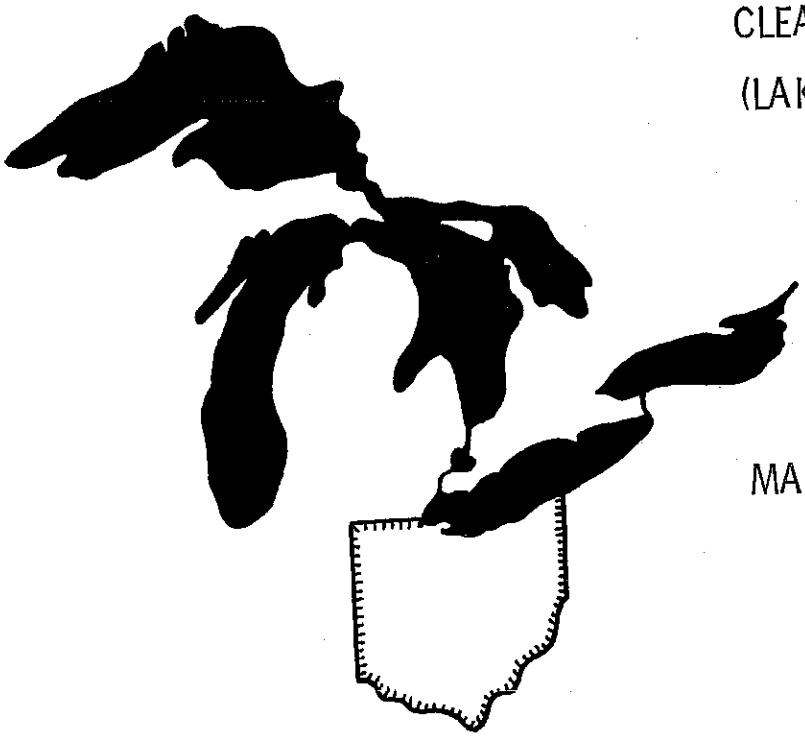

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(LAKE ERIE TAT CONTRIBUTION NO. 24)

LAKE ERIE INTENSIVE STUDY: MAIN LAKE WATER QUALITY TRENDS

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EXECUTIVE SUMMARY

An analysis of Lake Erie water quality data for the past decade, as an assessment of trends, indicates a general improvement in lake quality. Water levels in Lake Erie have been above the long-term mean since 1970, which have provided some dilution of contaminants. Thermal structure of the lake is influenced by meteorological conditions which have resulted in thin hypolimnions and severe depletion of oxygen, as in 1973, and thick hypolimnions and relatively small areas of anoxia, as in 1975. In the past decade the oxygen demand rate in the central basin has been relatively constant after increasing dramatically from 1930 to 1970. The oxygen demand rate of the eastern basin may still be increasing slightly.

Concentrations of total phosphorus in the western and central basins were relatively constant during the period 1970 to 1977; however, in the past three years (1978-1980) significant declines in the concentrations and quantities in these basins have been observed. This improvement coincides with the approximate 800-metric-ton-per-year reduction in total phosphorus loaded to the lake during the period 1970-1979. Eastern basin data also indicates a progressive decline in phosphorus since the mid-1970's. Transparency shows no discernable trends, but in 1980 the central basin had the highest average summer transparency during the period of record, 1973-1980. Chlorophyll a concentrations in 1980 were also the lowest average annual values on record (1970-1980). for the western and central basins. Dissolved substances, as measured by conductivity and chloride, also show a significant decline in the past 15 years.

Many of these trends are preliminary interpretations and must stand the test of further scientific scrutiny. However, the evidence is continuing to mount that Lake Erie is no longer degrading and that future improvements are eminent.

INTRODUCTION

Background

Lake Erie, as one of the Great Lakes of North America, represents a significant source of fresh surface water for the people of Canada and the United States. In recognition of the importance of this resource and the need to restore and maintain its water quality, the Canadian and United States governments entered into the Great Lakes Water Quality Agreement in 1972. The agreement was reaffirmed in 1978 by further actions to enhance water quality in the Great Lakes Basin ecosystem.

The International Joint Commission has been mandated to assist in the implementation of these agreements. Within that mandate, the Commission is to collect, analyze and disseminate information relating to Great Lakes water quality. Recognizing the need for a uniform surveillance effort by both parties of the agreements and the cooperating state and provincial jurisdictions, the Commission directed the Water Quality Board to develop an international surveillance plan. Work groups were established for each lake, with the responsibility for developing detailed plans.

The Lake Erie Work Group prepared a nine-year surveillance plan in 1977, which was designed to provide an understanding of the overall, long-range responses of the lake to pollution abatement efforts. The main lake portion of the plan called for intensive investigations in 1978 and 1979 and annual assessments at a less intensive level for the period 1980-1986. With the support of the United States Environmental Protection Agency and Environment Canada, the majority-recommended plan was implemented on schedule. The results of the 1978-1980 main lake surveillance cruises, as well as an assessment of Lake Erie water quality trends for the preceding decade, are presented in this report.

Objective

The primary objective of the main lake component of the surveillance plan is to provide an annual assessment of the priority issues in Lake Erie eutrophication, utilizing key trophic-related parameters. Monitoring cruises were undertaken during the ice-free period of 1970-1980 in the western, central and eastern basins to determine:

1. oxygen depletion rates in the hypolimnion of central Lake Erie, areas of anoxia and the duration of anoxia;

2. concentrations and amount of nutrients (phosphorus, nitrogen and silicon) in the lake and the quantity regenerated during anoxia;

3. response of the lake, via primary productivity, to to the availability of nutrients as measured by the concentration and quantity of chlorophyll and related lake characteristics such as light penetration and suspended particles;

4. trends in dissolved substances in the lake as indicated by measurements of conductivity, alkalinity and pH;

5. trophic status of various regions of the lake for spring, summer and autumn.

The broader objective of the main lake component is to provide, on an annual basis, open water data necessary to determine long-term changes in water quality and biota. These changes are generally very slow and subtle and cannot be accurately assessed without repetitive annual surveys. The annual state-of-the-lake assessment reports are intended to provide the information analysis analysis needed to support the Great Lakes water quality management process, including establishment of goals, planning future strategies and recommending remedial programs.

WATER QUALITY TRENDS: 1970-1980

Prior to 1970, water quality investigations of Lake Erie were conducted at sporadic intervals with a wide variety of field procedures and analytical techniques. For these reasons it is difficult to document long-term trends to any degree of accuracy. Starting with Project Hypo in 1970 (a joint Canadian-United States project to investigate the eutrophication of Lake Erie), consistent shipboard and laboratory procedures have been utilized by the several research groups monitoring the status of the open waters of Lake Erie. Cruises have been undertaken each year in the three basins of the lake by the following organizations: 1) Canada Centre for Inland Waters (CCIW), 2) Center for Lake Erie Area Research (CLEAR), 3) Great Lakes Laboratory (GLL) and 4) Great Lakes National Program Office (USEPA). The schedules for these cruises are presented in Appendix A, and essential water quality findings are listed in Appendices B, C and D for the western, central and eastern basins, respectively. Appendices E, F and G contain information on the stratification characteristics of these basins for each cruise.

Water quality trends for the period 1970-1980 are discussed in this section. Data has been analyzed for the following characteristics: 1) water level, 2) thermal structure, 3) dissolved oxygen, 4) nutrients, 5) transparency, 6) chlorophyll and 7) dissolved substances. An assessment of the significance of these trends in terms of loading and trophic status is also presented.

Water Level

During the past decade (1970-1980) the mean annual water level in Lake Erie has been well above the 1900-1980 mean level of the lake (Figure 1). In 1973 the lake attained the maximum recorded level, nearly one meter above the long-term mean. In the last decade, the lowest lake levels were recorded in 1970 and 1977 when the lake stood only slightly above the long-term mean.

Water level changes of these magnitudes can have a significant influence on the volume of water in the lake (Appendix C). A comparison of maximum volume of water held in the central basin for 1970 and 1973 is given below:

Volume of Water in Lake Erie

Year	Central Basin	Percent Difference
1970	274.5 km^3	12%
1973	312.2 km^3	

Periods of low water level, such as 1970 and 1977, appear to be associated with periods of high turbidity in the western basin and high concentrations of total phosphorus in the western and central basins (Figure 5). but these associations are not strong or statistically significant. However, the loading of total phosphorus to Lake Erie (Figure 4). does show a more positive correlation with water levels. High water represents periods of high flow from the Detroit River and other tributaries, which enhances the delivery of phosphorus to Lake Erie.

Thermal Structure

The western basin of Lake Erie is essentially isothermal throughout the year. This basin was determined to be unstratified during all 64 cruises undertaken during the period 1970-1980 (Appendix E). However, periods of temporary stratification in isolated areas of the western basin have been reported by Britt (1955), Carr et al. (1965) and Zapotosky and Herdendorf (1980). Such stratification is usually transitory in nature but can result in severe oxygen depletion conditions due to high oxygen demand of the sediments.

The central basin of Lake Erie typically stratifies in early June and turns over in early September (Table 1 and Appendix F). The mean thicknesses of the epilimnion, mesolimnion and hypolimnion during the period 1973-1980 are presented below:

Central Lake Erie Thermal Strata

Strata	Thickness (m)
epilimnion	12.4 ± 2.3
mesolimnion	2.3 ± 1.4
hypolimnion	5.0 ± 1.6

In general, the hypolimnion decreases in thickness and increases in temperature throughout the stratified period. Table 1 shows the mean thicknesses and temperatures as follows for the period 1973-1980:

Hypolimnion Thicknesses and Temperatures

Period	Thickness (m)	Temperature (°C)
June	6.6 ± 0.8	8.9 ± 1.5
July	5.5 ± 1.1	11.4 ± 2.0
August	4.7 ± 1.4	12.3 ± 1.3
September	3.7 ± 1.3	13.8 ± 2.8

The thickness of the hypolimnion appears to be related to the extent of anoxic conditions in the central basin. Herdendorf (1980) found that in 1975 the thickness of the hypolimnion was considerably thicker than earlier years of the decade and that the areal extent of anoxia was greatly reduced (Table 2). The average hypolimnion thicknesses and temperatures for the central basin, 1973-1980, are listed below:

Average Hypolimnion Characteristics

Year	Thickness (m)	Temperature (°C)
1973	4.1 ± 1.0	12.0 ± 1.8
1974	5.0 ± 1.0	11.5 ± 2.5
1975	7.1 ± 0.6	8.1 ± 1.9
1976	4.8 ± 2.6	11.6 ± 3.0
1977	4.1 ± 2.1	11.1 ± 0.6
1978	5.6 ± 1.2	11.6 ± 1.7
1979	4.2 ± 1.5	14.1 ± 4.6
1980	5.7 ± 0.5	12.8 ± 0.3

The eastern basin of Lake Erie is normally stratified from June through October or early November (Appendix G). The mean thicknesses of the epilimnion, mesolimnion and hypolimnion during 1978 are presented below:

Eastern Lake Erie Thermal Strata

Strata	Thickness (m)
epilimnion	13.1 ± 6.0
mesolimnion	8.5 ± 4.0
hypolimnion	12.5 ± 1.0

Generally the hypolimnion in the eastern basin is of sufficient thickness that severe oxygen depletion problems do not develop.

The thermal structure of Lake Erie is highly dependent on wind and other meteorological conditions. Calm weather in the western basin can be effective in forming transitory stratification during the summer months. In the central and eastern basins, calm weather during the late spring can result in a shallow thermocline and a correspondingly thick hypolimnion. This situation occurred in 1975 with a dramatic impact on the oxygen levels in the central basin hypolimnion and is well-documented by Herdendorf (1980).

Dissolved Oxygen

Low concentrations of dissolved oxygen, particularly in the central basin hypolimnion, is one of the most important environmental problems plaguing Lake Erie. Small areas of anoxic water in the central basin were observed as early as 1930 (Fish, 1960). The size of the late summer anoxic portion of the lake continued to grow for the next several decades until 1973 (Figure 2), when 94 percent of the hypolimnion had oxygen concentrations below 0.5 mg/l (Herdendorf, 1980). More recent surveys have shown wide fluctuations in the size of the anoxic area in the central basin, primarily due to the meteorological conditions discussed earlier, but the area and the percent of the hypolimnion experiencing anoxia have declined significantly in the period 1975 to 1980:

Central Lake Erie Anoxic Trends

Period	Anoxic Area (km^2)	Percent Hypolimnion	Total Basin
1970-1974	9,000 ± 2,100	78 ± 15	56 ± 13
1975-1980	3,800 ± 2,500	40 ± 28	26 ± 18

The estimated areas of anoxic hypolimnion of central Lake Erie for the period 1930 to 1980 are presented in Table 2.

Another method for determining trends in the oxygen concentrations in hypolimnetic waters of the central and eastern basins involves determining the loss of oxygen in the interval between two cruises. Table 3 lists the net oxygen demand for 1930 to 1980 based on daily losses per unit area and per unit volume. Rates of loss for major blocks of years are compared below:

Net Oxygen Loss Per Day

	CENTRAL BASIN		EASTERN BASIN	
Period	Area (g/m^2)	Volume (mg/l)	Area (g/m^2)	Volume (mg/l)
1930-1970	0.25 ± .13	0.079 ± .022		
1970-1975	0.55 ± .12	0.115 ± .013	0.57 ± .24	0.034 ± .017
1976-1980	0.57 ± .13	0.111 ± .016	0.59 ± .01	0.048 ± .013

From these data it can be seen that the central basin hypolimnion has experienced a significant increase in the rate of oxygen loss for the period 1930-1970, but since 1970 the net oxygen demand has been relatively stable. The stability of the oxygen depletion rate from 1970 to 1980 in central Lake Erie, particularly during the month of August, is illustrated in Figure 3. Early data is not available for the eastern basin, but a slight increase is indicated from the first half to the second half of the past decade.

Nutrients

Phosphorus has been identified as a limiting nutrient for algal productivity in Lake Erie (Hartley and Potos, 1971). Cruise mean concentrations and quantities of total and soluble reactive phosphorus for the period 1970-1980 are presented in Appendices B, C and D for the western, central and eastern basins of Lake Erie, respectively. Annual mean concentrations for this period for the three basins are presented below:

Total Phosphorus Concentrations in Lake Erie (µg/l)

Year	BASIN Western	Central	Eastern
1970 (CCIW)	44.6 ± 9.6	20.5 ± 7.8	17.5 ± 7.0
1973 (CLEAR/GLL)	34.7 ± 11.9	18.5 ± 6.2	31.1 ± 22.6
1974 (CLEAR/GLL)	35.1 ± 8.8	16.8 ± 2.7	20.8 ± 6.9
1975 (CLEAR/GLL)	42.3 ± 8.6	20.3 ± 6.8	27.6 ± 9.2
1976 (CLEAR)	44.9 ± 15.0	22.5 ± 5.2	
1977 (CLEAR)	40.7 ± 10.9	24.1 ± 8.1	18.3 ± 4.1
1978 (CCIW)		14.2 ± 1.2	13.0 ± 2.5
1979 (GLNPO)	33.9 ± 24.8	13.4 ± 2.7	10.8 ± 5.4
1980 (CLEAR)	28.8 ± 6.6	13.7 ± 6.9	
1970-1975	39.2 ± 5.0	19.0 ± 1.7	24.3 ± 6.2
1976-1980	37.1 ± 7.4	17.6 ± 5.3	14.0 ± 3.9
1978-1980	31.4 ± 3.6	13.8 ± 0.4	11.9 ± 1.6

When concentrations for the first half of the decade are compared to those of the second half, very little difference can be seen between the western and central basins; however, data for 1978-1980 does show a significant decline. The eastern basin data shows a consistent reduction in total phosphorus from 1975 to 1979.

The loading of total phosphorus to the lake has declined at an average rate of 814 metric tons per year for the period 1970-1979 (Figure 4). The 1970 loading to the entire lake from all sources, except shoreline erosion, was 23,724 metric tons; in 1979 the total loading is estimated at 13,809 metric tons. Figure 5 illustrates the quantity

of total phosphorus in the central basin during the period 1970-1980. A progressive decline in the quantity of phosphorus in the lake, similar to that shown in the loading diagram (Figure 4). is not apparent. This can be partially explained by phosphorus releases from sediment through wave resuspension and anoxic regeneration. Several investigations have demonstrated that approximately 80 percent of the phosphorus loading to Lake Erie becomes incorporated into the bottom sediments (Burns, 1976 and Herdendorf, 1980).

Figure 6 shows both total and soluble reactive phosphorus increasing in minimum summer quantities in the central basin for the period 1970 to 1976. Cruise data for 1978-1980, however, begins to show a response to decreasing phosphorus loading with lower summer minima and annual quantities.

Transparency

An analysis of Lake Erie transparency was performed for the period 1973-1980 by area-weighting secchi disk results from 35 cruises in the western basin, 41 in the central basin and 5 in the eastern basin (Table 4). No significant trends or improvements were demonstrated by the data. The mean summer values for each basin are presented below:

Secchi Disk Transparency

Year	Western	Central	Eastern
1973	1.94 ± 0.17 m	5.45 ± 1.01 m	
1974	1.72 ± 0.50 m	5.69 ± 0.81 m	
1975	1.21 ± 0.39 m	5.51 ± 2.24 m	
1976	1.82 ± 1.36 m	4.41 ± 0.02 m	
1977	1.09 ± 0.00 m	5.55 ± 0.94 m	5.60 ± 1.78 m
1978	2.14 ± 0.30 m	5.52 ± 1.45 m	5.74 ± 1.27 m
1979	2.19 ± 0.68 m	5.02 ± 1.33 m	5.27 ± 1.98 m
1980	1.58 ± 0.13 m	5.88 ± 1.18 m	

The year with the poorest water clarity in the western basin (1977) coincides with the year of the lowest lake level (Figure 1). This suggests that wave resuspension of bottom sediments may be more effective during low water periods. Transparency in the central basin was relatively constant throughout the period with the exception of 1976 when the mean decreased more than one meter from adjacent years. This may be the result of an early fall turnover (Table 1). From the limited data for the eastern basin, it appears that mean transparencies in the eastern and central basins are very similar. In general, the central basin transparency exceeds that of the western basin by a factor of 3.5.

Chlorophyll

Chlorophyll serves as a useful indicator of algal productivity in Lake Erie. Concentrations and quantities of corrected chlorophyll a for 1970-1980 cruises are given in Appendices B, C and D for the western, central and eastern basins, respectively. Annual mean concentrations for the three basins are listed below:

Chlorophyll a, Corrected, Concentrations in Lake Erie (ug/l)

Year	BASIN Western	Central	Eastern
1970 (CCIW)	8.6 ± 4.6	4.5 ± 2.1	3.3 ± 1.4
1973 (CLEAR/GLL)	10.7 ± 2.1	4.6 ± 2.9	5.1 ± 1.8
1974 (CLEAR/GLL)	13.4 ± 3.4	4.2 ± 2.6	5.1 ± 1.6
1975 (CLEAR/GLL)	13.7 ± 5.9	5.9 ± 2.8	3.6 ± 1.3
1976 (CLEAR)	12.4 ± 4.6	5.2 ± 2.4	
1977 (CLEAR)	10.8 ± 6.1	4.0 ± 1.4	3.0 ± 1.1
1978 (GLNPO)	12.5 ± 4.3	5.2 ± 2.1	3.2 ± 1.3
1979 (GLNPO)	11.5 ± 4.5	5.1 ± 1.7	2.7 ± 0.9
1980 (CLEAR)	8.4 ± 3.1	3.1 ± 1.0	
1970-1975	11.6 ± 2.4	4.8 ± 0.8	4.3 ± 1.0
1976-1980	11.1 ± 1.7	4.5 ± 0.9	3.0 ± 0.3
1979-1980	10.0 ± 2.2	4.1 ± 1.4	2.7 ± 0.9

A comparison of the first half of the past decade to the last half shows very small differences and no discernable trends for the western and central basins. However, in likely response to reduced phosphorus concentrations, the 1980 chlorophyll levels indicate a possible decline in algal biomass. Figure 7 also demonstrates this trend with a marked lowering in the quantity of central basin chlorophyll a in 1980. Similar trends for surface water chlorophyll a concentrations in all three basins are illustrated in Figures 8-10, with decreased minima, maxima and means compared with most years of the preceding decade.

Dissolved Substances

Trends in dissolved substances in Lake Erie water can be inferred from Lake Erie conductivity measurements and determination of major conservative ions, such as sulfate and chloride. STORET data files for the period 1966 to 1980 were used for a trend analysis, based on central basin cruise data supplied by Canada Centre for Inland Waters (CCIW), Ontario Ministry of Environment (MOE), USEPA, Great Lakes National Program Office (GLNPO) and Ohio State University, Center for Lake Erie Area Research (CLEAR). Ontario Ministry of Environment data was obtained from stations 1-7 km offshore, while data from the other three groups were from open

lake stations, generally five or more km offshore. Data points on Figures 11-13 represent cruise mean values for periods of isothermal lake conditions (March-May and October-December). Annual mean values for conductivity, chloride and sulfate are listed below:

Dissolved Substances Trends in Central Lake Erie

Year	Conductivity (umhos/cm)	Chloride (mg/l)	Sulfate (mg/l)
1966	311	25.0	
1967	319 ± 0.6	24.4 ± 0.4	
1968	314 ± 3.4	24.4 ± 1.4	26.4 ± 1.1
1969	308 ± 8.6	23.7 ± 0.9	23.4
1970	312 ± 7.2	22.5 ± 1.0	23.1 ± 1.7
1971	318 ± 9.5	24.3 ± 1.2	24.0 ± 0.8
1972	303 ± 8.3	22.2 ± 1.5	
1973	289 ± 3.1	21.2 ± 2.6	22.4 ± 0.9
1974	282 ± 24.9	19.4 ± 2.8	21.7 ± 3.5
1975	282 ± 20.0	19.9 ± 1.6	22.5 ± 3.4
1976	283 ± 23.3	19.4 ± 4.2	
1977	272	19.5 ± 1.7	
1978	289 ± 8.4	19.6 ± 1.4	21.6 ± 5.2
1979	288 ± 2.9	18.4 ± 1.3	23.4 ± 1.1
1980	287 ± 10.7		
1966-1970	313 ± 4.1	24.0 ± 1.0	24.3 ± 1.8
1970-1975	298 ± 15.6	21.6 ± 1.8	22.7 ± 0.8
1975-1980	284 ± 6.3	19.4 ± 0.6	22.5 ± 0.9

Conductivity (Figure 11) indicates a rather slow decline for mean levels for the period of record. The mean value for 1975-1980 (284 umhos/cm) is approximately nine percent lower than the mean 1966-1970 value (313 umhos/cm). Trends in central basin chloride (Figure 12) shows a more noticeable decline from a mean concentration of 24.0 mg/l for 1966-1970 to 19.4 mg/l for 1975-1979. Sulfate concentrations showed a weaker but discernable trend (Figure 13), falling from a mean concentration of 24.8 mg/l for 1968-1970 to 22.5 mg/l for 1975-1979.

REFERENCES CITED

Britt, N.W. 1955. Stratification in western Lake Erie, 1959-1960. Great Lakes Fish. Comm. Tech. Rept. 6. 32 p.

Burns, N.M. (ed.) 1976. Lake Erie in the early seventies. J. Fish. Res. Board Can. 33(3): 349-645.

Burns, N.M. and C. Ross (eds.). 1972. Project Hypo. Canada Centre for Inland Water, Paper No. 6 and USEPA Tech. Rept. TS-05-71-208-24. 182 p.

Carr, J.F., V.C. Applegate and M. Keller. 1965. A recent occurrence of thermal stratification and low dissolved oxygen in western Lake Erie. Ohio J. Sci. 65(6): 319-327.

Dobson, H.H. and M. Gilbertson. 1971. Oxygen depletion in the hypolimnion of the central basin of Lake Erie. Proc. 14th Conf. Great Lakes Res., Internat. Assoc. Great Lakes Res. 1971: 743-748.

Fish, C.J. and Associates. 1960. Limnological survey of eastern and central Lake Erie, 1928-1929. U.S. Fish and Wildl. Serv., Spec. Sci. Rept. - Fisheries No. 334. 198 p.

Hartley, R.P. and C.P. Potos. 1971. Algal-temperature-nutritional relationships and distribution in Lake Erie 1968. U.S. Environ. Protection Agency. 87 p.

Herdendorf, C.E. (ed.) 1980. Lake Erie nutrient control program: an assessment of its effectiveness in controlling lake eutrophication. U.S. Environ. Protection Agency Pub. No. EPA-600/3-80-062. 354 p.

Hutchinson, G.E. 1957. A treatise on limnology Vol. 1 geography, physics, and chemistry. John Wiley and Sons, New York. 1015 p.

Rockwell, D.C., D.S. DeVault III, M.F. Palmer, C.V. Marion and R.J. Bowden. 1980. Lake Michigan intensive survey 1976-1977. U.S. Environ. Protection Agency, Great Lakes National Program Office. Pub. No. EPA-905/4-80-003-A. 155 p.

Thomas, N.A. 1963. Oxygen deficit rates for the central basin of Lake Erie. U.S. Public Health Serv., Robert A. Taft Sanitary Engineering Center, Cincinnati. 8 p.

Zapotosky, J.E. 1980. Transparency, conductivity, and temperature surveys in the central and western basins of Lake Erie. U.S. Environ. Protection Agency. Pub. No. EPA-600/3-80-062. p. 103-117.

Zapotosky, J.E. and C.E. Herdendorf. 1980. Oxygen depletion and anoxia in the central and western basins of Lake Erie, 1973-1975. U.S. Environ. Protection Agency. Pub. No. EPA-600/3-80-062. p. 71-102.

Zapotosky, J.E. and W. Sedgefield White. 1980. A reconnaissance survey for lightweight and carbon tetrachloride extractable hydrocarbons in the central and eastern basins of Lake Erie: September 1978. Argonne National Laboratory. ANL/ES-87. 150 p.

TABLES

TABLE 1. COMPARISON OF 1970-1980 CHARACTERISTICS OF HYPOLIMNION IN CENTRAL LAKE ERIE

	1970 (Project Hypo)	1973	1974	1975	1976	1977	1978	1979	1980
MAY									
Thick (m)	-	-	-	-	-	-	-	5.6	-
DO (mg/l)	-	-	-	-	-	-	-	12.0	-
Temp. (°C)	-	-	-	-	-	-	-	9.8	-
JUNE									
Thick (m)	-	-	6.2	7.7	6.6	6.8	5.6	N.A.	-
DO (mg/l)	-	-	9.9	10.0	9.6	8.3	11.0	N.A.	-
Temp. (°C)	-	-	8.8	6.5	9.4	10.4	9.3	N.A.	-
JULY									
Thick (m)	-	5.0	4.6	6.7	-	4.6	7.1	4.4	6.2
DO (mg/l)	-	4.9	5.2	7.8	-	5.1	7.5	7.2	7.8
Temp. (°C)	-	10.3	11.8	7.7	-	11.0	12.5	14.0	12.7
EARLY AUGUST									
Thick (m)	-	4.4	4.3	6.8	3.0	3.0	5.5	N.A.	5.8
DO (mg/l)	-	1.6	2.1	3.3	0.7	2.1	5.4	N.A.	4.5
Temp. (°C)	-	11.9	13.5	10.2	13.7	11.9	11.5	N.A.	13.1
SEPTEMBER									
Thick (m)	-	3.0	-	-	-	2.1	4.3	2.7	5.2
DO (mg/l)	-	1.1	-	-	-	0.5	3.0	6.3	3.0
Temp. (°C)	-	13.8	-	-	-	11.2	13.1	18.5	12.5
NET OXYGEN DEMAND (loss/day)									
Volume rate (mg O_2/l)	0.11	0.12	0.13	0.10	0.13	0.13	0.09	0.09	0.11
Area rate (g O_2/m^2)	0.38	0.53	0.60	0.67	0.75	0.58	0.51	0.41	0.63

Data sources: 1970--CCIW; 1973 to 1977, 1980--OSU/CLEAR; 1978 and 1979--USEPA/GLNPO.

TABLE 2. ESTIMATED AREA OF THE ANOXIC HYPOLIMNION OF THE CENTRAL BASIN OF LAKE ERIE 1930-1980

YEAR	AREA (km^2)	PERCENT OF CENTRAL BASIN	
		Hypolimnion	Total Basin
1930	300	3.0	1.9
1959	3,600	33.0	22.3
1960	1,660	15.0	10.3
1961	3,640	33.0	22.5
1964	5,870	53.0	36.3
1970	6,600	60.0	40.4
1972	7,970	72.5	49.3
1973	11,270	93.7	69.8
1974	10,250	87.0	63.4
1975	400	4.1	2.5
1976	7,300	63.0	53.0
1977	2,870	24.8	20.8
1978	3,980	71.7	24.6
1979	N.A.	N.A.	N.A.
1980	4,330	35.9	26.8

Data Sources:
1930--Fish (1960)
1959-1961--Thomas (1963)
1964--FWPCA (1968)
1970--CCIW (Burns and Ross, 1972)
1972-1977, 1980--OSU/CLEAR
1978--ANL (Zapotosky and White, 1980).

TABLE 3. TRENDS IN NET OXYGEN DEMAND OF THE CENTRAL AND EASTERN BASIN HYPOLIMNIONS OF LAKE ERIE 1930-1980

DATA SOURCE*	YEAR	NET OXYGEN DEMAND			
		Rate Per Unit Area ($g\ O_2\ m^{-2}\ day^{-1}$)		Rate Per Unit Volume ($mg\ O_2\ l^{-1}\ day^{-1}$)	
		Central Basin	Eastern Basin	Central Basin	Eastern Basin
1	1930	0.08	-	0.054	-
1	1940	0.15	-	0.067	-
1	1950	0.25	-	0.070	-
1	1960	0.37	-	0.093	-
2	1970	0.38	0.70	0.110	0.055
3,4	1973	0.53	0.23	0.120	0.016
3,4	1974	0.60	0.57	0.130	0.026
3,4	1975	0.67	0.76	0.100	0.040
3,4	1976	0.75	-	0.130	0.032
3	1977	0.58	0.68	0.130	0.060
2	1977	0.48	0.51	0.120	0.065
5	1978	0.51	0.58	0.092	0.048
2	1978	0.54	0.61	0.111	0.047
5	1979	0.41	0.58	0.090	0.049
3	1980	0.63	-	0.109	-

*Data sources: 1) Dobson and Gilbertson, 1971; 2) CCIW--Noel Burns, personal communication; 3) OSU/CLEAR--Central Basin, 1973-1977; Eastern Basin, 1977; 4) SUNY/GLL--Eastern Basin, 1973-1976; 5) USEPA/GLNPO--rate calculation OSU/CLEAR.

TABLE 4. LAKE ERIE TRANSPARENCY MEASUREMENTS 1973-1980

Date	Year	Cruise No.	Area-Weighted Transparency, Secchi Disk (m) Western	Central	Eastern
6/28- 7/12	1973	1	1.92	4.31	N.A.
7/17- 7/23		2	N.A.	6.72	N.A.
7/25- 8/2		3	1.78	5.86	N.A.
8/7 - 8/11		4	N.A.	5.85	N.A.
8/29- 9/4		5	2.12	4.53	N.A.
9/19- 9/29		6	1.14	3.77	N.A.
10/14-10/24		7	0.87	3.35	N.A.
11/7 -11/15		8	1.01	2.26	N.A.
12/4		9	1.30	1.75	N.A.
4/7 - 4/17	1974	1	0.56	1.62	N.A.
4/25- 5/4		2	0.60	3.03	N.A.
5/14- 5/24		3	1.05	3.34	N.A.
6/1 - 6/10		4	2.35	4.38	N.A.
6/28- 7/7		5	1.31	6.28	N.A.
7/26- 8/4		6	2.16	5.93	N.A.
8/12- 8/19		7	1.54	6.36	N.A.
8/26- 9/7		8	1.25	5.51	N.A.
9/24- 9/27		9	1.08	N.A.	N.A.
10/21-11/1		10	1.96	3.31	N.A.
12/11-12/14		12	0.56	0.76	N.A.
3/19- 3/31	1975	1A	0.64	0.90	N.A.
4/21- 4/25		1B	0.45	1.65	N.A.
6/9 - 6/19		2	1.28	4.92	N.A.
7/13- 7/21		3	1.56	7.99	N.A.
8/30- 9/7		4	0.79	3.63	N.A.
9/27-10/6		5	0.94	2.70	N.A.
12/2 -12/10		6	0.44	1.03	N.A.
3/22- 3/30	1976	1	0.81	2.27	N.A.
6/2 - 6/10		2	2.78	4.39	N.A.
8/21- 8/29		3	N.A.	4.42	N.A.
9/8 - 9/17		4	0.85	3.12	N.A.
10/18-10/30		5	1.01	2.08	N.A.
3/20- 3/31	1977	1	1.75	4.90	N.A.
4/29- 5/8		2	N.A.	4.56	4.98
6/20- 6/30		3	N.A.	5.41	3.69
7/12- 7/22		4	N.A.	6.55	7.21
8/11- 8/21		5	N.A.	4.69	5.91
9/11-10/8		6	1.09	4.01	4.50
11/7 -11/20		7	1.36	2.22	2.88

(continued)

TABLE 4 CONT.

Date	Year	Cruise No.	Area-Weighted Transparency, Secchi Disk (m) Western	Central	Eastern
	1978	1	N.A.	N.A.	N.A.
5/18- 5/27		2	2.50	3.87	3.96
6/5 - 6/15		3	2.02	4.31	4.22
6/23- 7/1		4	2.00	4.22	6.87
7/19- 7/29		5	2.06	6.93	5.95
8/8 - 8/16		6	2.68	6.60	7.03
8/29- 9/6		7	1.94	5.16	4.65
10/3 -10/12		8	1.58	4.31	3.20
10/24-11/1		9	2.08	2.93	3.63
11/10-11/19		10	0.65	3.42	3.16
	1979	1	N.A.	N.A.	N.A.
4/17- 4/20		2	0.67	1.28	N.A.
5/15- 5/26		3	1.81	2.82	3.16
6/12- 6/21		4	1.44	3.49	3.07
7/11- 7/19		5	3.03	5.80	6.91
7/31- 8/4		6	2.38	5.78	N.A.
8/23- 9/4		7	1.91	N.A.	N.A.
9/11- 9/21		8	1.29	3.92	5.82
10/2 -10/14		9	1.59	3.50	4.26
11/7 -11/16		10	0.96	5.03	3.67
6/29- 7/6	1980	4	1.51	7.02	N.A.
7/28- 8/8		5	1.73	5.95	N.A.
8/18- 8/23		6	1.50	4.66	N.A.

FIGURES

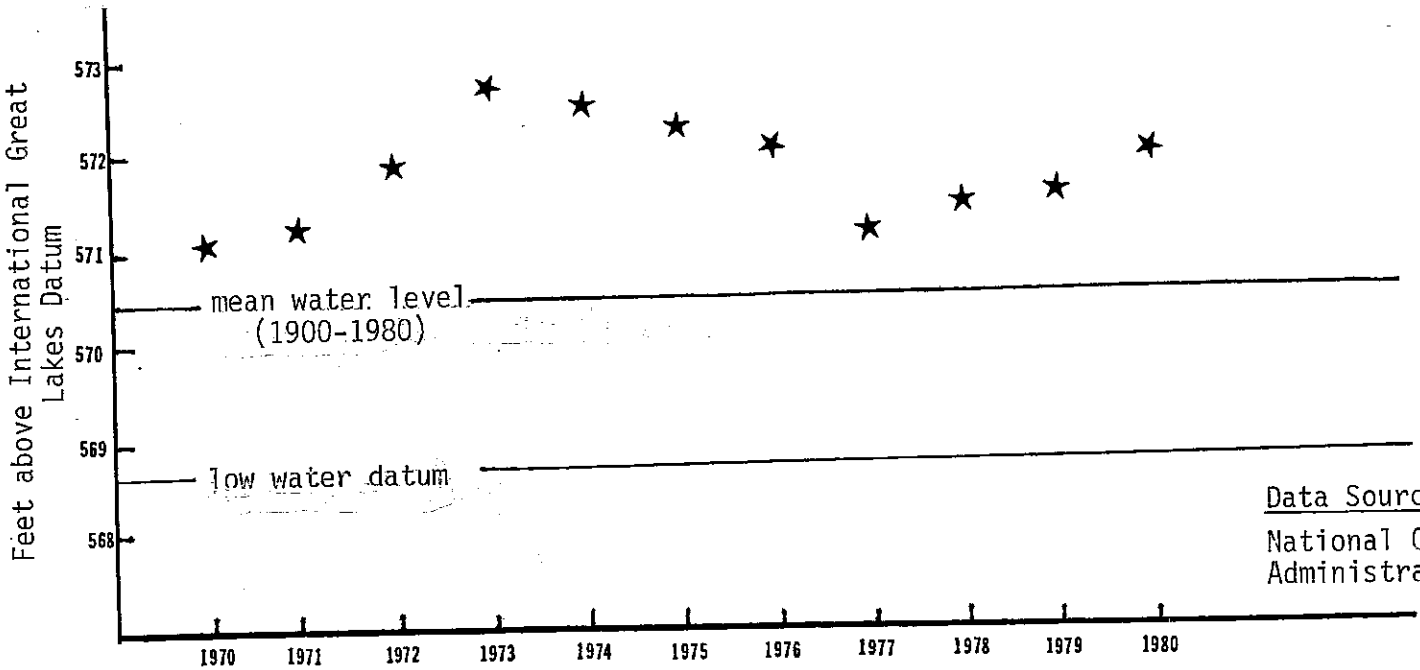

Figure 1. Average annual water levels for Lake Erie 1970-1980.

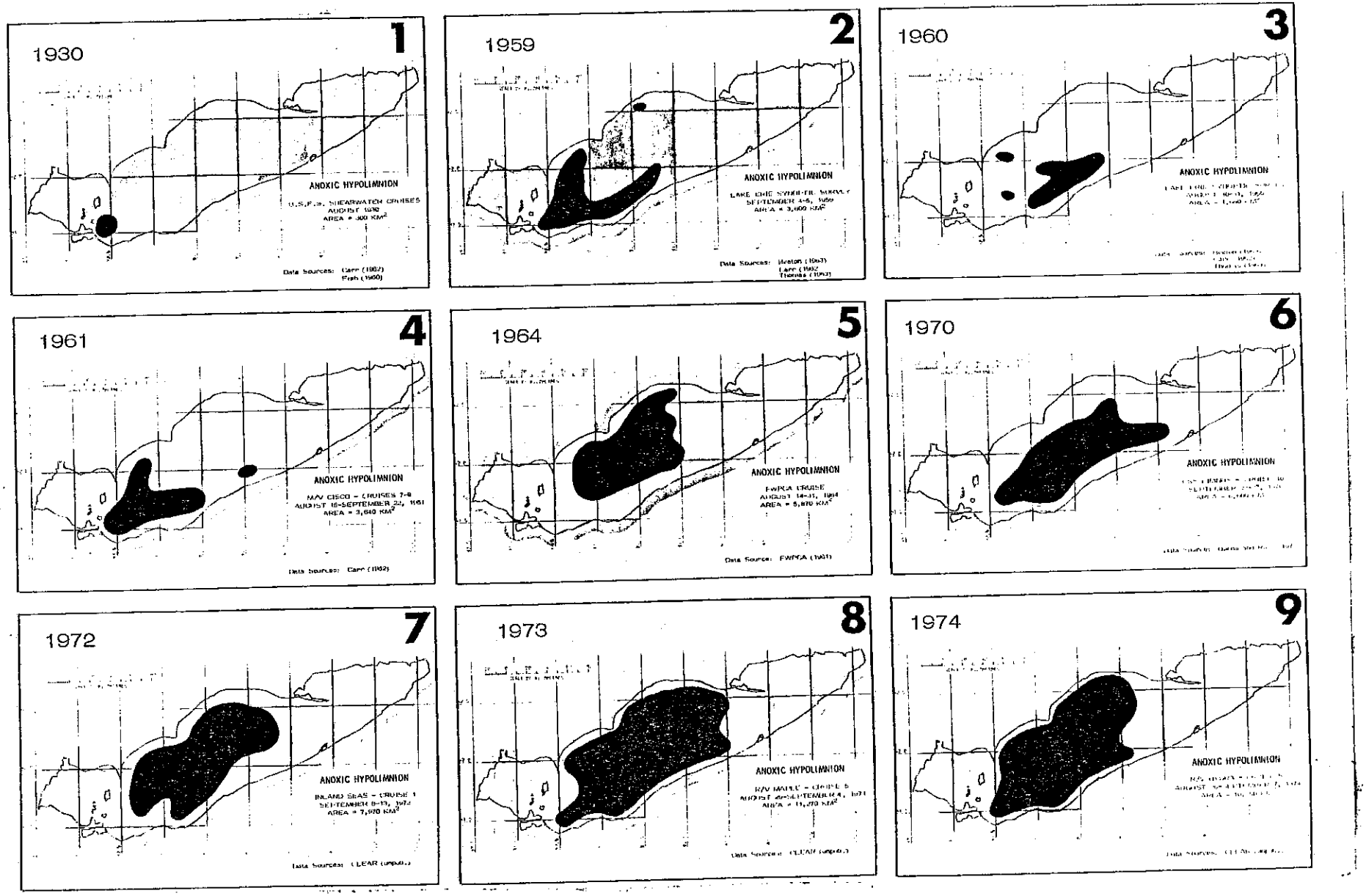

Figure 2. Trends in Anoxic Hypolimnion of Lake Erie 1930-1974.

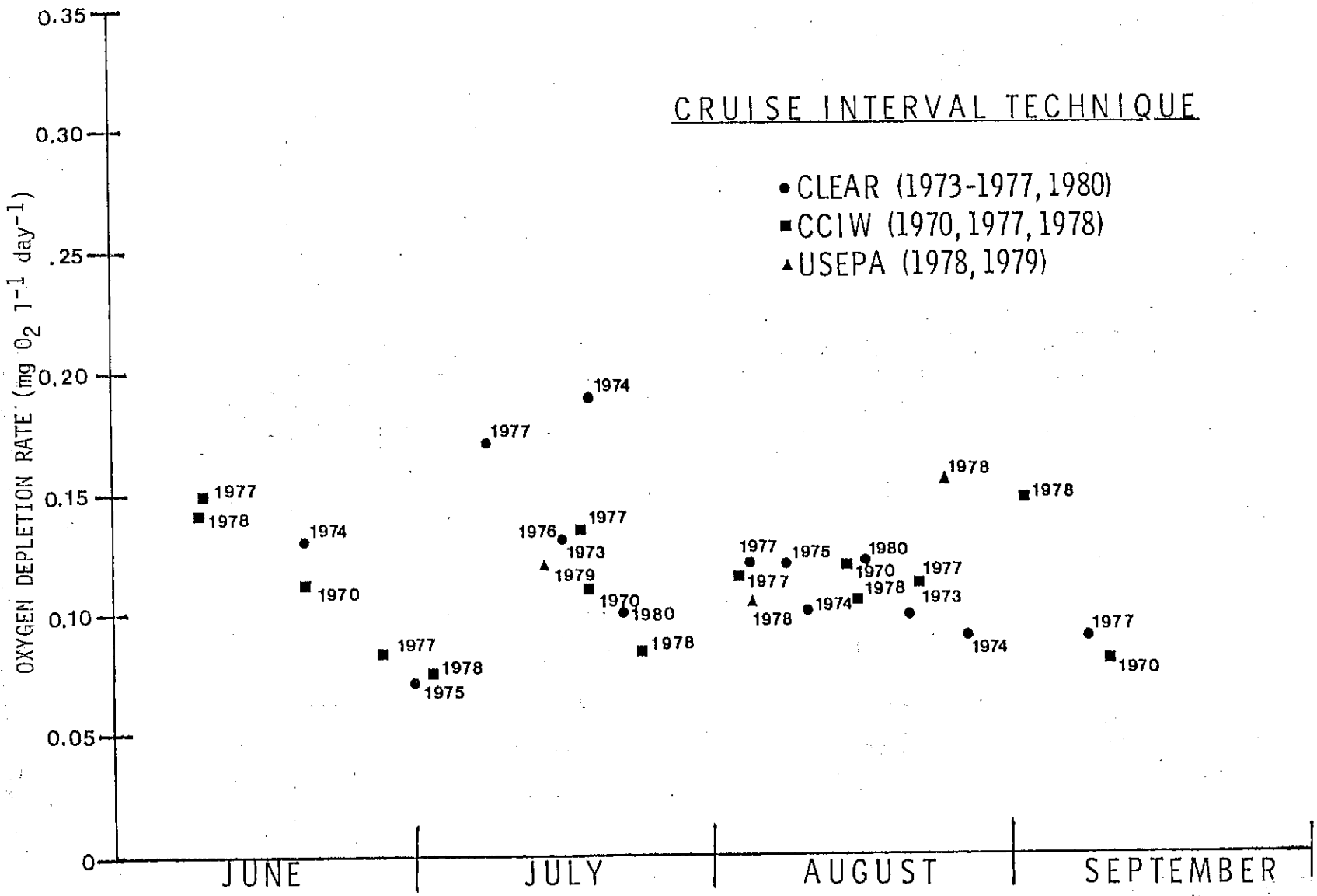

Figure 3. Hypolimnetic oxygen depletion rates for central Lake Erie 1970-1980.

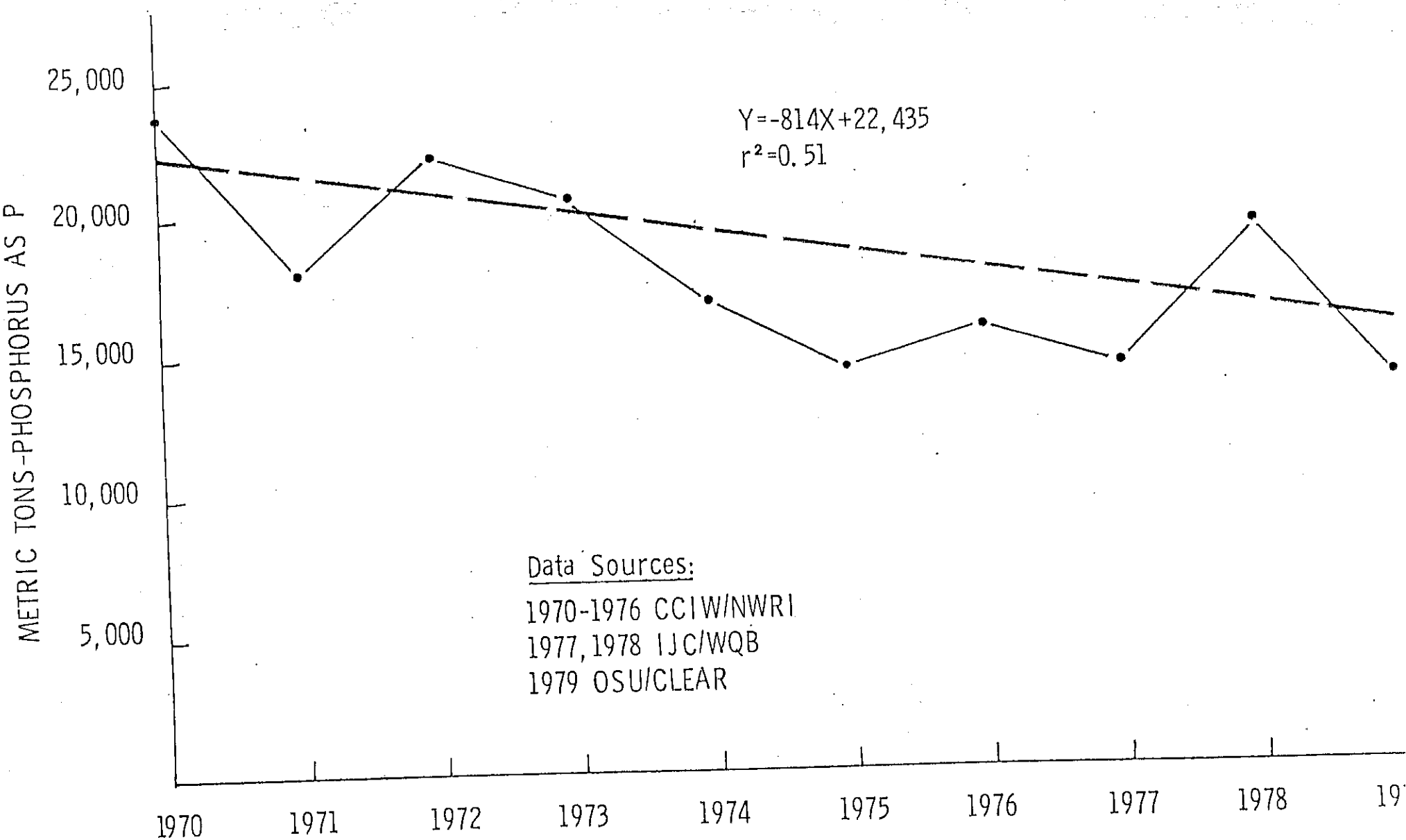

Figure 4. Loading of total phosphorus to Lake Erie 1970-1979.

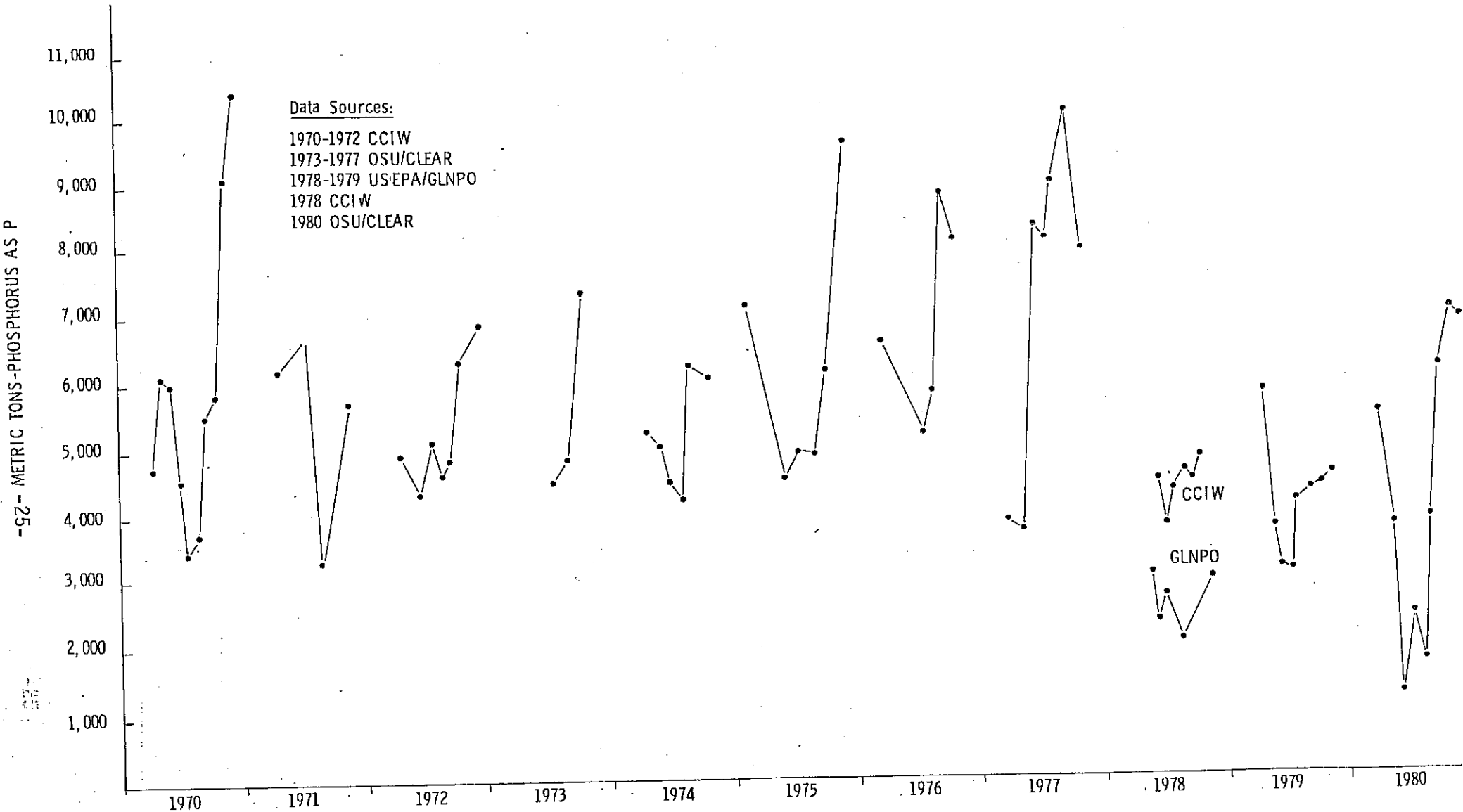

Figure 5. Total Phosphorus quantities in the central basin of Lake Erie 1970-1980.

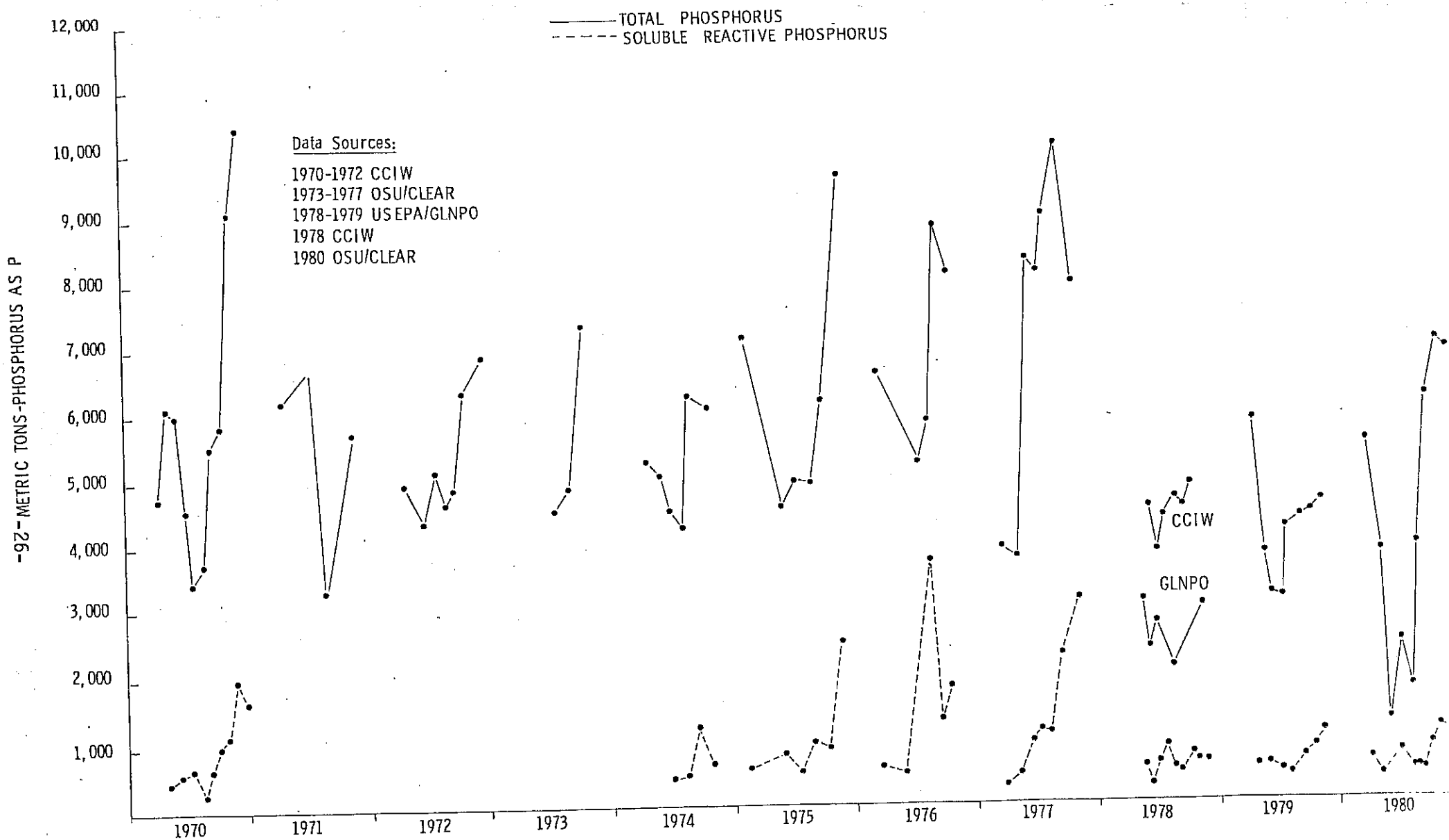

Figure 6. Total and soluble reactive phosphorus quantities in the central basin of Lake Erie 1970-1980.

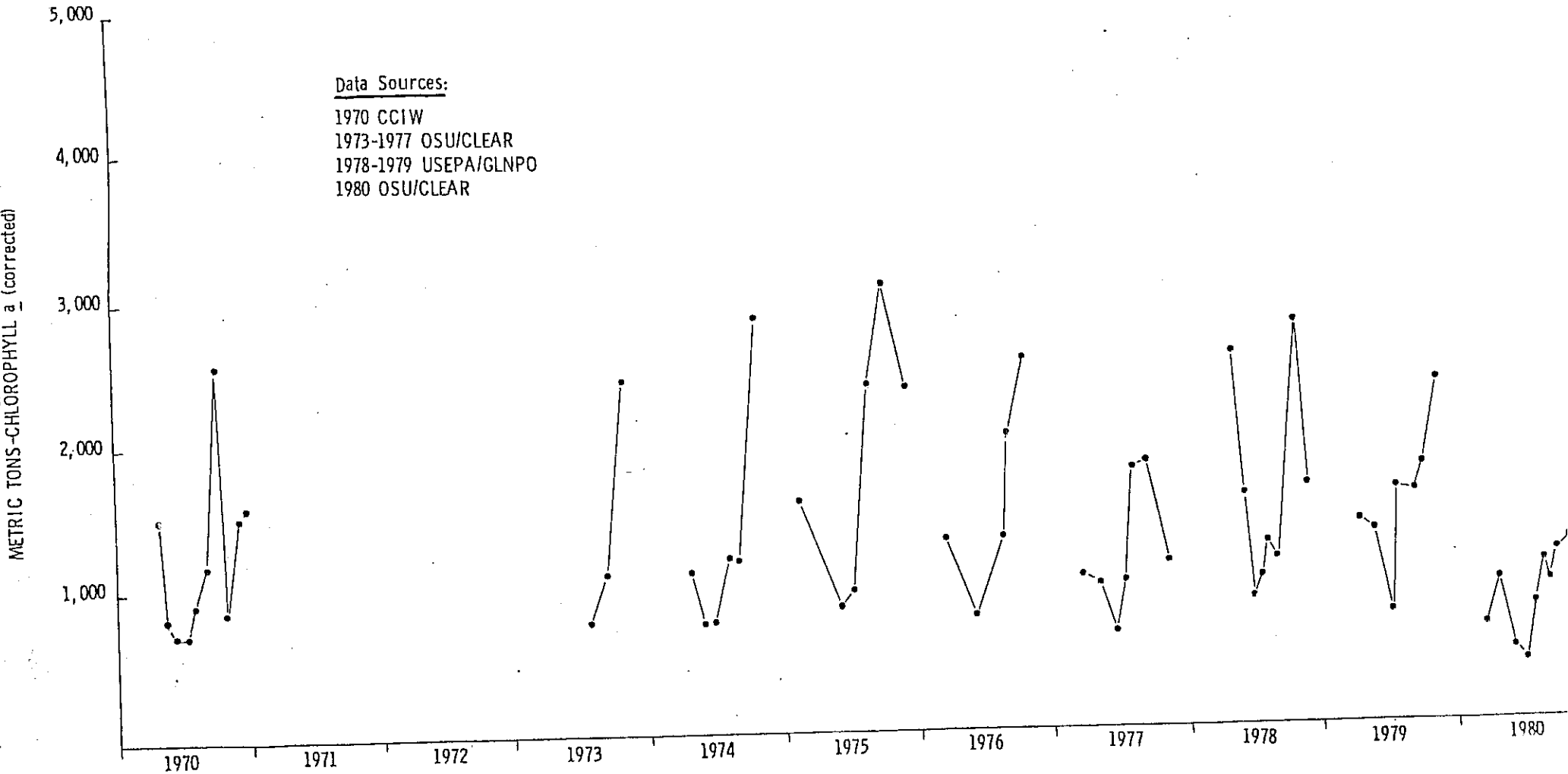

Figure 7. Chlorophyll a quantities in the central basin of Lake Erie 1970-1980.

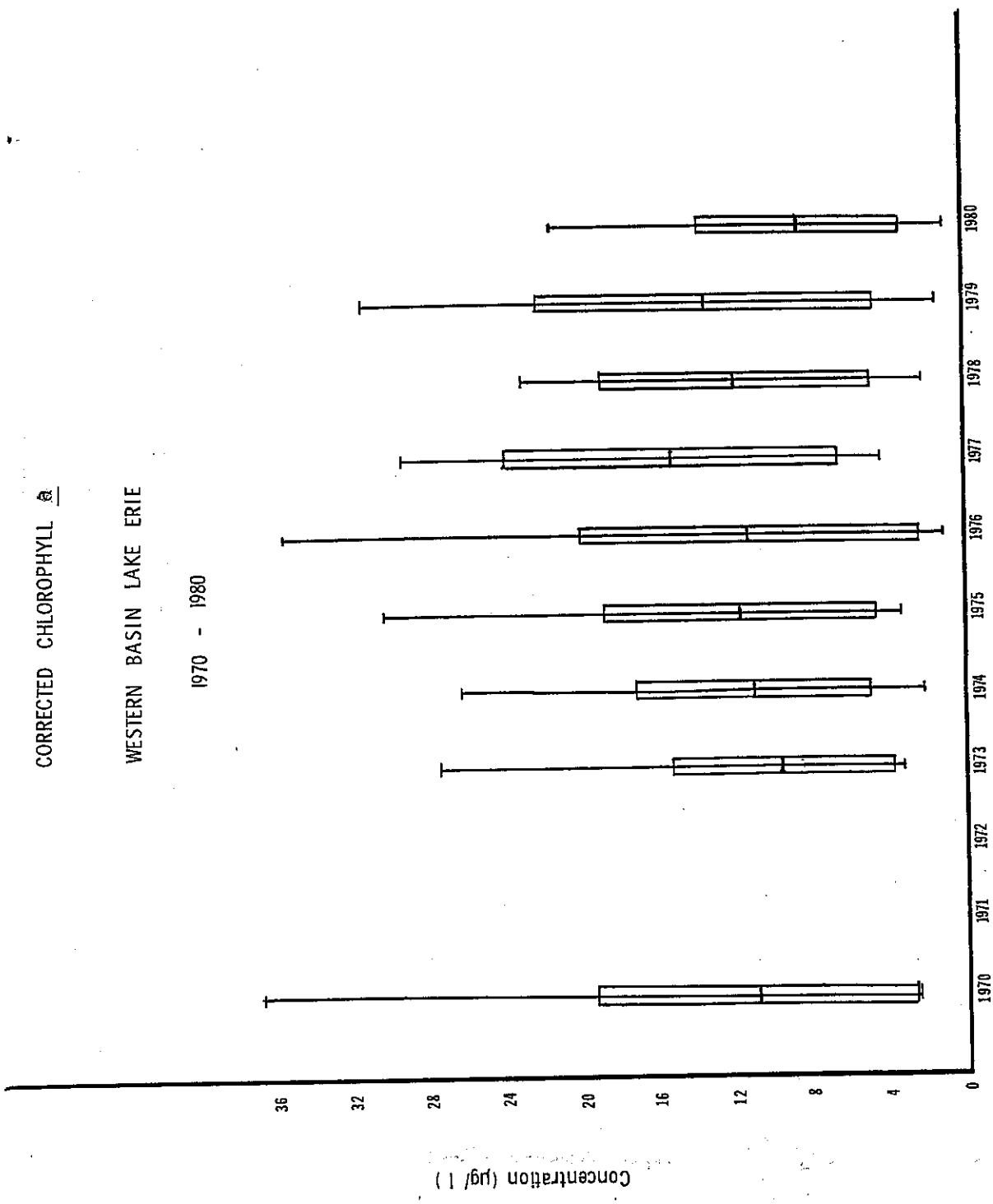

Figure 8. Chlorophyll a concentrations in surface waters of western Lake Erie 1970-1980.

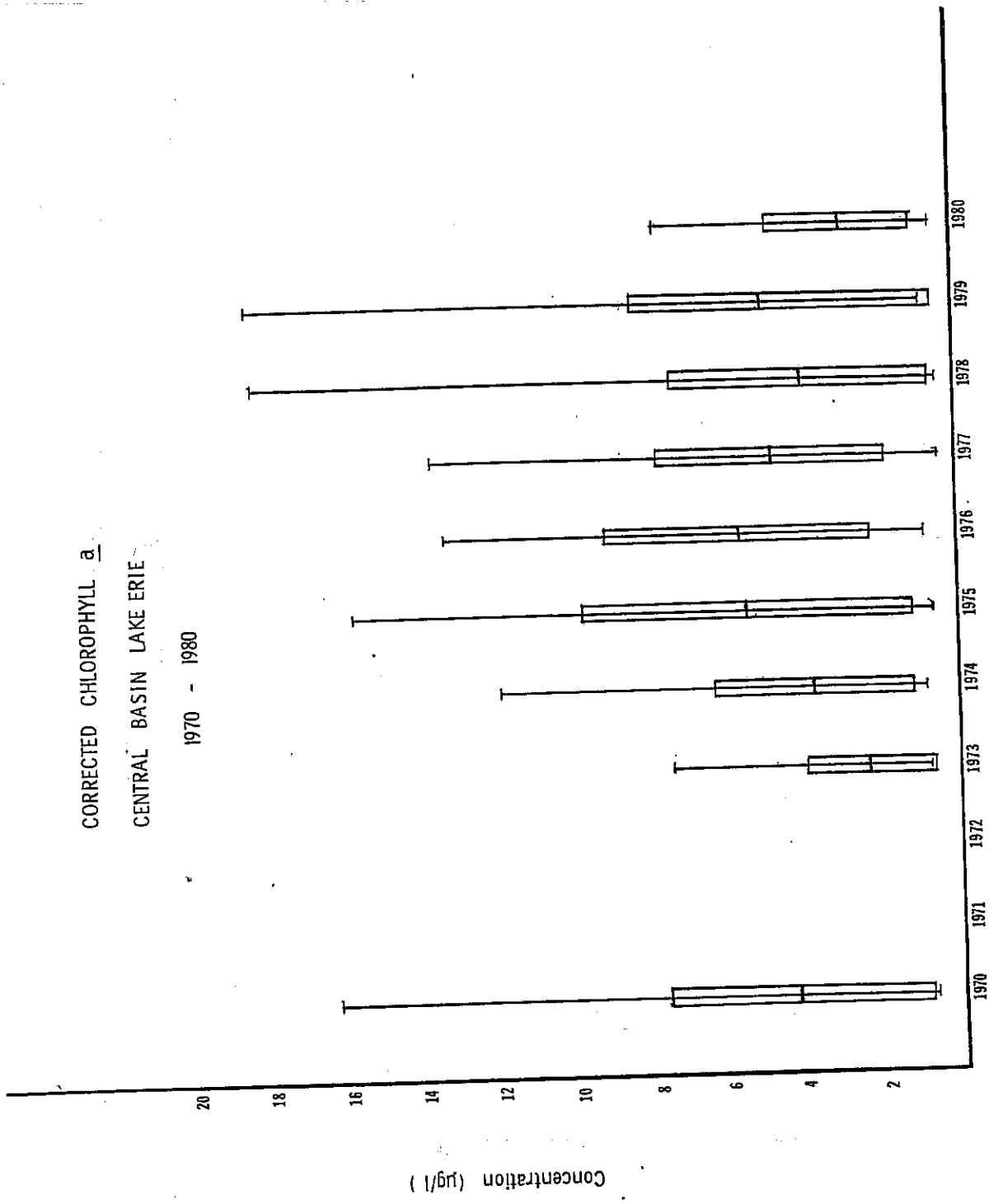

Figure 9. Chlorophyll a concentrations in surface waters of central Lake Erie 1970-1980.

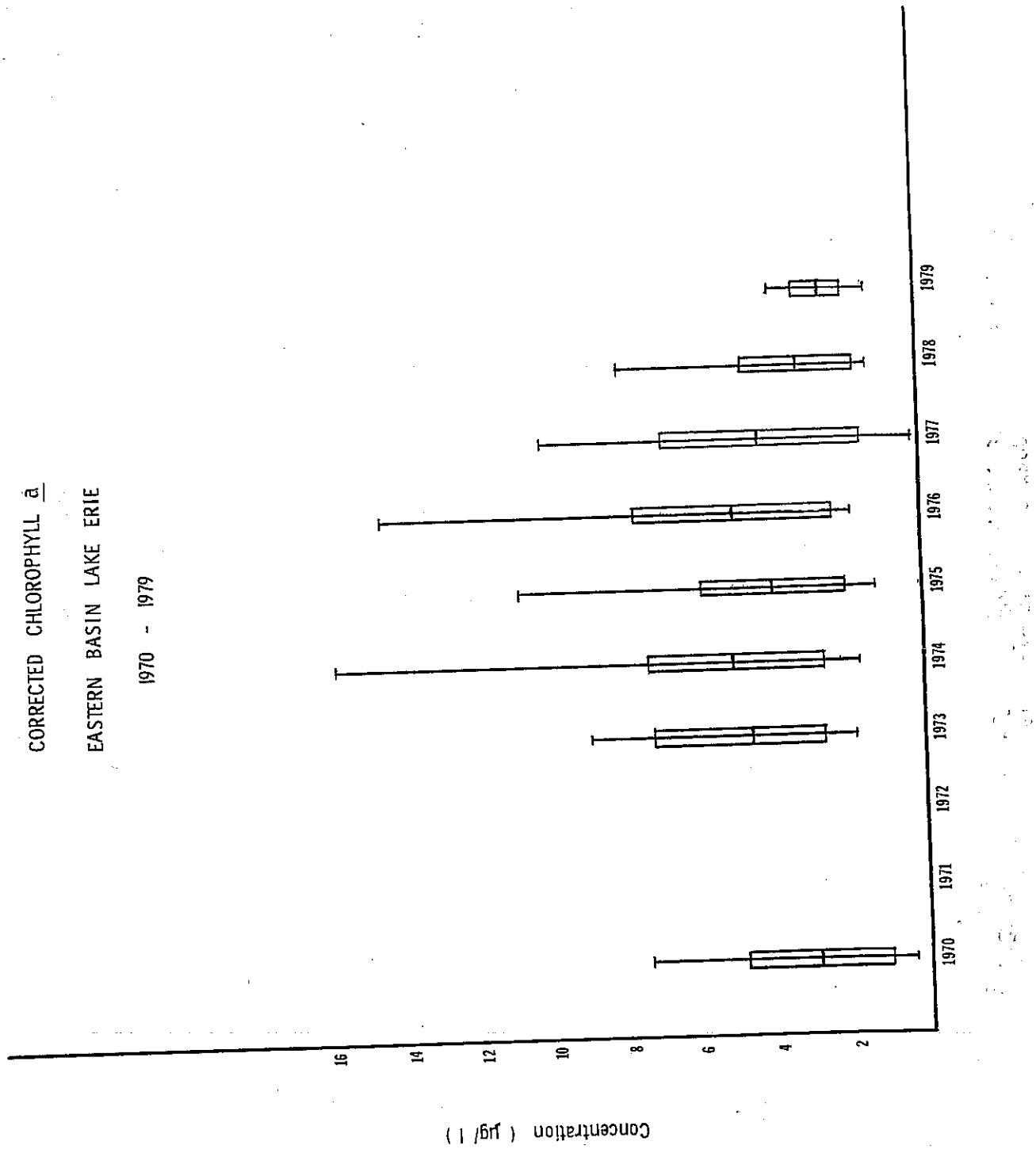

Figure 10. Chlorophyll a concentrations in surface waters of eastern Lake Erie 1970-1980.

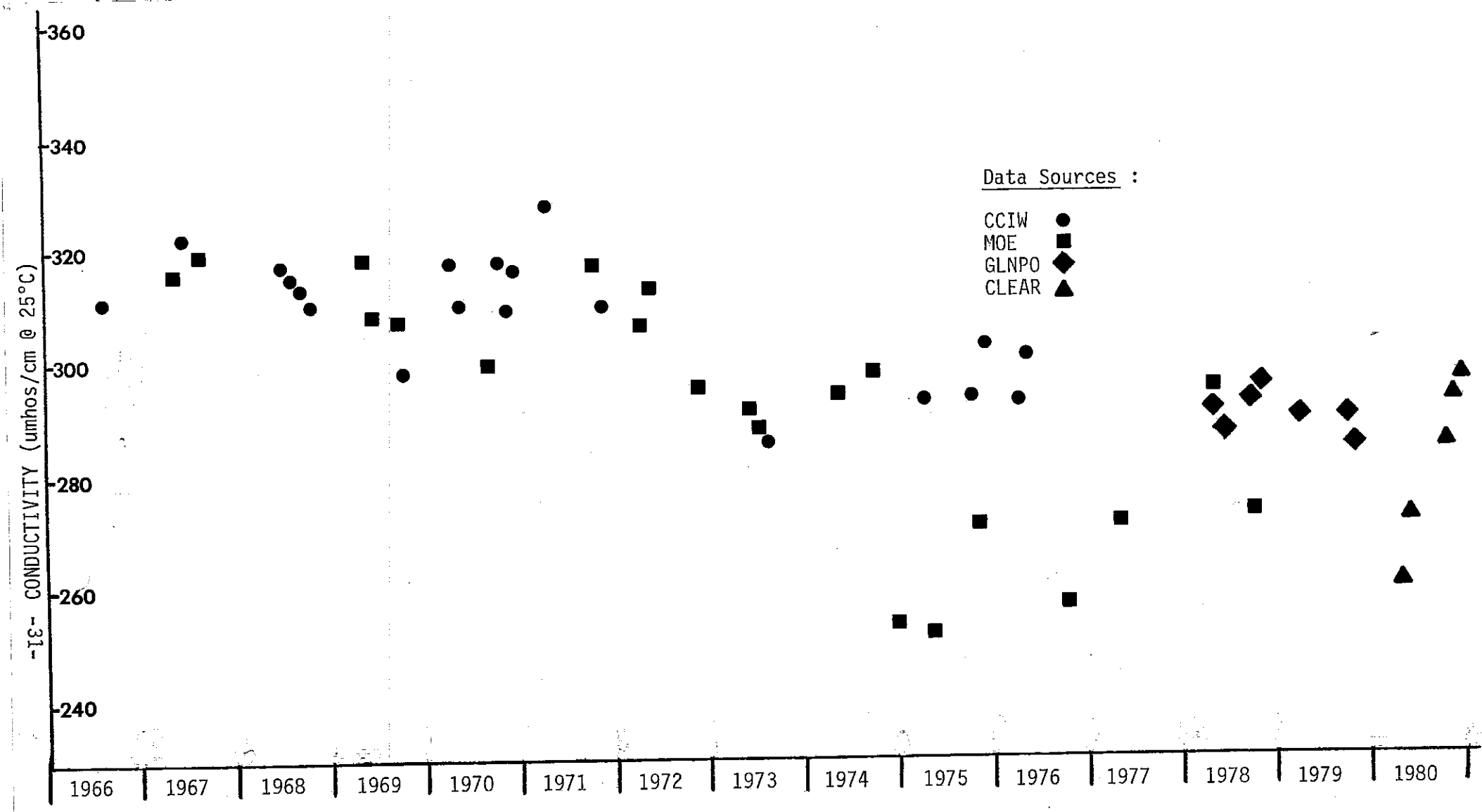

Figure 11. Specific conductance of central Lake Erie 1966-1980.

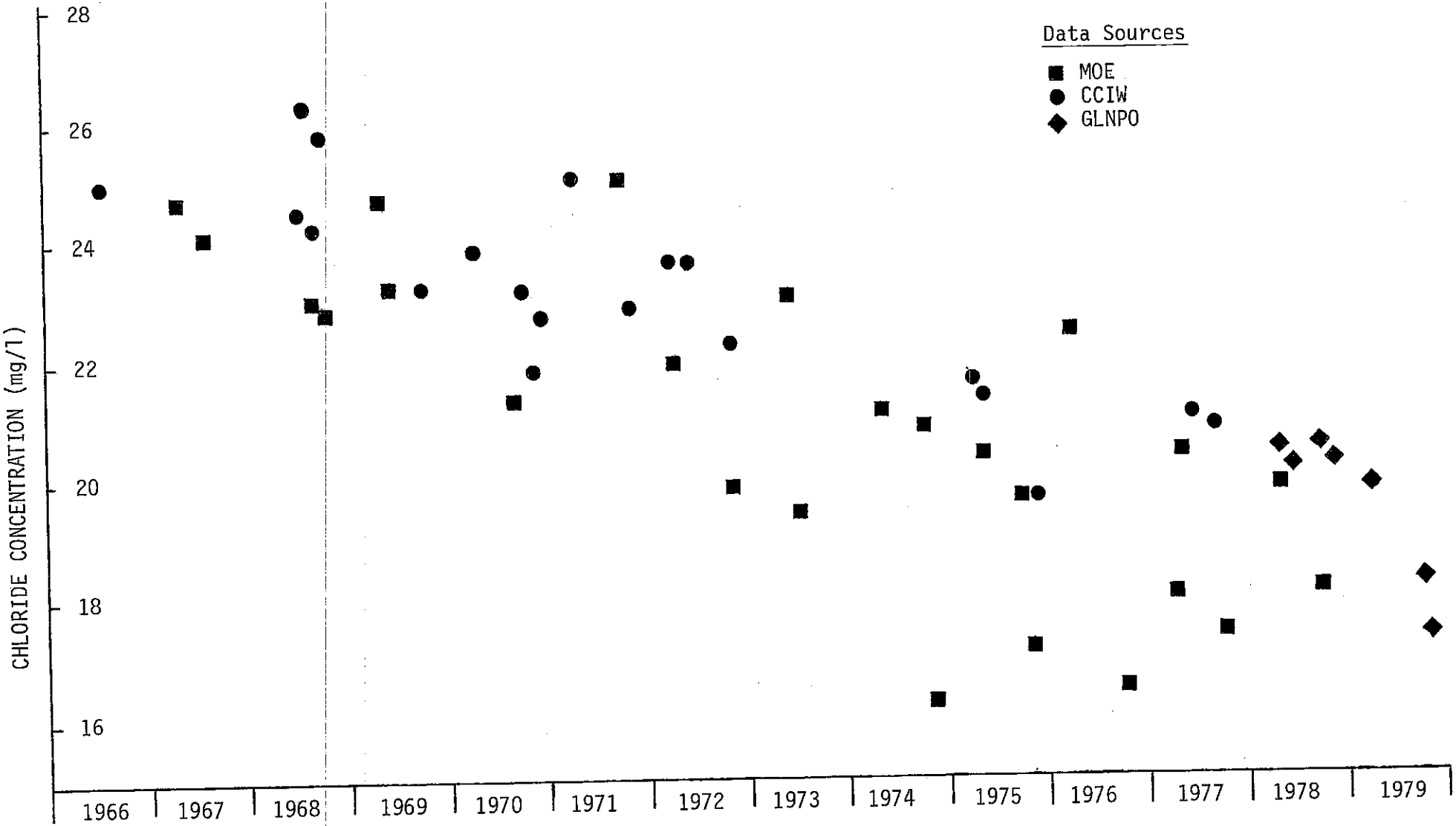

Figure 12. Chloride concentrations in central Lake Erie 1966-1979.

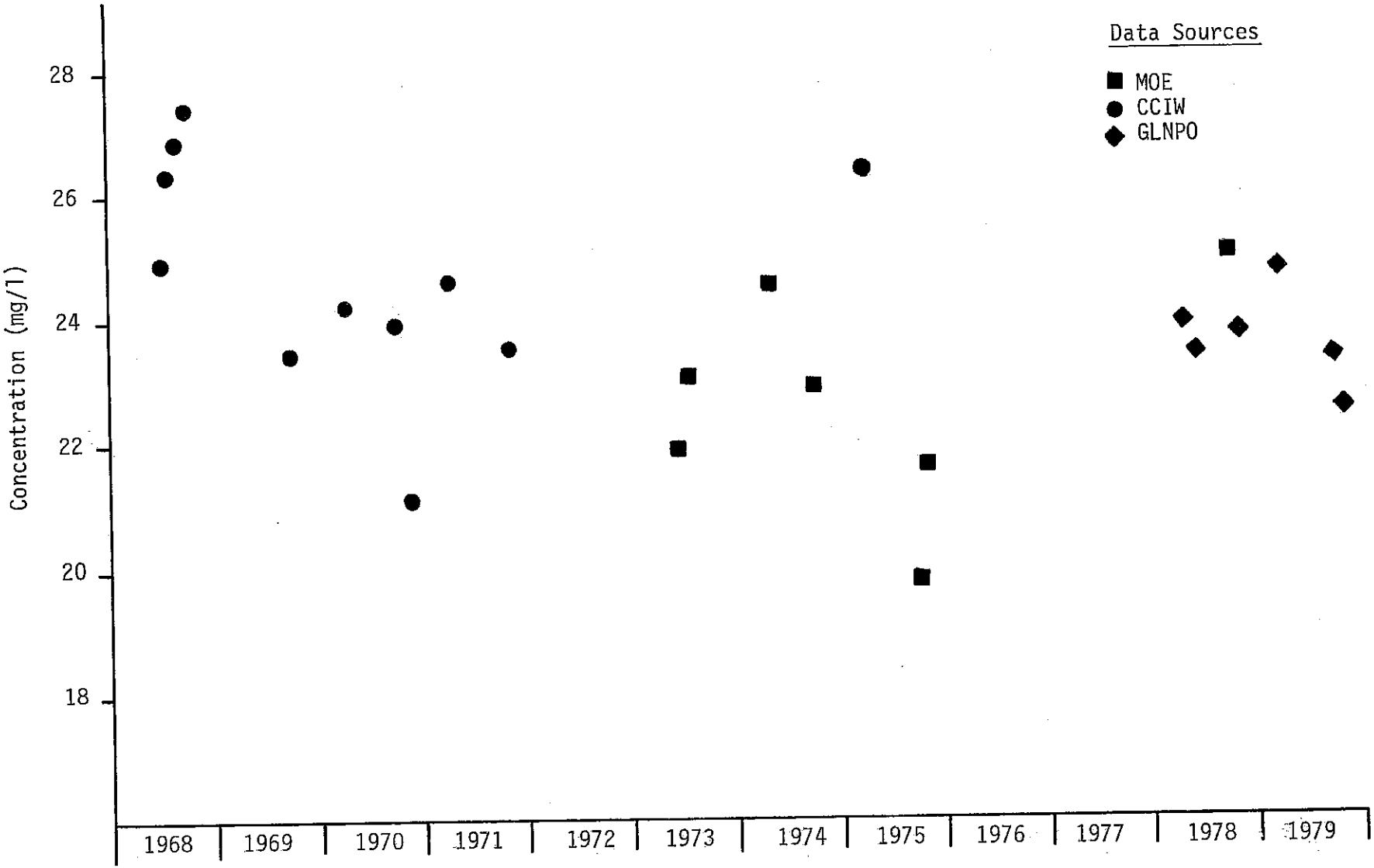

Figure 13. Sulfate concentrations in central Lake Erie 1968-1979.

APPENDIX

APPENDIX A

LAKE ERIE CRUISE SCHEDULES 1970-1980

Basin*	Year	Cruise	Date	Julian Date	Julian Mid Point
WB, CB, EB	1970 (CCIW)	1	April 7 - April 11	097 - 101	099
		2	May 6 - May 10	126 - 130	128
		3	June 2 - June 6	153 - 157	155
		4	July 3 - July 7	184 - 188	186
		5	July 28 - August 2	209 - 214	212
		6	August 25 - August 30	237 - 242	239
		7	September 23 - September 27	266 - 270	268
		8	October 21 - October 26	294 - 299	297
		9	November 25 - November 30	329 - 334	332
		10	December 14 - December 18	348 - 352	350
WB, CB	1973 (CLEAR)	1	June 28 - July 12	179 - 193	186
		2	July 17 - July 23	198 - 204	201
		3	July 25 - August 2	206 - 214	210
		4	August 7 - August 11	219 - 223	221
		5	August 29 - September 4	241 - 247	244
		6	September 19 - September 29	262 - 272	267
		7	October 14 - October 24	287 - 297	292
		8	November 7 - November 15	311 - 319	315
		9	December 4	338	338
EB	1973 (GLL)	1	June 11 - June 27	162 - 178	170
		2	July 4 - July 11	185 - 191	188
		3	July 11 - July 16	191 - 197	194
		4	July 31 - August 6	212 - 218	215
		5	August 15 - August 20	227 - 232	230
		6	September 11 - September 15	254 - 258	256
		7	October 1 - October 4	274 - 277	276
		8	October 8 - October 11	281 - 284	283
		9	October 22 - October 26	295 - 299	297
		10	December 8 - December 12	342 - 346	344
WB, CB	1974 (CLEAR)	1	April 7 - April 17	097 - 107	102
		2	April 25 - May 4	115 - 124	120
		3	May 14 - May 24	134 - 144	139
		4	June 1 - June 10	152 - 161	157
		5	June 28 - July 7	179 - 188	184
		6	July 26 - August 4	207 - 216	212
		7	August 12 - August 19	224 - 231	228
		8	August 26 - September 7	238 - 250	244
		9	September 24 - September 27	267 - 270	269
		10	October 21 - November 1	294 - 305	300
		11	December 11 - December 14	345 - 348	347

Basin*	Year	Cruise	Date	Julian Date	Julian Mid Point
EB	1974 (GLL)	1-3	Mechanical Failure		
		4	May 21 - June 1	141 - 152	147
		5	June 4 - June 7	155 - 158	157
		6	June 18 - June 22	169 - 173	171
		7	July 8 - July 11	189 - 192	191
		8	July 26 - July 30	207 - 211	209
		9	August 6 - August 9	218 - 221	220
		10	August 12 - August 16	224 - 228	226
		11	September 6 - September 9	249 - 252	251
		12	September 16 - September 21	259 - 264	262
		13	October 1 - October 9	274 - 282	278
		14	October 23 - October 27	296 - 300	298
		15	November 5 - November 11	309 - 315	312
		16	November 19 - December 5	323 - 339	331
WB, CB	1975 (CLEAR)	1	a. March 19 - March 31	078 - 090	084 > 099
		1	b. April 21 - April 25	111 - 115	113
		2	June 9 - June 19	160 - 170	165
		3	July 13 - July 21	194 - 202	198
		4	August 30 - September 7	243 - 250	247
		5	September 27 - October 6	270 - 279	274
		6	December 2 - December 10	336 - 344	340
EB	1975 (GLL)	1	April 9 - April 12	099 - 103	101
		2	June 2 - June 5	153 - 156	155
		3	July 25 - July 29	206 - 210	208
		4	September 15 - September 18	258 - 261	260
		5	December 1 - December 5	335 - 339	337
WB, CB	1976 (CLEAR)	1	March 22 - March 30	083 - 090	087
		2	June 2 - June 10	154 - 162	158
		3	August 21 - August 29	234 - 242	238
		4	September 8 - September 17	252 - 261	256
		5	October 18 - October 30	292 - 304	298
EB	1976 (GLL)	1	April 30 - May 2	121 - 123	122
		2	July 14 - July 21	196 - 203	200
		3	August 2 - August 6	215 - 219	217
		4	September 27 - October 2	271 - 276	273

Basin*	Year	Cruise	Date	Julian Date	Julian Mid Point
WB, CB, EB	1977 (CLEAR)	1	March 20 - March 31	080 - 093	086
		2	April 29 - May 8	119 - 128	124
		3	June 20 - June 30	171 - 181	176
		4	July 12 - July 22	193 - 203	198
		5	August 11 - August 21	223 - 233	228
		6	September 11 - October 8	254 - 281	267
		7	November 7 - November 20	311 - 324	317
WB, CB, EB	1978 (USEPA)	1	cancelled		
		2	May 18 - May 27	138 - 147	143
		3	June 5 - June 15	156 - 166	161
		4	June 23 - July 1	174 - 182	178
		5	July 19 - July 29	200 - 210	205
		6	August 8 - August 16	220 - 228	224
		7	August 29 - September 6	241 - 249	245
		8	October 3 - October 12	276 - 285	281
		9	October 24 - November 1	297 - 305	301
		10	November 10 - November 19	314 - 323	318
WB, CB, EB	1978 (CCIW)	103	May 29 - June 2	149 - 157	153
		104	June 19 - June 24	170 - 175	173
		106	July 13 - July 18	194 - 199	197
		110	August 19 - August 23	231 - 235	233
		111	September 13 - September 19	256 - 262	259
		114	September 30 - October 4	273 - 277	275
WB, CB, EB	1979 (USEPA)	W1	January 16 - January 18	016 - 018	017
		W2	February 27 - March 1	058 - 060	059
		W3	March 27 - March 29	086 - 088	087
		2	April 17 - April 20 (WB & WCB only)	107 - 110	109
		3	May 15 - May 26	135 - 146	141
		4	June 12 - June 21	163 - 172	167
		5	July 11 - July 19	192 - 200	196
		6	July 31 - August 4 (WB & WCB only)	212 - 216	214
		7	August 23 - September 4	235 - 247	241
		8	September 11 - September 21	254 - 264	259
		9	October 2 - October 14	275 - 287	281
		10	November 7 - November 16	311 - 320	316

Basin*	Year	Cruise	Date	Julian Date	Julian Mid Point
WB, CB	1980 (CLEAR)	1	April 1 - April 4	092 - 095	094
		2	April 28 - May 2 plus May 13	119 - 123 + 134	121
		3	May 27 - June 2	148 - 154	151
		4	June 29 - July 6	181 - 188	185
		5	July 28 - August 8	210 - 221	216
(CB only)		6	August 18 - August 23	231 - 236	234
WB, CB		7	August 28 - September 6	241 - 250	246
		8	September 27 - October 1	271 - 275	273
		9	October 27 - November 5	301 - 310	306
		10	November 23 - December 4	328 - 339	334

*WB--western basin; CB--central basin; EB--eastern basin.

APPENDIX B

LAKE ERIE WATER QUALITY--WESTERN BASIN 1970-1980

DATE	YEAR	CRUISE NO.	STRATIFICATION	LIMNION	VOLUME (km^3)	TOTAL PHOSPHORUS		SOLUBLE REACTIVE PHOSPHORUS		CORRECTED CHLOROPHYLL a	
						METRIC TONS	CONC. (µg/l)	METRIC TONS	CONC. (µg/l)	METRIC TONS	CONC. (µg/l)
4/7-4/11	1970	1	Unstratified	total	28.2	1678.0	59.48	453.7	16.09	166.4	5.9
5/6-5/11	(CCIW)	2	Unstratified	total	28.2	941.0	33.36	74.3	2.64	124.1	4.4
6/2-6/6		3	Unstratified	total	28.2	1048.0	37.16	292.9	10.39	166.4	5.9
7/3-7/7		4	Unstratified	total	28.2	1068.0	37.88	144.3	5.12	335.5	11.9
7/28-8/2		5	Unstratified	total	25.9	891.0	34.38	81.3	2.88	254.0	9.8
8/25-8/30		6	Unstratified	total	28.2	1352.0	47.96	23.6	0.84	544.1	19.3
9/23-9/27		7	Unstratified	total	28.2	1199.0	42.53	194.9	6.91	287.6	10.2
10/21-10/26		8	Unstratified	total	28.2	1218.0	43.18	226.4	8.03	220.0	7.8
11/25-11/30		9	Unstratified	total	28.2	1691.0	59.95	352.3	12.49	214.4	7.6
12/14-12/18		10	Unstratified	total	28.2	1422.0	50.44	243.9	8.65	93.0	3.3
7/17-7/23	1973	2	Unstratified	total	23.90	648.0	27.1	ND	ND	199.3	8.34
8/29-9/4	(CLEAR)	5	Unstratified	total	23.65	677.0	28.6	ND	ND	277.6	11.74
10/14-10/24		7	Unstratified	total	22.54	1091.0	48.4	ND	ND	269.4	11.99
4/25-5/4	1974	2	Unstratified	total	24.00	1056.0	44.0	ND	ND	210.0	8.75
6/1-6/10	(CLEAR)	4	Unstratified	total	24.11	746.0	31.0	ND	ND	241.7	10.03
6/28-7/7		5	Unstratified	total	23.95	734.0	30.6	166.0	6.90	395.1	16.50
8/12-8/19		7	Unstratified	total	23.53	855.0	36.3	79.4	3.40	403.2	17.14
8/26-9/7		8	Unstratified	total	23.45	1075.0	45.9	250.0	10.70	316.1	13.48
10/21-11/1		10	Unstratified	total	22.62	517.0	22.9	23.2	1.00	331.4	14.65
3/19-3/31	1975	1	Unstratified	total	23.64	1338.0	56.61	215.0	9.10	244.5	10.34
4/21-4/25	(CLEAR)	2	Unstratified	total	23.50	760.0	32.40	147.0	6.20	495.1	21.07
6/9-6/19		3	Unstratified	total	23.35	1085.0	46.50	293.0	12.60	410.8	17.59
7/13-7/21		4	Unstratified	total	23.35	893.0	38.20	109.0	4.70	380.9	16.31
8/30-9/7		5	Unstratified	total	23.07	997.0	43.20	248.0	10.80	284.6	12.34
9/27-10/6		6	Unstratified	total	22.54	835.0	37.00	181.0	8.00	105.0	4.66
12/2-12/10											
3/22-3/30	1976	1	Unstratified	total	23.62	1582.0	66.99	243.6	10.31	207.0	8.75
6/2-6/10	(CLEAR)	2	Unstratified	total	23.62	696.0	29.48	84.6	3.58	152.0	6.44
8/21-8/29		3	Unstratified	total	23.30	886.0	38.01	82.4	3.54	365.0	15.66
9/8-9/17		4	Unstratified	total	23.01	1212.0	52.70	118.2	5.14	389.0	16.90
10/18-10/30		5	Unstratified	total	22.43	832.0	37.08	97.5	4.35	323.0	14.40
3/21-4/3	1977	1	Unstratified	total	22.16	773.0	34.89	142.0	6.39	144.7	6.53
4/28-5/8	(CLEAR)	2	Unstratified	total	ND	ND	ND	ND	ND	ND	ND
6/20-6/30		3	Unstratified	total	ND	ND	ND	ND	ND	ND	ND
7/12-7/31		4	Unstratified	total	ND	ND	ND	ND	ND	ND	ND
8/11-8/21		5	Unstratified	total	ND	ND	ND	ND	ND	ND	ND
9/10-10/9		6	Unstratified	total	22.57	1204.0	53.32	189.0	8.35		
11/7-11/20		7	Unstratified	total	22.48	762.0	33.91	130.0	5.77	339.4	15.10
5/18-5/27	1978	2	Unstratified	total	25.09	335.5	13.19	36.4	1.45	243.4	9.57
6/5-6/15	(USEPA)	3	Unstratified	total	25.07	433.3	17.27	75.5	3.01	129.6	5.16
6/23-7/1		4	Unstratified	total	25.10	654.3	26.06	96.6	3.85	326.2	13.06
7/19-7/29		5	Unstratified	total	24.40	ND	ND	176.6	7.24	422.0	17.29
8/8-8/16		6	Unstratified	total	24.33	ND	ND	38.6	1.59	434.6	17.76
8/29-9/6		7	Unstratified	total	24.14	ND	ND	43.9	1.82	369.1	15.26
10/3-10/12		8	Unstratified	total	23.85	ND	ND	145.8	6.11	ND	ND
10/24-11/1		9	Unstratified	total	23.80	ND	ND	38.4	1.61	302.3	12.65
11/10-11/19		10	Unstratified	total	23.89	532.6	22.29	66.1	2.77	219.7	9.21
4/17-4/20	1979	2	Unstratified	total	24.80	2427.9	98.02	149.5	6.03	113.3	4.58
5/15-5/26	(USEPA)	3	Unstratified	total	24.99	476.3	19.06	61.3	2.45	245.1	9.84
6/12-6/21		4	Unstratified	total	24.76	480.1	19.39	ND	ND	ND	ND
7/11-7/19		5	Unstratified	total	25.02	463.7	18.48	70.3	2.81	197.5	7.89
7/31-8/4		6	Unstratified	total	25.07	671.4	26.73	53.6	2.13	392.3	15.65
8/23-9/4		7	Unstratified	total	25.11	779.4	31.03	39.8	1.59	ND	ND
9/11-9/21		8	Unstratified	total	24.75	871.6	35.15	65.6	2.66	432.9	17.49
10/2-10/14		9	Unstratified	total	24.42	594.2	24.32	41.0	1.68	274.4	11.24
11/7-11/16		10	Unstratified	total	24.19	790.4	32.67	51.6	2.13	330.9	13.68
4/1-4/2	1980	1	Unstratified	total	25.4	959.1	37.72	180.8	7.11	107.0	4.21
4/28-4/30	(CLEAR)	2	Unstratified	total	25.4	711.3	27.98	93.4	3.67	204.1	8.03
5/27-5/29		3	Unstratified	total	25.4	449.9	17.69	59.9	2.36	156.3	6.15
6/29-6/30		4	Unstratified	total	25.4	753.5	29.65	118.4	4.66	144.4	5.68
7/28		5	Unstratified	total	25.41	565.9	22.27	70.8	2.81	271.5	10.75
ND		6	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/28-8/29		7	Unstratified	total	24.9	756.1	30.29	56.1	2.11	310.6	12.44
9/27-9/28		8	Unstratified	total	25.1	952.1	37.91	51.8	2.08	320.9	12.78
11/5		9	Unstratified	total	24.2	726.1	30.01	62.9	2.59	220.7	9.12
11/23		10	Unstratified	total	24.2	611.3	25.27	43.3	1.79	143.1	5.92

APPENDIX C

LAKE ERIE WATER QUALITY--CENTRAL BASIN 1970-1980

DATE	YEAR	CRUISE NO.	STRATIFICATION	LIMNION	VOLUME (km^3)	TOTAL PHOSPHORUS		SOLUBLE REACTIVE PHOSPHORUS		CORRECTED CHLOROPHYLL	
						METRIC TONS	CONC. (µg/l)	METRIC TONS	CONC. (µg/l)	METRIC TONS	CONC. (µg/l)
4/7-4/11	1970 CCIW	1	Unstratified	total	274.4	4611.0	16.80	655.0	2.39	1459.9*	5.3
5/6-5/11		2	Unstratified	total	274.4	5852.0	21.33	442.3	1.61	793.4	2.9
6/2-6/6		3	Stratified	epi	229.0	4714.0	20.58	440.1	1.92		
				meso	19.5	351.0	17.98	33.3	1.71		
				hypo	25.9	463.0	17.86	59.4	2.29		
				total	274.4	5528.0	20.15	532.8	1.95	697.8	2.7
7/3-7/7		4	Stratified	epi	213.8	3188.0	14.91	424.2	1.98		
				meso	19.9	270.0	13.55	38.3	1.92		
				hypo	40.8	726.0	17.79	142.9	3.50		
				total	274.5	4184.0	15.24	605.4	2.23	688.6	2.5
7/28-8/2		5	Stratified	epi	220.4	2542.0	11.53	191.3	0.87		
				meso	23.6	271.0	11.47	17.6	0.74		
				hypo	30.5	357.0	11.69	38.9	1.27		
				total	274.5	3170.0	11.55	247.8	0.90	879.9	3.7
8/25-8/30		6	Stratified	epi	222.0	2560.0	11.53	240.9	1.09		
				meso	20.0	306.0	15.28	71.9	3.60		
				hypo	32.5	844.0	25.98	281.1	8.65		
				total	274.5	3710.0	13.52	593.9	2.23	1141.1	4.1
9/23-9/27		7	Stratified	epi	260.0	4151.0	15.97	443.3	1.71		
				meso	7.6	321.0	42.16	106.7	14.04		
				hypo	6.9	761.0	110.30	407.3	59.02		
				total	274.5	5233.0	19.06	957.3	3.41	2545.9	9.2
10/21-10/26		8	Unstratified	total	274.4	5351.0	19.50	1063.3	3.88	822.0	3.0
11/25-11/30		9	Unstratified	total	274.4	8719.0	31.78	1922.5	7.00	1474.6	5.4
12/14-12/18		10	Unstratified	total	274.4	9876.0	35.99	1607.7	5.86	1563.1	5.7
7/17-7/23	1973 CLEAR	2	Stratified	epi	228.63	3221.4	14.09	-	-	535.2	2.34
				meso	22.22	349.8	15.62	-	-	64.0	2.86
				hypo	61.31	894.4	14.57	-	-	152.2	2.48
				total	312.16	4465.6	14.31	-	-	751.4	2.41
8/29-9/4		5	Stratified	epi	238.20	3484.6	14.63	-	-	885.0	3.72
				meso	24.86	342.3	13.77	-	-	75.9	3.05
				hypo	47.07	1003.0	21.31	-	-	129.4	2.75
				total	310.13	4829.9	15.57	-	-	1090.3	3.52
10/14-10/24		7	Unstratified	total	306.09	7839.9	25.61	-	-	2409.1	7.87
4/25-5/4	1974 CLEAR	2	Unstratified	total	311.94	5247.2	16.82	-	-	1082.7	3.50
6/1-6/10		4	Stratified	epi	195.82	2635.5	13.46	-	-	458.1	2.34
				meso	22.74	431.6	18.98	-	-	58.3	2.56
				hypo	93.67	1962.4	20.95	-	-	233.2	2.49
				total	312.23	5029.5	16.11	-	-	749.6	2.40
6/28-7/7		5	Stratified	epi	249.10	3362.9	13.50	269.0	1.10	641.8	2.58
				meso	12.52	203.9	16.29	27.8	2.20	18.3	1.46
				hypo	50.12	961.3	19.18	140.2	2.79	92.2	1.84
				total	311.74	4528.1	14.53	437.0	1.40	752.3	2.41
8/12-8/19		7	Stratified	epi	235.35	3058.2	12.99	247.5	1.05	985.2	4.19
				meso	23.83	282.4	11.85	41.7	1.75	72.8	3.05
				hypo	50.63	864.2	17.07	170.7	3.37	127.0	2.51
				total	309.81	4204.8	13.57	459.9	1.48	1185.0	3.82
8/26-9/7		8	Stratified	epi	243.01	4534.9	18.66	395.2	1.63	1036.0	4.26
				meso	17.45	296.4	16.98	109.1	6.25	41.6	2.38
				hypo	48.38	1378.2	28.49	743.1	15.36	85.2	1.76
				total	308.84	6209.5	20.11	1247.4	4.04	1162.8	3.76
10/21-11/1		10	Unstratified	total	303.97	6046.2	19.89	629.0	2.07	2871.4	9.40

DATE	YEAR	CRUISE NO.	STRATIFICATION	LIMNION	VOLUME (km^3)	TOTAL PHOSPHORUS		SOLUBLE REACTIVE PHOSPHORUS		CORRECTED CHLOROPHYLL	
						METRIC TONS	CONC. (µg/l)	METRIC TONS	CONC. (µg/l)	METRIC TONS	CONC. (µg/l)
3/19-3/31	1975 CLEAR	1	Unstratified	total	308.69	7100.9	23.00	568.0	1.80	1571.0	5.10
4/21-4/25											
6/9-6/19		2	Stratified	epi	174.03	2421.4	13.91	457.2	2.63	395.1	2.27
				meso	30.76	469.3	15.26	70.9	2.31	81.5	2.65
				hypo	104.70	1638.3	15.65	242.0	2.31	362.8	3.47
				total	309.49	4529.0	14.63	770.1	2.49	839.4	2.71
7/13-7/21		3	Stratified	epi	182.64	2357.0	12.91	288.9	1.58	482.7	2.64
				meso	35.56	637.7	17.94	66.3	1.86	121.3	3.41
				hypo	90.49	1919.8	21.22	209.0	2.31	351.8	3.89
				total	308.69	4914.5	15.92	564.2	1.83	955.8	3.10
8/30-9/7		4	Stratified	epi	227.39	3488.5	15.34	632.1	2.78	1894.4	8.33
				meso	15.23	215.9	14.17	40.1	2.63	109.0	7.16
				hypo	66.07	1183.6	17.91	273.0	4.13	381.0	5.77
				total	308.69	4888.0	15.83	945.2	3.06	2384.4	7.72
9/27-10/6		5	Unstratified	total	307.06	6134.2	19.98	812.4	2.65	3086.3	10.05
12/2-12/10		6	Unstratified	total	303.96	9623.0	31.66	2480.6	8.16	2103.3	6.92
3/22-3/30	1976 CLEAR	1	Unstratified	total	309.83	6644.8	21.45	561.8	1.81	1311.5	4.23
6/2-6/10		2	Stratified	epi	216.92	3590.8	16.55	356.2	1.64	501.5	2.31
				meso	13.19	206.3	15.64	17.4	1.32	36.3	2.75
				hypo	80.07	1311.4	16.38	115.9	1.45	250.2	3.12
				total	310.18	5108.5	16.47	489.5	1.58	788.0	2.54
8/21-8/29		3	Stratified	epi	249.94	3807.6	15.23	1956.6	7.83	1115.4	4.46
				meso	23.81	516.9	21.71	256.3	10.77	98.1	4.12
				hypo	34.57	1521.0	44.00	1505.4	43.55	110.7	3.20
				total	308.32	5845.5	18.96	3718.3	12.06	1324.2	4.29
9/8-9/17		4	Stratified	epi	291.19	8267.9	28.39	1094.2	3.76	1996.9	6.86
				meso	8.72	202.2	23.19	37.2	4.26	43.3	4.96
				hypo	6.85	373.4	54.51	140.3	20.49	12.0	1.76
				total	306.76	8843.5	28.83	1271.7	4.15	2052.2	6.69
10/18-10/30		5	Unstratified	total	303.34	8108.0	26.73	1780.4	5.87	2590.1	8.54
3/20-3/31	1977 CLEAR	1	Unstratified	total	302.20	3988.1	13.20	294.6	0.97	1045.0	3.46
4/29-5/8		2	Unstratified	total	306.08	3747.7	12.24	450.0	1.47	986.8	3.22
6/20-6/30		3	Stratified	epi	178.79	5090.5	28.47	564.4	3.16	463.8	2.59
				meso	35.24	805.2	22.85	84.3	2.39	73.6	2.09
				hypo	89.91	2433.1	27.06	272.2	3.03	155.8	1.73
				total	303.94	8328.8	27.40	920.9	3.03	693.2	2.28
7/12-7/22		4	Stratified	epi	219.21	5759.0	26.27	825.9	3.77	762.3	3.48
				meso	25.45	591.7	23.25	86.4	3.39	82.2	3.29
				hypo	59.82	1792.9	29.97	196.8	3.29	156.0	2.61
				total	304.48	8143.6	26.75	1109.1	3.64	1000.4	3.28
8/11-8/21		5	Stratified	epi	256.94	7361.7	28.65	741.4	2.89	1544.0	6.01
				meso	11.59	423.2	36.52	55.4	4.78	71.5	6.17
				hypo	35.44	1182.0	33.35	314.3	8.87	168.5	4.75
				total	303.97	8966.9	29.50	1111.1	3.66	1784.0	5.87
9/11-10/8		6	Stratified	epi	298.34	9509.8	31.88	2069.6	6.94	1787.5	5.99
				meso	2.25	184.4	81.94	53.4	23.73	19.6	8.7
				hypo	3.89	388.7	99.91	134.5	34.58	20.5	5.3
				total	304.48	10082.9	33.12	2257.5	7.41	1828.6	6.0
11/7-11/20		7	Unstratified	total	300.45	7912.2	26.33	3094.9	10.30	1131.8	3.77

DATE	YEAR	CRUISE NO.	STRATIFICATION	LIMNION	VOLUME (km^3)	TOTAL PHOSPHORUS		SOLUBLE REACTIVE PHOSPHORUS		CORRECTED CHLOROPHYLL	
						METRIC TONS	CONC. (µg/l)	METRIC TONS	CONC. (µg/l)	METRIC TONS	CONC. (µg/l)
5/18-5/27	1978 USEPA	2	Unstratified	total	315.93	3040.0	9.60	524.8	1.66	2590.7	8.17
6/5-6/15		3	Stratified	total	305.47	2314.9	7.54	255.4	0.83	1630.4	5.32
6/23-7/1		4	Stratified	epi	129.97	975.5	7.51	277.5	2.13	215.3	1.65
				meso	105.30	969.8	9.19	182.5	1.73	295.8	2.80
				hypo	79.76	789.6	9.91	140.0	1.75	385.2	4.83
				total	315.03	2734.9	8.68	600.0	1.90	896.3	2.85
7/19-7/29		5	Stratified	epi	118.54	ND	ND	294.9	2.49	444.2	3.75
				meso	93.14	ND	ND	419.2	4.50	242.2	2.60
				hypo	100.30	ND	ND	171.6	1.71	342.4	3.41
				total	311.98	ND	ND	885.7	2.84	1028.8	3.30
8/8-8/16		6	Stratified	epi	172.07	912.2	5.31	300.7	1.75	582.3	3.38
				meso	69.66	384.8	5.52	112.3	1.61	387.8	5.55
				hypo	69.66	720.1	10.35	113.1	1.62	298.0	4.27
				total	311.39	2017.0	6.48	526.1	1.69	1268.1	4.07
8/29-9/6		7	Stratified	epi	201.96	ND	ND	347.9	1.72	706.8	3.49
				meso	56.71	ND	ND	79.7	1.41	197.3	3.48
				hypo	51.62	ND	ND	54.2	1.05	269.8	5.22
				total	310.29	ND	ND	481.8	1.55	1173.9	3.78
10/3-10/12		8	Unstratified	total	308.81	ND	ND	731.4	2.37	ND	ND
10/24-11/1		9	Unstratified	total	308.81	ND	ND	620.1	2.01	2562.9	8.29
11/10-11/19		10	Unstratified	total	299.54	2968.4	9.88	617.5	2.06	1649.1	5.49
5/29-6/2	1978 CCIW	103	Stratified	epi	93.8	1245.2	13.3				
				meso	101.2	1479.6	14.6				
				hypo	121.9	1754.5	14.4				
				total	316.9	4479.3	14.1				
6/19-6/24		104	Stratified	epi	179.5	1975.9	11.0				
				meso	69.9	913.5	13.0				
				hypo	65.9	904.4	13.7				
				total	315.3	3793.8	12.0				
7/13-7/18		106	Stratified	epi	191.6	2281.8	11.9				
				meso	59.4	915.3	15.3				
				hypo	61.0	1146.1	18.8				
				total	312.0	4343.2	13.9				
8/19-8/23		110	Stratified	epi	220.7	2847.5	12.8				
				meso	37.5	686.9	18.3				
				hypo	53.8	1095.6	20.3				
				total	312.0	4630.0	14.8				
9/13-9/19		111	Stratified	epi	266.9	3752.2	14.2				
				meso	18.2	304.6	16.7				
				hypo	24.7	412.6	16.6				
				total	309.8	4469.4	14.4				
9/30-10/4		114	Stratified	epi	280.3	4254.5	15.1				
				meso	16.4	331.9	20.2				
				hypo	12.1	257.7	21.3				
				total	308.8	4844.1	15.7				
4/17-4/20	1979 USEPA	2	Unstratified	total	313.30	5758.2	18.36	508.5	1.62	1410.2	4.49
5/15-5/26		3	Stratified	epi	193.68	2192.1	11.32	321.9	1.66	852.3	4.40
				meso	43.27	515.9	11.91	63.3	1.46	171.6	3.96
				hypo	78.15	1038.4	13.27	135.8	1.73	336.5	4.31
				total	315.10	3746.4	11.89	521.0	1.65	1360.4	4.32
6/12-6/21		4	Stratified	epi	253.2	2652.8	10.48				
				meso	24.1	245.6	10.17				
				hypo	37.9	480.7	12.68	ND	ND	ND	ND
				total	315.20	3379.1	10.72				
7/11-7/19		5	Stratified	epi	232.92	2445.5	10.46	311.9	1.34	613.9	2.63
				meso	32.04	259.8	8.09	48.9	1.53	68.8	2.15
				hypo	49.23	424.6	8.59	110.8	2.25	105.1	2.13
				total	314.19	3129.9	9.96	471.6	1.50	787.8	2.51

DATE	YEAR	CRUISE NO.	STRATIFICATION	LIMNION	VOLUME (km^3)	TOTAL PHOSPHORUS		SOLUBLE REACTIVE PHOSPHORUS		CORRECTED CHLOROPHYLL	
						METRIC TONS	CONC. (ug/l)	METRIC TONS	CONC. (ug/l)	METRIC TONS	CONC. (ug/l)
7/31-8/4	1979 USEPA	6	Stratified	epi	219.16	3085.5	14.07	249.1	1.14	1253.5	5.72
				meso	30.32	327.4	10.79	49.2	1.62	124.7	4.11
				hypo	65.55	720.4	10.97	144.1	2.19	254.9	3.89
				total	315.03	4133.3	13.12	442.4	1.40	1633.1	5.18
8/23-9/4		7	Stratified	epi	ND	ND	ND	ND	ND	ND	ND
				meso							
				hypo							
				total							
9/11-9/21		8	Stratified	epi	272.91	3610.3	13.22	468.2	1.72	1464.7	5.37
				meso	16.87	209.2	12.38	50.7	2.99	56.7	3.36
				hypo	23.46	488.2	20.75	159.4	6.78	67.0	2.86
				total	313.24	4307.7	13.75	678.3	2.17	1588.4	5.07
10/2-10/14		9	Unstratified	total	303.29	4394.8	14.49	821.4	2.71	1794.7	5.92
11/7-11/16		10	Unstratified	total	301.63	4546.7	15.06	1064.4	3.53	2387.8	7.92
4/3-4/4	1980 CLEAR	1	Unstratified	total	308.3	5462.8	17.72	621.4	2.01	716.4	2.32
5/1-5/13		2	Unstratified	total	308.3	3798.6	12.32	368.5	1.19	1009.9	3.28
5/31-6/2		3	Stratified	epi	233.9	886.2	3.79	301.0	1.29	416.6	1.78
				meso	18.8	68.2	3.63	23.9	1.27	30.8	1.64
				hypo	55.5	285.0	5.13	91.5	1.65	91.0	1.64
				total	308.2	1239.4	4.02	416.4	1.35	538.4	1.75
7/2-7/6		4	Stratified	epi	203.4	1330.7	6.54	429.0	2.11	328.1	1.61
				meso	23.5	193.4	8.23	57.2	2.43	32.2	1.37
				hypo	81.4	868.7	10.67	261.5	3.21	107.2	1.32
				total	308.3	2392.8	7.76	747.7	2.43	467.5	1.52
8/4-8/8		5	Stratified	epi	201.4	846.6	4.20	266.1	1.32	561.7	2.79
				meso	34.0	237.3	6.98	45.9	1.35	91.7	2.69
				hypo	72.9	644.8	8.84	172.6	2.37	181.6	2.49
				total	308.3	1728.7	5.61	484.6	1.57	835.0	2.71
8/18-8/23		6	Stratified	epi	229.7	2765.1	12.04	319.7	1.39	955.6	4.16
				meso	22.1	280.3	12.66	34.6	1.56	74.5	3.37
				hypo	65.1	843.4	12.95	142.6	2.19	113.8	2.13
				total	316.9	3888.8	12.27	496.9	1.57	1143.9	3.61
9/3-9/6		7	Stratified	epi	215.9	2585.5		327.5	1.52	832.3	3.85
				meso	22.5	231.0	9.99	35.1	1.56	64.2	2.86
				hypo	68.3	735.9	10.41	134.3	1.97	101.6	1.49
				total	306.7	3522.4	11.27	496.9	1.62	998.1	3.25
9/29-10/1		8	Unstratified	total	306.7	6168.3	20.10	839.5	2.74	1202.4	3.92
10/27-10/29		9	Unstratified	total	301.9	6990.8	23.15	1081.4	3.58	1257.1	4.16
12/1-12/4		10	Unstratified	total	301.9	6859.2	22.72	1047.3	3.47	1387.1	4.59

*1970 Chlorophyll a quantities estimated by multiplying concentration x total volume.

APPENDIX D

LAKE ERIE WATER QUALITY--EASTERN BASIN 1970-1980

DATE	YEAR	CRUISE NO.	STRATIFICATION	LIMNION	VOLUME (km^3)	TOTAL PHOSPHORUS		SOLUBLE REACTIVE PHOSPHORUS		CORRECTED CHLOROPHYLL a	
						METRIC TONS	CONC. (µg/l)	METRIC TONS	CONC. (µg/l)	METRIC TONS	CONC. (µg/l)
4/7-4/11	1970	1	Unstratified	total	166.4	5143.0	30.90	629.3	3.78	682.4	4.1
5/6-5/11	(CCIW)	2	Unstratified	total	166.4	2770.0	16.65	438.5	2.64	582.4	3.5
6/2-6/6		3	Stratified	epi	50.8	1296.0	25.51	70.9	1.40		
				meso	32.0	658.0	20.55	47.6	1.49		
				hypo	83.5	1142.0	13.61	108.7	1.30		
				total	166.3	3096.0	18.62	227.2	1.37	898.0	5.4
7/3-7/7		4	Stratified	epi	90.9	1344.0	14.79	208.5	2.29		
				meso	21.2	279.0	13.14	58.5	2.76		
				hypo	54.2	729.0	13.45	247.0	4.56		
				total	166.3	2352.0	14.14	514.0	3.09	249.5	1.5
7/28-8/2		5	Stratified	epi	89.5	1243.0	13.89	105.4	1.18		
				meso	42.2	455.0	10.79	126.9	3.01		
				hypo	34.6	430.0	12.43	154.5	4.46		
				total	166.3	2128.0	12.80	386.8	2.33	731.7	4.4
8/25-8/30		6	Stratified	epi	98.9	923.0	9.33	82.8	0.84		
				meso	30.7	232.0	7.56	40.9	1.33		
				hypo	36.8	308.0	8.37	100.4	2.73		
				total	166.4	1463.0	8.79	224.1	1.35	449.3	2.7
9/23-9/27		7	Stratified	epi	131.6	1452.0	11.04	212.1	1.61		
				meso	6.2	61.0	9.86	21.1	3.41		
				hypo	28.5	348.0	12.21	155.5	5.46		
				total	166.3	1861.0	11.19	388.7	2.34	781.6	4.7
10/21-10/26		8	Stratified	epi	149.6	1999.0	13.36	607.5	4.06		
				meso	6.1	67.0	10.97	25.9	4.25		
				hypo	10.6	126.0	11.90	63.1	5.95		
				total	166.3	2192.0	13.18	696.5	4.19	232.8	1.4
11/25-11/30		9	Unstratified	total	166.3	3784.0	22.75	995.0	5.98	449.0	2.7
12/14-12/18		10	Unstratified	total	166.3	4279.0	25.73	1165.1	7.01	432.4	2.6
Summer	1973			total			47.0		ND		ND
7/4-7/11	(GLL)	2									2.75
7/31-8/6		4		total			15.1		ND		4.74
Fall											ND
10/1-10/4		7									6.59
10/8-10/11		8									6.40
Annual				total			30.6		ND		4.90
Spring	1974			total			21.5		ND		7.11
5/21-6/1	(GLL)	4									
Summer				total			27.3		ND		ND
6/18-6/22		6									4.97
7/26-7/30		8									3.33
Fall				total			13.6		ND		ND
9/6-9/9		11									4.25
10/23-10/27		14									7.14
11/19-12/5		16									3.91
Annual	1974 (GLL)			total			22.3		ND		5.11
Spring	1975	1		total			38.1		ND		3.24
4/9-4/12	(GLL)										
Summer				total			23.8		ND		ND
6/2-6/5		2									2.46
7/25-7/29		3									2.98
Fall				total			20.9		ND		ND
9/15-9/18		4									5.88
12/7-12/21		5									3.63
Annual				total			25.2		ND		3.66
3/21-4/3	1977	1	Unstratified	total	ND	ND	ND	ND	ND	ND	ND
	(CLEAR)										
4/28-5/8		2	Unstratified	total	169.16	2192.8	12.96	295.9	1.75	362.5	2.14
6/20-6/30		3	Stratified	epi	99.57	1888.3	18.96	232.5	2.34	246.3	2.47
				meso	14.33	246.7	17.22	27.0	1.89	28.2	1.97
				hypo	54.76	950.4	17.36	149.8	2.73	73.4	1.34
				total	168.66	3085.4	18.29	409.3	2.43	347.9	2.06
7/12-7/31		4	Stratified	epi	84.50	ND	ND	ND	ND	227.79	2.70
				meso	35.67					60.26	1.56
				hypo	48.02					53.07	1.11
				total	168.19					341.12	2.00
8/11-8/21		5	Stratified	epi	114.20	ND	ND	ND	ND	561.37	4.92
				meso	18.25					67.75	3.71
				hypo	36.40					61.84	1.70
				total	168.85					690.96	4.09

DATE	YEAR	CRUISE NO.	STRATIFICATION	LIMNION	VOLUME (km^3)	TOTAL PHOSPHORUS		SOLUBLE REACTIVE PHOSPHORUS		CORRECTED CHLOROPHYLL a	
						METRIC TONS	CONC. (µg/l)	METRIC TONS	CONC. (µg/l)	METRIC TONS	CONC. (µg/l)
9/10-10/9	1977	6	Stratified	epi	142.97	2719.0	19.02	661.7	4.63	700.97	4.90
				meso	2.43	48.6	19.98	13.4	5.53	5.92	2.44
				hypo	23.29	456.9	19.62	194.0	8.33	35.87	1.54
				total	168.69	3224.5	19.11	869.11	5.15	742.76	4.40
11/7-11/20		7	Unstratified	total	167.68	3844.7	22.93	873.8	5.21	548.5	3.27
5/18-5/27	1978 (USEPA)	2	Unstratified	total	160.28	1701.7	10.57	746.0	4.65	860.7	5.35
6/5-6/15		3	Stratified	total	159.07	1330.2	8.29	253.6	1.59	660.7	4.12
6/23-7/1		4	Stratified	epi	48.50	399.8	8.23	83.7	1.73	102.2	2.10
				meso	43.15	384.0	8.89	70.1	1.62	152.5	3.54
				hypo	68.51	634.6	9.26	164.9	2.40	146.9	2.14
				total	160.16	1418.4	8.86	318.7	1.99	401.6	2.51
7/19-7/29		5	Stratified	epi	63.62	ND	ND	79.9	1.25	210.6	3.30
				meso	41.64			59.6	1.43	71.8	1.72
				hypo	53.81			70.5	1.31	116.3	2.16
				total	159.07			210.0	1.32	398.7	2.51
8/8-8/16		6	Stratified	epi	85.35	821.2	9.58	93.1	1.09	178.3	2.08
				meso	28.65	242.6	8.54	31.6	1.10	52.9	1.81
				hypo	44.15	575.6	13.21	44.8	1.01	44.5	1.01
				total	158.15	1639.4	10.37	169.5	1.07	275.7	1.74
8/29-9/6		7	Stratified	epi	84.57	ND	ND	74.4	0.88	197.0	2.32
				meso	25.92			34.6	1.33	49.9	1.92
				hypo	47.49			51.7	1.09	38.3	0.81
				total	157.98			160.7	1.02	285.2	1.81
10/3-10/12		8	Unstratified	total	157.92	ND	ND	196.9	1.24	ND	ND
10/24-11/1		9	Unstratified	total	158.05	ND	ND	245.6	1.55	580.8	3.67
11/10-11/19		10	Unstratified	total	157.58	603.4	3.81	242.1	1.54	592.8	3.75
5/29-6/2	1978 (CCIW)	103	Stratified	epi	15.6	234.4	15.1				
				meso	92.6	1578.2	17.0				
				hypo	52.8	840.5	15.9				
				total	161.0	2653.1	16.5				
6/19-6/24		104	Stratified	epi	67.6	998.4	14.7				
				meso	42.0	571.6	13.6				
				hypo	50.7	726.3	14.3				
				total	160.3	2296.3	14.3				
7/13-7/18		106	Stratified	epi	68.7	863.5	12.5				
				meso	44.6	635.9	14.2				
				hypo	45.9	744.7	16.2				
				total	159.2	2244.1	14.1				
8/19-8/23		110	Stratified	epi	94.6	1177.5	12.4				
				meso	29.1	384.3	13.2				
				hypo	35.6	527.9	14.8				
				total	159.3	2089.7	13.1				
9/13-9/19		111	Stratified	epi	105.8	1110.0	10.5				
				meso	16.8	166.7	9.9				
				hypo	34.1	347.7	10.2				
				total	156.7	1624.4	10.4				
9/30-10/4		114	Stratified	epi	109.4	1103.7	10.1				
				meso	17.6	159.6	9.0				
				hypo	31.2	302.1	9.7				
				total	158.2	1565.4	9.9				
	1979 (USEPA)	2	Unstratified	total	ND	ND	ND	ND	ND	ND	ND
5/15-5/26		3	Stratified	epi	126.61	2340.2	18.47	323.2	2.55	408.0	3.22
				meso	8.91	147.2	16.47	19.7	2.21	34.8	3.89
				hypo	24.68	490.6	19.80	35.6	1.44	64.5	2.60
				total	160.20	2978.0	18.59	378.5	2.36	507.3	3.17
6/12-6/21		4	Stratified	epi							
				meso							
				hypo							
				total	160.4						
7/11-7/19		5	Stratified	epi	87.94	799.7	9.09	205.4	2.33	167.0	1.92
				meso	23.61	193.7	8.21	60.5	2.56	20.2	0.86
				hypo	48.62	457.9	9.42	162.8	3.35	38.2	0.79
				total	160.17	1451.3	9.06	428.7	2.68	225.4	1.41
7/31-8/4		6	Stratified	epi	ND	ND	ND	ND	ND	ND	ND
				meso							
				hypo							
				total							
8/23-9/4		7	Stratified	epi	ND	ND	ND	ND	ND	ND	ND
				meso							
				hypo							
				total							

DATE	YEAR	CRUISE NO.	STRATIFICATION	LIMNION	VOLUME (km^3)	TOTAL PHOSPHORUS		SOLUBLE REACTIVE PHOSPHORUS		CORRECTED CHLOROPHYLL a	
						METRIC TONS	CONC. (µg/l)	METRIC TONS	CONC. (µg/l)	METRIC TONS	CONC. (µg/l)
9/11-9/21	1979	8	Stratified	epi	109.09	610.6	5.61	108.3	1.00	312.0	2.86
				meso	18.38	77.1	4.16	29.2	1.59	46.5	2.53
				hypo	32.19	142.7	4.52	83.3	2.61	43.1	1.34
				total	159.66	830.4	5.20	220.8	1.38	401.6	2.52
10/2-10/14		9	Stratified	epi	129.03	957.4	7.42	226.5	1.75	333.6	2.59
				meso	12.99	79.0	5.94	27.3	2.10	26.1	2.01
				hypo	17.15	117.9	7.19	34.1	1.99	22.0	1.28
				total	159.17	1154.3	7.25	287.9	1.81	381.7	2.40
11/7-11/16		10	Stratified	total	158.64	2203.4	13.89	524.0	3.30	621.4	3.92

APPENDIX E

LAKE ERIE STRATIFICATION CHARACTERISTICS--WESTERN BASIN 1970-1980

DATE	YEAR	CRUISE	STRATIF.	LIMNION	VOL. km^3	AREA km^2	THICKNESS m
4/7-4/11	1970	1	unstratified	total	28.2	2840	9.93
5/6-5/11	(CCIW)	2	unstratified	total	28.2	2840	9.93
6/2-6/6		3	unstratified	total	28.2	2840	9.93
7/3-7/7		4	unstratified	total	28.2	2840	9.93
7/28-8/2		5	unstratified	total	25.9	2840	9.12
8/25-8/30		6	unstratified	total	28.2	2840	9.93
9/23-9/27		7	unstratified	total	28.2	2840	9.93
10/21-10/26		8	unstratified	total	28.2	2840	9.93
11/25-11/30		9	unstratified	total	28.2	2840	9.93
12/14-12/18		10	unstratified	total	28.2	2840	9.93
7/17-7/23	1973	2	unstratified	total	23.90	2840	8.42
8/29-9/4	(CLEAR)	5	unstratified	total	23.65	2840	8.33
10/14-10/24		7	unstratified	total	22.54	2840	7.94
4/25-5/4	1974	2	unstratified	total	24.00	2840	8.45
6/1-6/10	(CLEAR)	4	unstratified	total	24.11	2840	8.49
6/28-7/7		5	unstratified	total	23.95	2840	8.43
8/12-8/19		7	unstratified	total	23.53	2840	8.29
8/26-9/7		8	unstratified	total	23.45	2840	8.26
10/21-11/1		10	unstratified	total	22.62	2840	7.96
3/19-3/31							
4-21-4/25	1975	1	unstratified	total	23.64	2840	8.32
6/9-6/19	(CLEAR)	2	unstratified	total	23.50	2840	8.27
7/13-7/21		3	unstratified	total	23.35	2840	8.22
8/30-9/7		4	unstratified	total	23.35	2840	8.22
9/27-10/6		5	unstratified	total	23.07	2840	8.12
12/2-12/10		6	unstratified	total	22.54	2840	7.94
3/22-3/30	1976	1	unstratified	total	23.62	2840	8.32
6/2-6/10	(CLEAR)	2	unstratified	total	23.62	2840	8.32
8/21-8/29		3	unstratified	total	23.30	2840	8.20
9/8-9/17		4	unstratified	total	23.01	2840	8.10
10/18-10/30		5	unstratified	total	22.43	2840	7.90
3/21-4/3	1977	1	unstratified	total	22.16	2840	7.80
4/28-5/8	(CLEAR)	2	unstratified	total	ND	2840	ND
6/20-6/30		3	unstratified	total	ND	2840	ND
7/12-7/31		4	unstratified	total	ND	2840	ND
8/11-8/21		5	unstratified	total	ND	2840	ND
9/10-10/9		6	unstratified	total	22.57	2840	7.95
11/7-11/20		7	unstratified	total	22.48	2840	7.92

APPENDIX E CONT.

DATE	YEAR	CRUISE	STRATIF.	LIMNION	VOL. km^3	AREA km^2	THICKNESS m
5/18-5/27	1978	2	unstratified	total	25.09	2840	8.83
6/5-6/15	(USEPA)	3	unstratified	total	25.07	2840	8.83
6/23-7/1		4	unstratified	total	25.10	2840	8.84
7/19-7/29		5	unstratified	total	24.40	2840	8.59
8/8-8/16		6	unstratified	total	24.33	2840	8.57
8/29-9/6		7	unstratified	total	24.14	2840	8.50
10/3-10/12		8	unstratified	total	23.85	2840	8.40
10/24-11/1		9	unstratified	total	23.80	2840	8.38
11/10-11/19		10	unstratified	total	23.89	2840	8.41
4/17-4/20	1979	2	unstratified	total	24.80	2840	8.73
5/15-5/26	(USEPA)	3	unstratified	total	24.99	2840	8.80
6/12-6/21		4	unstratified	total	24.76	2840	8.72
7/11-7/19		5	unstratified	total	25.02	2840	8.81
7/31-8/4		6	unstratified	total	25.07	2840	8.83
8/23-9/4		7	unstratified	total	25.11	2840	8.84
9/11-9/21		8	unstratified	total	24.75	2840	8.71
10/2-10/14		9	unstratified	total	24.42	2840	8.60
11/7-11/16		10	unstratified	total	24.19	2840	8.52
4/1-4/2	1980	1	unstratified	total	25.4	2840	8.94
4/28-4/30	(CLEAR)	2	unstratified	total	25.4	2840	8.94
5/27-5/29		3	unstratified	total	25.4	2840	8.94
6/29-6/30		4	unstratified	total	25.4	2840	8.94
7/28		5	unstratified	total	25.4	2840	8.94
ND		6	ND	ND	ND	2840	ND
8/28-8/29		7	unstratified	total	24.9	2840	8.77
9/27-9/28		8	unstratified	total	25.1	2840	8.84
11/5		9	unstratified	total	24.2	2840	8.52
11/23		10	unstratified	total	24.2	2840	8.52

APPENDIX F

LAKE ERIE STRATIFICATION CHARACTERISTICS--CENTRAL BASIN 1973-1980

DATE	YEAR	CRUISE	STRATIF.	LIMNION	VOL. km^3	AREA km^2	THICKNESS m
7/17-7/23	1973 (CLEAR)	2	stratified	epi	228.6		12.5
				meso	22.2		1.7
				hypo	61.3	12,883	4.8
				total	312.1	16,426	19.0
8/7-8/11		4	stratified	epi	224.5		12.3
				meso	25.8		2.0
				hypo	60.8	12,962	4.7
				total	311.1	16,374	19.0
8/29-9/14		5	stratified	epi	238.2		13.0
				meso	24.9		2.0
				hypo	47.1	11,829	4.0
				total	310.2	16,326	19.0
9/19-9/29		6	stratified	epi	NA		14.4
				meso	NA		1.5
				hypo	11.3	3,660	3.1
				total	307.4	16,179	19.0
10/14-10/24		7	unstratified	total	306.1	16,111	19.0
6/1-6/10	1974 (CLEAR)	4	stratified	epi	195.8		11.2
				meso	22.7		1.6
				hypo	93.7	14,819	6.2
				total	312.2	16,432	19.0
6/28-7/7		5	stratified	epi	249.1		13.8
				meso	12.5		1.1
				hypo	50.1	11,860	4.1
				total	311.7	16,405	19.0
8/12-8/19		7	stratified	epi	235.4		12.6
				meso	23.8		1.4
				hypo	50.6	11,698	5.0
				total	309.8	16,305	19.0
8/26-9/7		8	stratified	epi	243.0		12.6
				meso	17.5		1.8
				hypo	48.4	10,556	4.6
				total	308.9	16,258	19.0
10/21-11/1		10	unstratified	total	304.0	16,000	19.0
3/19-3/31							
4/21-4/25	1975	1	unstratified	total	308.7	16,247	19.0
6/9-6/19	(CLEAR)	2	stratified	epi	174.0		9.2
				meso	30.8		2.1
				hypo	104.7	13,678	7.7
				total	309.5	16,290	19.0

APPENDIX F CONT.

DATE	YEAR	CRUISE	STRATIF.	LIMNION	VOL. km^3	AREA km^2	THICKNESS m
7/13-7/21	1975	3	stratified	epi	182.6		9.8
				meso	35.6		2.4
				hypo	90.5	13,385	6.8
				total	308.7	16,250	19.0
8/30-9/7		4	stratified	epi	227.4		10.5
				meso	15.2		1.6
				hypo	66.1	9,599	6.9
				total	308.7	16,250	19.0
9/27-10/6		5	unstratified	total	307.1	16,160	19.0
12/2-12/10		6	unstratified	total	304.0	16,000	19.0
3/22-3/30	1976	1	unstratified	total	309.8	16,310	19.0
6/2-6/10	(CLEAR)	2	stratified	epi	216.9		11.2
				meso	13.2		1.2
				hypo	80.1	12,105	6.6
				total	310.2	16,330	19.0
8/21-8/29		3	stratified	epi	249.9		14.0
				meso	23.8		2.0
				hypo	34.6	11,550	3.0
				total	308.3	16,230	19.0
9/8-9/17		4	stratified	epi	291.2		14.4
				meso	8.7		2.6
				hypo	6.9	3,380	2.0
				total	306.8	16,150	19.0
10/18-10/30		5	unstratified	total	303.3	15,960	19.0
3/20-3/31	1977	1	unstratified	total	302.2	15,910	19.0
4/29-5/8	(CLEAR)	2	unstratified	total	306.1	16,110	19.0
6/20-6/30		3	stratified	epi	178.8		9.5
				meso	35.2		2.7
				hypo	89.9	13,245	6.8
				total	303.9	15,999	19.0
7/12-7/22		4	stratified	epi	219.2		12.4
				meso	25.5		2.0
				hypo	59.8	12,876	4.6
				total	304.5	16,030	19.0
8/11-8/21		5	stratified	epi	256.9		15.0
				meso	11.6		1.0
				hypo	35.4	11,705	3.0
				total	303.9	15,990	19.0

APPENDIX F CONT.

DATE	YEAR	CRUISE	STRATIF.	LIMNION	VOL. km^3	AREA km^2	THICKNESS m
9/11-10/8	1977	6	stratified	epi	298.3		15.7
				meso	2.2		1.2
				hypo	3.9	1,891	2.1
				total	304.4	16,030	19.0
11/7-11/20		7	unstratified	total	300.5	15,820	19.0
5/18-5/27	1978	2	unstratified	total	315.9	16,280	19.4
6/5-6/15	(USEPA)	3	stratified	total	305.5	15,910	19.2
6/23-7/1		4	stratified	epi	130.0		7.9
				meso	105.3		6.8
				hypo	79.8	14,250	5.6
				total	315.1	15,520	20.3
7/19-7/29		5	stratified	epi	118.5		7.2
				meso	93.1		6.0
				hypo	100.3	14,130	7.1
				total	311.9	15,360	20.3
8/8-8/16		6	stratified	epi	172.1		10.5
				meso	69.7		4.7
				hypo	69.7	12,670	5.5
				total	311.5	15,050	20.7
8/29-9/6		7	stratified	epi	202.0		12.4
				meso	56.7		3.8
				hypo	51.6	12,000	4.3
				total	310.3	15,140	20.5
10/3-10/12		8	unstratified	total	308.8	16,340	18.9
10/24-11/1		9	unstratified	total	308.8	16,340	18.9
11/10-11/19		10	unstratified	total	299.5	15,850	18.9
5/29-6/2	1978 (CCIW)	103	stratified	epi	93.8		
				meso	101.2		
				hypo	121.9		
				total	316.9		
6/19-6/24		104	stratified	epi	179.5		
				meso	69.9		
				hypo	65.9		
				total	315.3		
7/13-7/18		106	stratified	epi	191.6		
				meso	59.4		
				hypo	61.0		
				total	312.0		

APPENDIX F CONT.

DATE	YEAR	CRUISE	STRATIF.	LIMNION	VOL. km^3	AREA km^2	THICKNESS m
8/19-8/23	1978	110	stratified	epi	220.7		
				meso	37.5		
				hypo	53.8		
				total	312.0		
9/13-9/19		111	stratified	epi	266.9		
				meso	18.2		
				hypo	24.7		
				total	309.8		
9/30-10/4		114	stratified	epi	280.3		
				meso	16.4		
				hypo	12.1		
				total	308.8		
4/17-4/20	1979	2	unstratified	total	313.3		
5/15-5/26	(USEPA)	3	stratified	epi	193.7		
				meso	43.3		
				hypo	78.2		
				total	315.2		
6/12-6/21		4	stratified	epi	253.2		
				meso	24.1		
				hypo	37.9		
				total	315.2		
7/11-7/19		5	stratified	epi	232.9		
				meso	32.0		
				hypo	49.2		
				total	314.1		
7/31-8/4		6	stratified	epi	219.2		
				meso	30.3		
				hypo	65.6		
				total	315.1		
8/23-9/4		7	stratified	epi			
				meso			
				hypo			
				total			
9/11-9/21		8	stratified	epi	272.9		16.7
				meso	16.9		1.5
				hypo	23.5	8,700	2.7
				total	313.3	14,990	20.9
10/2-10/14		9	unstratified	total	303.3	15,960	19.0
11/7-11/16		10	unstratified	total	301.6	15,960	18.9

APPENDIX F CONT.

DATE	YEAR	CRUISE	STRATIF.	LIMNION	VOL. km^3	AREA km^2	THICKNESS m
4/3-4/4	1980	1	unstratified	total	308.3	15,970	19.3
5/1-5/13	(CLEAR)	2	unstratified	total	308.3	15,970	19.3
5/31-6/2		3	stratified	epi	233.9		14.7
				meso	18.8		1.6
				hypo	55.5	11,330	4.9
				total	308.2	14,540	21.2
7/2-7/6		4	stratified	epi	203.4		12.7
				meso	23.5		1.7
				hypo	81.4	13,130	6.2
				total	308.3	14,970	20.6
8/4-8/8		5	stratified	epi	201.4		12.6
				meso	34.0		2.6
				hypo	72.9	12,570	5.8
				total	308.3	14,680	21.0
8/18-8/23		6	stratified	epi	229.7		14.0
				meso	22.1		1.5
				hypo	65.1	12,520	5.2
				total	316.9	15,310	20.7
9/3-9/6		7	stratified	epi	215.9		13.5
				meso	22.5		1.6
				hypo	68.3	12,890	5.3
				total	306.7	15,030	20.4
9/29-10/1		8	unstratified	total	306.7	15,970	19.2
10/27-10/29		9	unstratified	total	301.9	15,970	18.9
12/1-12/4		10	unstratified	total	301.9	15,970	18.9

APPENDIX G

LAKE ERIE STRATIFICATION CHARACTERISTICS--EASTERN BASIN 1970-1980

DATE	YEAR	CRUISE	STRATIF.	LIMNION	VOL. km^3	AREA km^2	THICKNESS m
4/7-4/11	1970	1	unstratified	total	166.4	6423	25.9
5/6-5/11	(CCIW)	2	unstratified	total	166.4	6423	25.9
6/2-6/6		3	stratified	epi	50.8		
				meso	32.0		
				hypo	83.5		
				total	166.3	6423	25.9
7/3-7/7		4	stratified	epi	90.9		
				meso	21.2		
				hypo	54.2		
				total	166.3	6423	25.9
7/28-8/2		5	stratified	epi	89.5		
				meso	42.2		
				hypo	34.6		
				total	166.3	6423	25.9
8/25-8/30		6	stratified	epi	98.9		
				meso	30.7		
				hypo	36.8		
				total	166.4	6423	25.9
9/23-9/27		7	stratified	epi	131.6		
				meso	6.2		
				hypo	28.5		
				total	166.3	6423	25.9
10/21-10/26		8	stratified	epi	149.6		
				meso	6.1		
				hypo	10.6		
				total	166.3	6423	25.9
11/25-11/30		9	unstratified	total	166.3	6423	25.9
12/14-12/18		10	unstratified	total	166.3	6423	25.9
3/21-4/3	1977	1	unstratified	total	ND	ND	ND
4/28-5/8	(CLEAR)	2	unstratified	total	169.1	6423	26.3
6/20-6/30		3	stratified	epi	99.5		
				meso	14.3		
				hypo	54.7		
				total	168.6	6423	26.3
7/12-7/31		4	stratified	epi	84.5		
				meso	35.6		
				hypo	48.0		
				total	168.1	6423	26.2

APPENDIX G CONT.

DATE	YEAR	CRUISE	STRATIF.	LIMNION	VOL. km^3	AREA km^2	THICKNESS m
8/11-8/21	1977	5	stratified	epi	114.2		
				meso	18.2		
				hypo	36.4		
				total	168.8	6423	26.3
9/10-10/9		6	stratified	epi	142.9		
				meso	2.4		
				hypo	23.2		
				total	168.6	6423	26.3
11/7-11/20		7	unstratified	total	167.6	6423	26.1
5/18-5/27	1978	2	unstratified	total	160.2	6423	25.0
6/5-6/15	(USEPA)	3	stratified	total	159.0	6423	24.8
6/23-7/1		4	stratified	epi	48.5		
				meso	43.1		
				hypo	68.5		
				total	160.1	6423	24.9
7/19-7/29		5	stratified	epi	63.6		
				meso	41.6		
				hypo	53.8		
				total	159.0	6423	24.8
8/8-8/16		6	stratified	epi	85.3		
				meso	28.6		
				hypo	44.1		
				total	158.1	6423	24.6
8/29-9/6		7	stratified	epi	84.5		
				meso	25.9		
				hypo	47.4		
				total	157.9	6423	24.6
10/3-10/12		8	unstratified	total	157.9	6423	24.6
10/24-11/1		9	unstratified	total	158.0	6423	24.6
11/10-11/19		10	unstratified	total	157.5	6423	24.5
5/29-6/2	1978 (CCIW)	103	stratified	epi	15.6		2.6
				meso	92.6		15.8
				hypo	52.8		13.3
				total	161.0	6423	25.0
6/19-6/24		104	stratified	epi	67.6		11.5
				meso	42.0		8.7
				hypo	50.7		14.0
				total	160.3	6423	25.0

APPENDIX G CONT.

DATE	YEAR	CRUISE	STRATIF.	LIMNION	VOL. km^3	AREA km^2	THICKNESS m
7/13-7/18	1978	106	stratified	epi	68.7		11.6
				meso	44.6		9.1
				hypo	45.9		12.1
				total	159.2	6423	24.8
8/19-8/23		110	stratified	epi	94.6		16.0
				meso	29.1		7.2
				hypo	35.6		11.3
				total	159.3	6423	24.8
9/13-9/19		111	stratified	epi	105.8		18.1
				meso	16.8		4.8
				hypo	34.1		12.1
				total	156.7	6423	24.4
9/30-10/4		114	stratified	epi	109.4		18.5
				meso	17.6		5.4
				hypo	31.2		12.4
				total	158.2	6423	24.6
	1979	2	unstratified	total	ND	6423	ND
5/15-5/26	(USEPA)	3	stratified	epi	126.6		
				meso	8.9		
				hypo	24.6		
				total	160.2	6423	24.9
6/12-6/21		4	stratified	epi			
				meso			
				hypo			
				total	160.4	6423	25.0
7/11-7/19		5	stratified	epi	87.9		
				meso	23.6		
				hypo	48.6		
				total	160.1	6423	24.9
7/31-8/4		6	stratified	epi	ND		
				meso			
				hypo			
				total	ND	6423	ND
8/23-9/4		7	stratified	epi	ND		
				meso			
				hypo			
				total	ND	6423	ND
9/11-9/21		8	stratified	epi	109.0		
				meso	18.3		
				hypo	32.1		
				total	159.6	6423	24.9

APPENDIX G CONT.

DATE	YEAR	CRUISE	STRATIF.	LIMNION	VOL. km^3	AREA km^2	THICKNESS m
10/2-10/14	1979	9	stratified	epi	129.0		
				meso	12.9		
				hypo	17.1		
				total	159.1	6423	24.8
11/7-11/16		10	stratified	total	158.6	6423	24.7