April-3 May) were sampled for rotifers. Twenty-nine species were identified (TABLE 1). The predominant species of Saginaw Bay were *Keratella cochlearis*, *Notholca foliacea*, *Synchaeta lakowitziana*, and *Polyarthra dolichoptera*. The eutrophic indicator species, *Brachionus calyciflorus*, occurred at 6.0 ind./liter. Rotifers which predominated in the open water of Lake Huron were *Notholca squamula*, *N. foliacea*, and *S. lakowitziana*. The cold stenotherm, *N. laurentiae*, occurred at 3.2 ind./liter.

The warmest water temperatures (10-14C) in Saginaw Bay occurred at near-shore areas along both coastlines (Figure 2). A tongue of cooler water (6-7C) extended from the outer bay to the south central portions of the inner bay. The warmest water temperatures (7-9C) in southern Lake Huron occurred in isolated areas along the eastern and western coasts. Surface temperatures in the central portions of the lake ranged from 3.5 to 6C.

Highest concentrations of chlorophyll *a* (15-50 μg/liter) occurred at near-shore stations in the lower portions of Saginaw Bay and were 15 to 20 times higher than the concentrations observed in the central portions of the lake (Figure 3). In southern Lake Huron most surface values of chlorophyll *a* (2-4 μg/liter) were uniformly distributed, but higher concentrations (16 μg/liter) occurred near Goderich.

Distribution of total rotifers corresponded closely with the distribution of temperature and chlorophyll *a*. Greatest rotifer abundance (800-1,200 ind./liter) occurred along the southeast coast of inner Saginaw Bay and was about 30 to 48 times greater than the abundance in the central portions of the lake (Figure 4). In southern Lake Huron highest rotifer densities (50-150 ind./liter) occurred along the western coast. Species diversity was generally higher (mean of 0.76) in Saginaw Bay than in southern Lake Huron (mean of 0.58) (Figure 5).

Cluster analysis of rotifer data divided the stations into five groups (Figure 6). Three groups occurred exclusively in Saginaw Bay. A fourth group was composed of outer Saginaw Bay stations as well as stations on the west-central coast of southern Lake Huron. A fifth group occupied the central Lake Huron water mass. The cluster analyses yielded a cophenetic correlation of 0.90.

Groups I, II, and III shared similar species composition percentages with the exception of *Polyarthra dolichoptera*, which predominated in Group III, contributing 61% of total abundance (TABLE 2). This species contributed 28 and 42%, respectively, in Groups I and II, where it was also the dominant rotifer.

Group I constituted a species assemblage most closely associated with Saginaw River stations. The lower abundance in this Group, as compared with Groups II and III, may reflect higher flushing rates of the Saginaw River during this time of year. *Synchaeta* spp., *Notholca foliacea* and *Keratella cochlearis*, prevalent in Group I, were also numerically important in Groups II and III. The eutrophic indicator species, *Brachionus calyciflorus*, contributed about 2% of total abundance in Group III, but only 0.2 and 0.1% in Groups I and II, respectively. In Group III the total abundance was 1.3 times that of Group II and twice that of Group I. Group III stations were the most eutrophic, based on the physicochemical data (TABLE 2).

Notholca squamula and *N. laurentiae* were the most prevalent species in Groups IV and V. They contributed 22 and 29%, respectively, to total abundance. In Group IV, *Polyarthra dolichoptera* comprised only 6% of total abundance and *B. calyciflorus* was absent. Total abundance in Group V was 3.8 times less than Group IV and 24 times less than Group III. In Group V, *P. dolichoptera* represented less than 1% and *B. calyciflorus*, *Filinia longiseta*, *K. earlinae*, and *K. hiemalis*, present in other groups, were absent (TABLE 2).

TABLE 1. SPECIES COMPOSITION AND MEAN ABUNDANCE (NUMBER/LITER) OF ROTIFERS IN SOUTHERN LAKE HURON AND SAGINAW BAY. TOP NUMBER REPRESENTS MEAN ABUNDANCE FOR SOUTHERN LAKE HURON STATIONS, AND BOTTOM NUMBER REPRESENTS MEAN ABUNDANCE FOR SAGINAW BAY STATIONS. A DASH (--) INDICATES NO DATA AVAILABLE. THE ABUNDANCE OF SPECIES LESS THAN 0.1 INDIVIDUALS/LITER IS REPRESENTED BY A PLUS SIGN (+)

Class Monogonata	Cruise Number							
Order Ploima	1	2	3	4	5	6	7	8
Family Brachionidae								
Subfamily Brachioninae								
Anuraeopsis fissa (Gosse)	0.0 0.0	0.0 0.0	0.0 --	0.0 0.0	+ 0.3	0.0 --	0.1 0.0	0.0 0.0
Brachionus angularis Gosse	+ 0.3	+ 8.4	0.2 --	+ 5.7	+ 20.8	+ --	+ 8.0	0.0 0.6
B. bidentata Anderson	0.0 0.0	0.0 0.0	0.0 --	0.0 0.2	0.0 +	0.0 --	+ 0.0	0.0 0.0
B. calyciflorus Pallas	+ 6.0	+ 4.1	0.0 --	0.0 0.6	0.0 1.0	0.0 --	0.0 6.2	0.0 3.0
B. caudatus Barrois and Daday	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
B. havanaensis Rousselet	0.0 0.0	0.0 0.0	0.0 --	0.0 +	0.0 +	0.0 --	0.0 0.0	0.0 0.0
B. quadridentatus Hermann	0.0 0.0	0.0 +	0.0 --	0.0 +	0.0 0.0	0.0 --	0.0 +	0.0 0.0

(continued)

TABLE 1 (continued)

	Cruise Number							
Subfamily Brachioninae - continued	1	2	3	4	5	6	7	8
B. urceolaris O. F. Müller	0.0	0.0	0.0	0.0	0.0	0.0	+	0.0
	1.0	+	--	0.0	+	--	0.0	0.0
B. variabilis Hempel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	--	0.0	+	--	0.0	0.0
Euchlanis dilatata Ehrbg.	0.0	0.0	0.0	0.8	0.5	+	0.3	0.0
	0.0	0.3	--	6.8	6.4	--	1.2	0.0
Kellicottia bostoniensis (Rousselet)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	--	0.0	0.0	--	+	+
K. longispina (Kellicott)	0.9	2.2	11.6	9.1	24.0	4.5	1.0	1.4
	2.6	16.2	--	12.3	2.6	--	0.7	3.0
Keratella cochlearis (Gosse)	4.0	8.3	43.2	41.6	108.1	30.8	62.1	37.4
	56.2	203.4	--	164.1	106.7	--	263.1	364.5
K. cochlearis v. hispida (Lauterborn)	0.0	0.0	+	2.7	5.6	0.6	0.8	+
	0.0	0.0	--	15.0	14.0	--	4.4	1.1
K. cochlearis v. robusta (Lauterborn)	0.0	0.0	6.2	1.8	2.0	1.5	2.1	3.1
	+	0.0	--	7.4	+	--	3.8	8.0

(continued)

TABLE 1 (continued)

	Cruise Number							
Subfamily Brachioninae - continued	1	2	3	4	5	6	7	8
K. cochlearis f. *tecta* (Gosse)	0.0	0.0	+	+	+	0.4	3.0	0.7
	+	2.0	--	11.5	24.4	--	35.6	7.4
K. crassa Ahlstrom	0.0	0.0	0.0	0.0	+	+	+	+
	0.0	+	--	0.0	+	--	+	0.0
K. earlinae Ahlstrom	+	5.7	41.3	21.3	10.4	2.3	3.0	3.3
	16.1	250.3	--	37.3	38.6	--	9.8	68.6
K. hiemalis Carlin	+	0.1	0.0	0.0	0.0	0.0	0.0	0.0
	1.2	+	--	0.0	0.0	--	0.0	+
K. quadrata (O. F. Müller)	1.6	7.0	10.6	6.1	6.2	1.3	0.6	2.2
	38.8	218.0	--	13.0	1.3	--	5.8	50.0
Lophocharis salpina (Ehrbg.)	0.0	0.0	0.0	+	0.0	0.0	0.0	0.0
	0.0	+	--	6.2	1.3	--	1.9	0.0
Notholca acuminata (Ehrbg.)	+	+	+	0.0	0.0	0.0	0.0	0.0
	2.1	2.1	--	0.0	0.0	--	0.0	0.0
N. foliacea (Ehrbg.)	6.0	5.8	0.7	1.0	+	+	+	0.0
	89.3	13.0	--	0.1	+	--	0.0	+

(continued)

TABLE 1 (continued)

	Cruise Number							
Subfamily Brachioninae - continued	1	2	3	4	5	6	7	8
N. laurentiae Stemberger	3.2	2.3	1.4	1.5	0.3	0.1	0.1	+
	4.0	1.0	--	0.5	+	--	0.0	0.0
N. squamula (O. F. Müller)	29.1	20.0	5.2	3.2	1.0	0.3	+	0.1
	24.0	4.2	--	0.3	+	--	0.0	0.0
Platyias patulus (O. F. Müller)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	--	0.0	+	--	0.0	0.0
P. quadricornis (Ehrbg.)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	--	+	0.0	--	0.0	0.0
Trichotria tetractis (Ehrbg.)	0.0	0.0	+	+	0.0	0.0	0.4	+
	0.0	+	--	1.5	0.4	--	1.2	0.3
Subfamily Colurinae								
Lepadella patella (O. F. Müller)	0.0	0.0	+	+	+	0.0	0.0	0.0
	0.0	0.0	--	0.0	0.0	--	0.0	0.0
Family Lecanidae								
Lecane flexilis (Gosse)	0.0	0.0	+	+	0.0	0.0	0.0	0.0
	0.0	0.0	--	+	0.0	--	0.0	0.0
L. luna (O. F. Müller)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	--	+	+	--	0.0	0.0

(continued)

TABLE 1 (continued)

	Cruise Number							
Family Lecanidae - continued	1	2	3	4	5	6	7	8
L. mucronata Harring & Myers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	+
	0.0	0.0	--	0.0	0.0	--	0.0	0.0
Lecane spp.	0.0	0.0	0.0	0.0	0.0	0.0	+	0.0
	0.0	0.0	--	0.0	0.0	--	0.0	0.0
Monostyla closterocerca (Schmarda)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	--	0.0	+	--	0.0	0.0
M. lunaris (Ehrbg.)	0.0	+	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	--	0.0	0.0	--	0.0	0.0
M. obtusa Murray	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	--	0.0	+	--	0.0	0.0
Monostyla spp.	0.0	0.0	0.0	0.0	0.0	0.0	+	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	+	0.0
Family Notommatidae								
Cephalodella gibba (Ehrbg.)	0.0	0.0	+	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	--	0.0	0.0	--	0.0	0.0

(continued)

TABLE 1 (continued)

	Cruise Number							
Family Trichocercidae	1	2	3	4	5	6	7	8
Trichocerca cylindrica (Imhof)	+	0.0	+	+	3.0	1.3	0.3	0.0
	+	+	--	0.2	2.9	--	3.3	+
T. mucosa (Stokes)	0.0	0.0	0.0	0.0	0.0	0.0	+	0.0
	0.0	0.0	--	0.0	0.0	--	0.0	0.0
T. multicrinis (Kellicott)	0.0	0.0	0.0	3.6	0.8	0.7	0.2	0.0
	+	0.3	--	22.2	10.5	--	1.9	0.2
T. porcellus (Gosse)	0.0	0.0	+	+	1.5	1.5	2.9	1.3
	+	0.3	--	5.4	5.1	--	12.4	1.0
T. pusilla (Jennings)	0.0	0.0	0.0	0.0	0.4	+	0.0	0.0
	0.0	0.0	--	2.8	17.9	--	2.1	0.0
T. rousseleti (Voigt)	0.0	0.0	+	0.0	0.0	0.2	1.2	1.1
	0.0	0.0	--	0.0	0.0	--	15.3	1.4
T. similis (Wierzejski)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	--	0.0	+	--	0.0	0.0
Family Gastropidae								
Ascomorpha saltans Bartsch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	--	0.0	0.2	--	0.0	0.0

(continued)

TABLE 1 (continued)

	Cruise Number							
Family Gastropidae - continued	1	2	3	4	5	6	7	8
Chromogaster ovalis (Bergendal)	0.0	0.0	0.0	0.0	0.5	0.4	0.4	+
	0.0	0.0	--	0.0	+	--	0.2	0.0
Gastropis stylifer Imhof	0.0	0.1	0.5	1.5	26.0	5.3	2.8	5.0
	0.0	+	--	+	3.0	--	0.2	1.2
Family Tylotrochidae								
Tylotrocha monopus (Jennings)	0.0	0.0	+	0.0	0.0	+	0.0	0.0
	0.0	0.0	--	0.0	0.0	--	0.0	0.0
Family Asplanchnidae								
Asplanchna brightwelli Gosse	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	--	0.0	+	--	0.0	0.1
A. herricki de Guerne	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	--	0.0	0.0	--	+	0.0
A. priodonta Gosse	+	0.2	1.5	1.7	0.8	0.8	0.6	0.0
	0.5	25.0	--	8.6	2.1	--	1.2	0.2

(continued)

TABLE 1 (continued)

	Cruise Number							
Family Synchaetidae	1	2	3	4	5	6	7	8
Ploesoma hudsoni (Imhof)	0.0	0.0	+	+	0.6	0.0	+	0.0
	0.0	0.0	--	+	0.8	--	0.0	0.0
P. lenticulare Herrick	0.0	0.0	0.0	+	2.2	0.3	0.2	+
	0.0	0.0	--	+	6.9	--	0.3	0.0
P. truncatum (Levander)	0.0	+	0.0	0.4	4.0	1.1	0.4	0.0
	0.0	0.2	--	2.8	13.4	--	1.6	0.0
Polyarthra dolichoptera Idelson	0.7	4.4	8.3	10.5	+	0.0	0.0	0.0
	228.1	609.4	--	98.1	0.0	--	+	1.1
P. euryptera Wierzejski	0.0	0.0	0.0	0.0	+	0.0	0.0	0.0
	0.0	0.0	--	0.3	0.2	--	0.0	0.0
P. major Burckhardt	0.0	0.0	0.0	+	6.1	1.3	0.6	+
	0.0	0.0	--	2.1	73.0	--	7.1	0.0
P. remata Skorikov	0.0	0.0	0.3	12.4	21.1	4.0	9.1	7.2
	0.0	1.1	--	101.0	129.2	--	57.5	140.8
P. vulgaris Carlin	0.0	+	1.0	22.1	71.6	26.3	15.0	4.4
	+	2.3	--	80.0	355.4	--	124.5	16.5

(continued)

TABLE 1 (continued)

	Cruise Number							
Family Synchaetidae - continued	1	2	3	4	5	6	7	8
Synchaeta grandis Zacharias	0.0	0.0	+	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	--	0.0	0.0	--	0.0	0.0
S. kitina Rousselet	1.2	3.1	32.5	14.6	2.3	0.3	0.6	10.1
	2.3	3.0	--	36.2	2.2	--	0.4	219.2
S. pectinata Ehrbg.	0.4	0.5	0.3	0.6	+	0.0	0.0	0.0
	12.0	5.0	--	35.5	4.7	--	0.4	3.1
S. stylata Wierzejski	0.0	0.0	9.7	3.2	40.0	2.2	1.9	+
	0.0	0.1	--	4.0	164.5	--	5.2	+
**Synchaeta* spp.	10.1	5.4	2.6	0.9	+	+	0.1	0.2
	97.0	59.1	--	9.6	9.6	--	17.5	30.5
Family Testudinellidae								
Filinia longiseta (Ehrbg.)	0.0	0.0	0.9	8.1	18.1	+	+	+
	0.0	0.0	--	76.1	207.5	--	32.5	3.6
F. terminalis (Plate)	+	+	0.2	+	+	0.0	0.0	+
	1.0	29.0	--	0.0	0.0	--	0.0	0.0
Pompholyx sulcata Hudson	0.0	0.0	+	0.2	10.1	0.2	0.1	+
	+	0.0	--	4.0	63.8	--	0.6	+

(continued)

TABLE 1 (continued)

	Cruise Number							
Family Conochilidae	1	2	3	4	5	6	7	8
Conochiloides dossuarius (Hudson)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	--	+	18.4	--	0.0	0.0
Conochilus unicornis Rousselet	0.0	0.1	6.3	57.5	32.1	17.0	4.3	2.4
	+	2.1	--	74.2	+	--	2.4	9.9
Family Collothecidae								
Collotheca mutabilis (Hudson)	0.0	0.0	+	+	1.2	2.7	1.8	1.0
	0.0	0.0	--	0.4	+	--	1.6	0.1
C. pelagica (Rousselet)	0.0	0.0	+	+	+	+	+	0.0
	0.0	0.0	--	0.0	+	--	0.0	0.0
Stephanocercos fimbriatus (Goldfuss)	0.0	0.0	0.0	0.0	+	0.0	0.0	0.0
	0.0	0.0	--	0.0	0.0	--	0.0	0.0
Class Bdelloidea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.3	0.0	--	0.0	0.0	--	0.0	0.0
Mean No. Rotifers/Liter/Cruise	63.2	65.3	183.1	226.7	401.0	107.7	116.4	81.9
	583.0	1461.1	--	847.9	1317.0	--	630.1	935.7

* Because of difficulties in distinguishing contracted specimens, *Synchaeta* spp. represents: *Synchaeta asymmetrica* Koch-Althaus, *S. lakowitziana* Lucks, and *S. oblonga* Ehrbg.

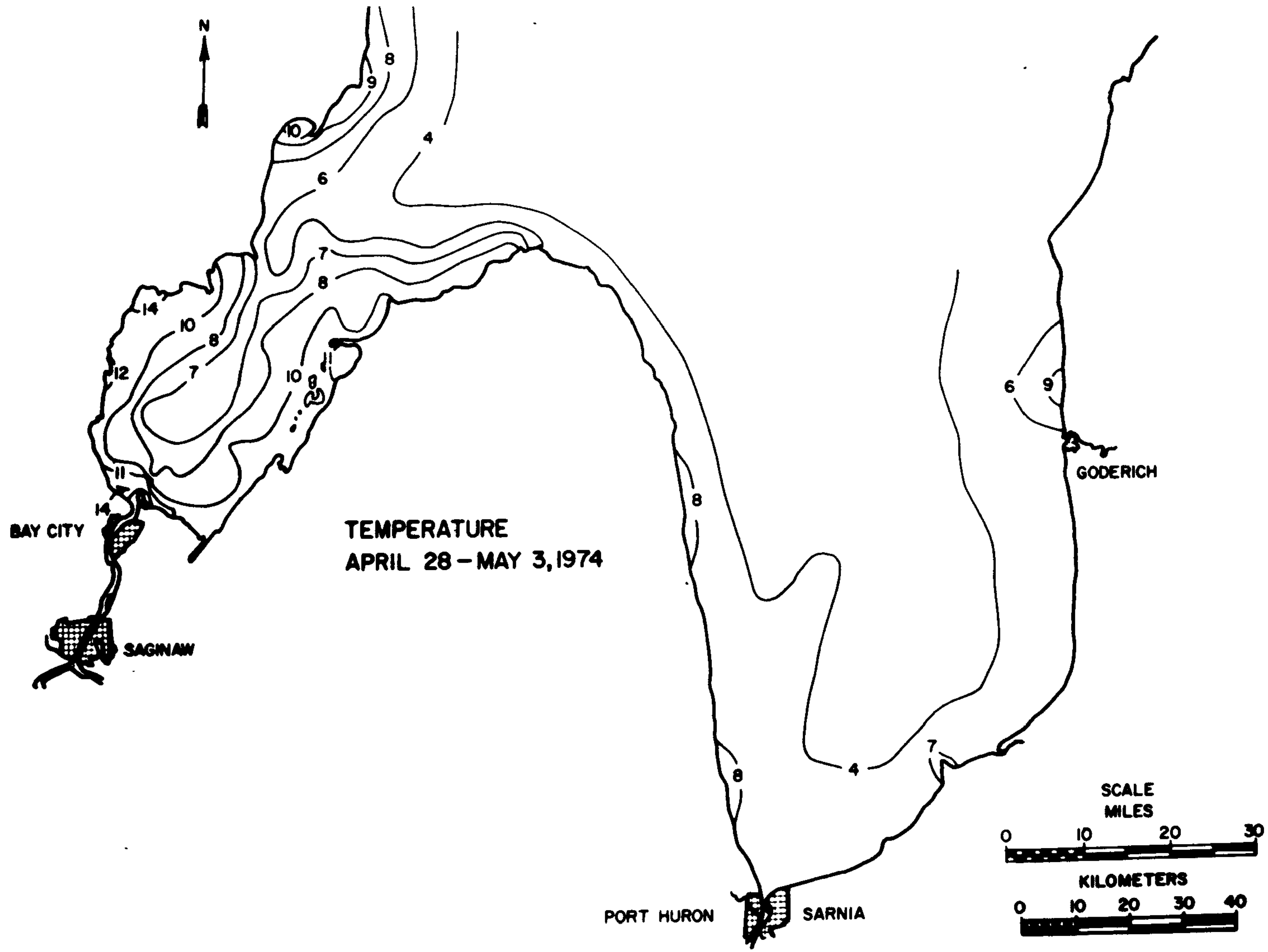

Figure 2. Surface temperatures (C) in Saginaw Bay and southern Lake Huron during 28 April - 3 May 1974.

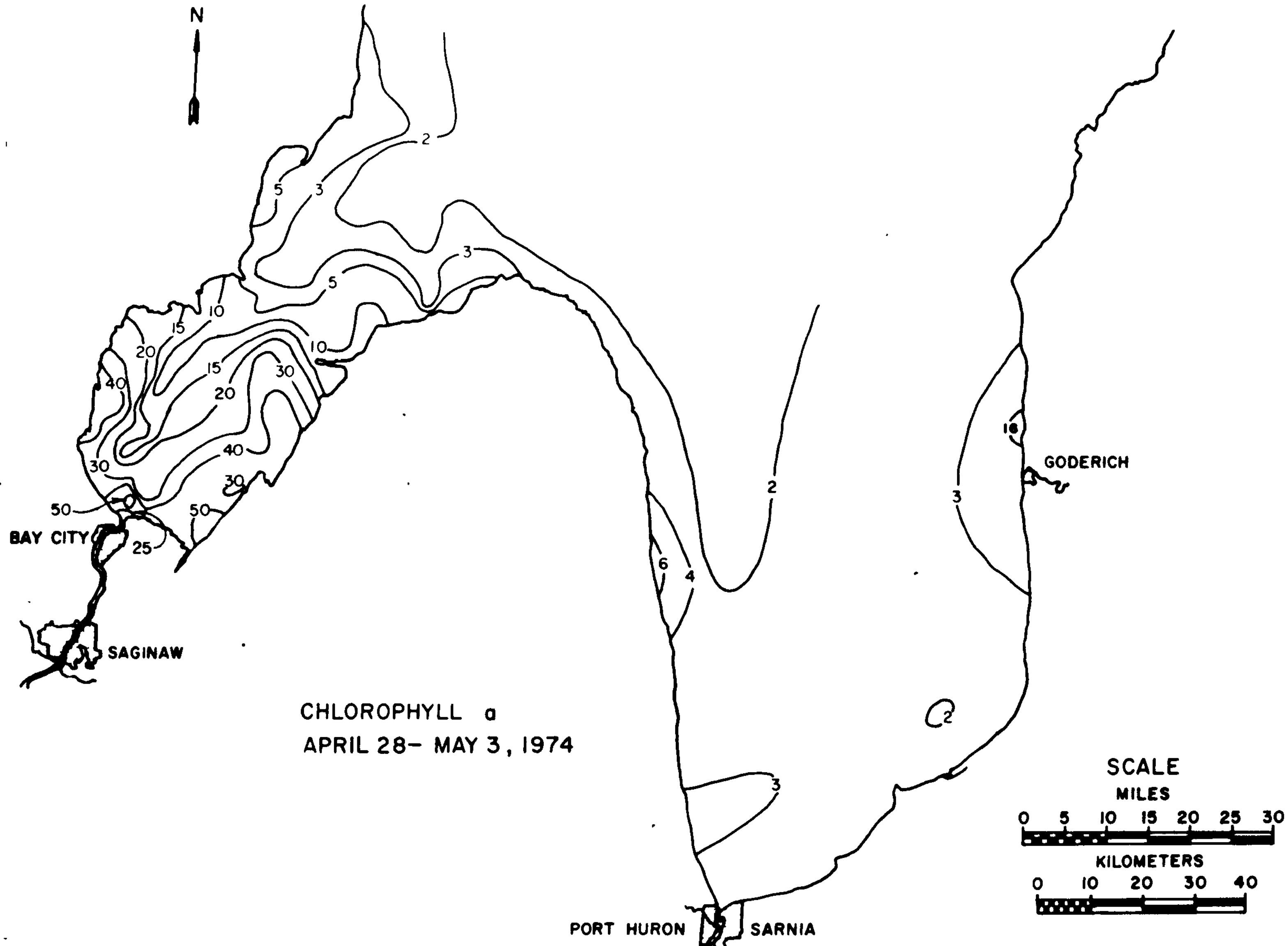

Figure 3. Surface chlorophyll *a* (μg/liter) in Saginaw Bay and southern Lake Huron during 28 April - 3 May 1974.

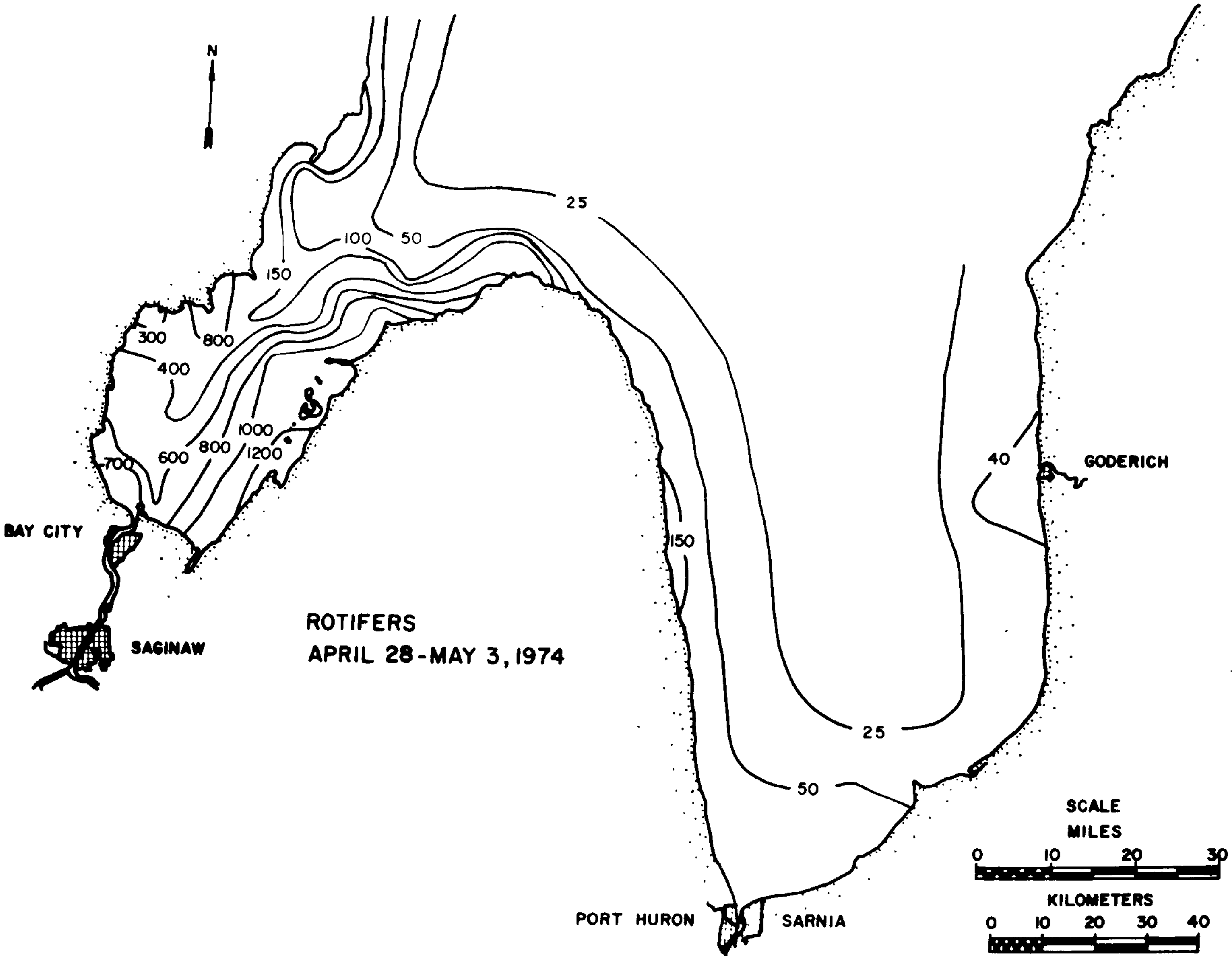

Figure 4. Distribution and abundance (number of ind./liter) of total rotifers in Saginaw Bay and southern Lake Huron during 28 April - 3 May 1974.

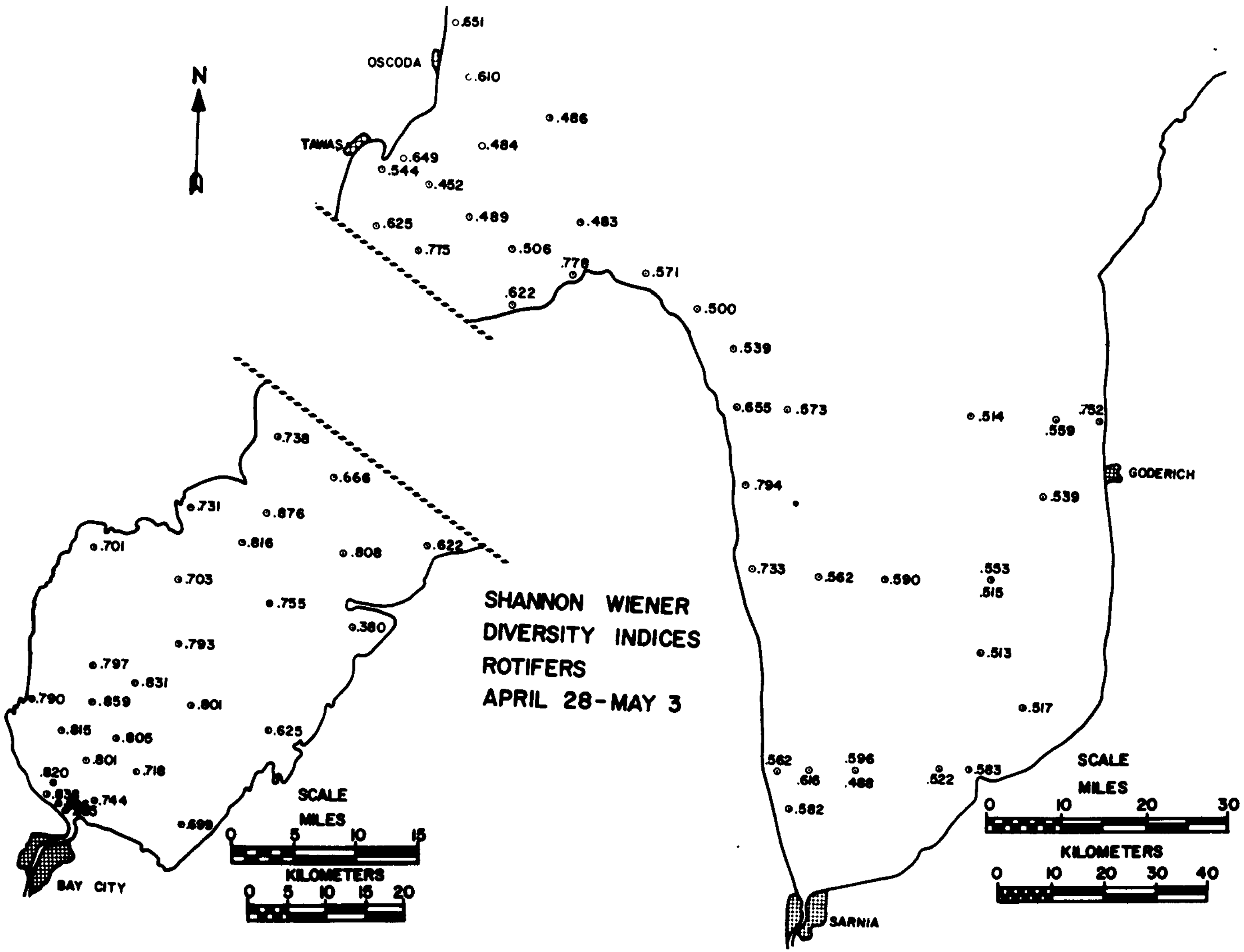

Figure 5. Shannon-Wiener diversity indices on rotifer data from 66 stations in Saginaw Bay and southern Lake Huron during 28 April - 3 May 1974.

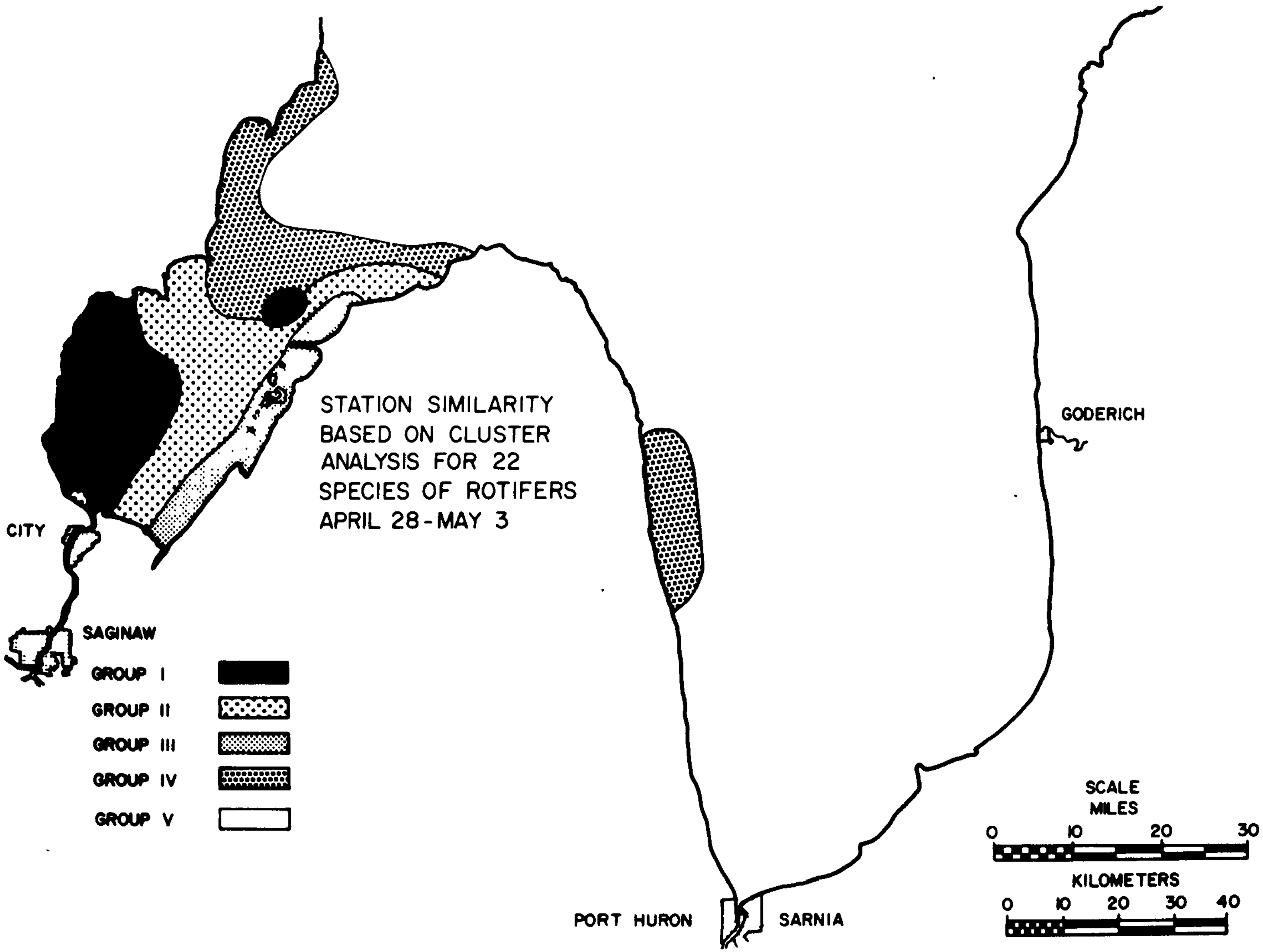

Figure 6. Grouping of 66 stations determined by cluster analysis of rotifer data for Saginaw Bay and southern Lake Huron during 28 April - 3 May 1974.

Cruise Two

Twenty-nine stations in Saginaw Bay (13-17 May) and 31 stations in southern Lake Huron (14-17 May) were sampled for rotifers. Thirty-six species of rotifers were identified, but only 28 species were numerically important (TABLE 1). The predominant species of Saginaw Bay waters were Keratella cochlearis, K. earlinae, K. quadrata, and Polyarthra dolichoptera. Keratella cochlearis, K. quadrata, and Notholca squamula predominated in the open waters of Lake Huron. The cold stenotherm, N. laurentiae, occurred at 2.2 ind./liter.

Isopleths for temperature, specific conductance, and chlorophyll a were similar to the distribution of total rotifers. Warmest temperatures (9-11 C) occurred throughout the lower bay and at near-shore areas in the upper bay (Figure 7). A 7 C isotherm was present near shore throughout southern Lake Huron and continued across outer Saginaw Bay. Coldest water temperatures (4 C) occurred in the central Lake Huron water mass and at the furthest reaches of outer Saginaw Bay. Conductivity and chlorophyll a values were highest (400-600 µmhos/cm and 20-80 µg/liter, respectively) at the mouth of the Saginaw River and at near-shore stations in the lower bay (Figures 8 and 9). Rotifer abundance was highest (1,000-45,00 ind./liter) at inner bay stations and lowest (25-500 ind./liter) at outer stations (Figure 10). Abundance in the lower bay was 20-180 times greater than in outer bay stations

Cluster analysis of rotifer data divided the study area into eight major groups (Figure 11). The cluster analysis yielded a cophenetic correlation of 0.80.

Six of the eight groups occurred in Saginaw Bay. Two groups (III and IV) were composed of single stations which differed greatly from adjacent stations in species composition and abundance (TABLE 3). Obviously, single stations cannot be interpreted as representing a particular water mass. In this instance, rotifer patchiness may account for the uniqueness of these two stations.

Although southern Lake Huron stations were included in three groups, Group VI was the only subregion which included both southern Lake Huron and Saginaw Bay stations. In general, the Saginaw Bay groups were much more loosely connected (i.e., more dissimilar) than southern Lake Huron groups. Group VII was composed of three stations along the northwest coast of southern Lake Huron and a single station on the southwest shore near Port Huron.

Groups I, II, III, V, and VI had similar species composition percentages but differed greatly in actual abundances of species (TABLE 3). Polyarthra dolichoptera was the predominant rotifer, accounting for 39 to 60% of the total abundance. Abundance of this species ranged from 129 to 2,793 ind./liter in these groups. Total abundance of all species ranged from 330 to 4,675 ind./liter.

Group IV, composed of a single station, had total abundance similar to that of the five groups discussed above, except that Keratella earlinae and K. cochlearis predominated (TABLE 3). Polyarthra dolichoptera accounted for only 9% of the total abundance.

Notholca squamula and *N. laurentiae* accounted for 40% of the total abundance in Group VII (TABLE 3). *Polyarthra dolichoptera* comprised only 14% of the abundance. *Synchaeta kitina*, absent in Groups I through VI, represented 2.4% of the abundance. Total abundance of Group VII was about 50% that of Group VI. Group VII was intermediate in rotifer abundance, composition, and physico-chemical variables between Groups VI and VIII.

Total rotifer abundance of Group VIII was 29% that of Group VII (TABLE 3). Both abundance and species composition percentage of *Polyarthra dolichoptera* were lowest in Group VIII. The composition percentages of the cold stenotherms, *Notholca* spp. and *Synchaeta lakowitziana*, were greatest in Group VIII (47 and 10%, respectively).

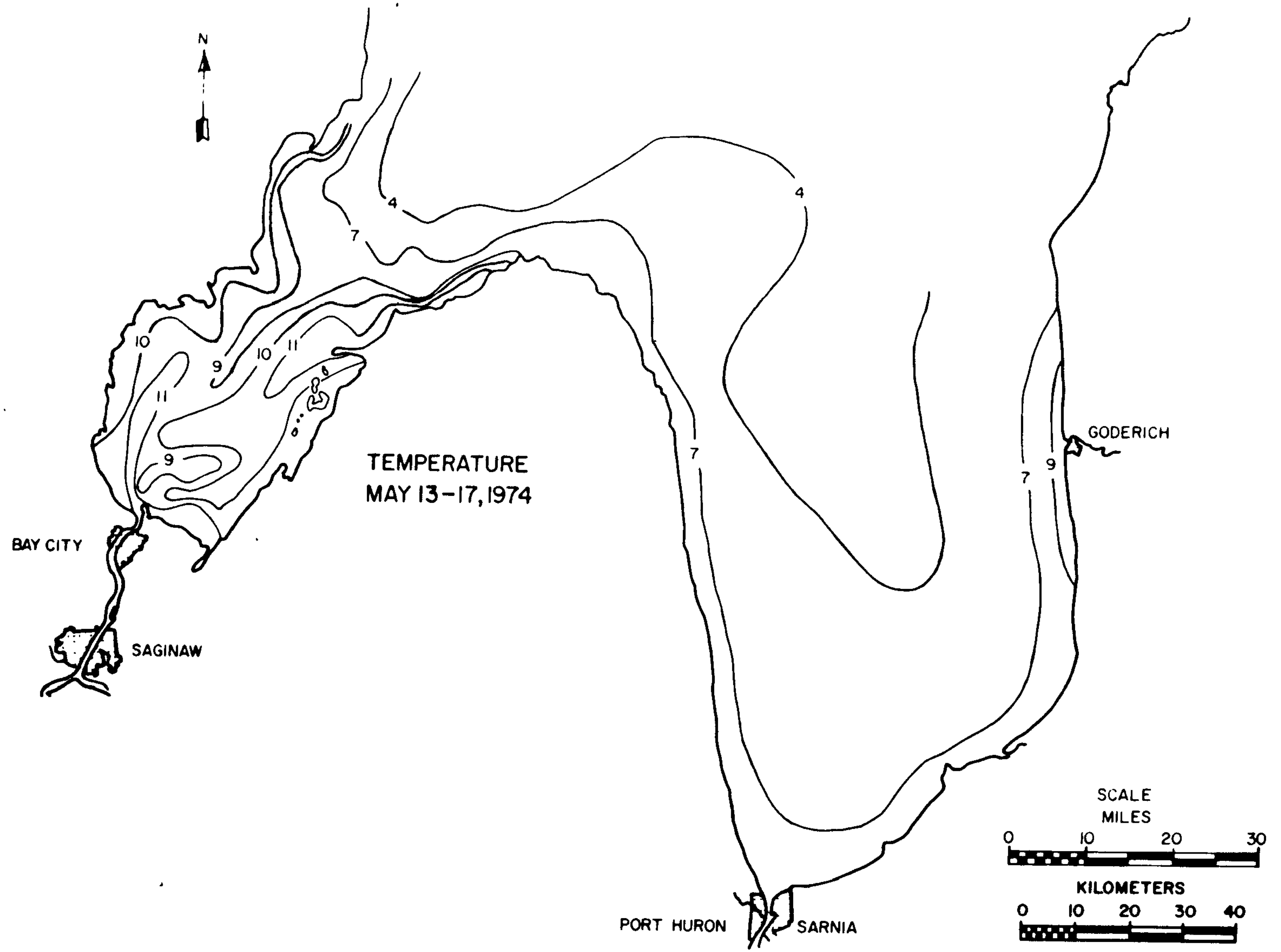

Figure 7. Surface temperatures (C) in Saginaw Bay and southern Lake Huron during 13-17 May 1974.

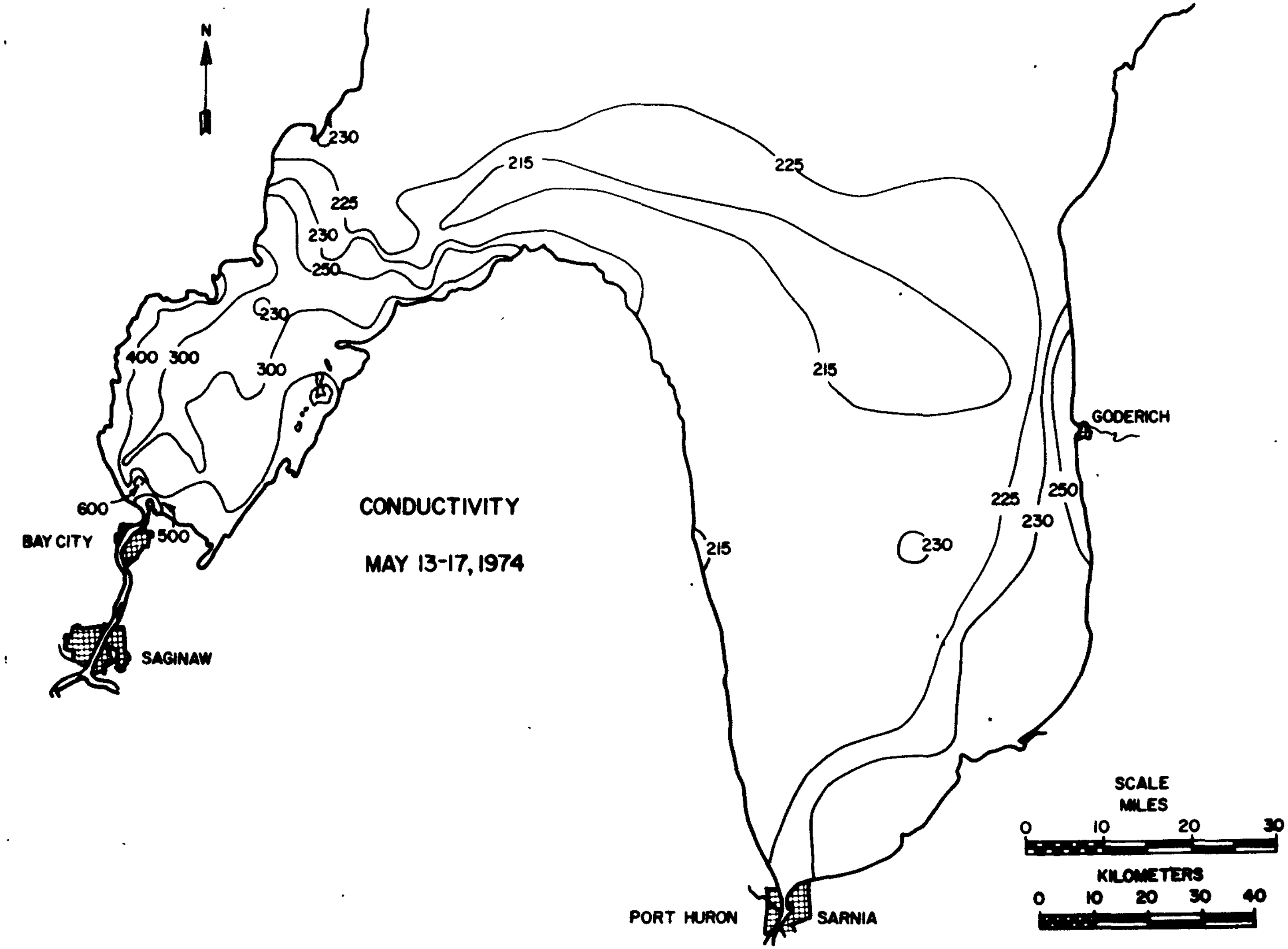

Figure 8. Surface specific conductance (μmhos/cm @ 25 C) in Saginaw Bay and southern Lake Huron during May 1974.

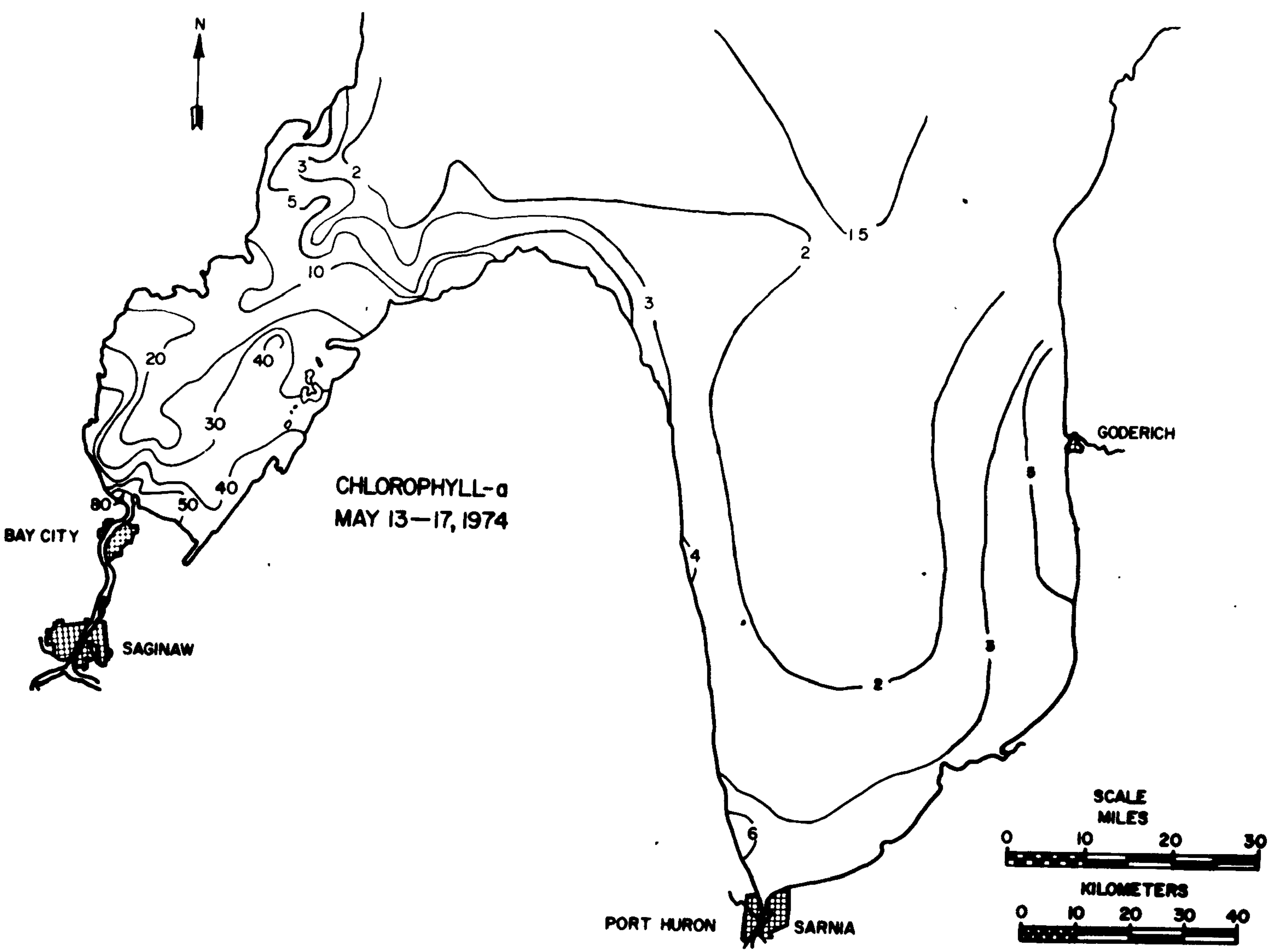

Figure 9. Surface chlorophyll a (μg/liter) in Saginaw Bay and southern Lake Huron during May 1974.

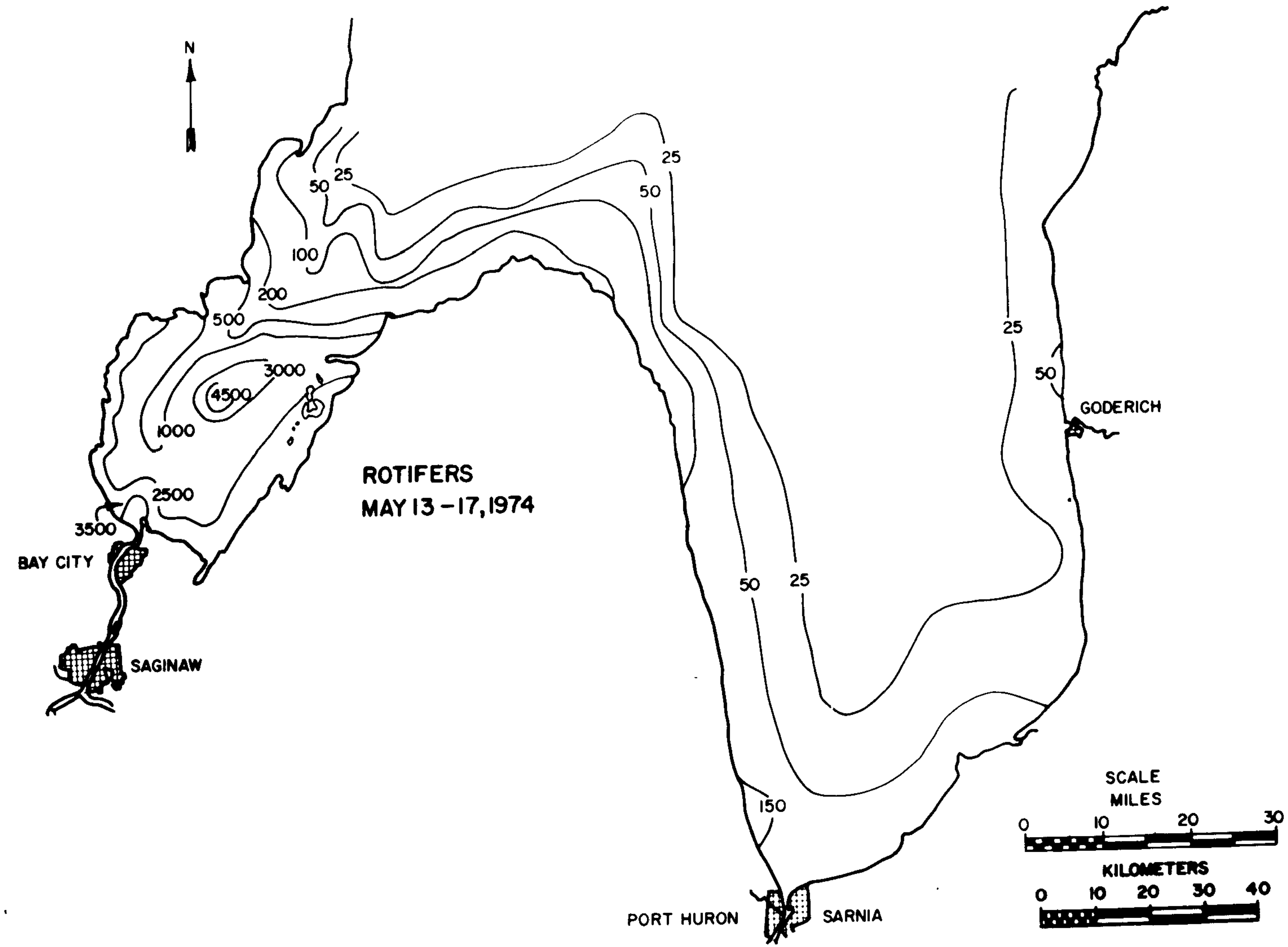

Figure 10. Distribution and abundance (number of ind./liter) of total rotifers in Saginaw Bay and southern Lake Huron during May 1974.

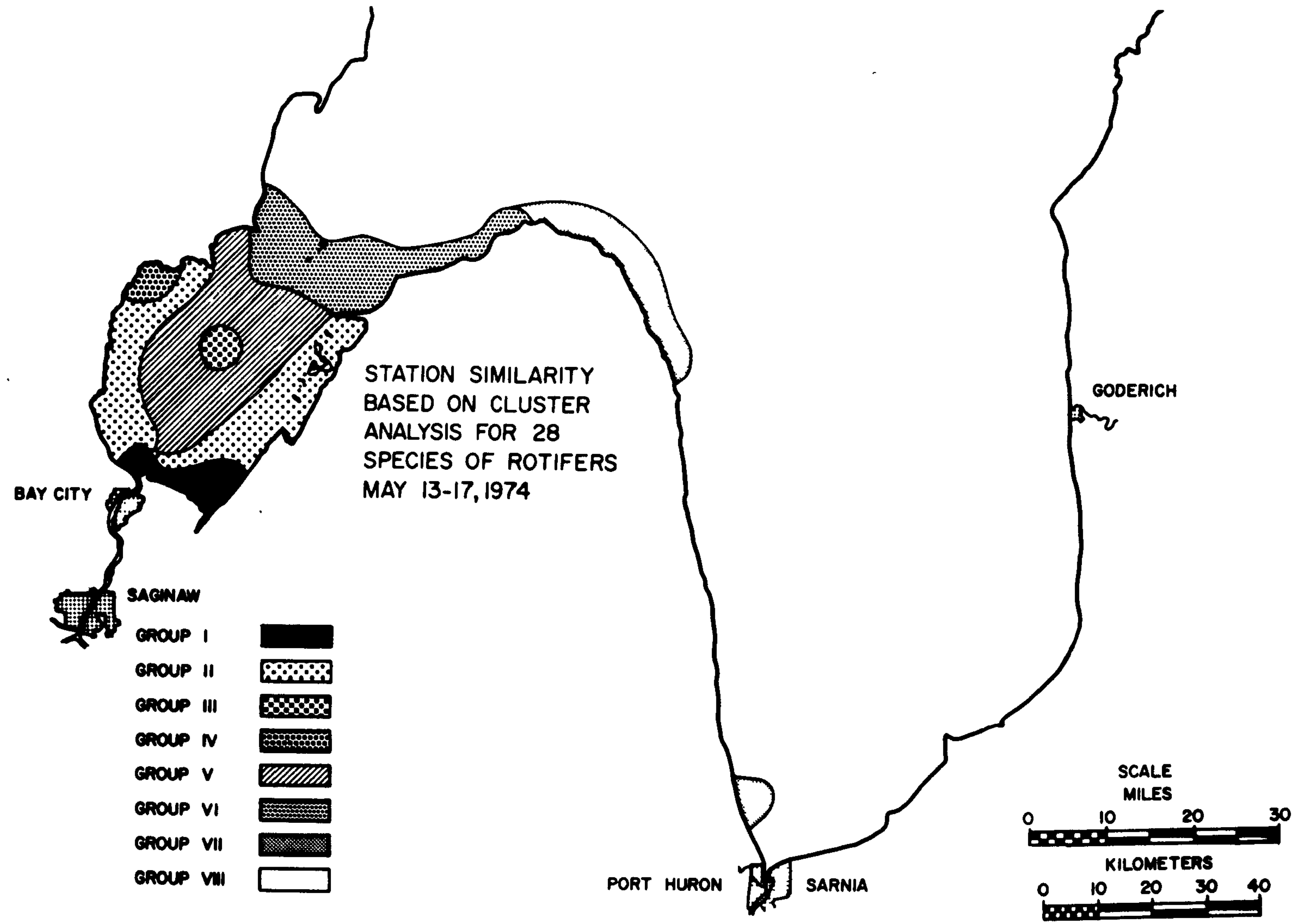

Figure 11. Grouping of 60 stations determined by cluster analysis of rotifer data for Saginaw Bay and southern Lake Huron during May 1974.

TABLE 2. ABUNDANCE (MEAN NUMBER OF INDIVIDUALS/LITER) OF SELECTED ROTIFERS, PERCENT COMPOSITION AND MEAN SURFACE VALUES OF SELECTED PHYSICOCHEMICAL VARIABLES IN GROUPS OF STATIONS IDENTIFIED BY CLUSTER ANALYSIS FOR CRUISE I

Taxon/Group	I		II		III		IV		V	
	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%
Asplanchna priodonta	1	0.2	1	0.1	1	0.1	0		0	
Brachionus calyciflorus	11	0.2	1	0.1	18	1.6	0		0	
Filinia longiseta	3	0.5	3	0.4	4	0.4	0.2	0.1	0	
Kellicottia longispina	3	0.5	3	0.4	2	0.2	2	1.3	1	2.4
Keratella cochlearis	68	12.4	76	8.9	77	6.8	12	7.6	2	4.8
K. earlinae	15	2.7	30	3.5	23	2.0	3	1.9	0	
K. hiemalis	1	0.2	2	0.2	1	0.1	1	0.6	0	
K. quadrata	41	7.5	54	6.4	69	6.1	6	3.8	1	2.4
Notholca spp.	11	2.0	15	1.8	7	0.6	34	21.7	12	29.3
Polyarthra dolichoptera	153	27.8	356	41.9	690	61.1	9.3	5.9	0.2	0.5
Synchaeta spp.	111	20.2	152	17.9	108	9.6	22	14.0	8	19.5
S. pectinata	12	2.2	10	1.2	11	1.0	2	1.3	12	0.5
S. kitina	2	0.4	5	0.6	3	0.3	2	1.3	1	2.4

(continued

TABLE 2 (continued)

Taxon/Group	I		II		III		IV		V	
	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%
Notholca foliacea	93	16.9	121	14.2	107	9.4	27	17.1	3	7.3
Other rotifers	25	0.4	21	0.02	9	0.01	37	23.2	1	1.9
Total rotifers/liter	550		850		1130		157		41	
Physiocochemical variables	I		II		III		IV		V	
Secchi disc (m)	1.39		1.48		1.05		3.79		5.39	
Temperature (°C)	9.49		8.97		10.35		7.3		4.84	
Chlorophyll *a* (μg/ℓ)	20.4		25.2		26.4		3.75		2.54	
Ammonia-nitrogen (μg/ℓ)	17.69		21.67		18.25		15.46		12.0	
Nitrate-nitrogen (μg/ℓ)	628		646.4		1373.7		313.8		370.7	
Chloride (μg/ℓ)	33.5		32		38.25		9.75		5.94	
No. Stations/Group	14		6		4		8		32	

TABLE 3. ABUNDANCE (MEAN NUMBER OF INDIVIDUALS/LITER) OF SELECTED ROTIFERS, PERCENT COMPOSITION AND MEAN SURFACE VALUES OF SELECTED PHYSICOCHEMICAL VARIABLES IN GROUPS OF STATIONS IDENTIFIED BY CLUSTER ANALYSIS FOR CRUISE 2

Taxon/Group	I		II		III		IV		V		VI		VII		VIII	
	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%
Asplanchna priodonta	76.2	2.1	50.8	2.1	3.6	0.1	17.9	0.7	10.0	1.4	1.1	0.3	0.5	0.3	0.0	
Brachionus spp.	40.5	1.1	19.9	0.8	7.1	0.2	10.7	0.4	1.3	0.2	0.4	0.1	0.1	<.1	0.1	0.2
Conochilus unicornis	0.0		1.9	0.1	3.6	0.1	53.6	2.0	1.4	0.2	0.1	<.1	0.0		0.1	0.2
Filinia longiseta	88.1	2.4	49.6	2.1	42.9	0.9	14.3	0.5	4.6	0.7	1.5	0.5	0.0		0.0	
Kellicottia longispina	45.3	1.2	20.8	0.9	64.3	1.4	28.6	1.1	13.9	2.0	5.6	1.7	5.9	3.6	2.1	4.5
Keratella cochlearis	511.9	13.9	338.3	14.2	321.4	6.9	607.1	23.0	79.0	11.3	44.7	13.5	16.9	10.3	5.7	12.2
K. earlinae	531	14.4	423.7	17.7	357.1	7.6	1139.3	43.1	132.8	19.0	53.0	16.1	11.4	6.7	1.9	4.1
K. quadrata	483.3	13.1	377.6	15.8	650.0	13.9	450	17.0	119.9	17.1	66.1	20	22.8	13.9	3.1	6.6
Notholca spp.	13.1	0.4	17.2	0.7	189.3	4.2	1.8	<.1	4.8	0.7	13.8	4.2	65.9	40.3	21.9	46.9
Polyarthra dolichoptera	1745.2	47.3	982.8	41.2	2792.9	59.7	235.7	8.9	317.2	45.3	128.9	39.0	22.5	13.7	2.9	6.2
Synchaeta lakowitziana	135.7	3.7	77.3	3.2	235.7	5.0	71.4	2.7	14.2	2.0	14.6	4.4	11.6	7.1	4.6	9.9
S. kitina	0.0		0.0		0.0		0.0		0.0		0.0		4.0	2.4	2.8	6.0
S. pectinata	14.5	0.4	10.6	0.4	0.0		0.0		0.3	<.05	0.4	0.1	1.6	1.0	0.5	1.1
Other rotifers	3.2	<0.01	13.5	0.6	7.1	0.2	10.6	0.4	0.6	0.1	0.0		0.8	0.5	1.3	2.8
Total rotifers/liter	3688		2384		4675		2641		700		330		164		47	

Physicochemical variables	I	II	III	IV	V	VI	VII	VIII
Secchi disc (m)	.9	.8	1.7	0.3	1.5	2.1	4.3	5.0
Temperature (°C)	9.6	9.8	9	10.0	10.3	10.1	7.6	6.0
Chlorophyll *a* (μg/ℓ)	40.6	32.3	17.9	14.1	25.0	10.3	5.0	2.8
Spec. Cond. (μmhos/cm)	383	395	313	381	324	266	227	228
Dissolved Phosphorus (μg/ℓ)	6	5	5	4	3.7	4	2	2
Ammonia-nitrogen (μg/ℓ)	8	14.1	5	29	18.7	6.8	13.6	11.6
Nitrate-nitrogen (μg/ℓ)	420	633	610	226	386	445	373	359
Chloride (μg/ℓ)	40	39	31	26	24	23	7	6
No. Stations/Group	3	11	1	1	6	6	4	28

Cruise Three

Forty-three stations were sampled during the period 4-8 June in southern Lake Huron. Thirty-nine species were recorded. *Keratella cochlearis*, *K. earlinae*, and *Synchaeta kitina* were numerically important at most stations (TABLE 1). *Notholca* spp. (cold stenotherms) occurred at 7.2 ind./liter, and *Filinia longiseta*, a possible eutrophic indicator, at 0.9 ind./liter.

Isopleths for temperature, specific conductance, and chlorophyll *a* were similar to the distribution of total rotifers. Warmest water temperatures (14-16 C) occurred in outer Saginaw Bay along the eastern shore of Lake Huron off Goderich (Figure 12). Lowest temperatures (6-7 C) were recorded in the northern portion of the study area in the central Lake Huron water mass and off the west-central Lake Huron shore. Values for specific conductance were highest (240-280 μmhos/cm) in outer Saginaw Bay and lowest (210-215 μmhos/cm) at the most northerly stations off Saginaw Bay in the west-central areas of southern Lake Huron (Figure 13). Isolated stations with relatively high conductivities (230 mhos/cm) were located along the eastern coast of Lake Huron. Highest chlorophyll *a* values (2.5-4.0 μg/liter) occurred in the outer bay and near the southwestern shore (Figure 14). Rotifer abundance was greatest in outer Saginaw Bay (300-1,000 ind./liter) and on the southeast shore of Lake Huron (1,200 ind./liter) (Figure 15). The 1,200 ind./liter isopleth represented the abundance at a single station and may have reflected local effects from river outfalls. Relatively high abundance (100-180 ind./liter) also occurred off Goderich.

Cluster analysis of rotifer data divided the study area into five groups (Figure 16). The analysis yielded a cophenetic correlation of 0.96.

Keratella earlinae and *K. cochlearis*, the most abundant rotifers in Group I, contributed 65% of total abundance (TABLE 4). *Keratella cochlearis* v. *robusta*, *K. quadrata*, *Synchaeta kitina*, *K. longispina*, *F. longiseta*, and *Conochilus unicornis* were less numerically important. Total abundance of Group II rotifers represented 29% of that in Group I. The species composition between the two groups was similar but cold-water forms such as *Notholca* spp., *Polyarthra dolichoptera*, and *Kellicottia longispina* were more abundant in Group II, suggesting some mixing with Lake Huron.

Group III, represented by station 6 (Figure 1), had the greatest abundance of any station. *Synchaeta kitina* and *S. stylata* comprised 78% of total abundance (TABLE 4). *Kellicottia* was absent from this group. Secchi disc visibility was lowest in this group.

Group IV stations consisted of a near-shore water mass on the east coast of Lake Huron and a single station on the southwest coast. *Synchaeta kitina* predominated, accounting for 45% of total abundance, and *Keratella cochlearis* comprised 15%.

Total abundance of Group V was 2.5 times less than that of Group IV (TABLE 4). In Group V, cold stenotherms like *Notholca* spp., *Polyarthra dolichoptera*, and *K. longispina* comprised 34% of the total abundance. However, *Synchaeta kitina* was the major species, contributing 20% of the total abundance. Mean Secchi disc visibility was greatest (5-8 m) and temperature, specific conductance, and total phosphorus were lowest for all groups.

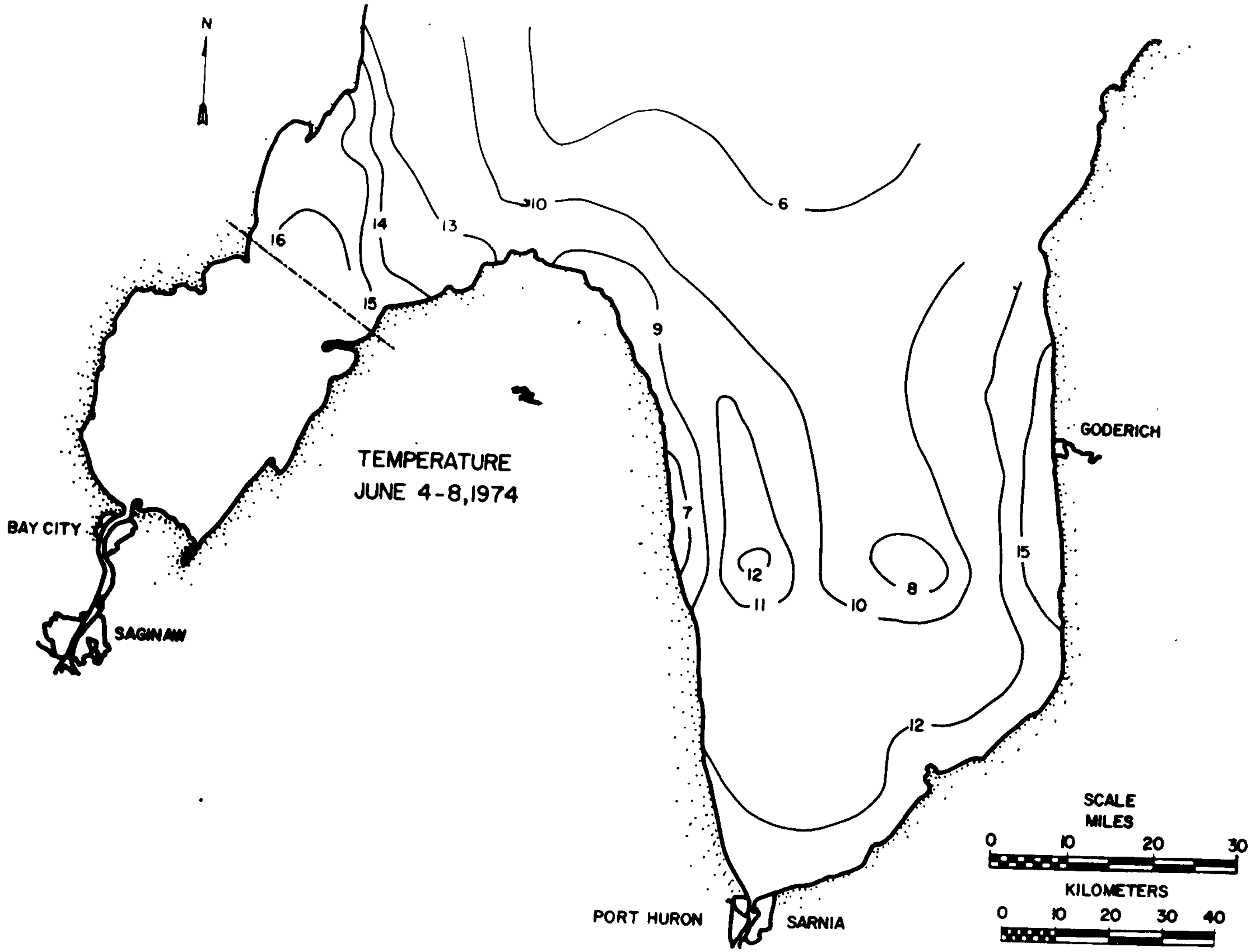

Figure 12. Surface temperatures (C) in southern Lake Huron during 4-8 June 1974.

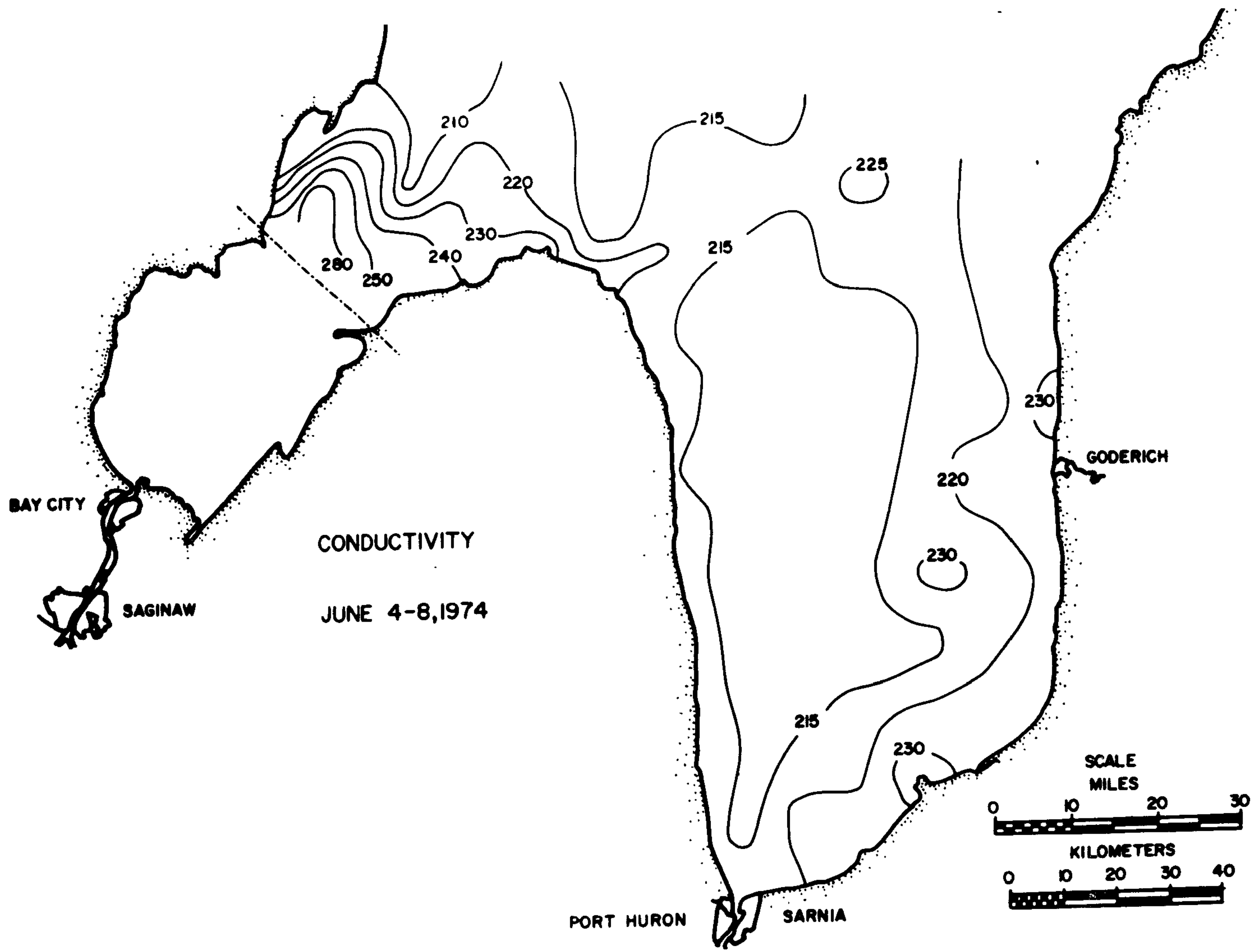

Figure 13. Surface specific conductance (μmhos/cm @ 25 C) in southern Lake Huron during early June 1974.

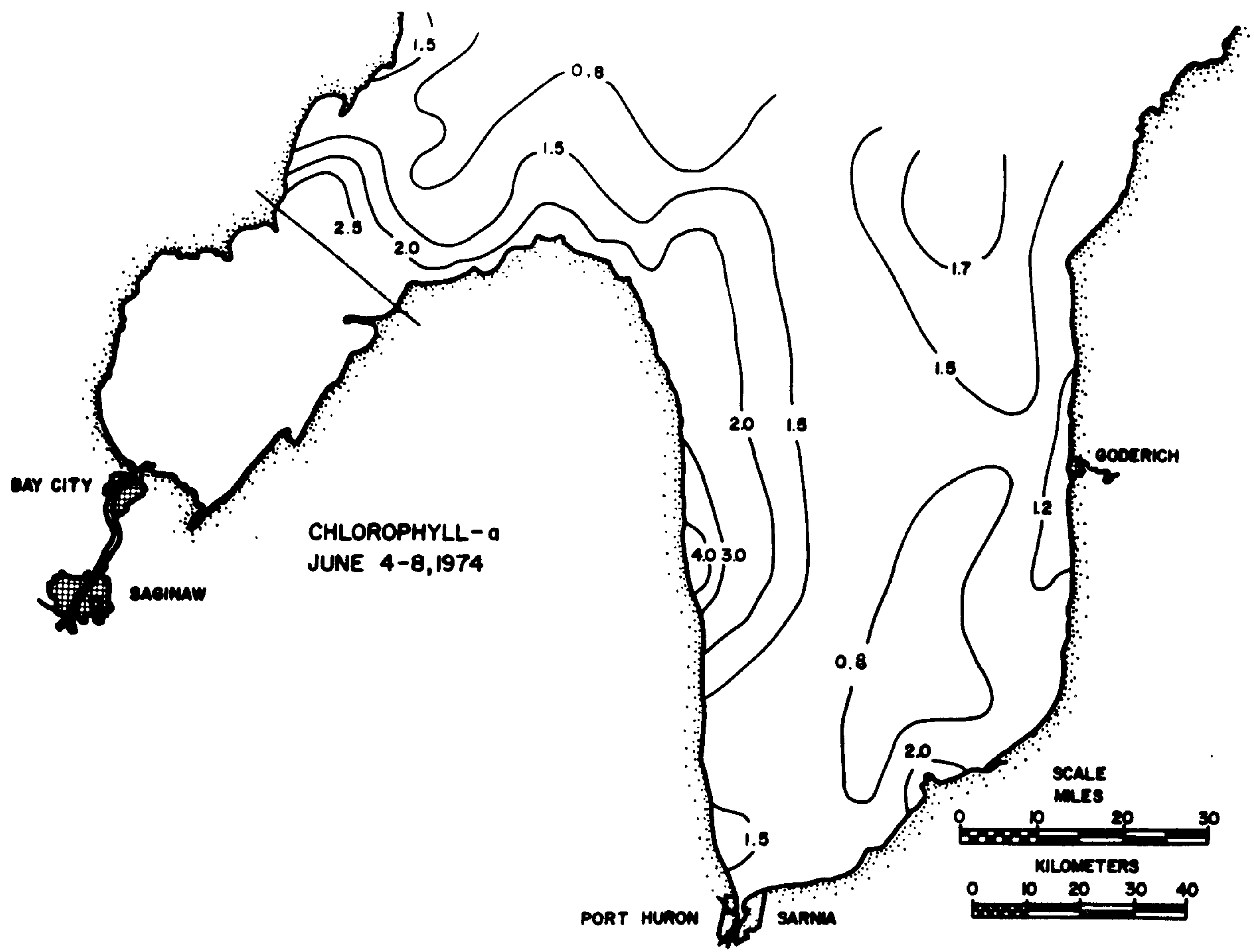

Figure 14. Surface chlorophyll *a* (μg/liter) in southern Lake Huron during early June 1974.

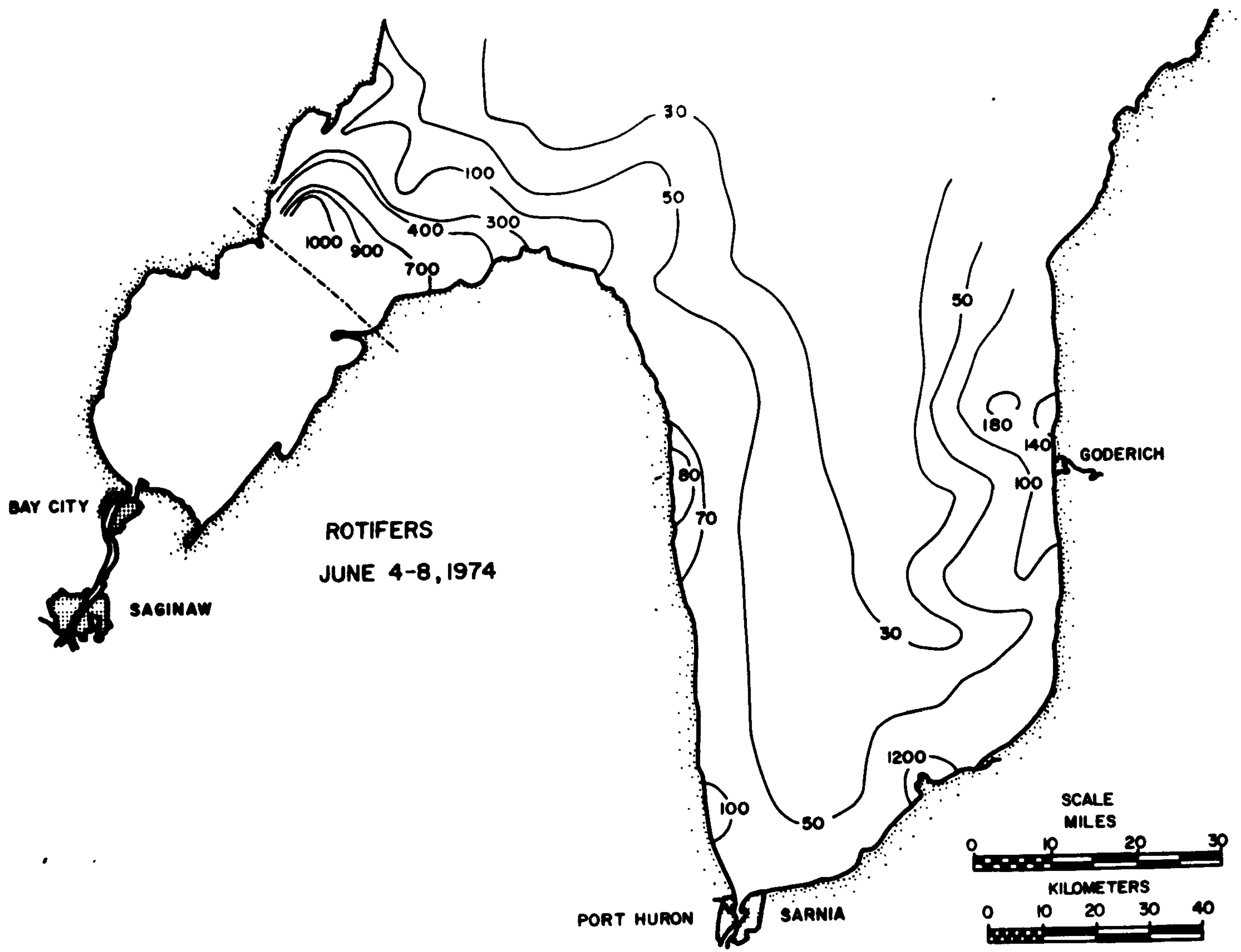

Figure 15. Distribution and abundance (number of ind./liter) of total rotifers in southern Lake Huron during early June 1974.

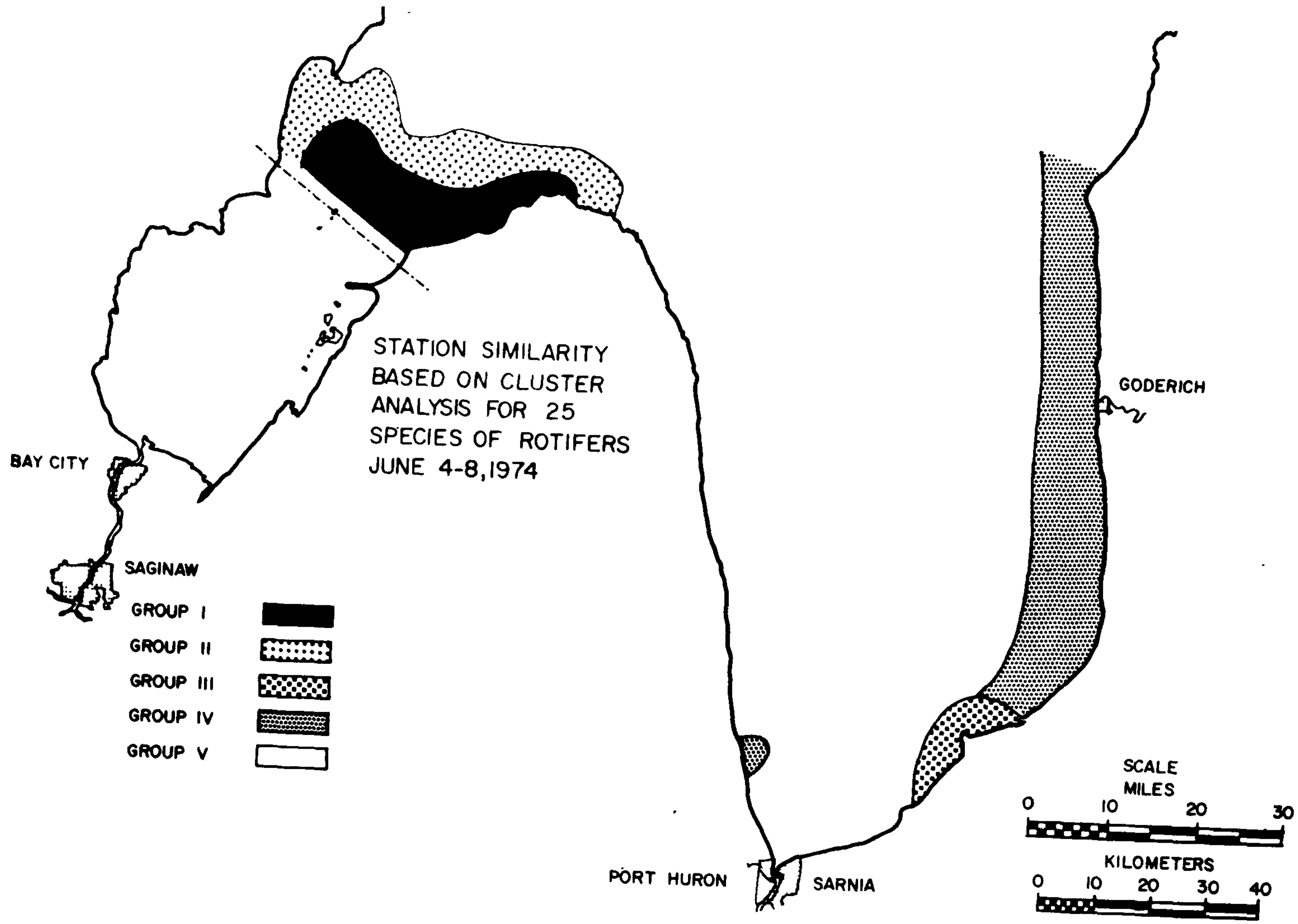

Figure 16. Grouping of 43 stations determined by cluster analysis of rotifer data for southern Lake Huron during early June 1974.

TABLE 4. ABUNDANCE (MEAN NUMBER OF INDIVIDUALS/LITER) OF SELECTED ROTIFERS, PERCENT COMPOSITION AND MEAN SURFACE VALUES OF SELECTED PHYSICOCHEMICAL VARIABLES IN GROUPS OF STATIONS IDENTIFIED BY CLUSTER ANALYSIS FOR CRUISE 3

Taxon/Group	I		II		III		IV		V	
	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%
Keratella cochlearis	247.0	32.6	37.0	17.0	126	10.7	18	14.6	7	14.0
K. cochlearis v. *robusta*	38	5.0	9	4.1	7	0.6	2	1.6	1	2.0
K. earlinae	246	32.6	64	29.4	24	2.0	3	2.4	7	14.0
K. quadrata	39	5.2	30	13.8	9	0.8	8	6.5	3	6.0
Brachionus angularis	1	0.1	0.1	0.1	0		0		0	
Notholca spp.	4	0.5	7	3.2	4	0.3	4	3.3	7	14.0
Polyarthra dolichoptera	9.1	1.2	7	3.2	7	0.6	10	8.1	6	12.0
P. vulgaris	5	0.7	4	1.8	0		7	5.7	0.5	1.0
Synchaeta kitina	36	4.8	24	11.0	552	46.9	55	44.7	10	20.0
S. stylata	4	0.5	3	1.4	365	31.0	4	3.3	0.2	0.4
S. pectinata	0.7	0.1	0.3	0.1	42	3.6	1	0.8	0.1	0.2
Kellocottia longispina	45	6.0	19	8.7	0		9	7.3	4	8.0
Gastropus stylifer	4	0.5	1	0.5	0		0.1	0.1	0.2	0.4

(continued)

TABLE 4 (continued)

Taxon/Group	I		II		III		IV		V	
	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%
Filinia longiseta	8	1.1	1	0.5	5	0.4	0.1	0.1	0.1	0.2
Conochilus unicornis	56	7.4	9	4.1	0		0		0.4	0.8
Other rotifers	11.2	1.5	2.6	1.2	35	3.0	1.8	1.5	3.5	7.0
Total rotifers/liter	754		218		1176		123		50	
Physicochemical variables										
	I		II		III		IV		V	
Secchi disc (m)	3.2		4.9		2		3.9		5.8	
Temperature (°C)	14.7		13.3		14.1		13.9		10	
Chlorophyll *a* (μg/ℓ)	2.1		1.5		2.0		1.3		1.5	
Spec. Cond. (μmhos/cm)	250		225		229		219		216	
Total Phosphorus (μg/ℓ)	13		9.1		9.0		8.6		5.3	
Chloride (μg/ℓ)	9.4		7.6		5.2		6.7		6.0	
No. Stations/Group	5		4		1		4		29	

Cruise Four

Rotifer samples were collected at 41 stations in Saginaw Bay (18-21 June) and at 40 stations in southern Lake Huron (17-21 June). Fifty-one species of rotifers, including 1 form and 2 varieties of Keratella cochlearis, were identified (TABLE 1). The predominant rotifers of Saginaw Bay were K. cochlearis, Polyarthra dolichoptera, P. remata, and P. vulgaris. The littoral species, Euchlanis dilatata and Lopocharis salpina, occurred at 6.8 and 6.2 ind./liter, respectively. Abundance of eutrophic indicator species such as Brachionus angularis, Filinia longiseta, Pompholyx sulcata, and Trichocerca multicrinis ranged from 4.0 to 76.1 ind./liter. In southern Lake Huron waters the following species predominated: Conochilus unicornis, K. cochlearis, K. earlinae, and Polyarthra vulgaris. Abundance of the cold stenotherms, Notholca foliacea, N. laurentiae, and N. squamula ranged from 1.0 to 3.2 ind./liter.

Isopleths for temperature, specific conductance, and chlorophyll a were similar to the distribution of rotifers. Surface temperatures were warmest (15-18 C) at near-shore stations in Saginaw Bay (Figure 17). A tongue of warm water (13-17 C) from Saginaw Bay extended southeasterly along the western shore of southern Lake Huron. Warm water (13-16 C) was also present along the eastern shore of Lake Huron. Specific conductance was highest (600 μmhos/cm) at the mouth of the Saginaw River, and was also high (220-290 μmhos/cm) along the eastern coast of Saginaw Bay (Figure 18). The 210 μmhos/cm isopleth in conjunction with the 11 C isopleth suggested that some upwelling occurred on the western shore. Concentration of chlorophyll a was greatest (4-45 μg/liter) at near-shore stations in Saginaw Bay (Figure 18). In Lake Huron the highest cholrophyll a values occurred on the eastern shoreline near Goderich (2-4 μg/liter). The greatest abundance of rotifers (>3,000 ind./liter) occurred at two isolated stations which also had high values for temperature, specific conductance, and chlorophyll a (Figures 17-20). Rotifer abundance near the Saginaw River mouth was 40 times greater than at midlake stations. Abundance on the western shore of southern Lake Huron below the mouth of the Saginaw Bay was 12 times greater than at midlake stations. Higher abundance also occurred at stations near Goderich (>200 ind./liter).

Cluster analysis of the rotifer data divided the study area into six major groups (Figure 21). Group I characterized the species assemblage associated with Saginaw River. Species indicative of eutrophy such as Brachionus spp. and Keratella cochlearis f. tecta, comprised 32% of total abundance (TABLE 5).

Group III stations encompassed a large area in Saginaw Bay and are delineated by the 700 ind./liter isopleth. Part of Group III is surrounded by Group IV stations (Figure 21). Group IV stations were characterized by much lower rotifer abundance but shared similar species composition and physicochemical characteristics (TABLE 5).

Group V consisted of stations located in outer Saginaw Bay and along the northwest coast of Lake Huron. Stations along the east coast of Lake Huron were closely related to outer bay stations and were incorporated into this group. Keratella cochlearis and Conochilus unicornis comprised 47% of the total abundance (TABLE 5). Total abundance in Group V was 68% of that in Group IV.

Group VI was similar to Group V in species composition and in some physicochemical characteristics but total abundance was only 25% of that in Group V (TABLE 5). The composition percentages of *Kellicottia longispina* and the cold stenotherms, *Notholca* spp. and *S. lakowitziana*, were greatest in this group.

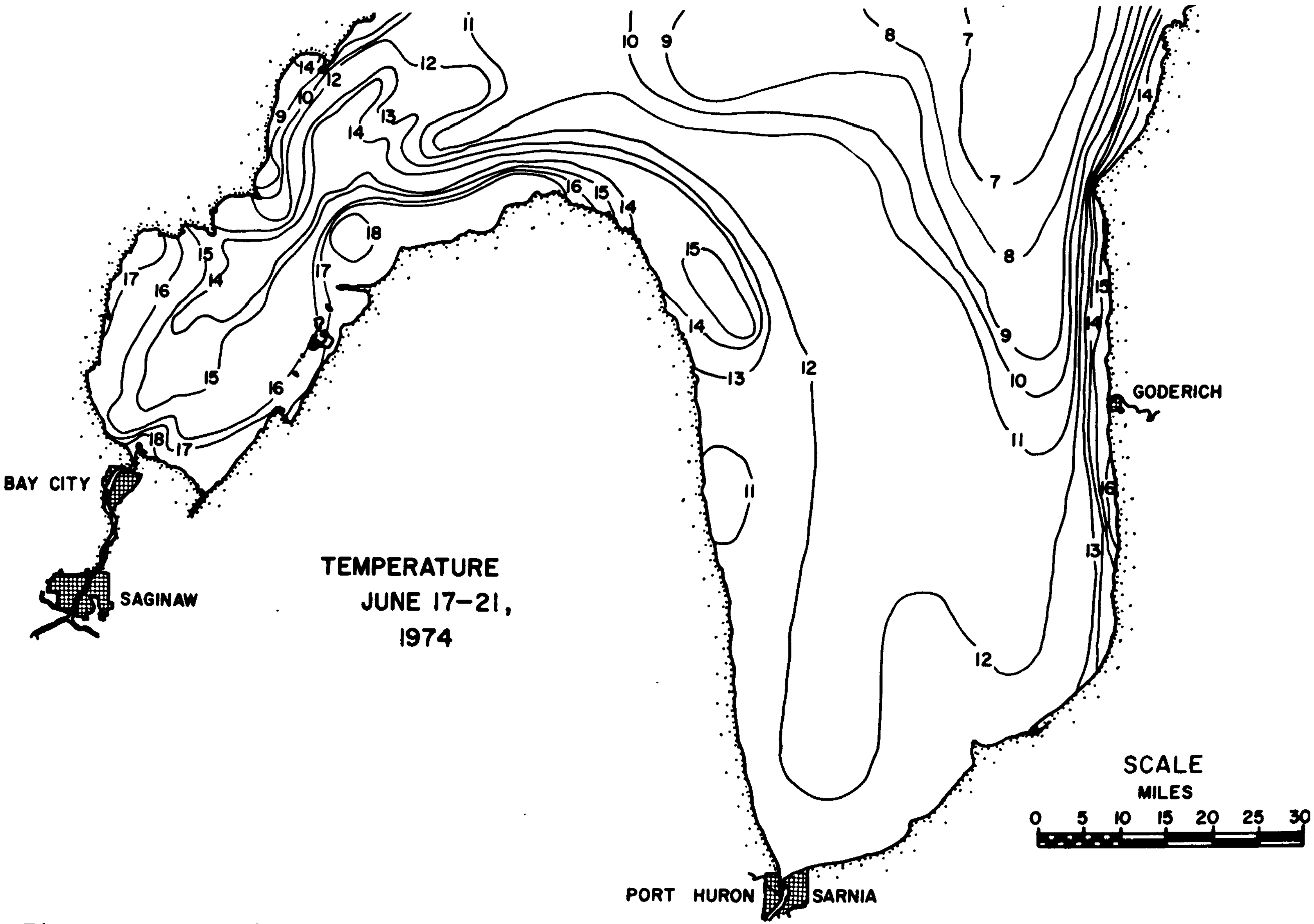

Figure 17. Surface temperatures (C) in Saginaw Bay and southern Lake Huron during 17-21 June 1974.

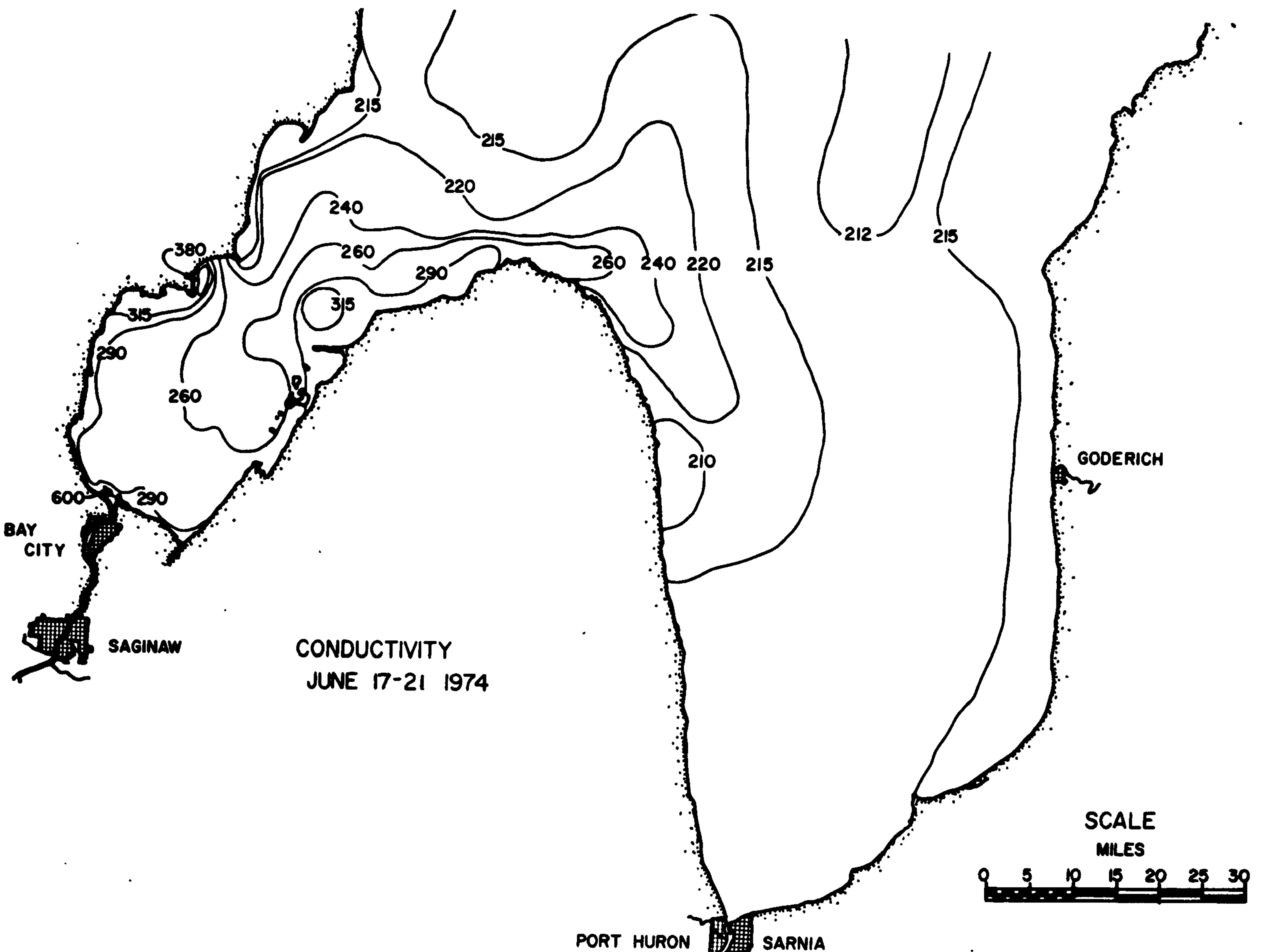

Figure 18. Surface specific conductance (μmhos/cm @ 25 C) in Saginaw Bay and southern Lake Huron during mid-June 1974.

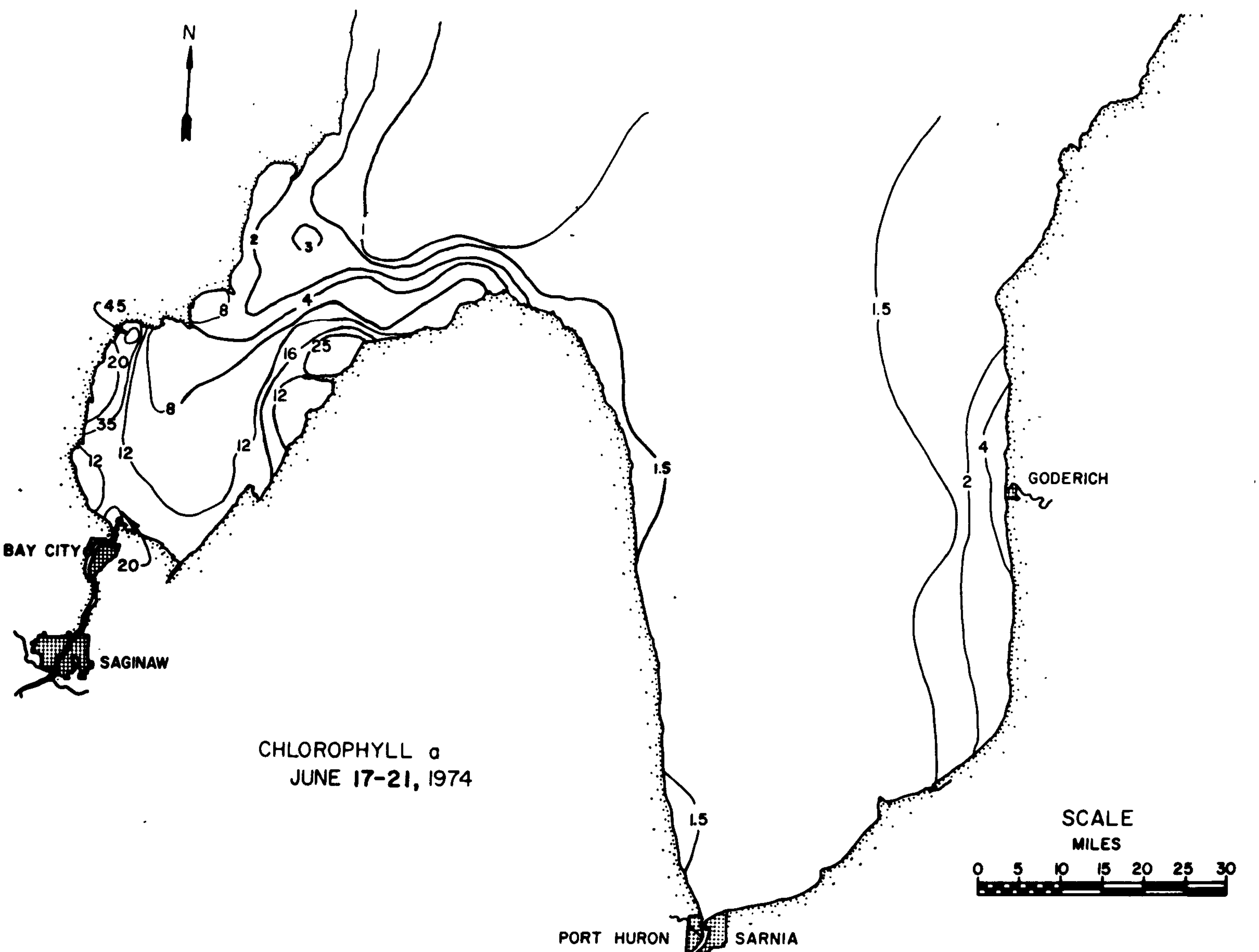

Figure 19. Surface chlorophyll *a* (μg/liter) in Saginaw Bay and southern Lake Huron during mid-June 1974.

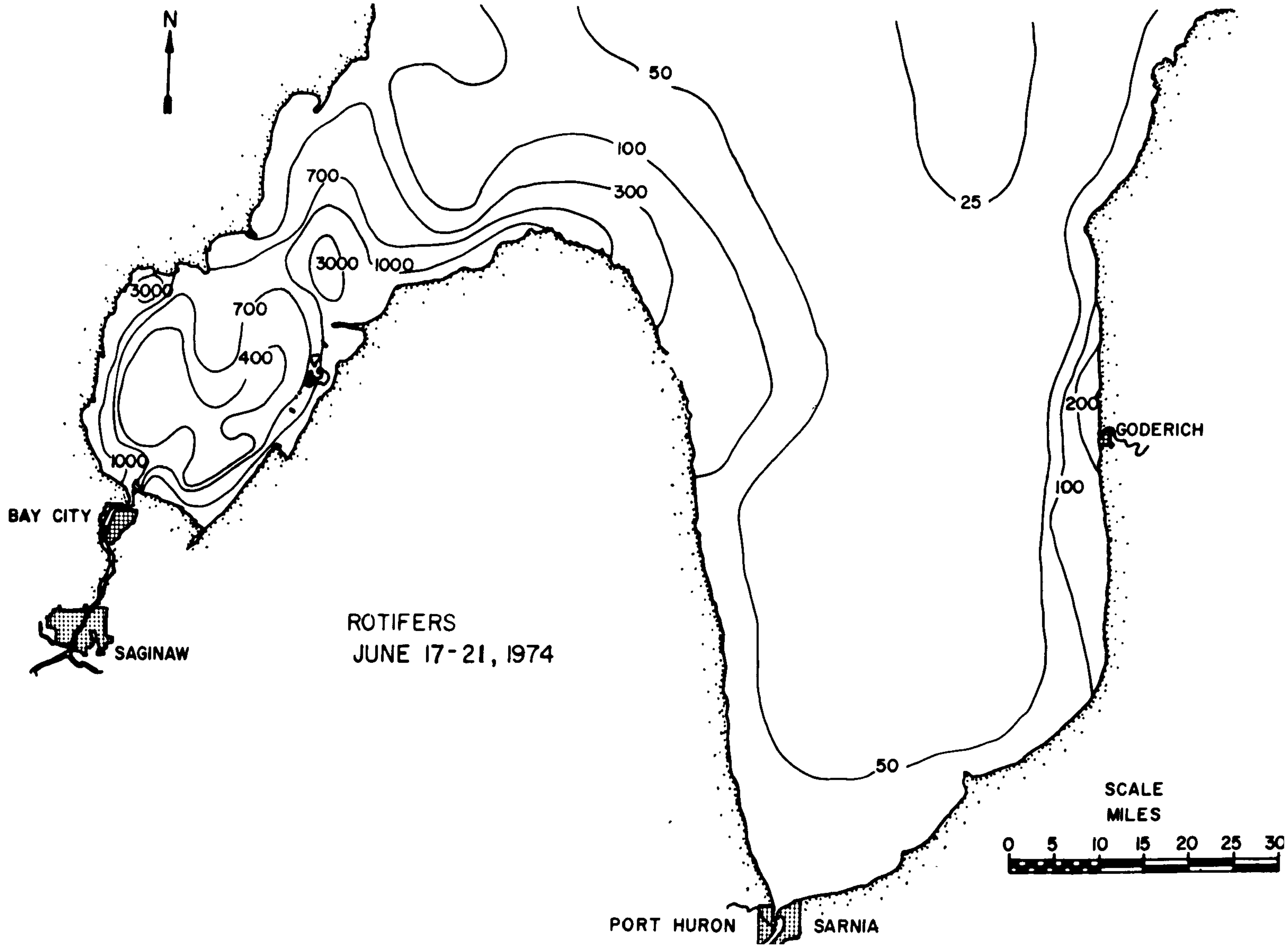

Figure 20. Distribution and abundance (number of ind./liter) of total rotifers in Saginaw Bay and southern Lake Huron during mid-June 1974.

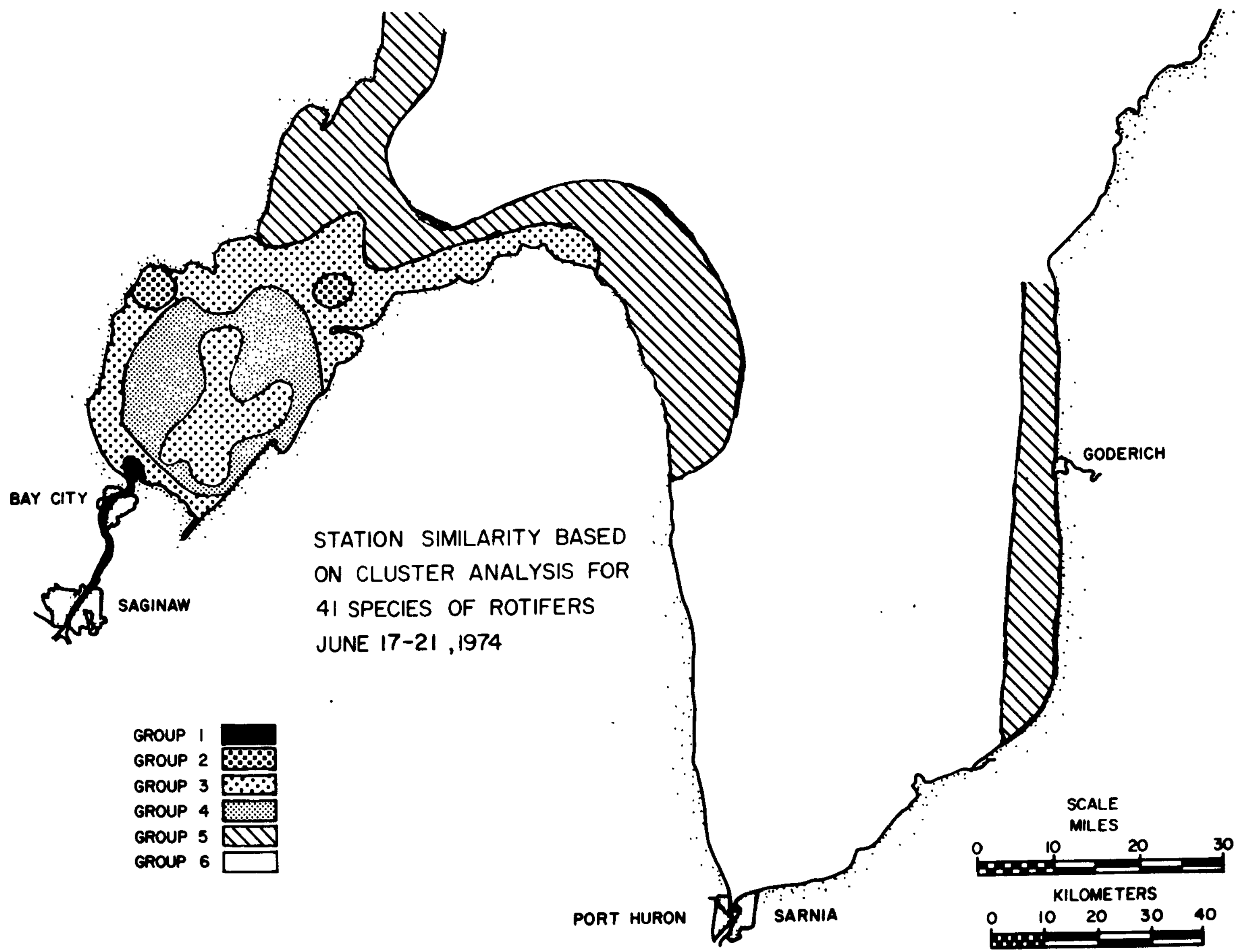

Figure 21. Grouping of 81 stations determined by cluster analysis of rotifer data for Saginaw Bay and southern Lake Huron during mid-June 1974.

TABLE 5. ABUNDANCE (MEAN NUMBER OF INDIVIDUALS/LITER) OF SELECTED ROTIFERS, PERCENT COMPOSITION AND MEAN SURFACE VALUES OF SELECTED PHYSICOCHEMICAL VARIABLES IN GROUPS OF STATIONS IDENTIFIED BY CLUSTER ANALYSIS FOR CRUISE 4

Taxon/Group	I		II		III		IV		V		VI	
	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%
Asplanchna priodonta	4	0.6	16	0.5	10	1.1	6	1.5	4	1.5	1	1.4
Brachionus spp.	92	13	29	0.9	2	0.2	2	0.5	0.2	0.1	0	
Conochiloides dossuarius	1	0.1	4	0.1	0		0		0		0	
Conochilus unicornis	0		98	3.1	73	8.2	67	16.9	68	25.2	7	9.9
Filinia longiseta	12	1.7	464	14.7	62	7.0	25	6.3	8	3	0.3	0.4
Kellicottia longispina	1	0.1	36	1.1	13	1.5	8	2.0	10	3.7	7	9.9
Keratella cochlearis	315	44.4	356	11.3	165	18.6	100	25.3	59	21.9	14	19.7
K. cochlearis v. *robusta*	0		24	0.8	8	0.9	4	1.0	4	1.5	0.6	0.8
K. cochlearis f. *tecta*	137	19.3	15	0.5	7	0.8	3	0.8	0.1	0.04	0	
K. cochlearis v. *hispida*	2	0.3	38	1.2	22	2.5	9	2.3	4	1.5	1	1.4
K. earlinae	9	1.3	89	2.8	39	4.4	15	3.8	34	12.6	9	12.7
K. quadrata	3	0.4	41	1.3	13	1.5	6	1.5	6	2.2	4	5.6
Lophocharis salpina	2	0.3	56	1.8	5	0.6	0.8	0.2	0.1	0.04	0	

(continued)

TABLE 5 (continued)

Taxon/Group	I		II		III		IV		V		VI	
	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%
Notholca spp.	0		0		1	0.1	1	0.3	4	1.9	6	8.4
Ploesoma truncatum	0		11	0.3	4	0.4	1	0.3	0.4	0.2	0	
Polyarthra dolichoptera	10	1.4	745	23.7	82	9.2	22	5.6	5	1.9	4	5.6
P. major	2	0.3	4	0.1	2	0.2	2	0.5	0.1	0.04	0	
P. remata	73	10.3	349	11.1	126	14.2	36	9.1	8	3	0.2	0.3
P. vulgaris	19	2.7	343	10.9	90	10.1	38	9.6	21	7.8	5	7.0
Pompholyx sulcata	3	0.4	9	0.3	2	0.2	1	0.3	0.2	0.1	0	
Synchaeta lakowitziana	0		0		0		0		1	0.4	1	1.4
S. oblonga	4	0.6	36	1.1	9	1.0	3	0.8	0		0	
S. pectinata	6	0.8	11	0.3	46	5.2	11	2.8	1	0.4	0.03	0.04
S. stylata	3	0.4	20	0.6	2	0.2	4	1.0	7	2.6	5	7.0
S. kitina	4	0.6	205	6.5	43	4.8	13	3.3	24	8.9	6	8.4
Trichocerca spp.	3	.4	96	3.1	33	3.7	15	3.8	2	0.7	0.06	0.1

(continued)

TABLE 5 (continued)

Taxon/Group	I		II		III		IV		V		VI	
	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%
Other rotifers	5	0.7	51	1.6	30	3.4	3	0.8	0		0	
Total Rotifers/liter	710		3146		889		396		270		71	
Physicochemical variables												
Secchi disc (m)	0.2		0.5		1.2		1.4		3.9		6.0	
Temperature (°C)	18.4		17.9		16.0		15.5		12.9		11.3	
Chlorophyll *a* (μg/ℓ)	21.6		30.8		11.9		10.1		2.1		1.2	
Spec. Cond. (μmhos/cm)	626		321		279		265		226		216	
Dissolved Phosphorus (μg/ℓ)	94.5		16.0		9.2		7.4		7.4		4.3	
Chloride (μg/ℓ)	86.5		25.0		18.4		17.0		8.4		6.2	
No. Stations/Group	2		2		26		13		16		22	

Cruise Five

Rotifer samples were collected at 78 stations during 8-10 July in Saginaw Bay and 17-22 July in southern Lake Huron. Fifty-nine species were recorded (TABLE 1). Polyarthra remata, P. vulgaris, Synchaeta stylata, and Filinia longiseta were numerically important in Saginaw Bay. Abundance of such eutrophic indicator species as Brachionus angularis, Keratella cochlearis f. tecta, and Pompholyx sulcata ranged from 20.8 to 63.8 ind./liter. Keratella cochlearis, P. vulgaris and S. stylata predominated in southern Lake Huron waters.

Isopleths for temperature, specific conductance and chlorophyll a were similar to the distribution of rotifers. Surface temperatures were warmest (23-26 C) in the lower portion of Saginaw Bay (Figure 22). Warm water (20-23 C) extended northward along the eastern coast of the bay. In southern Lake Huron, the warmest water (19-20 C) was present along the western coast. Temperatures in the open portion of the lake were near 18 C and the coldest water (16 C) was found at the eastern shore near Goderich, probably evidence of upwelling. Specific conductance was highest (280 μmhos/cm) in extreme lower Saginaw Bay, indicating the strong influence of the Saginaw River in this region (Figure 23). Chlorophyll a was highest near the mouth of the Saginaw River (Figure 24). Values were over 50 times lower in the outer portion of the bay and were over 100 times lower in the open waters of southern Lake Huron than in waters near the Saginaw River mouth. Chlorophyll a was slightly higher inshore than offshore in southern Lake Huron. Rotifer abundance was 40 times higher near the Saginaw River mouth than in the offshore waters of southern Lake Huron (Figure 25). Although relative abundance was considerably different between Saginaw Bay and southern Lake Huron, species diversity was similar throughout the study area (Figure 26).

Cluster analysis of rotifer data divided the study area into four groups (Figure 27). The analysis yielded a cophenetic correlation of 0.94.

Group I stations located in the Saginaw River were dominated by the eutrophic indicator species, Brachionus spp., Keratella cochlearis f. tecta, and Conochiloides dossuarius, which cmprised 40% of the total abundance (TABLE 6). Polyarthra vulgaris was numerically the most abundant species. Based on physicochemical variables, Group I clearly was most eutrophic.

Group II stations, which also occurred in nutrient-enriched waters of near-shore Saginaw Bay, had the greatest abundance of total rotifers (1,972 ind./liter), which was 1.7 times greater than that of Group I (TABLE 6). The species composition percentages of Brachionus spp., K. cochlearis f. tecta, and C. dossuarius changed conspicuously from Group I. Abundance of Filinia longiseta and Pompholyx sulcata was greater in Group II than in Group I, but that of P. vulgaris remained the same. Composition percentage of K. cochlearis was about half that of Group I.

Group III was comprised of central Saginaw Bay stations as well as near-shore stations along the perimeter of southern Lake Huron. Total abundance was 32% of that in Group II (TABLE 6). The eutrophic indicator species in Groups I and II were much less abundant in Group III. The composition percentages of *Conochilus unicornis* and *Kellicottia longispina* were greater in Group III, and the cold stenotherms, *Notholca squamula* and *N. laurentiae*, absent in Groups I and II, first appeared in Group III (TABLE 6).

Group IV was composed of stations in the central portions of the lake which displayed the most oligotrophic conditions (TABLE 6). Total abundance was 50% of that in Group III. *Keratella cochlearis* and *Polyarthra vulgaris*, the predominant Group IV rotifers, each contributed 16% of total abundance. The composition percentages of *C. unicornis*, *K. longispina*, and *Notholca* spp. were greatest in Group IV.

Identical multivariate tests performed on nine physicochemical variables revealed station groups bearing strong similarities to those obtained from rotifer data (Figures 27, 28).

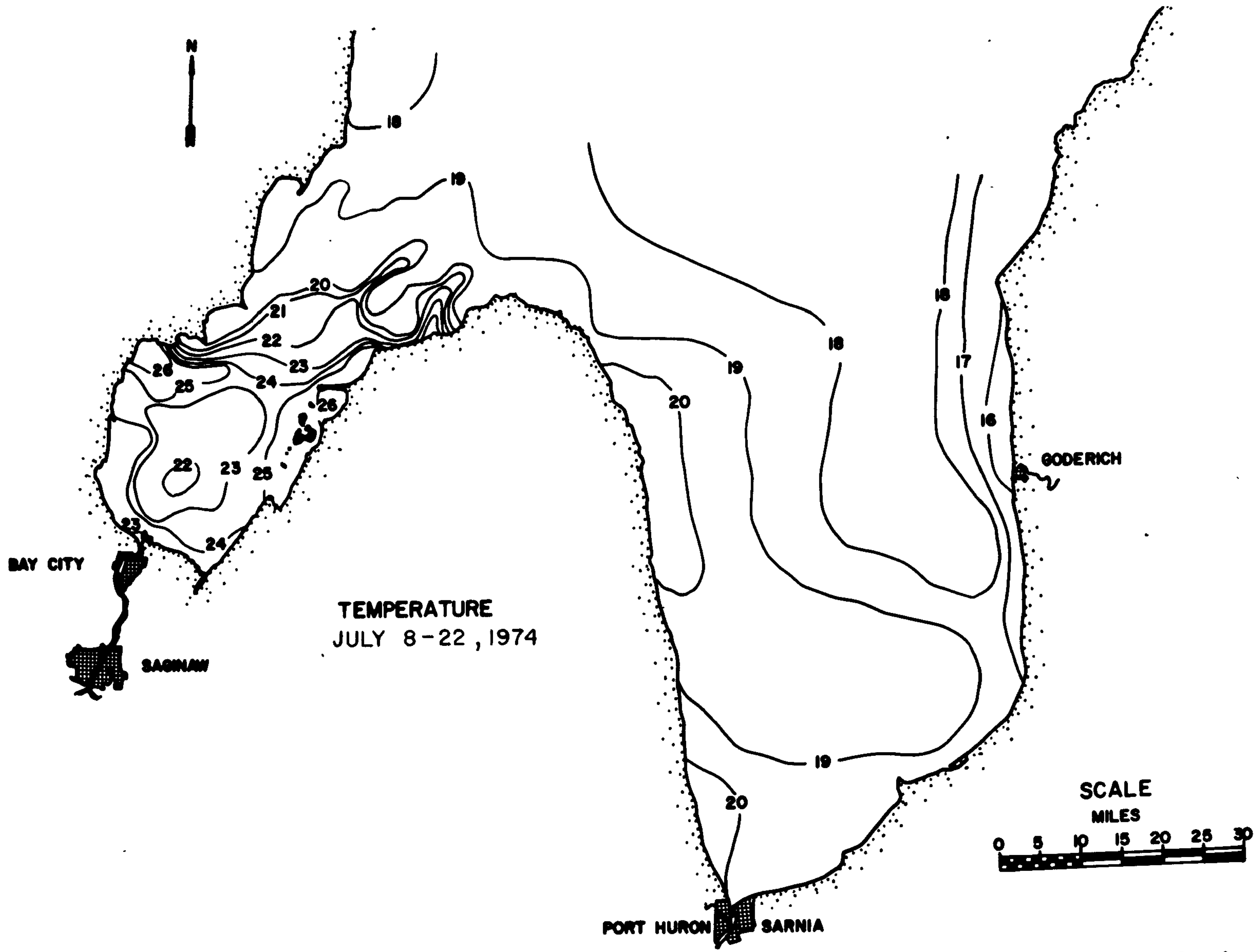

Figure 22. Surface temperatures (C) in Saginaw Bay and southern Lake Huron during 8-22 July 1974.

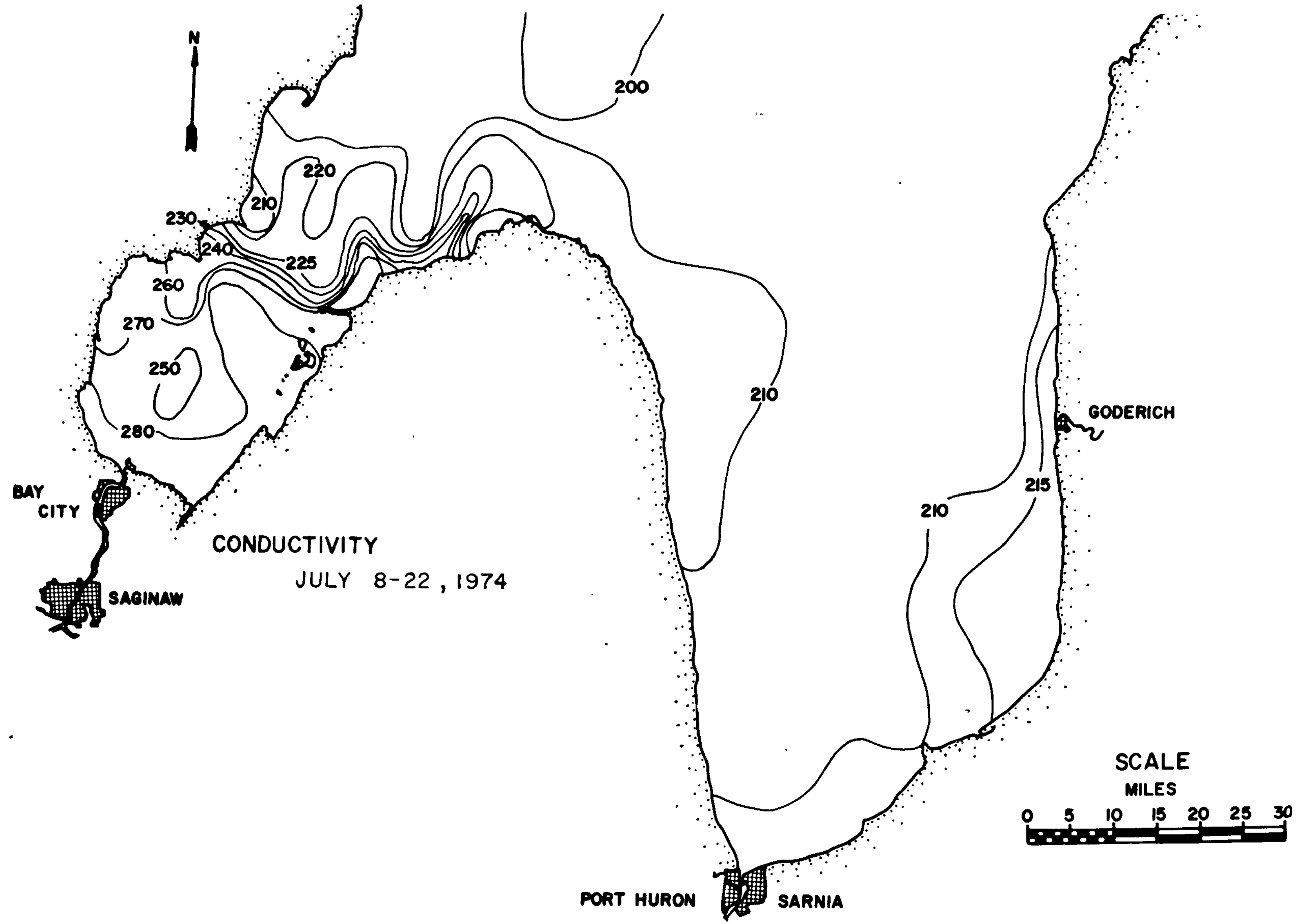

Figure 23. Surface specific conductance (µmhos/cm @ 25 C) in Saginaw Bay and southern Lake Huron during July 1974.

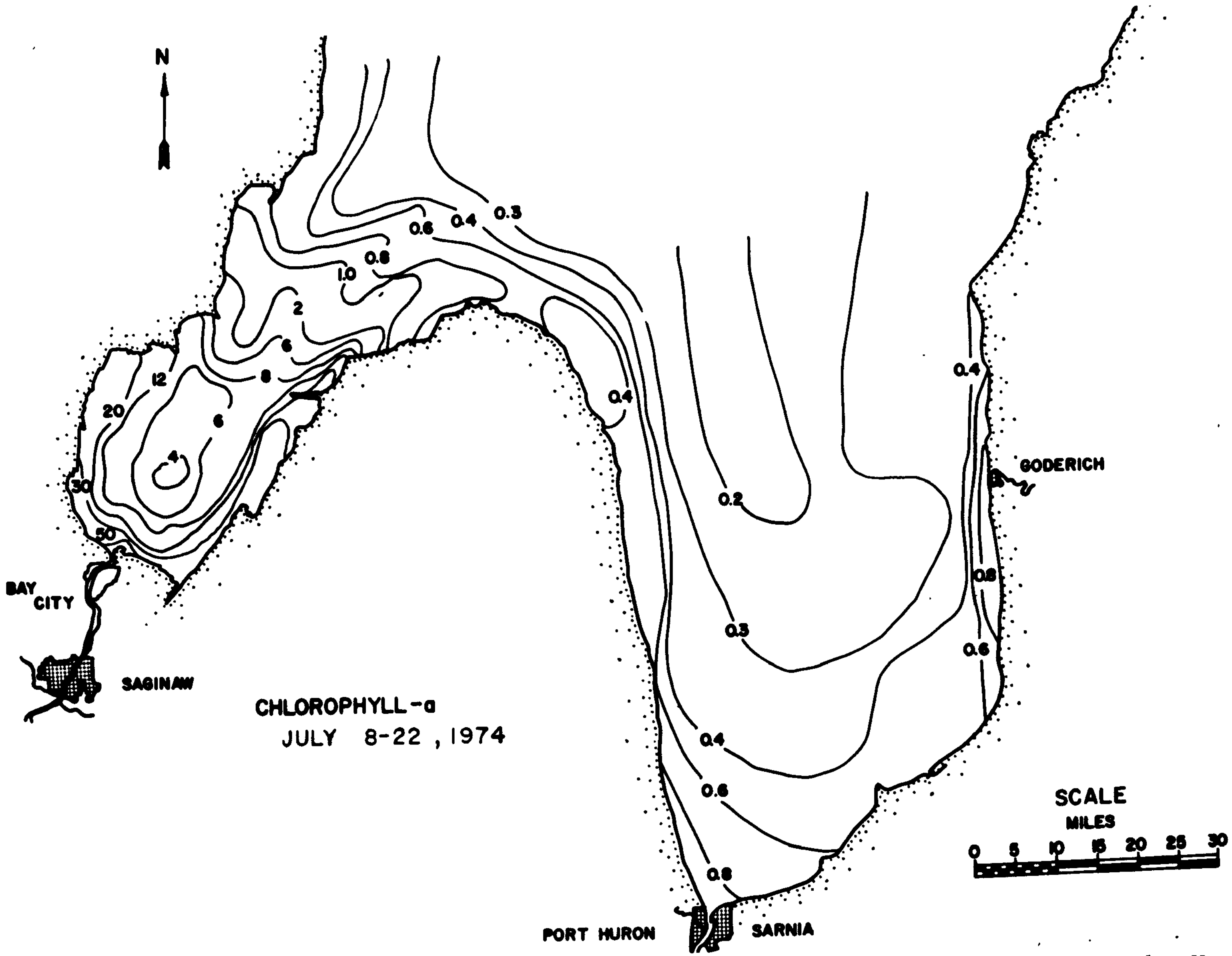

Figure 24. Surface chlorophyll a (μg/liter) in Saginaw Bay and southern Lake Huron during July 1974.

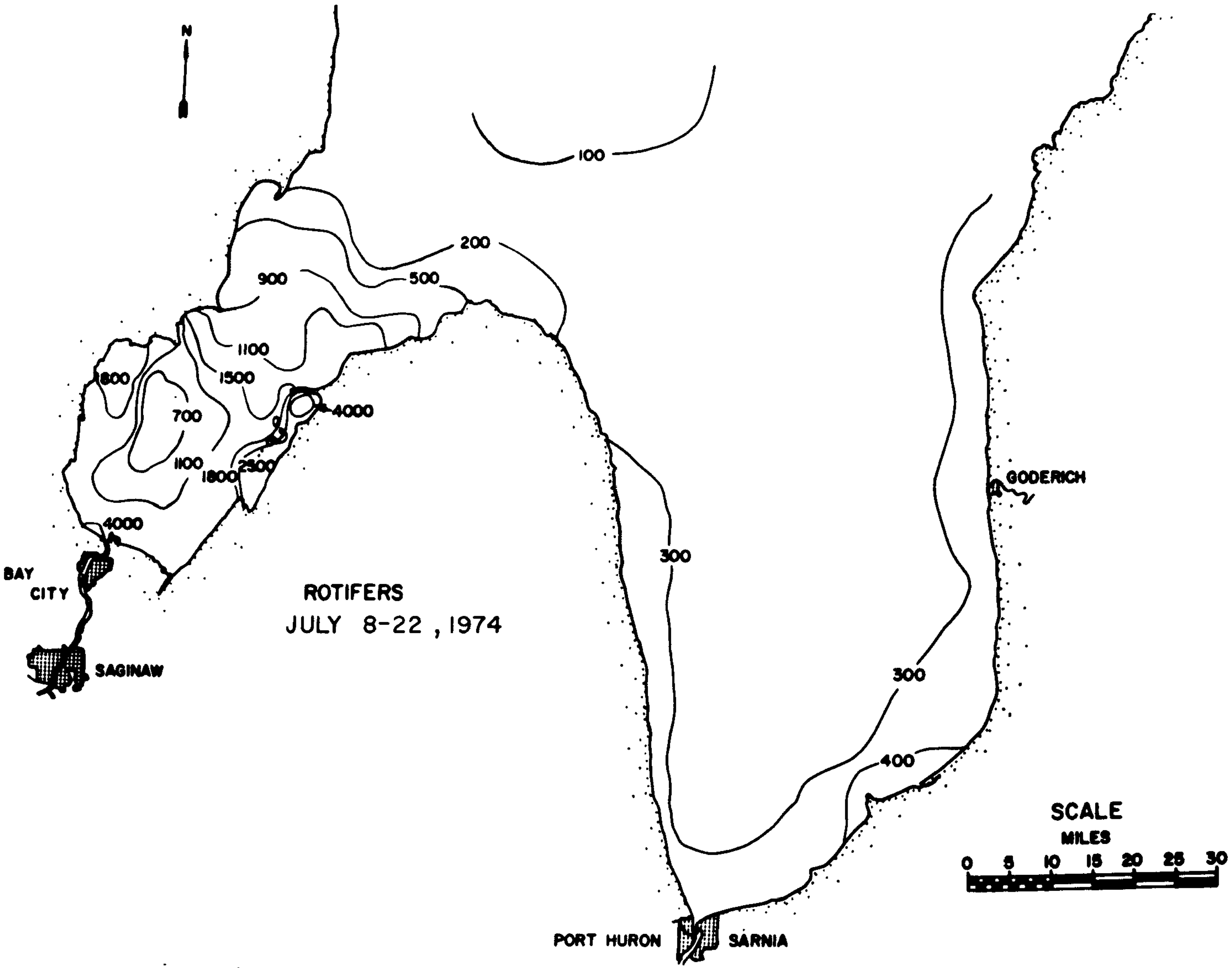

Figure 25. Distribution and abundance (number of ind./liter) of total rotifers in Saginaw Bay and southern Lake Huron during July 1974.

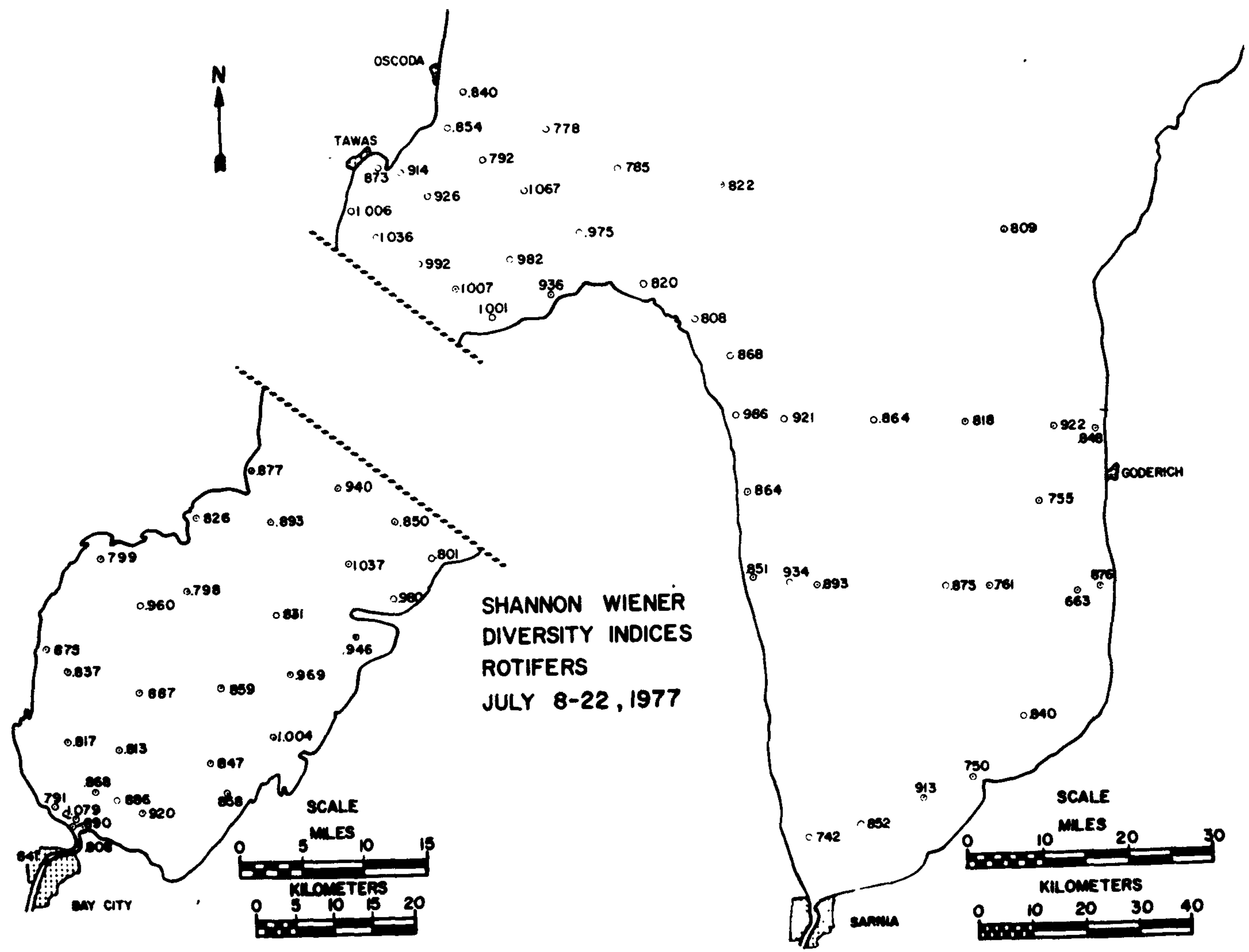

Figure 26. Shannon-Wiener diversity indices on rotifer data from 78 stations in Saginaw Bay and southern Lake Huron during July 1974.

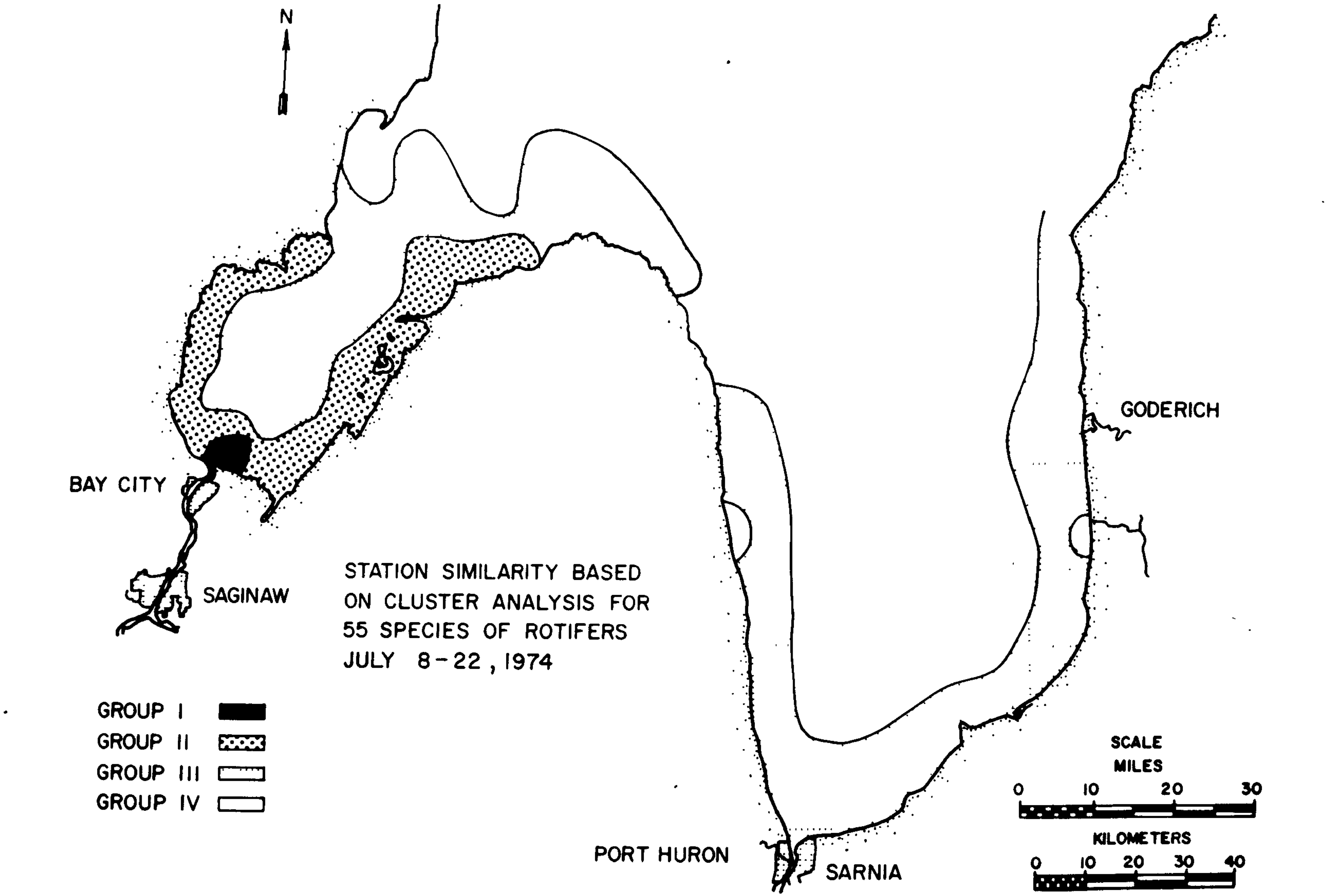

Figure 27. Grouping of 78 stations determined by cluster analysis of rotifer data for Saginaw Bay and southern Lake Huron during July 1974.

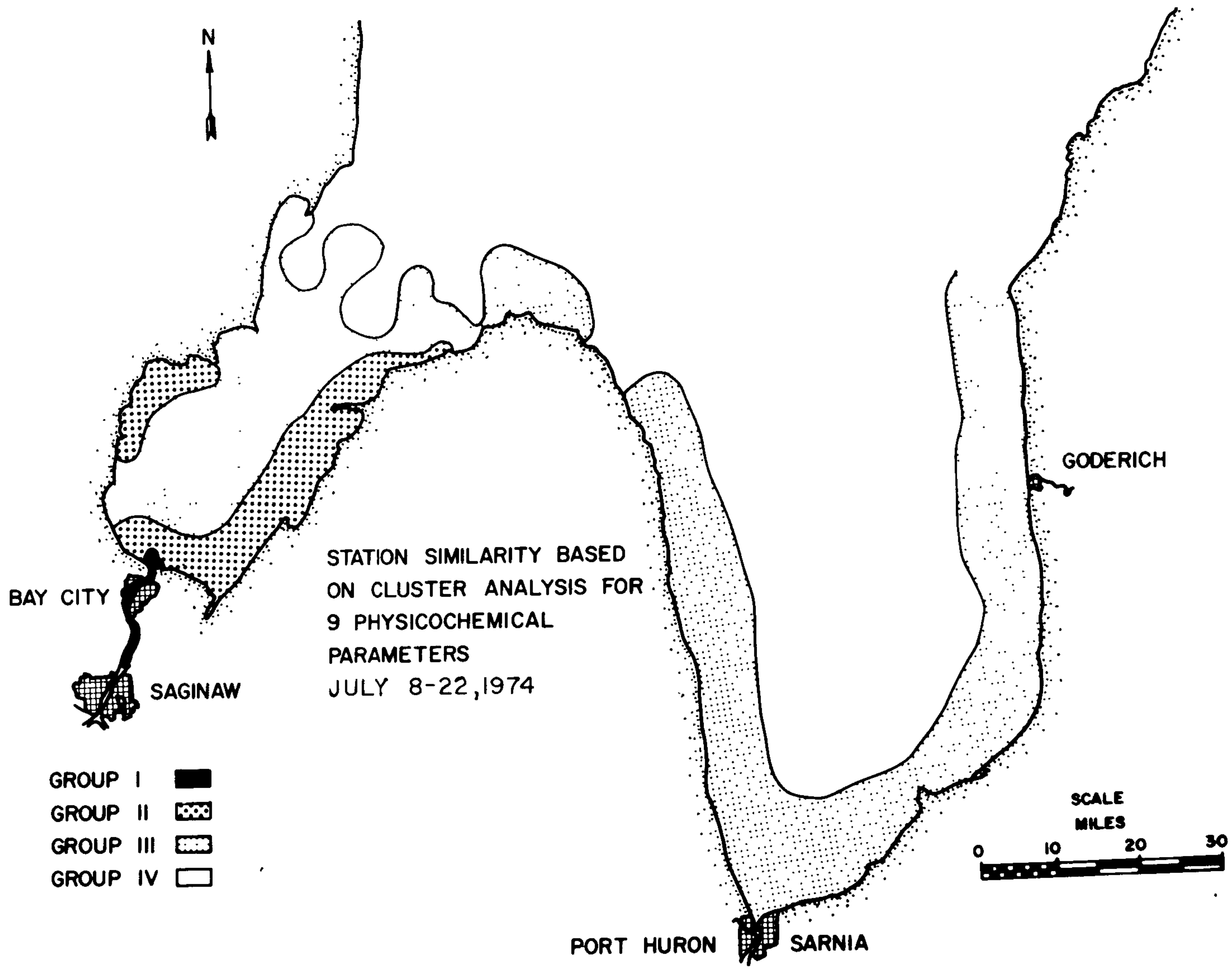

Figure 28. Grouping of 99 stations determined by cluster analysis of physicochemical data for Saginaw Bay and southern Lake Huron during July 1974.

TABLE 6. ABUNDANCE (MEAN NUMBER OF INDIVIDUALS/LITER) OF SELECTED ROTIFERS, PERCENT COMPOSITION AND MEAN SURFACE VALUES OF SELECTED PHYSICOCHEMICAL VARIABLES IN GROUPS OF STATIONS IDENTIFIED BY CLUSTER ANALYSIS FOR CRUISE 5

Taxon/Group	I		II		III		IV	
	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%
Brachionus spp.	140	12.2	20	1.0	<1	<.1	<<1	
Conochiloides dossuarius	150	13.1	4	.2	0		0	
Filinia longiseta	34	3.0	273	13.8	70	11.2	12	3.8
Pompholyx sulcata	11	1.0	126	6.4	14	2.2	7	2.2
Polyarthra vulgaris	294	25.7	528	26.8	132	21.1	51	16.3
Keratella cochlearis	193	16.9	154	7.8	102	16.3	51	16.3
K. cochlearis f. *tecta*	170	14.9	13	.7	1	.2	<<1	
Conochilus unicornis	<1	<.1	19	1.0	17	2.7	27	8.7
Kellicottia longispina	0		2	.1	11	1.8	25	8.0
Notholca spp.	0		0		<1	<.1	2	.6
Other rotifers	452	31.3	833	42.2	278	44.4	137	43.9
Total Rotifers/liter	1444		1972		626		312	

(continued)

TABLE 6 (continued)

Taxon/Group	I	II	III	IV
Physicochemical variables				
Secchi disc (m)	0.4	1.2	4.1	8.3
Temperature (°C)	23.5	23.3	20.7	19.0
Chlorophyll *a* (μg/ℓ)	57.1	18.8	2.4	0.6
Spec. Cond. (μmhos/cm)	636.0	277.0	228.0	210.0
Dissolved Phosphorus (μg/ℓ)	58.5	6.2	5.7	5.2
Ammonia-nitrogen (μg/ℓ)	121.0	53.0	41.0	10.0
Chloride (μg/ℓ)	119.0	24.4	11.9	6.3
No. Stations/Group	4	17	30	27

Cruise Six

Forty-three stations in southern Lake Huron were sampled for rotifers during the period 26-31 August. Thirty-seven species were recorded. The predominant species were Conochilus unicornis, Keratella cochlearis, and Polyarthra vulgaris (TABLE 1).

Isopleths for specific conductance and chlorophyll a were more similar to the distribution of rotifers than was temperature. The lowest surface temperature (19 C) occurred along the west-central Lake Huron coast (Figure 29). Highest temperatures (22-23 C) occurred in the central area of the lake and at an isolated station on the southwestern shore. Specific conductance was highest in the northern portions of outer Saginaw Bay (210-230 μmhos/cm) and along the southeastern coast below Goderich (Figure 30). The greatest chlorophyll a concentrations (1.5-4.8 μg/liter) and rotifer abundances occurred in the northern portion of the outer bay (Figures 31 and 32).

Cluster analysis of rotifer data divided the study area into five major groups (Figure 33). The analysis yielded a cophenetic correlation of 0.96.

Group I stations along the northwestern coast of outer Saginaw Bay had the greatest abundance of rotifers (419 ind./liter) (TABLE 7). Polyarthra vulgaris and Keratella cochlearis were the major species, accounting for 62% of the total abundance. Although the eutrophic indicator species, Anuraeopsis fissa and K. cochlearis f. tecta, accounted for only 1% of the abundance, their presence in Group I reflected the physicochemical environment (TABLE 7).

Group II was composed of two stations along the southeast coast of outer Saginaw Bay and a single station near the northwest coast of the outer Bay. Rotifer abundance in Group II was 33% of that in Group I. Conochilus unicornis and P. vulgaris were the major rotifers, contributing 73% to total abundance (TABLE 7).

Group III consisted of a single station located on the west-central coast. Conochilus unicornis accounted for 71% of total abundance (TABLE 7). Keratella cochlearis contributed 13.5% and Polyarthra vulgaris about 10%. Synchaeta stylata and Trichocerca spp., present in other groups, were absent in Group III.

Group IV was comprised of two stations along the eastern coast. Keratella cochlearis and Polyarthra vulgaris contributed about 50% of total abundance (TABLE 7). However, Conochilus unicornis, Gastropus stylifer, Polyarthra remata, and S. stylata were also important members, contributing 46% of total abundance. The low Secchi disc visibility may have been due to near-shore turbulence.

Group V had the least mean abundance of rotifers and represented the most oligotrophic areas of the lake. Secchi disc visibility was 9.6 m and chlorophyll a concentration was 0.6 μg/liter (TABLE 7). Keratella cochlearis comprised 40% of total abundance and Conochilus unicornis and Polyarthra vulgaris represented 15.7% and 13.2%, respectively. The cold stenotherms, Notholca spp. and K. longispina, contributed about 1% and 8% respectively.

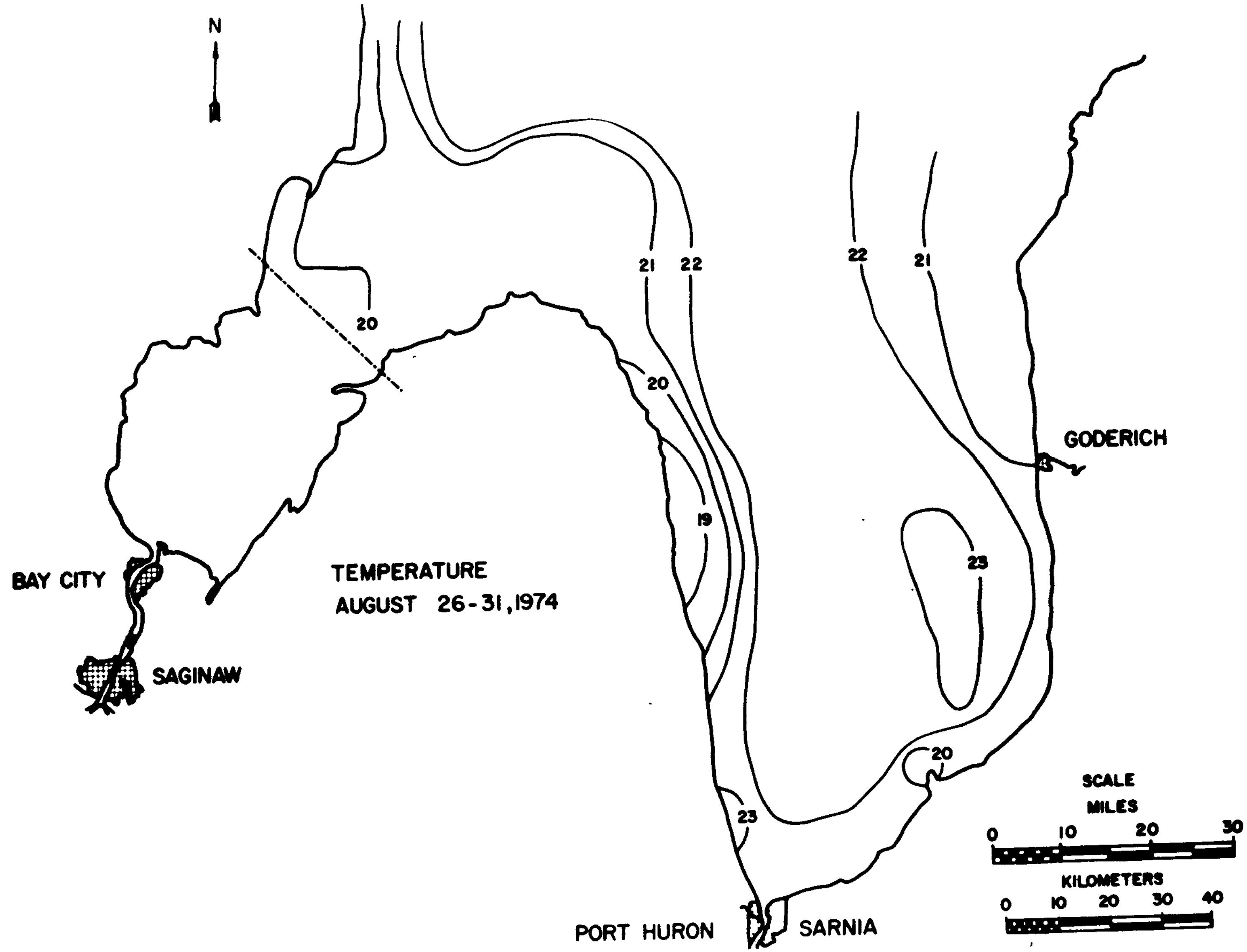

Figure 29. Surface temperatures (C) in southern Lake Huron during 26-31 August 1974.

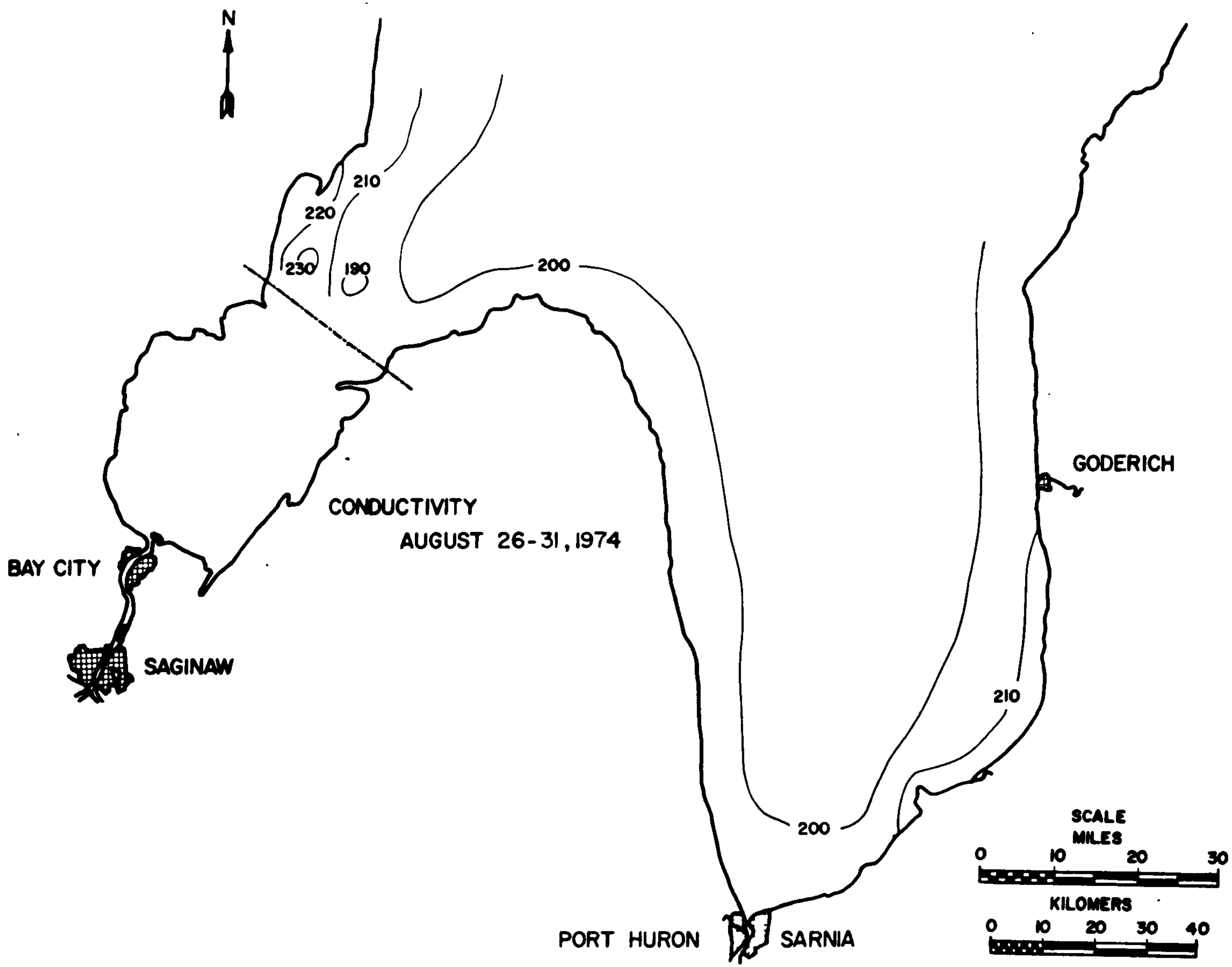

Figure 30. Surface specific conductance (µmhos/cm @ 25 C) in southern Lake Huron during August 1974.

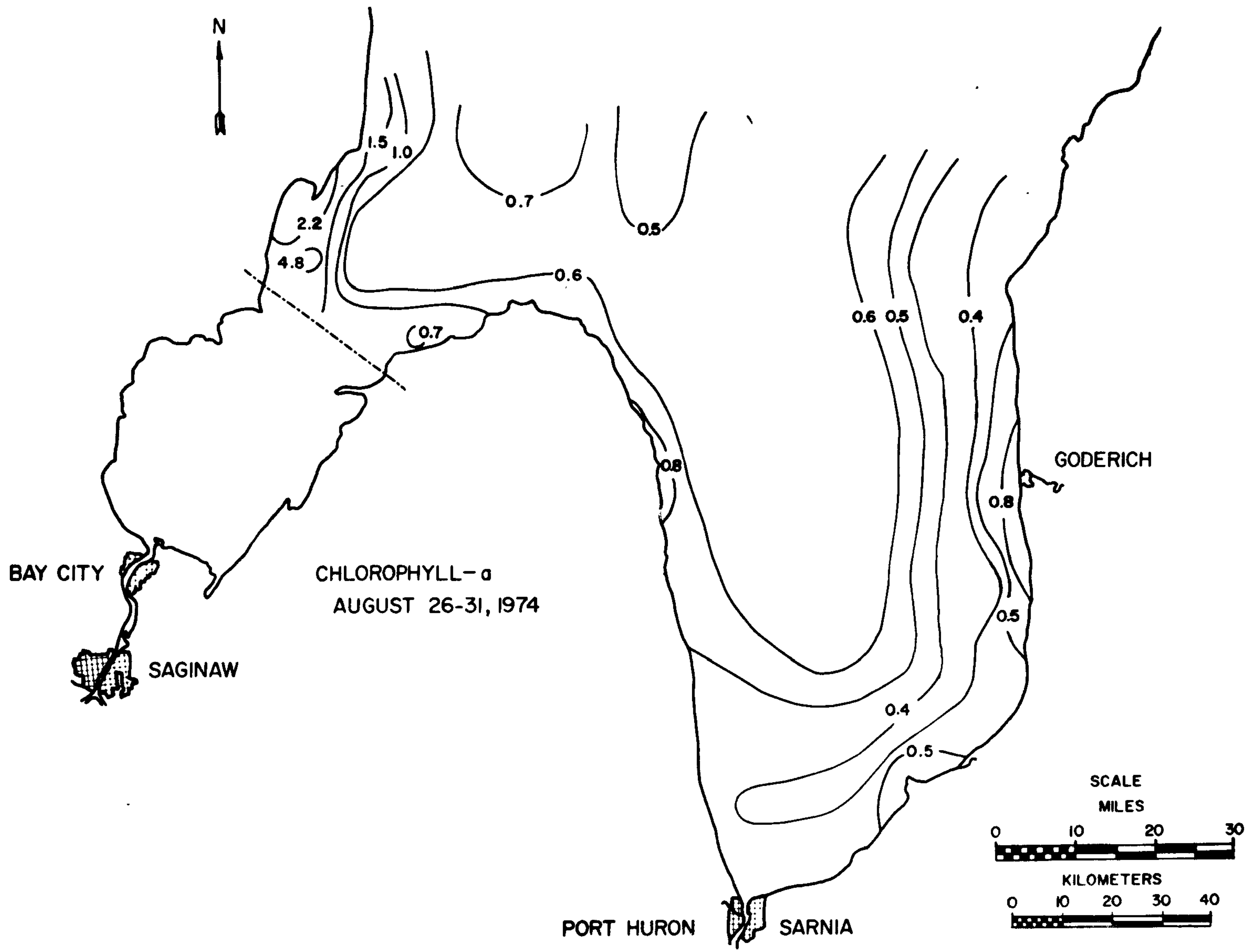

Figure 31. Surface chlorophyll *a* (μg/liter) in southern Lake Huron during August 1974.

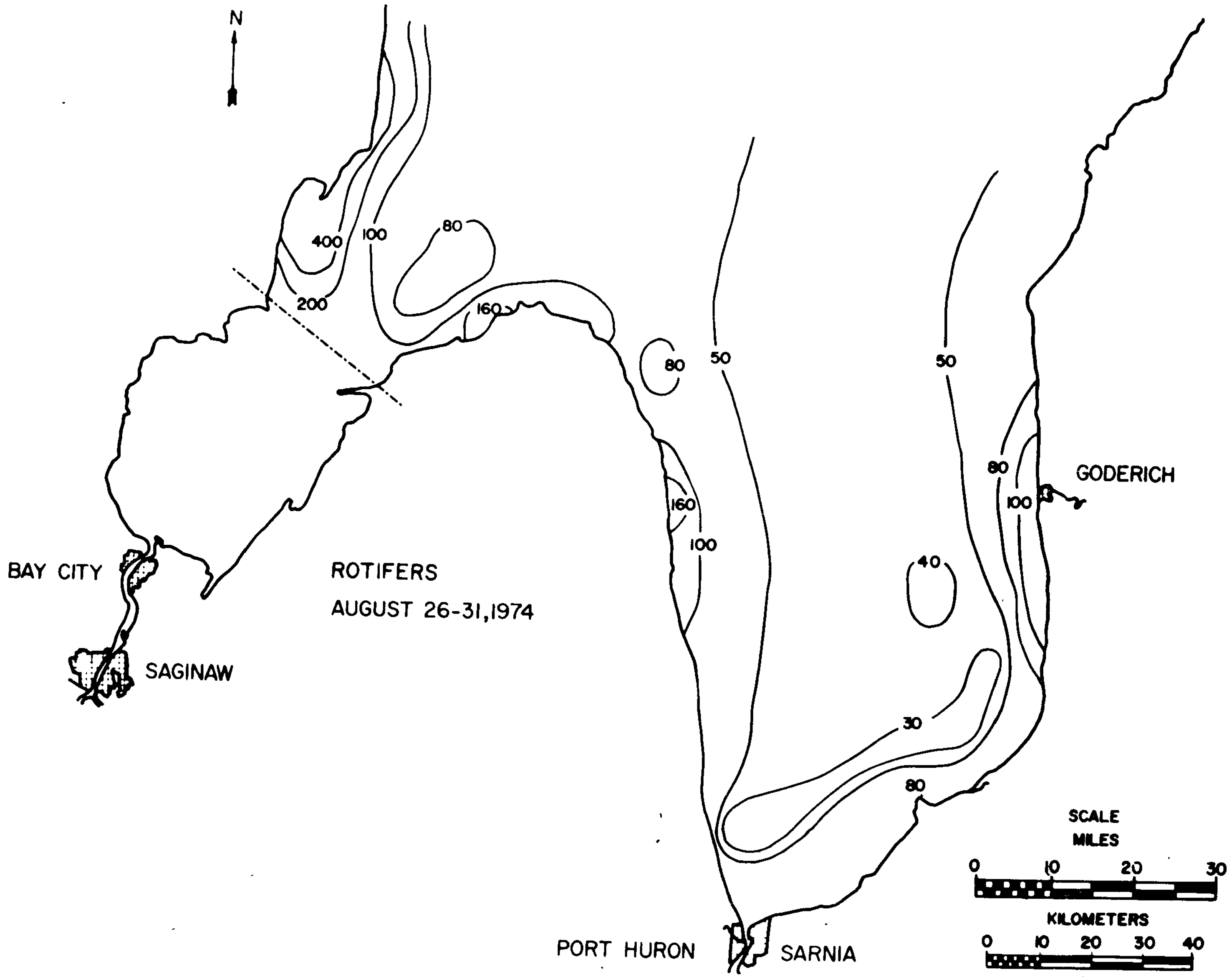

Figure 32. Distribution and abundance (number of ind./liter) of total rotifers in southern Lake Huron during August 1974

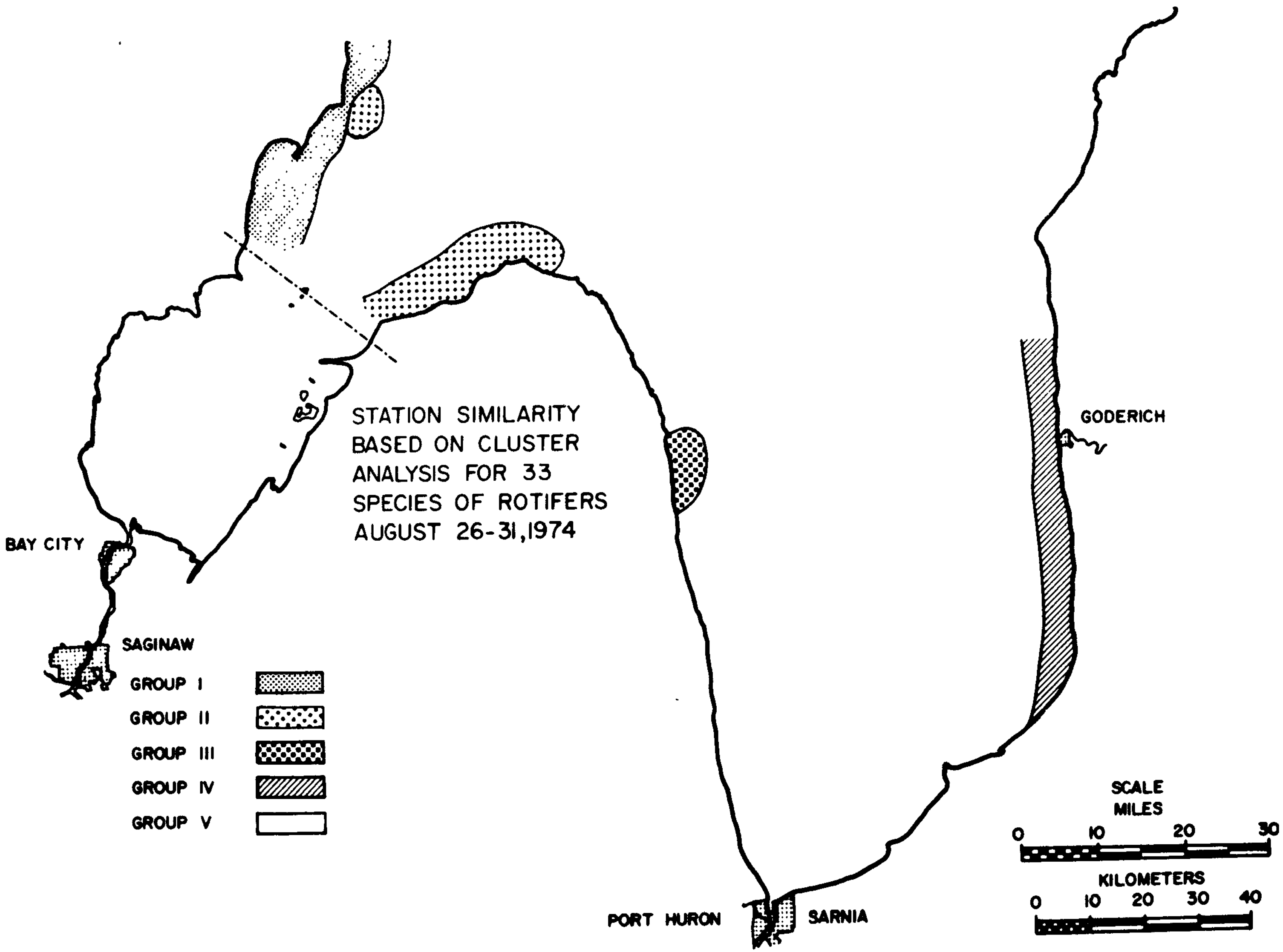

Figure 33. Grouping of 43 stations determined by cluster analysis of rotifer data for southern Lake Huron during August 1974.

TABLE 7. ABUNDANCE (MEAN NUMBER OF INDIVIDUALS/LITER) OF SELECTED ROTIFERS, PERCENT COMPOSITION AND MEAN SURFACE VALUES OF SELECTED PHYSICOCHEMICAL VARIABLES IN GROUPS OF STATIONS IDENTIFIED BY CLUSTER ANALYSIS FOR CRUISE 6

Taxon/Group	I		II		III		IV		V	
	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%
Anuraeopsis fissa	1.1	0.3	0		0		0		0	
Asplanchna priodonta	1.6	0.4	1.7	1.0	2.1	1.2	0.7	0.6	0.6	0.9
Conochilus unicornis	27.7	6.6	49.3	30.0	119.8	70.6	13.0	10.9	10.1	15.7
Collotheca mutabilis	9.0	1.0	2.1	1.3	2.1	1.2	0		2.0	3.1
Filinia longiseta	3.4	0.8	1.2	0.7	0		0		0.4	0.6
Gastropus stylifer	9.1	2.2	4.5	2.7	1.6	0.9	17.1	14.3	4.4	6.8
Kellicottia longispina	5.5	1.3	2.2	1.3	0.5	.3	1.5	1.3	5.1	7.9
Keratella cochlearis	98.0	23.4	18.8	11.4	22.9	13.5	31.0	25.9	25.9	40.2
K. cochlearis f. *tecta*	3.3	0.8	0		0		0		0	
K. cochlearis v. *hispida*	5.1	1.2	0		0		0		0.1	0.2
K. earlinae	21.4	5.1	1.4	0.9	0.5	0.3	0		1.7	2.6
Notholca spp.	0		0		0		0		0.6	0.9
Ploesoma lenticulare	2.0	0.5	0.2	0.1	0		0.9	0.8	0.1	0.2

(continued)

TABLE 7 (continued)

Taxon/Group	I		II		III		IV		V	
	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%
P. truncatum	9.3	2.2	1.7	1.0	0		0.3	0.3	0.2	0.3
Polyarthra major	5.8	1.4	3.6	2.2	0		0		0.4	0.6
P. remata	21.2	5.1	11.1	6.8	3.1	1.8	9.8	8.2	0.9	1.4
P. vulgaris	160.0	38.2	52.8	32.1	16.7	9.8	28.1	23.5	8.5	13.2
Pompholyx sulcata	1.6	0.4	0.3	0.2	0		0		0	
Synchaeta kitina	0		0		0		0		0.3	0.5
S. stylata	6.4	1.5	8.0	4.9	0		14.6	12.2	0.5	0.8
Trichocerca cylindrica	9.1	2.2	1.7	1.0	0		0.2	0.2	0.3	0.5
T. multicrinis	5.3	1.3	0.9	0.5	0		0.2	0.2	0.2	0.3
T. porcellus	5.2	1.2	0.3	0.1	0		0.4	0.3	1.3	2.0
Other rotifers	7.8	1.9	2.5	1.5	0.5	0.3	1.8	1.5	0.9	1.4
Total Rotifers/liter	418.9		164.3		169.8		119.6		64.5	

(continued)

TABLE 7 (continued)

Taxon/Group	I	II	III	IV	V
Physicochemical variables					
Secchi disc (m)	2.9	6.4	5.5	2.3	9.6
Temperature (°C)	20.6	20.3	18.2	21.2	20.5
Chlorophyll *a* (μg/ℓ)	2.7	1.0	0.81	1.0	0.6
Spec. Cond. (μmhos/cm)	222	209	206	208	201
Dissolved Phosphorus (μg/ℓ)	3.0	2.6	2.6	--	2.9
Total Phosphorus (μg/ℓ)	9.5	4.6	2.8	3.7	4.0
Chloride (μg/ℓ)	8.4	6.4	7.6	5.7	6.1
No. Stations/Group	4	3	1	2	33

Cruise Seven

Forty-two stations in Saginaw Bay and 37 stations in southern Lake Huron were sampled for rotifers during the period 6-12 October. Of the 51 species encountered, 40 occurred in Saginaw Bay and 43 in southern Lake Huron (TABLE 1). *Keratella cochlearis* and *Polyarthra vulgaris* were most abundant in Saginaw Bay. The eutrophic indicators, *K. cochlearis* f. *tecta* and *Filinia longiseta*, occurred at 35.6 and 32.5 ind./liter, respectively. *Keratella cochlearis* and *P. vulgaris* predominated in Lake Huron.

Surface temperatures in Lake Huron and Saginaw Bay had cooled more than 10 C from late August to early October (Figures 29 and 34). Distribution of surface temperatures in the open lake were nearly isothermal (12-13 C) in October and only varied slightly (10-13 C) in Saginaw Bay (Figure 34).

The highest conductivity value (600 μmhos/cm) was recorded at the mouth of the Saginaw River (Figure 35). A tongue of water from Saginaw Bay extended along the southeastern coast of Saginaw Bay to the northwest shore of southern Lake Huron. A tongue of Lake Huron water along the northwest shore of Saginaw Bay extended into the central inner bay area.

The distribution of chlorophyll *a* was similar to conductivity. High chlorophyll *a* values occurred throughout the inner bay with somewhat higher values along the southeastern shore (Figure 36). Chlorophyll *a* concentrations were 20 to 45 times higher at inner bay stations than in the open waters of Lake Huron.

The abundance of total rotifers was 20 to 40 times higher in the inner bay than in the open waters of Lake Huron (Figure 37). The high standing crop of rotifers at stations 36 and 44 in outer Saginaw Bay may have reflected patchiness due to nutrient inputs from nearby streams.

Species diversity in October was similar to that obtained in July. Although total abundance of rotifers in lower Saginaw Bay and southern Lake Huron differed significantly, species diversity indices were similar in both regions (Figure 26, 38).

Cluster analysis of the rotifer data divided the stations into seven groups (Figure 39). The analysis yielded a cophenetic correlation of 0.60, the lowest value for any cruise.

The species assemblage in Group I near the Saginaw River mouth was dominated by *Keratella cochlearis*, which comprised 46% of the total abundance (TABLE 8). Two eutrophic indicator species, *K. cochlearis* f. *tecta* and *Brachionus* spp., contributed 8.7% and 7.4%, respectively. The high standing crop of Group I (1,025 ind./liter) reflected nutrient enrichment effects from the Saginaw River. Ammonia, total phosphorus, chloride, and conductivity were 2-10 times greater than in any other group.

Group II consisted of 22 stations in the inner bay along the southeastern and northwest shores. Total abundance was about half of that in Group I, but twice as great as in adjacent Group VI. The composition percentages contributed by P. *vulgaris* (20%) and F. *longiseta* (7%) were higher than in Group I, but the composition percentage of *Brachionus* was much lower than in Group I, representing only 0.2% (TABLE 8).

Group III was represented by single inshore station (36) near the mouth of the Au Gres River, where the greatest abundance occurred (Figures 1 and 39). *Polyarthra vulgaris* and P. *remata* contributed 28.5 and 11.9%, respectively (TABLE 8). *Keratella cochlearis* contributed about 38%. The species composition percentages of Group IV were similar to Group III but the standing crop was 2.4 times less. Chlorophyll *a* values were 5 to 8 times lower than in the previous two groups.

Groups IV and V, located in near-shore areas of extreme outer Saginaw Bay, had similar total abundance, but species composition percentages of *Polyarthra vulgaris* and P. *remata* decreased significantly in Group V (TABLE 8). *Keratella cochlearis* accounted for 48% of the total abundance in Group V, about 15% greater than the species composition percentage in Group IV.

Group VI incorporated 11 stations from the middle bay region and 1 station (15) near the western shore of southern Lake Huron (Figures 1 and 39). Total abundance for this group was the lowest (355 ind./liter) of all Saginaw Bay groups (TABLE 8). The physicochemical characteristics of the group showed relatively high nutrient and chlorophyll *a* values in relation to abundance, which may reflect rapid mixing between Lake Huron and Saginaw Bay waters.

Group VII, composed of 32 open water Lake Huron stations, exhibited the lowest total abundance and most oligotrophic physicochemical environment (TABLE 8). Chlorophyll *a* was 20 to 40 times lower than in Saginaw Bay and Secchi disc depth was 13 times greater than at inner bay groups. *Keratella cochlearis* contributed 55% to total abundance and P. *vulgaris*, 13%. Cold stenotherms were poorly represented in the plankton, possibly because of relatively warm temperatures in the entire water column during autumnal overturn.

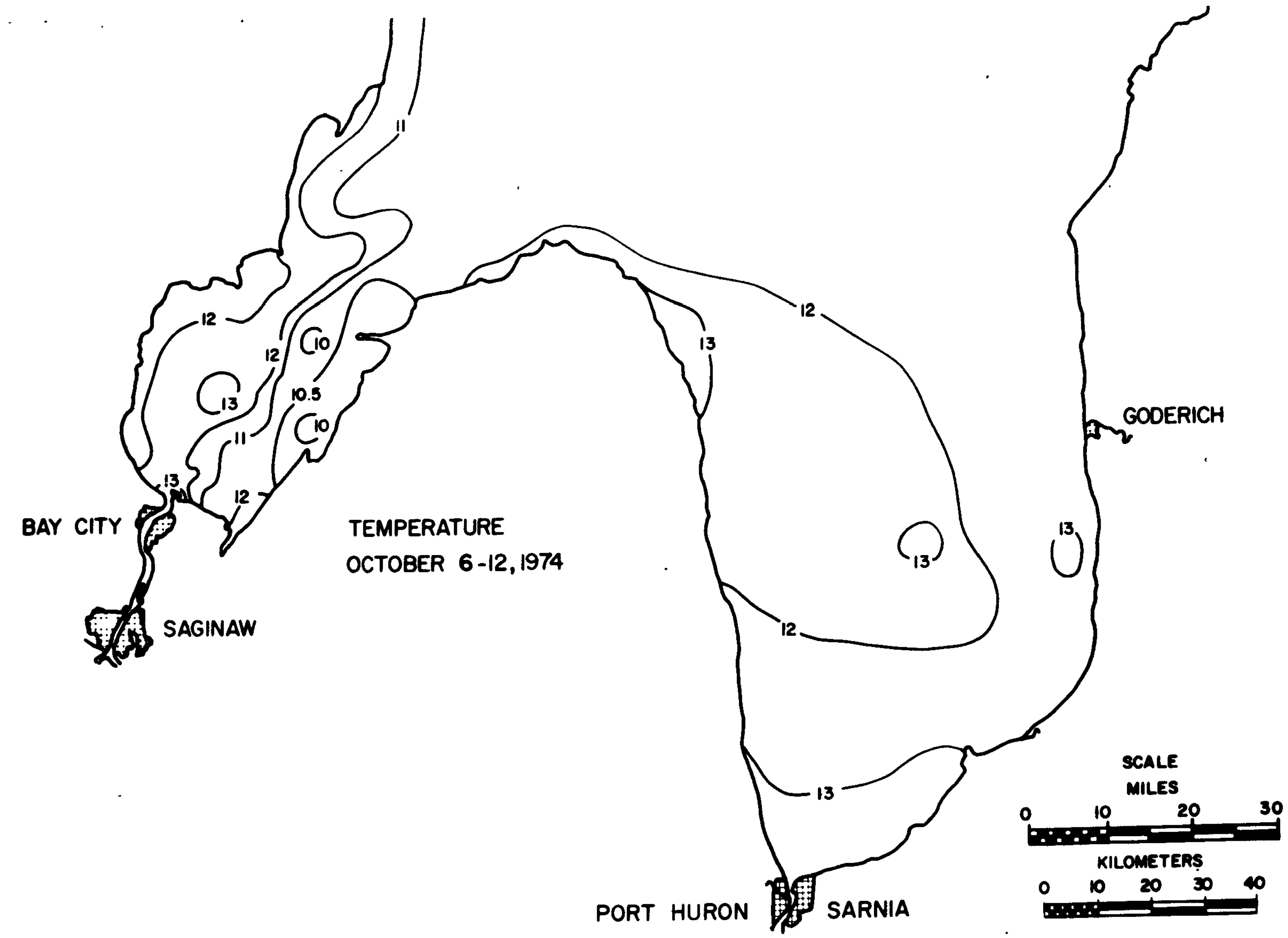

Figure 34. Surface temperatures (C) in Saginaw Bay and southern Lake Huron during 6-12 October 1974.

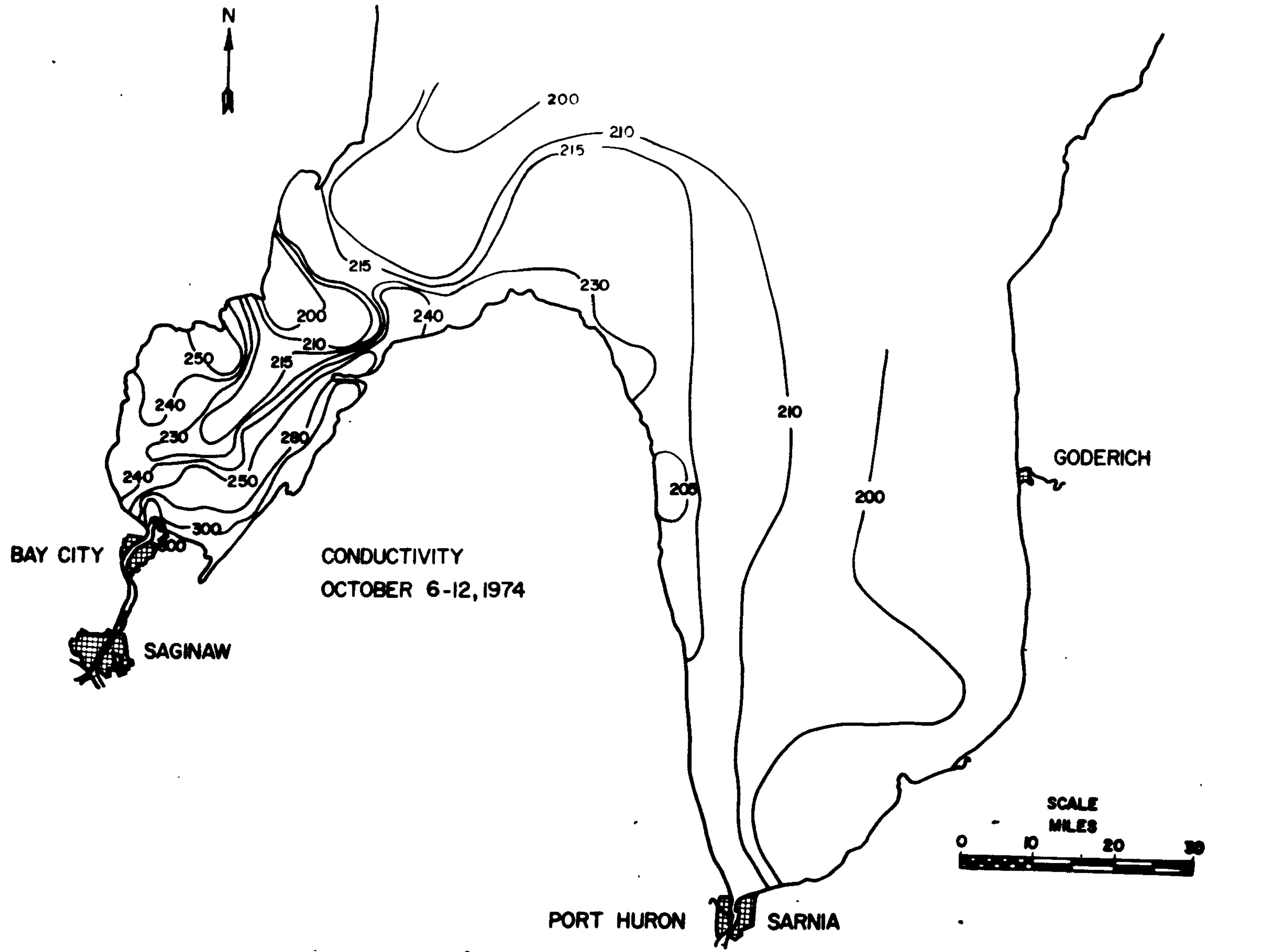

Figure 35. Surface specific conductance (µmhos/cm @ 25 C) in Saginaw Bay and southern Lake Huron during October 1974.

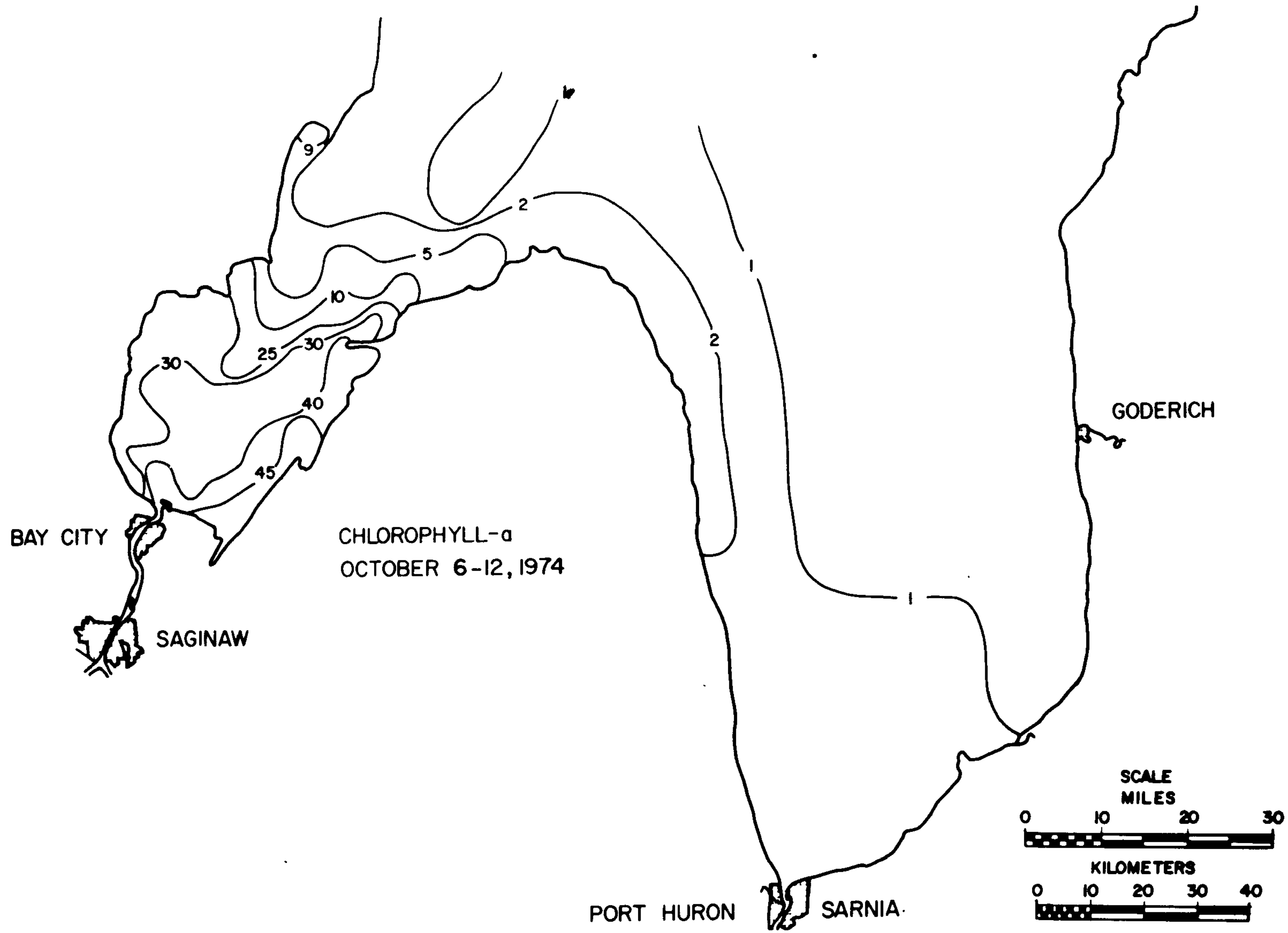

Figure 36. Surface chlorophyll a (μg/liter) in Saginaw Bay and southern Lake Huron during October 1974.

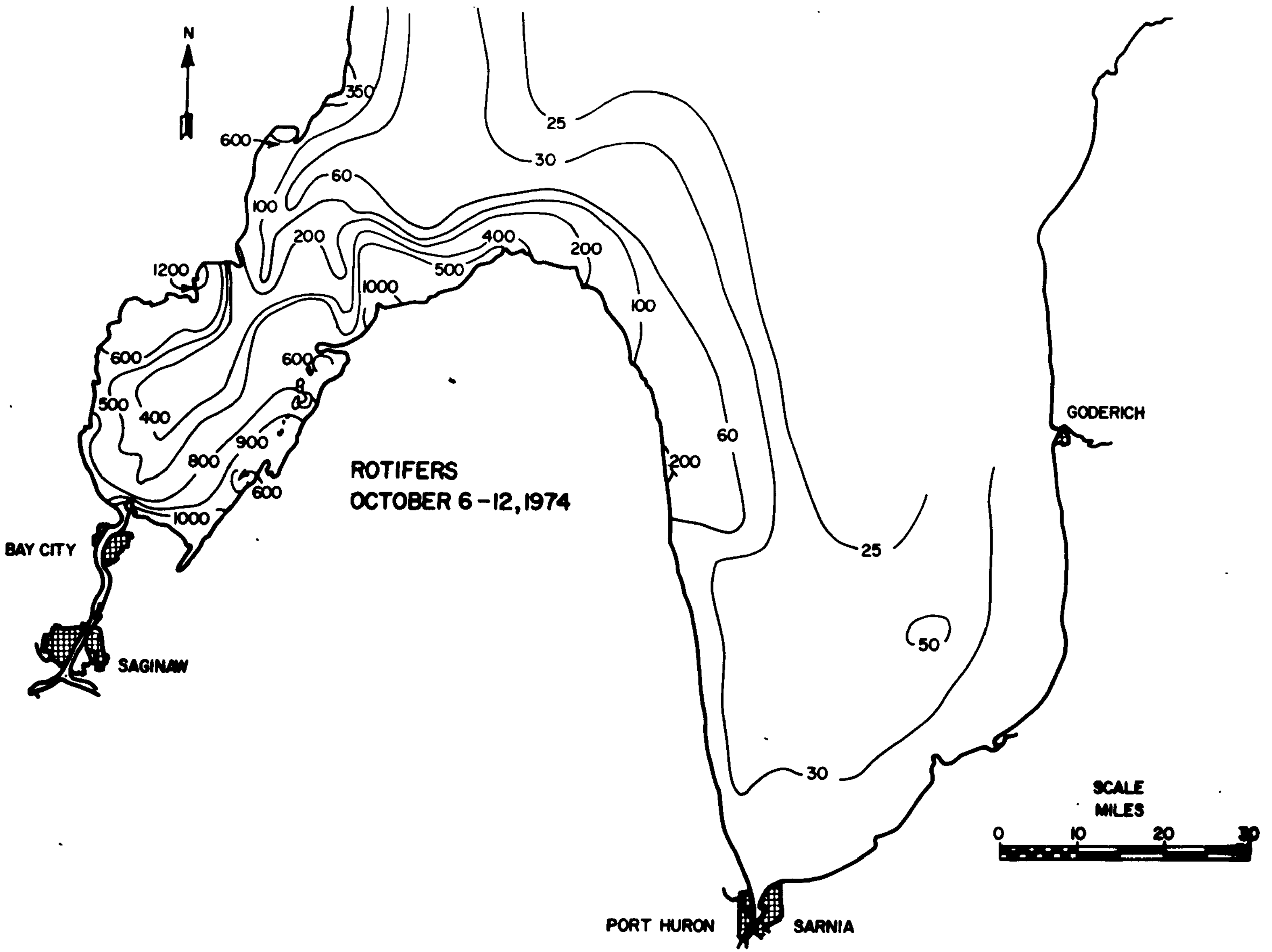

Figure 37. Distribution and abundance (number of ind./liter) of total rotifers in Saginaw Bay and southern Lake Huron during October 1974.

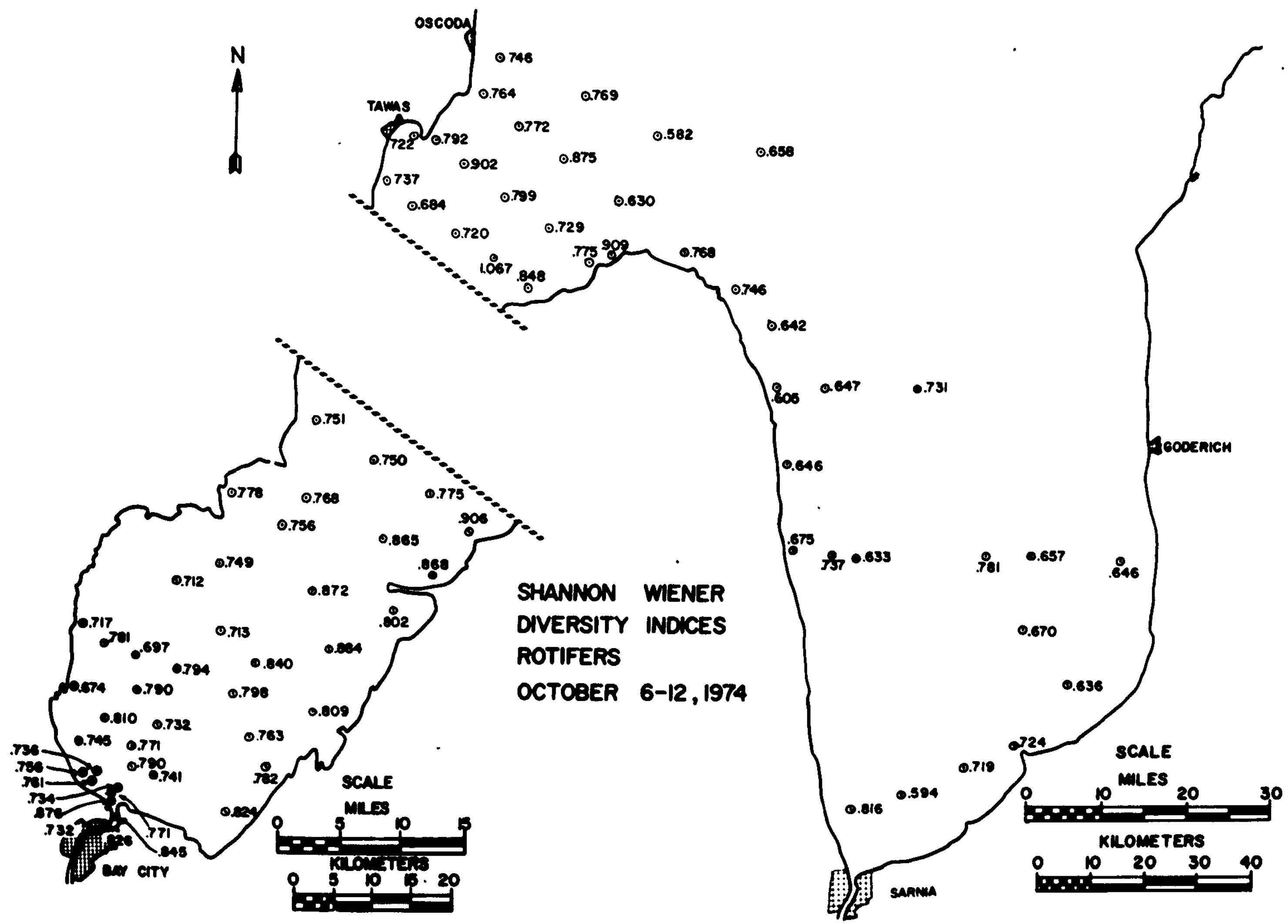

Figure 38. Shannon-Wiener diversity indices on rotifer data from 79 stations in Saginaw Bay and southern Lake Huron during October 1974.

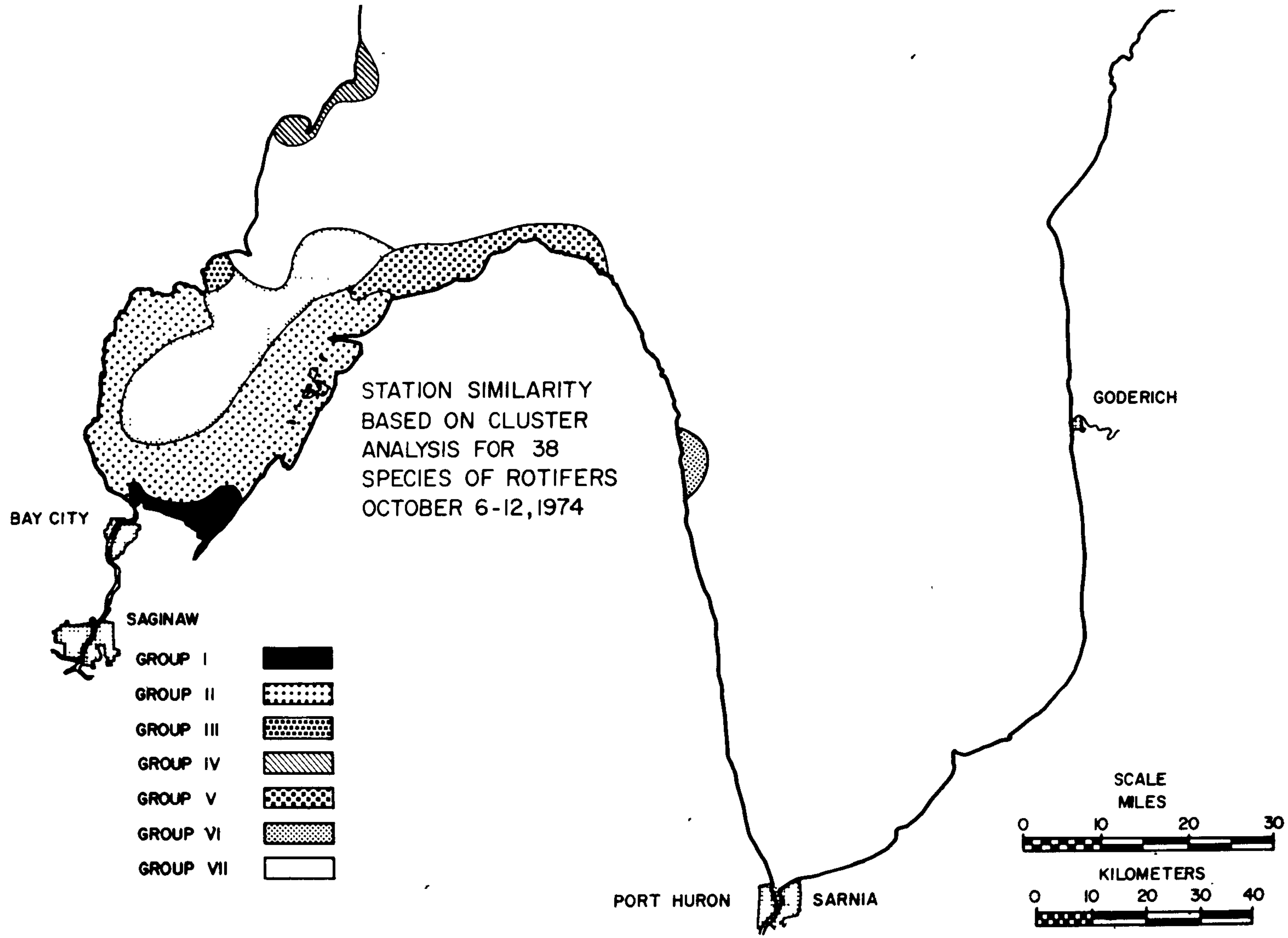

Figure 39. Grouping of 79 stations determined by cluster analysis of rotifer data for Saginaw Bay and southern Lake Huron during October 1974.

TABLE 8. ABUNDANCE (MEAN NUMBER OF INDIVIDUALS/LITER) OF SELECTED ROTIFERS, PERCENT COMPOSITION AND MEAN SURFACE VALUES OF SELECTED PHYSICOCHEMICAL VARIABLES IN GROUPS OF STATIONS IDENTIFIED BY CLUSTER ANALYSIS FOR CRUISE 7

Taxon/Group	I		II		III		IV		V		VI		VII	
	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%
Brachionus spp,	76	7.4	1	.2	0		0		0		0		0	
Chromogaster ovalis	0		0		0		0.5	.1	0.6	.1	0.4	.1	0.4	.7
Conochilus unicornis	2	.2	2	.2	3	.2	18	3.6	30	6.4	1	.3	3	4.5
Filinia longiseta	16	1.6	46	6.7	90	7.4	2	.4	6	1.2	12	3.6	0	
Gastropus stylifer	0		0		0		0		5	1.0	0.3	.1	2	4
Kellicottia longispina	0		1	.1	0		0		1	.3	1	.3	2	2.6
Keratella cochlearis	467	45.6	275	40.0	457	37.6	164	33	225	48	146	43.6	32	55.2
K. cochlearis v. *hispida*	1	.1	7	.9	6	.5	2	.3	6	1.2	4	1.0	0	
K. cochlearis v. *robusta*	0		5	.7	22	1.8	2	.3	9	2.0	3	.7	1	2.4
K. cochlearis f. *tecta*	89	8.7	35	5.1	31	2.5	3	.5	18	3.9	3	.9	0	
K. earlinae	6	.6	11	1.6	6	.5	9	1.7	20	4.3	9	2.7	1	1.3
Polyarthra remata	70	6.8	66	9.6	145	11.9	120	24	45	9.6	28	8.4	3	4.6
P. vulgaris	139	13.6	139	20.2	346	28.5	140	28	56	12	87	26	8	13.1
Synchaeta spp.	67	6.5	10	1.5	0		2	.4	0.2	.01	5	1.4	0	
S. kitina	2	.2	0.3	.1	0		0		1	.2	2	.5	0.2	.7
S. stylata	14	1.4	5	.7	0		10	2.0	9	1.9	2	.5	0.3	.5

(continued)

TABLE 8 (continued)

Taxon/Group	I		II		III		IV		V		VI		VII	
	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%	no./ℓ	%
Trichocerca cylindrica	3	0.3	5	0.7	12	1.0	3	0.5	1	0.3	1	0.4	0	
T. porcellus	13	1.3	15	2.2	6	0.5	9	1.7	7	1.4	11	3.2	2	3.1
T. rousseleti	16	1.6	20	2.9	50	4.0	4	0.8	3	0.7	8	7.6	2	3.1
T. pusilla	5	0.5	3	0.4	6	0.5	0.5	0.1	0.1	0.01	0.9	0.9	0	
T. multicrinis	2	0.2	3	0.5	0		2	0.4	2	0.5	1	0.2	0	
Lophocharis salpina	2	0.2	3	0.4	0		0		0.7	0.1	0		0	
Other rotifers	35	3.4	35.7	5.2	36	3.0	10.0	2.0	24.4	5.2	9.4	2.8	1.1	1.9
Total Rotifers/liter	1025		688		1216		501		470		335		58	
Physicochemical variables														
Secchi disc (m)	0.7		0.8		0.7		2.1		2.6		1.6		9.5	
Temperature (°C)	12.6		11.2		10.5		10.9		11.1		11.9		11.8	
Chlorophyll *a* (μg/ℓ)	43.0		33.0		24.0		5.0		11.2		20.6		1.5	
Spec. Cond. (μmhos/cm)	546		258		247		208		240		220		208	
Dissolved Phosphorus (μg/ℓ)	64		7.0		6.0		3.1		6.1		5.8		2.9	
Total Phosphorus (μg/ℓ)	132		34		24		13		17		30		5.0	
Ammonia-nitrogen (μg/ℓ)	134		31		19		35		9		23		6.3	
Chloride (μg/ℓ)	81		16		13		8.0		12		9.0		6.2	
No. Stations/Group	5		22		1		2		5		12		32	

Cruise Eight

Twenty-six stations in Saginaw Bay (11-12 November) and 40 stations in southern Lake Huron (10-14 November) were sampled for rotifers. Thirty-three species occurred in Saginaw Bay and 30 were identified in southern Lake Huron (TABLE 1). The major species in both Saginaw Bay and southern Lake Huron were *Keratella cochlearis*, *Polyarthra remata*, and *Synchaeta kitina*.

Isopleths for temperature and specific conductance were less similar to rotifer distribution than was chlorophyll *a*. Surface temperatures during this period were nearly uniform over the entire study area (Figure 40). The southeast shore of Saginaw Bay had a slightly lower temperature (8 C) than the northwest shore (9 C). In southern Lake Huron, a 10 C isotherm occurred along the eastern half of the lake. Specific conductance was 1 to 4 times greater near the Saginaw River mouth than in other areas of the lake (Figure 41). A tongue of water low in conductivity (210 μmhos/cm) penetrated into the middle bay region from the north, indicating a counter-clockwise circulation. Values ranging fom 215 to 225 μmhos/cm occurred in southern Lake Huron. Chlorophyll *a* concentrations were 40 to 50 times higher at inner bay stations than in the open waters of Lake Huron, ranging from 30 μg/liter near Saginaw River to less than 1 μg/liter at outer bay and open lake stations (Figure 42). Rotifer distribution was most similar to chlorohyll *a* distribution, especially in Saginaw Bay and along the southwest shore of Lake Huron (Figures 42 and 43). Greatest abundance (1,000-2,500 ind./liter) occurred at near-shore inner bay stations. A standing crop of 300 to 1,000 rotifers/liter extended along the northwestern shore of the bay. Greatest abundance in southern Lake Huron (50-100/liter) occurred along the western shore below the mouth of Saginaw Bay. Abundance at open lake stations was only 20 to 25 ind./liter.

Cluster analysis divided other Saginaw Bay and southern Lake Huron stations into three groups (Figure 44). Saginaw Bay stations were omitted from the analysis since bad weather did not permit the sampling of a sufficient number of stations. The analysis yielded a cophenetic correlation of 0.78.

Group I abundance was three times greater than Group II and nine times greater than Group III (TABLE 9). The species composition percentage of *Keratella cochlearis* was similar for the three groups (40-49%). *Polyarthra remata*, however, accounted for 12 to 13.5% of total abundance in Groups I and II but only 5% in Group III. *Synchaeta kitina* displayed a similar distribution, contributing 10.6 and 12.2% to total abundance in Groups I and II, respectively, but only 5% in Group III. In contrast, composition percentage of *Gastropus stylifer* was greater in Group III. The abundance of *Notholca* spp. was too low to assess any significance to its distribution.

The trends in chlorophyll *a* distribution, Secchi disc visibility, chloride and total phosphorus concentration among the three groups parallelled the trends in rotifer abundance. However, specific conductance, temperature, and dissolved phosphorus values were inconsistant with the trends in other physicochemical variables (TABLE 9; Figures 42, 43, and 44).

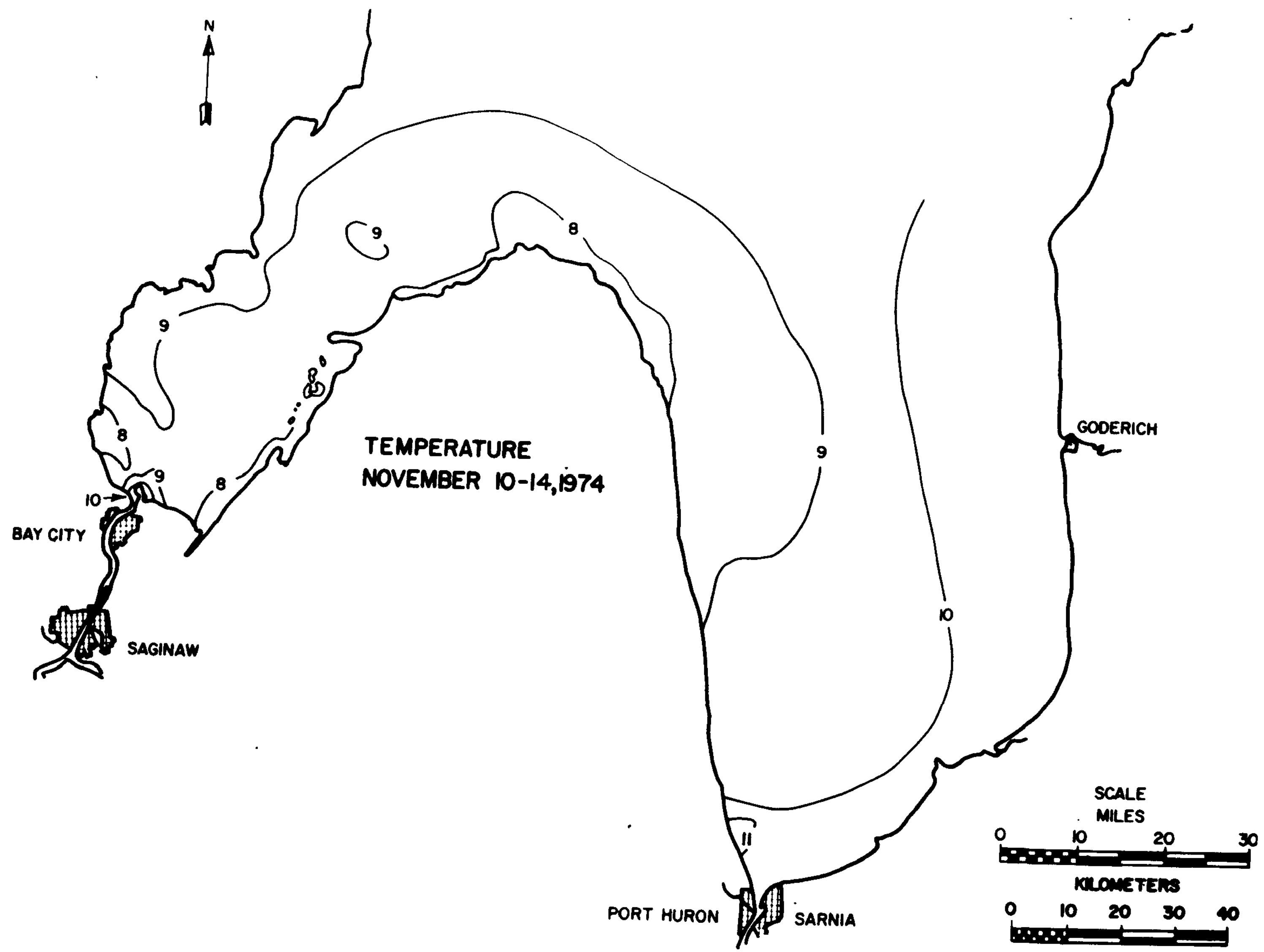

Figure 40. Surface temperatures (C) in Saginaw Bay and southern Lake Huron during 10-13 November 1974.

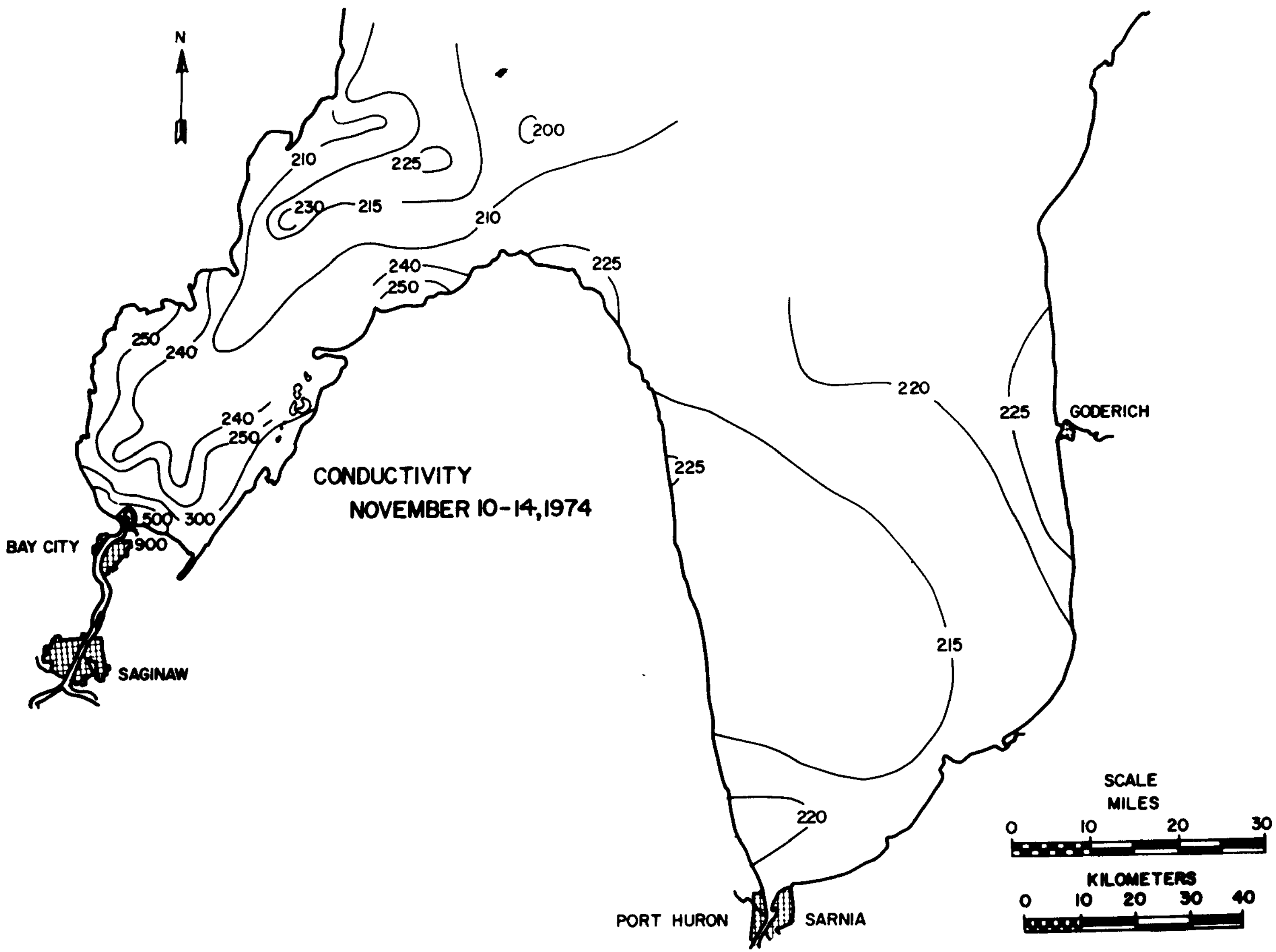

Figure 41. Surface specific conductance (μmhos/cm @ 25 C) in Saginaw Bay and southern Lake Huron during November 1974.

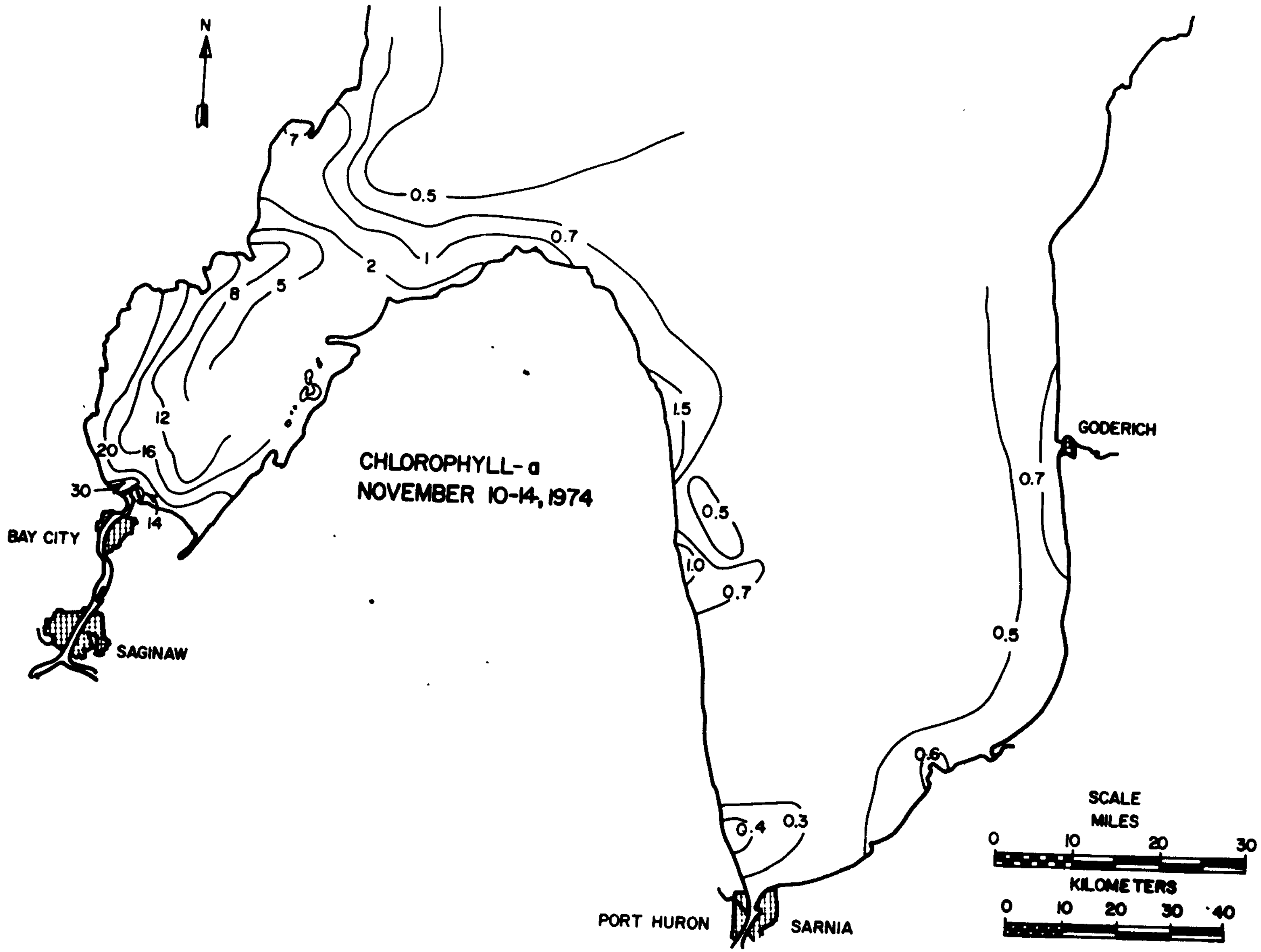

Figure 42. Surface chlorophyll *a* (μg/liter) in Saginaw Bay and southern Lake Huron during November 1974.

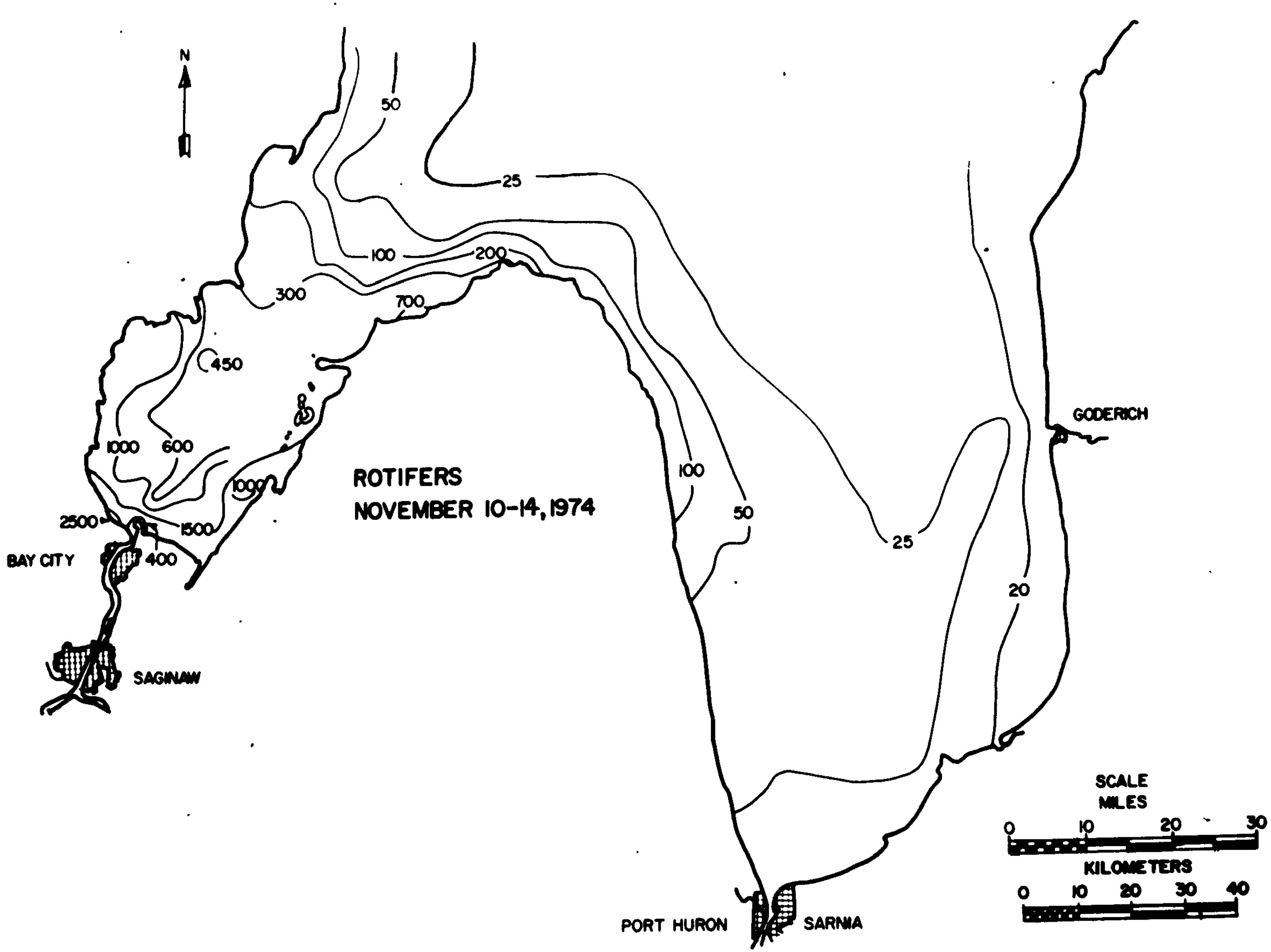

Figure 43. Distribution and abundance (number of ind./liter) of total rotifers in Saginaw Bay and southern Lake Huron during November 1974.

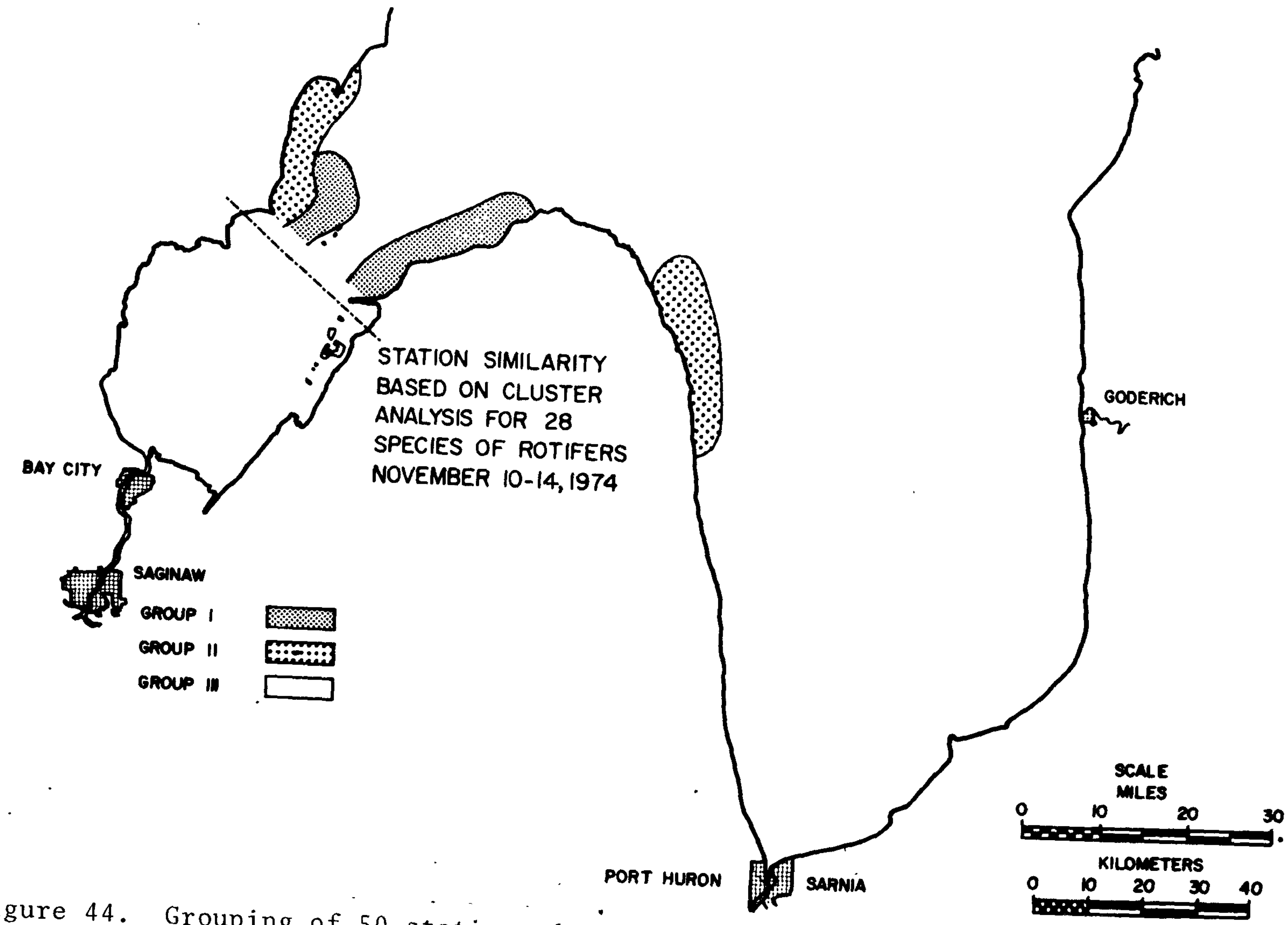

Figure 44. Grouping of 50 stations determined by cluster analysis of rotifer data for southern Lake Huron during November 1974.

TABLE 9. ABUNDANCE (MEAN NUMBER OF INDIVIDUALS/LITER) OF SELECTED ROTIFERS, PERCENT COMPOSITION AND MEAN SURFACE VALUES OF SELECTED PHYSICOCHEMICAL VARIABLES IN GROUPS OF STATIONS IDENTIFIED BY CLUSTER ANALYSIS FOR CRUISE 8

Taxon/Group	I		II		III	
	no./ℓ	%	no./ℓ	%	no./ℓ	%
Collotheca mutabilis	1	0.3	1	0.8	1	2.4
Conochilus unicornis	8	2.2	2	1.6	2	4.9
Gastropus stylifer	7	2.0	8	6.5	5	12.2
Kellicottia longispina	3	0.8	3	2.4	1	2.4
Keratella cochlearis	145	40.1	54	43.9	20	48.8
K. cochlearis f. *tecta*	3	0.8	0		0	
K. cochlearis v. *robusta*	11	3.0	4	3.3	1	2.4
K. earlinae	26	7.2	6	4.9	2	4.9
K. quadrata	16	4.4	2	1.6	1	2.4
Notholca spp.	0.4	0.1	0.1	0.1	0.2	.5
Polyarthra major	0.2	0.1	0		0	
P. remata	49	13.5	15	12.2	2	4.9
P. vulgaris	13	3.6	9	7.3	3	7.3
Pompholyx sulcata	0.2	0.1	0		0	
Synchaeta spp.	1	0.3	0.4	0.3	0.1	0.2
S. kitina	71	19.6	15	12.2	2	4.9
Trichocerca porcellus	1	0.3	2	1.6	1	2.4
T. rousseleti	2	0.6	1	0.8	1	2.4
Other rotifers	42	1.2	0.5	0.4	0	
Total Rotifers/liter	362		123		41	

(continued)

TABLE 9 (continued)

Taxon/Group	I	II	III
Physicochemical variables			
Secchi disc (m)	2.8	4.0	7.2
Temperature (°C)	8.6	8.7	9.3
Chlorophyll *a* (μg/ℓ)	3.8	1.6	0.6
Spec. Cond. (μmhos/cm)	230	216	216
Dissolved Phosphorus (μg/ℓ)	3.1	4.2	3.6
Total Phosphorus (μg/ℓ)	10.2	5.7	5.5
Ammonia-nitrogen (μg/ℓ)	13.7	16.7	6.2
Chloride (μg/ℓ)	7.6	6.3	6.0
No. Stations/Group	6	6	32

VERTICAL DISTRIBUTION

Cruises One and Two

In May, temperature and chlorophyll a distribution were uniform throughout the water column (Figures 45 and 46). Rotifer abundances were also evenly distributed in the column, with the exception of Notholca squamula, which displayed maximum abundance near bottom (Figures 45 and 46). This cold stenotherm was the predominant species, comprising between 50 and 75% of the total rotifers at each depth.

Cruises Three and Four

In early June, nearly isothermal conditions prevailed at station 21, the deep, open-water station, but thermal stratification occurred at stations 43 and 60 (Figure 47). Chlorophyll a concentrations were lower in the upper waters, but remained at approximately 3 µg/liter from mid-depth to the bottom at all three stations (Figure 47). Considerable differences in vertical distribution, species composition, and abundance of rotifers were apparent. Relatively low, but evenly distributed abundance occurred throughout the column at station 21 and Notholca spp. predominated. However, at the shallower stations (43 ad 60), stratification of rotifer speccies occurred, with major concentrations in and around the metalimnion. The eurythermal species, Keratella cochlearis and Kellicottia longispina, were most abundant in the warmer waters of the upper and middle portions of the column. Synchaeta kitina, the most abundant rotifer at station 43, represented 50% of the total abundance in the lower depths of the hypolimnion.

In mid-June, thermal stratification was still weakly developed and chlorophyll a concentrations remained low throughout the water column (Figure 48). Although the metalimnion was poorly defined, total rotifers exhibited a pronounced maximum in this zone. The peak was primarily due to population maxima for Notholca squamula, Keratella cochlearis, and Conochilus unicornis in the metalimnion (Figure 48). Maximum abundance of Polyarthra vulgaris consistently occurred in shallower depths than the peak abundance of K. cochlearis. The cold stenothern, N. laurentiae, was most prevalent in thee hypolimnion where water temperatures were less than 8 C (Figure 48).

Cruises Five and Six

Thermal stratification was well-developed in July ad August. chlorophyll a levels increased slightly and a peak occurred near the top of the hypolimnion (Figures 49 and 50). Rotifer abundances reqched maximum levels in July at all three stations. Rotifer values at the inshore station (43) were 2 to 10 times higher than at the two offshore station (Figure 49). Rotifer concetrations were greatly reduced in August at all three stations (Figure 50).

Many rotifer species exhibited pronounced vertical stratification with greatest concentrations in and near the metalimnion (Figures 49 and 50). Conochilus unicornis, Polyarthra remata, and P. vulgaris exhibited maximum abundance in the epilimnion and Keratella cochlearis, Keratella spp., and Kellicottia longispina were most abundant in the middle to bottom of the metalimnion. Cold water stenotherms such as Notholca laurentiae, N. squamula, and *Synchaeta lakowitziana* occurred only in the hypolimnion (Figures 49 and 50). *Synchaeta kitina*, primarily a spring and fall species, also exhibited a hypolimnetic maximum.

Cruises Seven and Eight

Isothermal condition occurred at all stations in October and November. Both chlorophyll *a* and rotifers were again more evenly distributed at all depths. *Keratella cochlearis* was the predominant species, comprising between 50 and 60% of the total rotifer plankton (Figure 51).

Correlation analyses based on raw values for physicochemical variables and log-transformed rotifer data at discrete depths were performed as an exploratory procedure to evaluate those factors related to vertical distribution of major species (TABLES 10 and 11).

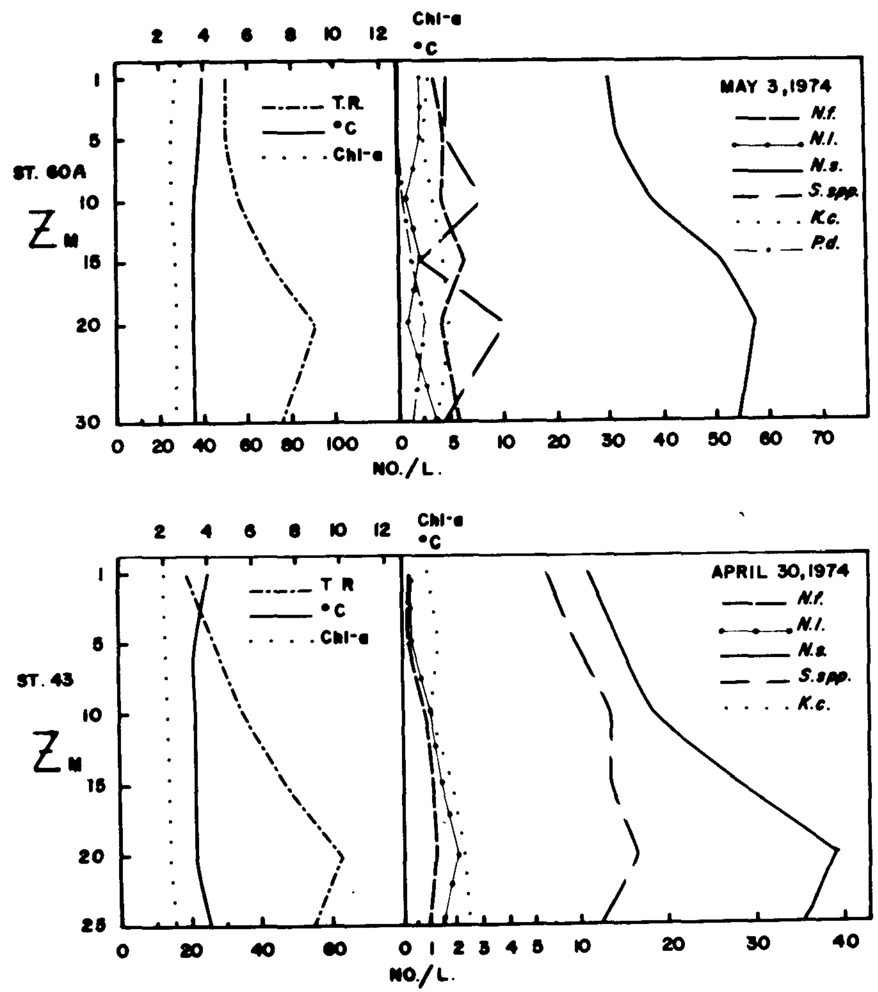

Figure 45. Vertical distribution of temperature (C), chlorophyll *a* (μg/liter), total rotifers and selected rotifer species (number of ind./liter) during Cruise 1 at stations 43 and 60A. N.f. = *Notholca foliacea;* N.l. = *N. laurentiae;* N.s. = *N. squamula;* S. spp. = *Synchaeta asymmetrica, S. lakowitziana, S. oblonga;* K.c. = *Keratella cochlearis;* P.d. = *Polyarthra dolichoptera.*

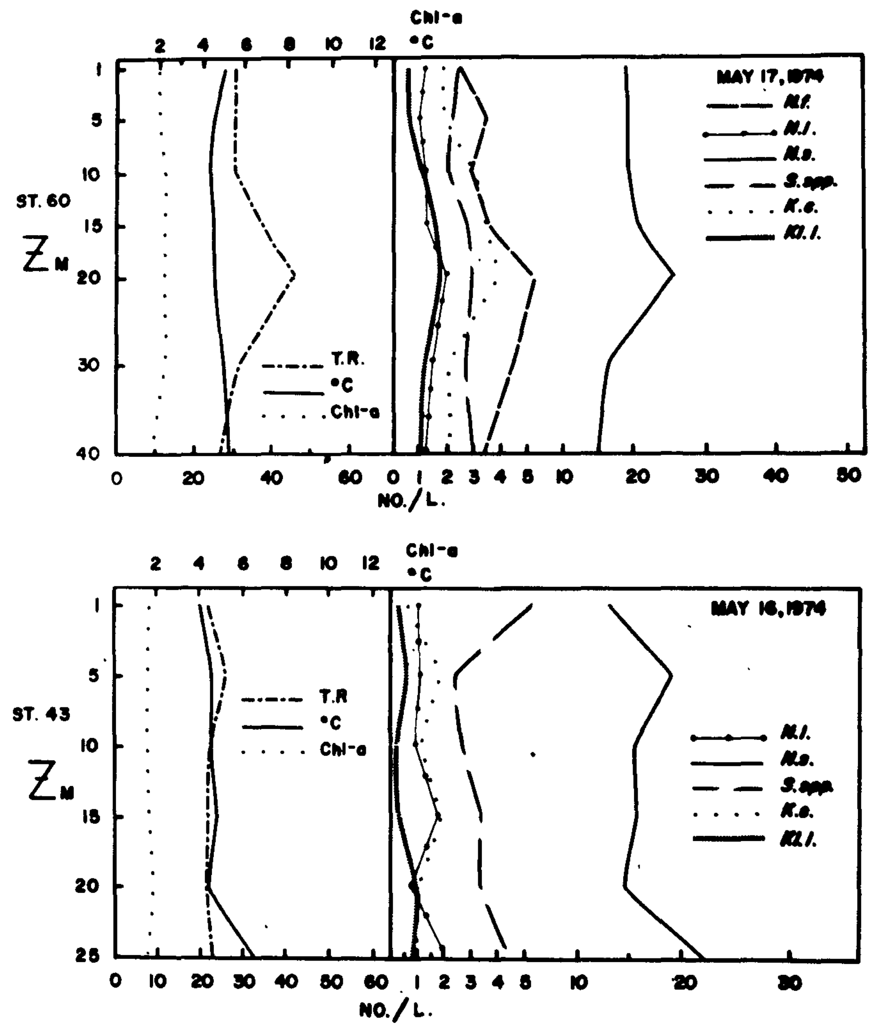

Figure 46. Vertical distribution of temperature (C), chlorophyll *a* (μg/liter), total rotifers and selected rotifer species (number of ind./liter) during Cruise 2 at stations 43 and 60. N.f. = *Notholca foliacea;* N.l. = *N. laurentiae;* N.s. = *N. squamula;* S. spp. = *Synchaeta asymmetrica, S. lakowitziana, S. oblonga;* K.c. = *Keratella cochlearis;* Kl.l. = *Kellicottia longispina.*

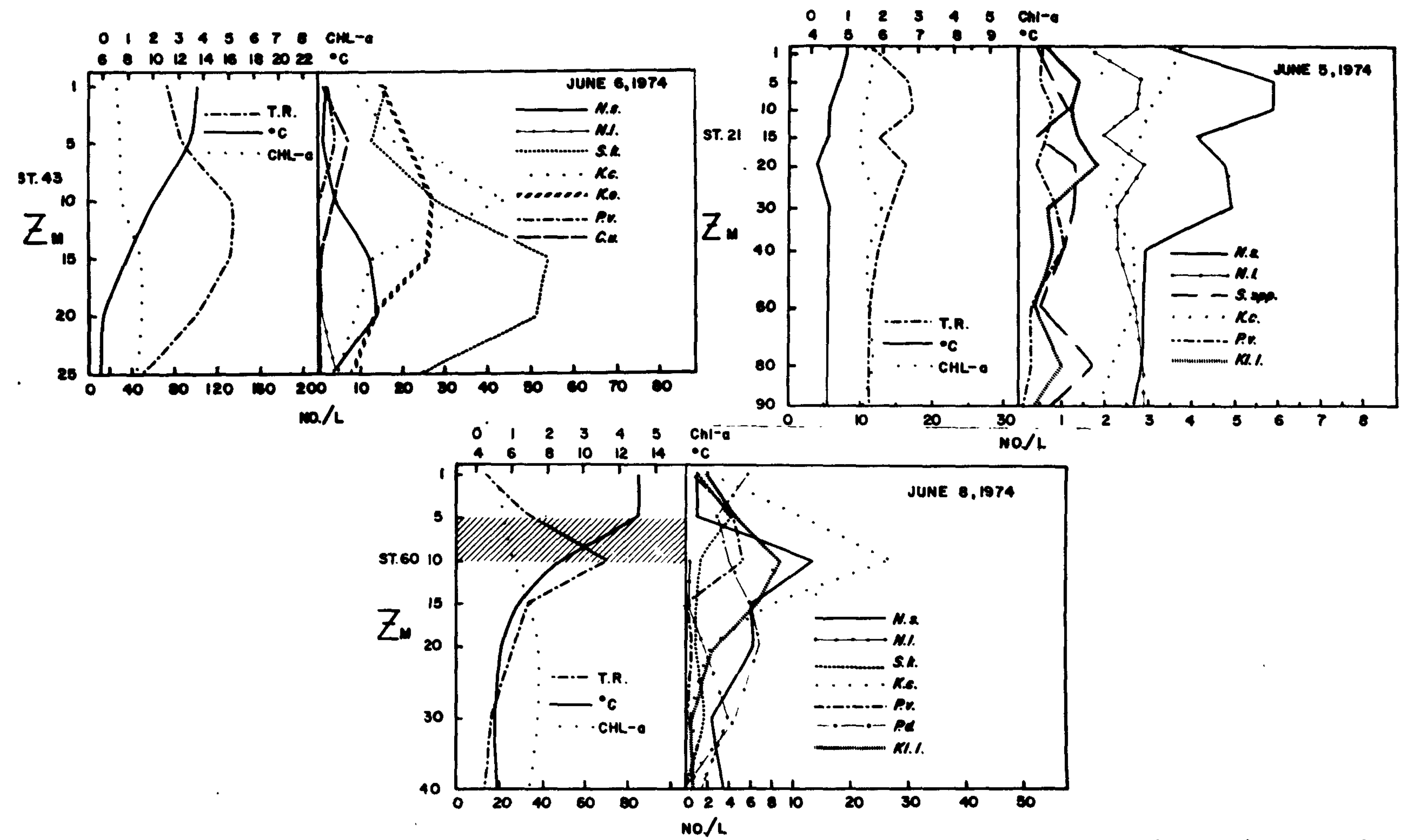

Figure 47. Vertical distribution of temperature (C), chlorophyll *a* (µg/liter), total rotifers and selected rotifer species (number of ind./liter) during Cruise 3 at stations 21, 43, and 60. N.s. = *Notholca squamula;* N.l. = *N. laurentiae;* S. spp. = *Synchaeta asymmetrica, S. lakowitziana, S. oblonga;* S.k. = *Synchaeta kitina;* K.c. = *Keratella cochlearis;* K.e. = *K. earlinae;* P.v. = *Polyarthra vulgaris;* P.d. = *P. dolichoptera;* Kl.l. = *Kellicottia longispina;* C.u. = *Conochilus unicornis.* The shaded area delineates the metalimnion.

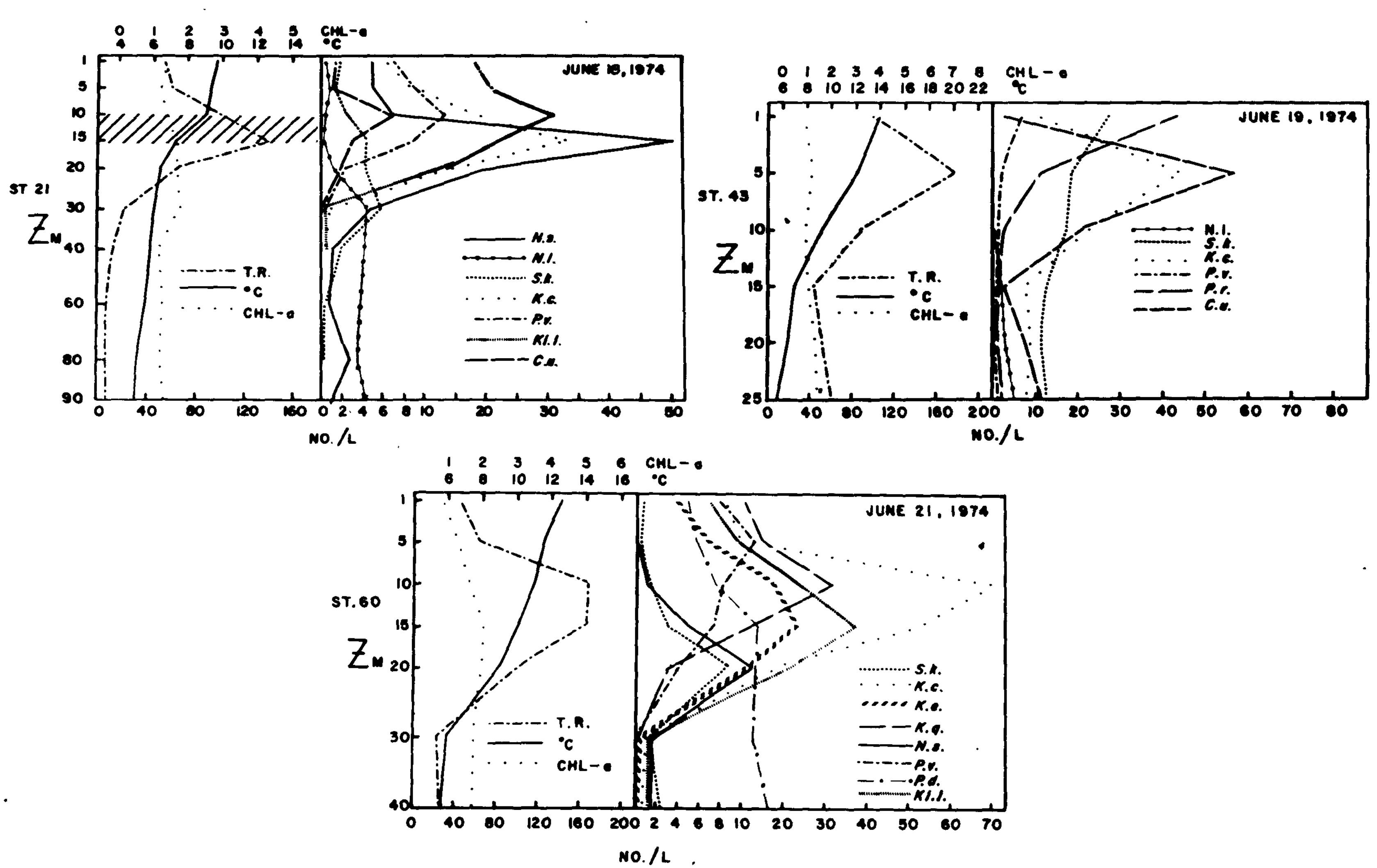

Figure 48. Vertical distribution of temperature (C), chlorophyll *a* (μg/liter), total rotifers and selected rotifer species (number of ind./liter) during Cruise 4 at stations 21, 43, and 60. N.s. = *Notholca squamula;* N.l. = *N. laurentiae;* S.k. = *Synchaeta kitina;* K.q. = *K. quadrata;* P.v. = *Polyarthra vulgaris;* P.d. = *P. dolichoptera;* P.r. = *P. remata;* Kl.l. = *Kellicottia longispina;* C.u. = *Conochilus unicornis.* The shaded area delineates the metalimnion.

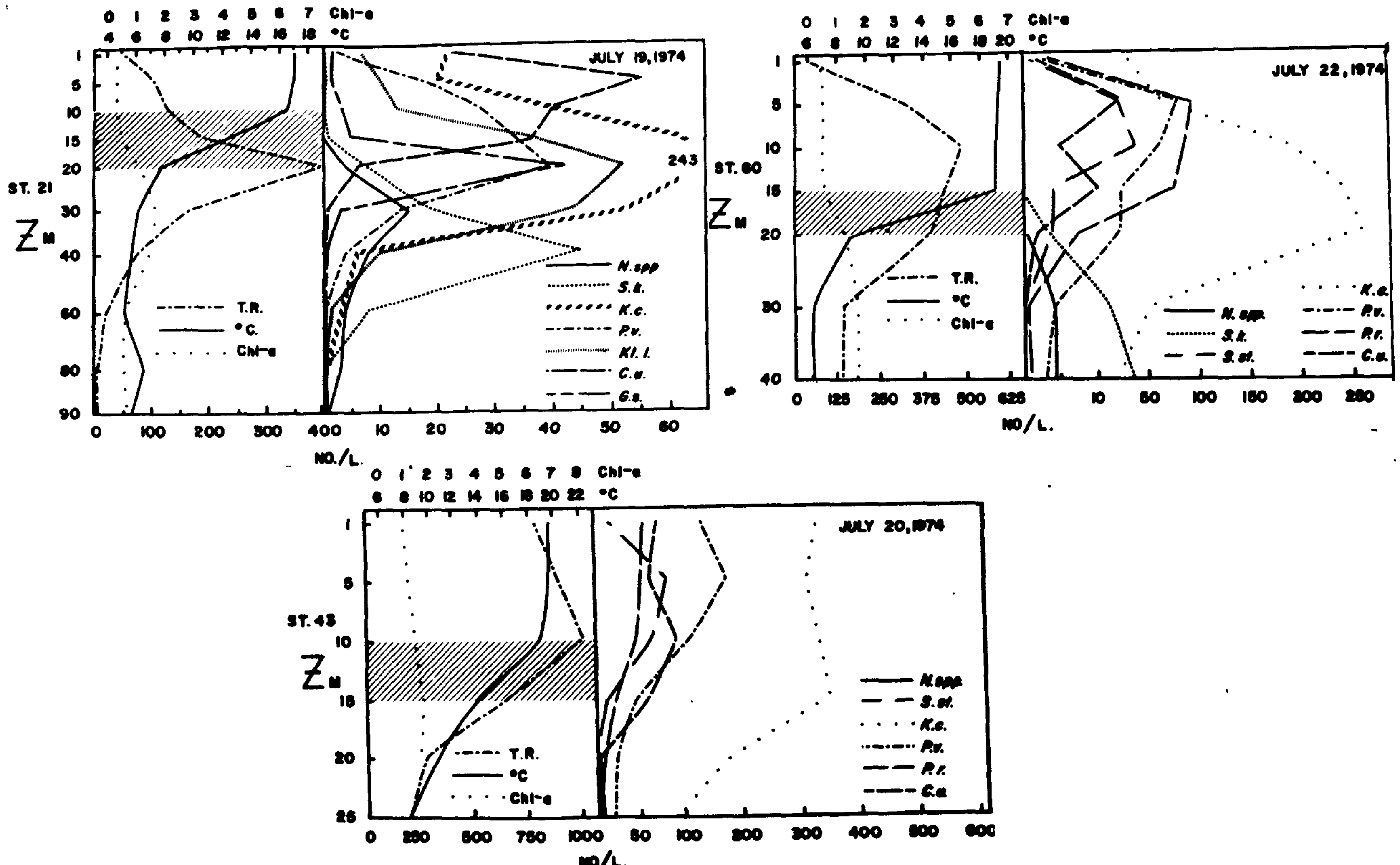

Figure 49. Vertical distribution of temperature (C), chlorophyll *a* (µg/liter), total rotifers and selected rotifer species (number of ind./liter) during Cruise 5 at stations 21, 43, and 60. N.spp. = *Notholca squamula* and *N. laurentiae;* S.k. = *Synchaeta kitina;* S.st. = *S. stylata;* K.c. = *Keratella cochlearis;* P.v. = *Polyarthra vulgaris;* P.r. = *P. remata;* Kl.l. = *Kellicottia longispina;* C.u. = *Conochilus unicornis;* G.s. = *Gastropus stylifer.* The shaded area delineates the metalimnion.

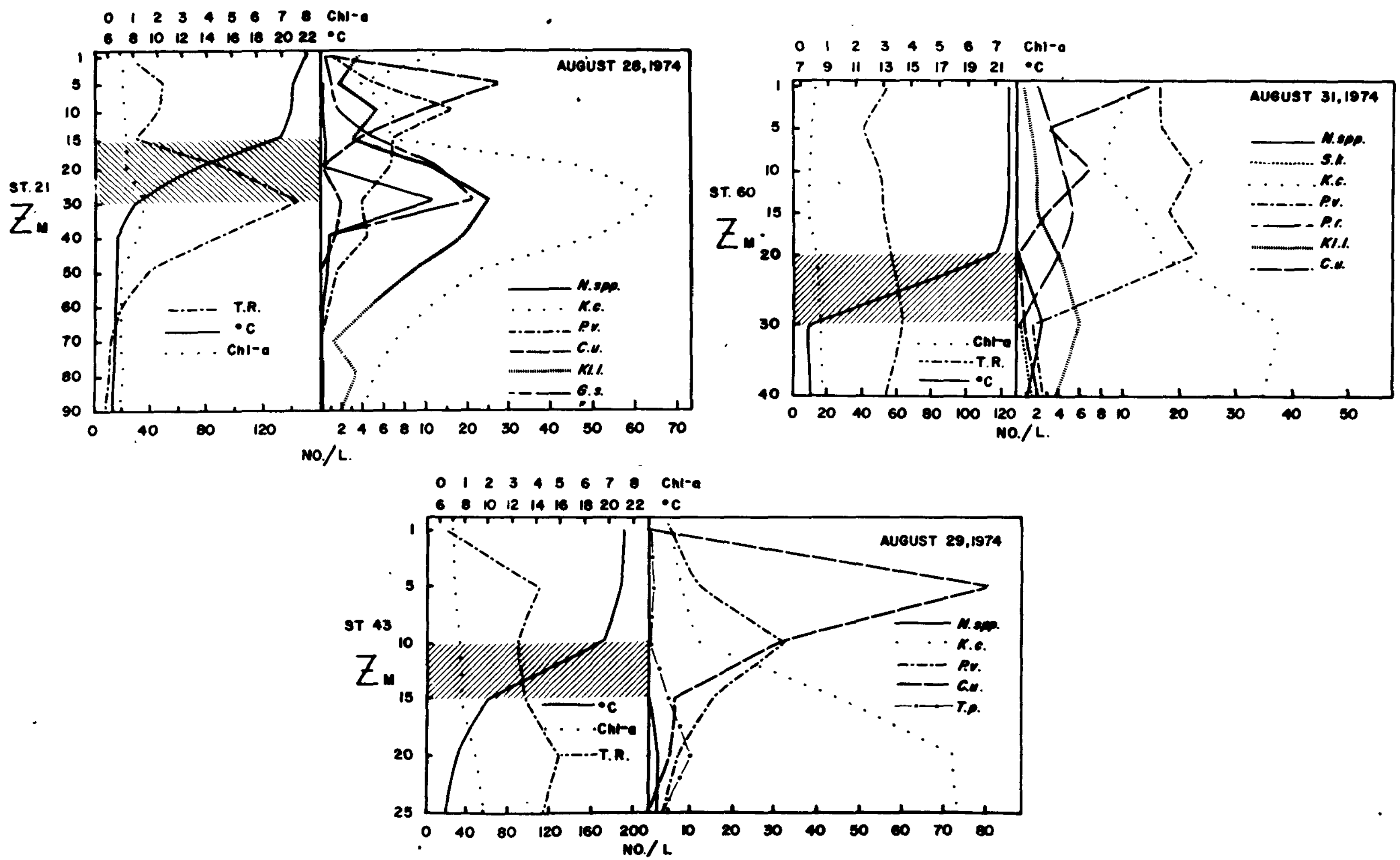

Figure 50. Vertical distribution of temperature (C), chlorophyll *a* (µg/liter), total rotifers and selected rotifer species (number of ind./liter) during Cruise 6 at stations 21, 43, and 60. N.spp. = *Notholca squamula* and *N. laurentiae;* K.c. = *Keratella cochlearis;* P.v. = *Polyarthra vulgaris;* P.r. = *P. remata;* C.u. = *Conochilus unicornis;* Kl.l. = *Kellicottia longispina;* G.s. = *Gastropus stylifer;* S.k. = *Synchaeta kitina;* T.p. = *Trichocerca porcellus.* The shaded area delineates the metalimnion.

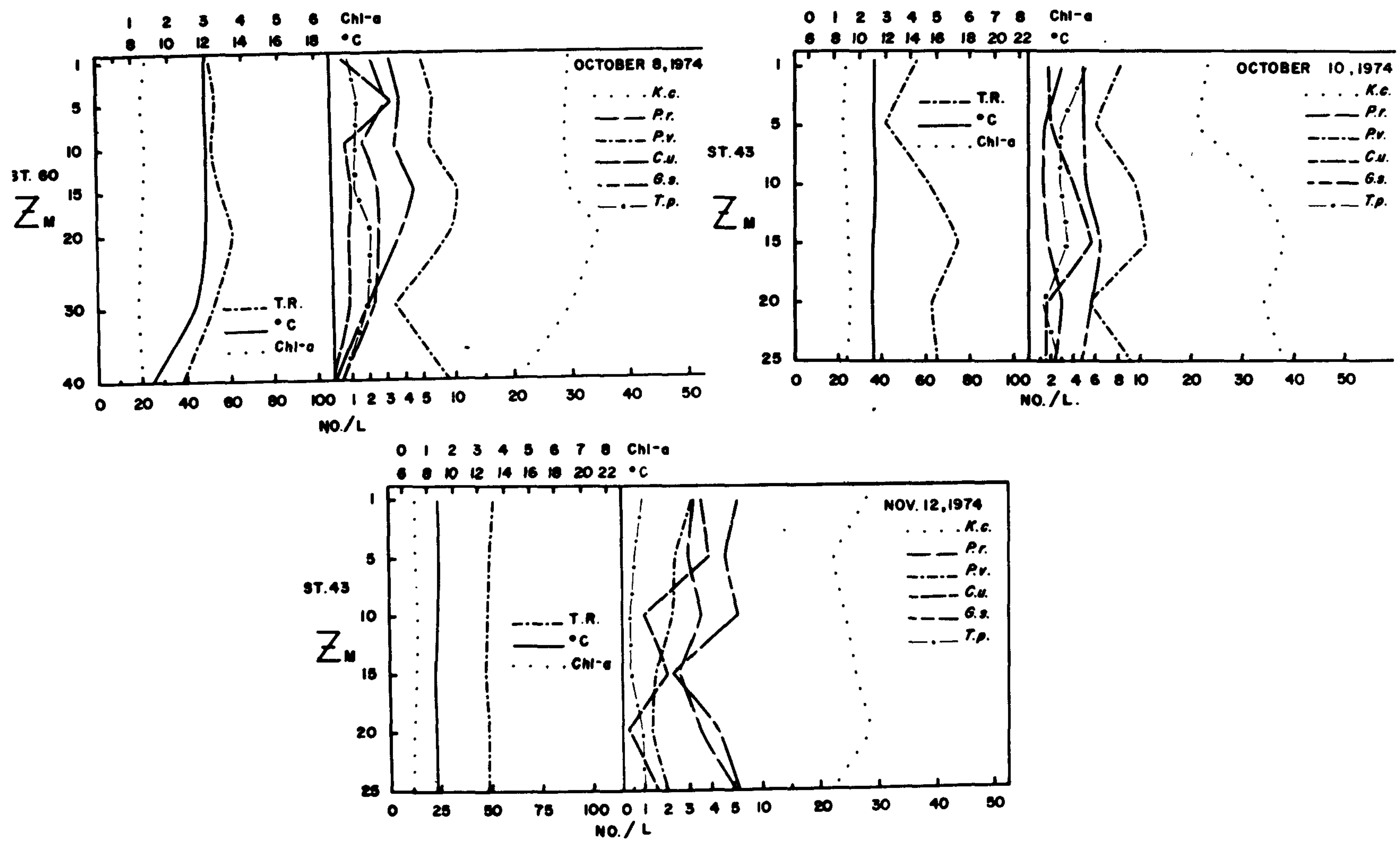

Figure 51. Vertical distribution of temperature (C), chlorophyll *a* (μg/liter), total rotifers and selected rotifer species (number of ind./liter) during Cruises 7 and 8 at stations 43 and 60. K.c. = *Keratella cochlearis*; P.r. = *Polyarthra remata*; P.v. = *P. vulgaris*; C.u. = *Conochilus unicornis*; G.s. = *Gastropus stylifer*; T.p. = *Trichocerca porcellus*.

TABLE 10. CORRELATIONS BETWEEN ROTIFERS AND SELECTED PHYSICOCHEMICAL VARIABLES. VALUES EXCEEDING .228 ARE SIGNIFICANT AT THE .01 PROBABILITY LEVEL AND ARE DESIGNATED BY AN ASTERISK (*)

	Temp.	Chloro. *a*	Conduct.	NO_3	TPO_4	Secchi
C. unicornis	.488*	-.237*	-.036	.013	-.005	.005
P. remata	.390*	-.229*	.088	-.073	-.065	-.193
P. vulgaris	.456*	-.208	.040	-.104	.026	-.099
S. stylata	.329*	-.079	.146	-.063	.111	-.216
G. stylifer	.313*	-.138	.140	-.153	.104	-.125
K. cochlearis	.196	-.075	.133	-.105	.102	-.120
K. longispina	-.174	-.013	.113	-.029	.050	.149
T. porcellus	.032	.003	-.024	-.083	.001	.061
P. dolichoptera	-.121	.183	.091	.026	-.062	-.070
S. kitina	-.267*	.093	-.040	.203	.286*	.006
N. squamula	-.253*	.631*	.085	.224	.213	-.300*
N. foliacea	-.456*	.523*	.098	.399*	.155	-.218
N. laurentiae	-.512*	.441*	.336*	.378*	.200	-.154
S. asymmetrica + *S. lakowitziana*	-.352*	.567*	.118	.104	.113	-.229*
Total Rotifers	.293*	-.065	.129	-.064	.130	-.173

TABLE 11. CORRELATIONS BETWEEN ROTIFERS. VALUES EXCEEDING .228 ARE SIGNIFICANT AT THE .01 PROBABILITY LEVEL AND ARE DESIGNATED BY AN ASTERISK (*)

	C. uni.	*P. rem.*	*P. vul.*	*S. sty.*	*G. sty.*	*K. coch.*	*K. long.*	*T. por.*	*P. doli.*	*S. kit.*	*N. squ.*	*N. lau.*	*S. as.*
C. unicornis	1.000												
P. remata	.427*	1.000											
P. vulgaris	.693*	.727*	1.000										
S. stylata	.583*	.684*	.858*	1.000									
G. stylifer	.582*	.701*	.887*	.847*	1.000								
K. cochlearis	.577*	.607*	.798*	.660*	.854*	1.000							
K. longispina	.122	.134	.278*	.112	.285*	.477*	1.000						
T. porcellus	.155	.096	.196	.163	.216	.297*	-.023	1.000					
P. dolichoptera	-.128	-.105	-.103	-.068	-.116	-.085*	.173	-.136	1.000				
S. kitina	-.045	-.031	-.102	-.062	-.086	-.052	.135	-.138	.132	1.000			
N. squamula	-.209	-.174	-.205	-.117	-.178	-.202	-.021	-.214	-.028	.043	1.000		
N. laurentiae	-.259*	-.216	-.275*	-.149	-.218	-.275*	-.144	-.234*	.936*	.100	.178	1.000	
S. asymmetrica + S. lakowitziana	-.172	-.133	-.176	-.088	-.146	-.189	-.187	-.170	-.052	-.079	.678*	.166	1.000
Total Rotifers	.696*	.693*	.902*	.817*	.914*	.948*	.429*	.232*	-.045	.032	-.137	-.254*	-.148

SECTION 5

DISCUSSION

HORIZONTAL DISTRIBUTION

A striking difference existed in species compostion and abundance between Saginaw Bay and the open waters of Lake Huron. Eutrophic indicator species occurred persistently in Saginaw Bay and occasionally along the western shore of Lake Huron. The rotifer community of the central basin had much lower standing crops and was well-represented by cold stenothermal species. These differences in composition and abundance can be largely attributed to the trophic differences between the two areas of the lake and to differences in depth. Cold stenotherms of the central basin were present in the hypolimnion during thermal stratification. In Saginaw Bay, no hypolimnion was present so cold stenotherms were absent.

Littoral genera such as Brachionus, Euchlanis, Platyias, Lecane, Monostyla, Lophocharis, and Trichotria, as well as some members of the Class Digononta occurred in Saginaw Bay. These littoral species are able to inhabit the limnetic zone because of morphological structures and behavioral patterns having preadaptive value to planktonic existence (Pejler 1957a). Voigt (1904) and Green (1967, 1972) have observed similar instances where littoral or benthic species inhabited the limnetic zone in response to algal blooms which may serve as food or substrate for attachment.

The lower abundance of rotifers in the highly enriched Saginaw River as compared to nearshore Saginaw Bay stations may reflect an unfavorable environment for growth and reproduction caused by the high flushing rate. The predominance of eutrophic indicator species in the Saginaw River suggests that these species may be more tolerant of industrial and municipal toxicants (and possibly algal metabolites) than most open lake forms.

Pronounced horizontal patchiness was evident for some species such as Synchaeta kitina and S. stylata (Figures A-35, and A-42). However, during all cruises, definite spatial or seasonal abundance of species occurred (see Appendix A). Nearly all species displayed greatest abundances in Saginaw Bay and along the coastal area immediately below the mouth of the Bay, indicating the strong influence of Saginaw Bay on southern Lake Huron waters. This distribution resembles major circulation features between Saginaw Bay and southern Lake Huron (Ayers et al. 1956).

The differences in seasonal species composition and abundance suggests that the distinction between inshore and offshore species composition is most highly developed during thermal stratification. In the upper Great Lakes, stratification usually coincides with maximum rotifer abundance during July. No sampling occurred during winter months, but Stemberger (1974) found that no clear distinction existed during winter between nearshore and offshore species composition in Lake Michigan waters adjacent to Milwaukee Harbor. A more homogenous species composition probably also occurs between the Saginaw embayment and Lake Huron waters during winter. This homogeneity in comosition is probably brought about by more thorough mixing as well as a general reduction in the number of species that occur in cold water.

All cluster analyses grouped Saginaw Bay stations along the southeast coast to southern Lake Huron stations immediately below the mouth of the bay, reflecting the dominant current. In addition, cluster analyses showed a distinct inshore community on the east and west coasts of Lake Huron. The existence of these groups suggests that internal wave dynamics, particularly Kelvin waves, may cause entrainment of inshore waters. Mortimer (1971) reported that Kelvin waves may have effects as far as 20 km offshore and that the currents generated by these waves in Lakes Michigan and Ontario move parallel to the shore in a counter-clockwise direction. Ayers et al. (1956) showed that near-shore surface currents in Lake Huron often move in a counter-clockwise direction, moving to the south along the western shore below Saginaw Bay, and to the north along the eastern shore.

On the majority of cruises, cluster analyses identified an isolated group on the western shore of southern Lake Huron which consisted of only one or two stations. In most instances, the station(s) comprising these groups were closely related in Euclidean distance to Saginaw Bay groups, and may represent remnants of water which may have originated from the Bay.

Clusters based on physicochemical variables revealed station groups with strong similarities to those obtained from rotifer data. These results may be indicative of a tight coupling of rotifers to their physicochemical environment.

The Shannon-Wiener diversity index provided no useful information to help interpret the rotifer data. In fact, index numbers for southern Lake Huron stations were similar to Saginaw Bay stations for all cruises, even though great differences in species composition existed between these areas. These indices were presented to demonstrate their ineffectiveness in dealing with quantitative rotifer data.

VERTICAL DISTRIBUTION

Discrete depth samples taken throughout the water column appear to adequately reflect the vertical distribution of rotifers, providing that metalimnetic collections are made. Rotifers show a distinct maximum in the metalimnion during thermal stratification. Rotifer stratification was most strongly developed at deep stations during late June, July, and August (Cruises 5, 6, and 7). In remaining cruises pronounced species stratification was not evident.

The cold stenothermal species which occur in the hypolimnion may also affect cluster analysis of distribution data. The abrupt decline in total abundance in the hypolimnion, when averaged for the entire column, effectively decreases the calculated mean standing crop. This effect is a function of depth and varies with the number of samples taken in the hypolimnion. If samples had been taken only from the epilimnion and metalimnion, the differences in abundance between inshore and offshore stations during the thermal stratification period might not have been as pronounced. However, Stemberger (1974) was able to show strong inshore-offshore differences in abundance with samples collected at a single depth (2 m).

Abundance at 2 m was also strongly influenced by weather conditions (Stemberger 1974). Wave turbulence usually distributed rotifers more evenly throughout the epilimnion, whereas during calm weather, rotifers usually avoided near-surface waters. Thus, multiple depth samples avoid problems associated with wind-generated turbulence.

In addition to thermal stratification and wind-generated turbulence, vertical stratification of species may be influenced by a variety of other factors. These factors include food, temperature, light, oxygen, and predator-prey relationships with other plankters (Fairchild et al. 1977).

Peak abundance of *Polyarthra vulgaris* was usually above the peak of *Keratella cochlearis*. Discrete sampling may have missed these peaks on some occasions where the distribution of these species was not distinct during thermal stratification. Stemberger (1974) reported similar findings for Lake Michigan. Pejler (1957*b*) suggested that differences in light preferences between these two species may account for this distribution.

Conochilus unicornis showed a strong tendency to predominate in the epilimnion and near-surface waters. However, during isothermal conditions, the species occurred from the surface to the bottom. Stemberger (1974) noted similar near-surface distribution for the species. Fairchild et al. (1977) reported that a population of *C. unicornis* in Lancaster Lake, Michigan was concentrated near the surface at night, but was more uniformly distributed in the water column in the daytime. Shindler and Noven (1971) found that the species had a maximum both at the surface and at a depth of 4 m in Lake 122, Ontario. Distribution of *C. unicornis*, *P. vulgaris*, *P. remata*, *Synchaeta stylata*, and *Gastropus stylifer* correlated significantly with water temperature. Distribution of these species was also strongly intercorrelated.

Synchaeta kitina occurred in the hypolimnion during July and August but was present throughout the water column in June. Larsson (1971) reported *S. kitina* in the epilimnion of Lake Blankvatn, Norway during the summer. In Lake Huron the species displayed a significantly negative correlation with temperature, indicating a cold water preference.

The cold stenotherms *Notholca foliacea*, *N. laurentiae*, *N. squamula*, *Synchaeta asymmetrica*, and *S. lakowitziana* were more uniformly distributed throughout the water column during spring prior to thermal stratification. During thermal stratification, these species occurred in the lower depths of the metalimnion and hypolimnion, indicating their cold water preference. Their distribution was positively correlated with chlorophyll *a*. Chlorophyll *a* biomass displayed a maximum in the hypolimnion, thus accounting for the high correlation coefficient. These cold forms were not as strongly intercorrelated as the warm water species.

INDICATOR VALUE OF ROTIFERS

Consistent presence of certain species in waters of extreme trophic conditions suggests they have some value in lake biomonitoring studies. The species most consistent as eutrophic indicators in Lake Huron were the warm stenotherms *Anuraeopsis fissa*, *Brachionus* spp., *Conochiloides dossuarius*, and *Keratella cochlearis* f. *tecta*. In addition, littoral genera, mainly warm stenotherms, which occur in the limnetic environment may be considered as indicators of eutrophy (Gannon and Stemberger 1978).

Cold stenothermal species which have potential as oligotrophic indicators were *Notholca laurentiae* and *Synchaeta asymmetrica*. However, the presence of these species may be more indicative of their preference for the cold waters of the hypolimnion than a reflection of actual trophic conditions. During winter months, these species occur in nutrient-enriched embayments (Stemberger 1974), thus precluding their designation as oligotrophic indicators. Only after we acquire further knowledge of the ecology of indicator species can we realistically evaluate their importance in lake monitoring studies.

Certain species which exhibited limited distribution in Lake Huron were related empirically to the physicochemical environment through cluster analysis. However, such correlative data based on distributional inferences did not explain the presence of indicator species. Reasons for their occurrence were undoubtedly complex and related not only to physicochemical conditions but also to seasonal distribution, diet, and competition or predation with other zooplankters. Complications may have also resulted from relative differences in tolerance of various species to toxic industrial or municipal pollutants and algal metabolites.

Qualitative presence-absence data on indicator species is not always useful in Lake Huron and other large water bodies. Massive water movements can transport species to environmentally different areas of the lake where they normally do not actively reproduce. Their presence in such waters may be without indicator value. A judgement can be made on the significance of the indicator's presence by comparing its abundance and composition percentage to stations with similar physicochemical conditions. If the indicator is absent from similar stations and its abundance and composition percentage is low, occurrence at a single station or a few stations is probably accidental. However, if the species is present at most stations with similar physicochemical conditions, its presence may be of indicator value even though it displays low abundance and composition percentage.

A major advantage of cluster analysis was that it eliminated the need to make subjective decisions on the presence of indicator species. With cluster analysis the entire rotifer community was evaluated, not merely one or two of its components.

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APPENDIX A
COMPUTER-PLOTTED HORIZONTAL DISTRIBUTION OF ROTIFER ABUNDANCE

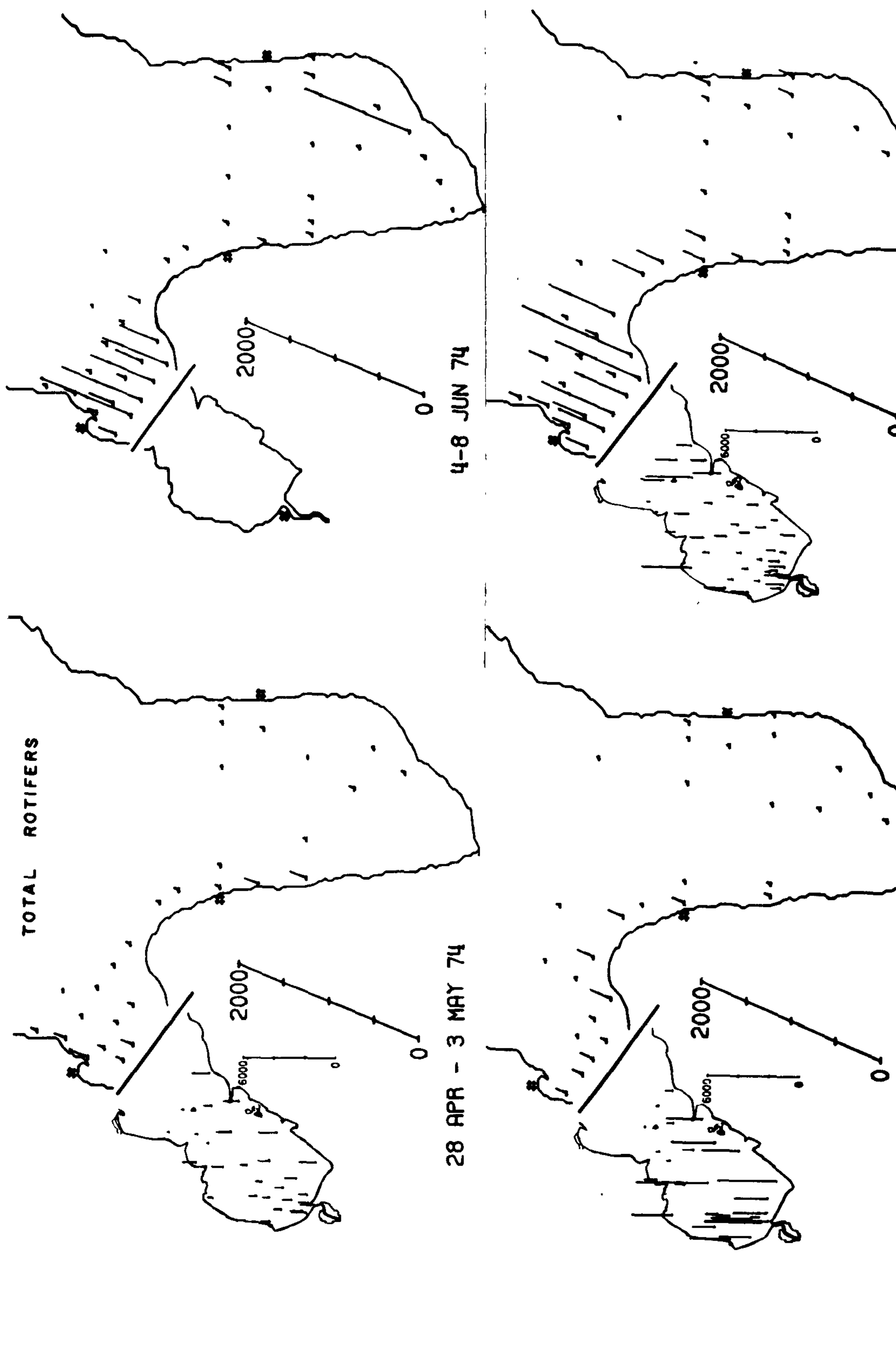

Figure A-1. Distribution and abundance (number of ind./liter) of total rotifers for spring 1974.

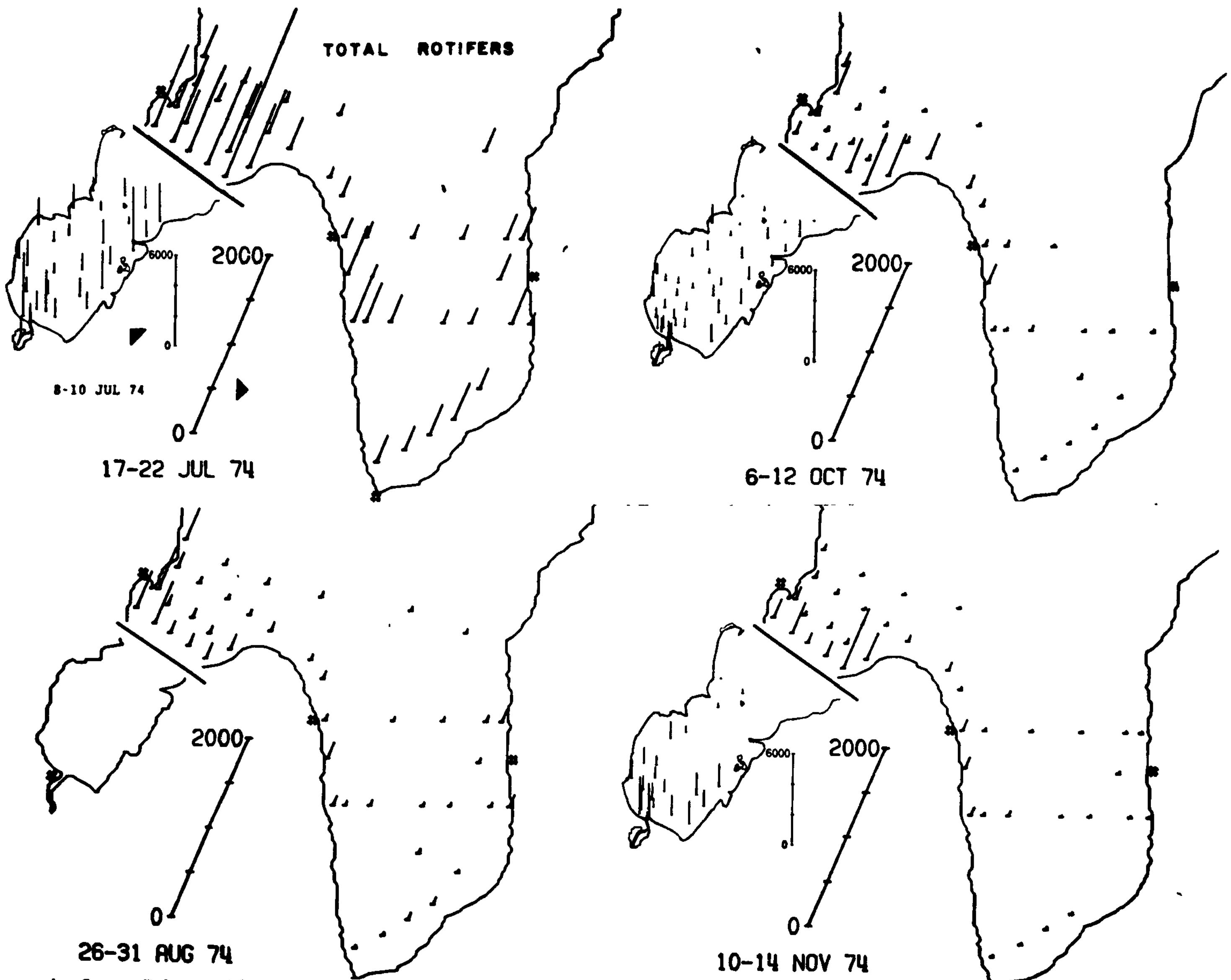

Figure A-2. Distribution and abundance (number of ind./liter) of total rotifers for summer and fall 1974.

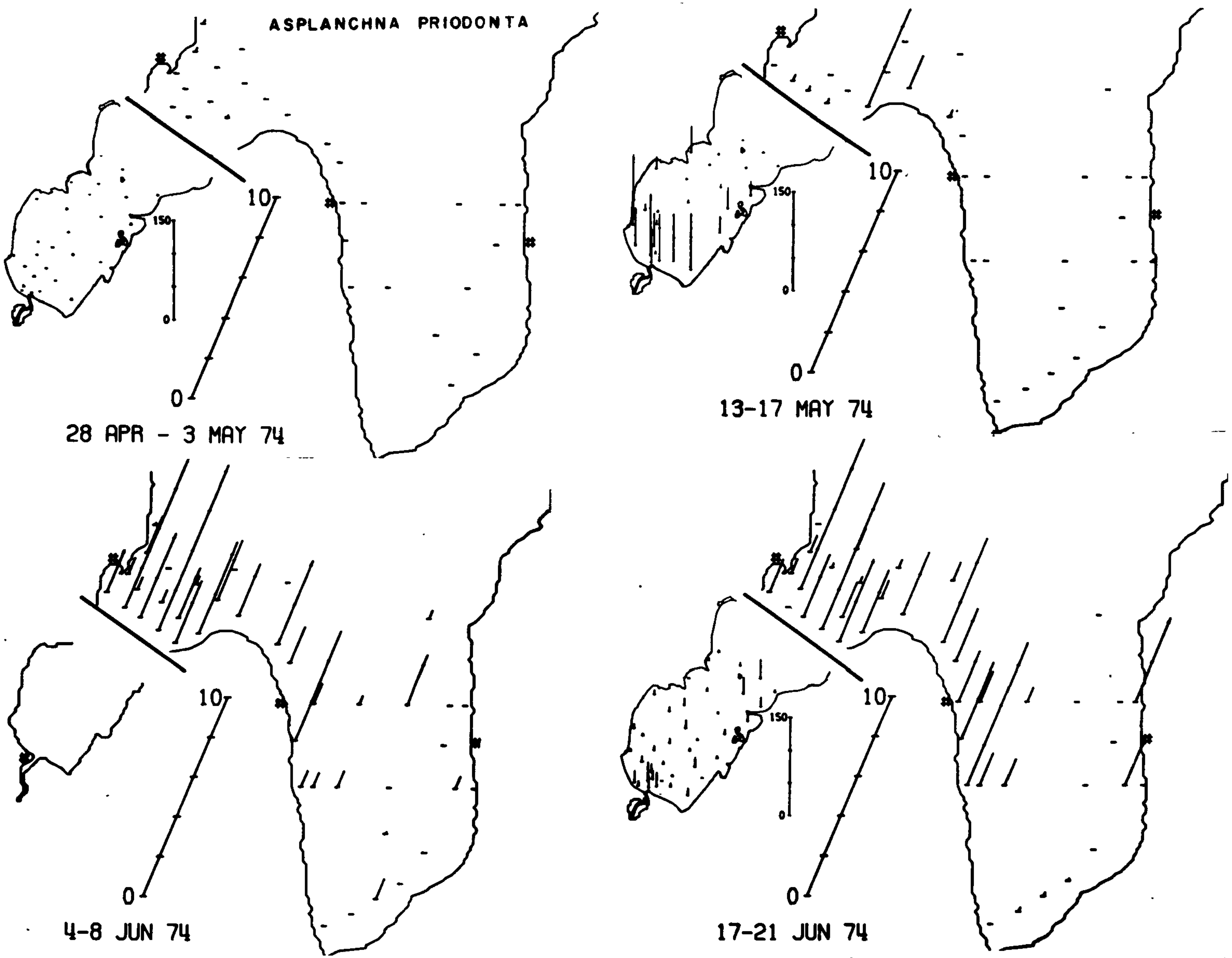

Figure A-3. Distribution and abundance (number of ind./liter) of *Asplanchna priodonta* for spring 1974.

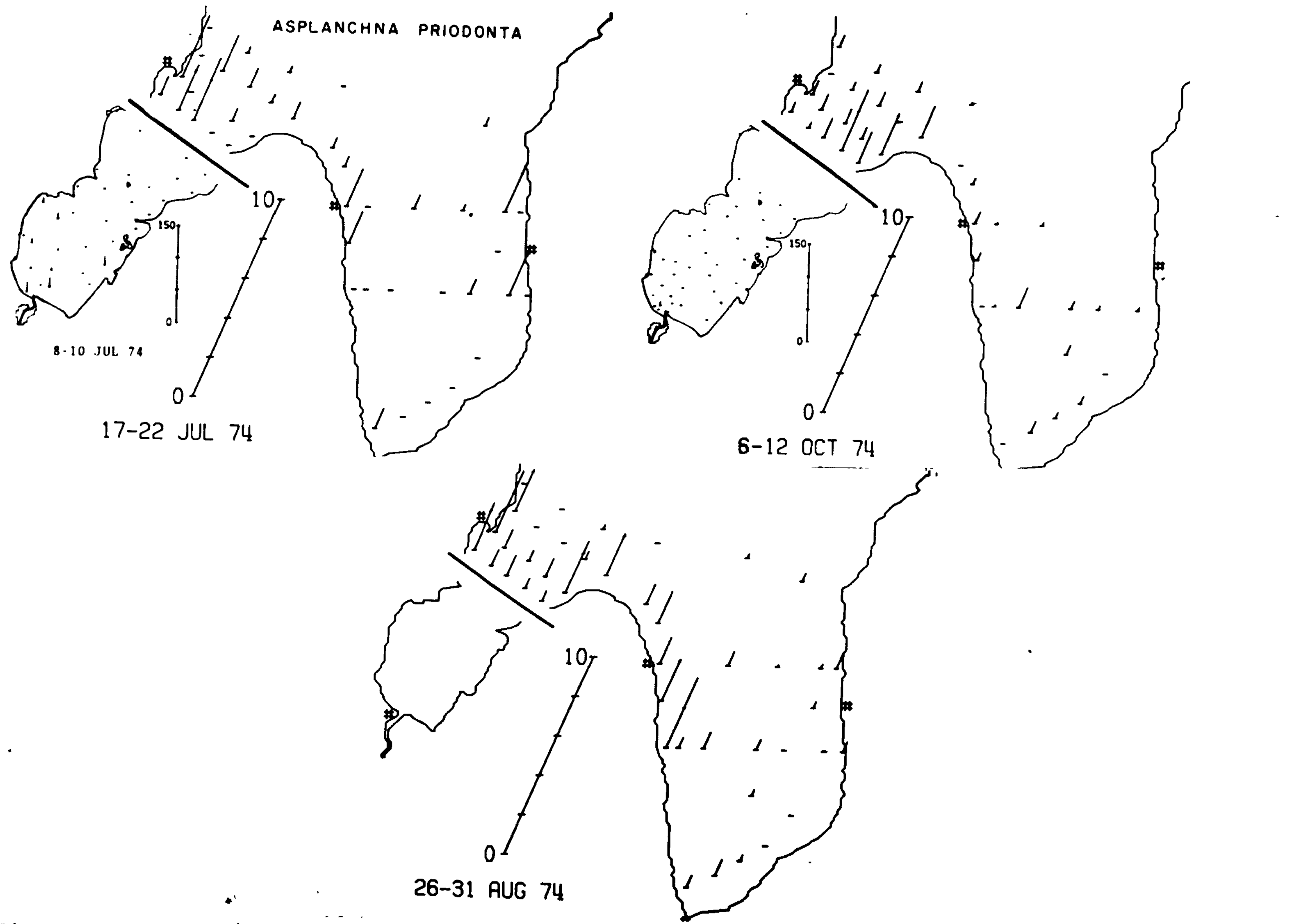

Figure A-4. Distribution and abundance (number of ind./liter) of *Asplanchna priodonta* for summer and fall 1974.

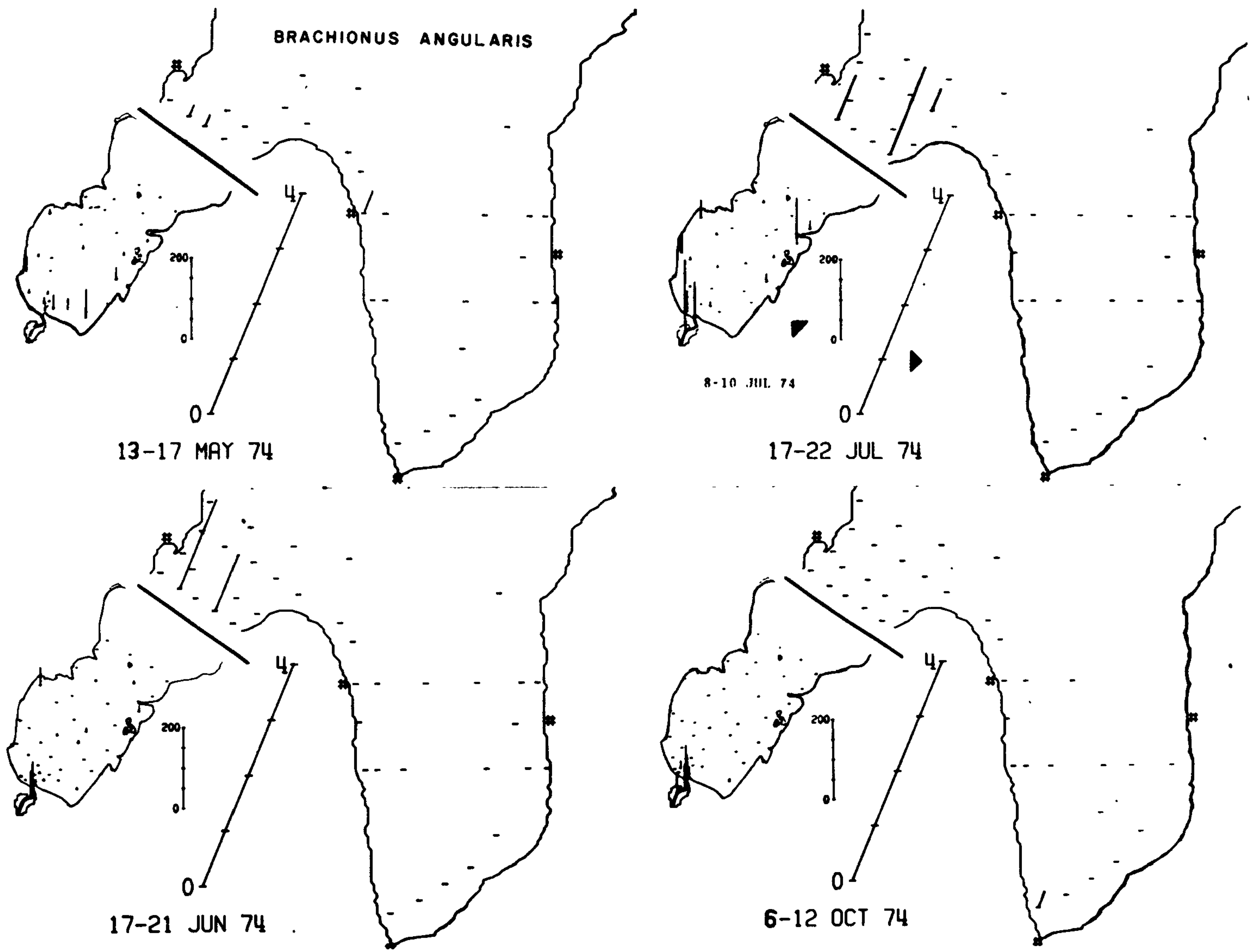

Figure A-5. Distribution and abundance (number of ind./liter) of *Brachionus angularis* from spring through fall 1974.

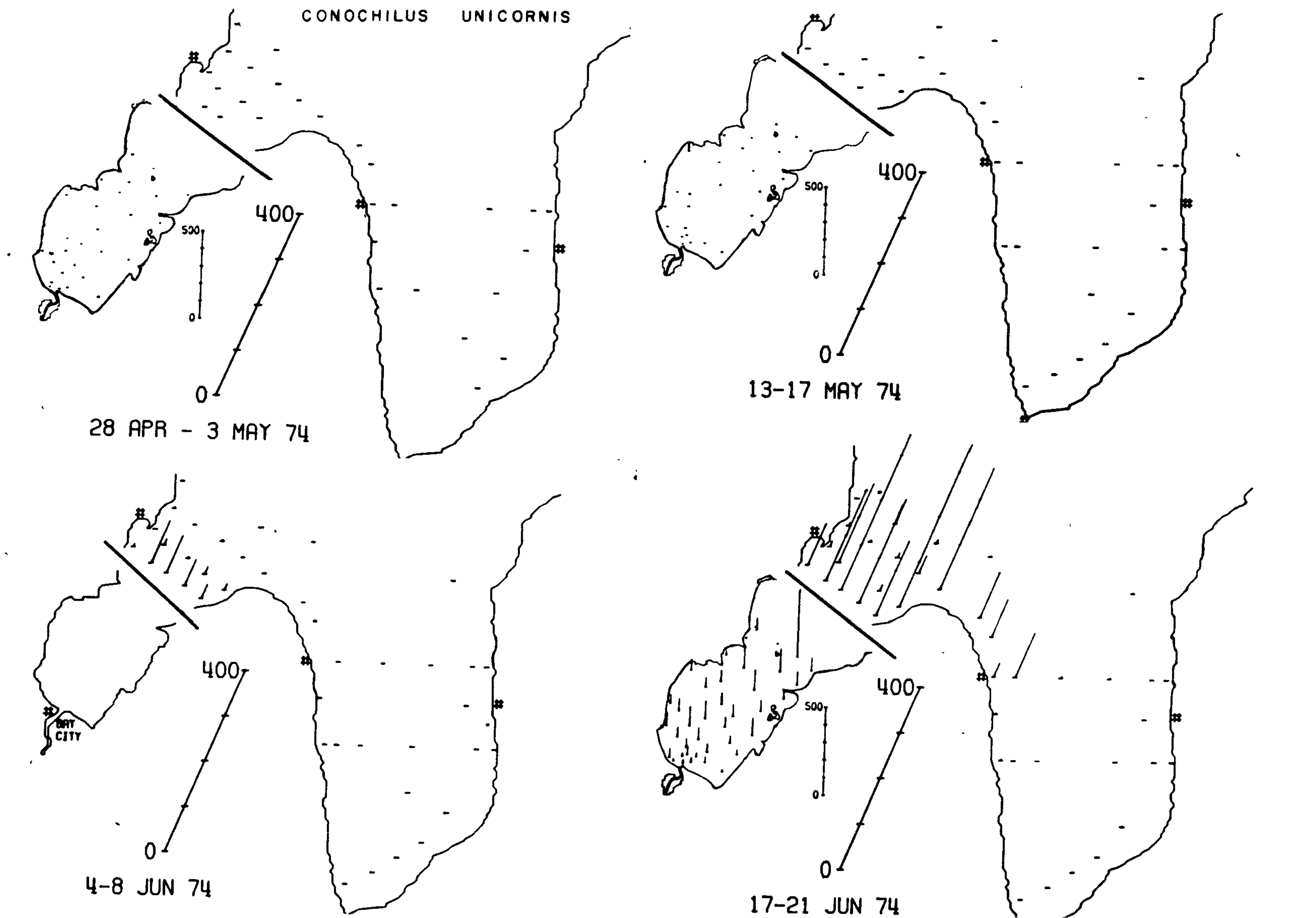

Figure A-6. Distribution and abundance (number of ind./liter) of *Conochilus unicornis* for spring 1974.

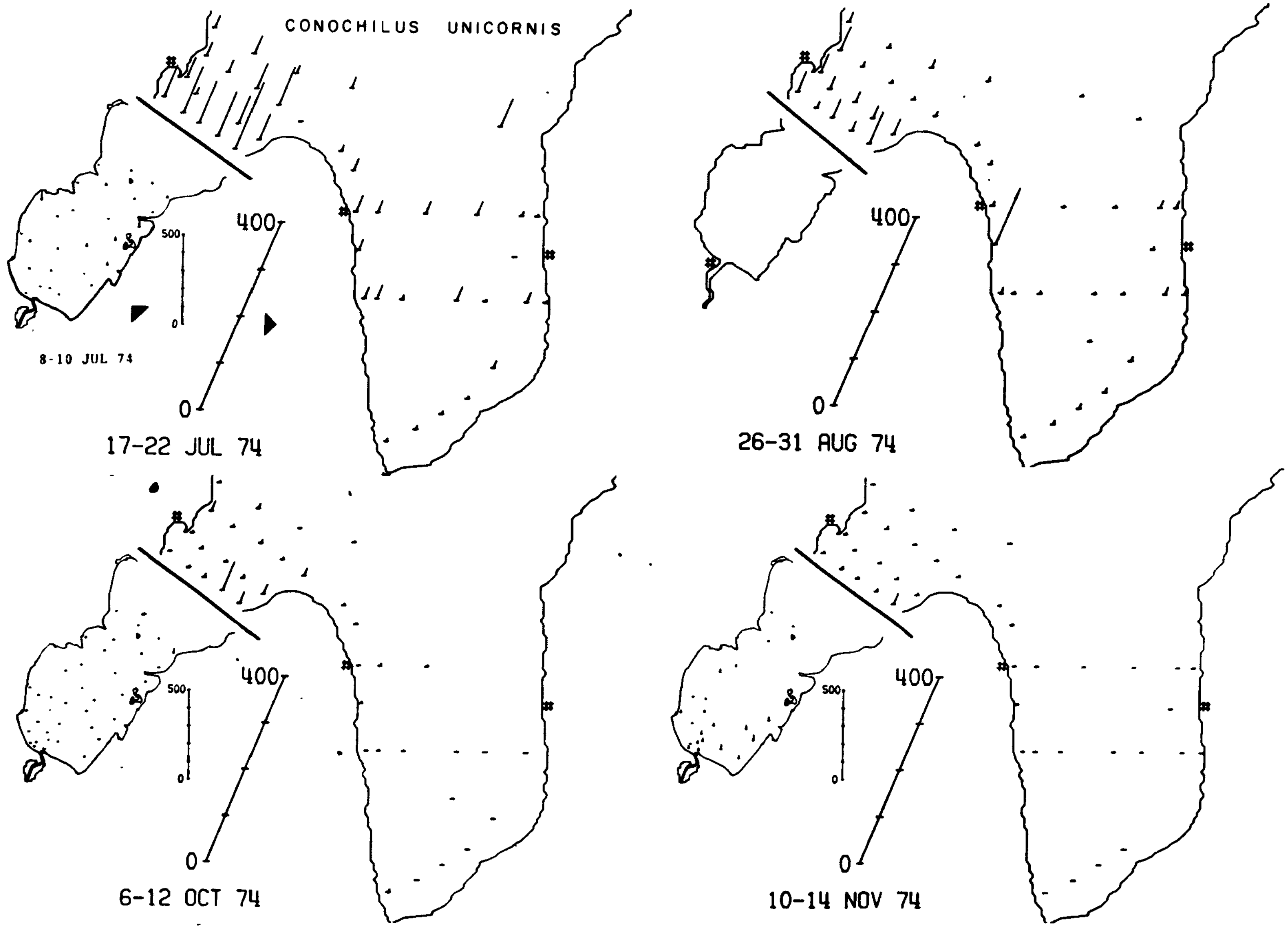

Figure A-7. Distribution and abundance (number of ind./liter) of *Conochilus unicornis* for summer and fall 1974.

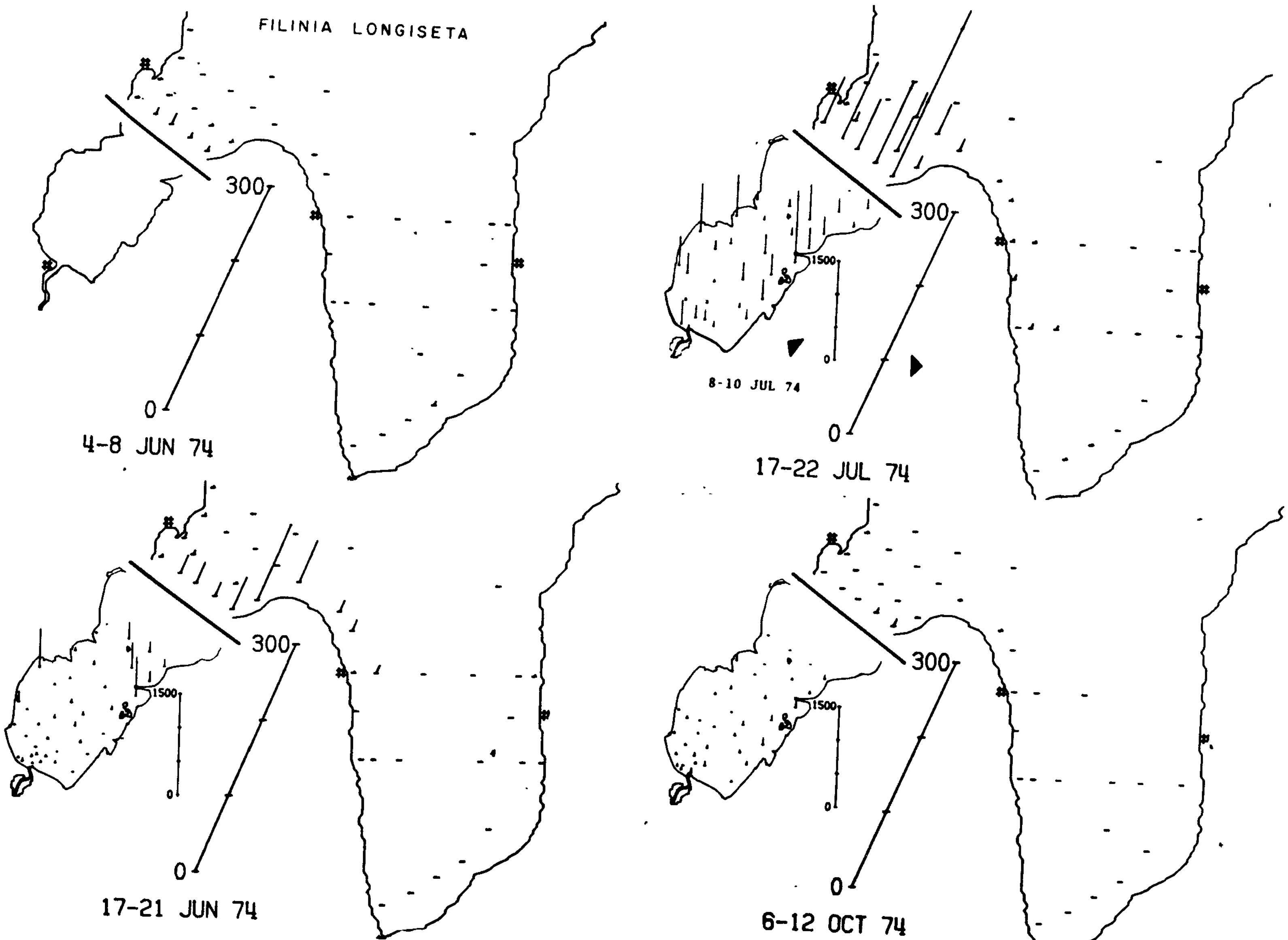

Figure A-8. Distribution and abundance (number of ind./liter) of *Filinia longiseta* from spring through fall 1974.

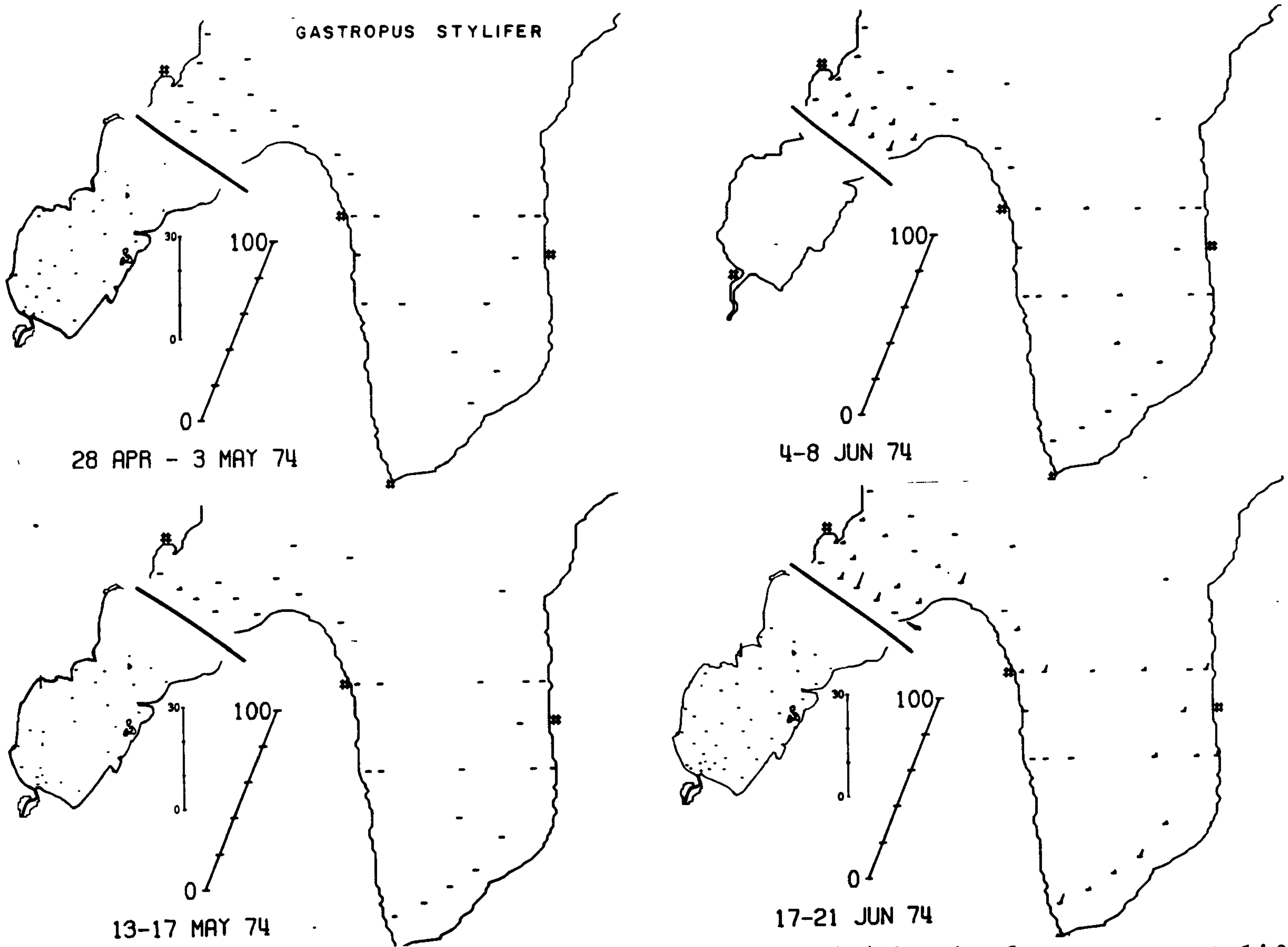

Figure A-9. Distribution and abundance (number of ind./liter) of *Gastropus stylifer* for spring 1974.

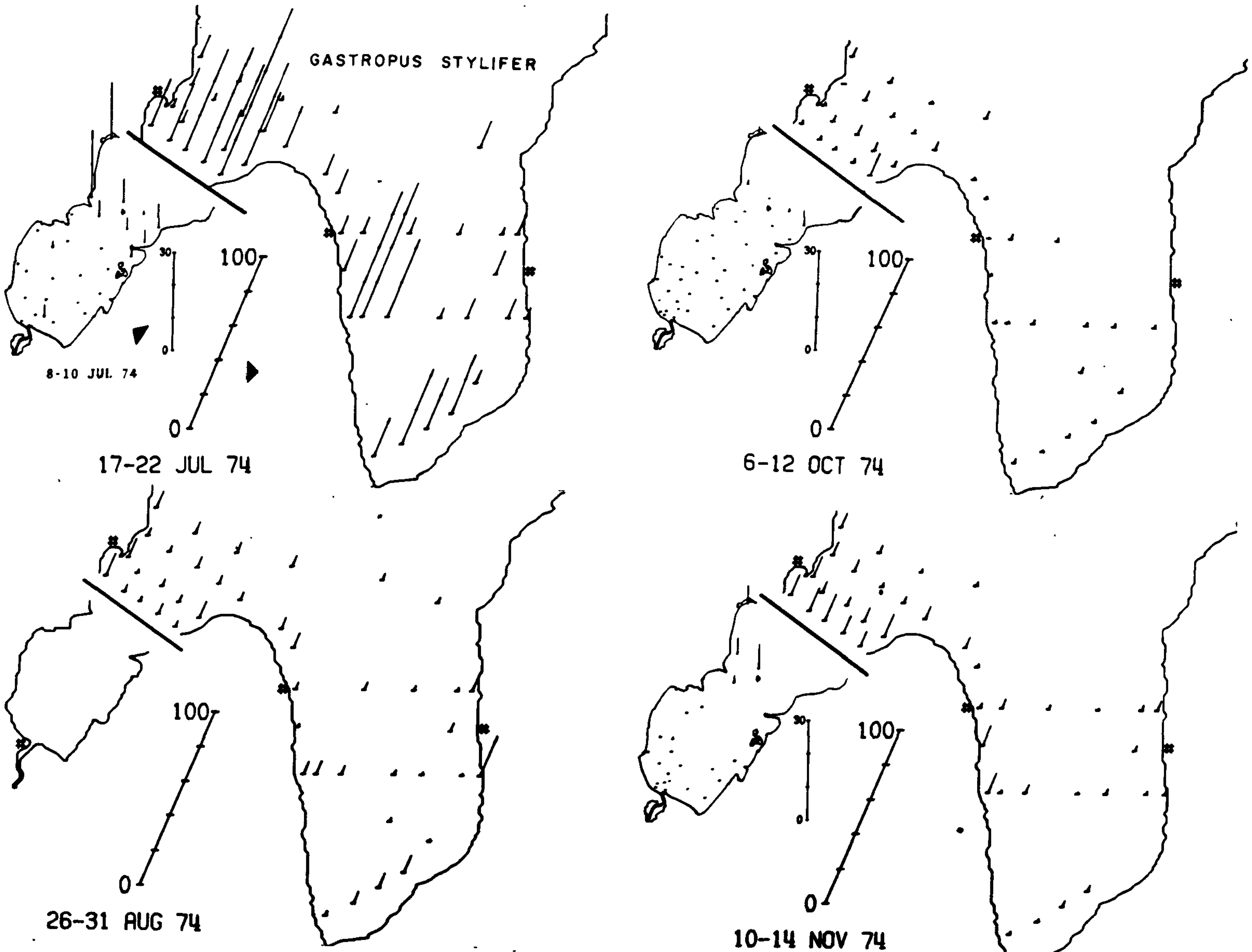

Figure A-10. Distribution and abundance (number of ind./liter) of *Gastropus stylifer* for summer and fall 1974.

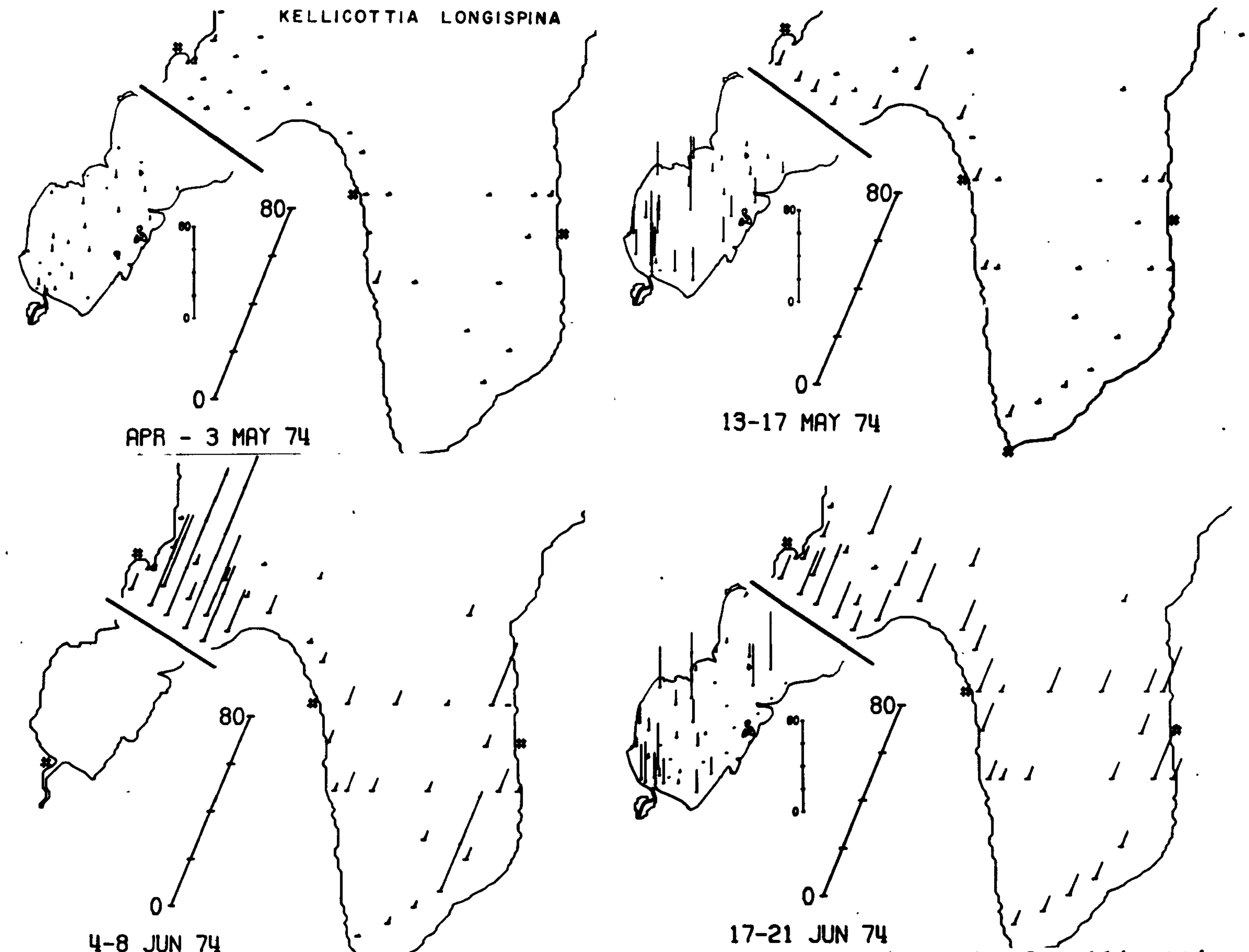

Figure A-11. Distribution and abundance (number of ind./liter) of *Kellicottia longispina* for spring 1974.

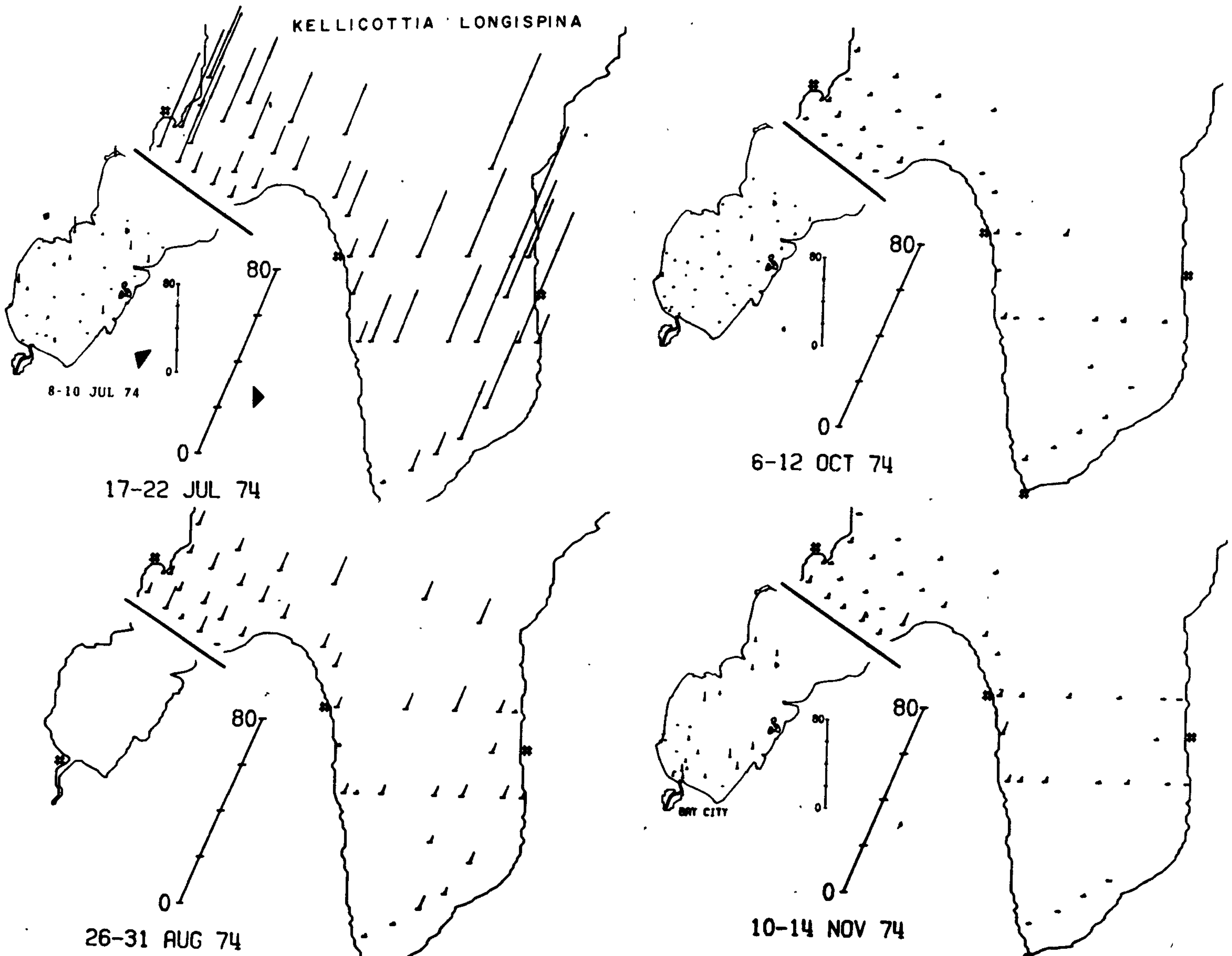

Figure A-12. Distribution and abundance (number of ind./liter) of *Kellicottia longispina* for summer and fall 1974.

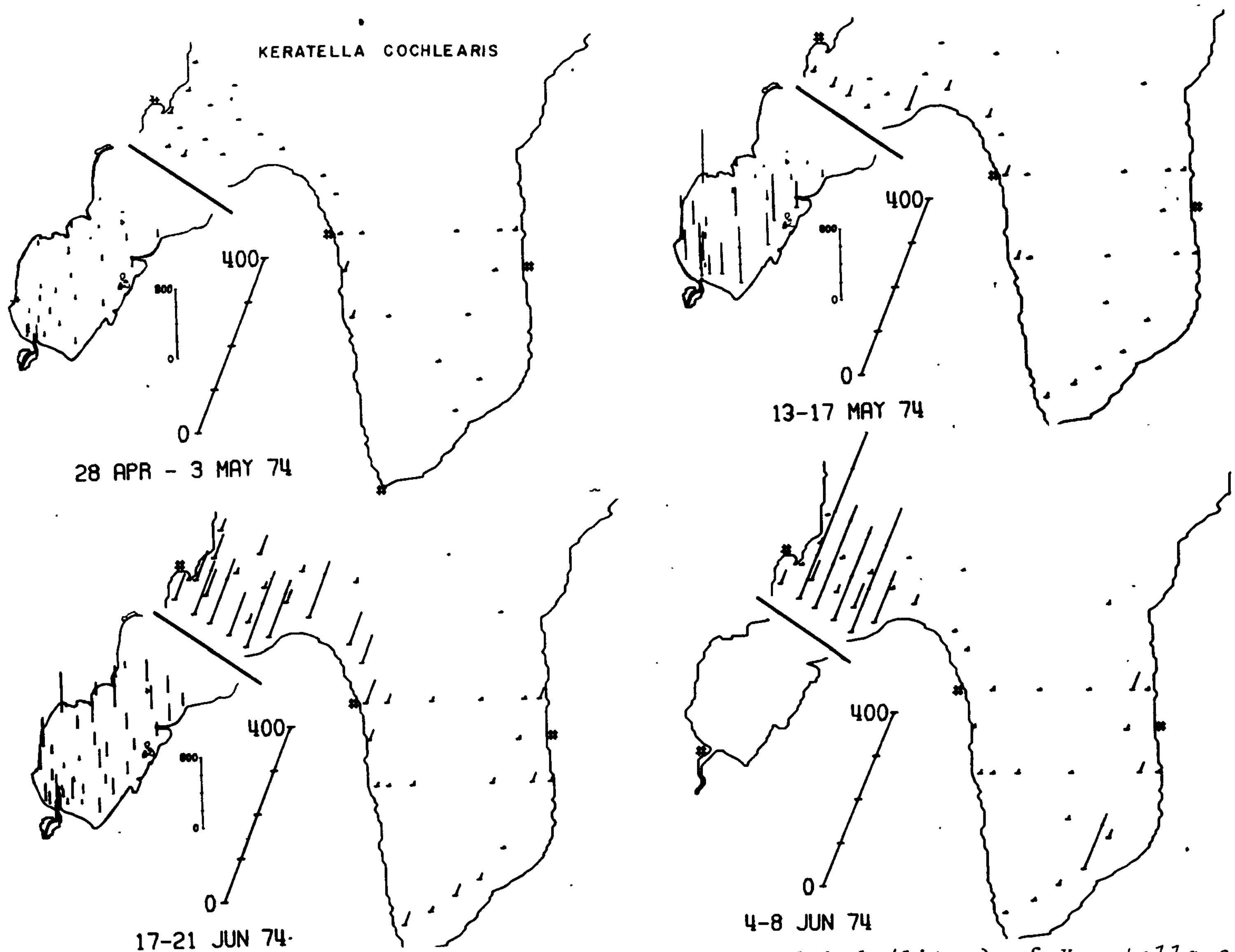

Figure A-13. Distribution and abundance (number of ind./liter) of *Keratella cochlearis* for spring 1974.

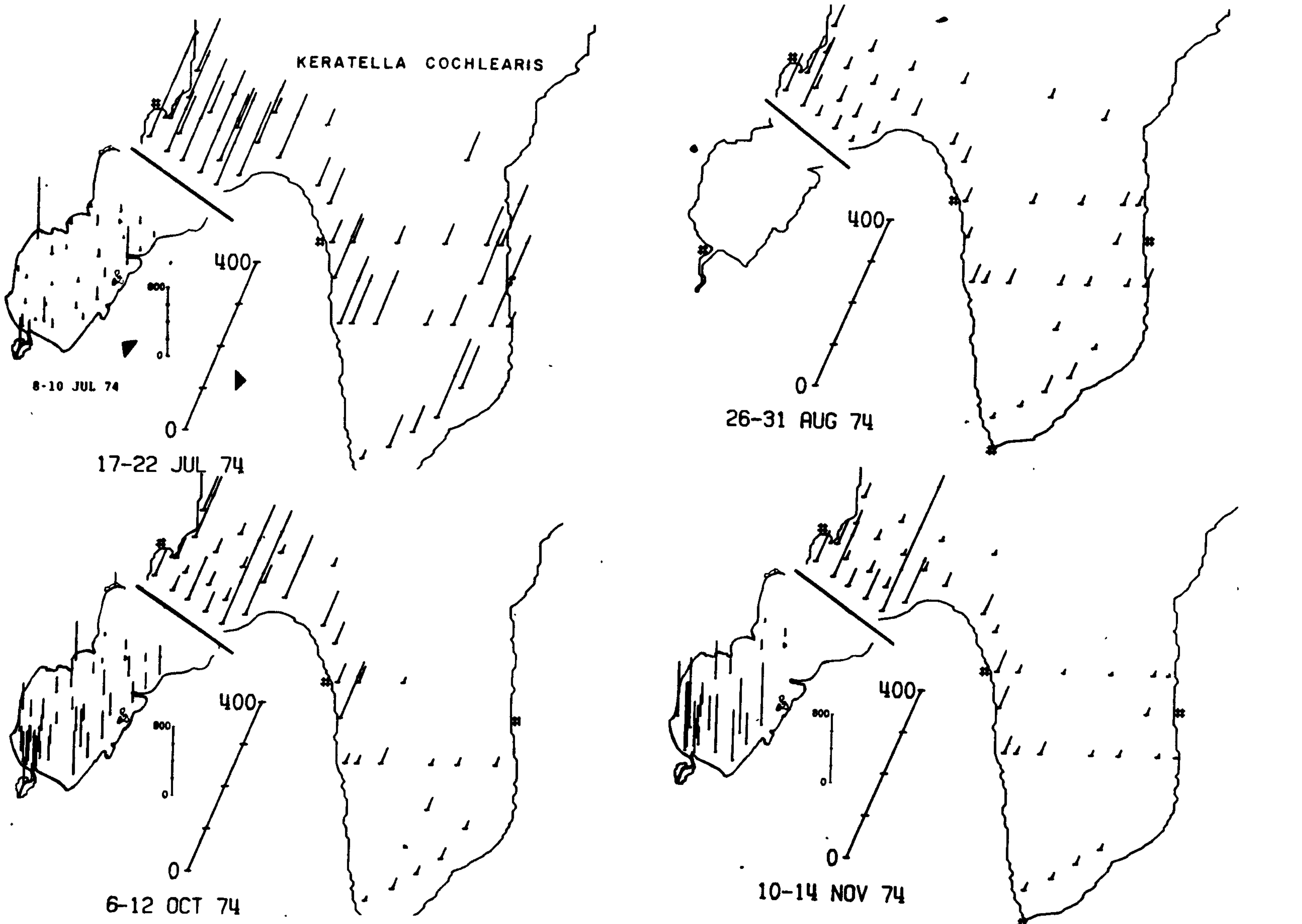

Figure A-14. Distribution and abundance (number of ind./liter) of *Keratella cochlearis* for summer and fall 1974.

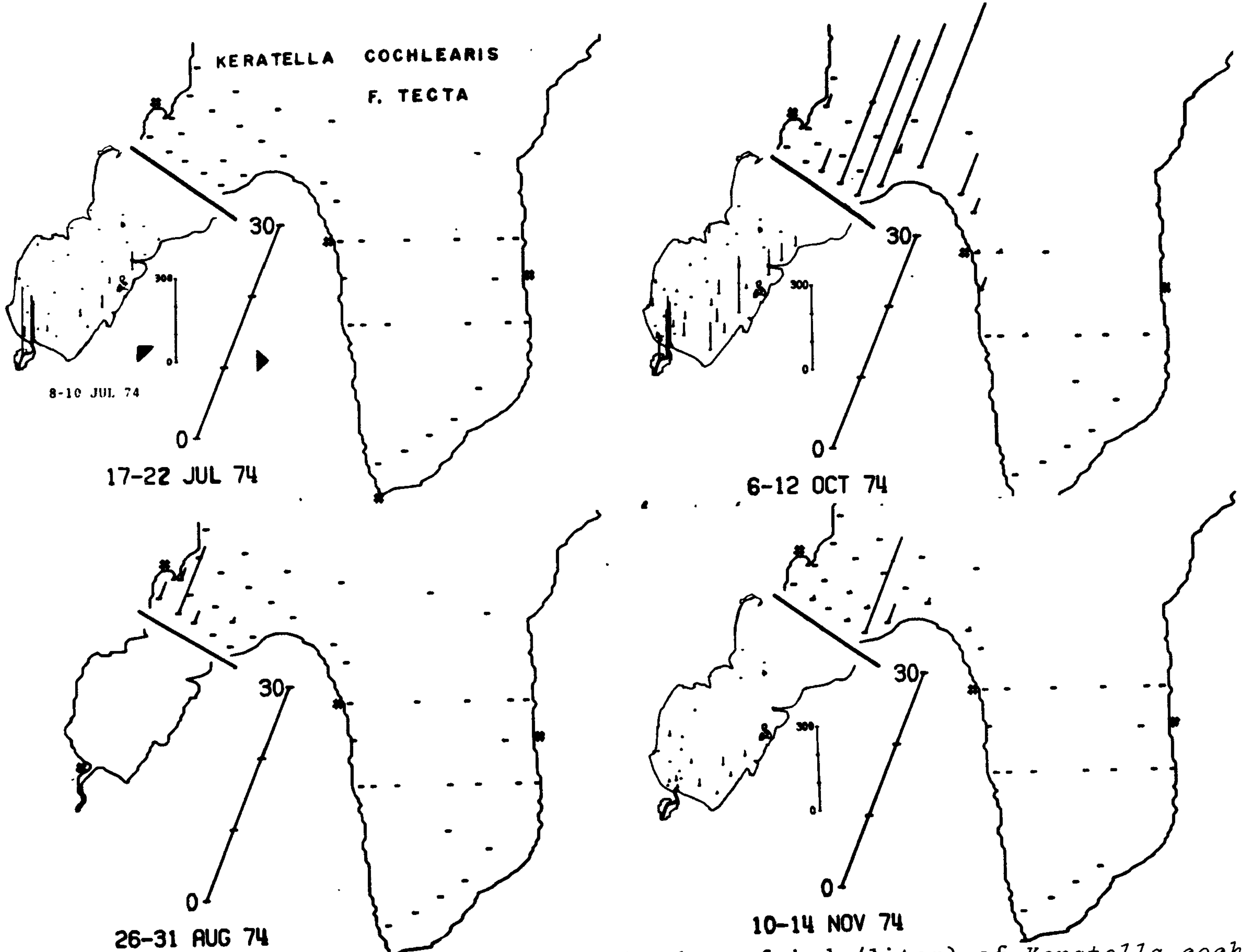

Figure A-15. Distribution and abundance (number of ind./liter) of *Keratella cochlearis* f. *tecta* for summer and fall 1974.

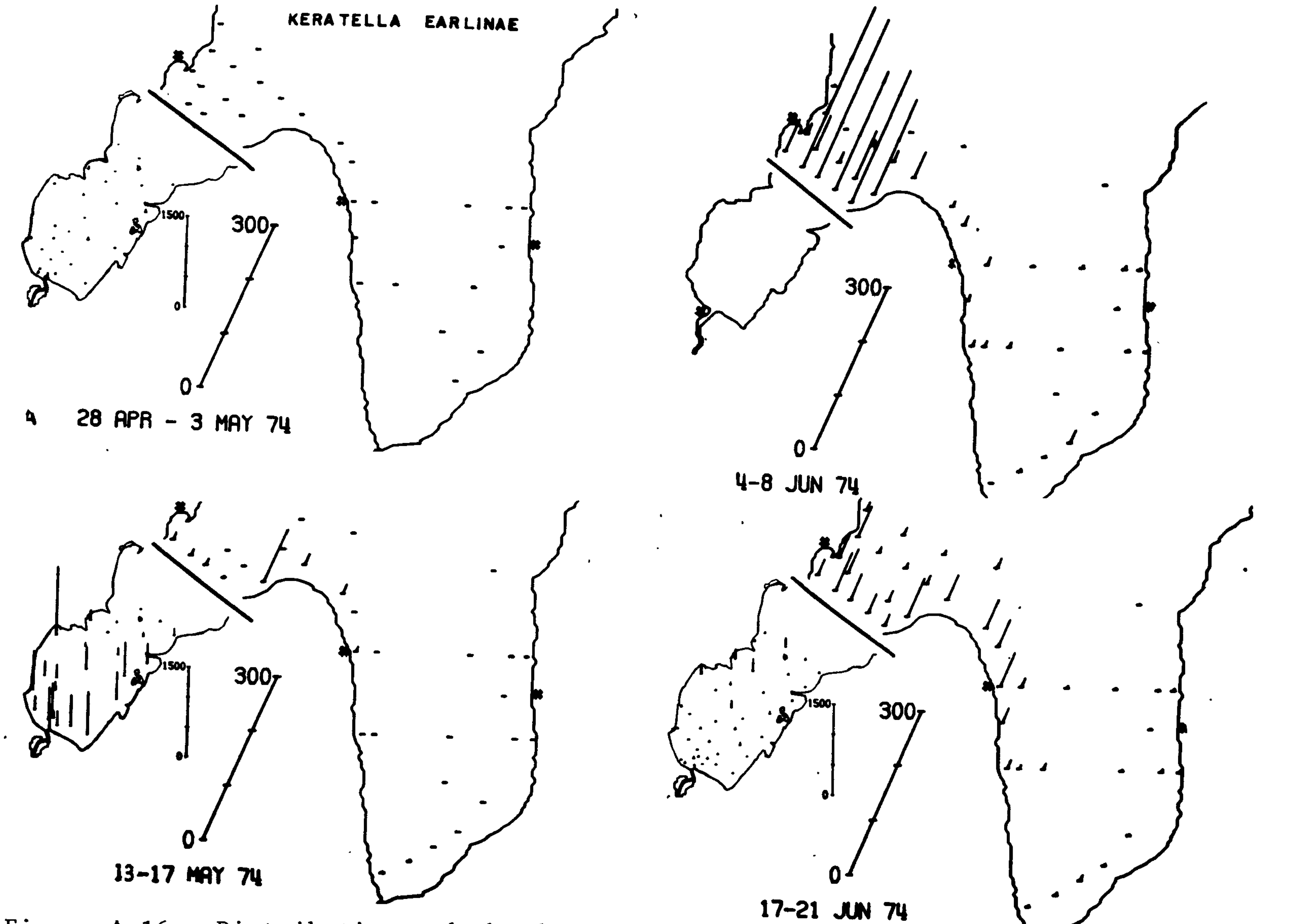

Figure A-16. Distribution and abundance (number of ind./liter) of *Keratella earlinae* for spring 1974.

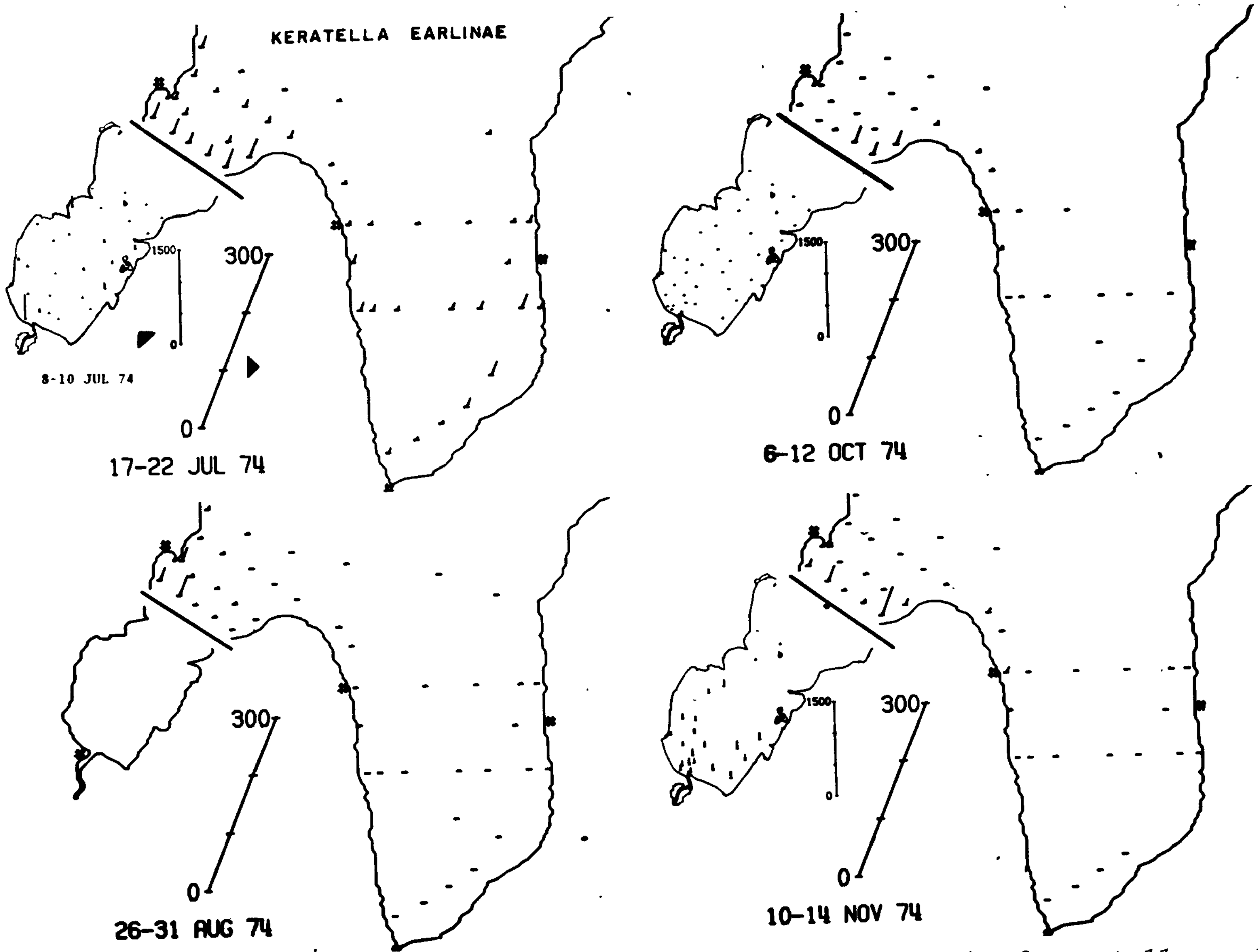

Figure A-17. Distribution and abundance (number of ind./liter) of *Keratella earlinae* for summer and fall 1974.

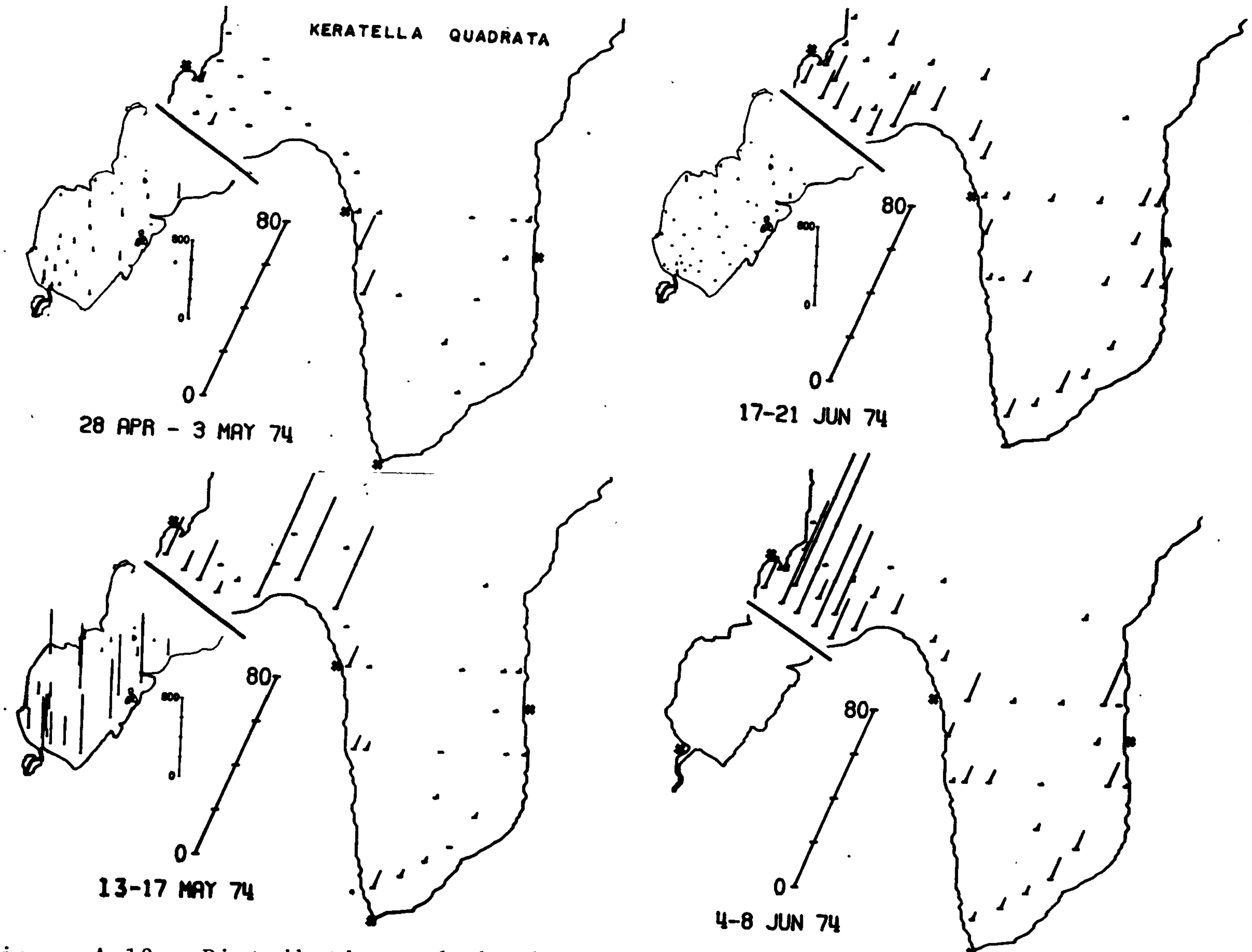

Figure A-18. Distribution and abundance (number of ind./liter) of *Keratella quadrata* for spring 1974.

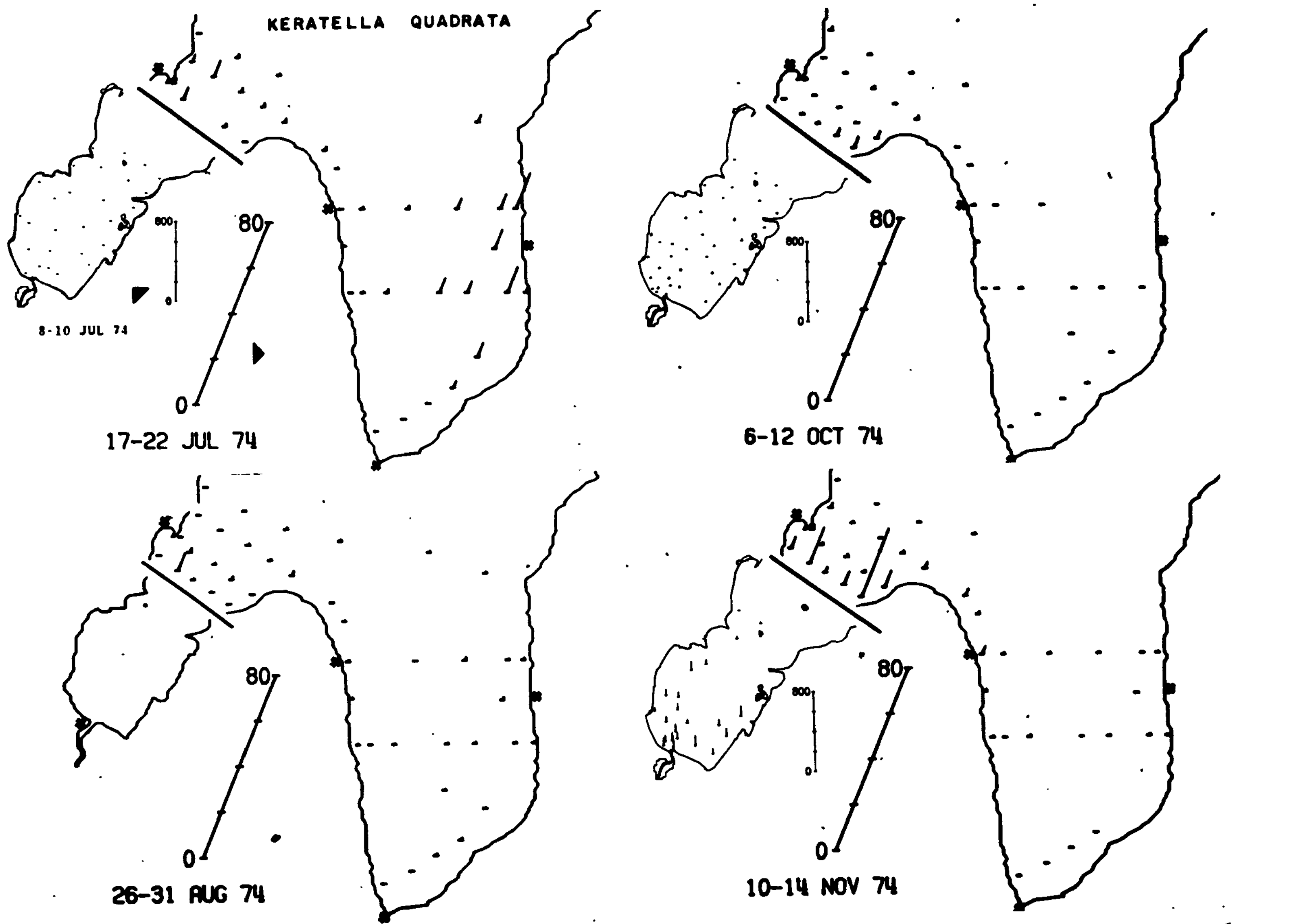

Figure A-19. Distribution and abundance (number of ind./liter) of *Keratella quadrata* for summer and fall 1974.

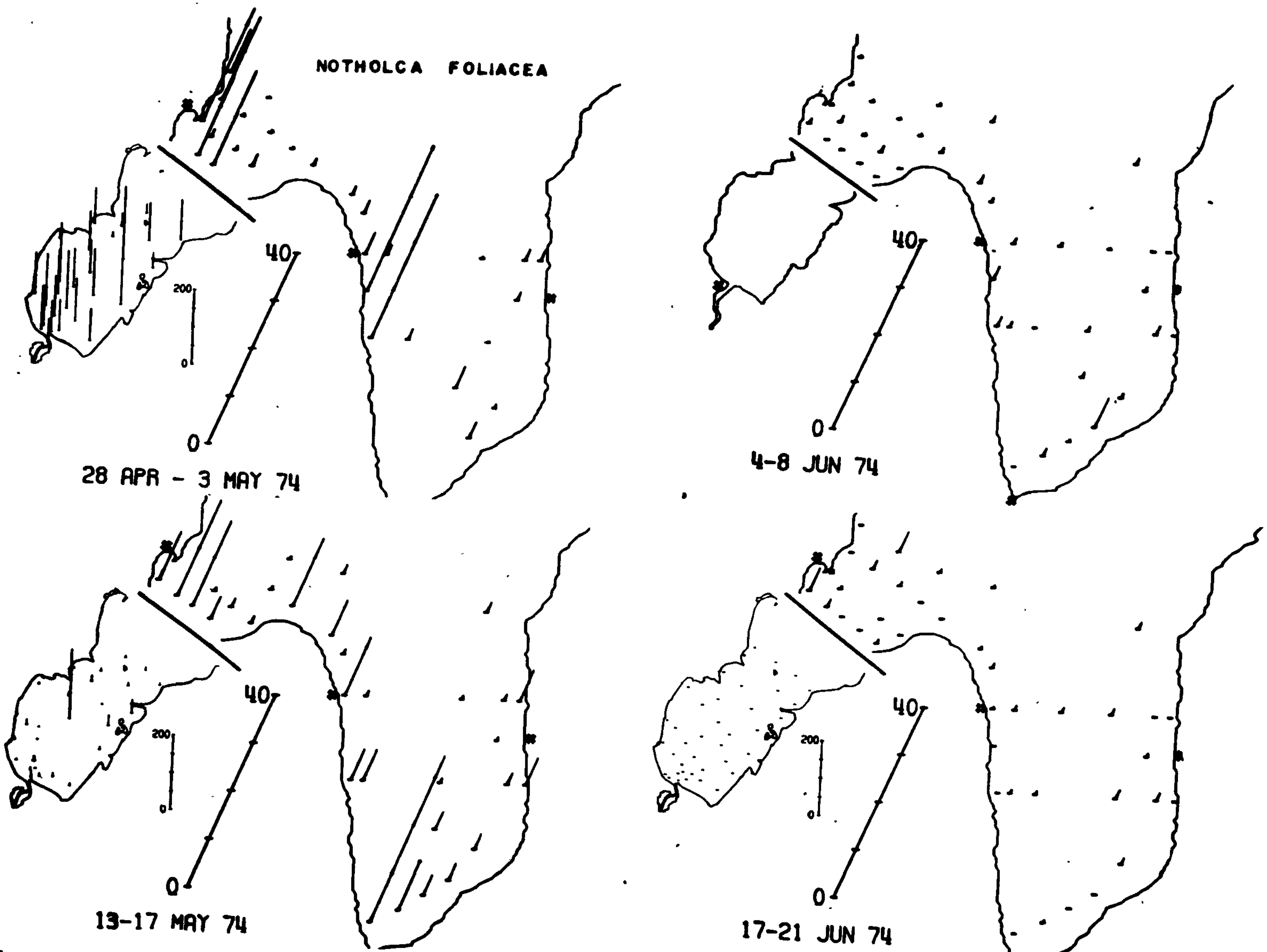

Figure A-20. Distribution and abundance (number of ind./liter) of *Notholca foliacea* for spring 1974.

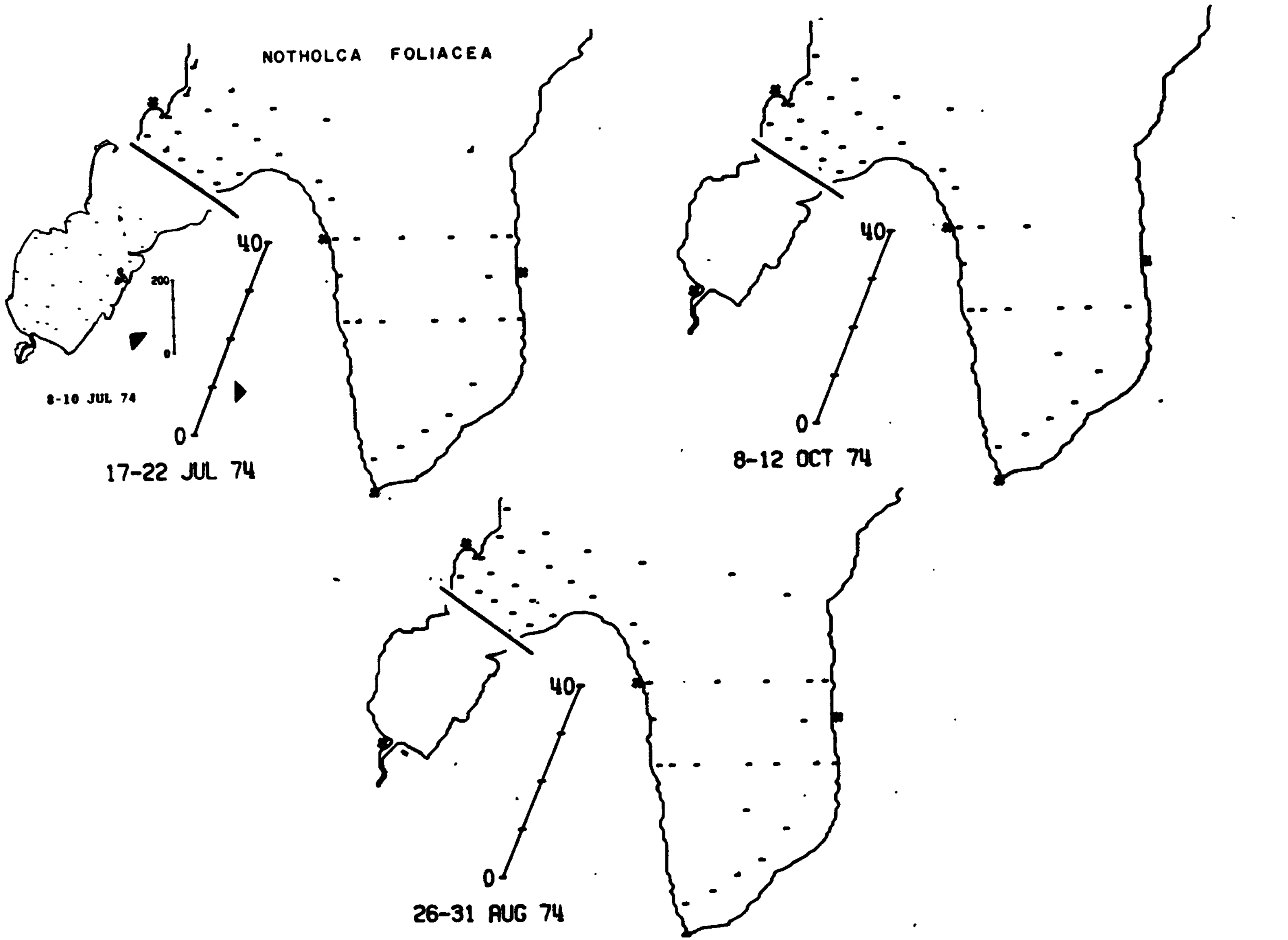

Figure A-21. Distribution and abundance (number of ind./liter) of *Notholca foliacea* for summer and fall 1974.

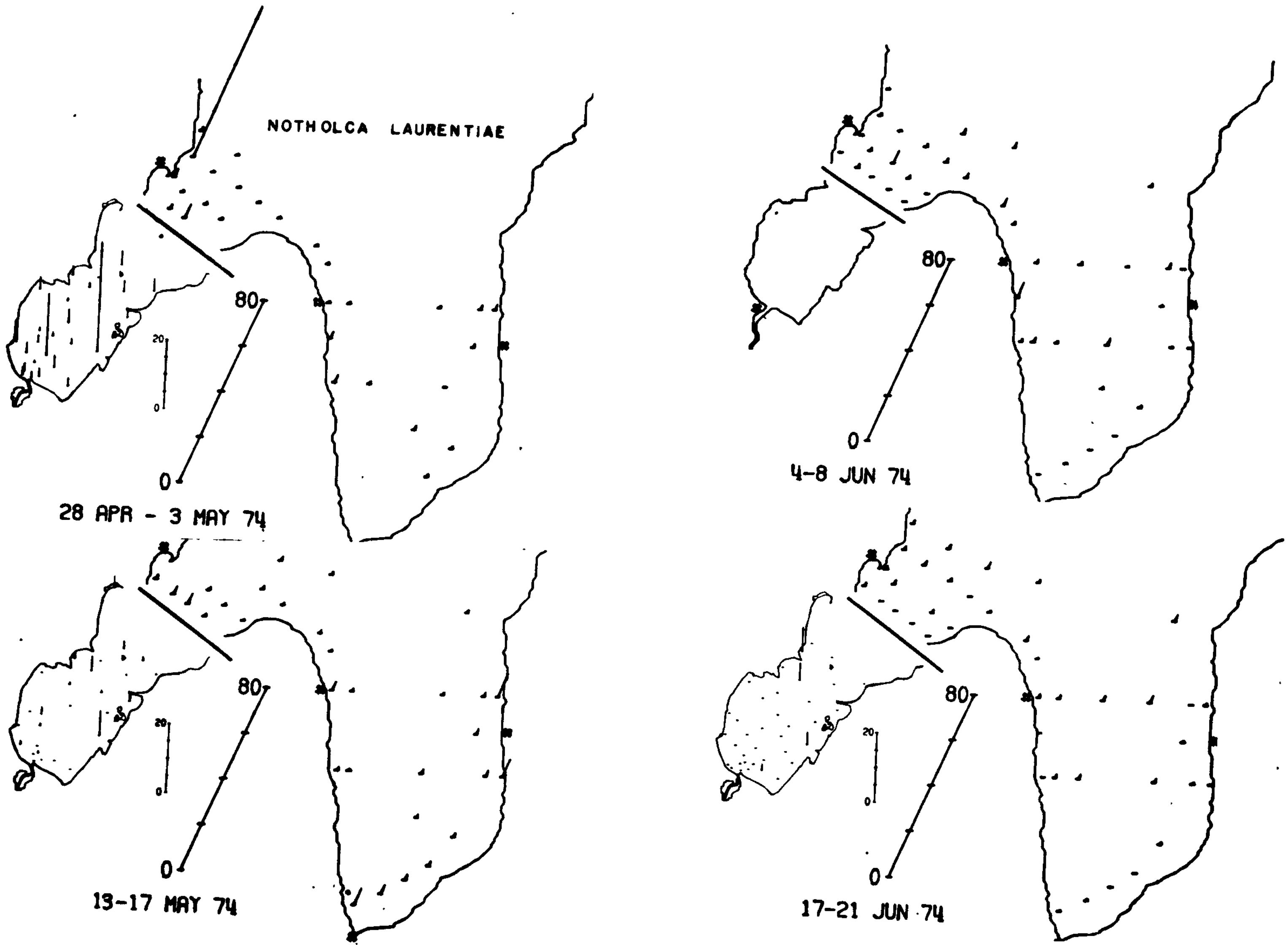

Figure A-22. Distribution and abundance (number of ind./liter) of *Notholca laurentiae* for spring 1974.

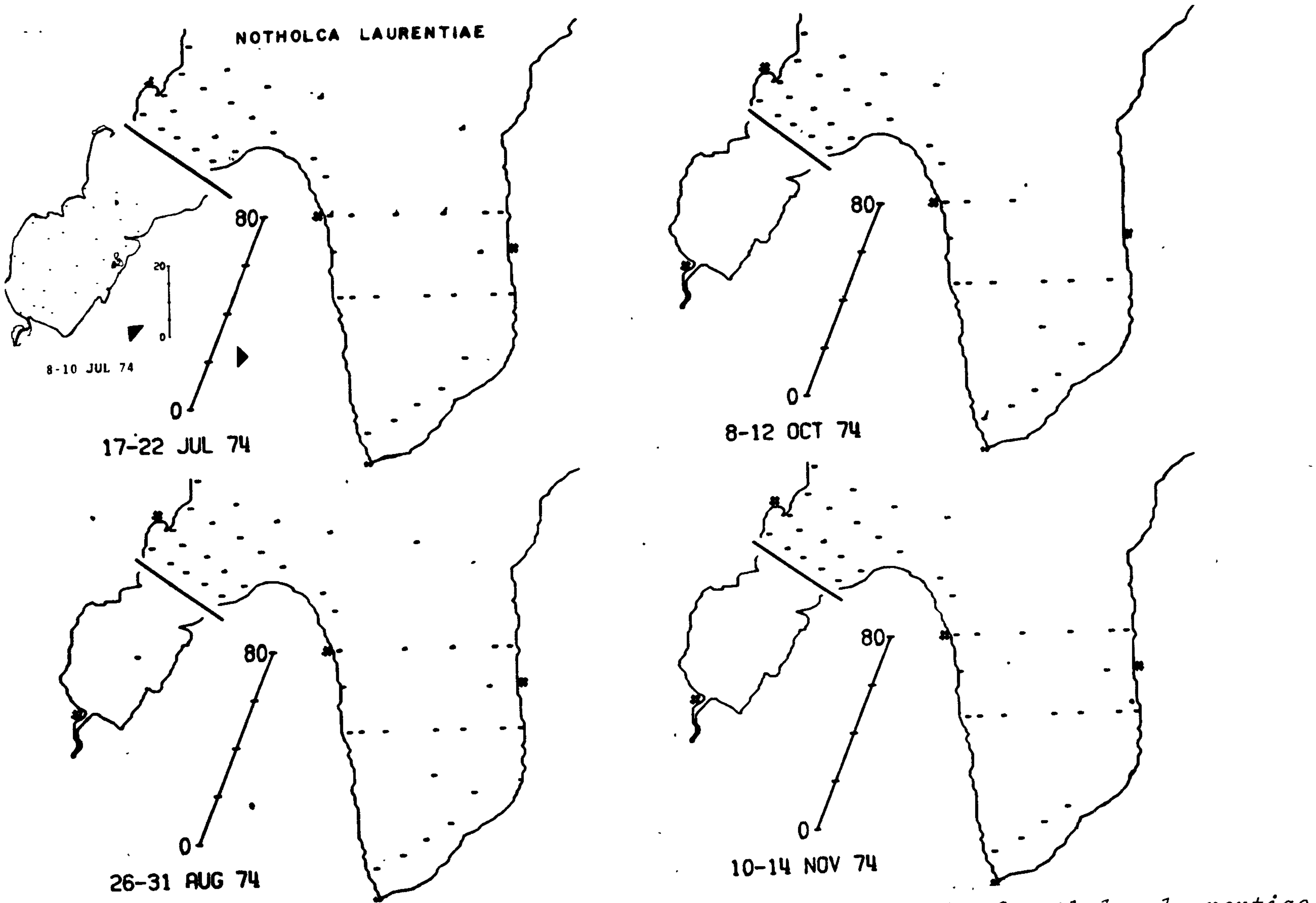

Figure A-23. Distribution and abundance (number of ind./liter) of *Notholca laurentiae* for summer and fall 1974.

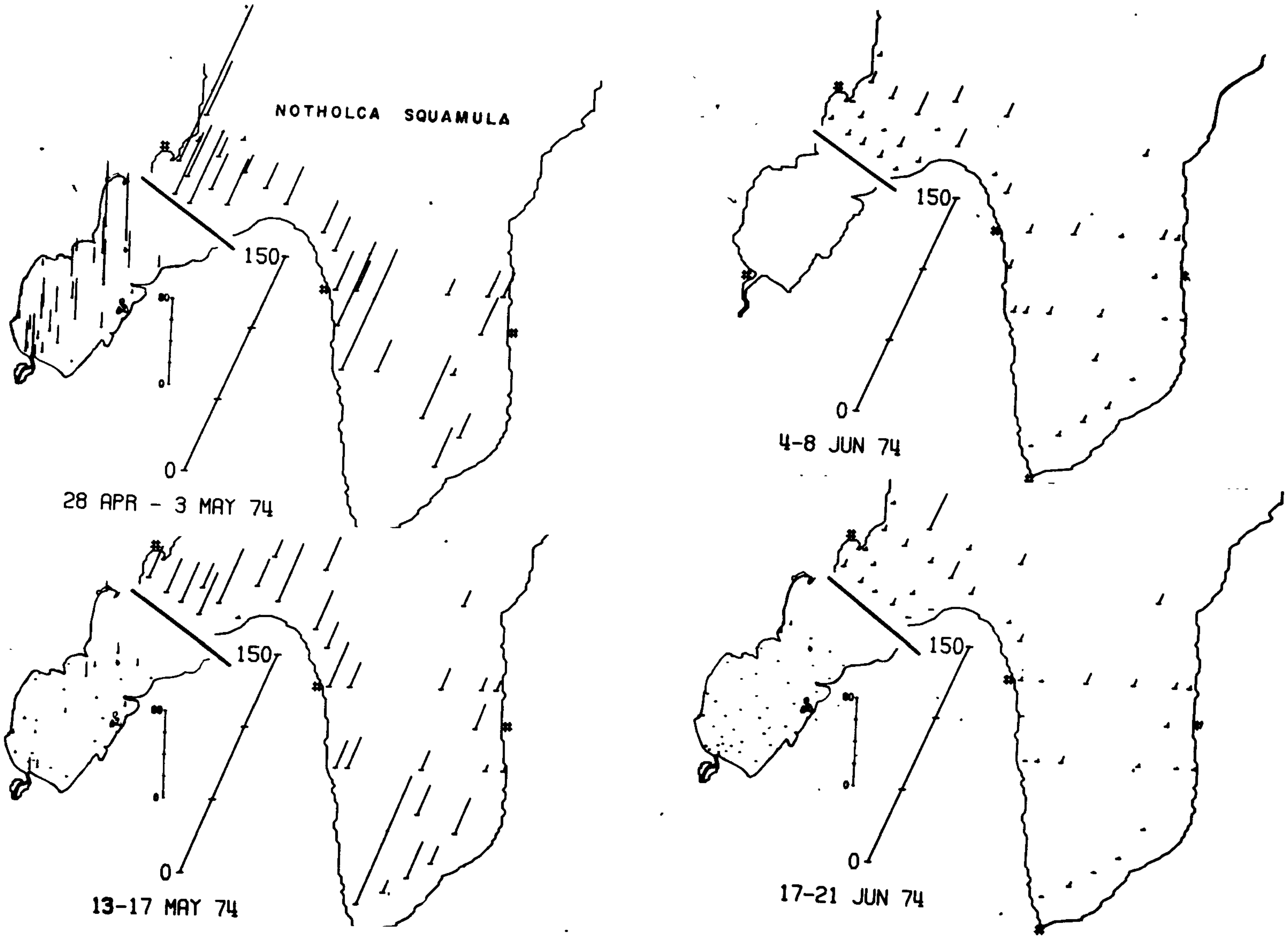

Figure A-24. Distribution and abundance (number of ind./liter) of *Notholca squamula* for spring 1974.

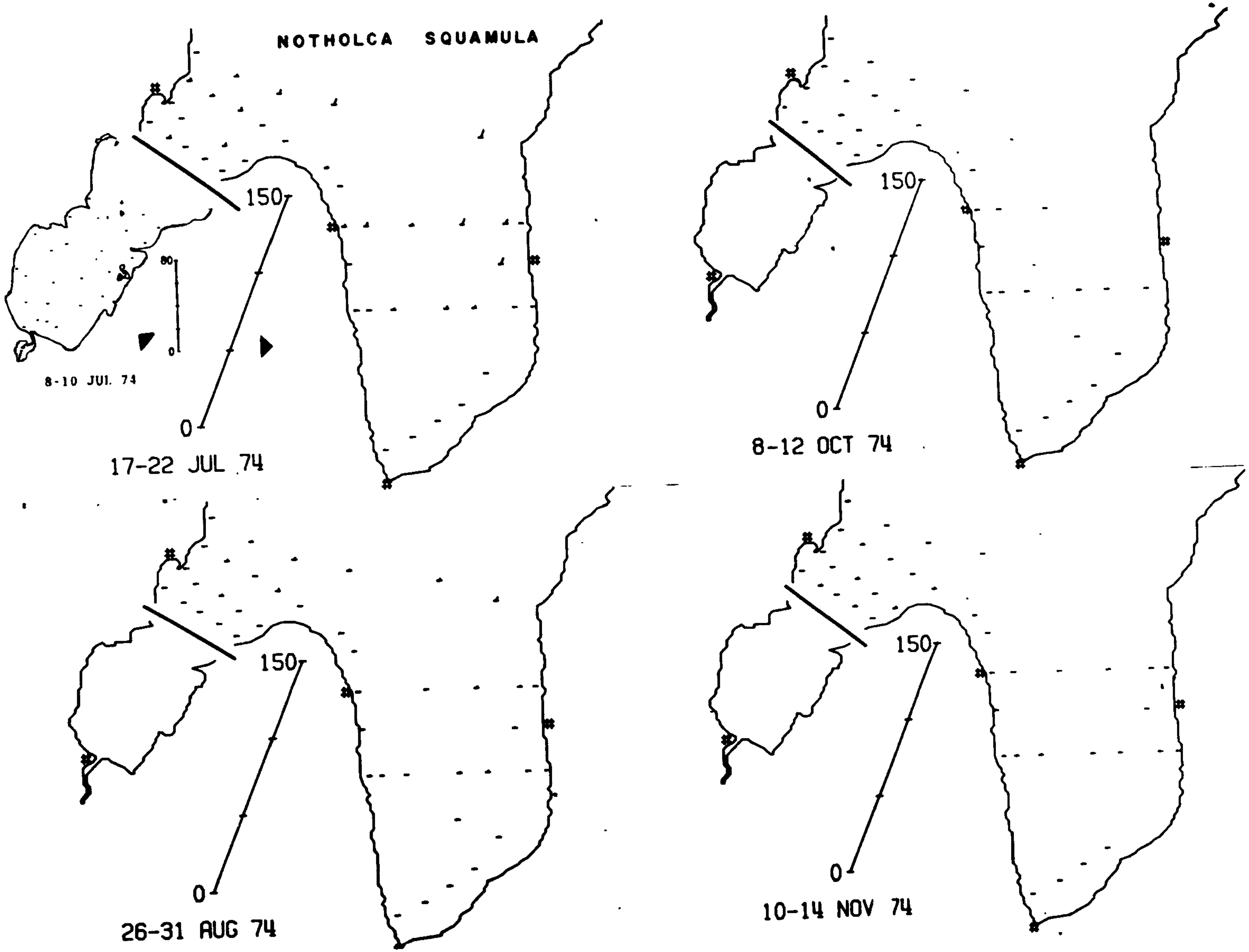

Figure A-25. Distribution and abundance (number of ind./liter) of *Notholca squamula* for summer and fall 1974.

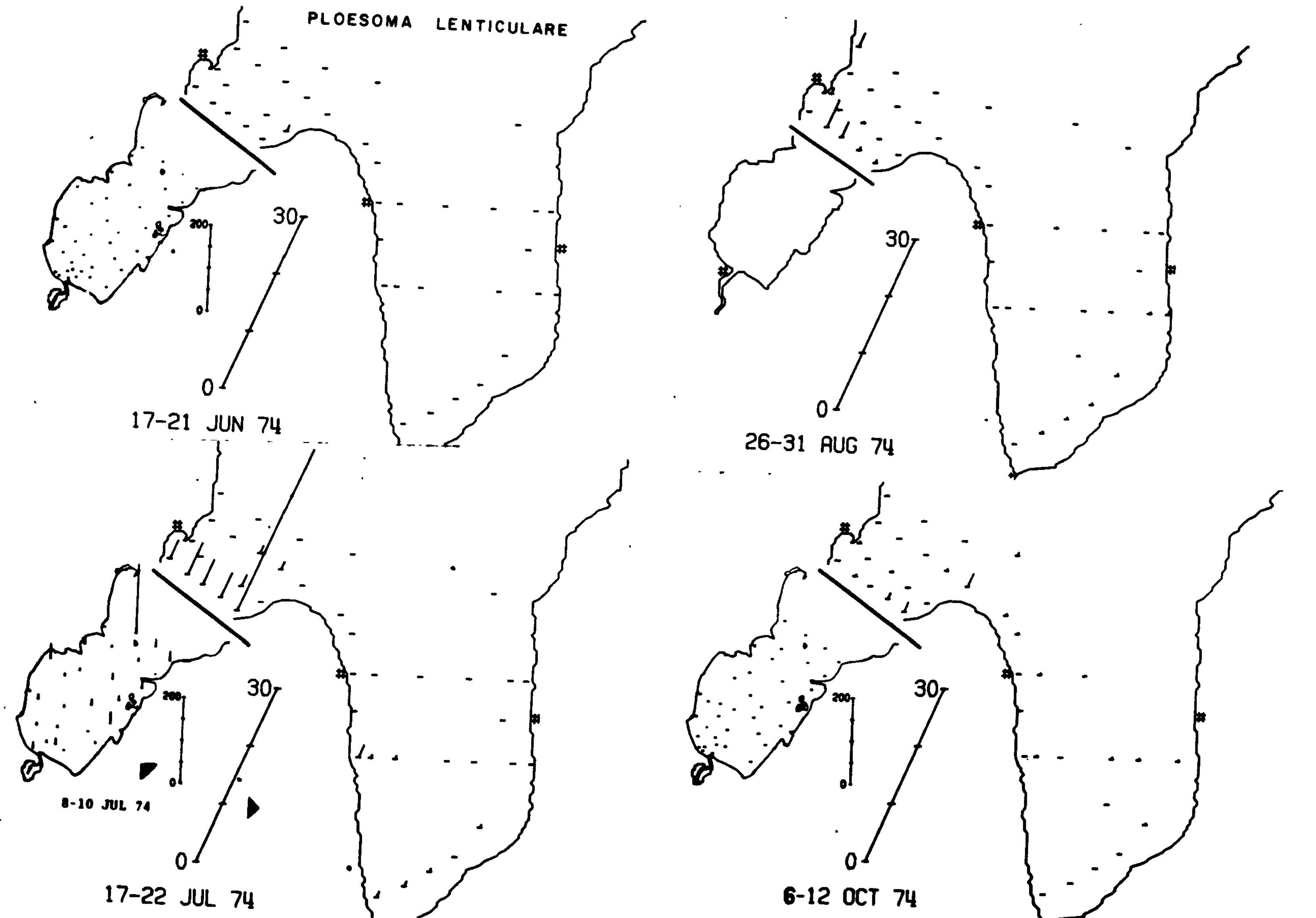

Figure A-26. Distribution and abundance (number of ind./liter) of *Ploesoma lenticulare* from spring through fall 1974.

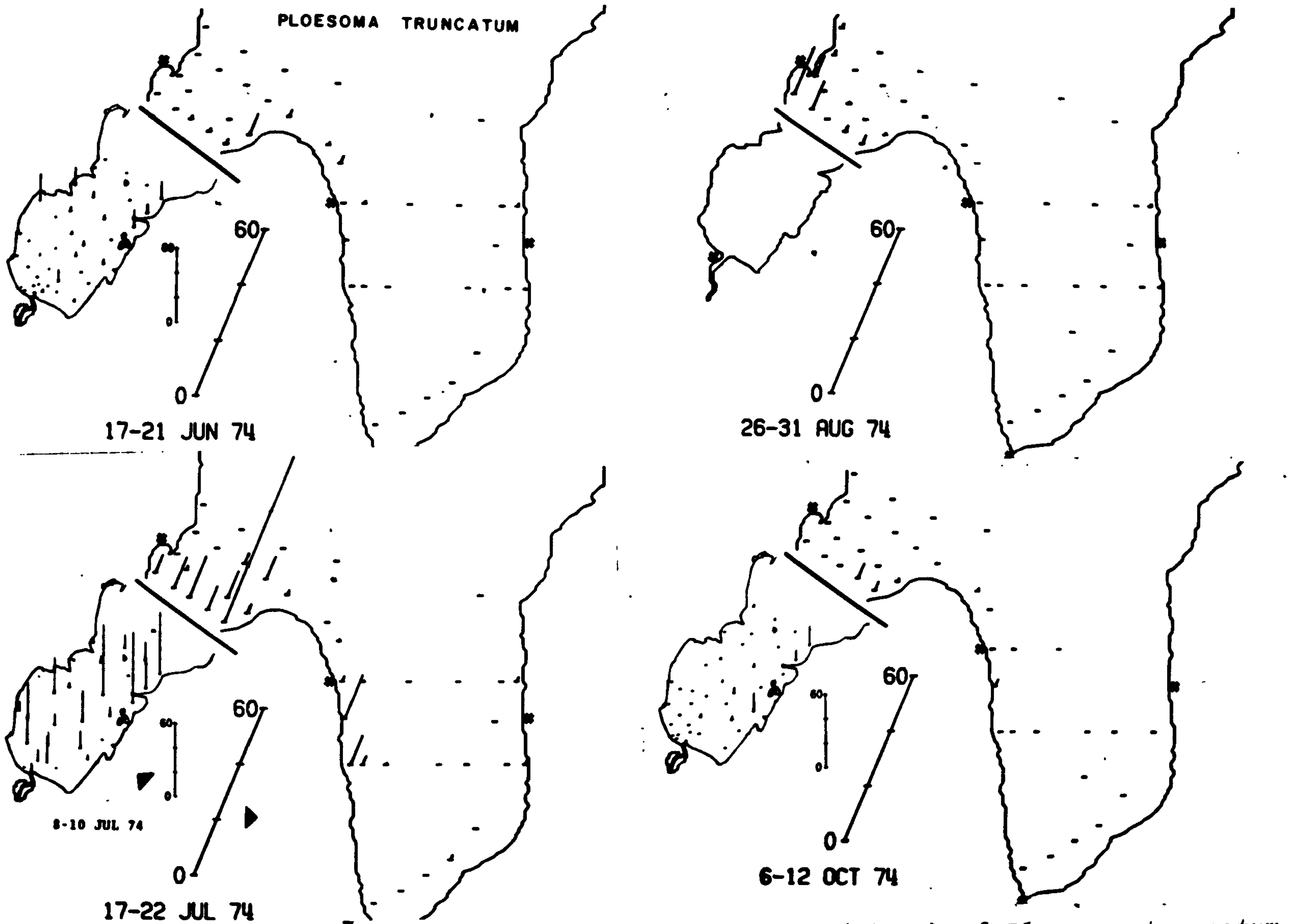

Figure A-27. Distribution and abundance (number of ind./liter) of *Ploesoma truncatum* from spring through fall 1974.

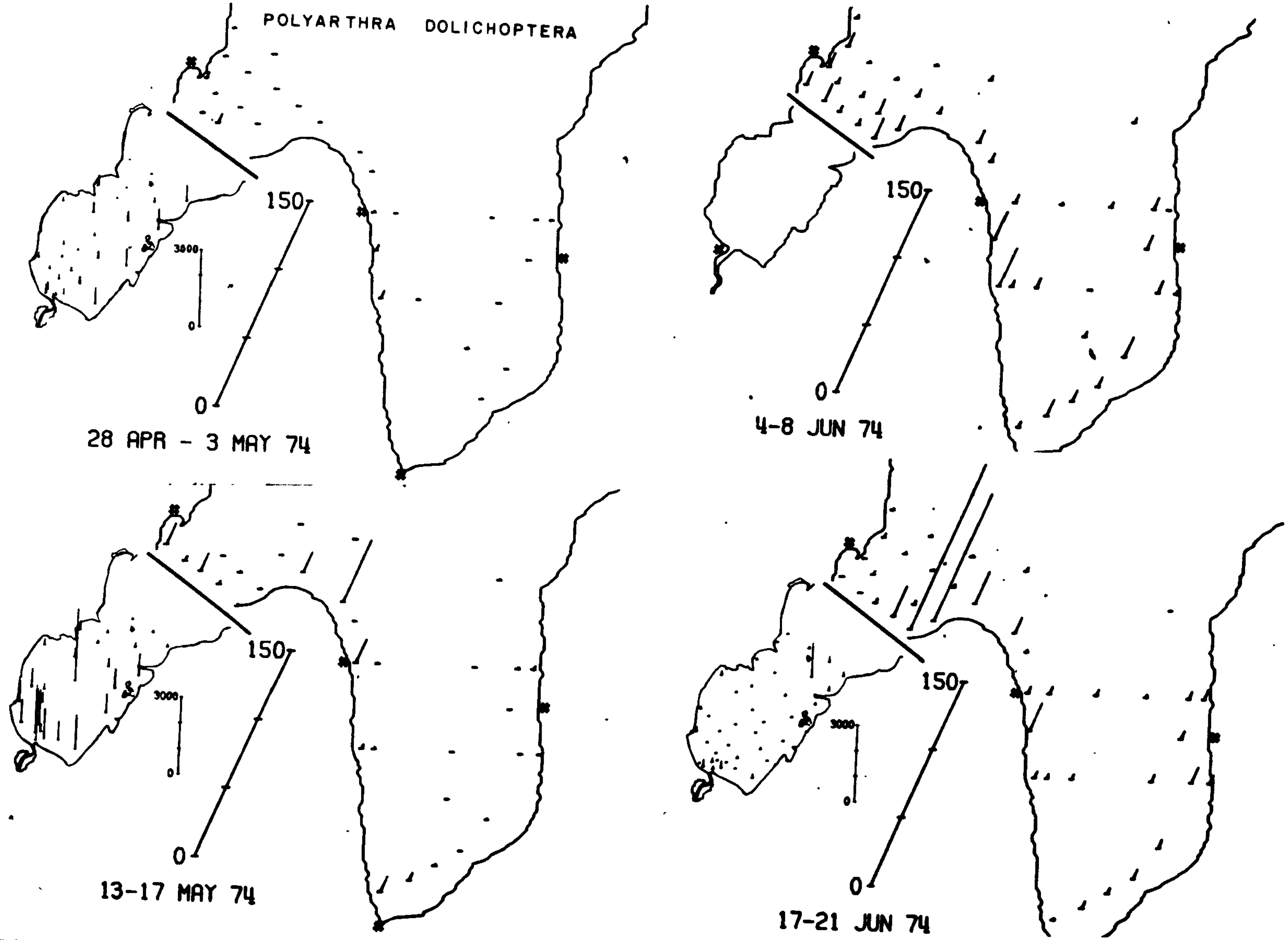

Figure A-28. Distribution and abundance (number of ind./liter) of *Polyarthra dolichoptera* for spring 1974.

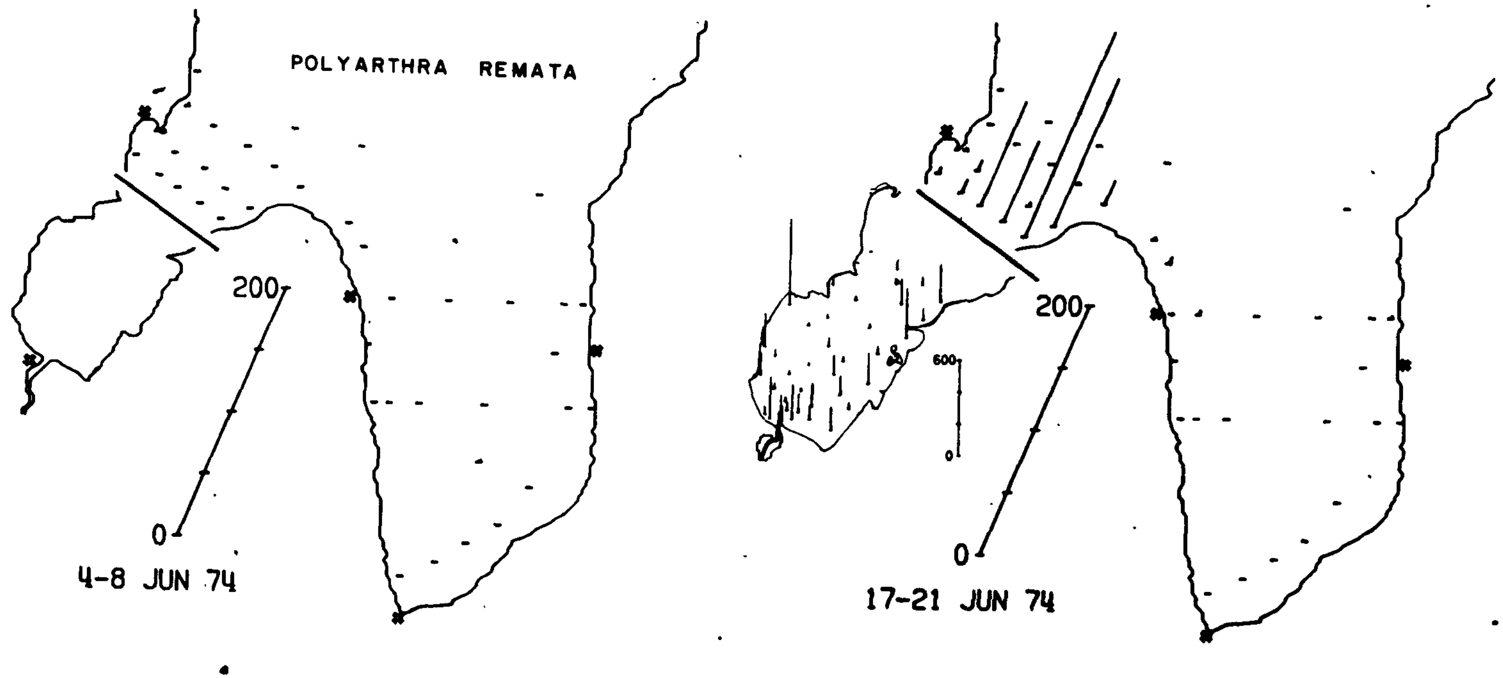

Figure A-29. Distribution and abundance (number of ind./liter) of *Polyarthra remata* for spring 1974.

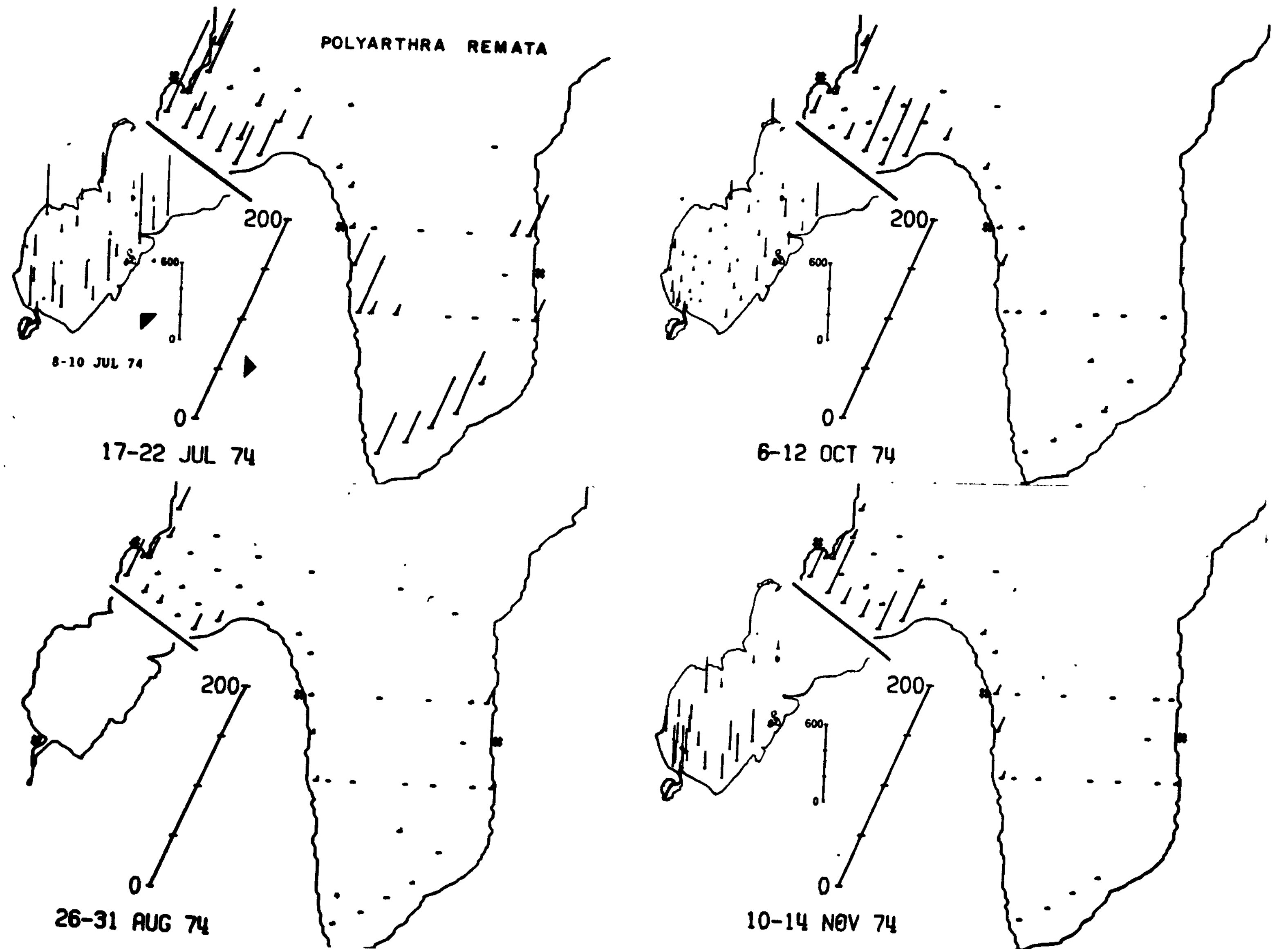

Figure A-30. Distribution and abundance (number of ind./liter) of *Polyarthra remata* for summer and fall 1974.

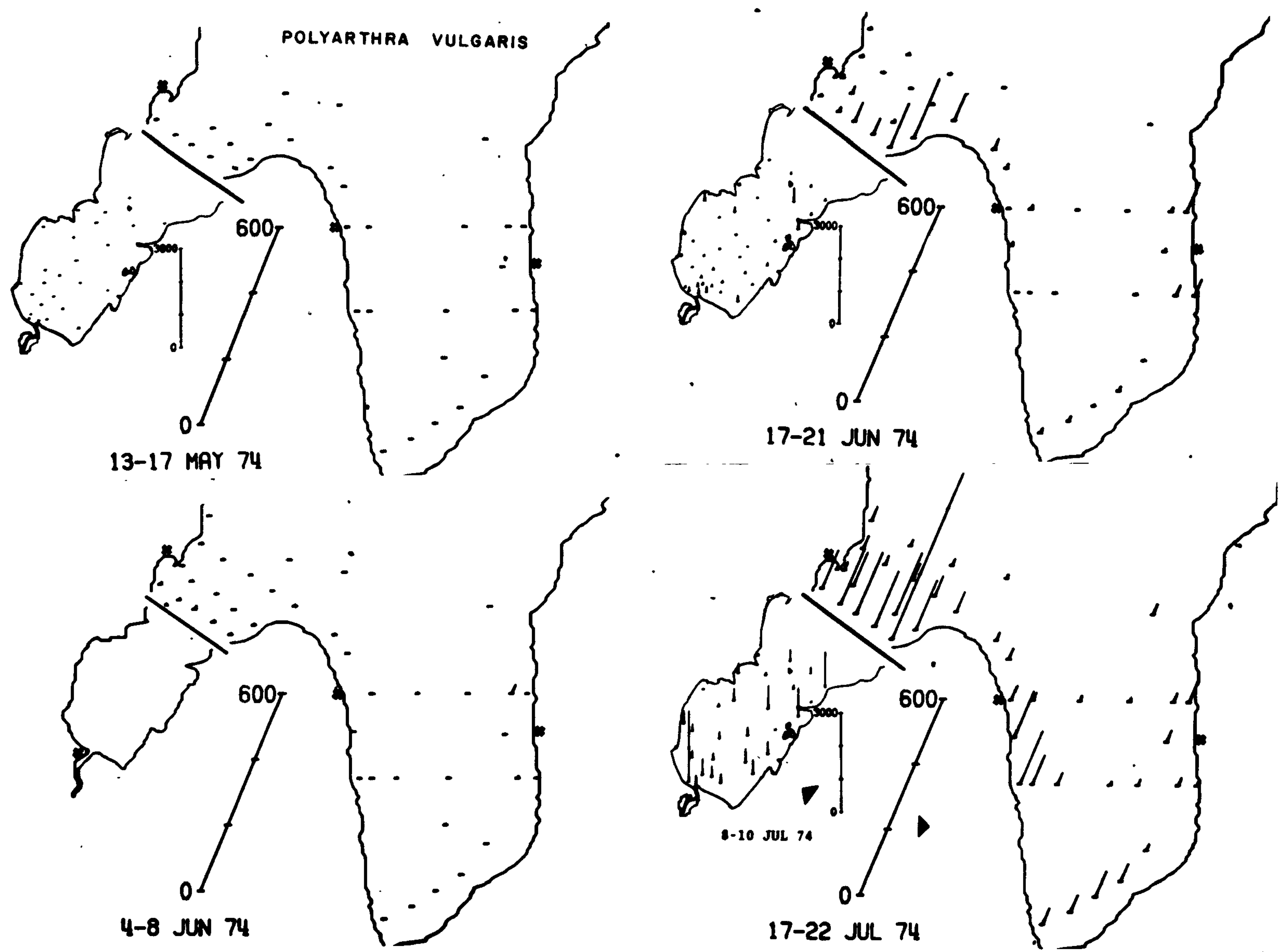

Figure A-31. Distribution and abundance (number of ind./liter) of *Polyarthra vulgaris* for spring and summer 1974.

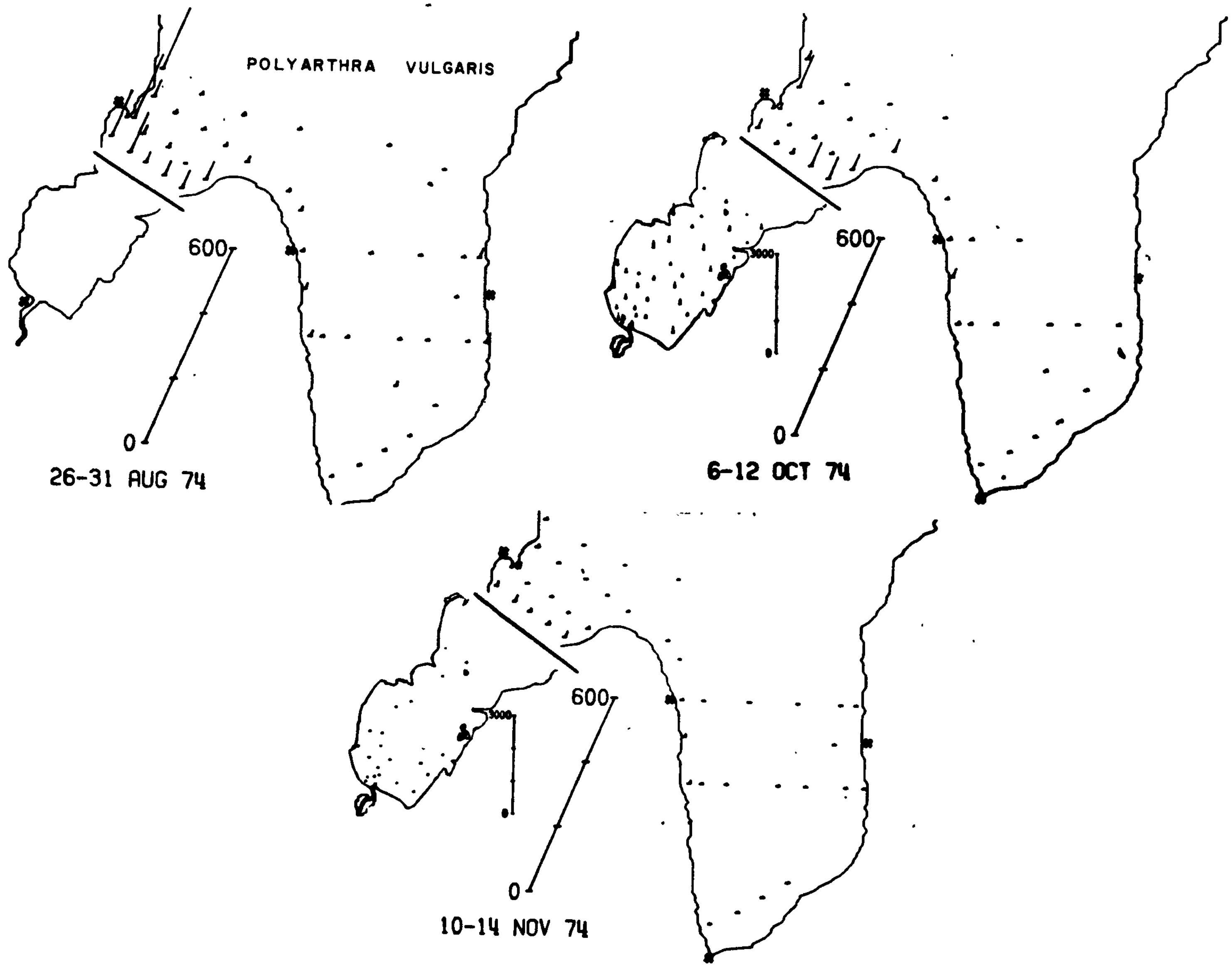

Figure A-32. Distribution and abundance (number of ind./liter) of *Polyarthra vulgaris* for summer and fall 1974.

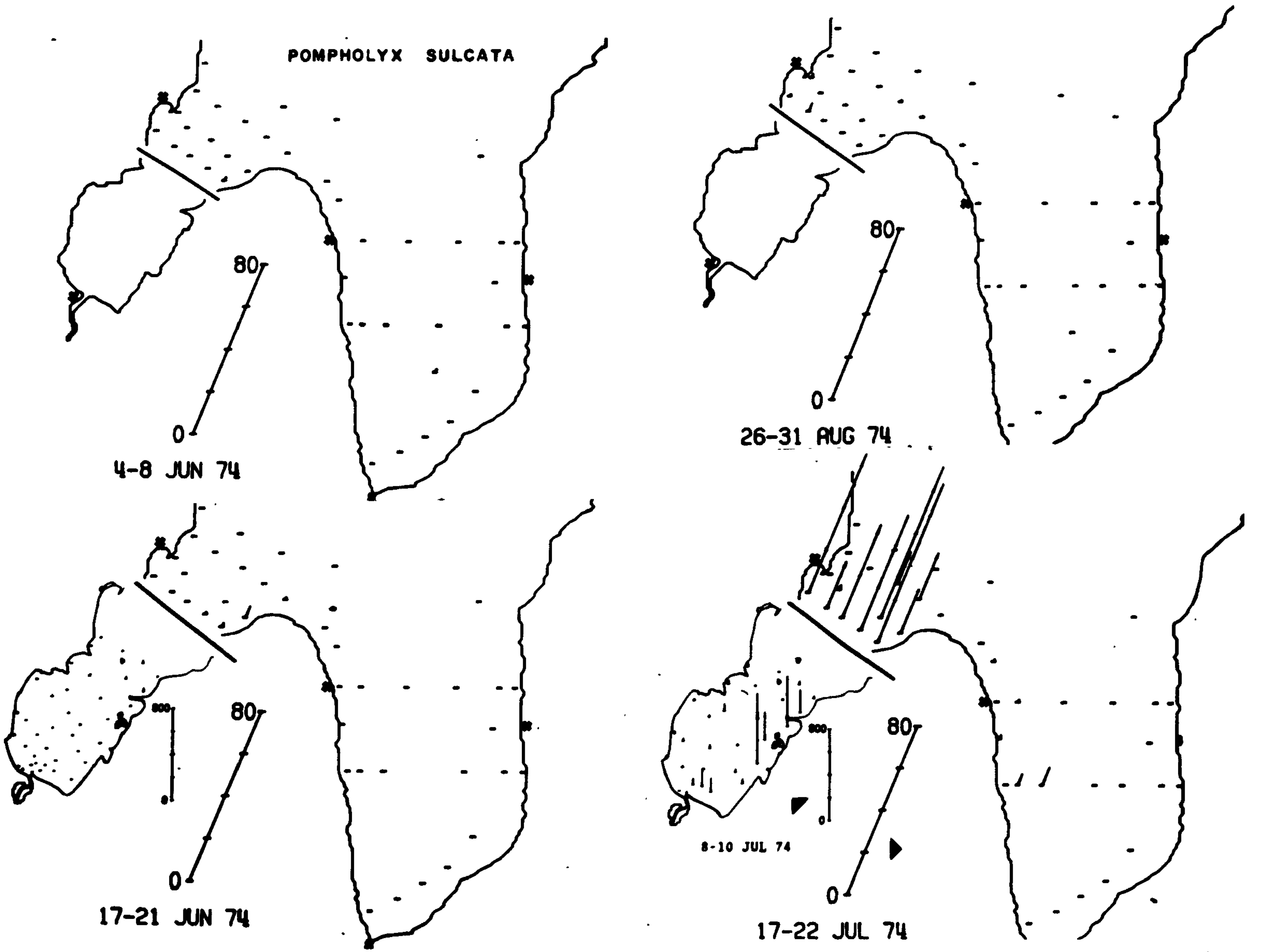

Figure A-33. Distribution and abundance (number of ind./liter) of *Pompholyx sulcata* for spring and summer 1974.

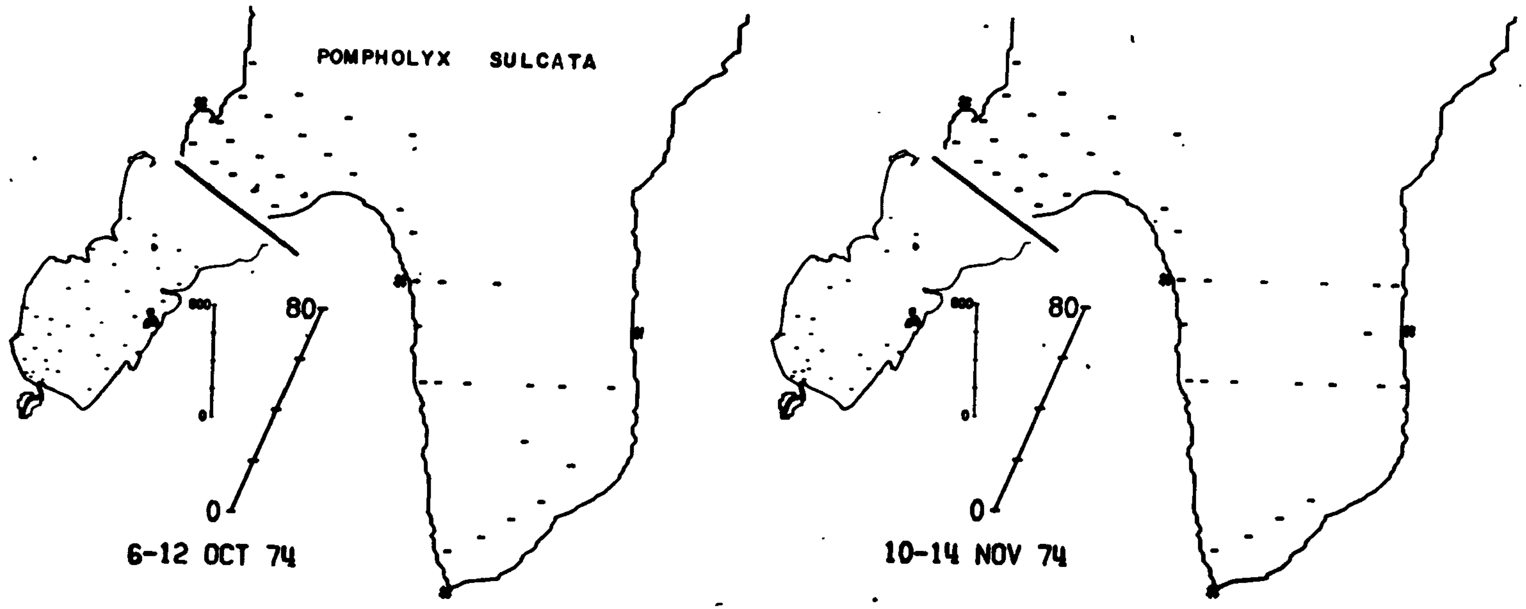

Figure A-34. Distribution and abundance (number of ind./liter) of *Pompholyx sulcata* for fall 1974.

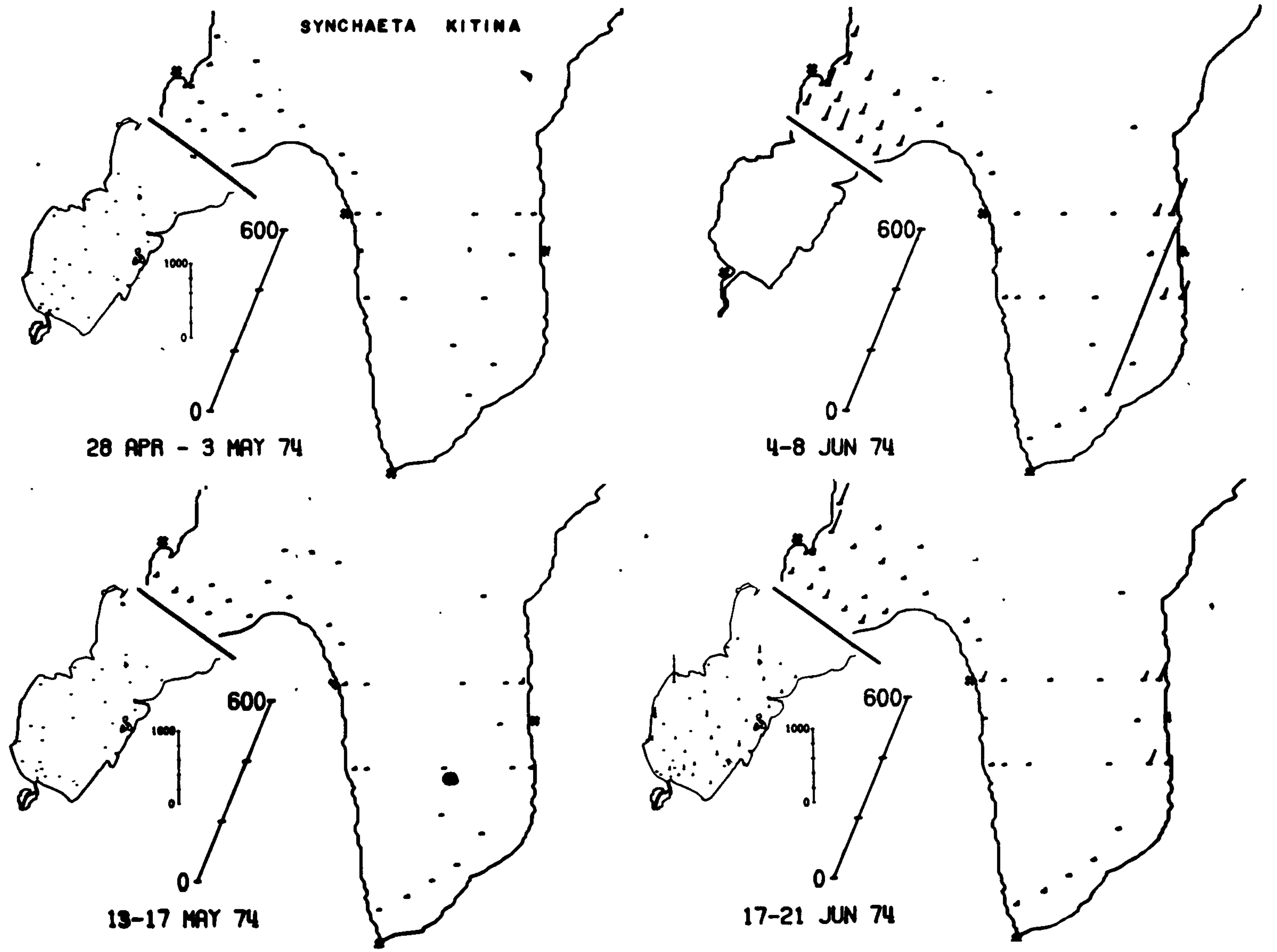

Figure A-35. Distribution and abundance (number of ind./liter) of *Synchaeta kitina* for spring 1974.

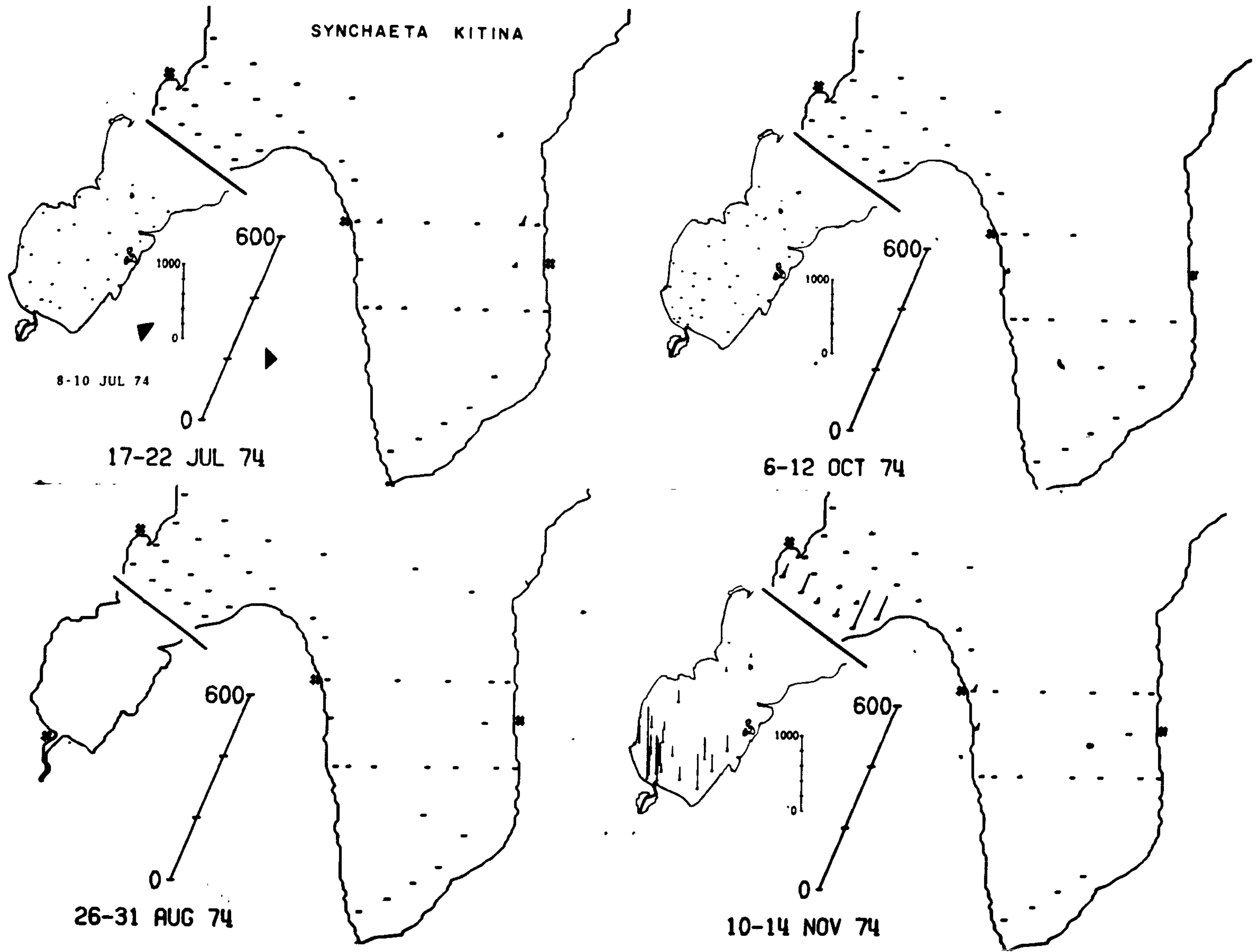

Figure A-36. Distribution and abundance (number of ind./liter) of *Synchaeta kitina* for summer and fall 1974.

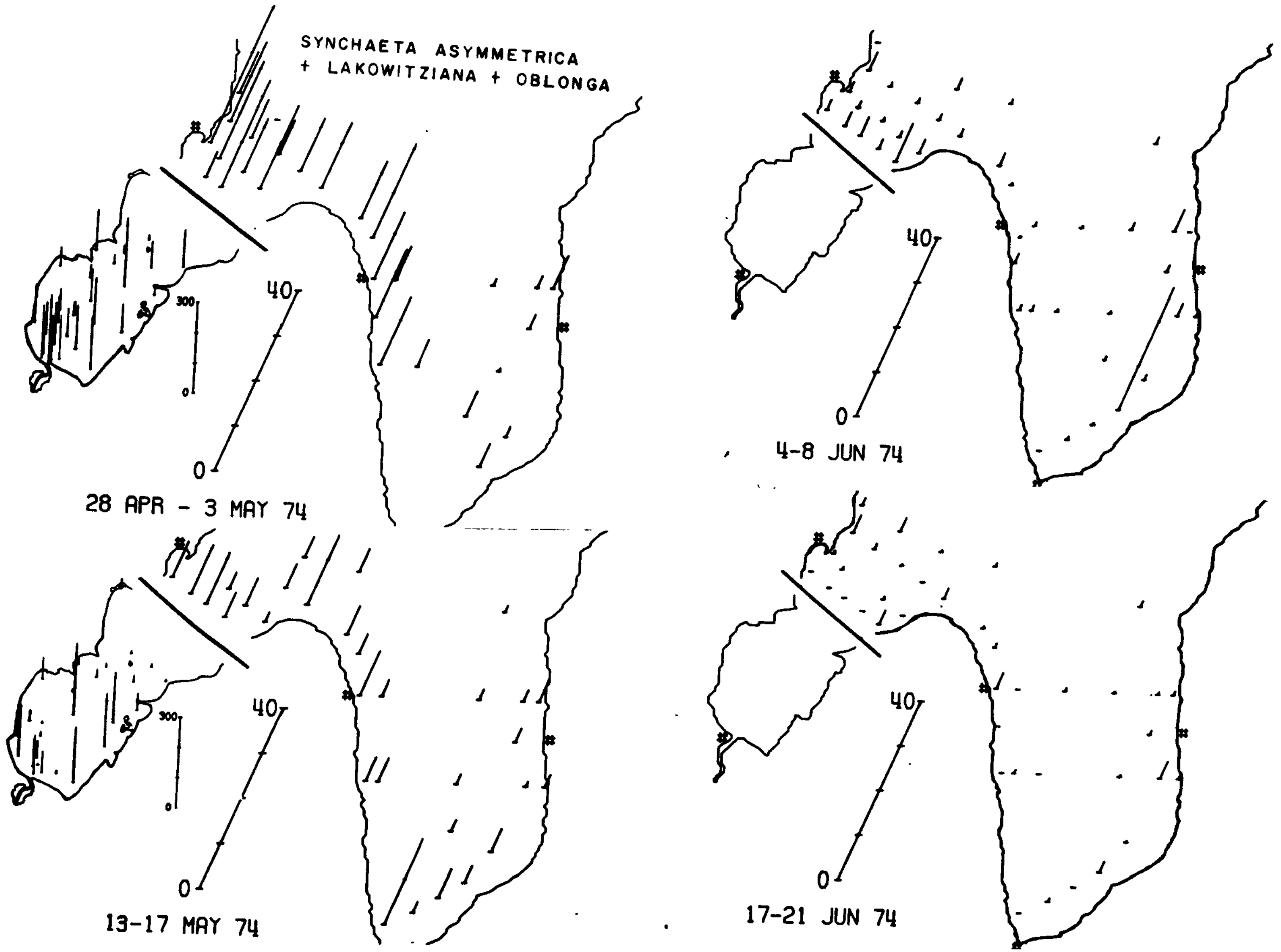

Figure A-37. Distribution and abundance (number of ind./liter) of *Synchaeta* spp. for spring 1974. *Synchaeta* spp. represents contracted specimens of *S. asymmetrica*, *S. lakowitziana* and *S. oblonga*.

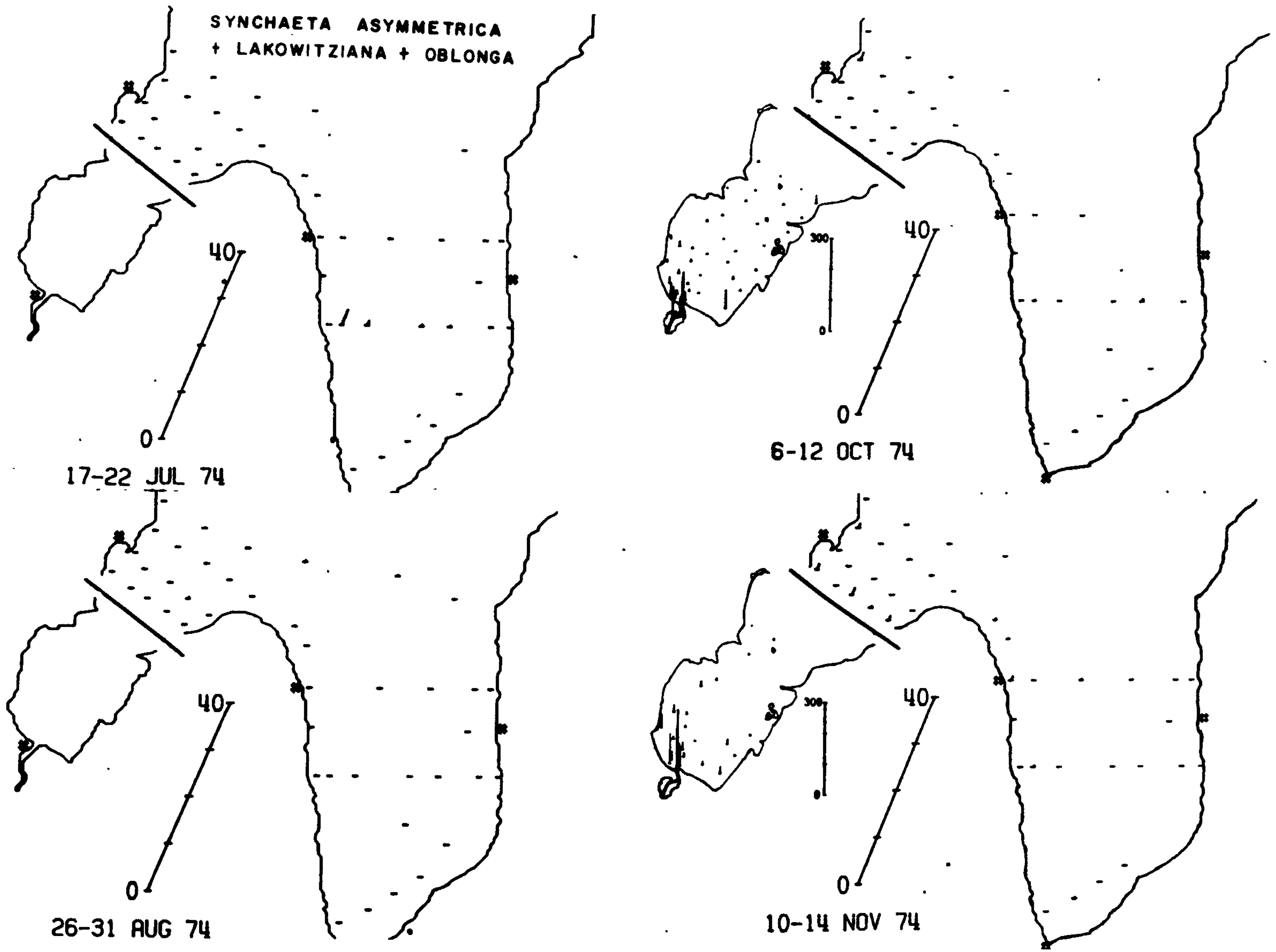

Figure A-38. Distribution and abundance (number of ind./liter) of *Synchaeta* spp. for summer and fall 1974. *Synchaeta* spp. represents contracted specimens of *S. asymmetrica*, *S. lakowitziana* and *S. oblonga*.

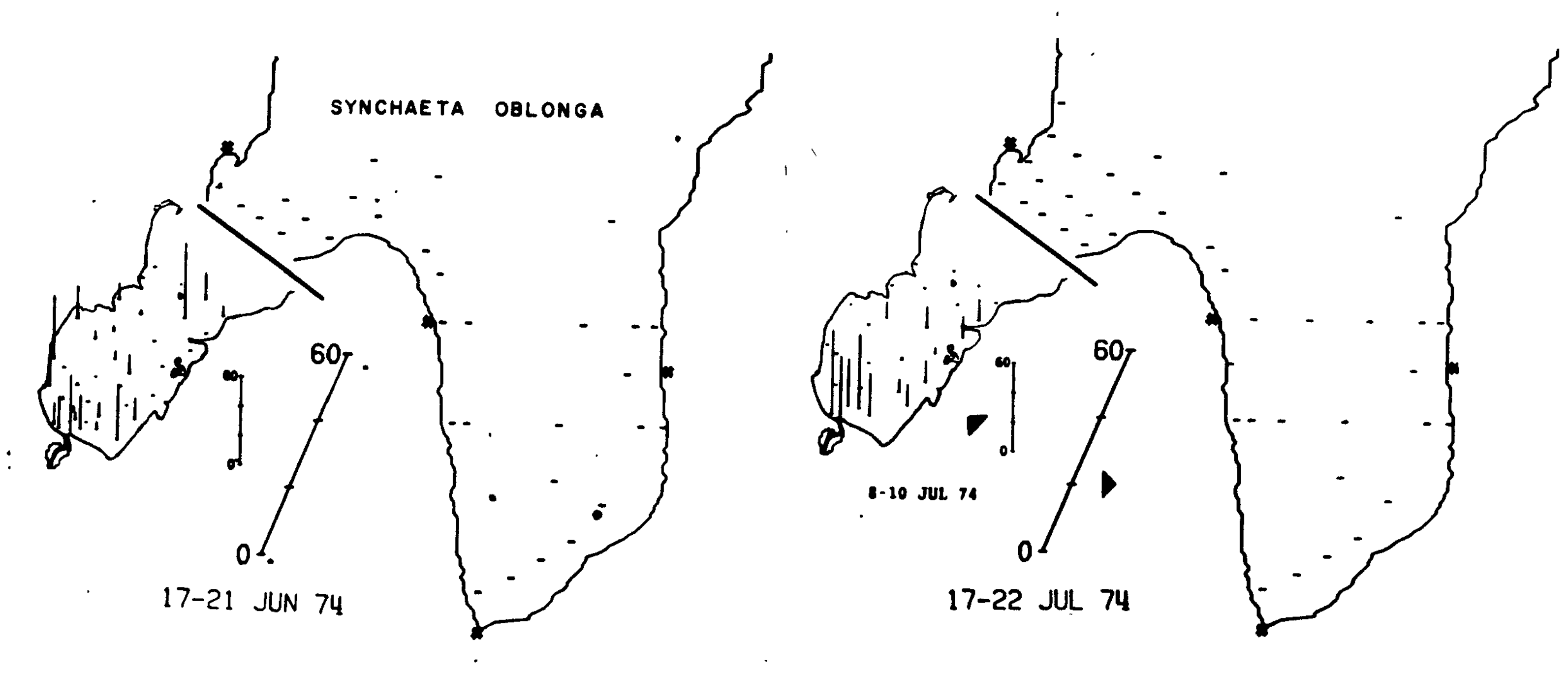

Figure A-39. Distribution and abundance (number of ind./liter) of *Synchaeta oblonga* for spring and summer 1974.

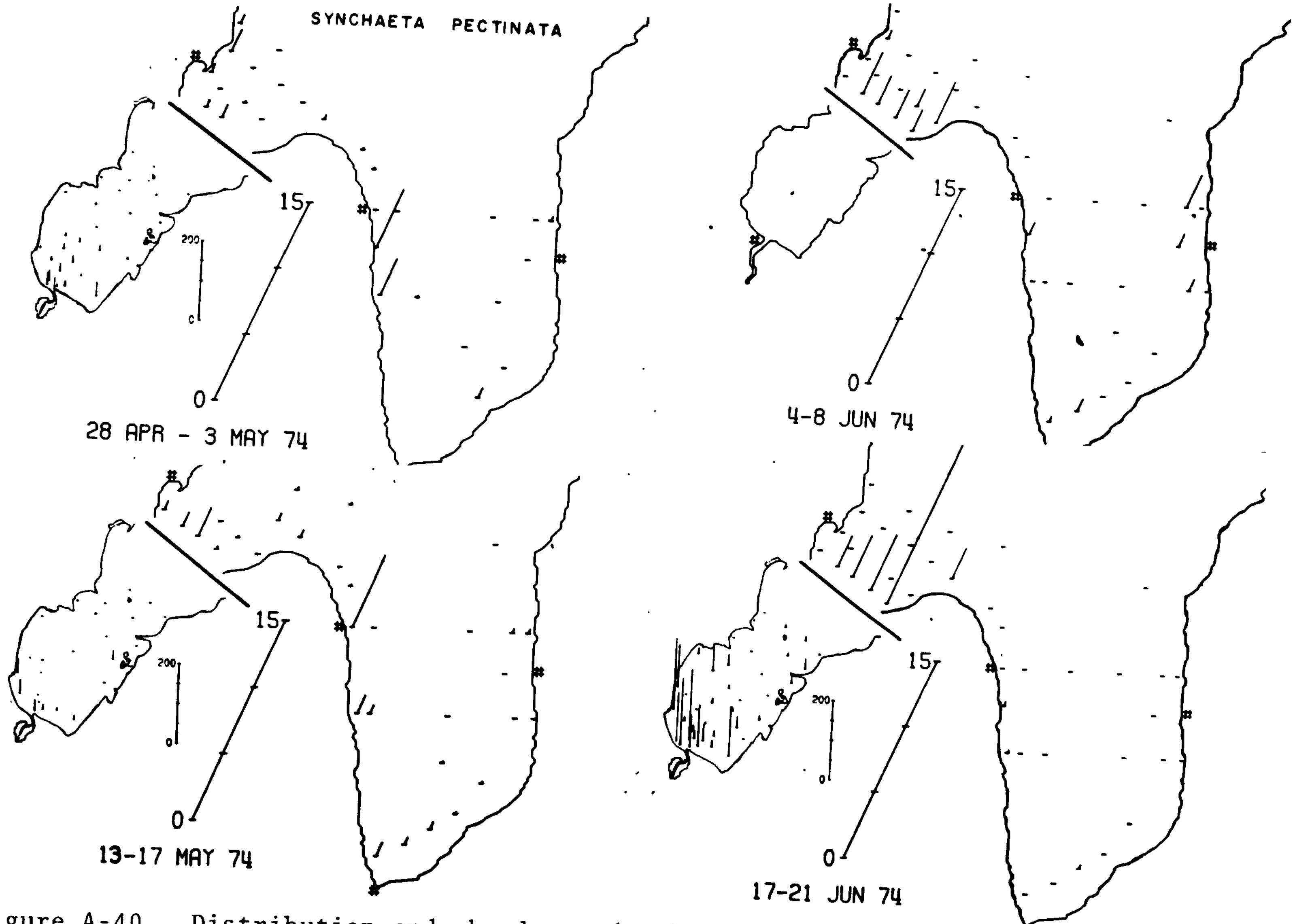

Figure A-40. Distribution and abundance (number of ind./liter) of *Synchaeta pectinata* for spring 1974.

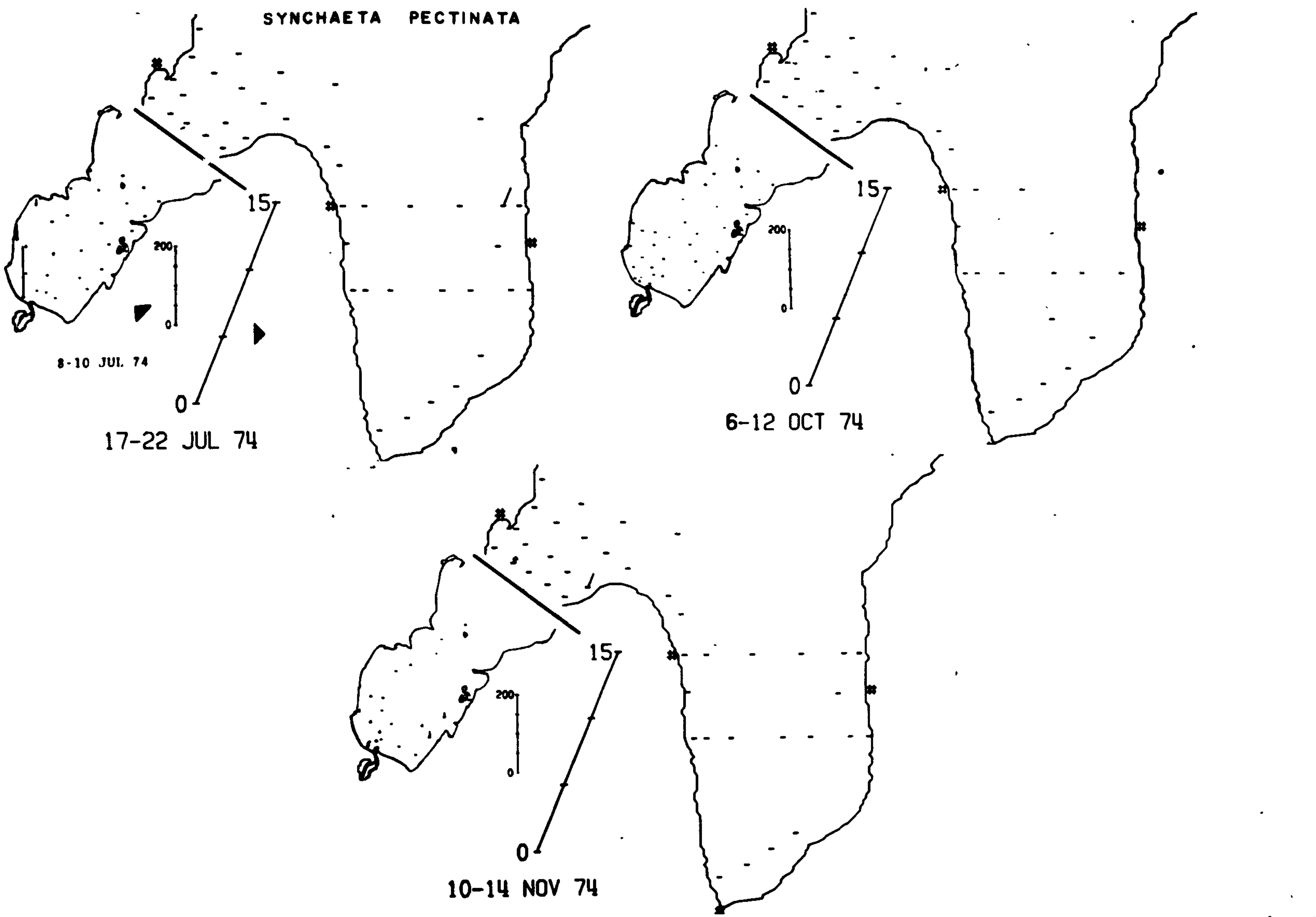

Figure A-41. Distribution and abundance (number of ind./liter) of *Synchaeta pectinata* for summer and fall 1974.

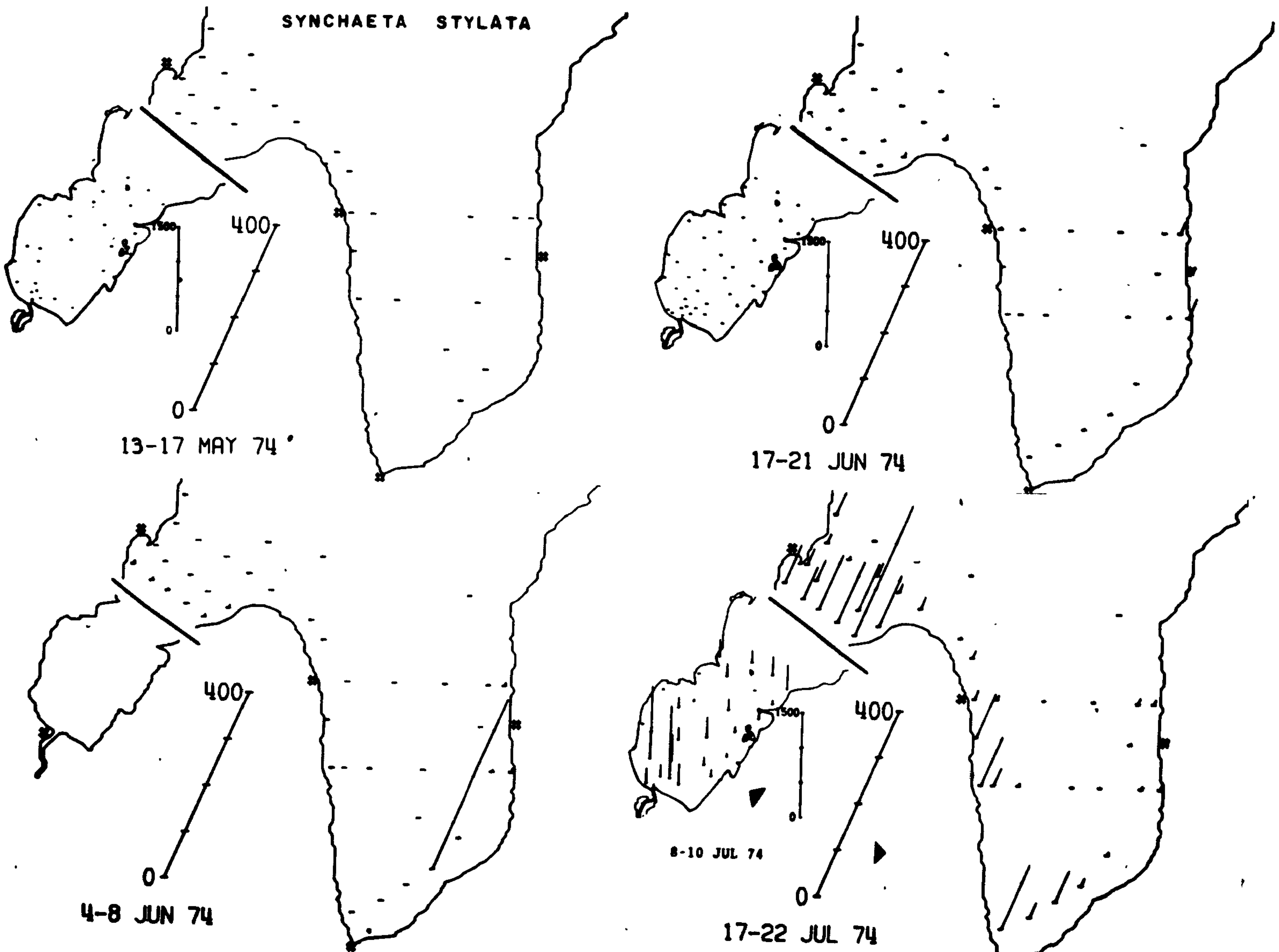

Figure A-42. Distribution and abundance (number of ind./liter) of *Synchaeta stylata* for spring and summer 1974.

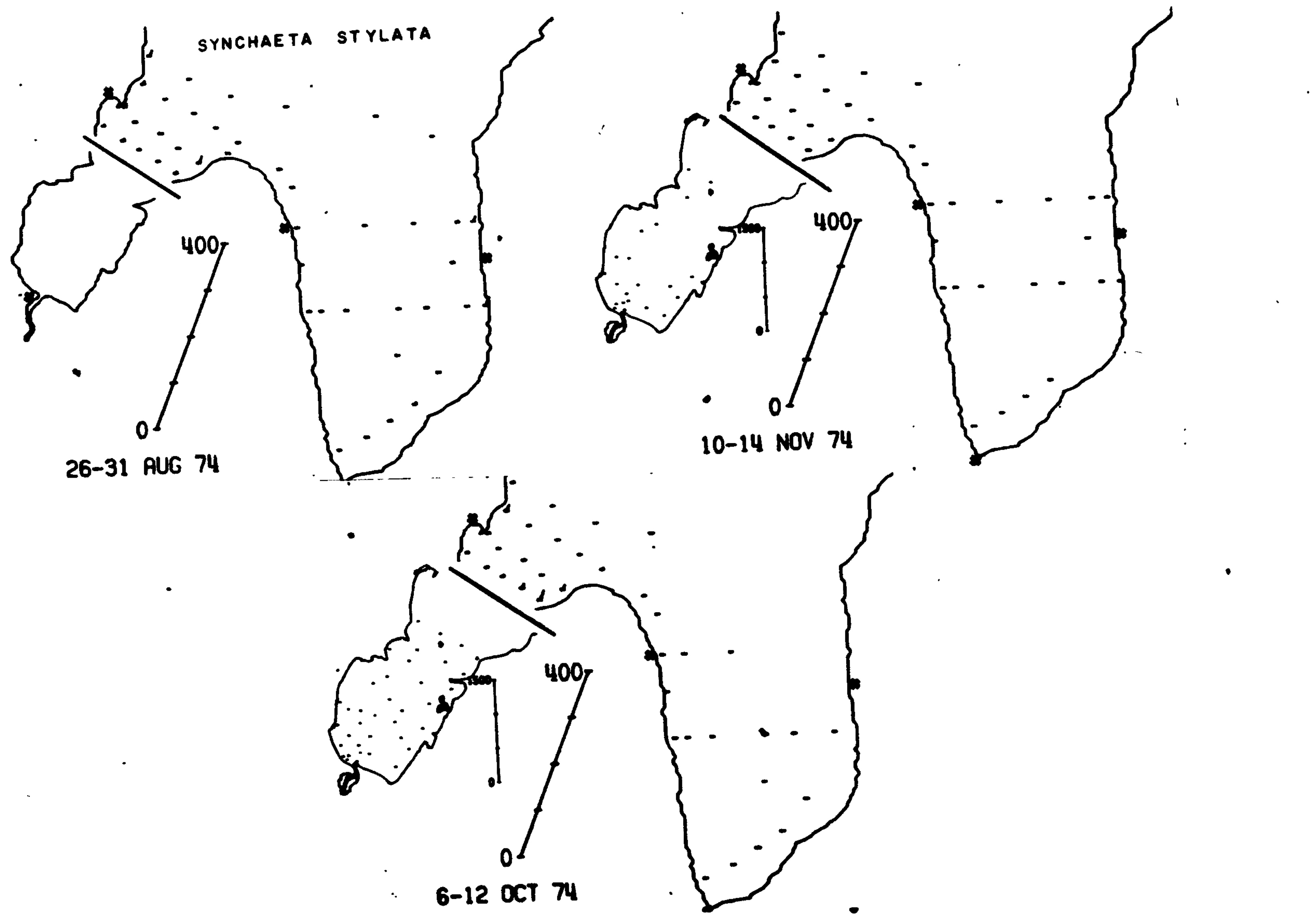

Figure A-43. Distribution and abundance (number of ind./liter) of *Synchaeta stylata*. for summer and fall 1974.

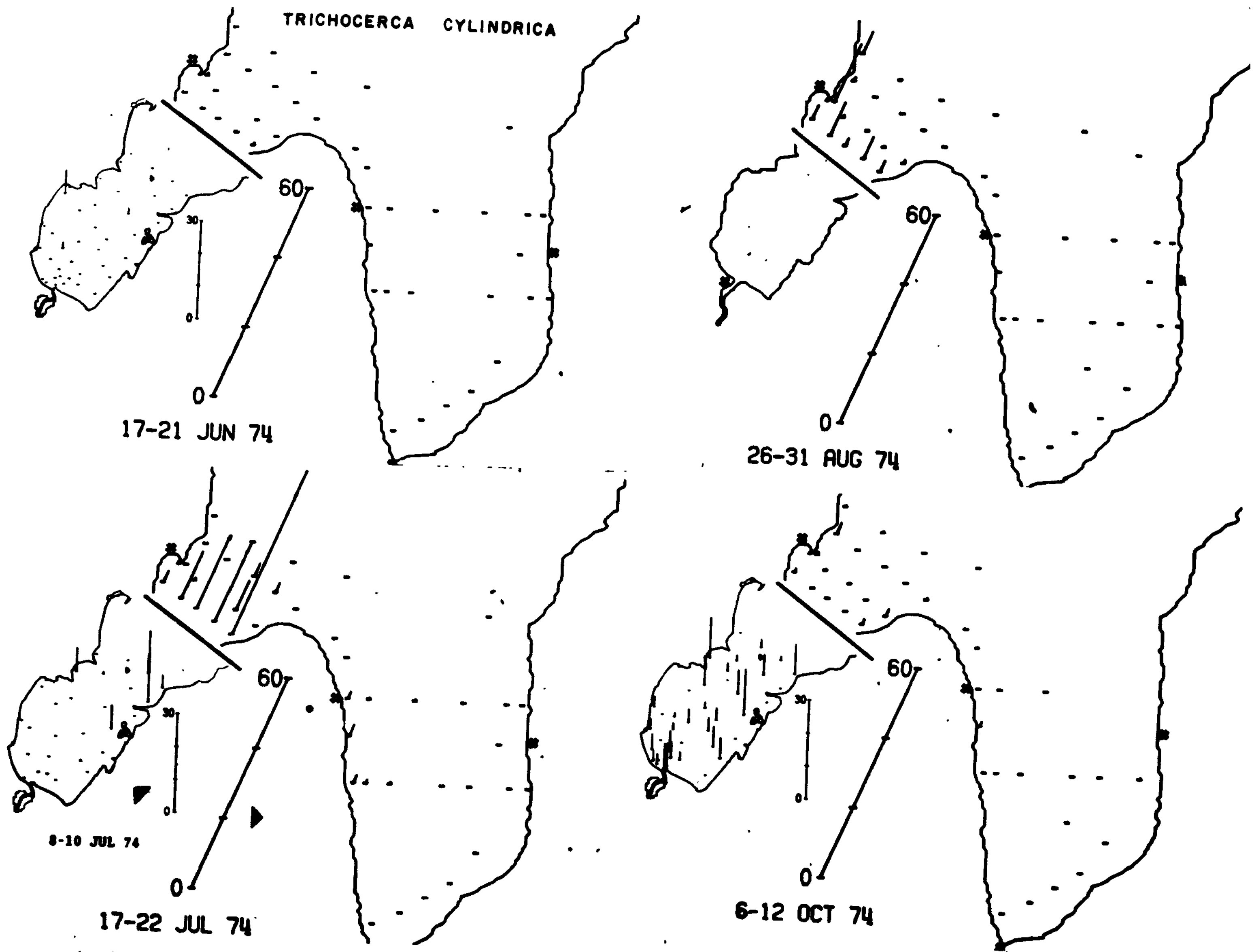

Figure A-44. Distribution and abundance (number of ind./liter) of *Trichocerca cylindrica* from spring through fall 1974.

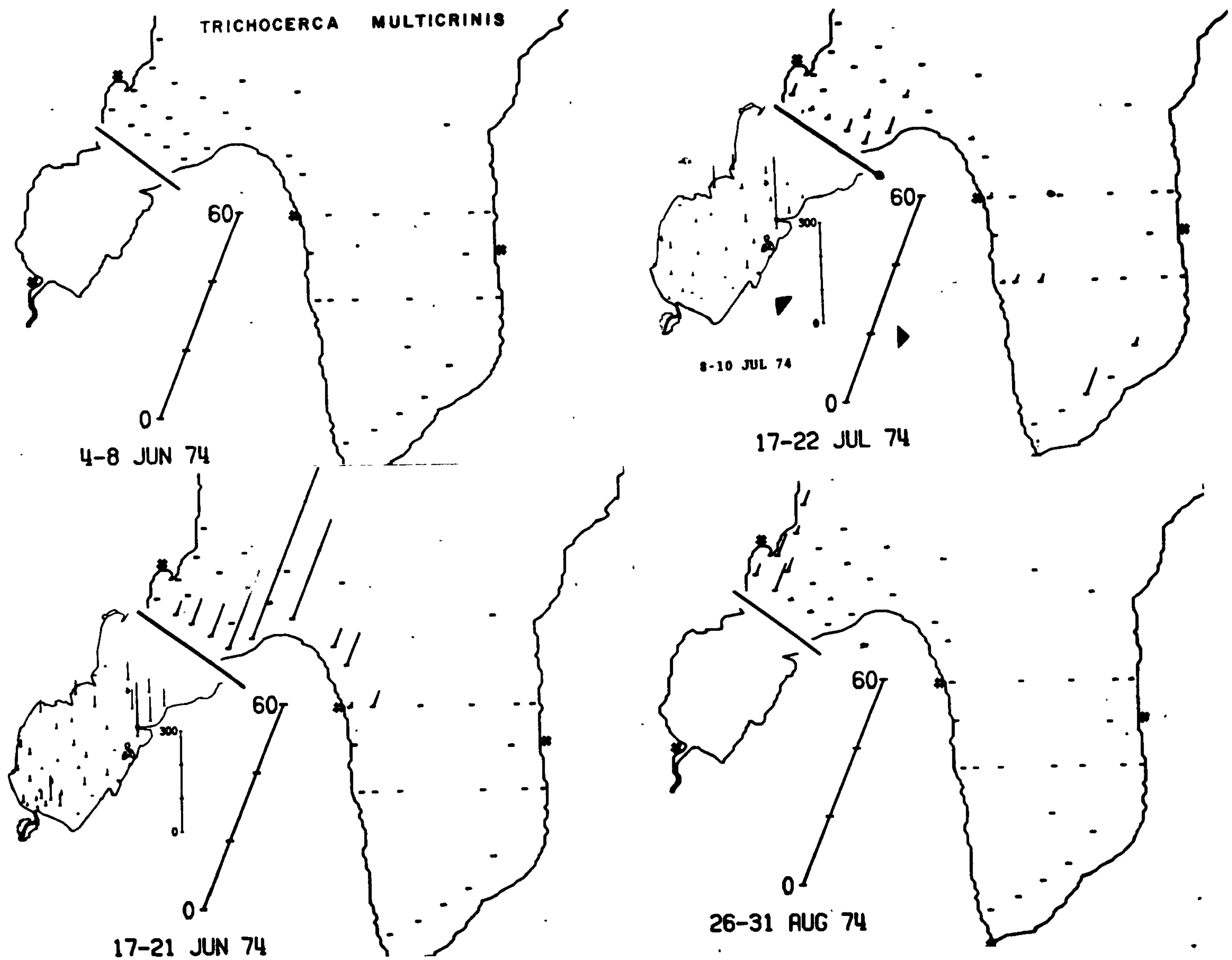

Figure A-45. Distribution and abundance (number of ind./liter) of *Trichocerca multicrinis* for spring and summer 1974.

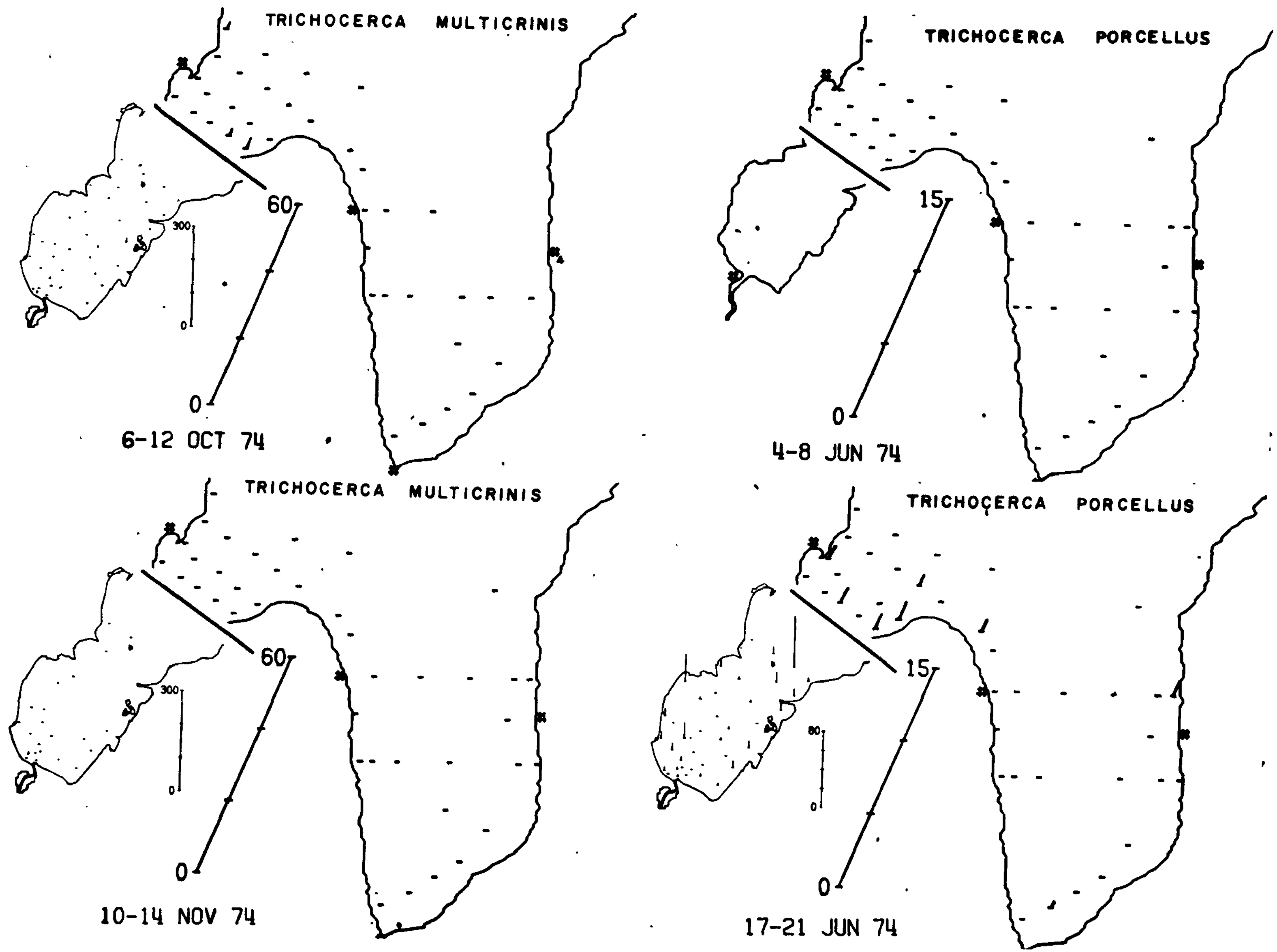

Figure A-46. Distribution and abundance (number of ind./liter) of *Trichocerca multicrinis* for fall 1974 and of *T. porcellus* for spring 1974.

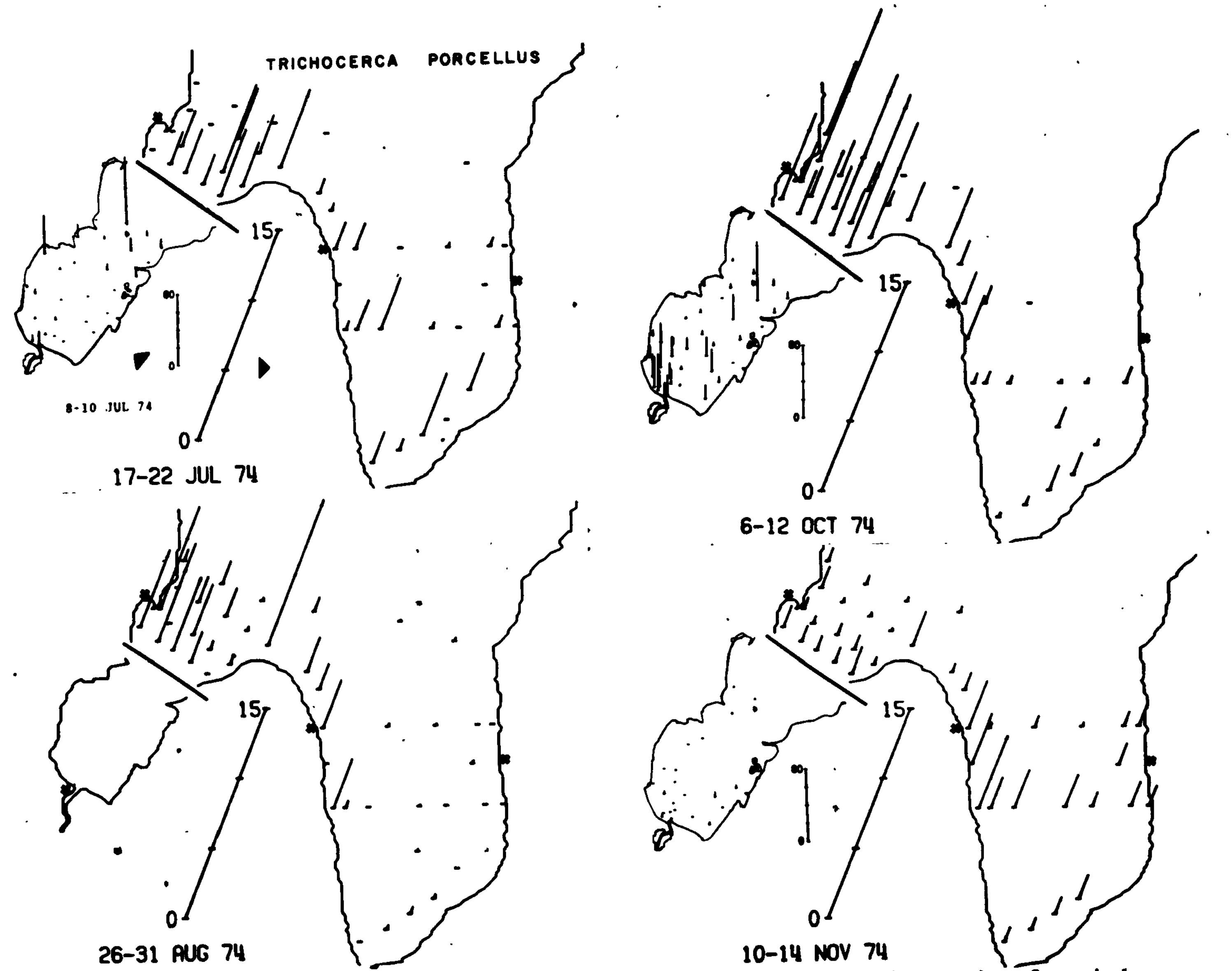

Figure A-47. Distribution and abundance (number of ind./liter) of *Trichocerca porcellus* for summer and fall 1974.

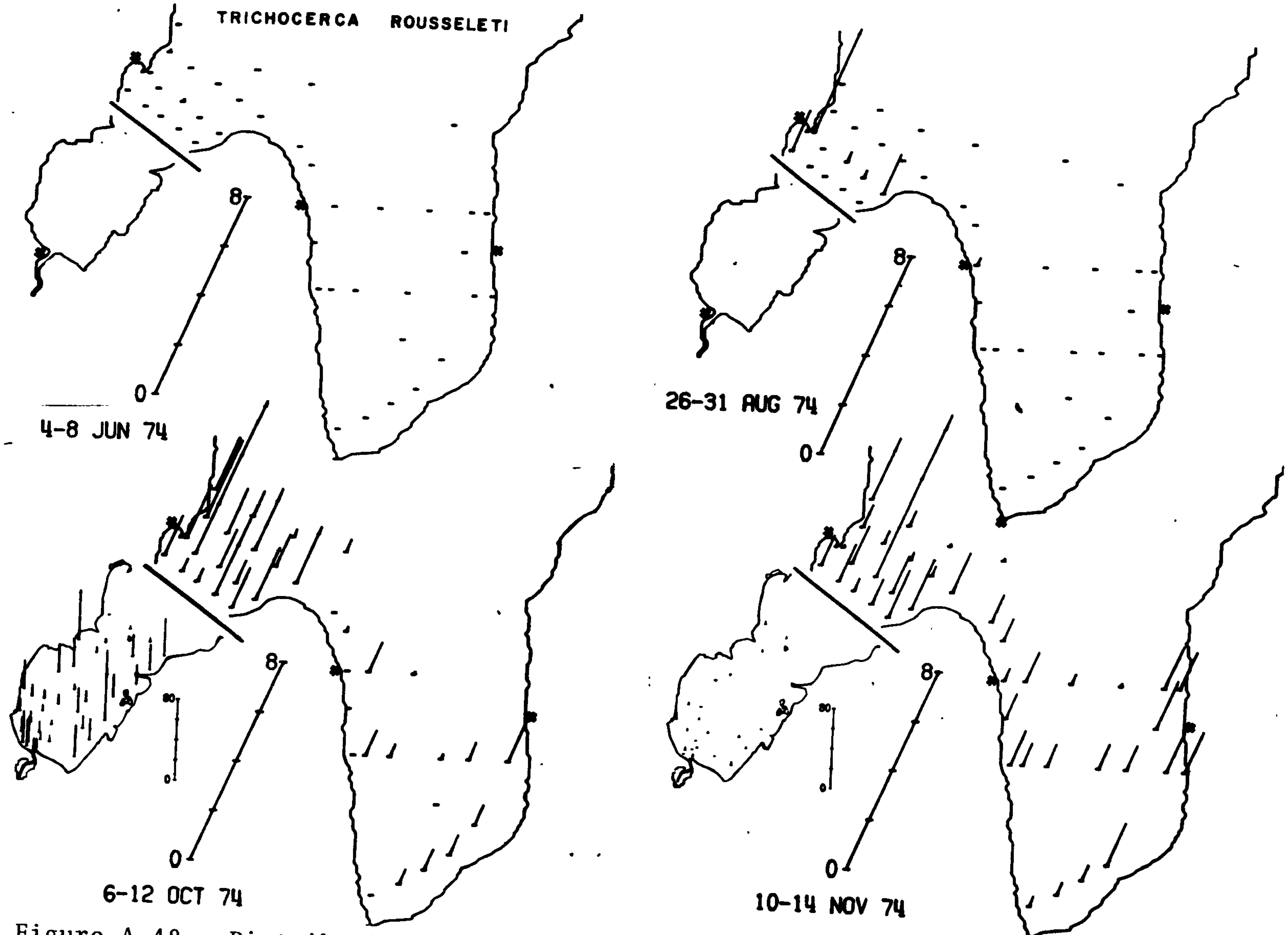

Figure A-48. Distribution and abundance (number of ind./liter) of *Trichocerca rousseleti* from spring, summer and fall 1974.

APPENDIX B

STATION BEARINGS

Southern Lake Huron Stations

Station no.	Lat. N.	Long. W.	Station no.	Lat. N.	Long. W.
01	43°09.8'	82°27.9'	18	44°05.6'	82°23.5'
02	43°14.6'	82°30.0'	19	44°06.7'	82°10.4'
03	43°14.6'	82°25.4'	20	44°07.8'	81°57.0'
04	43°14.6'	82°17.4'	21	44°12.0'	82°13.0'
05	43°14.6'	82°09.2'	22	44°13.0'	82°27.0'
06	43°14.6'	82°04.4'	23	44°14.0'	82°39.0'
07	43°21.0'	81°57.3'	24	44°16.3'	82°55.0'
08	43°27.4'	81°50.3'	25	44°20.1'	83°05.7'
09	43°33.8'	81°43.2'	26	44°23.9'	83°16.2'
10	43°33.9'	81°48.2'	27	44°30.0'	83°15.8'
11	43°33.9'	82°00.2'	28	44°28.7'	83°02.6'
12	43°33.9'	82°14.8'	29	44°27.5'	82°49.4'
13	43°33.9'	82°22.0'	30	44°26.5'	82°40.0'
14	43°33.9'	82°33.3'	31	44°24.9'	82°26.0'
15	43°42.4'	82°34.8'	32	44°23.0'	82°16.0'
16	43°57.6'	82°36.6'	33	44°22.5'	82°29.9'
17	44°04.5'	82°36.6'	34	44°21.0'	82°52.5'

Station no.	Lat. N.	Long. W.
35	44°20.1'	83°05.7'
36	44°10.9'	83°31.2'
37	44°08.5'	83°25.8'
38	44°06.0'	83°20.6'
39	44°03.6'	83°15.3'
40	44°01.2'	83°09.9'
41	44°03.3'	83°02.9'
42	44°06.2'	83°08.9'
43	44°09.0'	83°14.6'
44	44°11.7'	83°20.6'
45	44°14.7'	83°26.3'
46	44°19.7'	83°18.8'
47	44°16.5'	83°12.0'
48	44°13.2'	83°05.4'
49	44°09.9'	82°58.9'

Station no.	Lat. N.	Long. W.
50	44°06.7'	82°52.2'
51	44°01.4'	82°40.2'
52	43°50.7'	82°35.6'
53	43°50.7'	82°30.0'
54	43°50.7'	82°16.5'
55	43°50.7'	82°03.1'
56	43°50.7'	81°50.0'
57	43°50.7'	81°45.0'
58	43°42.3'	81°52.5'
59	43°33.9'	82°00.2'
60	43°24.3'	82°08.6'
60 A	43°20.0'	82°15.5'
61	43°14.6'	82°17.4'
62	43°10.0'	82°21.5'

Saginaw Bay Stations

Station no.	Lat. N.	Long. W.
01	43°38.0'	83°51.0'
02	43°43.0'	83°53.3'
03	43°51.4'	83°54.0'
04	44°06.5'	83°31.8'
05	43°40.3'	83°51.8'

Station no.	Lat. N.	Long. W.
06	43°39.7'	83°50.3'
07	43°40.3'	83°50.4'
08	43°39.8'	83°48.3'
09	43°39.1'	83°50.9'
10	43°41.4'	83°49.0'

Station no.	Lat. N.	Long. W.	Station no.	Lat. N.	Long. W.
11	43°39.8'	83°44.0'	36	44°01.3'	83°39.5'
12	43°38.3'	83°39.5'	37	44°00.9'	83°32.5'
13	43°41.0'	83°46.5'	38	43°58.1'	83°24.9'
14	43°42.7'	83°38.8'	39	43°55.7'	83°20.0'
15	43°44.8'	83°51.4'	40	44°04.7'	83°34.8'
16	43°46.8'	83°54.8'	41	43°38.8'	83°51.0'
17	43°42.0'	83°44.0'	42	44°03.7'	83°26.3'
18	43°44.3'	83°46.3'	43	44°01.2'	83°20.6'
19	43°46.9'	83°48.5'	44	43°59.0'	83°16.5'
20	43°50.0'	83°51.8'	45	44°11.0'	83°24.0'
21	43°39.9'	83°52.5'	46	44°00.3'	83°08.6'
22	43°49.4'	83°38.4'	47	44°16.5'	83°29.5'
23	43°48.4'	83°44.5'	48	44°14.5'	83°28.3'
24	43°46.9'	83°39.1'	49	44°12.4'	83°23.0'
25	43°42.0'	83°37.0'	50	44°10.3'	83°17.7'
26	43°45.5'	83°31.3'	51	44°07.4'	83°10.2'
27	43°48.9'	83°36.8'	52	44°04.3'	83°05.0'
28	43°51.5'	83°40.3'	53	44°03.3'	82°59.8'
29	43°54.9'	83°44.6'	54	43°36.8'	83°51.4'
30	43°58.0'	83°48.8'	55	43°36.1'	83°53.5'
31	43°56.0'	83°40.4'	56	43°44.0'	83°37.5'
32	43°54.5'	83°31.6'	57	44°08.0'	83°24.0'
33	43°50.1'	83°29.8'	58	44°03.2'	83°13.0'
34	43°53.0'	83°23.8'	59	43°40.4'	83°53.9'
35	43°58.8'	83°34.8'			

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

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16. ABSTRACT

This report presents comprehensive data on species composition and distribution of planktonic rotifers in Saginaw Bay and southern Lake Huron from April to November, 1974. Rotifer species composition and abundance differed greatly between Saginaw Bay and open Lake Huron waters. Through cluster analyses, these differences were empirically related to the physicochemical environment. The results of these analyses suggest that rotifers are valuable organisms in water quality assessment studies. Several species which displayed distribution limited to eutrophic Saginaw Bay stations or to oligotrophic offshore Lake Huron stations were potentially useful as environmental indicators. Based on rotifer data, the greatest impact of Saginaw Bay waters on Lake Huron occurred along the western shore of southern Lake Huron below the mouth of the bay. In general, inshore stations of southern Lake Huron displayed greater rotifer abundances than mid-lake stations.

Certain rotifers displayed distinct epilimnetic of hypolimnetic vertical distributions. However, maxima of total rotifer abundance usually occurred in the vicinity of the metalimnion. Wind-generated turbulence often distributed rotifers more evenly in the epilimnion.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Plankton Bloom and Zooplankton	Lake Huron	57H

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