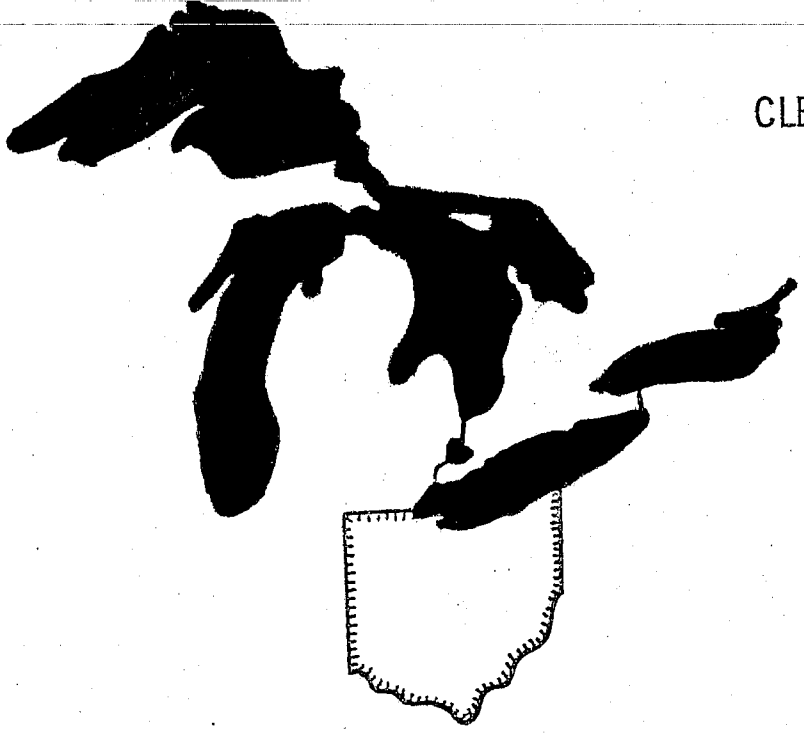

CLEAR TECHNICAL REPORT NO. 60

LAKE ERIE WATER QUALITY REPORT FOR 1976

Edited by

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Prepared for

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Environmental Research Laboratory
U. S. Environmental Protection Agency
Grosse Ile, Michigan

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CENTER FOR LAKE ERIE AREA RESEARCH
THE OHIO STATE UNIVERSITY
COLUMBUS, OHIO

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LAKE ERIE WATER QUALITY REPORT FOR 1976

Introduction

Five water quality monitoring cruises were conducted by the Center for Lake Erie Area Research (CLEAR) in the central and western basins of Lake Erie between March and October 1976:

	Central Basin	Western Basin
Cruise 1	March 23-30	March 8-12
Cruise 2	June 2-8	June 9-10
Cruise 3	August 21-27	August 28-29
Cruise 4	September 8-15	September 16-18
Cruise 5	October 23-31	October 18-19

The stations monitored during these cruises are shown in Figure 1. Sampling methods and analytical procedures are described in CLEAR Technical Report No. 59 (1977).

The following preliminary report of water quality in these two basins deals with three parameters: (1) dissolved oxygen, (2) total phosphorus and (3) chlorophyll. Results of measurements for 20 additional parameters will be included in a more complete report which will be prepared later this year.

Dissolved Oxygen

Figures 2-6 depict the dissolved oxygen (DO) concentrations in the bottom waters of the central and western basins. Cruise 1 was completed in March, within a month after ice cover had melted from the lake surface (Figure 2). DO concentrations were at saturation in the bottom waters (12-13 ppm).

By early June (Cruise 2) the central basin had thermally stratified but still contained high DO levels (8-10 ppm). Figure 3 indicates a temporary depression of oxygen in the middle portion of the western basin (4-5 ppm). Surface winds at Toledo, Ohio for five days prior to the western basin cruise averaged less than 7 mph which caused some ephemeral stratification and the associated oxygen depletion.

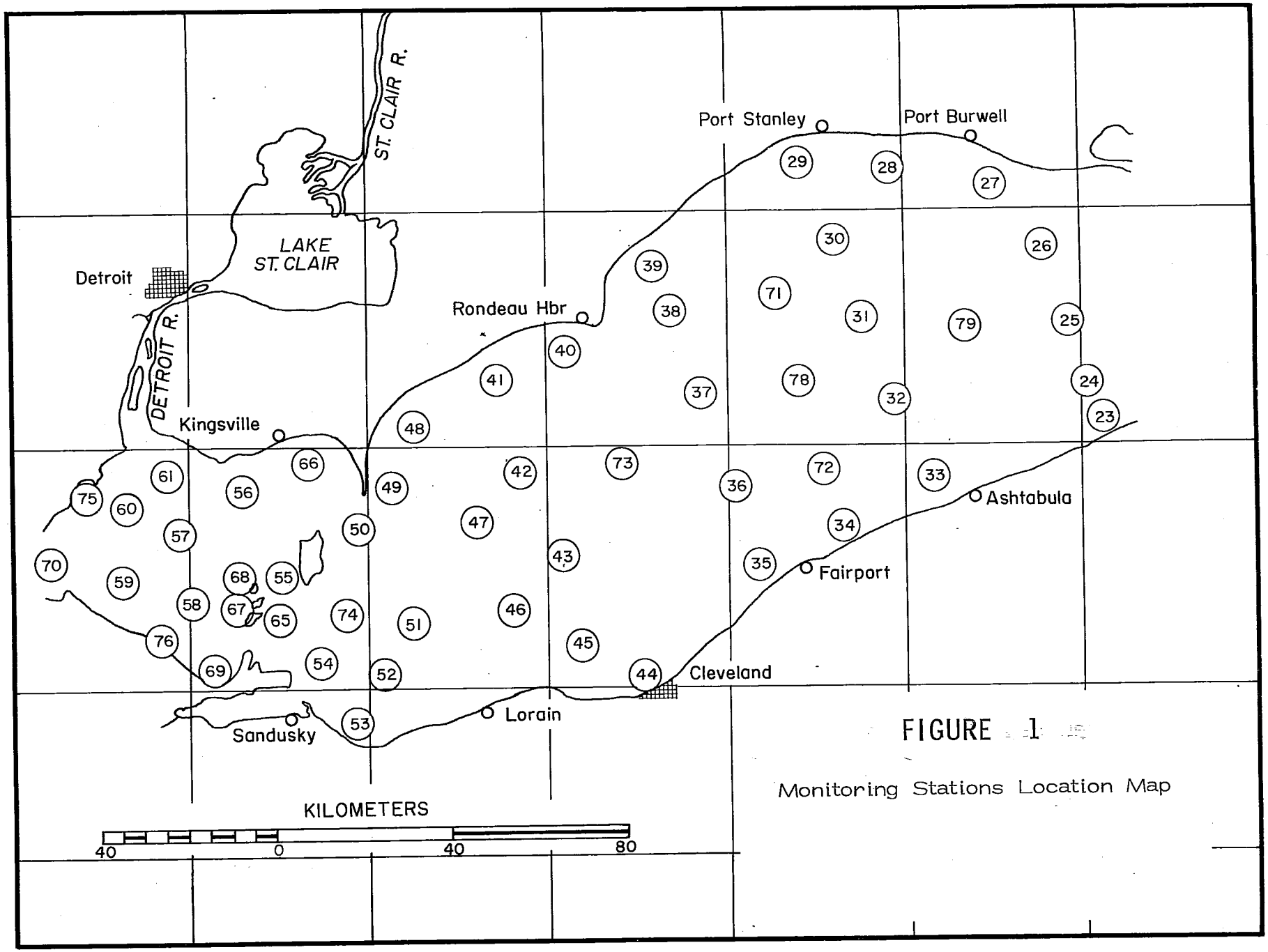

FIGURE 1

Monitoring Stations Location Map

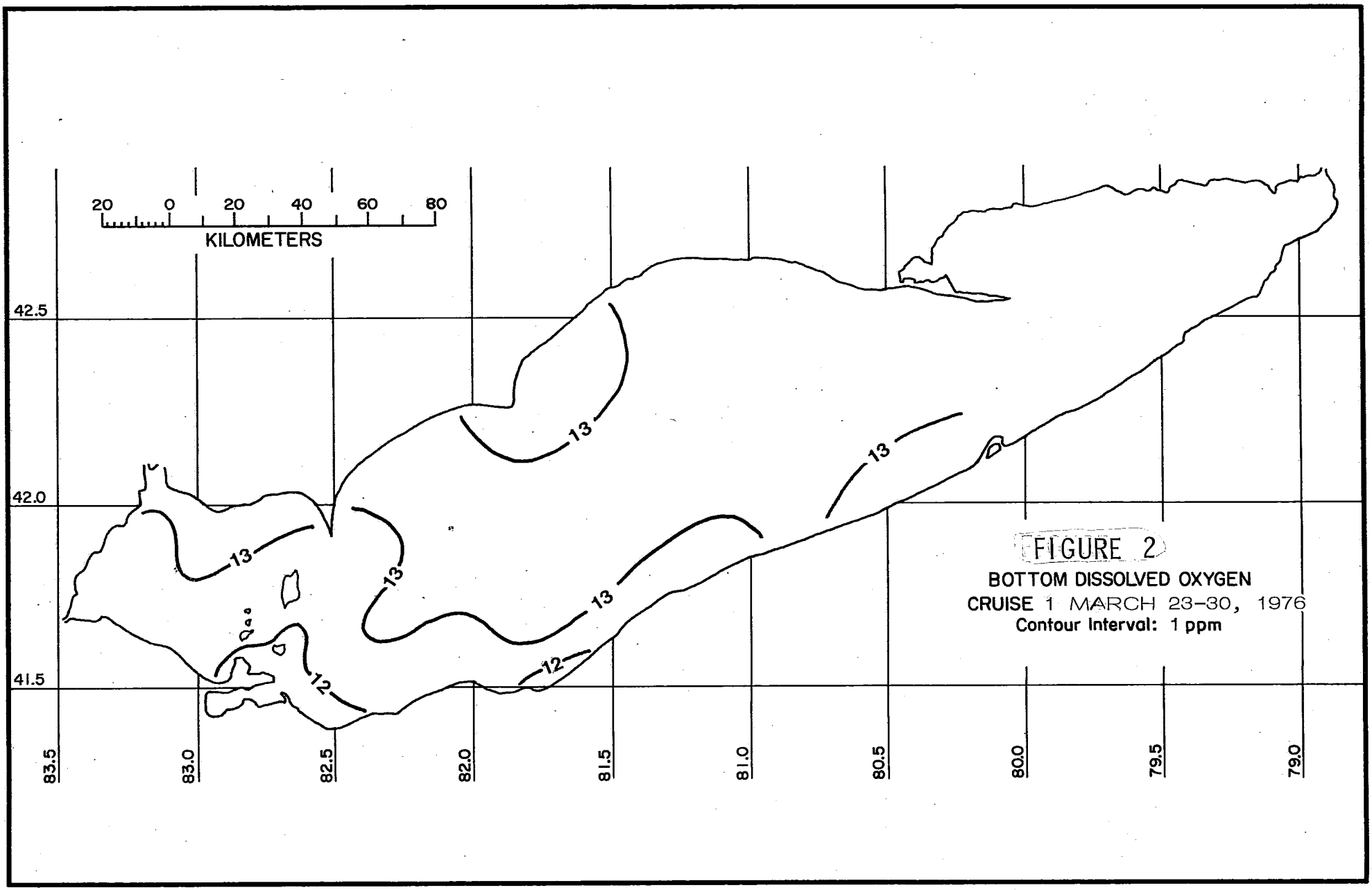

FIGURE 2

BOTTOM DISSOLVED OXYGEN

CRUISE 1 MARCH 23-30, 1976

Contour Interval: 1 ppm

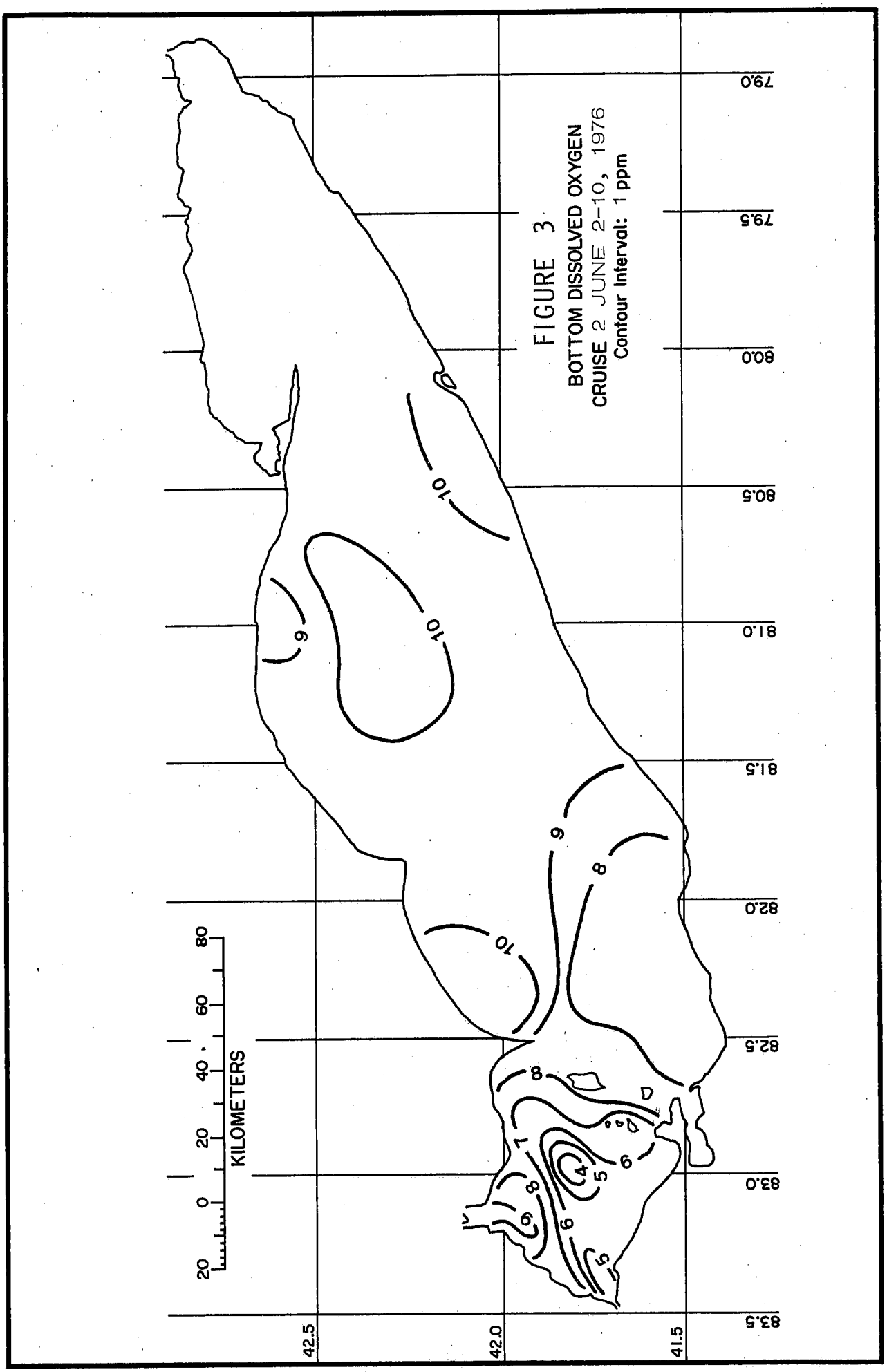
FIGURE 3
BOTTOM DISSOLVED OXYGEN
CRUISE 2 JUNE 2-10, 1976
Contour Interval: 1 ppm
KILOMETERS
20 0 20 40 60 80
42.5
42.0
41.5
83.5
83.0
82.5
82.0
81.5
81.0
80.5
80.0
79.5
79.0

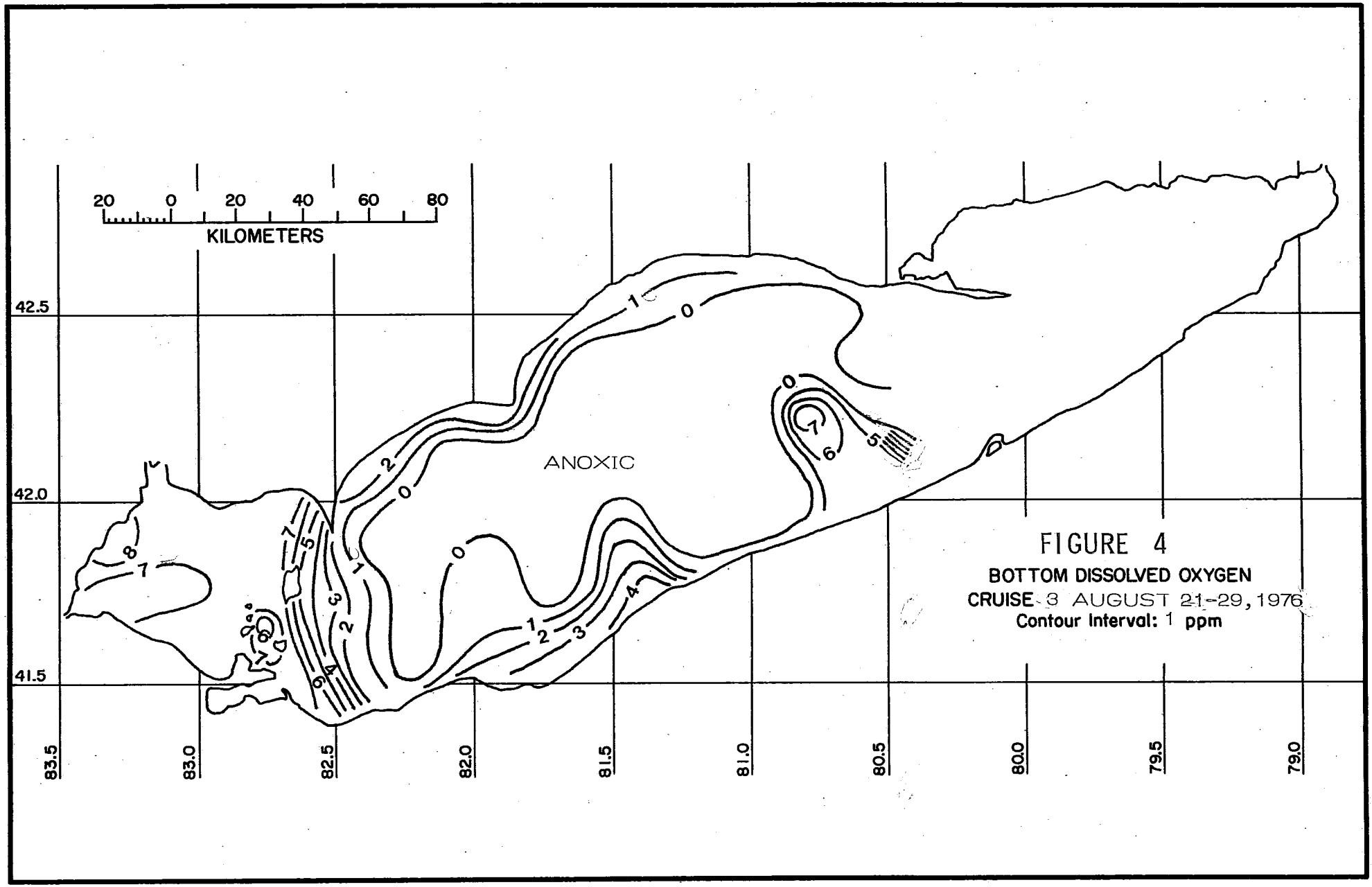

FIGURE 4

BOTTOM DISSOLVED OXYGEN

CRUISE 3 AUGUST 21-29, 1976

Contour Interval: 1 **ppm**

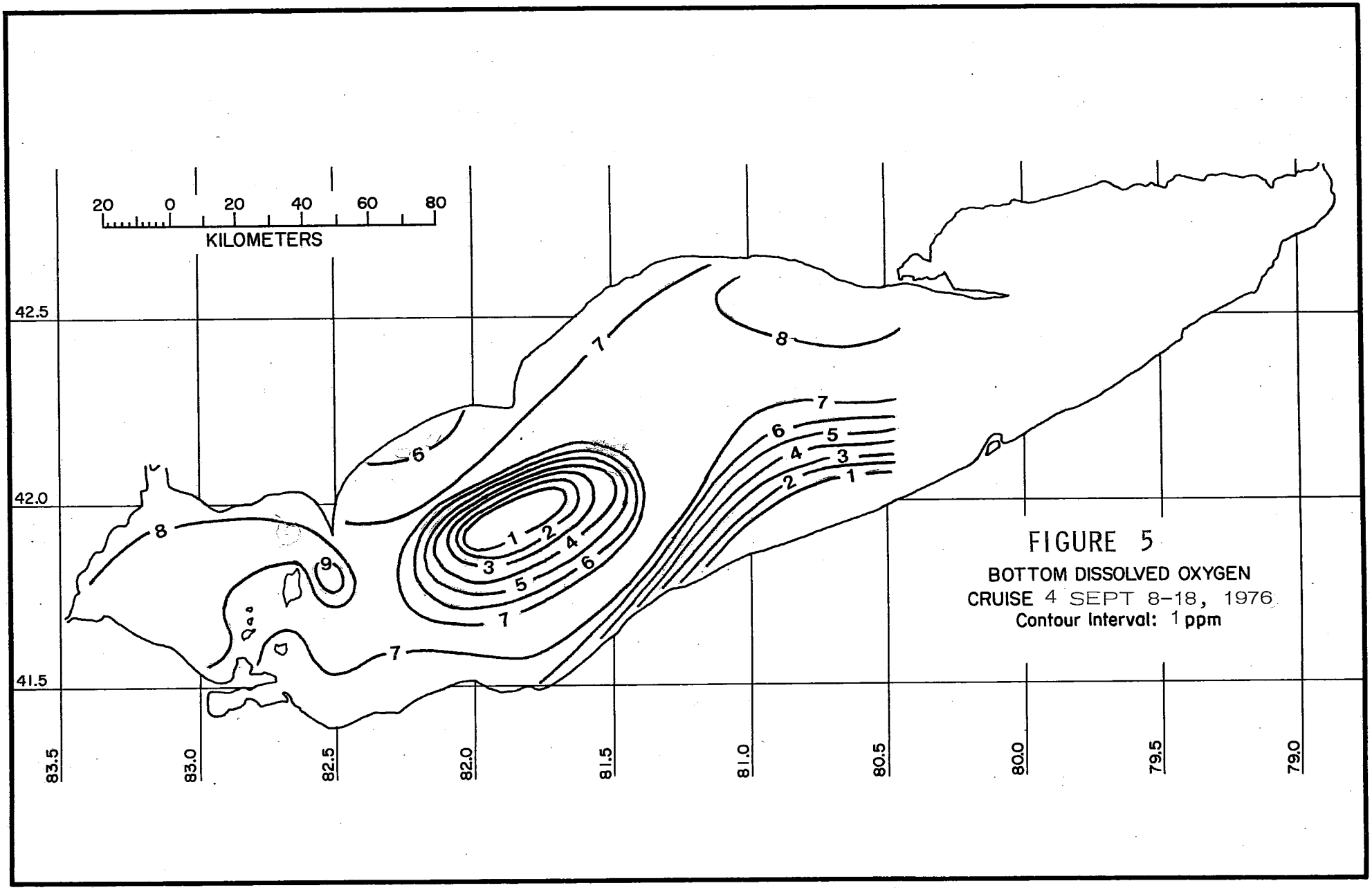

FIGURE 5

BOTTOM DISSOLVED OXYGEN

CRUISE 4 SEPT 8-18, 1976

Contour Interval: 1 ppm

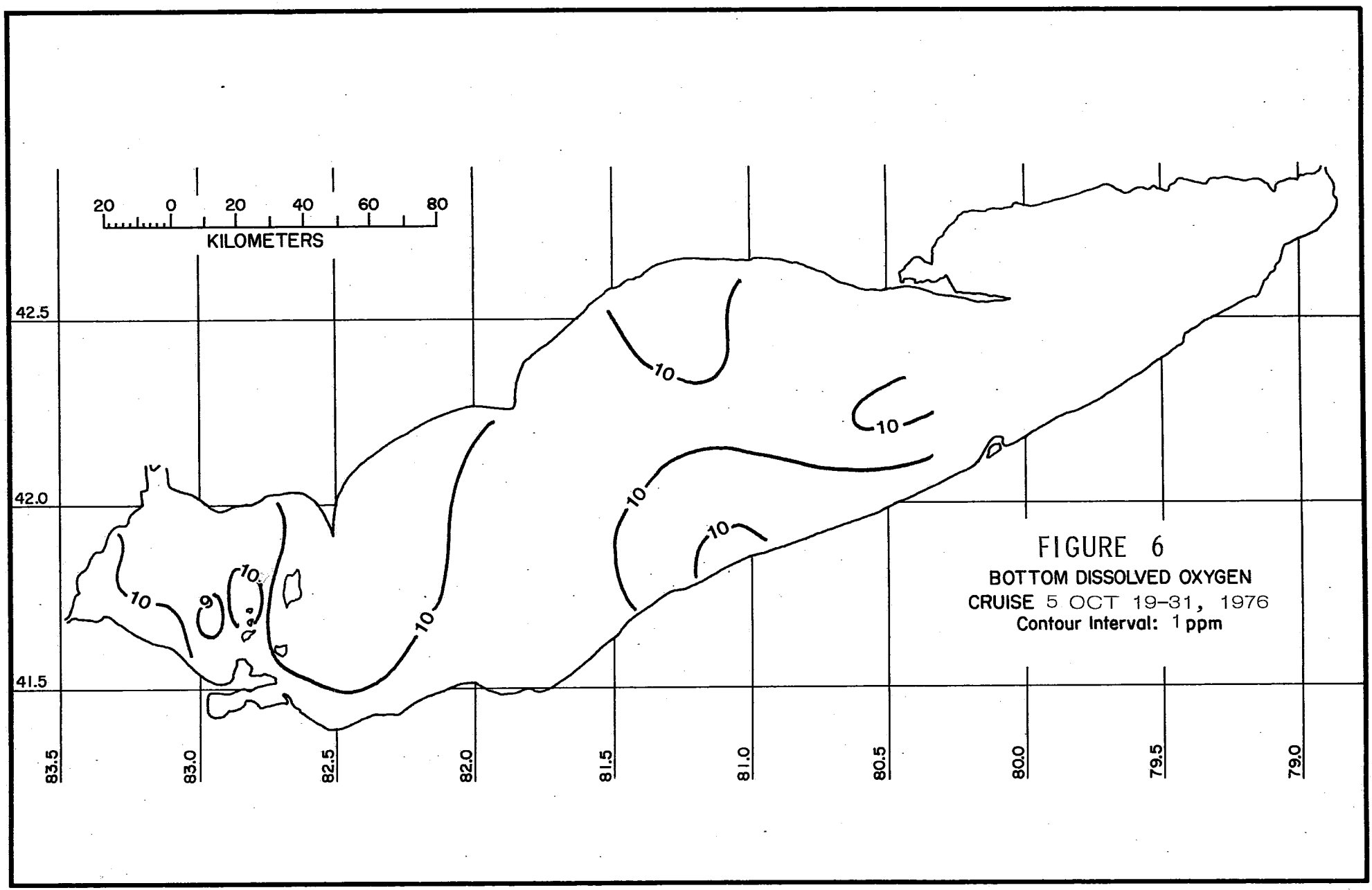

FIGURE 6

BOTTOM DISSOLVED OXYGEN

CRUISE 5 OCT 19-31, 1976

Contour Interval: 1 ppm

Through the summer the central basin hypolimnion increased in temperature from 9.4°C in early June to 13.7°C in late August and decreased in dissolved oxygen from 9.6 ppm to 0.7 ppm during the same period (Table 1). By late August (Cruise 3) approximately 63% of the central basin hypolimnion was anoxic (DO<0.5 ppm at 1.0 meter above lake bottom). Figure 4 illustrates the maximum measured extent of anoxia in the central basin for 1976, approximately 7,300 km^2. This represents a sizable increase (18x) from the 1975 area but a significant decrease (31-24%) from the 1973 and 1974 areas (Table 2).

Table 3 presents a comparison of hypolimnion characteristics for the period 1973-1976. In August 1976, the hypolimnion was less than half as thick as it was in August 1975, largely due to meteorological variations. This relatively thin bottom layer facilitated the oxygen depletion process and resulted in a large anoxic area. A secondary reason for the enlargement may be a slight increase in the areal rate of oxygen loss in the hypolimnion. Table 4 indicates a progressive increase in the net oxygen demand rate per unit area since 1930 while the demand rate per unit volume of water in the hypolimnion has remained relatively stable since 1970. It now appears that wind conditions in the spring at the time of initial stratification, which dictate the thickness of the hypolimnion, and the number of days that the central basin is stratified are the two most important factors influencing the development of anoxia, given the relatively stable depletion rate in the basin.

Total Phosphorus

The 1976 concentrations and quantities of total phosphorus (TP) in the western and central basins are listed in Table 5 by stratum for each cruise. High concentrations and quantities in each basin were observed in March and September. March values were highest in the western basin due to tributary inputs and wave resuspension; whereas, central basin levels were highest in September as a result of anoxic regeneration and resuspension during fall turnover. In the central basin these two processes yielded a 3,000 metric ton increase in TP to the water column from bottom sediments between Cruises 3 and 4.

TABLE 1

SUMMARY OF 1976 HYPOLIMNETIC SURVEYS OF THE CENTRAL BASIN OF LAKE ERIE

Cruise	Dates	Area (KM^2)	Volume (KM^3)	Ave. Thick. (M)	Total Heat ($kcal \times 10^{12}$)	Ave. Temp. (^oC)	Total O_2 ($kgO_2 \times 10^6$)	Ave. O_2 Conc. (ppm)	Ave. Temp. Grad. Across Meso. ($^oCM^{-1}$)	Ave. O_2 Grad. Across Meso. (gO_2M^{-4})
1	3/23-3/30		Unstratified							
2	6/2-6/8	12,105	80.1	6.6	752.7	9.4	770.6	9.6	2.6	1.2
3	8/21-8/27	11,550	34.6	3.0	474.8	13.7	23.5	0.7	4.0	3.8
4	9/8-9/15	3,380	6.8	2.0						
5	10/23-10/30		Unstratified							

TABLE 2

ESTIMATED AREA OF THE ANOXIC HYPOLIMNION OF THE CENTRAL BASIN OF LAKE ERIE 1930–1974

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
1967	7,500	68.0	46.4
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

TABLE 3

COMPARISON OF 1973, 1974 AND 1975
CHARACTERISTICS OF HYPOLIMNION IN CENTRAL LAKE ERIE

YEAR	JUNE			JULY			AUGUST			SEPTEMBER			NET OXYGEN DEMAND	
	Thick (m)	DO (ppm)	Temp (^{o}C)	Thick (m)	DO (ppm)	Temp (^{o}C)	Thick (m)	DO (ppm)	Temp (^{o}C)	Thick (m)	DO (ppm)	Temp (^{o}C)	loss/day (mg O_2/cm^2) Rate per unit area	loss/day (mg O_2/ l) Rate per unit volume
1970 (Project Hypo)	–	–	–	–	–	–	–	–	–	–	–	–	0.039	0.13
1973	–	–	–	5.0	4.9	10.3	4.4	1.6	11.9	3.0	1.1	13.8	0.053	0.12
1974	6.2	9.9	8.8	4.6	5.2	11.8	4.3	2.1	13.5	–	–	–	0.060	0.13
1975	7.7	10.0	6.5	6.7	7.8	7.7	6.8	3.3	10.2	–	–	–	0.067	0.12
1976	6.6	9.6	9.4	–	–	–	3.0	0.7	13.7	–	–	–	0.075	0.13

TABLE 4

TRENDS IN NET OXYGEN DEMAND OF THE CENTRAL AND EASTERN BASIN HYPOLIMNIONS OF LAKE ERIE

YEAR	NET OXYGEN DEMAND			
	Rate Per Unit Area (mg O_2 cm^{-2} day^{-1})		Rate Per Unit Volume (mg O_2 l^{-1} day^{-1})	
	Central Basin	Eastern Basin	Central Basin	Eastern Basin
1930	0.008	–	0.054	–
1940	0.015	–	0.067	–
1950	0.025	–	0.070	–
1960	0.037	–	0.093	–
1970	0.039	–	0.13	–
1973	0.053	0.023	0.12	0.012
1974	0.60	0.018	0.13	0.011
1975	0.067		0.12	
1976	0.075		0.10–0.15	

TABLE 5

TOTAL PHOSPHORUS 1976
LAKE ERIE WESTERN AND CENTRAL BASINS

Cruise No.	Date	Limnion	WESTERN BASIN			CENTRAL BASIN		
			Volume km^3	P_T M-Tons	P_T conc. µg/l	Volume km^3	P_T M-Tons	P_T conc. µg/l
1	3/8-3/30	TOTAL	23.62	1582.27	66.99	309.83	6644.79	21.45
2	6/2-6/10	EPI				216.92	3590.76	16.55
		MESO				13.19	206.31	15.64
		HYPO				80.07	1311.43	16.38
		TOTAL	23.62	696.30	29.48	310.18	5108.50	16.47
3	8/21-8/29	EPI				249.94	3807.57	15.23
		MESO				23.81	516.89	21.71
		HYPO				34.57	1521.03	44.00
		TOTAL	23.30	885.58	38.01	308.32	5845.49	18.96
4.	9/8-9/17	EPI				291.19	8267.90	28.39
		MESO				8.72	202.21	23.19
		HYPO				6.85	373.42	54.51
		TOTAL	23.01	1212.69	52.70	306.76	8843.53	28.83
5.	10/18-10/30	TOTAL	22.43	831.74	37.08	303.34	8107.99	26.73

Figures 7 and 8 show the concentrations and quantities of TP in the western and central basins of Lake Erie for the period 1970-1976. During this period the mean cruise concentrations have varied from approximately 0.025 to 0.067 mg/l in the western basin and 0.011 to 0.036 in the central basin. These variations are seasonal, resulting mostly from the conditions mentioned above for 1976, yielding a rather stable pattern from year to year. This apparent stability leads to the conclusion that TP loading to the lake has also been relatively stable during the past 7 years.

Chlorophyll

Corrected chlorophyll a (CHL a) concentrations and quantities in the western and central basins during 1976 are listed in Table 6 by stratum for each cruise. The highest concentrations in each basin were observed during the late summer and fall cruises (4 and 5). This inferred algal growth appears to be the result of increased nutrient supply after turnover when the lake is still warm enough to foster high primary production.

Table 7 presents the ratio of CHL a concentrations between the two basins from 1973 to 1976. The ratios show a slight narrowing of the difference between the basins during this period, indicative of some improvement in the western basin water quality. Figures 9 and 10 are also suggestive of a slight decrease in the 1976 concentrations and quantities of CHL a from the 1975 levels. However, viewed over the period 1973-1976 the inferred biomass of the lake appears to be relatively stable on an annual basis with only seasonal variations.

TABLE 6

CORRECTED CHLOROPHYLL a 1976
LAKE ERIE WESTERN AND CENTRAL BASINS

Cruise No.	Date	Limnion	WESTERN BASIN			CENTRAL BASIN		
			Volume km^3	Chl a M-Tons	Chl a conc. ug/l	Volume km^3	Chl a M-Tons	Chl a conc. ug/l
1	3/8-3/30	TOTAL	23.62	206.79	8.75	309.83	1311.47	4.23
2	6/2-6/10	EPI				216.92	501.54	2.31
		MESO				13.19	36.32	2.75
		HYPO				80.07	250.18	3.12
		TOTAL	23.62	152.21	6.44	310.18	788.04	2.54
3	8/21-8/29	EPI				249.94	1115.38	4.46
		MESO				23.81	98.14	4.12
		HYPO				34.57	110.70	3.20
		TOTAL	23.30	364.78	15.66	308.32	1324.22	4.29
4.	9/8-9/17	EPI				291.19	1996.85	6.86
		MESO				8.72	43.26	4.96
		HYPO				6.85	12.03	1.76
		TOTAL	23.01	388.91	16.90	306.76	2052.14	6.69
5.	10/18-10/30	TOTAL	22.43	323.07	14.40	303.34	2590.08	8.54

TABLE 7

RATIO OF CORRECTED CHLOROPHYLL a CONCENTRATION[1] IN WESTERN AND CENTRAL BASINS OF LAKE ERIE 1973 - 1976

DATE	WESTERN BASIN	CENTRAL BASIN	
		West Half	East Half
March			
1976	2.49	1.58	1.00
April			
1974	2.91	1.44	1.00
1975	2.33	1.41	1.00
1976			
June			
1974	3.95	0.80	1.00
1975	8.78	1.37	1.00
1976	2.41	0.87	1.00
July			
1973	4.77	2.05	1.00
1974	9.82	2.23	1.00
1975	7.45	1.90	1.00
August			
1974	6.21	2.09	1.00
1976	4.19	1.42	1.00
September			
1973	4.95	2.20	1.00
1974	4.75	1.92	1.00
1975	2.57	1.62	1.00
1976	2.83	1.34	1.00
October			
1973	1.56	1.08	1.00
1974	1.89	1.62	1.00
1975	1.22	0.98	1.00
1976	-	-	-
December			
1975	0.70	1.13	1.00

1. Corrected Chlorophyll a

FIGURE 7. TOTAL PHOSPHORUS CONCENTRATIONS IN LAKE ERIE 1970 - 1976

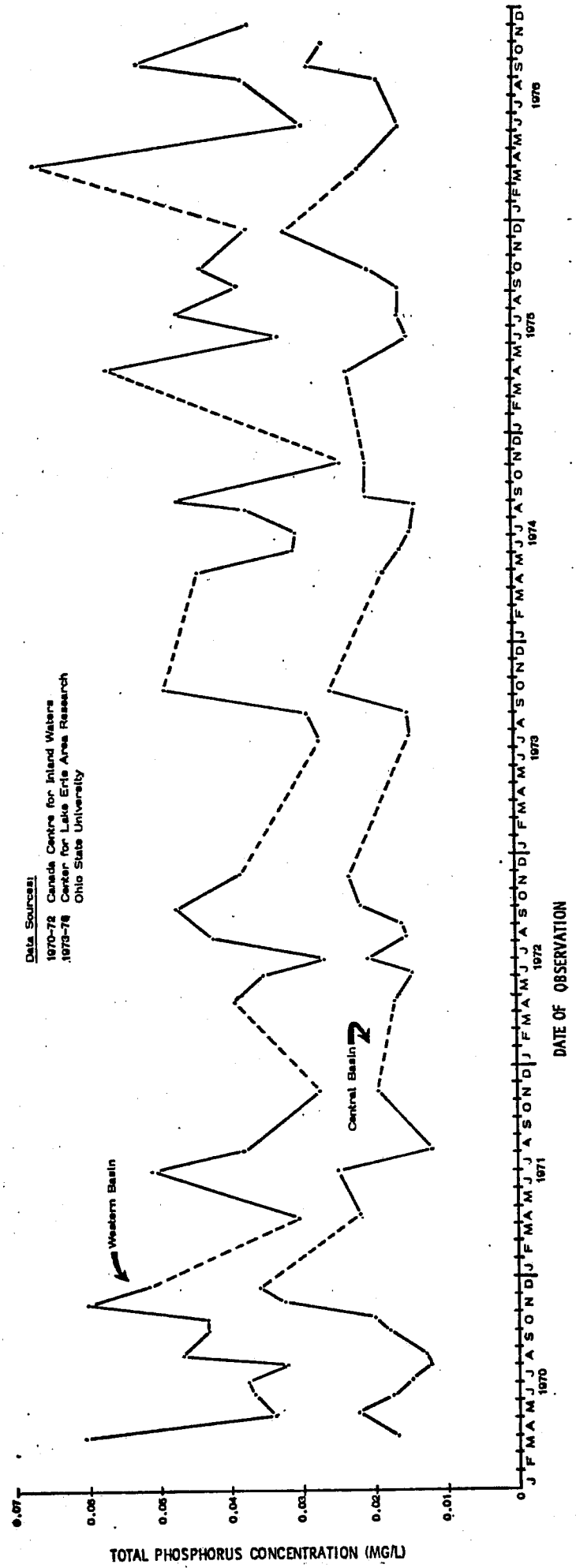

FIGURE 8. QUANTITY OF PHOSPHORUS IN LAKE ERIE 1970 - 1976

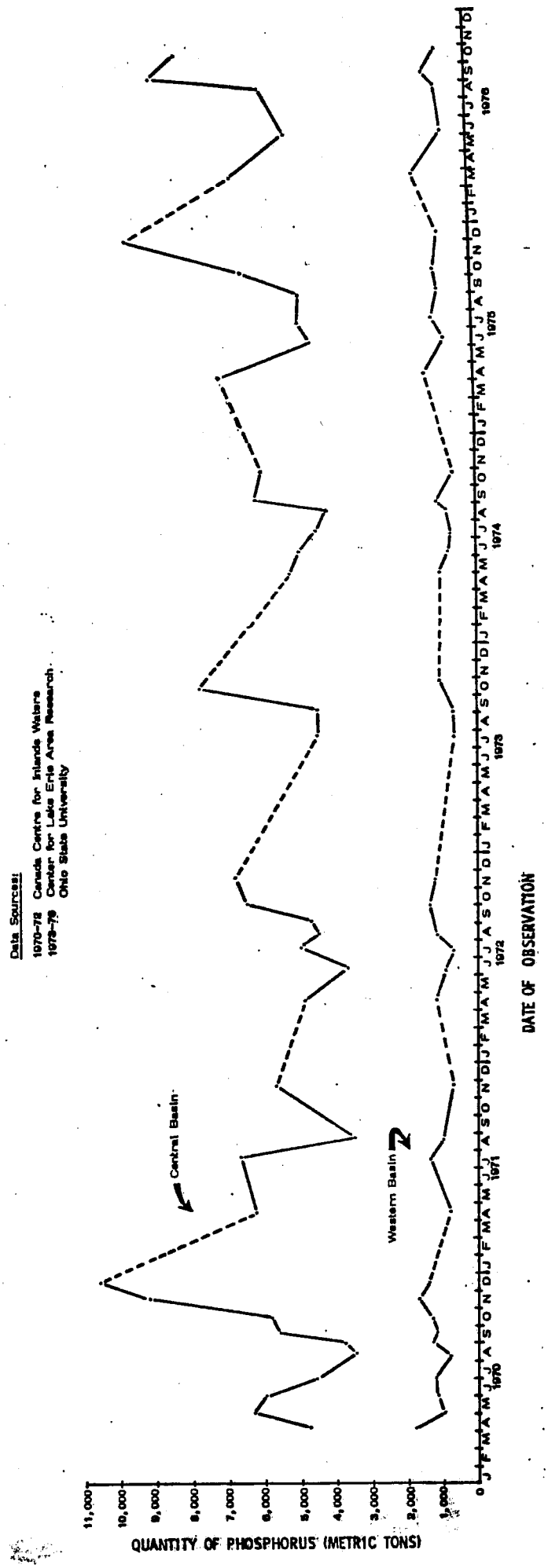

FIGURE 9. CORRECTED CHLOROPHYLL a WESTERN AND CENTRAL BASINS OF LAKE ERIE 1973 - 1976

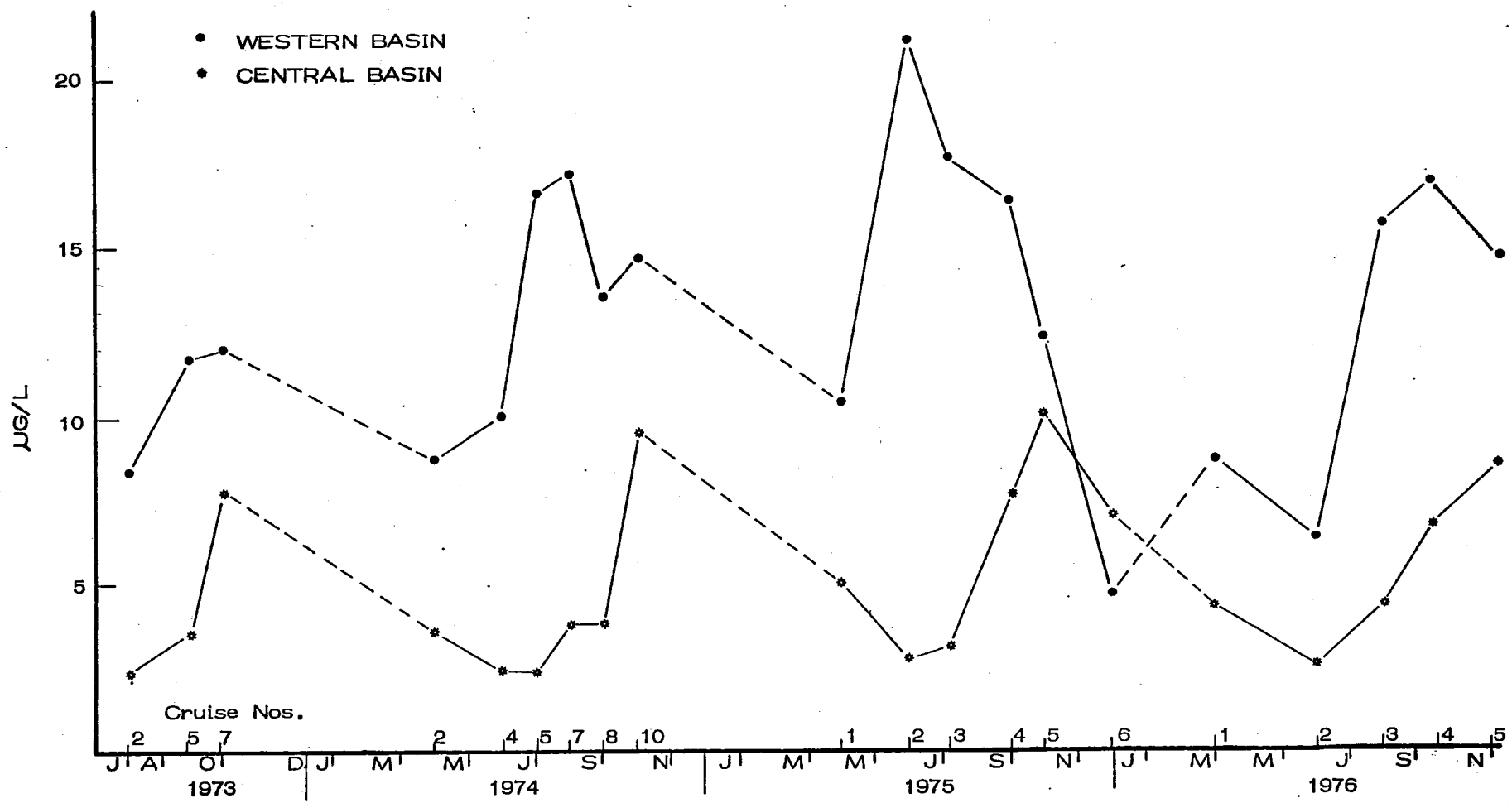

FIGURE 10. VOLUME WEIGHTED QUANTITY (METRIC TONS) OF CORRECTED CHLOROPHYLL a IN LAKE ERIE 1973 - 1976