PHYTOPLANKTON STUDIES IN THE NANTICOKE AREA OF LAKE ERIE 1969 - 1978

Ontario

Ministry of the Environment

The Honourable
Harry C. Parrott, D.D.S.,
Minister

Graham W. S. Scott. Q.C.,
Deputy Minister

PHYTOPLANKTON STUDIES IN THE NANTICOKE AREA OF LAKE ERIE 1969-1978

by

G.J. Hopkins and C. Lea
Ontario Ministry of the Environment
Limnology and Toxicity Section
Water Resources Branch
Box 213, Rexdale, Ontario, M9W 5L1

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PREFACE

Since the establishment of the Nanticoke Environmental Committee in 1968, annual phytoplankton surveys have been conducted in the vicinity of the Nanticoke thermal generating site on Lake Erie. Reports on the phytoplankton have been prepared every three years. The third report included a fourth year of data to finalize the first ten years of the Nanticoke study.

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ABSTRACT

Changes in abundance and seasonal composition of phytoplankton of the Nanticoke area of Lake Erie have been evaluated at eight to thirteen stations from 1969 to 1978. Water clarity, chlorophyll, phosphorus and temperature values were also assessed. These data are reported in three separate reports by Michalski (1972), Hopkins (1975) and Hopkins (1979).

Quantitative measurements of phytoplankton were recorded as Areal Standard Units per millilitre (A.S.U. per ml). The mean value for the ten year period is 382 A.S.U. per ml. The lowest annual mean value of 220 A.S.U. per ml occurred in 1969. The highest annual mean value was 634 A.S.U. per ml and occurred in 1978. However, the second highest level was attained in 1970 when an annual mean of 530 A.S.U. per ml was recorded. Statistical trend analyses of the phytoplankton data indicate that there is only a small increase (~4% per annum) with time.

Seasonal succession patterns and biomass levels showed fluctuations expressing unimodal, bimodal and even trimodal peaks from station-to-station and year-to-year. Of the four dominant taxa recorded each year, the first three were always *Fragilaria, Cryptomonas* and *Rhodomonas.* This is a good indication of the stability of the algal community at Nanticoke.

While phytoplankton densities have decreased in the western basin of Lake Erie coincident with decreased phosphorus loadings, there has been a slight increase in phytoplankton densities and only a small decrease in P concentrations in the Nanticoke area of the eastern basin of Lake Erie.

Temperature data collected from continuous recorders in the Nanticoke area showed that while temperatures frequently exceed 20°C during the summer months each year, they rarely exceed 25°C. There is no indication that the number of days in which the temperature exceeds 20°C or 25°C is increasing.

The long term stability of the phytoplankton community and temperature regime would suggest that heated inputs to Long Point Bay are well assimilated and are not affecting the biomass or species composition of phytoplankton in the study area.

INTRODUCTION

Since the establishment of the Nanticoke Environmental Committee in 1968, annual phytoplankton surveys have been conducted in the vicinity of the Nanticoke site on Lake Erie. Reports on the phytoplankton have been prepared every three years. The third report included a fourth year of data to finalize the first ten years of the Nanticoke study. This report is a summary of the findings of the previous three data reports.

METHODS

Field and laboratory methods are outlined in the triannual phytoplankton reports. Phytoplankton results throughout the ten year period of study have been reported as A.S.U. per ml (Areal Standard Units per millilitre) to maintain continuity. One areal standard unit is the area subtended by 400 square microns. The A.S.U. method has been used in conjunction with the Sedgwick-Rafter counting cell (A.P.H.A. 1960) and was adopted by the Ministry of the Environment (M.O.E.) for monitoring phytoplankton densities in water supplies and Great Lakes water quality studies in the early 1960's. For comparative purposes average algal densities have been reported as A.S.U. per ml and mm^3/L in Table 2, using the regression equation [1 A.S.U./ml = (476 mm^3/L) -55]; (r=0.98) developed by Nicholls (1977). Table 1 and Figure 1 show the frequency and locations of the phytoplankton monitoring programme.

RESULTS AND DISCUSSION

I. Annual Report Summaries

In the first report by Michalski (1972) emphasis was placed on differences between onshore and offshore phytoplankton densities. He indicated that the offshore stations 112, 501 and 648 (Fig. 1) had a higher biomass and that turbidity may have curtailed algal development at the onshore stations. Chlorophyll analyses indicated that the area was spatially homogeneous Chlorophyll-Secchi disc relationships and phytoplankton density and composition suggested that the area had an oligo-mesotrophic status. During the first three years there was an annual bimodal pattern of algal development at most

stations with maximum biomass occurring in August. The seasonal succession of phytoplankton was characterized by diatoms and cryptophytes in the spring, cryptophytes and greens in early summer followed by blue-greens in late summer and reverting back to cryptophytes and diatoms in the autumn. *Stephanodiscus, Fragilaria crotonensis, Cryptomonas erosa,* and *Rhodomonas minuta* were the most prominent algal forms observed.

The second report (Hopkins, 1975) covered the time period 1972 to 1974 and was compared to the first three year period. Secchi disc and chlorophyll data suggested that there was a slight shift toward a more mesotrophic state (Fig. 2). In 1972 there was a bimodal pattern of algal development but this pattern was not evident in 1973 and 1974 when an unimodal algal peak occurred in August represented at most stations by *Fragilaria crotonensis* and *Rhodomonas minuta.* This was followed by a rapid change to an almost exclusive population of blue-green algae later in the summer and during early autumn.

Both these occurrences, while suggesting a shift toward mesotrophy are offset by the fact that the annual mean algal biomass levels fluctuated between 1972 and 1974 and that turbidity increases derived from non-algal material may have influenced the chlorophyll-Secchi disc relationship.

The third report (Hopkins, 1979) covering the period 1975 to 1978 indicated no great change in algal biomass or species composition from 1975 to 1977. There was a return to bimodal and even trimodal algal peaks throughout the area at most stations. Annual mean values of 389, 335 and 393 A.S.U. per ml for the period 1975-1977 are very close to the mean value of 348 ± 38 A.S.U. per ml for the nine year period 1969 to 1977. In 1978, however, the annual mean biomass rose to 625 A.S.U. per ml, a substantial increase which caused the ten year mean to rise to 382 A.S.U. per ml (Fig. 3).

Nutrients, temperature, light conditions and zooplankton grazing are probably the most important factors controlling phytoplankton growth at Nanticoke. Chemical and other limnological data collected during the ten year period of study have been documented in "Nanticoke Water Chemistry" reports prepared by staff of the Water Resources Branch, Ontario Ministry of the Environment. Information on water clarity, (Secchi disc readings and turbidity), chlorophyll a and total phosphorus concentrations

may be obtained from the Appendices of these reports. Temperature records have been reported by Ontario Hydro in annual reports since 1970. Continuous recorders were used at twelve locations and vertical temperature profiles were taken at all chemical and phytoplankton sampling stations from April to December each year.

II. Phytoplankton, 1969-1978

(a) Biomass

The ten years of phytoplankton data collected from the Nanticoke area have shown a remarkably stable phytoplankton community. Year-to-year differences in seasonal periodicity, species composition and biomass have been only slight (Table 2).

The lowest annual mean phytoplankton biomass at Nanticoke was recorded in 1969 (220 A.S.U. per ml or 0.58 mm^3/L) and the highest value was recorded in 1978 (634 A.S.U. per ml or 1.45 mm^3/L). However, the previous high of 530 A.S.U. per ml (1.23 mm^3/L) was recorded in 1970 during the second full year of the study (Table 3).

Table 4 provides a summary of the mean phytoplankton densities for all stations by date for the years 1969 to 1978. Low values of 94 A.S.U. per ml on June 30, 1969, 71 A.S.U. per ml on May 5, 1974 and 72 A.S.U. per ml on June 22, 1976 were recorded. High values of 1,474 A.S.U. per ml on September 22, 1970, 833 A.S.U. per ml on April 19, 1977 and 1270 A.S.U. per ml on June 5, 1978 were recorded. The highest value of 1474 A.S.U. per ml on September 22, 1970 was caused by high densities of *Aphanothece* spp. The 1978 high was caused by a diatom pulse of *Fragilaria crotonensis* and *F. capucina.*

Mean algal biomass values of less than 200 A.S.U. per ml are considered very low and values of less than 500 are considered to be moderately low and representative of meso-oligotrophic conditions. Nicholls (1976) reporting in the Kawartha Lakes Water Management Study reported algal densities of 0.5 to 1.1 mm^3/L as low and values from 1.6 to 3.3 mm^3/L as being characteristic of moderate densities, while eutrophic lakes in the area had values ranging from 4.8 to 23.6 mm3/L.

Phytoplankton densities at Nanticoke are plotted against total phosphorus concentration in Figure 4, which shows the narrow range of these parameters from year to year.

Statistical analyses performed by Polak (1978) and by Heathcote (1979) indicated that up to 1977 there was no spatial or temporal change in the phytoplankton and that there was no statistically significant trend with time from 1969 to 1977. With the addition of the 1978 phytoplankton data there was a change in the long term trend indicating a small statistical increase of ~4% per annum over the ten year period.

(b) Taxonomic Composition

The three dominant taxa each year were *Fragilaria crotonensis, Cryptomonas erosa* and *Rhodomonas minuta* (Table 2). Dominant taxa were determined as those contributing most to the biomass of each class and expressed as a percentage of the total. Other genera that frequented the algal community were *Ceratium, Aphanothece, Oocystis, Scenedesmus, Melosira* and *Stephanodiscus.*

Another factor which points out the spatial homogeneity of the area was the dominance by a single taxon at all stations on specific dates. On August 25, 1969 *Ceratium hirundinella* was present at all ten stations and dominant at six of them. On August 25, 1970, *Aphanothece nidulans* was the dominant alga at all eight stations. In July, 1976 *Cryptomonas erosa* represented greater than 80% of the total biomass at nine of the ten stations. In 1978, *Chrysochromulina parva* dominated at eleven of thirteen stations on May 15th. *Fragilaria* spp. dominated at 12 stations on June 5th and at thirteen stations on October 11th. *Cryptomonas erosa* was present as the dominant alga at all thirteen stations on July 17th but on the next sampling date, August 14th, 1978 the algal population was dominated at all stations by the green alga Scenedesmus.

Phytoplankton - Temperature Relationships

Temperature may be a controlling factor or a lethal factor affecting phytoplankton growth. The controlling effect of temperature lies between the upper and lower lethal limits (McCombie, 1953). Most algae have an optimum temperature for growth and if this temperature is not reached or is exceeded then growth will be curtailed. The Nanticoke area of Lake Erie is typical of deep lakes in the North Temperate climatic zone where the temporal pattern of phytoplankton development is usually bimodal with minimum densities in winter and in midsummer and maximum densities occurring as vernal and autumnal pulses. The temperature regime at the time of these maximal pulses according

to McCombie (1953) ranges from 14°C to 20°C and, with the exception of some blue-green algae, temperatures of 25°C may be inhibitory to algal growth.

Makarewicz *et al* (1979) describing apparent changes in temperature optima of plankton in Lake Michigan showed that maximum algal densities were observed at the Chicago water plant when the water temperature was 10°C from 1936 to 1956. Since 1956 this optimum temperature dropped to 0-4°C with a concomitant change in algal species. Moore (1976) stated that *Cladophora* had an optimal growth temperature of ~20°C in the Nanticoke region and that temperatures approaching 25°C became inhibitory.

Ontario Hydro has summarized water temperature data in eight reports since 1967 presenting monthly mean, daily mean, and maximum and minimum hourly temperatures. The maximum monthly mean temperature recorded for all stations was 23.9°C in 1970 and 1978. It is interesting to note that this corresponds to the year of maximum annual mean phytoplankton density between 1969 and 1977.

Water temperatures of approximately 20°C during mid-summer can be considered "normal" for the Nanticoke area and changes of a few degrees over a few days would be unlikely to have important effects on the seasonal succession of phytoplankton. However, short periods of increased temperature may promote increases in densities of the resident population and this may account for the higher densities observed in 1978, particularly on June 5th and August 30th (Hopkins, 1979).

Other temperature data (Table 5) provided by Ontario Hydro (Walker, 1978) indicate that there have not been any increases in the number of days in which water temperatures have exceeded 20°C or 25°C. Summer season (June 21 - Sept. 21) daily temperatures exceeded 20°C on 67, 82 and 65 days in 1971, 1975 and 1978 respectively but reached 25°C on 0 days in 1971, on 9 days in 1975 and on 0 days in 1978. These selected data were taken from the Tower site at the 2 metre depth close to the Ontario Hydro heated effluent plume.

Data from Peacock Point, a location remote from the effluent plume, shows that in 1973 there were 71 days of 20°C temperature and 16 days of 25°C temperature. Clearly, it can be seen that there has been no increase in the number of days in which the

water temperature exceeded 20°C or 25°C and consequently water temperature has probably not had any important lethal effect on the phytoplankton of the Nanticoke area. Regression analyses do not indicate a statistically significant correlation (r = 0.03) between phytoplankton biomass and the number of days with water temperature greater than 20°C.

Phytoplankton-Nutrient relationships

Nutrient supply is another important factor which can have a limiting or controlling effect on phytoplankton growth. It is widely recognized that phosphorus is the most important element governing the trophic status of most lakes. Dillon *et al* (1978) document three well defined cases whereby changes in P concentration show a parallel change in phytoplankton yield. Given little year-to-year change in nutrient concentration, seasonal distribution of phytoplankton will also be remarkably constant. This appears to he the case at Nanticoke where the 10 year mean for total P concentration is 0.017 ± 0.001 mg/L and the 10 year mean for phytoplankton biomass is 382 ± 129.8 A.S.U. per ml. In the Great Lakes, low concentrations of phosphorus are associated with low densities of algae and high phosphorus concentrations are associated with high algal densities (Fig. 4). This relationship (Fig. 4) is especially useful for predicting the response of phytoplankton to changes in P concentrations brought about by increases or decreases in the P input.

With the implementation of P removal programmes on the lower Great Lakes in 1972, we anticipated lower algal biomass with decreased phosphorus loadings. Nicholls *et al* (1977) showed that in the western basin of Lake Erie there has been a 42% reduction in phytoplankton at the Union Water Treatment Plant between 1971 and 1975. This decline in phytoplankton was coincident with decreased phosphorus loadings from the Detroit River and P concentration in the nearshore areas of Lake Erie's western Basin.

However, there has been a 4% per annum increase in phytoplankton from 1969 to 1978 at Nanticoke even though the phosphorus loading to the eastern basin presumably has been reduced since P removal programmes were introduced in 1971. The mean P concentration at Nanticoke for the period 1969 to 1973 has shown a small decline (2% per annum) for this parameter over time (Weiler and Heathcote, 1979). The western basin of L. Erie by comparison is a eutrophic body of water with a ten fold higher algal

density, while the Nanticoke area is an oligotrophic area with P concentrations about one half that of the Union Area in the western basin of Lake Erie. Declines in phosphorus concentrations of at least 30-40% may be necessary to show a decrease in phytoplankton in the Nanticoke area.

SUMMARY

In summary, the ten years of phytoplankton data from the Nanticoke area of Lake Erie have shown a remarkably stable community. Year-to-year differences in seasonal periodicity, species composition and biomass have been only slight. Temperature and nutrient regimes have also shown a stable pattern over the ten year period of study. In view of this stability, the phytoplankton data base should be valuable in any future assessment of the Nanticoke study area.

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TABLE 1: Summary of Phytoplankton Data Collection - Nanticoke, Lake Erie, 1969-1978

Year	No. of Stations	Station Locations	No. of Sampling Dates	Sampling Depth
1969	8	112,501,518,648, 810, 994, 1008, 1016	16	1m or Photic Zone
1970	8	same as above	15	"
1971	9	" " " plus1040	13	"
1972	9	" " "	14	"
1973	9	" " "	15	"
1974	9	" " "	16	"
1975	11	" " " plus 1041,1042	15	Photic Zone
1976	10	" " " minus 1008	17	"
1977	10	" " "	12	"
1978	13	" " " plus1085,1086 & 1087	11	"

TABLE 2: Summary of Total P and Phytoplankton Data - Nanticoke, Lake Erie, 1969-1978.

Year	Reported By	Ave. µg/L	Average Density		Dominant Taxa
			A.S.U./ml	mm^3/L	1^{st}, 2^{nd},3^{rd}, 4^{th}
1969	M. Michalski 1972	23	220	0.58	Fragilaria, Cryptomonas Rhodomonas, Ceratium
1970	" " "	19	530	1.23	Fragilaria, Cryptomonas, Rhodomonas, Aphanothece
1971	" " "	16	387	0.93	Fragilaria, Cryptomonas, Rhodomonas, Oocystis
1972	G.J. Hopkins 1975	14	272	0.67	Cryptomonas, Rhodomonas, Fragilaria, Ceratium
1973	" " "	17	417	0.99	Fragilaria, Rhodomonas, Cryptomonas, Greens
1974	" " "	19	242	0.62	Fragilaria, Cryptomonas, Rhodomonas, Aphanothece
1975	G.J. Hopkins 1979	14	388	0.93	Fragilaria, Cryptomonas, Rhodomonas, Greens
1976	" " "	12	334	0.82	Fragilaria, Cryptomonas, Rhodomonas, Greens
1977	" " "	19	393	0.94	Fragilaria, Cryptomonas, Rhodomonas, Ceratium
1978	" " "	15	635	1.45	Fragilaria, Cryptomonas Rhodomonas, Aphanothece

Table 3: Summary of annual mean standing stock of phytoplankton at eleven stations at Nanticoke and at Dunnville, eastern basin, Lake Erie 1969-1978. All values expressed as Areal Standard Units per ml.

Station	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
112	172	445	335	250	386	201	340	252	331	503
501	231	487	518	199	341	192	435	241	270	592
518	245	538	452	254	307	249	351	333	480	521
648	204	516	304	278	466	264	357	288	325	566
810	228	539	332	301	497	233	481	347	354	715
994	320	664	446	324	654	286	403	450	384	653
1008	178	586	381	310	408	254	378	-	-	-
1016	167	478	414	214	334	248	360	265	321	692
1040	-	-	301	312	361	256	440	316	519	761
1041	-	-	-	-	-	-	359	337	435	593
1042	-	-	-	-	-	-	359	512	514	658
1085	-	-	-	-	-	-	-	-	-	790
1086	-	-	-	-	-	-	-	-	-	616
1087	-	-	-	-	-	-	-	-	-	590
All Stations	220	530	387	272	417	242	388	334	393	635
Dunnville	785	563	761	719	699	937	1228	1420	1342	1110

TABLE 4. Phytoplankton Data. Nanticoke, Lake Erie, 1969-1978. Mean biomass for all stations by date. All values expressed as A.S.U. per ml.

	Apr.		May		June			July		August		Sept.		Oct		Nov.			Dec.
Year	wk #	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	40	50
1969		232	366	160	105	142	94	393	222	211	383	145	194	211	234	266	—	162	
1970		-	538	444	200	396	330	357	687	584	910	869	1474	222	403	272	259	-	
1971	-	-	446	-	250	276	202	472	598	523	432	344	567	331	228	360	-		
1972	187	282	398	-	323	253	175	129	153	-	364	427	284	320	220	-	286		
1973	-	-	445	345	672	414	265	423	971	203	183	258	463	344	308	362	487		
1974		167	71	208	225	145	128	168	695	240	129	386	373	382	244	182	-	135	
1975	-	270	260	364	348	-	213	-	421	472	431	644	494	-	501	409	-	363	248
1976	435	479	-	132	80	72	344	308	222	516	749	449	327	193	359	402	-	279	
1977		833	356	294	389	193	448	463	442	463	503	-	167	169					
1978		353	476	1270	410	569	556	1177	521	682	583	-	384						

Table 5. Number of days in which water temperature exceeded 20°C and 25°C at various locations and depths, between June 21 and September 21, 1971-1978, Nanticoke Area, Lake Erie. Source: Ontario Hydro, Hydraulic Studies and Development Department.

Location	Depth (m)	Year	Number of days in which Temperature Exceeded	
			20°C	25°C
Peacock Point	2	1971	73	0
	2	1972	-	-
	2	1973	71	16
	2	1974	65	1
	2	1975	81	3
	2	1976	57e	0e
	2	1977	73	0
	2	1978	71	3
Tower Site (Sta.1040)	0.5	1974	55e	1e
	0.5	1975	86e	15e
	0.5	1976	67	1
	0.5	1977	64	5
	0.5	1978	66e	0e
Tower Site	1.5	1971	67	0
	1.5	1972	-	-
	1.5	1973	67	2
	2	1974	47e	0e
	2	1975	82e	9e
	2	1976	72	1
	2	1977	72	0
	2	1978	65e	0e

e = Records incomplete, some temperatures estimated from nearby measuring locations.

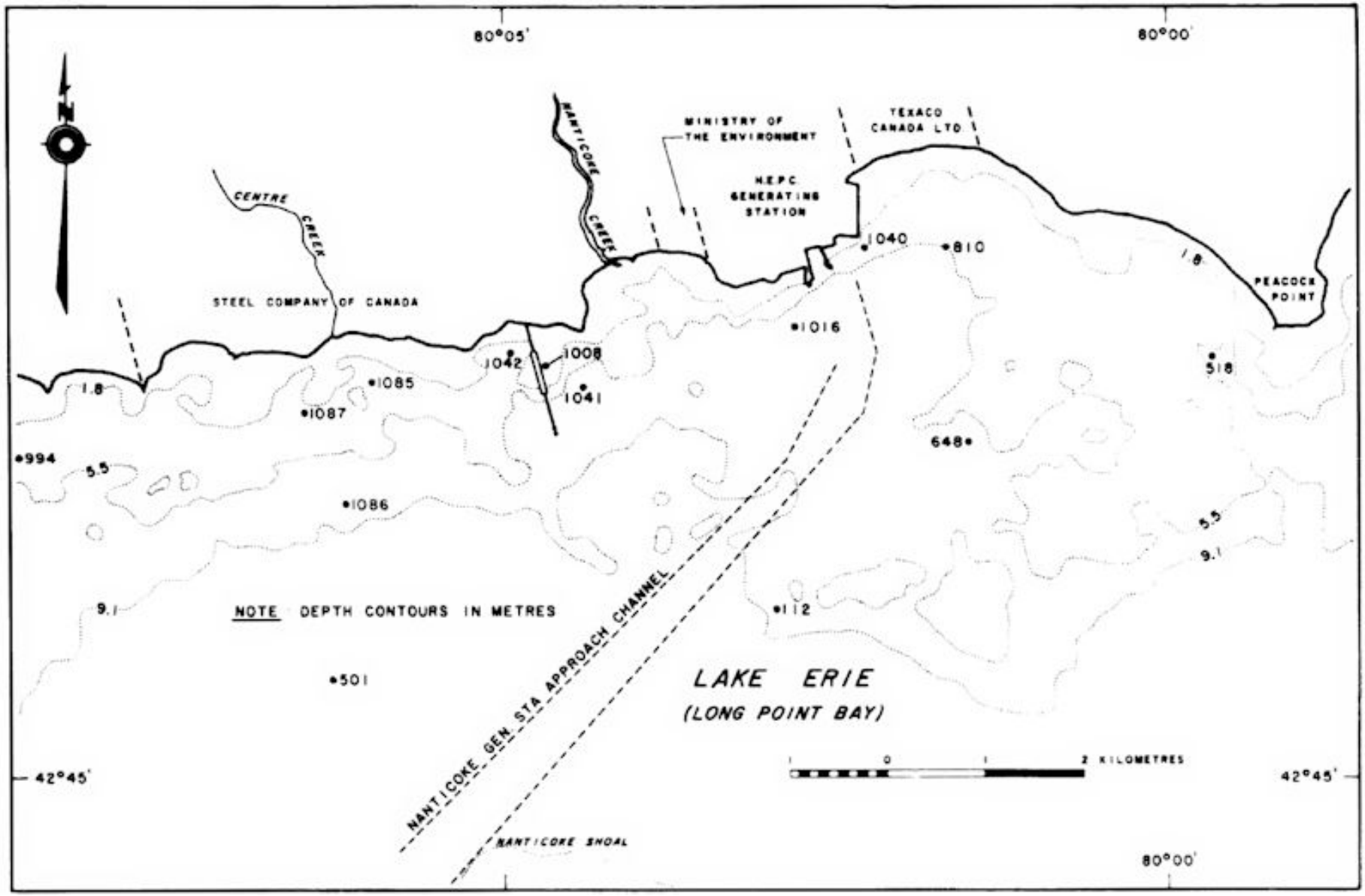

FIGURE 1: Nanticoke Sampling Stations (M.O.E.)

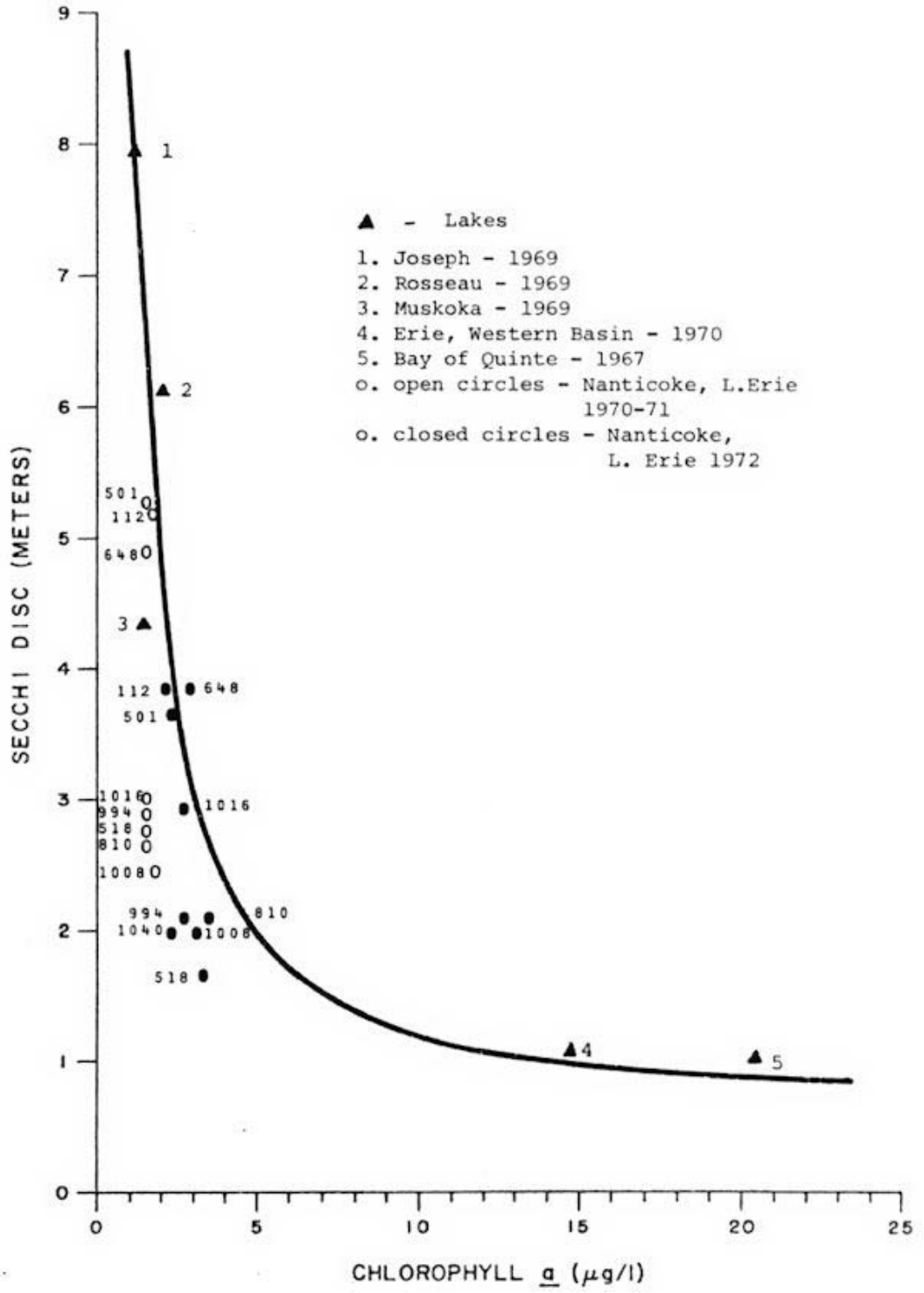

Figure 2: Chlorophyll a - Secchi disc relationship for nine stations in the Nanticoke Area of Lake Erie. Curve was developed from data on many Ontario lakes and data shown (other than Nanticoke data) are from Michalski et al. (1975).

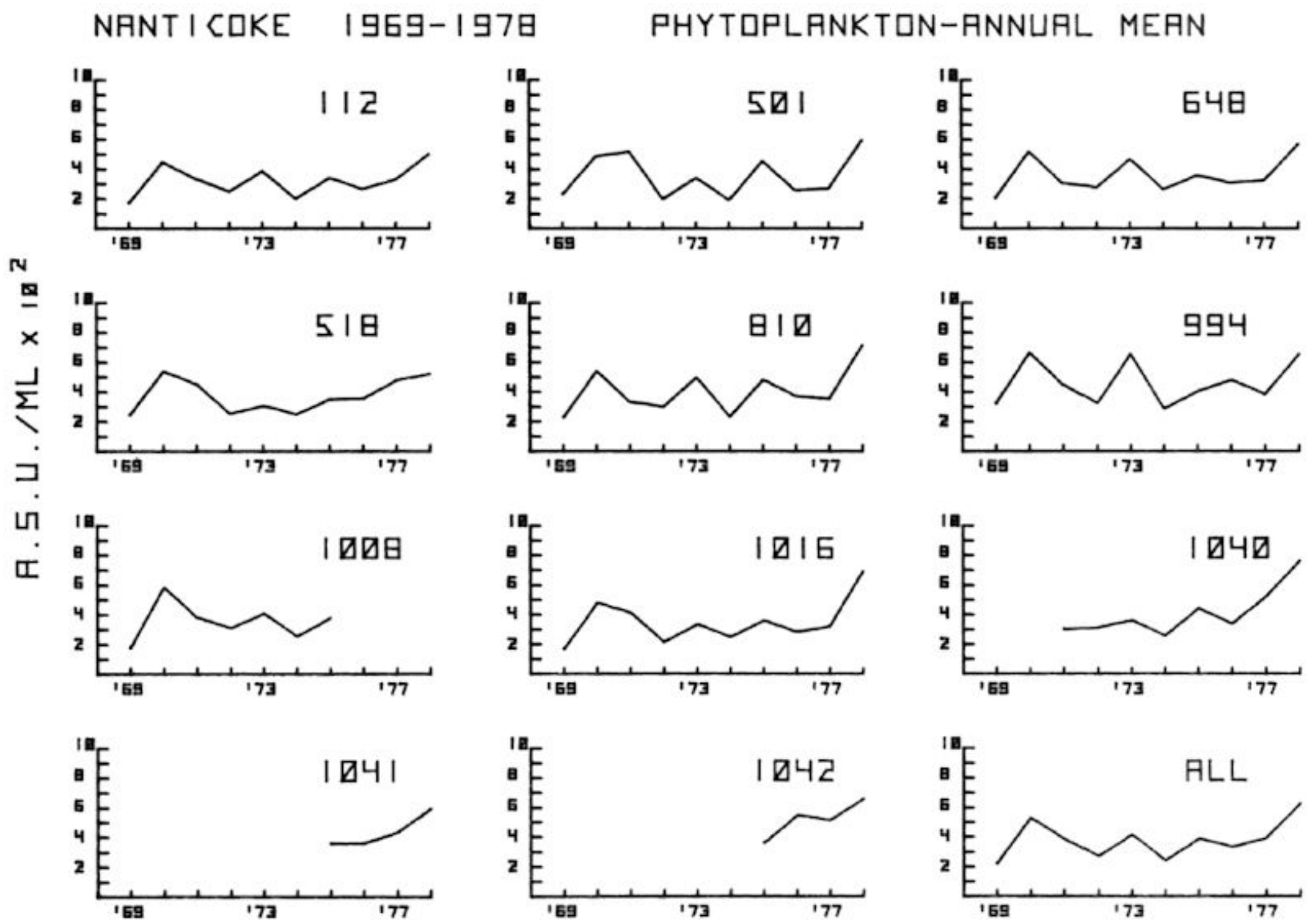
NANTICOKE 1969-1978 PHYTOPLANKTON-ANNUAL MEAN
A.S.U./ML x 10²
112
501
648
518
810
994
1008
1016
1040
1041
1042
ALL
2
4
6
8
10
'69
'73
'77

FIGURE 3:

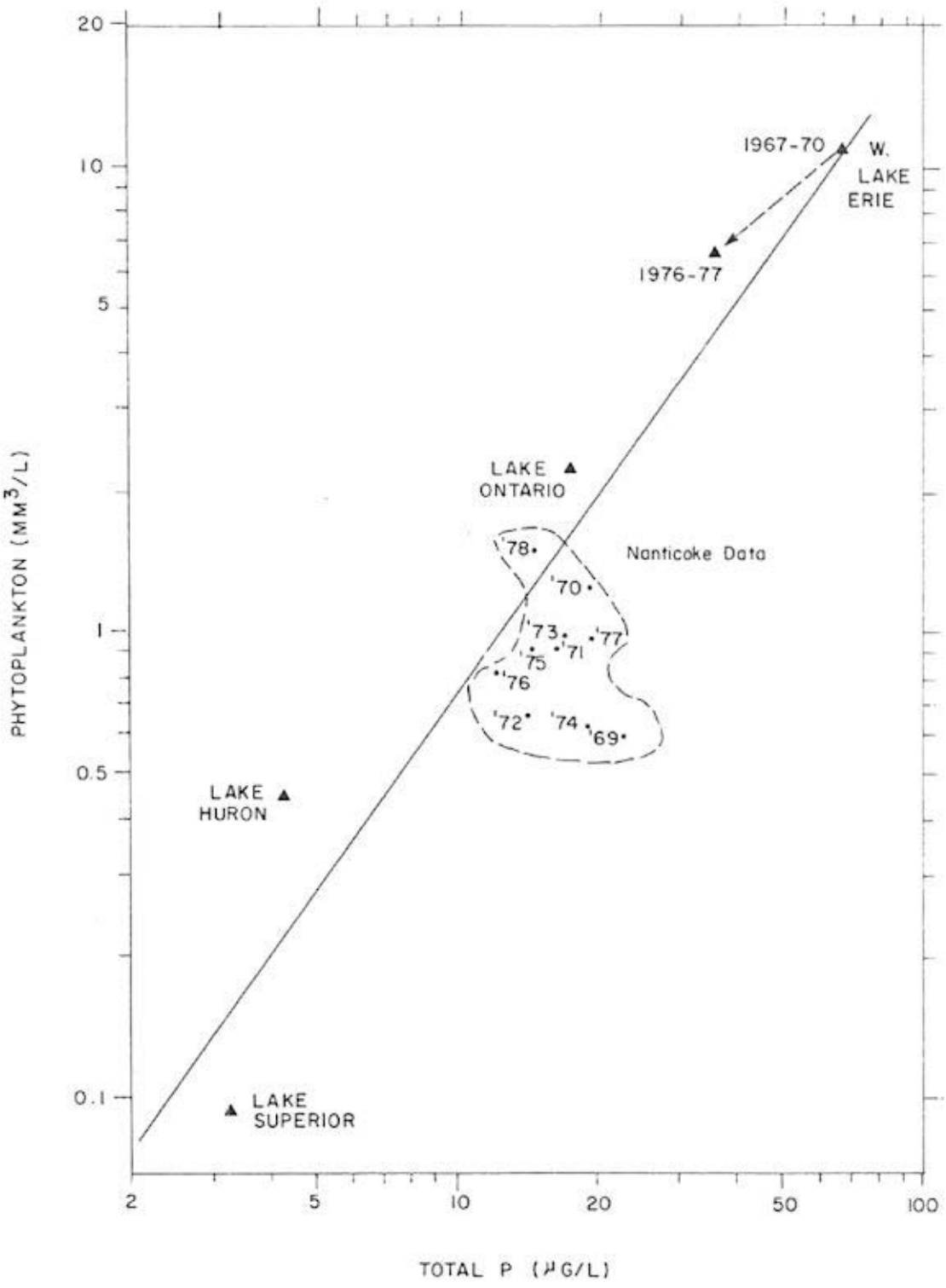

FIGURE 4: Relationship Between Phytoplankton Biomass And Total P Concentrations At Nanticoke And Other Great Lakes Locations.