NOAA Data Report ERL GLERL-13

SOUTHERN LAKE MICHIGAN CHEMICAL AND PHYSICAL CHARACTERISTICS DATA FOR 1975

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January 1980

Data available on microfiche
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ATMOSPHERIC ADMINISTRATION
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SOUTHERN LAKE MICHIGAN CHEMICAL AND PHYSICAL CHARACTERISTICS DATA FOR 1975*

Gerald L. Bell

Water samples at standard depths, bottom sediment, and meteorological data were collected at established stations in Southern Lake Michigan, in six harbors, and at one nearshore site during the 1975 open-water season. There were 5 lake cruises and 9 to 11 one-day cruises at each harbor. The sampling programs and analytical methods are described. Chemical characteristics of the water and of the bottom sediment sampled during one cruise are listed by cruise for each station and sampling depth. Wind, wave, and sediment data are listed by cruise for each station. The statistical summaries showing lake-wide means, standard deviations, and sample sizes of selected variables are presented by depth for each lake cruise period. These means do not include the harbor data.

1. INTRODUCTION

This basic data report presents data collected aboard the Research Vessel *Shenehon* between 28 May and 24 November 1975 in Southern Lake Michigan and at seven harbor and nearshore areas by the Chemistry-Biology Group of the U.S. Department of Commerce, NOAA, Great Lakes Environmental Research Laboratory (GLERL).

The GLERL Priority Initiatives Workshop in 1974 resulted in a general agreement that the nearshore zone should be the area of principal focus (Pinsak, 1975). In line with this objective, an investigation was conducted by GLERL during 1975 under Task 6.6 to describe the broad aspects of the spatial and temporal variability of selected variables in the nearshore environment at sites chosen to reflect a wide range of conditions, to compare the nearshore and open lake environment, and to establish gradients through the nearshore environment (GLERL, 1975).

Southern Lake Michigan is subject to a wide range of stresses imposed by municipal, industrial, and agricultural input as well as natural input from streams. An understanding of the variations within the nearshore area is essential to the development and use of this resource. Although a number of significant studies have been conducted in Lake Michigan, the majority of these have been limited to the open lake or to a specific area or problem, and have not been designed to study the variability of different segments of the nearshore area and to compare the areas with each other and the open lake. These data provide information useful in determining the relative roles of the inshore and open-lake areas in the total system, gaining insights into the nearshore variability, managing the coastal zone, and designing new studies in this as well as the other Great Lakes.

*GLERL Contribution No. 178.

Interpretations of the data are not within the scope of this report and will be presented in subsequent publications. Neither meteorological conditions, nor profiles of water temperature and transparency recorded at each station are included in this report. One report on these data is available (Bell and Chambers, 1976).

2. METHODS

2.1 Sampling Program

Water characteristics, bottom sediment, and meteorological data were collected at seven harbor and nearshore areas and along lake traverses (Figures 1-8, Tables 1-8).

Surveys of 2 days each were conducted at Manitowoc, Port Washington, and Kenosha, Wis.; Michigan City, Ind.; and St. Joseph, Grand Haven, and Little Sable Point, Mich. (Table 9). There were a total of 9 surveys at Michigan City, 11 at Port Washington, and 10 at the other ports. Five regional lake cruises were conducted at 37 stations to connect the 7 sites so that the characteristics of each area could be related. The lake station network includes stations at or in the vicinity of earlier surveys.

Two types of surveys were conducted. Samples were taken the first day at a given site and along all lake traverses at standard depths for analysis aboard the R/V *Shenehon* and at the GLERL Ann Arbor laboratory. Samples collected at standard depths during the second day at a given site were analyzed aboard ship. In selected nearshore areas, specific conductance measurements were made every 6 min on samples collected at a depth of 1.5 m from the ship's intake system while underway. The shipboard and laboratory determinations made during each cruise are summarized in Table 10.

The ship was navigated and stations were established by using a gyro compass, radar, a sextant, and visual fixes. Loran C equipment was installed prior to the start of the first survey. Positioning tests gave satisfactory results in western Lake Erie, but were too erratic in southern Lake Michigan. Water sample depths were determined by a meter wheel to the nearest meter. The water depth to the bottom was determined by a Raytheon Precision Survey Fathometer, Model DE-723B, with a range of 0 to 250 in feet or fathoms and the depth presented as a graphic record on a calibrated paper chart.

Water samples were taken at multiple levels in 5-1 Niskin bottles. Samples from stations located in shallow water were taken at the surface, mid-depth, and near bottom. In the upper 100 m, samples from stations located in deep water were taken at the surface and spaced at 10-, 20-, or 25-m intervals. Below 100 m the deepest sample was taken near the bottom. The one representative set of bottom sediment samples collected from each area was taken with a Shipek Sampler.

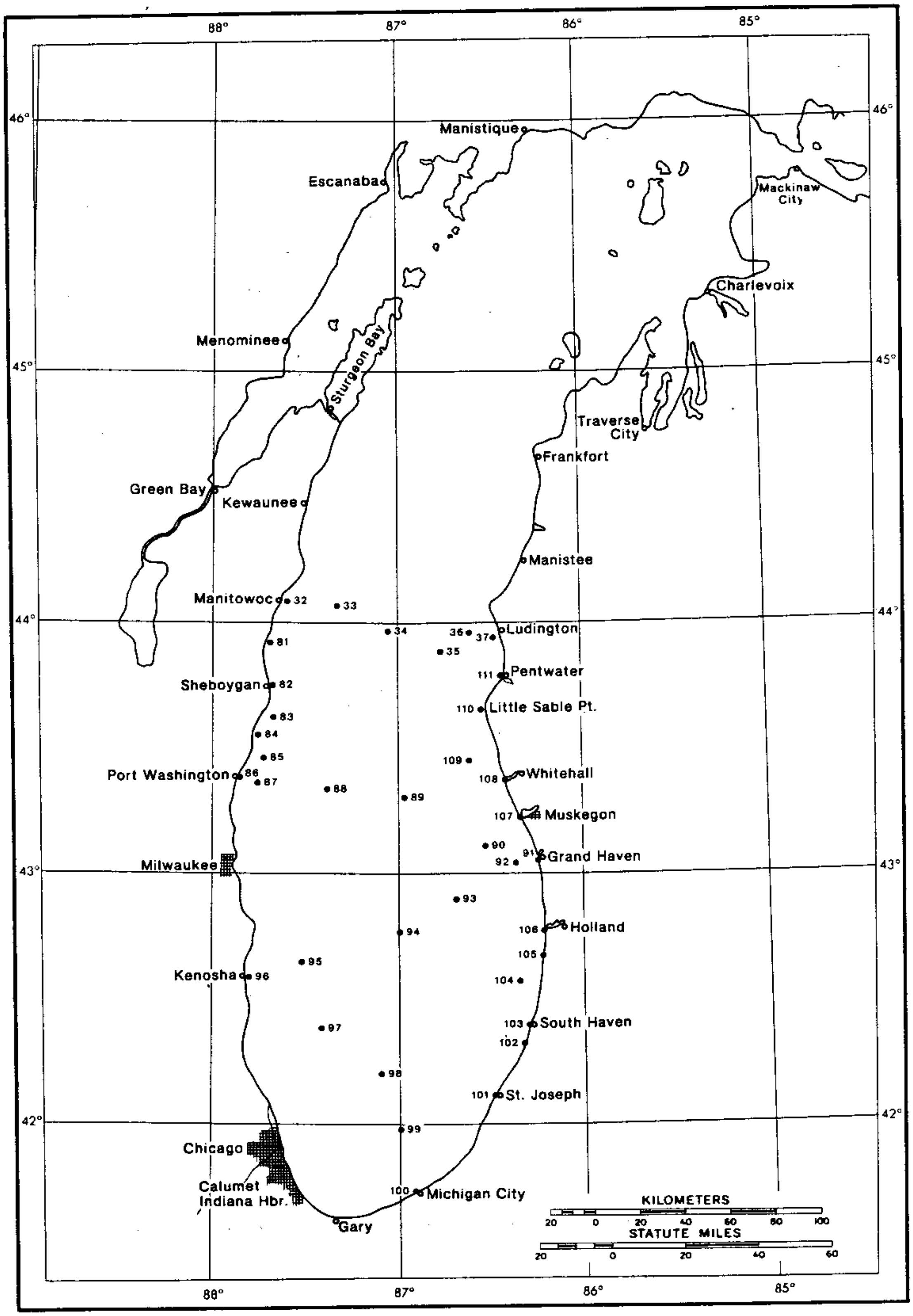

Figure 1. Station locations in Southern Lake Michigan during 1975.

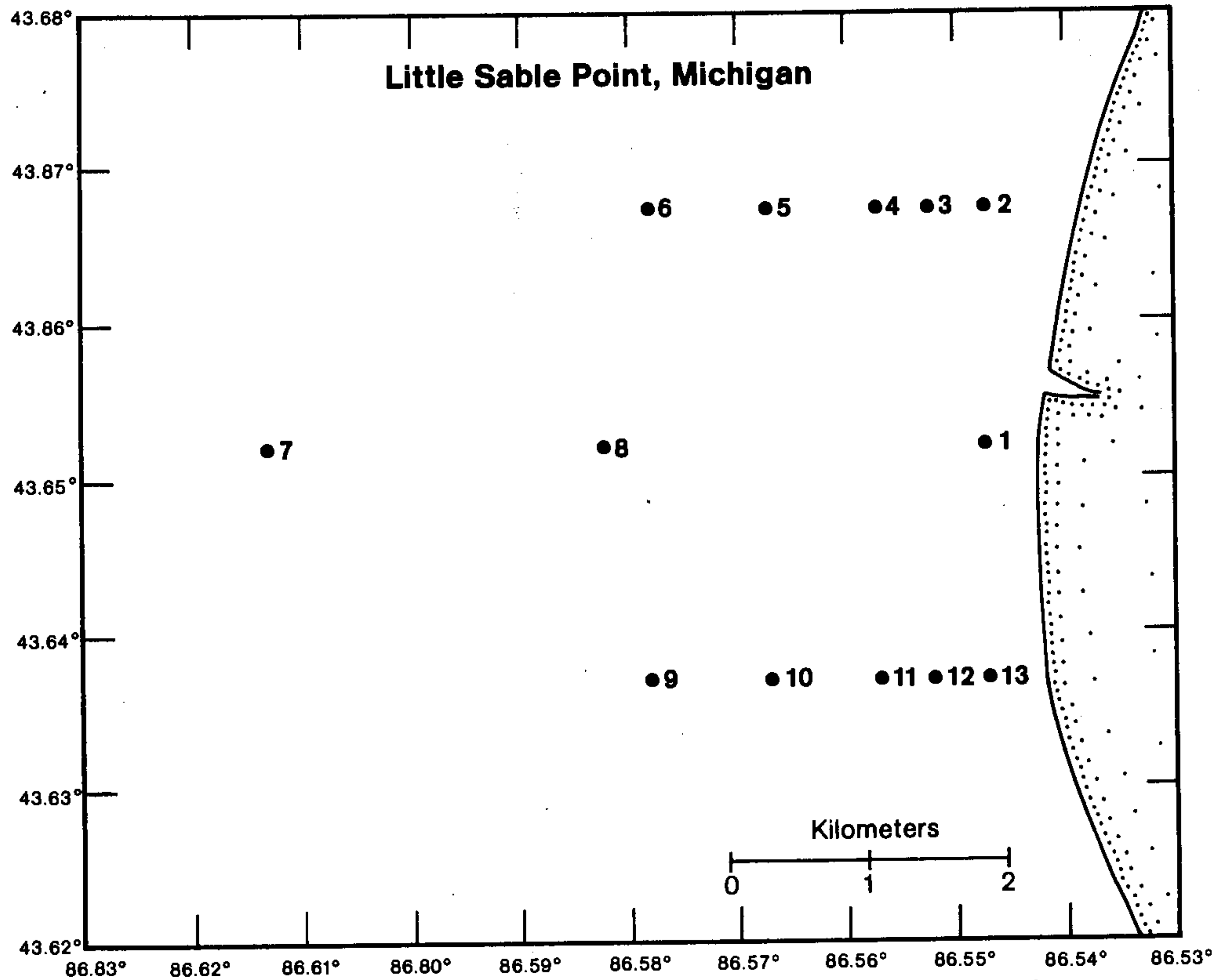

Figure 2. Station locations at Little Sable Point, Mich., during 1975.

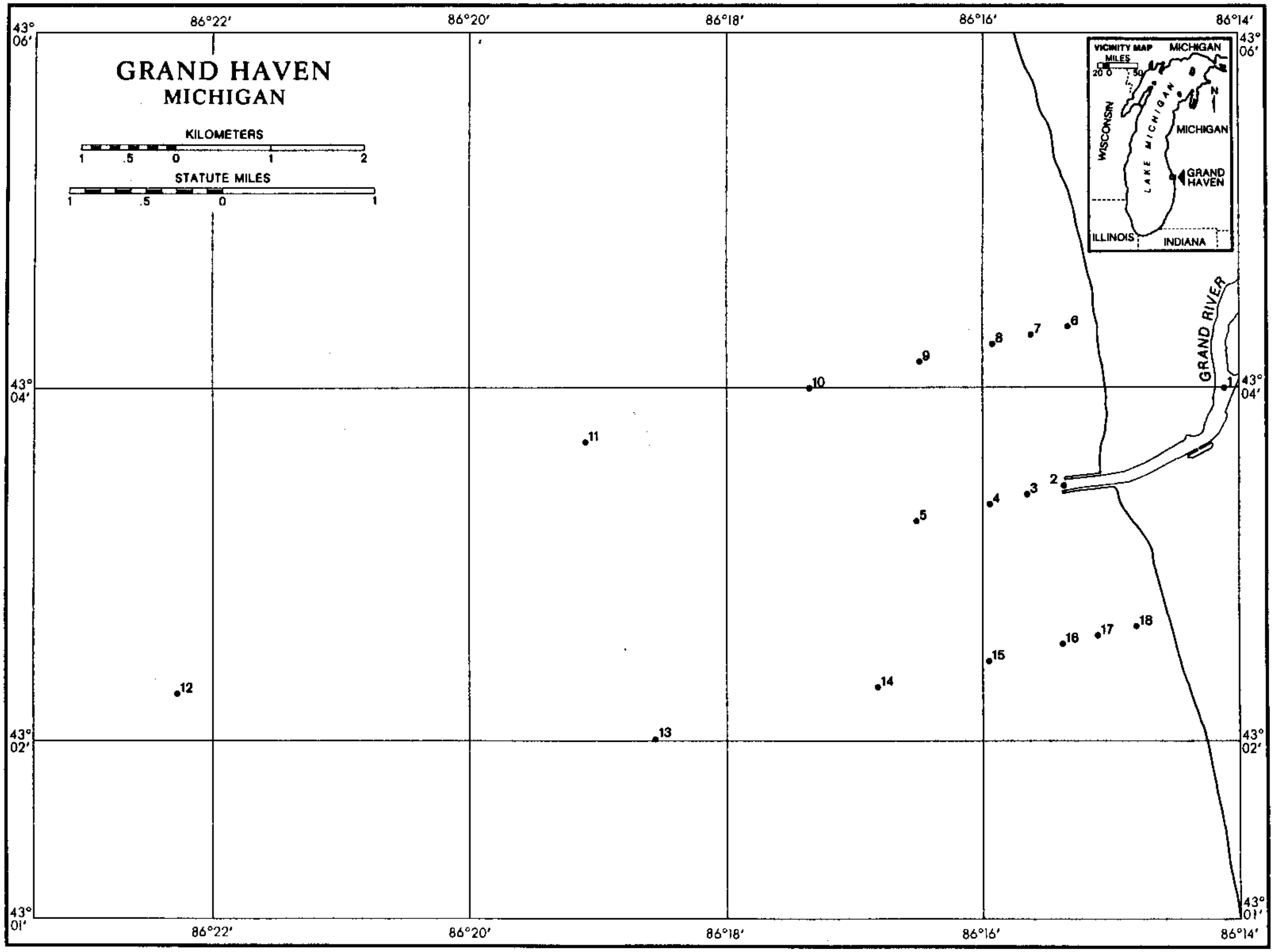

Figure 3. Station locations at Grand Haven, Mich., during 1975.

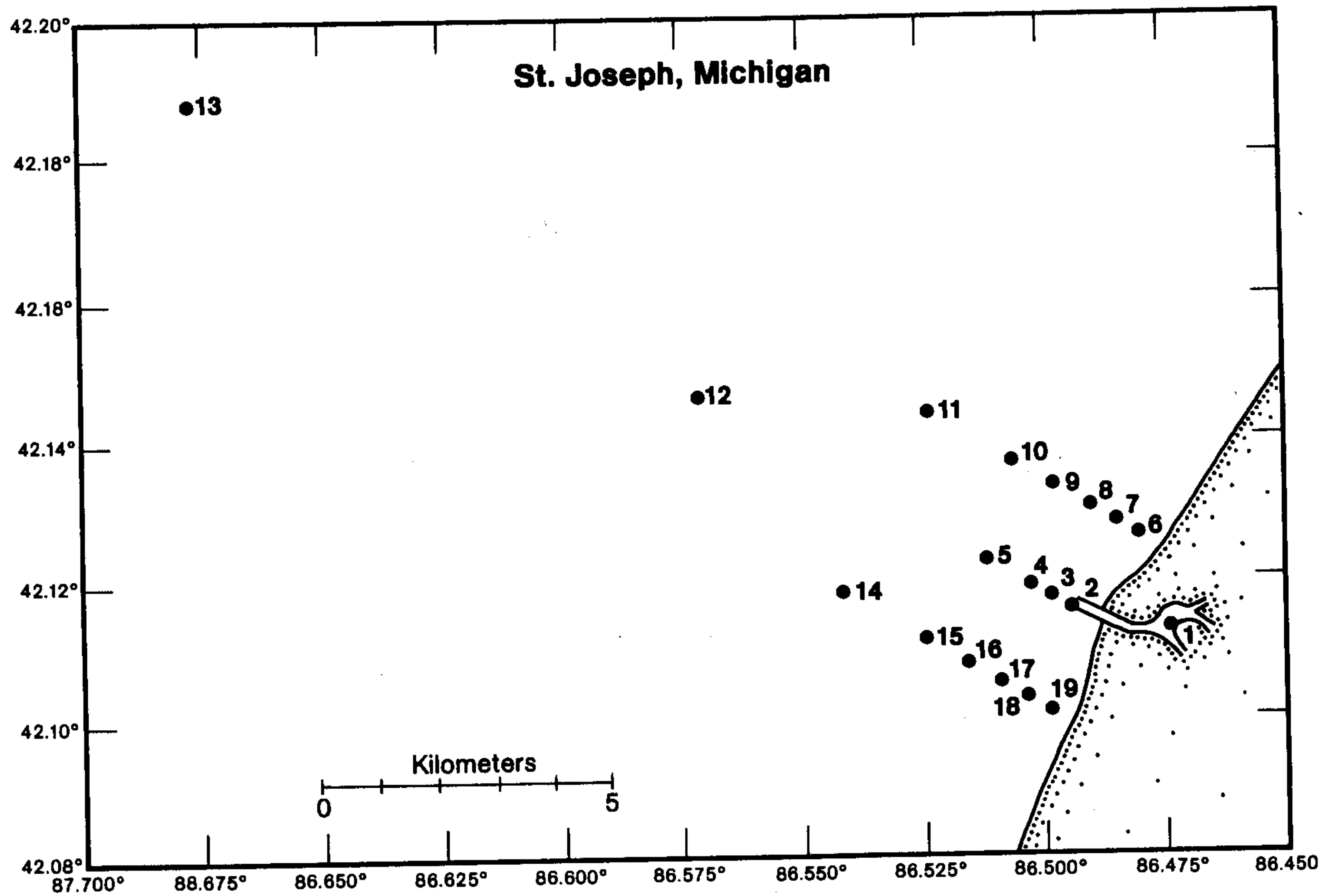

Figure 4. Station locations at St. Joseph, Mich., during 1975.

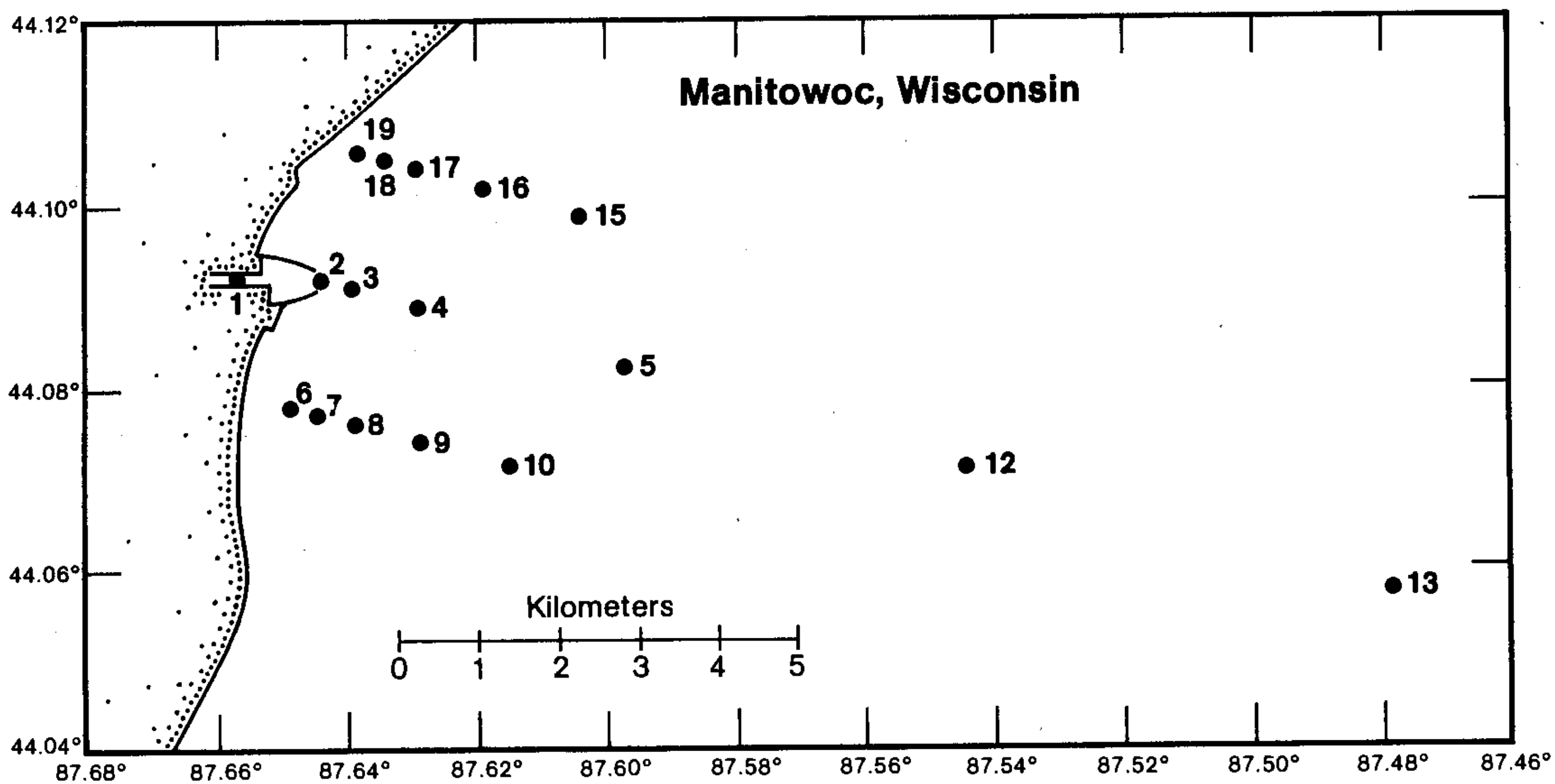

Figure 5. Station locations at Manitowoc, Wis., during 1975.

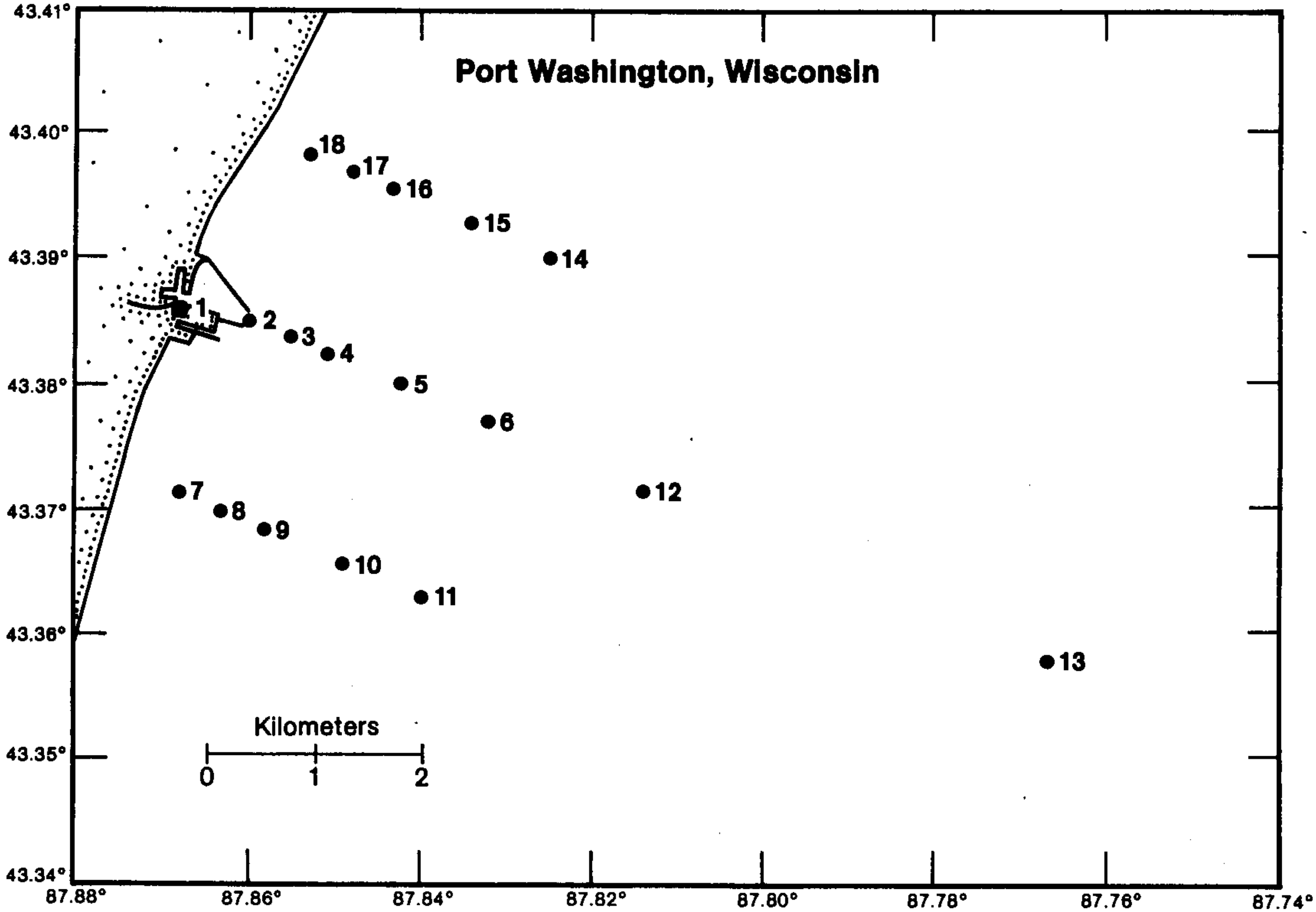

Figure 6. Station locations at Port Washington, Wis., during 1975.

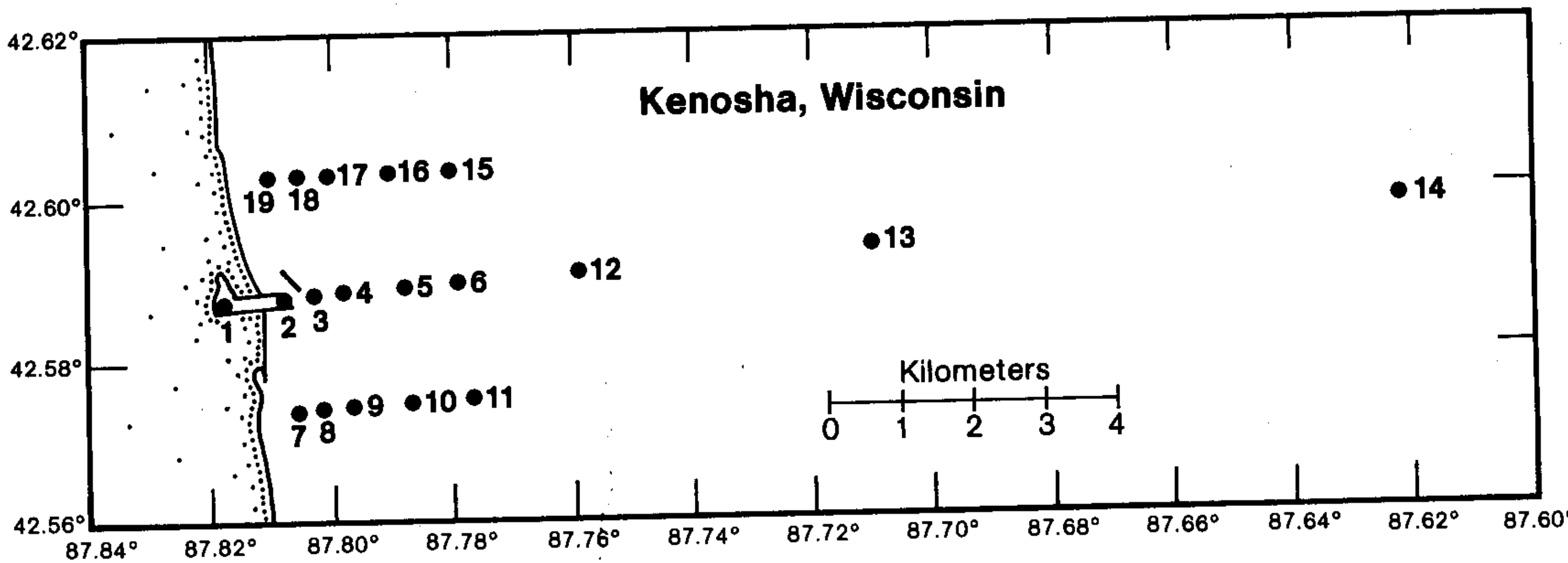

Figure 7. Station locations at Kenosha, Wis., during 1975.

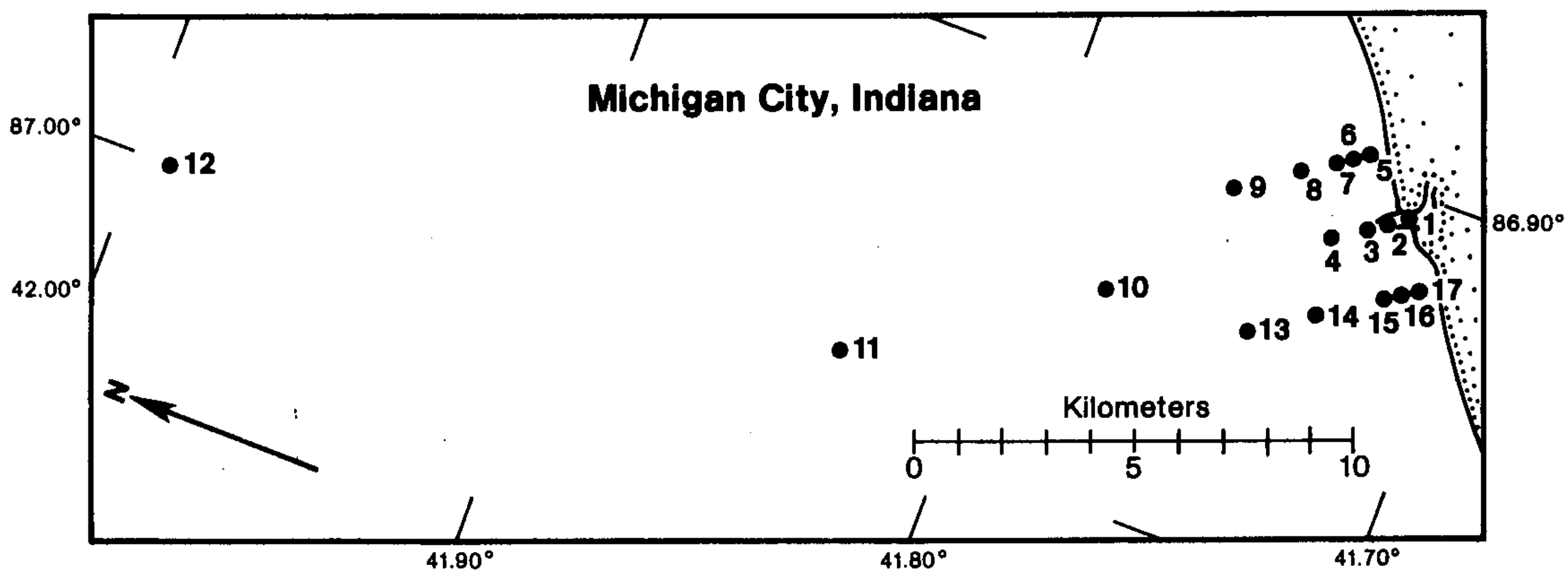

Figure 8. Station locations at Michigan City, Ind., during 1975.

Table 1. Station Locations in Lake Michigan During 1975 (by Latitude and Longitude)

Station	Latitude	Longitude
32	44.083°N	87.597°W
33	44.085°N	87.346°W
34	43.980°N	87.049°W
35	43.907°N	86.752°W
36	43.963°N	86.611°W
37	43.940°N	86.480°W
81	43.917°N	87.704°W
82	43.749°N	87.694°W
83	43.618°N	87.682°W
84	43.566°N	87.764°W
85	43.467°N	87.730°W
86	43.385°N	87.860°W
87	43.358°N	87.767°W
88	43.333°N	87.393°W
89	43.297°N	86.977°W
90	43.140°N	86.535°W
91	43.058°N	86.256°W
92	43.038°N	86.372°W
93	42.900°N	86.697°W
94	42.768°N	87.000°W
95	42.647°N	87.530°W
96	42.588°N	87.808°W
97	42.383°N	87.417°W
98	42.200°N	87.100°W
99	41.983°N	87.000°W
100	41.725°N	86.909°W
101	42.116°N	86.494°W
102	42.325°N	86.322°W
103	42.401°N	86.288°W
104	42.575°N	86.347°W
105	42.677°N	86.216°W
106	42.773°N	86.217°W
107	43.225°N	86.348°W
108	43.377°N	86.429°W
109	43.450°N	86.617°W
110	43.652°N	86.547°W
111	43.782°N	86.444°W

Table 2. Station Locations at Little Sable Point, Mich., During 1975 (by Latitude and Longitude)

Station	Latitude	Longitude
1	43.652°N	86.547°W
2	43.667°N	86.547°W
3	43.667°N	86.552°W
4	43.667°N	86.557°W
5	43.667°N	86.567°W
6	43.667°N	86.578°W
7	43.652°N	86.613°W
8	43.652°N	86.582°W
9	43.637°N	86.578°W
10	43.637°N	86.567°W
11	43.637°N	86.557°W
12	43.637°N	86.552°W
13	43.637°N	86.547°W

Table 3. Station Locations at Grand Haven, Mich., During 1975 (by Latitude and Longitude)

Station	Latitude	Longitude
1	43.067°N	86.235°W
2	43.058°N	86.256°W
3	43.057°N	86.261°W
4	43.056°N	86.265°W
5	43.054°N	86.275°W
6	43.072°N	86.256°W
7	43.072°N	86.260°W
8	43.071°N	86.265°W
9	43.069°N	86.275°W
10	43.067°N	86.288°W
11	43.062°N	86.318°W
12	43.038°N	86.372°W
13	43.034°N	86.310°W
14	43.039°N	86.280°W
15	43.042°N	86.266°W
16	43.043°N	86.256°W
17	43.044°N	86.252°W
18	43.044°N	86.247°W

Table 4. Station Locations at St. Joseph, Mich., During 1975 (by Latitude and Longitude)

Station	Latitude	Longitude
1	42.113°N	86.474°W
2	42.116°N	86.494°W
3	42.118°N	86.499°W
4	42.119°N	86.503°W
5	42.123°N	86.512°W
6	42.127°N	86.481°W
7	42.129°N	86.485°W
8	42.130°N	86.490°W
9	42.134°N	86.498°W
10	42.137°N	86.507°W
11	42.144°N	86.524°W
12	42.146°N	86.572°W
13	42.188°N	86.677°W
14	42.118°N	86.542°W
15	42.112°N	86.525°W
16	42.108°N	86.516°W
17	42.105°N	86.508°W
18	42.103°N	86.504°W
19	42.101°N	86.499°W

Table 5. Station Locations at Manitowoc, Wis., During 1975 (by Latitude and Longitude)

Station	Latitude	Longitude
1	44.092°N	87.657°W
2	44.092°N	87.644°W
3	44.091°N	87.639°W
4	44.089°N	87.629°W
5	44.083°N	87.597°W
6	44.078°N	87.649°W
7	44.077°N	87.644°W
8	44.076°N	87.639°W
9	44.074°N	87.629°W
10	44.072°N	87.615°W
11	44.066°N	87.586°W
12	44.072°N	87.544°W
13	44.057°N	87.479°W
14	44.094°N	87.575°W
15	44.099°N	87.604°W
16	44.102°N	87.619°W
17	44.104°N	87.629°W
18	44.105°N	87.634°W
19	44.106°N	87.638°W

Table 6. Station Locations at Port Washington, Wis., During 1975 (by Latitude and Longitude)

Station	Latitude	Longitude
1	43.386°N	87.868°W
2	43.385°N	87.860°W
3	43.384°N	87.855°W
4	43.382°N	87.851°W
5	43.380°N	87.842°W
6	43.377°N	87.832°W
7	43.371°N	87.868°W
8	43.370°N	87.863°W
9	43.369°N	87.858°W
10	43.366°N	87.849°W
11	43.363°N	87.840°W
12	43.371°N	87.814°W
13	43.358°N	87.767°W
14	43.390°N	87.825°W
15	43.393°N	87.834°W
16	43.396°N	87.843°W
17	43.397°N	87.848°W
18	43.398°N	87.853°W

Table 7. Station Locations at Kenosha, Wis., During 1975 (by Latitude and Longitude)

Station	Latitude	Longitude
1	42.588°N	87.818°W
2	42.588°N	87.808°W
3	42.589°N	87.803°W
4	42.589°N	87.798°W
5	42.590°N	87.788°W
6	42.590°N	87.779°W
7	42.574°N	87.806°W
8	42.574°N	87.802°W
9	42.575°N	87.797°W
10	42.575°N	87.787°W
11	42.576°N	87.777°W
12	42.591°N	87.759°W
13	42.594°N	87.710°W
14	42.600°N	87.622°W
15	42.604°N	87.780°W
16	42.604°N	87.790°W
17	42.603°N	87.800°W
18	42.603°N	87.805°W
19	42.603°N	87.810°W

Table 8. Station Locations at Michigan City, Ind., During 1975 (by Latitude and Longitude)

Station	Latitude	Longitude
1	41.725°N	86.909°W
2	41.728°N	86.912°W
3	41.731°N	86.914°W
4	41.738°N	86.919°W
5	41.735°N	86.895°W
6	41.738°N	86.897°W
7	41.742°N	86.899°W
8	41.748°N	86.904°W
9	41.761°N	86.913°W
10	41.780°N	86.949°W
11	41.832°N	86.985°W
12	41.983°N	87.000°W
13	41.744°N	86.945°W
14	41.731°N	86.936°W
15	41.724°N	86.931°W
16	41.721°N	86.929°W
17	41.718°N	86.927°W

Table 9. *Cruise Schedule*

Cruise number	Lake Michigan Start	Lake Michigan End	Little Sable	Manitowoc	Pt. Washington	Grand Haven	Kenosha	Michigan City	St. Joseph
1	28 May	1 July	28 May	31 May	4 June	14 June	21 June	25 June	27 June
2	2 July	30 July	29 May	1 June	18 June	16 June	23 June	26 June	28 June
3	31 July	6 Sept.	2 July	10 July	19 June	17 July	22 July	25 July	28 July
4	6 Sept.	14 Oct.	3 July	11 July	14 July	18 July	23 July	26 July	29 July
5	15 Oct.	24 Nov.	31 July	12 Aug.	15 July	19 Aug.	25 Aug.	28 Aug.	2 Sept.
6			1 Aug.	13 Aug.	15 Aug.	20 Aug.	26 Aug.	29 Aug.	3 Sept.
7			6 Sept.	17 Sept.	16 Aug.	27 Sept.	3 Oct.	7 Oct.	9 Oct.
8			9 Sept.	19 Sept.	22 Sept.	29 Sept.	4 Oct.	8 Oct.	10 Oct.
9			21 Oct.	29 Oct.	23 Sept.	7 Nov.	12 Nov.	17 Nov.	18 Nov.
10			22 Oct.	30 Oct.	3 Nov.	8 Nov.	14 Nov.		19 Nov.
11					4 Nov.				

Table 10. Shipboard and Laboratory Measurements in Connection with Limnological Studies

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Shipboard Measurements

Meteorological data (printout each 6 min)

- Wind speed (m/sec) (10 m above water)
- Wind direction (10 m above water)
- Barometric pressure (millibars) (3 m above water)
- Air temperature (°C) (3 and 10 m above water)
- Water temperature (1.5 m below water surface)
- Solar radiation (incident) (gram-calories per sq. cm) (10 m above water)
- Solar radiation (reflected and incident) (3 m above water)
- Relative humidity (3 m above water)
- Dew point

On station

- Water
  - Water temperature (°C)
    - Reversing thermometers at sample depth
    - Electronic bathythermograph
    - Air-water interface temperatures
  - Transparency (relative to 100% in air)
  - Secchi disc (m)
  - pH
  - Eh (volts)
  - Total and phenolphthalein alkalinity (mg/l $CaCO_3$)
  - Specific conductance (micromhos at 25°C)
  - Dissolved oxygen (mg/l and pct. sat.)
  - Coliform bacteria (membrane filter proc.)
- Waves
  - Height (m)
  - Period (sec)
  - Direction (nearest 10°)
- Bottom sediment
  - Description (physical)
  - pH
  - Eh

Chemistry Laboratory

Dissolved ions

Nitrate[1]	(Brucine method, A.P.H.A.[2], 1965)
Phosphate[1]	(Ammonium molybdate method, U.S.G.S.[3], 1965)
Sulfate[1]	(Turbidimetric method, A.P.H.A.[2], 1965)
Silica[1]	(Molybdate blue method, U.S.G.S.[3], 1960)
Magnesium[4]	(Atomic absorption tech., P.E.[5], 1971)
Calcium[4]	(Atomic absorption tech., P.E.[5], 1971)
Sodium[4]	(Atomic absorption tech., P.E.[5], 1971)
Potassium[4]	(Atomic absorption tech., P.E.[5], 1971)
Chloride	($AgNO_3$ titration)

Suspended sediment (mg/l)

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[1] Beckman DU-2 Spectrophotometer.
[2] American Public Health Association.
[3] U.S. Geological Survey.
[4] Perkin-Elmer Atomic Absorption Spectrophotometer.
[5] The Perkin-Elmer Corporation.

Water temperatures were recorded at the sampling depths to the nearest hundredth degree Celsius by protected reversing thermometers (±0.02° accuracy) attached to each Niskin bottle. The temperature of the water circulating through the sea chest, approximately 1.5 m below the surface, was recorded to the nearest tenth degree Celsius and printed with the meteorological data at 6-min intervals. Temperature profiles were recorded at each station with a Guildline Electronic Bathythermograph, Model 1800. The bathythermograph profiles were corrected by adding or subtracting the average difference between the reversing thermometer and bathythermograph temperatures.

Transparency measurements were made with a G.M. Mfg. and Instrument Corp. Deep-Water Turbidity Meter, Model 17-M-11, modified by the U.S. Lake Survey. Transparency was determined by relating light transmission along a 1-m path through the water to the transmission along the same path through air, expressed as a percent. Color filters were not used.

Suspended materials were determined in the field by filtering 1 to 2 liters of water through Whatman 40 and 0.45 micron Millipore filters at standard depths at the mouths of selected rivers and harbors. Approximately 475 ml of all water samples were passed through Whatman-40 filters after analyzing for nitrate and phosphate and the weight of suspended materials was reported with the limnological data.

Meteorological observations were recorded automatically at 0.1-hr intervals by a digital system employing solid state data gathering modules. Wind and wave observations were made while on station. The wave direction was not reported at all stations and in such cases the wind direction was used. Wave height observations are estimations. The period is based on an average time of 10 successive waves.

2.2 Chemical Analyses

The methods used in the water analysis are those described in Standard Methods (American Public Health Association, 1965), Rainwater and Thatcher (1960), Fishman and Skougstad (1965), and the Perkin-Elmer Corporation (1971).

Water samples were analyzed immediately in the *Shenehon* laboratory for dissolved oxygen, specific conductance, phenolphthalein and total alkalinity, pH, Eh (oxidation-reduction potential), the pH and Eh of the interstitial water of the bottom sediment, and total coliforms.

Dissolved oxygen values were determined with a Beckman Dissolved Oxygen Analyzer, Model 777. After two separate tests were made on each sample, the highest partial pressure and the lowest sample temperature readings were used for calculating the dissolved oxygen. *In situ* temperature was recorded by the reversing thermometer at the sampling depth.

Specific conductance was measured with an Industrial Instruments Conductivity Bridge, Model RC-19. Two separate tests were made on each sample and the average expressed in micromhos at 25°C.

Phenolphthalein and total alkalinity values were determined by titrating 100-ml water samples with standard acid (H_2SO_4) to the end-points of pH 8.2 and 4.5, respectively. The end-points were determined with the pH meter and the results expressed in mg/l of calcium carbonate.

Measurements of pH and Eh were made with a Beckman Digital pH Meter, a glass pH electrode, a calomel fiber junction reference electrode, and a platinum Eh electrode. As a means of avoiding contamination, the electrodes were rinsed in a sample of the lake water to be tested. Between tests, the electrodes were immersed in distilled water. Tests of the interstitial water of the bottom sediment were made by inserting the electrodes into the soft sample.

Water samples to be analyzed later were preserved with chloroform and stored in 500-ml plastic bottles in a dark area below deck. These samples were transferred at the end of each cruise or survey period to the GLERL laboratory in Ann Arbor.

Chloride concentrations were determined by the argentometric method and titratiion of a 100-ml sample of lake water. The silver nitrate was standardized and the reagent blank value determined at the beginning of each day of testing. A Beckman DU-2 Spectrophotometer with flame attachment was used for analysis of nitrate, phosphate, sulfate, and silica, and a Perkin-Elmer Atomic Absorption Spectrophotometer was used for calcium, magnesium, sodium and potassium. Standard curves were constructed for each test and cruise. Tests for nitrate and phosphate were made on unfiltered samples upon arrival at the laboratory. Sample anion concentrations were determined by computer application of the absorbancy values to a standard curve that was adjusted by paired test standards run after each set of 10 to 20 samples in order to compensate for any change or drift in the spectrophotometer response. The cation concentrations were also adjusted by paired test standards and read directly from a recorder strip chart.

The bottom sediment samples were described, analyzed for pH and Eh of the intersititial water, and then treated with concentrated sulphuric acid. No further tests were made.

3. PRECISION LIMITS

The degrees of precision shown in Table 11 were determined for nitrate, phosphate, sulfate, and silica by a computer comparison of pairs of test standards to the standard curve that was used to determine the sample concentrations. A pair of test standards was run after each set of 10 samples for nitrate and after each set of 20 samples for phosphate, sulfate, and silica. Calcium, magnesium, sodium, and potassium analyses were run in sets of 10 samples followed by one standard and at least one additional standard bracketing the concentration range after each 20 samples. For both chloride and alkalinity the estimated

Table 11. Measurement Precision

Variable	Units	Estimated precision	Average deviation*
Nitrate-N**	mg/l		±0.004
Phosphate-P**	mg/l		±0.0003
Sulfate	mg/l		±0.14
Silica	mg/l		±0.01
Calcium	mg/l	±0.5	
Magnesium	mg/l	±0.1	
Sodium	mg/l	±0.5	
Potassium	mg/l	±0.1	
Chloride	mg/l	±0.25	
Specific conductance	micromhos at 25°C		±1.0
Total alkalinity	mg/l $CaCO_3$	±0.5	
Dissolved oxygen	mg/l	±0.1	
Dissolved oxygen	Percent sat.	±1.0	

*Average of the deviations of the test standards from the standard curve.

**Analysis of unfiltered samples which were $CHCl_3$ poisoned and stored for variable lengths of time.

precision is based on the change in concentration produced by one drop (0.05 ml) of titrant and on the assumption that the end-point was within ± one drop. Two readings were made on each sample for specific conductance, and deviations from the mean of each pair were used to compute the average deviation. Of the 105 sample pairs randomly selected, 99 percent were within 1 micromho of the mean. The estimated precision of the dissolved oxygen determinations is based on the assumption that the partial pressure is accurate to 1 mm of mercury. The average difference in the two partial pressure readings for each sample was less than 1 mm of mercury.

Tests for nitrate and phosphate were made on unfiltered samples. From the end of a cruise at a given harbor to the date of analysis, there was an interval of from 1 to 14 days for phosphate and from 2 to 15 days for nitrate. Some of the lake water samples were not analyzed until the end of a given cruise, with delays ranging up to 30 days in some cases. The Grand Haven samples were processed within an average of 3 days following collection.

4. DATA PRESENTATION

The limnological data are summarized by cruise for each sampling depth at a given station (Appendix A). Nitrogen concentrations were calculated from nitrate by multiplying by a factor of 0.226. Phosphorus concentrations were calculated from phosphate by multiplying by a factor of 0.326.

The wind direction and wave data are summarized by cruise and station (Appendix B).

In the statistical summary, lake wide means, standard deviations, and sample sizes are presented by depth and cruise period for selected variables in Lake Michigan (Appendix C). The harbors are not included.

5. ACKNOWLEDGMENTS

The task scientist responsibilities were shared by R. L. Chambers, who formulated and directed the sediment phase of the program. Ship services were provided by the Lake Survey Facilities Division of National Ocean Survey, NOAA. *Shenehon* operations were under the direction of Lt. (jg.) F. Arbusto.

I wish to thank the GLERL Computer Systems Group for computer operations, programming assistance, and keypunching; Party Chief P. H. Hendershot and staff for field operations and sample collection; J. M. Malczyk, A. L. Langston, and staff for laboratory analyses; J. L. Grumblatt for meteorological data reduction; W. R. Lee and D. Landay of the GLERL Chemistry-Biology Group for assistance in data reduction; and A. Robertson and B. J. Eadie for review and suggestions. Final programming was by V. Maxey, J. Boyd, and J. Manor of GLERL.

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☆U.S. GOVERNMENT PRINTING OFFICE:1980—677-403/259