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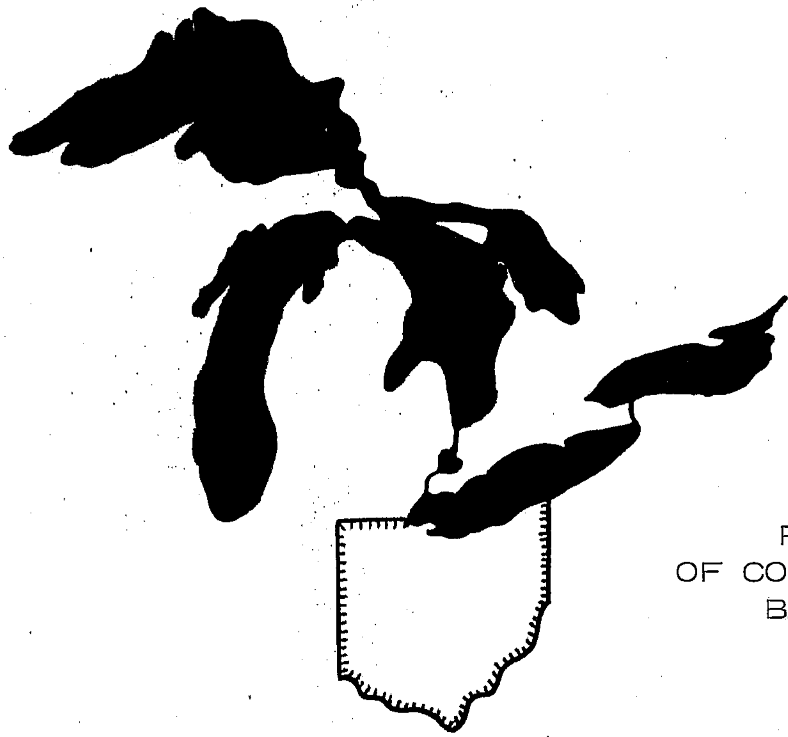

PRELIMINARY REPORT OF CONDITIONS IN THE CENTRAL BASIN HYPOLIMNION OF LAKE ERIE - 1975

CLEAR TECHNICAL REPORT NO. 39

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CONDITIONS IN THE CENTRAL BASIN
HYPOLIMNION OF LAKE ERIE - 1975

Introduction

Each year in late spring the central basin of Lake Erie undergoes thermal stratification. Every comprehensive survey of the hypolimnion since the late 1950's has shown extensive areas of anoxia in late summer. The size of the anoxic region reached its maximum development in 1973 and 1974 with areas of 11,220 km^2 and 10,250 km^2 respectively. In 1973, the anoxic region comprised 94% of the hypolimnion and 70% of the entire central basin.

In 1975, a dramatic change in this situation appears to have taken place. Although a significant amount of oxygen depletion did occur, only a relatively small portion of the basin experienced complete anoxia (approximately 400 km^2). Equally important as the improvement in dissolved oxygen concentrations, was the signigicant decline in regenerated phosphorus from the bottom sediments as a result of maintaining an oxic zone at the sediment/water interface throughout most of the basin.

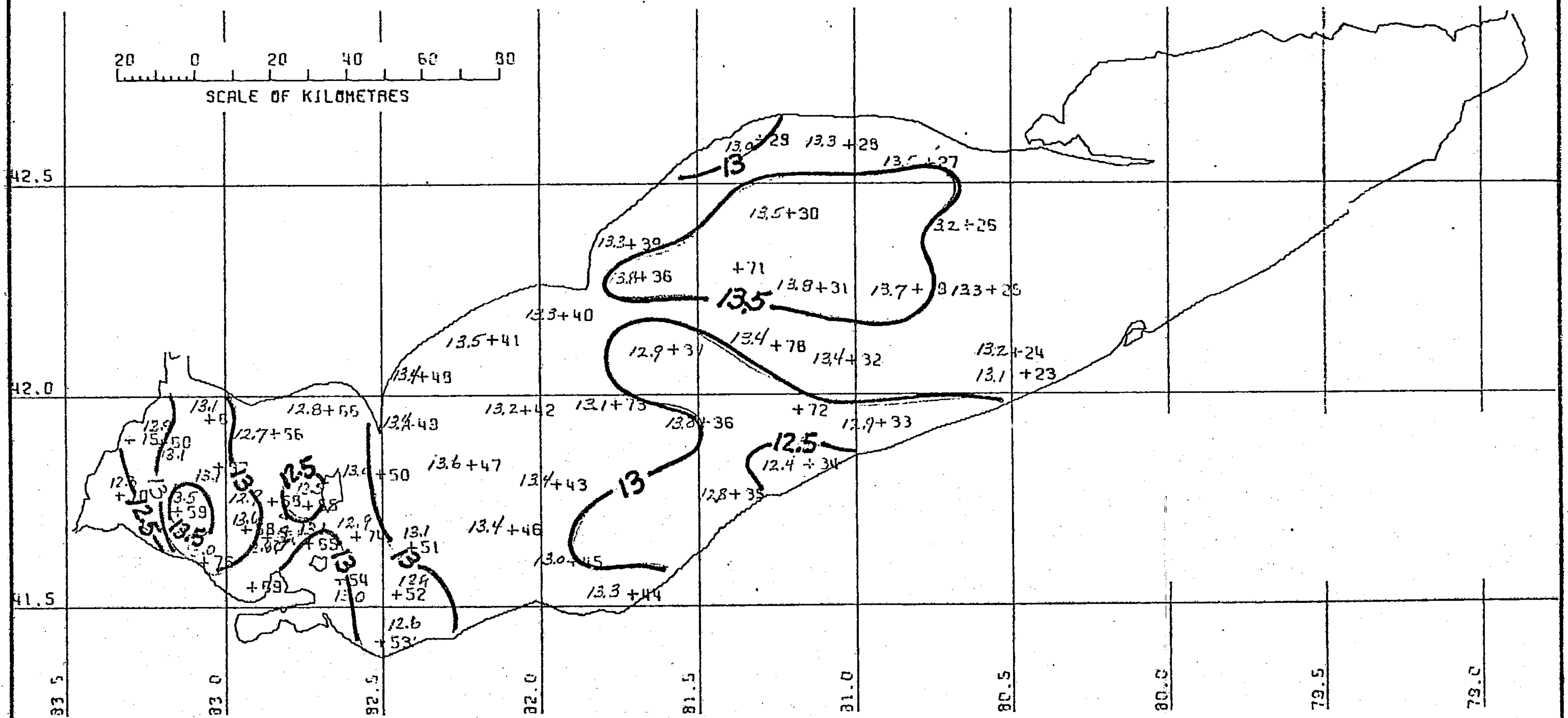
The reason for this major shift in the oxygen regime of the hypolimnion is not immediately apparent. Reductions in nutrient loadings would be expected to produce gradual improvements but not the dramatic situation observed in a single year. A preliminary analysis analysis of meteorological conditions and resultant water circulation phenomena provide some basis for an explanation.

Oxygen Regime

Five cruises were conducted in the western and central basins of Lake Erie between March and October 1975 and a sixth is scheduled for December. Dissolved oxygen concentrations were measured at one-meter intervals at 51 stations during each cruise. The results of readings taken one meter above the bottom sediment are shown on the contour maps in Figures 1-5. In March and April the lake was nearly isothermal and all DO levels were between 12-14 ppm (Figure 1). By mid-June the central basin had stratified and slight DO depressions were noted in Ohio waters north of Ashtabula and Huron (Figure 2). In mid-July this depression deepened on the American side of the lake, while the Canadian side continued to enjoy relatively high DO levels (Figure 3). At this time, an

FIGORE 1

CRUISE 1 3/18 - 4/25/75



1

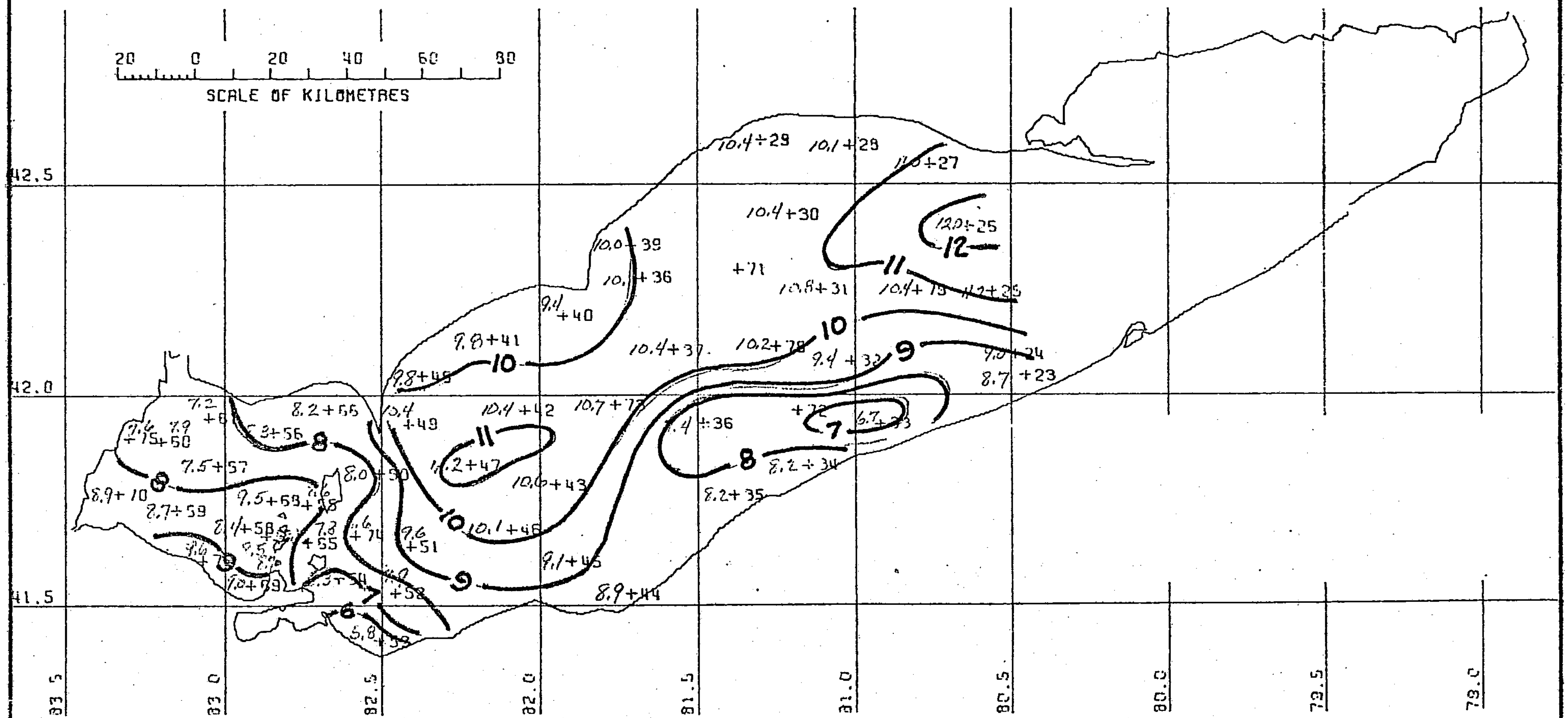
Bottom DO

Contour Interval: 0.5ppm

CRUISE 1B 4-21/4-25
1A 3-18/3-31

FIGURE 2

CRUISE 2 6/9-19/75



2

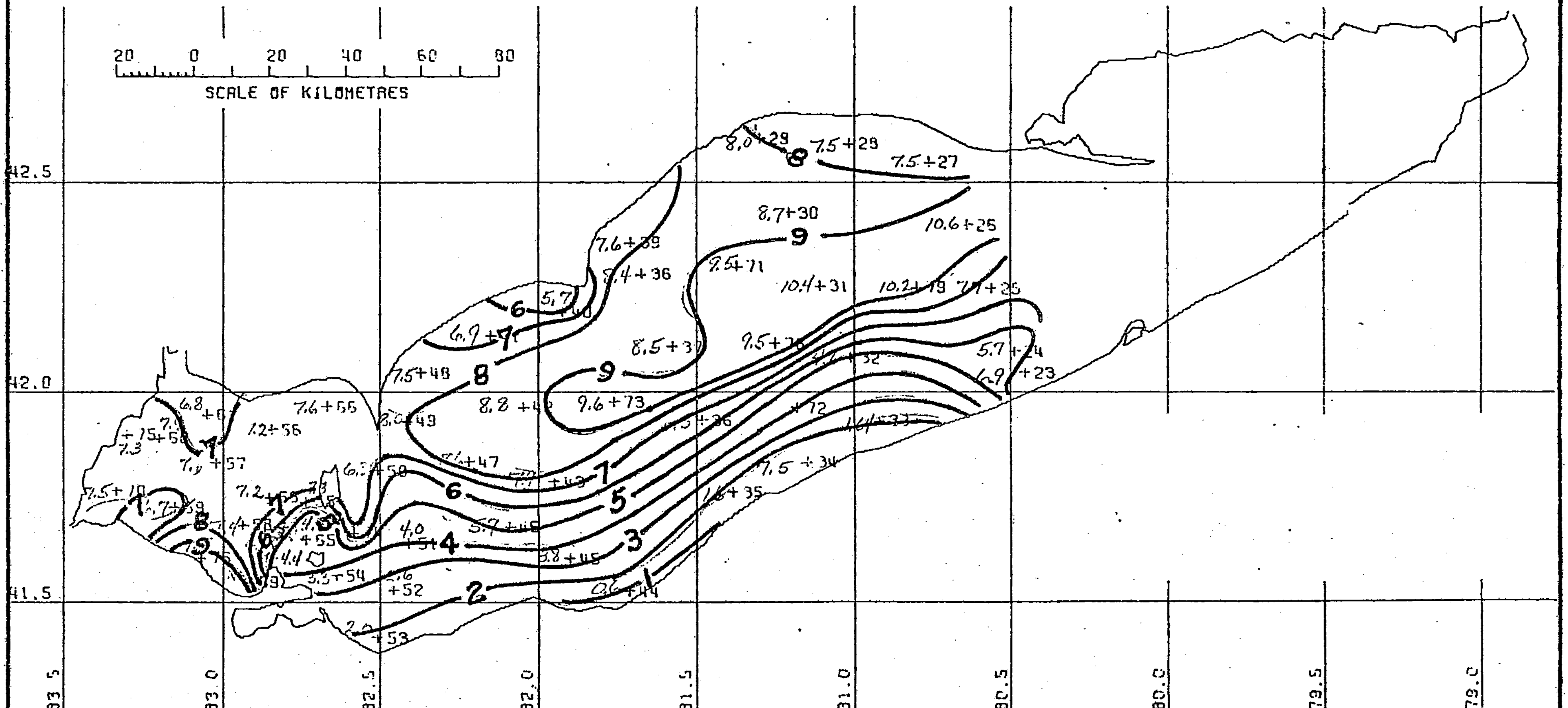
Bottom DO

Contour Interval: 1ppm

CRUISE 2 6-16/6-19 6-9/6-16

FIGURE 3

CRUISE 3 7/13-24/75



3

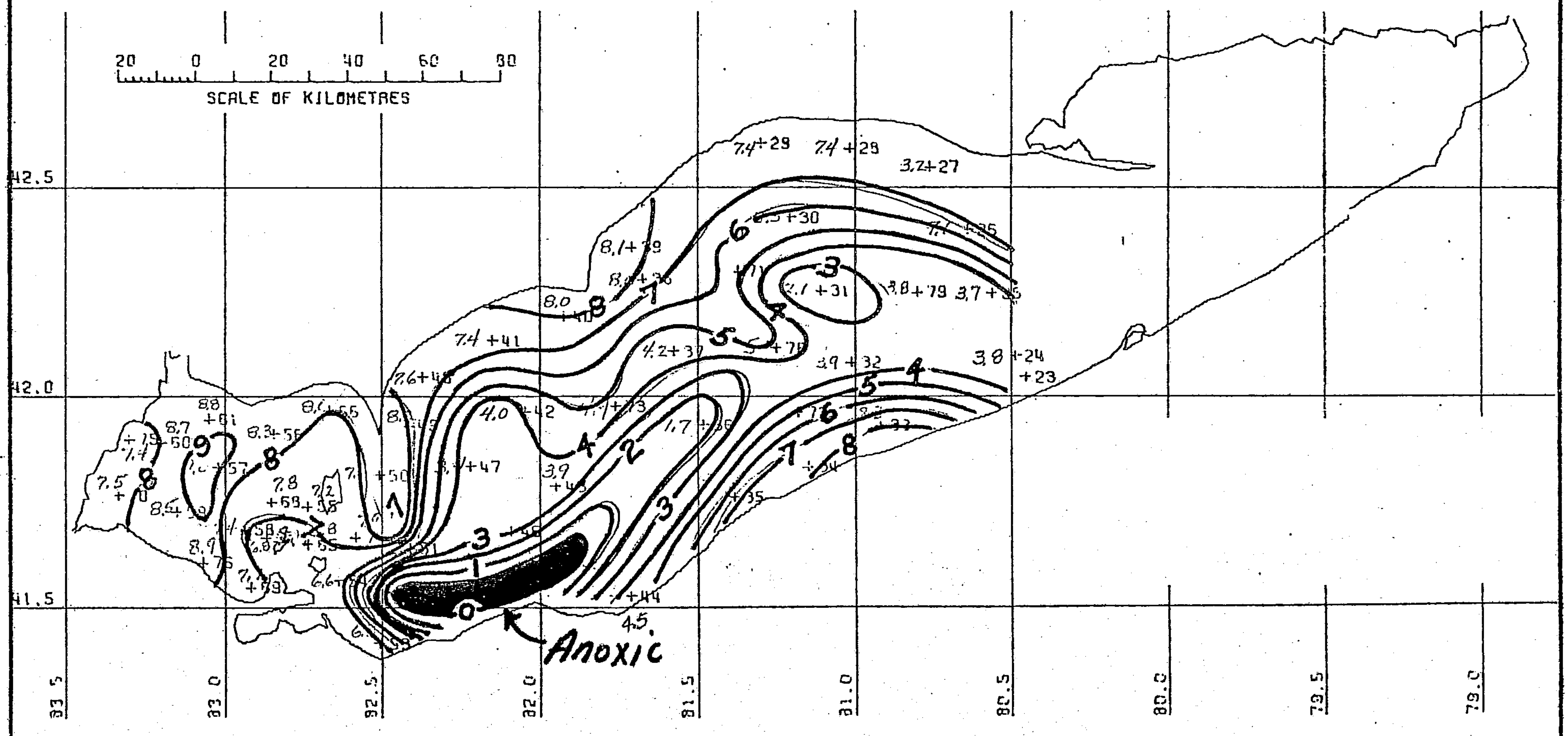
Bottom DO

Contour Interval: 1 ppm

CRUISE 3 7-20/7-21 7/13/7-20 & 7-24

FIGURE 4

CRUISE 4 8/27-9/7/75



4

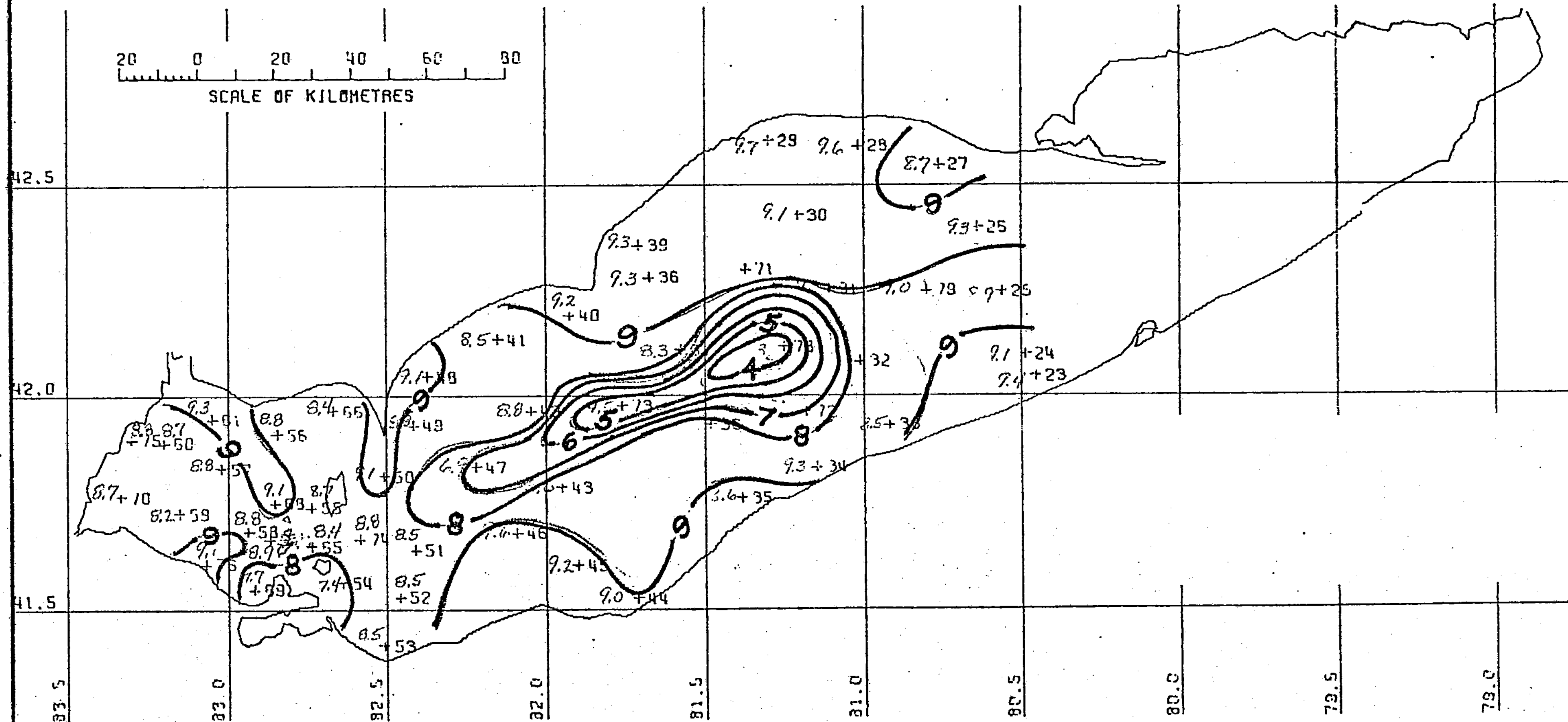
Bottom DO

Contour Interval: 1ppm

CRUISE 4 9-6/9-7 8-27/9-5

FIGURE 5

CRUISE 5 9/27-10/6/75



5

Bottom DO
Contour Interval: 1ppm

CRUISE 5 9/27 - 9/28 9/29 - 10/6

extensive area with less than 4 ppm DO persisted within a thin portion of the hypolimnion offshore from the Ohio shore. In late August and early September the maximum oxygen depletion occurred and resulted in the formation of an anoxic zone 50 km long and 8 km wide offshore between Cleveland and Huron, Ohio (Figure 4). The zone of water with less than 4 ppm DO occupied a more central part of the lake at this time flanked by more oxygenated water east of Cleveland and on the Canadian side of the lake. The nearshore portions of the lake had overturned by late September and early October dissipating the anoxic zone and leaving only a small zone of oxygen depression near the center of the basin where the lake remained stratified (Figure 5).

Oxygen Demand Rates

Changes in the configuration of the hypolimnion during 1975 are shown in Figure 6. The shape and area (Table 1) of the hypolimnion remain fairly uniform between Cruises 2 and 3 and experienced only moderate alterations between Cruises 3 and 4 which permits reasonable estimates of the oxygen demand rates within that layer of the lake. Table 1 lists the area, volume and mean thickness of the hypolimnion and the average temperature and dissolved oxygen of this layer during each cruise. This information permitted a preliminary calculation of oxygen demand rates between the cruises. The results of these calculations are presented in Table 2. Because the hypolimnion had undergone major modification between Cruises 4 and 5 (e.g. water temperature had risen from 10.5°C to 14.5°C indicating entrainment of warmer, more oxygenated water from overlying layers), calculations of oxygen demand rates are not as reliable as those for the earlier cruises.

Both the oxygen loss rates per unit area and per unit volume are comparable with rates obtained in 1973 and 1974 (Table 3). Therefore, the answer to the question why the lake did not go anoxic does not lie in a reduced oxygen demand in the hypolimnion.

Nutrient Regeneration

Although the analysis of nutrient data from the 1975 cruises has been completed, inspection of the results from representative stations show a profound decrease in the amount of nutrients regenerated when compared with 1974 results. For example, at Station 47 (mid-lake, northwest of Cleveland) in 1974, under anoxic conditions, the concentration of soluble reactive phosphorus (SRP) was 68.5 μg/l

FIGURE 6
HYPOLIMNION CONFIGURATION
CRUISES 2-5 1975

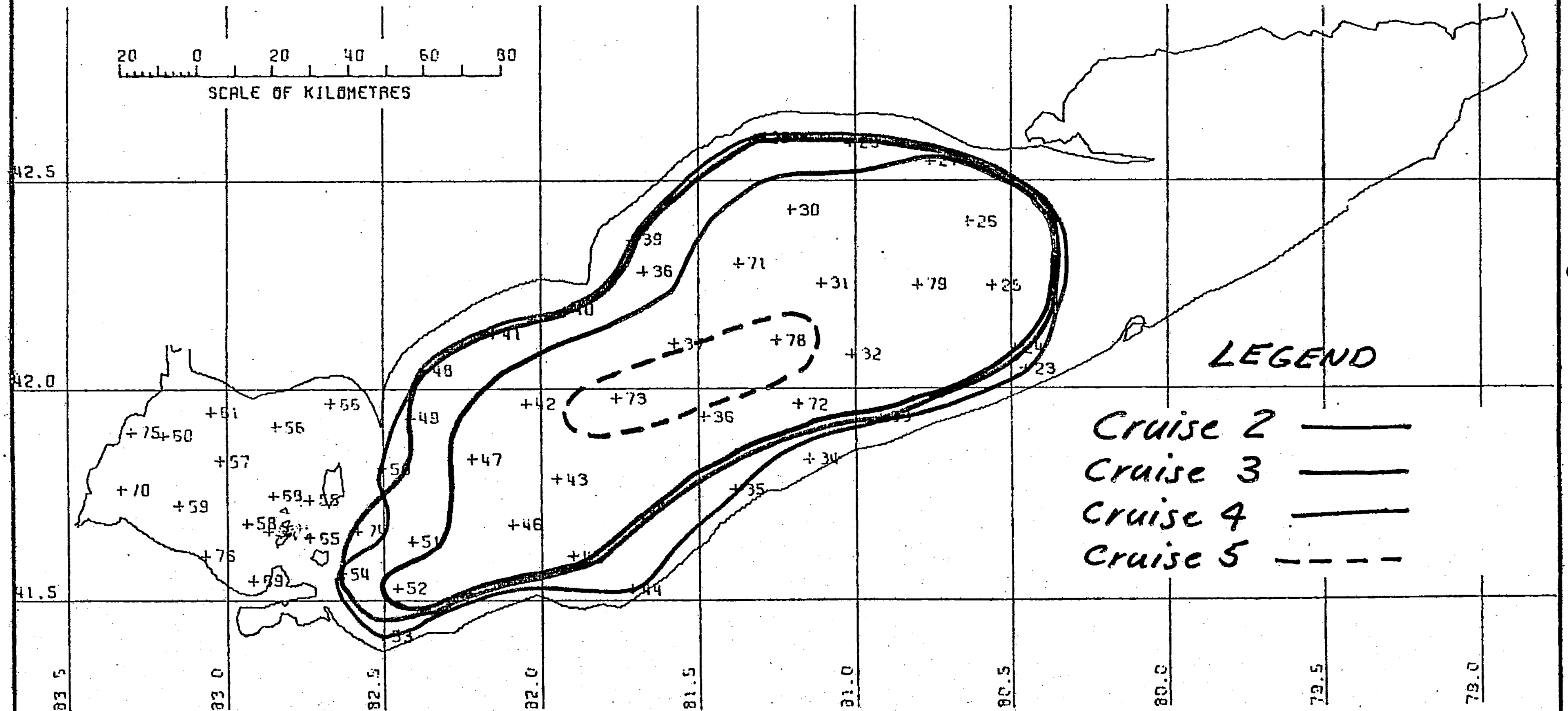


TABLE 1

HYPOLIMNION CHARACTERISTICS
CENTRAL BASIN OF LAKE ERIE
MARCH - OCTOBER 1975

Cruise No.	Dates	HYPOLIMNION CHARACTERISTICS Area (km^2)	Thickness (m)	Volume (km^3)	Temp. (^oC)	DO (ppm)	Anoxic Area (km^2)
1	3/29-4/25	0	0	0	-	-	0
2	6/9-6/16	12,400	6.9	86	7.4	10.1	0
3	7/13-7/24	13,300	5.7	76	9.0	7.5	0
4	8/27-9/5	9,800	5.8	57	10.5	3.5	400
5	9/26-10/6	1,100	3.0	3	14.5	4.3	0

TABLE 2

PRELIMINARY OXYGEN DEMAND CALCULATIONS FOR THE
CENTRAL BASIN HYPOLIMNION OF LAKE ERIE
JUNE - OCTOBER 1975

CRUISE	Days	DO loss ($mg\ O_2 \times 10^{12}$)	Ave. Area ($cm \times 10^{12}$)	Ave. Vol. ($l \times 10^{12}$)	Total DO loss/day ($mg\ O_2 \times 10^{12}$)	Area loss/day ($mg\ O_2/cm$)	Volume loss/day ($mg\ O_2/l$)
2-3	35	295.90	128.79	80.87	8.45	0.066	0.10
3-4	46	371.50	115.56	66.36	8.08	0.070	0.12
4-5*	29	184.94	54.16	29.93	6.38	0.118	0.21
2-4					8.24	0.067	0.11
2-5*					7.75	0.078	0.13

* At the time of Cruise 5, the hypolimnion had already undergone major modifications and, therefore, oxygen demand calculations are less meaningful than those from Cruises 2, 3 and 4.

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 (°C)	Thick (m)	DO (ppm)	Temp (°C)	Thick (m)	DO (ppm)	Temp (°C)	Thick (m)	DO (ppm)	Temp (°C)	loss/day ($mg\ O_2/cm^2$) Rate per unit area	loss/day ($mg\ O_2/cm^2$) Rate per unit area
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	–	–	–	0.049	0.11
1975	6.9	10.1	7.4	5.7	7.5	9.0	5.8	3.5	10.5	3.0	4.3	14.5	0.067	0.11

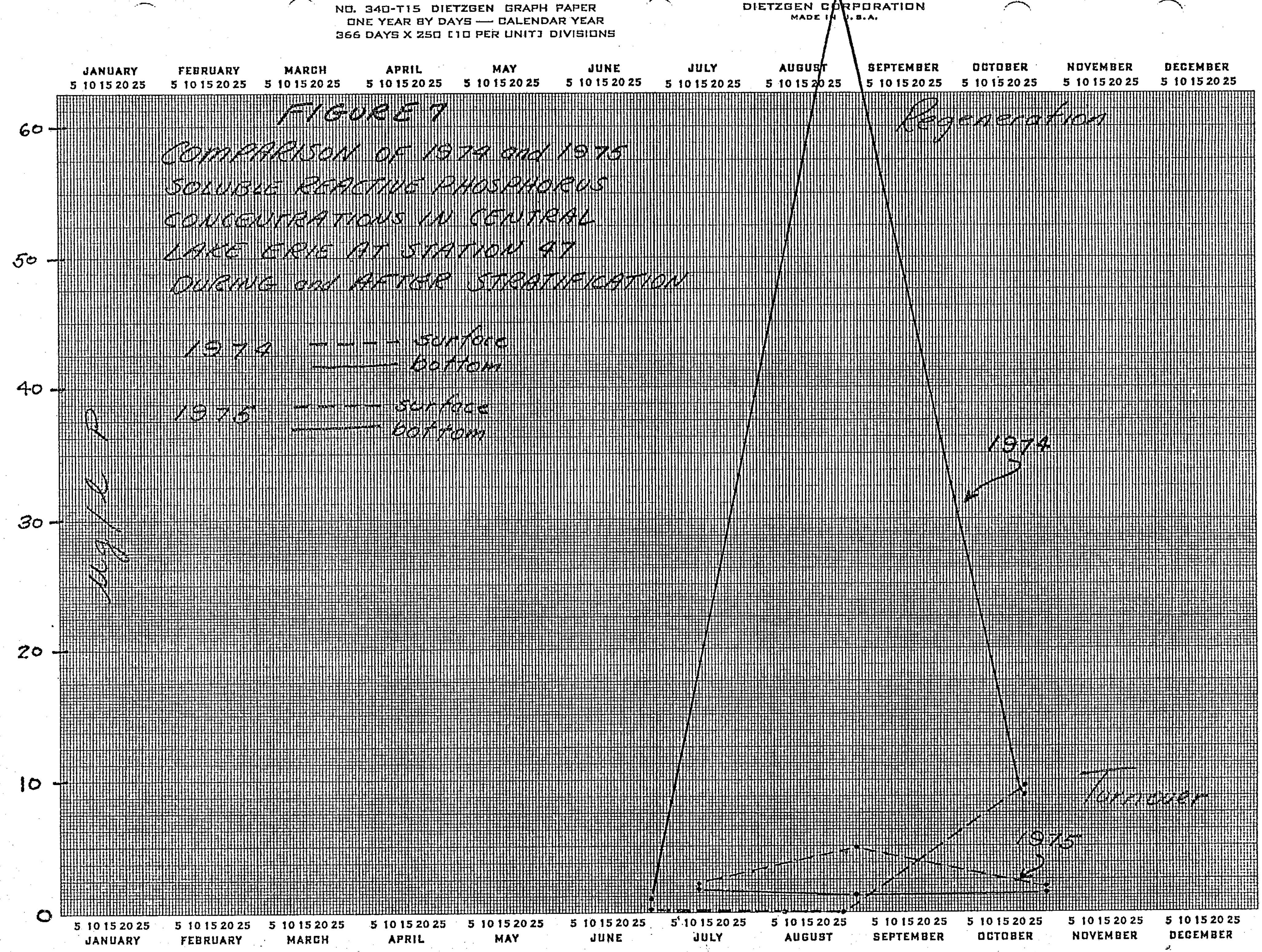
(Figure 7). In 1975, the hypolimnetic concentrations of SRP never exceeded 2.1 μg/l at this station because oxic conditions prevailed. After turnover and substantial mixing of the lake, the 1975 concentration of SRP at Station 47 was only 22% of SRP at this station after turnover in 1974. However, at Station 45 (15 km, north of Cleveland) the oxic microzone at the sediment/water interface was interrupted by anoxic conditions allowing the sediments to be reduced. Regeneration at this station resulted in a SRP concentration of 16.7 μg/l during Cruise 4.

In 1974, approximately 2100 metric tons of total phosphorus were regenerated into the central basin hypolimnion. Based on the results of selected 1975 station information it is estimated that a 25% to 50% reduction in total phosphorus loading from this source will be realized this year. If the estimated nutrient reduction is correct, a significant decline in algal biomass can be anticipated for 1976. Biomass reduction, in turn, can have a positive effect on lowering the rate of hypolimnetic oxygen demand.

Meteorological Conditions

A major change in the oxygen demand rate within the hypolimnion can be discounted as the reason for the remarkable improvement in the DO content of that layer. However, a comparison of hypolimnetic conditions for 1973, 1974 and 1975 provides some insight to this problem (Table 3). Compared with earlier years, from the onset the 1975 hypolimnion was thicker and contained a higher dissolved oxygen concentration. This situation persisted throughout the period of stratification. Apparently there was enough oxygen in the initial reservoir to satisfy the demand without depleting the hypolimnetic supply before the fall turnover replenished oxygen to the bottom.

The most plausible explanation for the thick hypolimnion involves the meteorological conditions at the time of thermocline formation. Figure 8 is a comparison of average monthly air temperature and wind recordings at Toledo, Ohio, for 1974 and 1975. In both 1973 and 1974 the air warming from April to May was approximately 7°F, whereas in 1975 the air temperature increased 20°F during the same period. During the spring months the wind speeds were considerably lower in 1975 (25% slower in May). It appears that a calm, rapidly warming spring can cause the thermocline to be fixed higher in the water column yielding a thicker hypolimnion. It was initially suspected that storms throughout the summer period resulted in the entrainment of warmer, oxygen-rich water from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ONE YEAR BY DAYS — CALENDAR YEAR
366 DAYS X 250 [10 PER UNIT] DIVISIONS
DIETZGEN CORPORATION
MADE IN U.S.A.
JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
5 10 15 20 25
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60
FIGURE 7
COMPARISON OF 1974 and 1975
SOLUBLE REACTIVE PHOSPHORUS
CONCENTRATIONS IN CENTRAL
LAKE ERIE AT STATION 47
DURING and AFTER STRATIFICATION
1974 - - - - surface
——— bottom
1975 - - - - surface
——— bottom
Regeneration
Turnover
1974
1975

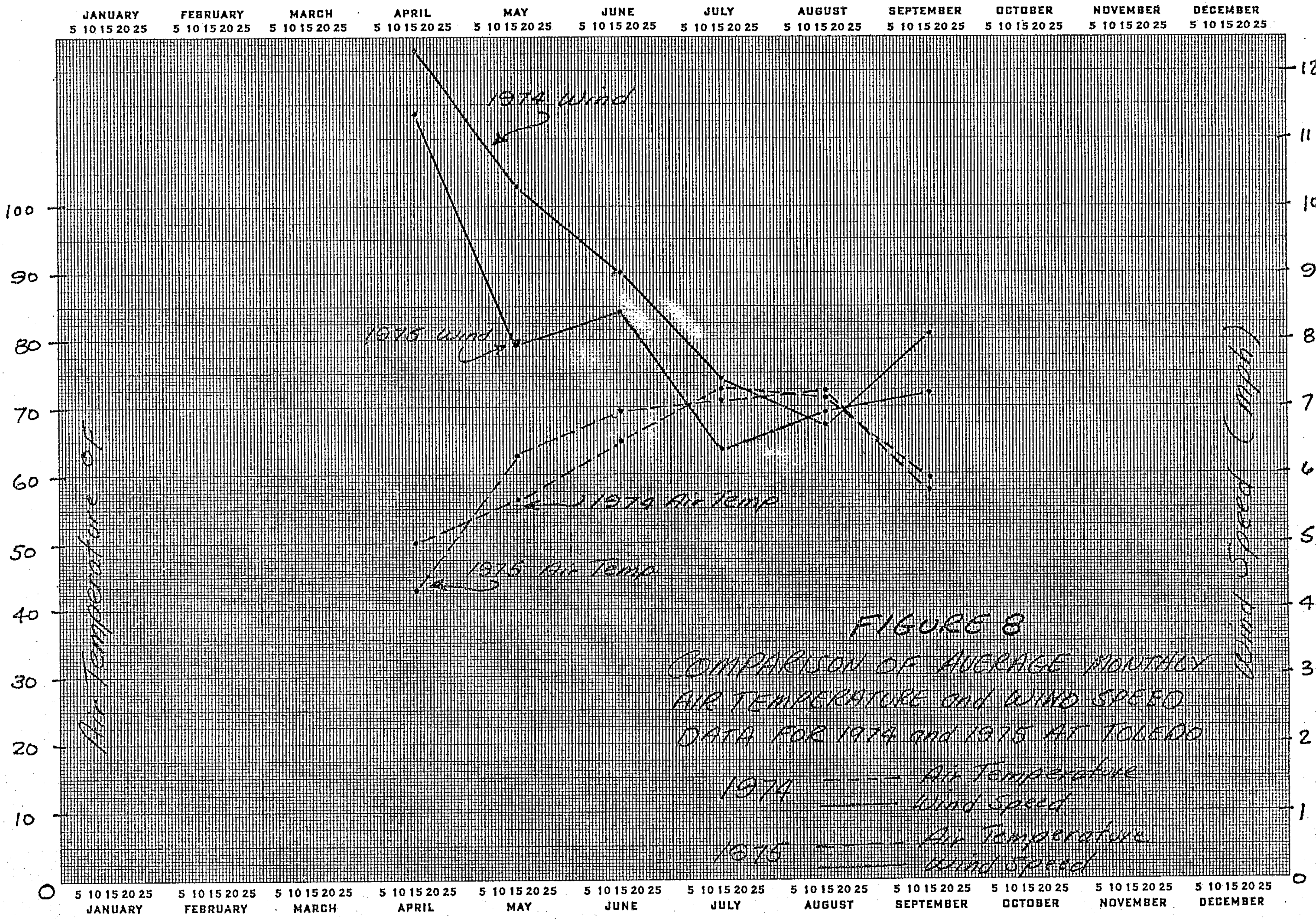

FIGURE 8
COMPARISON OF AVERAGE MONTHLY AIR TEMPERATURE and WIND SPEED DATA FOR 1974 and 1975 AT TOLEDO

the upper layers. However, the warming of the hypolimnion was not significantly different in the three years under consideration with the exception of September 1975 which occurred in conjunction with the fall turnover and has been discussed earlier. Average monthly wind speeds for June to September at Toledo were within one mile per hour for 1974 and 1975. This further substantiates the fact that increased entrainment did not occur as a result of unusual summer wind velocities in 1975.

The present information leads to the preliminary conclusion that spring weather conditions can greatly influence the thermal structure of Lake Erie and thereby affect the degree of oxygen depletion which takes place in the central basin. A much more detailed inspection of meteorological data throughout the Lake Erie basin should be undertaken to verify these effects.