PHYTOPLANKTON CONDITIONS IN THE NANTICOKE AREA OF LAKE ERIE 1972-1974

Ontario

Ministry
of the
Environment

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by

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SUMMARY

Changes in abundance and seasonal composition of standing stocks of phytoplankton were evaluated at nine stations in 1972, 1973 and 1974. These data were compared to previously reported data from 1969 to 1971 (Michalski, 1972). Water clarity, chlorophyll and phosphorus levels were also assessed.

Quantitative measurements of phytoplankton were recorded as areal standard units per millilitre. Over the period 1969-1974 there has been a small overall decrease in algal populations in the Nanticoke region with the exception of 1970 when there was a substantial increase in algal levels. The bimodal pattern of algae development described for 1969-1971, while present in 1972, was less pronounced and was not distinctly observable in 1973 and 1974.

Major changes in species composition were not detected from one year to the next. However, there was a shift toward a more homogeneous representation of all algal groups with a greater representation of the chlorophycean species during the mid-summer months.

While the overall picture of phytoplankton conditions at Nanticoke suggests that the area is both homogeneous and mesotrophic, continued monitoring will be important to ascertain if these conditions are altered.

INTRODUCTION

As part of preoperational biological water quality data, phytoplankton samples were collected at nine locations in the Nanticoke area of Lake Erie during 1972, 1973 and 1974. This report evaluates the abundance and changes in seasonal composition of standing stocks of phytoplankton at these locations and relates it to complementary chemical and physical data for the same period. During this time Ontario Hydro put its first two generators into commercial service at Nanticoke.

METHODS

Field Methods

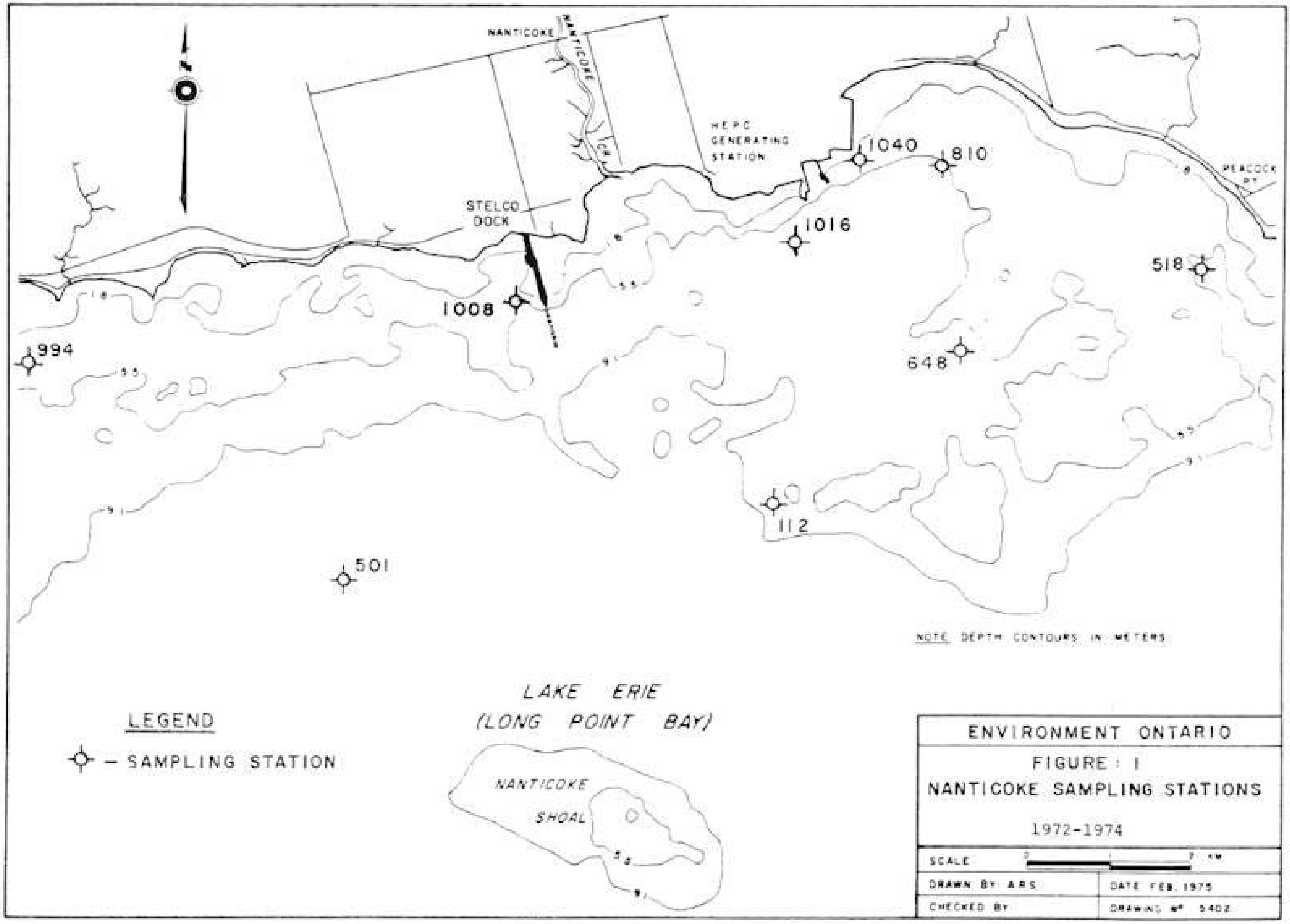
As in previous years, samples in 1972-73 were collected at nine stations (Figure 1) in the Nanticoke Area of Lake Erie for phytoplankton analyses. These stations were sited in by transit and permanently marked with aluminum spar buoys to ensure that all sampling occurred at identical locations as previously reported. Samples were collected as composites through the euphotic zone (twice the Secchi disc depth) at stations 112, 501, 648, 810, 994 and 1016, or at 1 metre of depth at stations 518, 1008 and 1040 approximately every two weeks during the ice-free season.

All samples were preserved with Lugol's iodine solution at the time of sampling and transported to the Ministry of the Environment's laboratories in Toronto for analyses.

Data on water clarity (Secchi disc recordings and turbidity measurements) chlorophyll a concentrations and total phosphorus were obtained from Water Chemistry reports of the Nanticoke region by Palmer (1972), Polak and Kennedy (1975a) and Polak (1975b).

Laboratory Methods

Algal samples were analysed as previously outlined in the preoperational report on "Phytoplankton Conditions in the Nanticoke Area of Lake Erie, 1969 - 1971" (Michalski, 1972).


NANTICOKE
NANTICOKE
C.R.
H.E.P.C.
GENERATING
STATION
STELCO
DOCK
1040
1810
1016
518
1008
994
648
112
501
PEACOCK
PT.
NOTE: DEPTH CONTOURS IN METERS
LAKE ERIE
(LONG POINT BAY)
NANTICOKE
SHOAL
LEGEND
– SAMPLING STATION
ENVIRONMENT ONTARIO
FIGURE: I
NANTICOKE SAMPLING STATIONS
1972-1974
SCALE
DRAWN BY: A.R.S.
DATE FEB. 1975
CHECKED BY
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The Bacillariophyceae (diatoms) were analysed taxonomically to the generic level and diatom slides were prepared for all sample submissions and placed in a permanent reference file. The smaller nannoplankton was identified and measured at 600X magnification using a 5 cc sedimentation chamber on a Nikon Inverted microscope. Quantitative results were expressed as areal standard units per millilitre (a.s.u. per ml). Taxonomic references included Prescott (1961), Patrick and Reimer (1966), Sieminska (1964), (1966), Huber-Pestalozzi (1938), (1941), (1942), (1968), Skuja (1948), (1956), (1964), Tiffany and Britton (1952), Bourrelly (1966), (1968), (1970) and Weber (1971).

Chemical analyses involved standard techniques utilized by the Water Quality Laboratory Section of the Ministry of the Environment.

RESULTS

Water Clarity, *Chlorophyll a* and Phosphorus Levels

Information on water clarity (Secchi disc readings and turbidity levels), chlorophyll a and total phosphorus concentrations for 1972 to 1974 is presented in Tables 1, 2 and 3. A close examination of the data indicates that water clarity was better at the three off-shore stations 112, 501 and 648 than at the six near-shore stations each year. There was no Secchi disc information collected in 1974. As indicated by Palmer (1972), Polak and Kennedy (1975a) and Polak (1975b) there was a pronounced seasonal difference but no significant station difference for turbidity, chlorophyll a and total phosphorus.

Standing Stocks of Phytoplankton

Tables 4, 5 and 6 summarize the standing stocks of phytoplankton in areal standard units per ml for the years 1972, 1973 and 1974 respectively. Additionally, mean a.s.u. values are provided by station and by date. 1974 mean a.s.u. values at the three off-shore stations were the lowest recorded to date.

Changes in the seasonal development and composition of the major taxonomic groupings (i.e. Bacillariophyceae, Chlorophyceae, Chrysophyceae, Cryptophyceae, Dinophyceae and Myxophyceae) are presented for the years 1972, 1973 and 1974 in Figures 1 through 9 of the Appendix.

Table 1. Summary of Secchi disc (m), Turbidity (J.T.U. - 1972, F.T.U. - 1973), Chlorophyll a (µg/L) and Phosphorus concentrations (µg/L) 1972.

	Secchi disc			Turbidity			Chlorophyll a			Total Phosphorus		
	Range	Mean	No. Analyses	Range	Mean	No. Analyses	Range	Mean	No. Analyses	Range	Mean	No. Analyses
In-Shore Stations												
518	1.0-3.5	1.7	5	1.8-8.5	4.8	9	1.0-5.6	3.5	9	7-22	13	9
810	1.0-5.0	2.1	6	2.0-8.0	4.3	9	1.0-5.6	3.6	8	6-16	13	9
994	1.0-5.0	2.1	9	6.1-8.9	8.3	9	1.2-5.3	2.9	9	9-19	14	9
1008	0.5-3.5	2.0	9	1.6-11	4.8	9	1.0-5.6	3.3	9	9-20	15	9
1016	1.5-5.0	2.9	6	1.8-5.5	3.5	9	1.4-5.6	3.0	9	5-22	15	9
1040	0.6-4.0	2.0	5	2.0-8.0	4.7	9	1.0-4.9	2.6	9	5-24	15	9
Off-Shore Stations												
112	2.5-6.0	3.8	9	1.8-5.5	3.2	9	0.6-4.6	2.5	9	7-22	14	9
501	2.0-7.5	3.6	9	1.8-6.5	3.6	9	1.3-4.6	2.6	9	5-19	13	9
648	2.0-7.2	3.8	9	1.6-5.5	3.1	9	1.2-5.2	3.0	9	7-16	12	9

Table 2. Summary of Secchi disc (m), Turbidity (J.T.U. - 1972, F.T.U. - 1973), Chlorophyll a (µg/L) and Phosphorus concentrations (µg/L) 1973.

	Secchi disc			Turbidity			Chlorophyll a			Total Phosphorus		
	Range	Mean	No. Analyses	Range	Mean	No. Analyses	Range	Mean	No. Analyses	Range	Mean	No. Analyses
In-Shore Stations												
518	1.0	1.0	1	1.2-12.0	5.2	7	1.1-3.1	1.87	3	11-30	18	7
810	1.5	1.5	1	1.0-8.7	4.7	7	1.3-3.8	2.13	3	9-31	18	7
994	1.2-1.3	1.25	2	1.1-9.8	4.8	7	1.8-4.2	2.80	3	14-27	19	7
1008	0.6-1.2	0.9	2	2.4-9.3	5.4	7	1.2-3.4	2.30	2	14-29	21	7
1016	1.5	1.5	1	1.7-9.8	4.4	7	1.2-4.6	2.90	2	10-24	15	7
1040	1.8-2.0	1.9	2	1.7-16.0	5.9	7	1.1-4.0	2.27	3	10-37	21	7
Off-Shore Stations												
112	3.4-7.3	5.35	2	1.1-2.9	1.6	6	1.2-3.4	2.20	3	8-22	14	6
501	4.3-6.0	5.15	2	0.7-3.3	1.5	6	1.2-3.8	2.07	3	9-27	14	6
648	3.0-4.3	3.65	2	0.9-3.5	1.8	7	1.1-3.1	1.87	3	7-19	14	7

Table 3. Summary of Turbidity (F.T.U.), Chlorophyll a (µg/L) and Phosphorus concentrations (µg/L) at nine stations, Nanticoke, L. Erie, 1974.

	Turbidity			Chlorophyll a			Total Phosphorus		
	Range	Mean	No. Analyses	Range	Mean	No. Analyses	Range	Mean	No. Analyses
In-Shore Stations									
518	0.20-13.0	4.7	10	0.3-2.8	1.5	10	10-39	23	9
810	0.20-10.0	4.1	10	0.4-2.1	1.1	10	10-38	19	9
994	1.20-11.0	4.9	10	0.7-3.3	1.5	10	7-42	34	9
1008	1.00-9.2	4.3	10	0.6-2.9	1.3	10	15-42	25	9
1016	0.88-9.4	4.5	10	0.3-3.0	1.3	10	10-39	22	9
1040	6.8	6.8	1	0.4-2.4	1.4	10	21	21	1
Off-Shore Stations									
112	0.69-4.5	2.4	10	0.3-3.0	1.1	10	12-33	19	9
501	0.55-4.2	1.9	10	0.3-3.0	1.2	10	8-20	14	9
648	0.90-10.0	3.0	9	0.4-3.3	1.5	10	8-30	17	9

Table 4. Summary of phytoplankton data at nine sampling stations in the Nanticoke area, Lake Erie, 1972. All results are expressed as areal standard units per millilitre.

Station	Apr 12	Apr 24	May 8	June 7	June 19	July 4	July 18	Aug 1	Aug 31	Sept 12	Sept 27	Oct 12	Oct 24	Nov 20	mean
112	105	399	424	290	276	160	86	190	369	403	258	89	203	252	250.29
501	121	271	510	243	163	219	183	113	233	54	217	267	48	141	198.79
518	104	211	507	117	190	247	159	145	261	335	438	378	169	294	253.93
648	55	220	493	439	189	235	132	146	698	361	264	19	252	400	278.79
810	253	297	445	304	488	121	120	171	168	409	248	399	491	294	300.57
994	128	301	462	395	236	192	97	171	578	774	279	473	166	286	324.14
1008	141	242	290	502	345	165	177	142	392	775	308	252	333	280	310.28
1016	285	245	151	283	179	75	102	149	278	224		313	209	293	214.31
1040	494	352	307	342	216	167	105	150	300	516	266	696	110	341	311.57
mean	187	282	398	323	253	175	129	153	364	427	284	320	220	286	

Table 5. Summary of phytoplankton data at nine sampling stations in the Nanticoke area, Lake Erie, 1973. All results are expressed as areal standard units per millilitre.

Station	May 14	May 28	June 11	June 25	July 7	July 23	Aug 7	Aug 21	Sept 4	Sept 19	Oct 1	Oct 15	Oct 31	Nov 13	Nov 28	Mean
112	454	235	524	220	-	361	756	303	139	-	575	322	-	162	586	386.42
501	309	106	394	105	197	416	1032	192	134	364	395	399	-	291	442	341.14
518	152	310	125	65	387	471	637	201	200	-	491	228	391	341	-	307.00
648	565	345	664	1400	38	472	676	177	227	-	546	-	184	182	578	465.69
810	187	495	1492	93	267	412	1116	177	291	-	469	471	320	581	591	497.29
994	815	201	1504	1025	465	-	2468	306	287	186	611	284	290	275	432	653.50
1008	688	683	491	701	406	505	522	168	107	306	342	161	308	539	189	407.73
1016	469	478	318	48	65	324	895	131	133	165	499	493	208	263	517	333.73
1040	367	257	536	74	299	-	643	175	129	273	247	400	461	626	564	360.79
mean	445	345	672	414	265	423	971	203	183	258	463	344	308	362	487	

Table 6. Summary of phytoplankton data at nine sampling stations in the Nanticoke area, Lake Erie, 1974. All results are expressed as areal standard units per ml.

Station	Apr 24	May 5	May 22	June 4	June 18	July 5	July 16	July 30	Aug. 13	Aug. 27	Sept 10	Sept 24	Oct. 9	Oct. 24	Nov. 6	Dec. 4	Mean
112	220	108	225	136	104	151	244	243	199	96	397	120	434	186	167	181	201
501	152	23	152	321	124	157	87	574	250	63	274	138	256	-	152	164	192
518	223	79	146	231	171	104	137	857	257	153	426	434	269	206	161	122	249
648	111	102	228	284	143	70	187	925	203	121	206	285	499	546	232	85	264
810	163	104	134	103	167	190	245	578	231	145	279	559	378	182	150	116	233
994	157	42	353	257	253	169	143	813	287	176	593	430	490	99	116	195	286
1008	162	4	234	196	160	85	161	592	297	136	547	477	350	211	371	77	254
1016	171	83	259	281	114	131	187	737	313	115	259	489	426	214	97	145	248
1040	148	97	141	220	74	96	125	943	127	162	493	428	341	313	261	133	256
Mean	167	71	208	225	145	128	168	695	240	129	386	373	382	244	182	135	

The bi-modal pattern of phytoplankton development in which two definite maximal peaks occurred at the off-shore stations in the 1969-1971 sampling period, while not distinct, was observed in 1972. This pattern was not well defined at any station in 1973 or 1974 but a distinct mid-summer maximum was reached in early August of both years with the exception of Sta. 112.

During each season similar proportions of major taxonomic groups were present throughout the study area. Major changes were not detected from one year to the next. Generally, cryptophycean and bacillariophycean (i.e. diatoms) algae predominated during the early spring and late autumn seasons although small to moderate numbers of chlorophycean (i.e. green), dinophycean and chrysophycean algae were encountered. During May and June of each year the diatoms dominated, followed by a cryptophycean pulse in July, 1972, a myxophycean pulse in June and July of 1973 and a diatom pulse in July of 1974. This was followed by a mixture of cryptophytes and greens in August with the addition of blue-greens to this flora in early September. In late autumn the diatoms dominated again with fewer numbers of Chrysophyceae, Cryptophyceae, Chlorophyceae and Dinophyceae present.

Specifically, during 1972 the cryptophycean algae *Cryptomonas* spp. and *Rhodomonas minuta* Skuja were present throughout the entire sampling period and dominated the flora in July and September. In April and May the chrysophyte *Dinobryon* spp. and the dinophycean alga *Peridinium* spp. were the most important forms present with moderate numbers of *Asterionella formosa* Hass., *Stephanodiscus binderanus* (Kütz.) Krieger, *Cryptomonas* spp. and *R. minuta* observed. In June, *Fragilaria crotonensis* Kitt. was the single most abundant organism present being replaced in July by *R. minuta*, and in early August by *Cryptomonas* spp. In the latter part of August and early September *Ceratium hirundinella* (O.F. Muell.) Dujardin appeared as the dominant form as it had in previous years. During this same period a variety of chlorophyceae forms including *Staurastrum* spp., *Coelastrum* spp., *Oocystis* spp. and the myxophyceans (blue-greens), *Gomphosphaeria* spp. and *Anabaena* spp. appeared. By the end of September *R. minuta* and *Cryptomonas* spp. had reappeared and dominated until overtaken by *Fragilaria capucina* Desm., *F. crotonensis,* and *S. binderanus* in October and by *S. binderanus* and *A. formosa* in November.

In 1973 phytoplankton samples were not collected in the month of April. *R. minuta, Cryptomonas* spp., *A. formosa, Tabellaria fenestrata* (Lyngb.) Kütz. and *S. binderanus* dominated the flora during mid-May being replaced in dominance by *Dinobryon* spp. by the end of the month. Lesser quantities of *R. minuta, Cryptomonas* spp., *Peridinium* spp. and *Tabellaria* spp. completed the flora until the end of June at which time the myxophycean *Merismopedia* spp. dominated for a short period. *R. minuta* reappeared as the dominant form in early July followed by *Anabaena* spp. toward the end of the month. From early August through to mid-October no single alga or algal group dominated the flora at any station with the occasional exception of *F. crotonensis.* Instead, each of the chrysophycean, cryptophycean, chlorophyceae, myxophycean and bacillariophycean groups were represented by a fairly homogeneous representation of taxa of which *R. minuta, Cryptomonas* spp., *F. crotonensis, S. binderanus, Tabellaria* spp., *C. hirundinella, Dinobryon* spp., *Oedogonium* spp., *Oocystis* spp., *Sphaerocystis* sp., *Coelastrum* spp., *Pediastrum* spp. and several unidentified chrysomonads were the most abundant. By late November the diatoms *S. binderanus* and *A. formosa* were the most important forms present.

1974 phytoplankton samples were obtained from the last week in April through to the first week of December. *T. fenestrata* was the dominant early spring diatom with *Peridinium* spp. present as the sub-dominant form until the end of May when the cryptophycean algae *Cryptomonas* spp. and *R. minuta* dominated and the diatoms *S. binderanus* and *F. crotonensis* became the sub-dominant forms. In early June *R. minuta* took over as the dominant alga with *Peridinium* spp. and *Dinobryon* spp. present as sub-dominant species. The cryptophyceans *R. minuta* and *Cryptomonas* spp. prevailed as the most important algae until the end of July when *F. crotonensis* appeared as the dominant form at a time when the algal biomass was at the season's highest level.

During the month of August, no one species dominated but representatives of the diatoms, greens, Cryptophyceae and Chrysophyceae were present. In late August and early September the myxophycean *Aphanothece* sp. appeared as the dominant form representing approximately 60% of the mean total for that time. By the end of September the diatoms were again the dominant form represented by *F. crotonensis* on September 24 and then being replaced by *Stephanodiscus* spp. until the end of the sampling season. During this autumn period the cryptophytes *R. minuta* and *Cryptomonas* spp. were the sub-dominant species as in previous years.

DISCUSSION

In the pre-operational report on phytoplankton conditions during 1969-71 (Michalski, 1972) chlorophyll a concentrations and Secchi disc readings for the nine sampling stations at Nanticoke were incorporated into a curve showing a near-hyperbolic relation for approximately sixty lakes including the Great Lakes. 1970-71 data are represented by open circles on the curve (Figure 2). It may be seen that the three off-shore stations 112, 501 and 648 are up on the oligotrophic arm of the curve whereas the in-shore stations 518, 810, 994, 1008 and 1016 tend toward the mesotrophic portion of the curve. The 1972 data represented by closed circles on the same curve (Figure 2) indicate that all the stations have moved farther down on the curve toward more mesotrophic conditions. However, this may be due to increased turbidity alone as the generally lower 1972 algal levels do not support this shift toward mesotrophy. Unfortunately, there were insufficient Secchi disc data available in 1973 and 1974 to incorporate into this curve.

Chlorophyll a and total phosphorus data from 1972-1974 (Palmer, 1972 and Polak, 1975b) were also plotted (Figure 3) and agree reasonably well with the relationship developed by Brydges (1971) for the Western Basin of Lake Erie. There is a good deal of year-to-year variability in mean phytoplankton biomass, although the fluctuations in the annual means for all stations follow a similar pattern from 1969 to 1974 (Figure 4). Data collected from the Dunnville Regional Water Supply located in the Eastern Basin of Lake Erie for the same time period have been included in Figure 4 for comparative purposes.

The lowest mean algal values at Nanticoke were recorded in 1969 (167 asu per ml at Station 1016) while the highest values were recorded in 1970 (667 asu per ml at Station 994). The 1972 and 1974 means were very near the low values of 1969 while the 1973 mean levels approximated the highs of 1970. The two-way analyses of variance test used by Polak (1975b) for chemical parameters was applied to the phytoplankton data from 1969-1974. The results indicated that there was no statistical trend for the data with time.

The temporal bimodal pattern of algal development observed from 1969 to 1971 (Michalski, 1972) was present in 1972. The mid-summer sag in nutrient concentrations corresponded with the midsummer low in algal levels and chlorophyll a values in 1972. In 1973 this bimodal pattern was not observed but a seasonal maximum was reached in August. This followed closely a nutrient pulse observed in July of 1973.

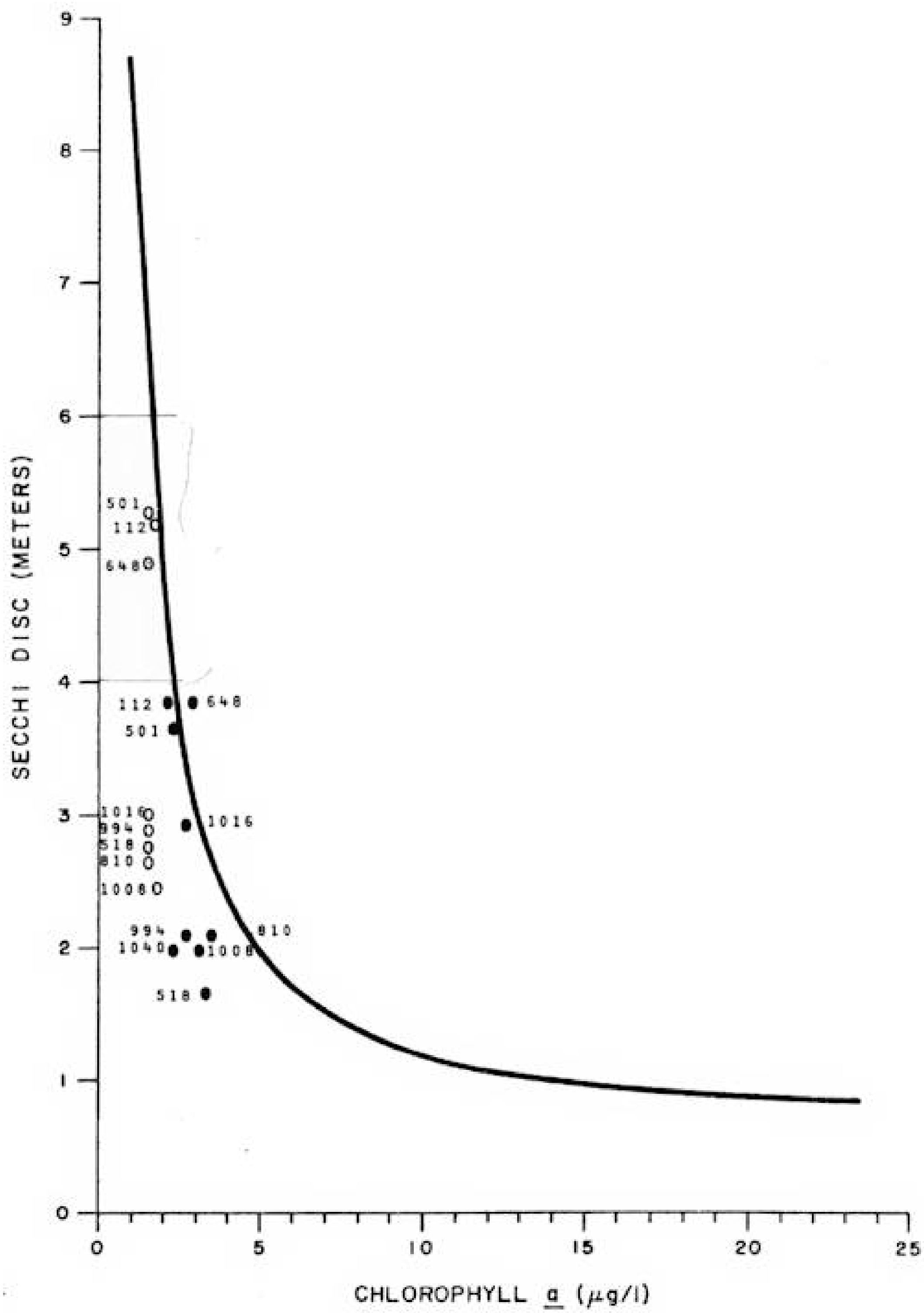

Figure 2: Chlorophyll a - Secchi disc relationship for nine stations in the Nanticoke Area of Lake Erie. Open circles represent mean values of 1970-71 data. Closed circles represent 1972 data.

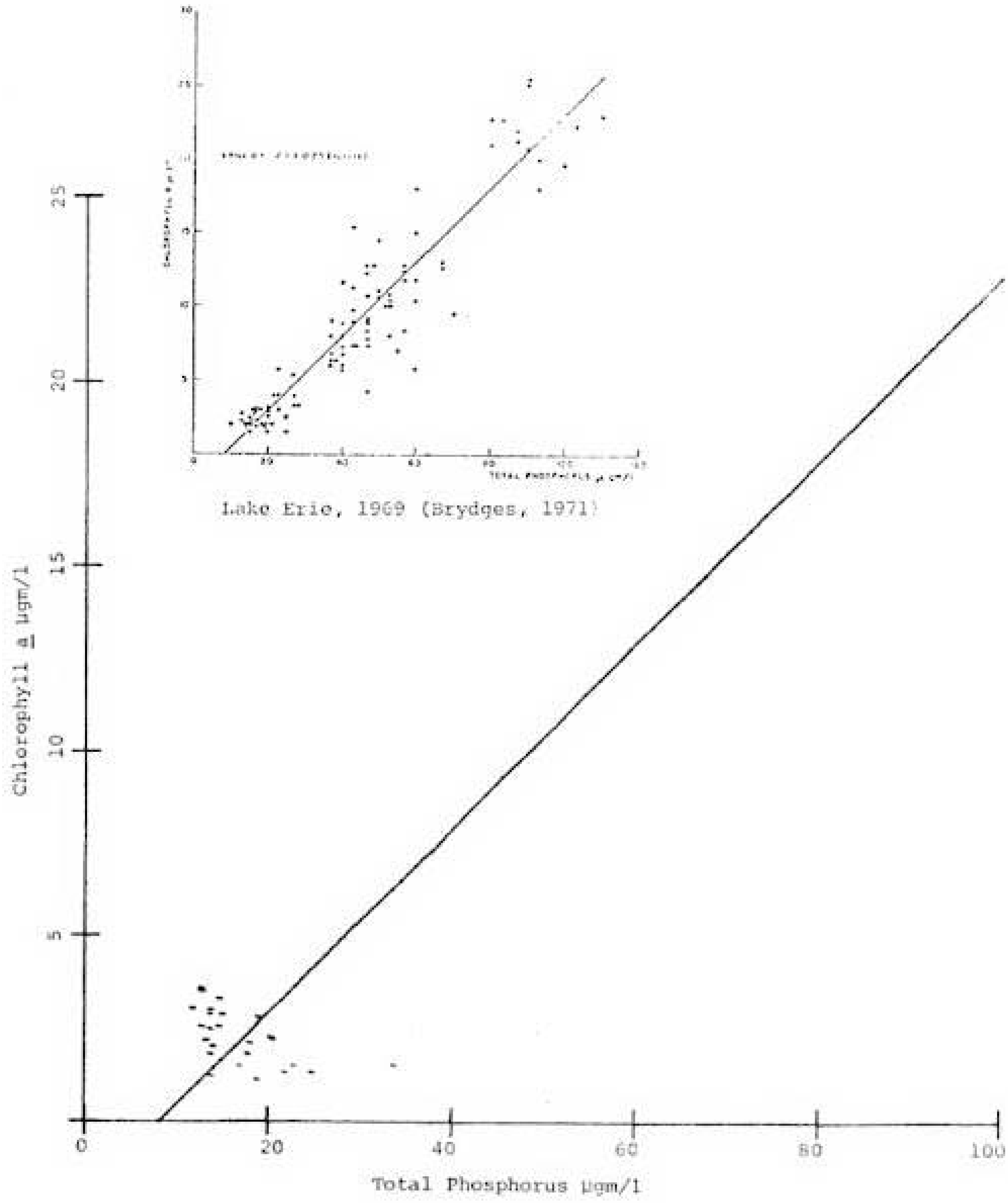

Figure 3: Chlorophyll a - Total Phosphorus relationship at eight stations (1972) and nine stations (1973 & 1974) in the Nanticoke Area of Lake Erie, with respect to Lake Erie data 1969 (Brydges, 1971).

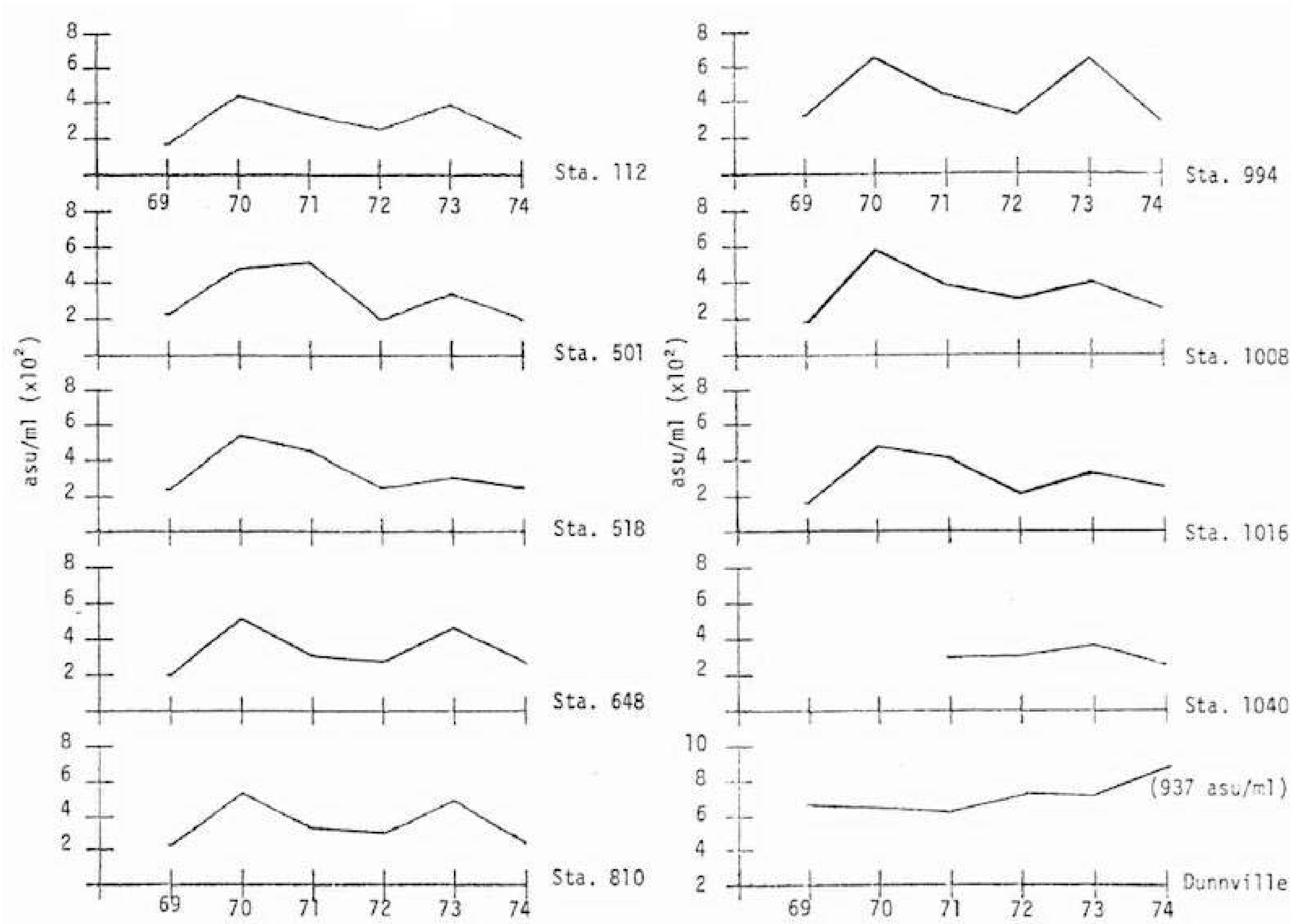

Figure 4. Annual mean phytoplankton levels (expressed as a.s.u./ml) at nine sampling stations in the Nanticoke Area and at Dunnville, Lake Erie, 1969-1974. (Note scale for Dunnville is 200 units higher than for other stations).

In 1974 the seasonal maximum was observed at the end of July.

A change from bimodal distributions of phytoplankton to more uniform seasonal distributions including mid-summer maxima characterized the eutrophication process in the Western Basin of Lake Erie over the period 1919-1963 (Davis, 1964). In addition to conclusions derived from the chlorophyll a / Secchi disc data (above), the absence of a bimodal distribution and the presence of a mid-summer phytoplankton peak during 1973 and 1974 may be further recent evidence for slightly increasing eutrophy of the study area.

In 1973 and 1974 no single alga or algal group, with the occasional exception of *Fragilaria crotonensis,* dominated at any station during the midsummer period. Rather, a more homogeneous representation of each group including numerous species of the chlorophycean group was present. In each of these years the mid-summer peak was followed by a blue-green pulse.

Water clarity varied from station to station from 1972 to 1974. While Michalski (1972) suggested that high turbidity at the near-shore stations curtailed development of algal biomass, re-examination of the data shows that the onshore areas had consistently higher levels (6 - 17% higher) of algal biomass throughout the entire study period.

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APPENDIX

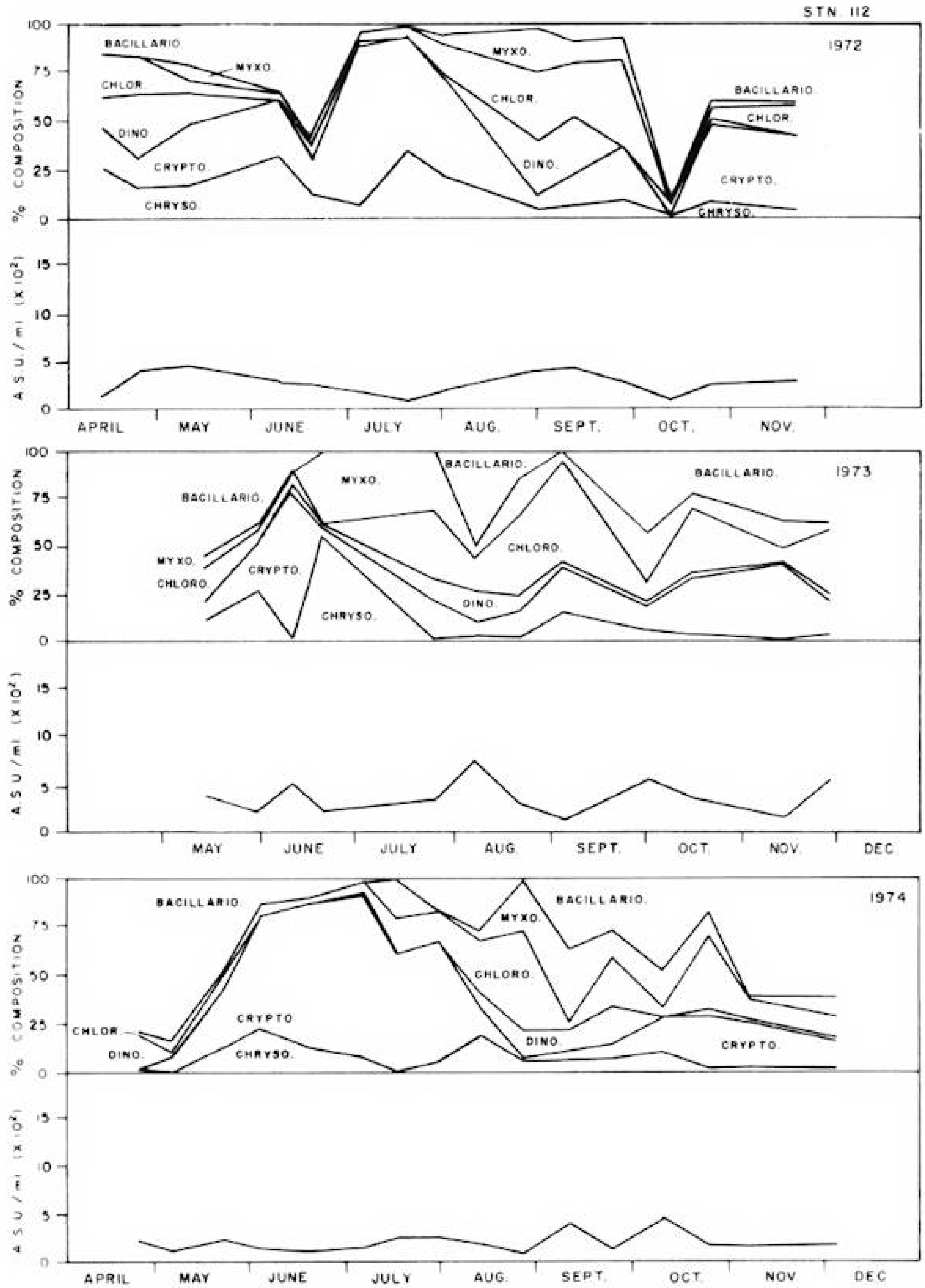

Figure 1: Seasonal changes in phytoplankton abundance (in a.s.u./ml) and species composition (%) at Station 112 in the Nanticoke area of Lake Erie. Data are presented for 1972, 1973 and 1974.

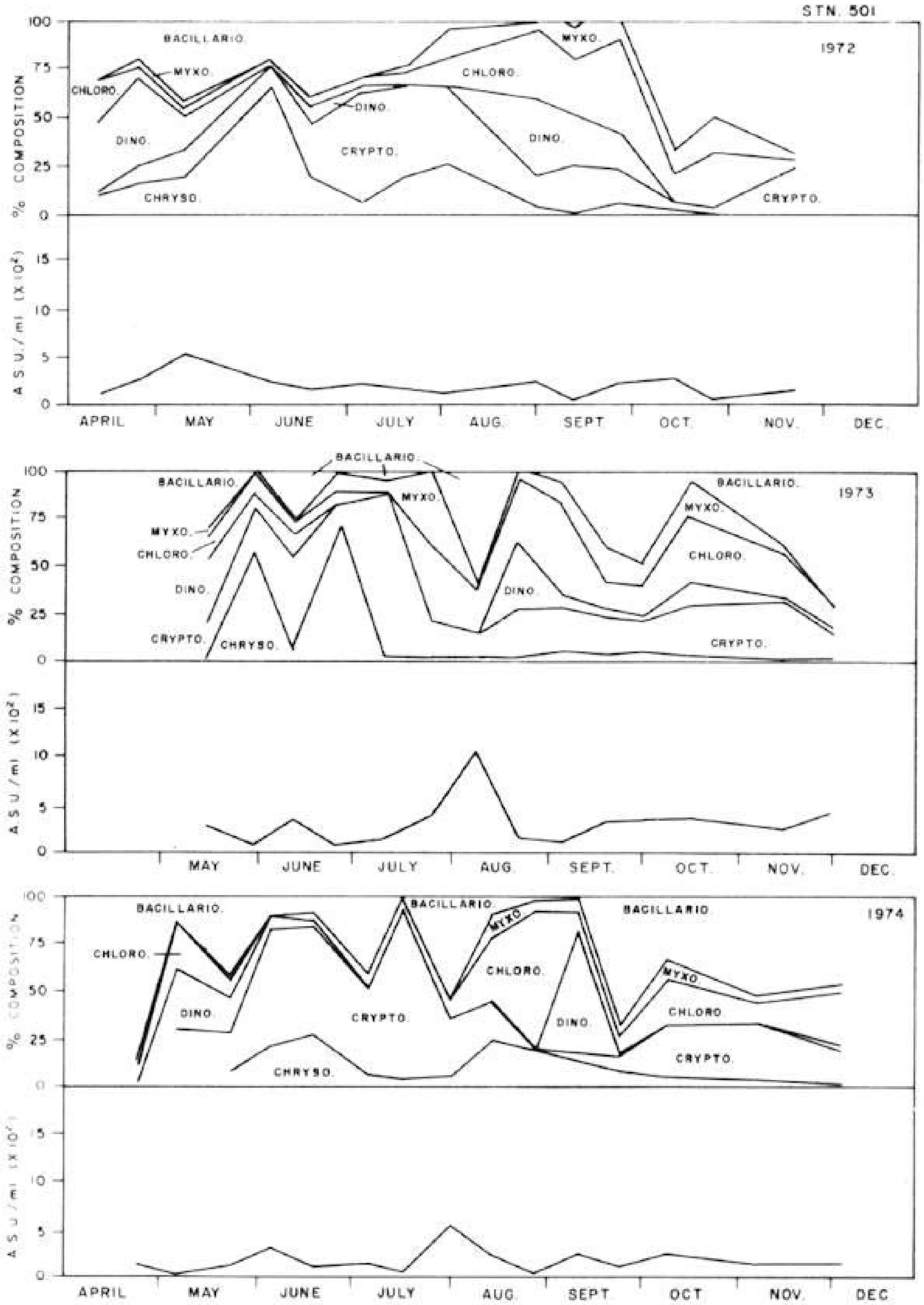

Figure 2: Seasonal changes in phytoplankton abundance (in a.s.u./ml) and species composition (%) at Station 501 in the Nanticoke area of Lake Erie. Data are presented for 1972, 1973 and 1974.

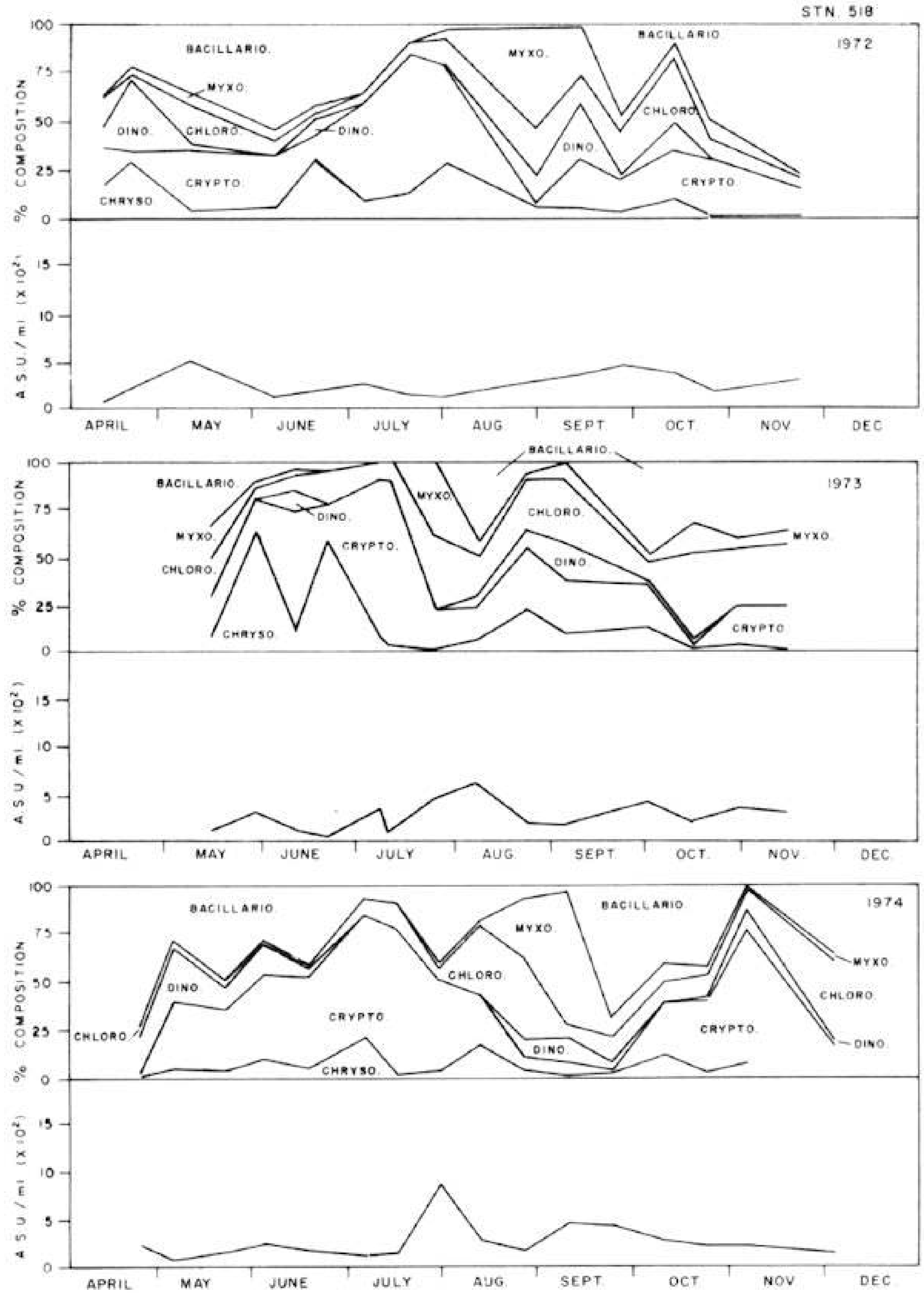

Figure 3: Seasonal changes in phytoplankton abundance (in a.s.u./ml) and species composition (%) at Station 518 in the Nanticoke area of Lake Erie. Data are presented for 1972, 1973 and 1974.

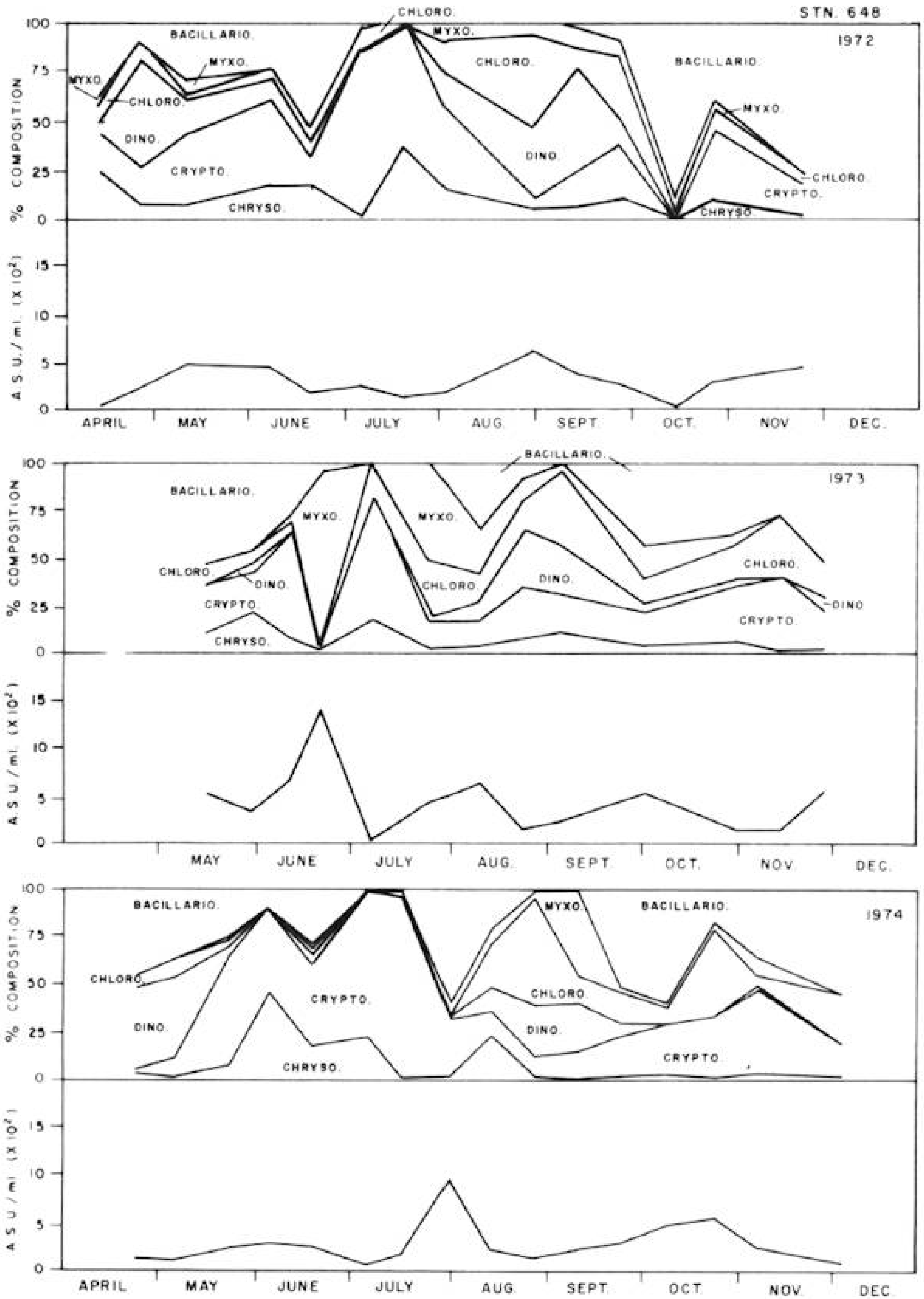

Figure 4: Seasonal changes in phytoplankton abundance (in a.s.u./ml) and species composition (%) at Station 648 in the Nanticoke area of Lake Erie. Data are presented for 1972, 1973 and 1974.

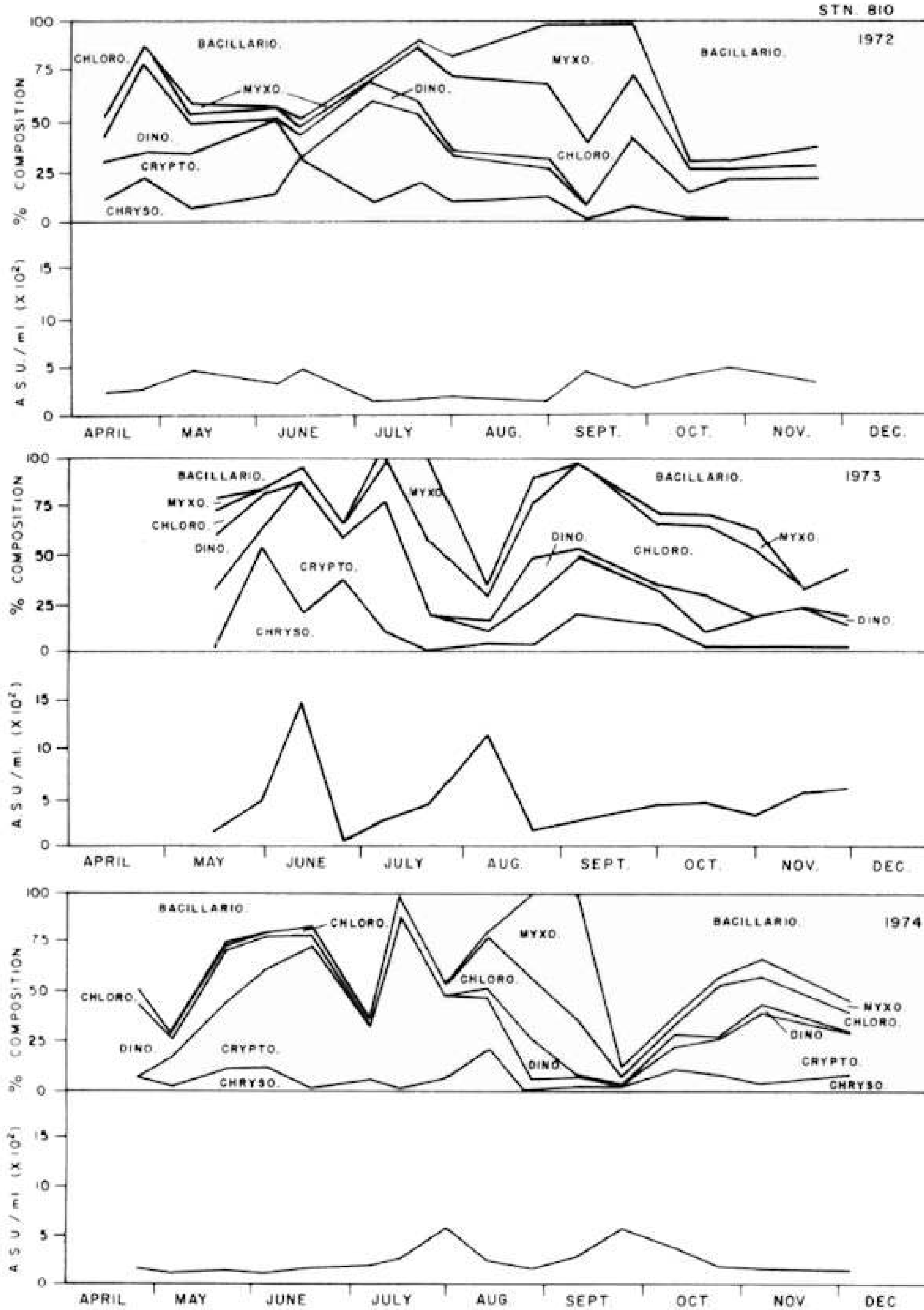

Figure 5: Seasonal changes in phytoplankton abundance (in a.s.u./ml) and species composition (%) at Station 810 in the Nanticoke area of Lake Erie. Data are presented for 1972, 1973 and 1974.

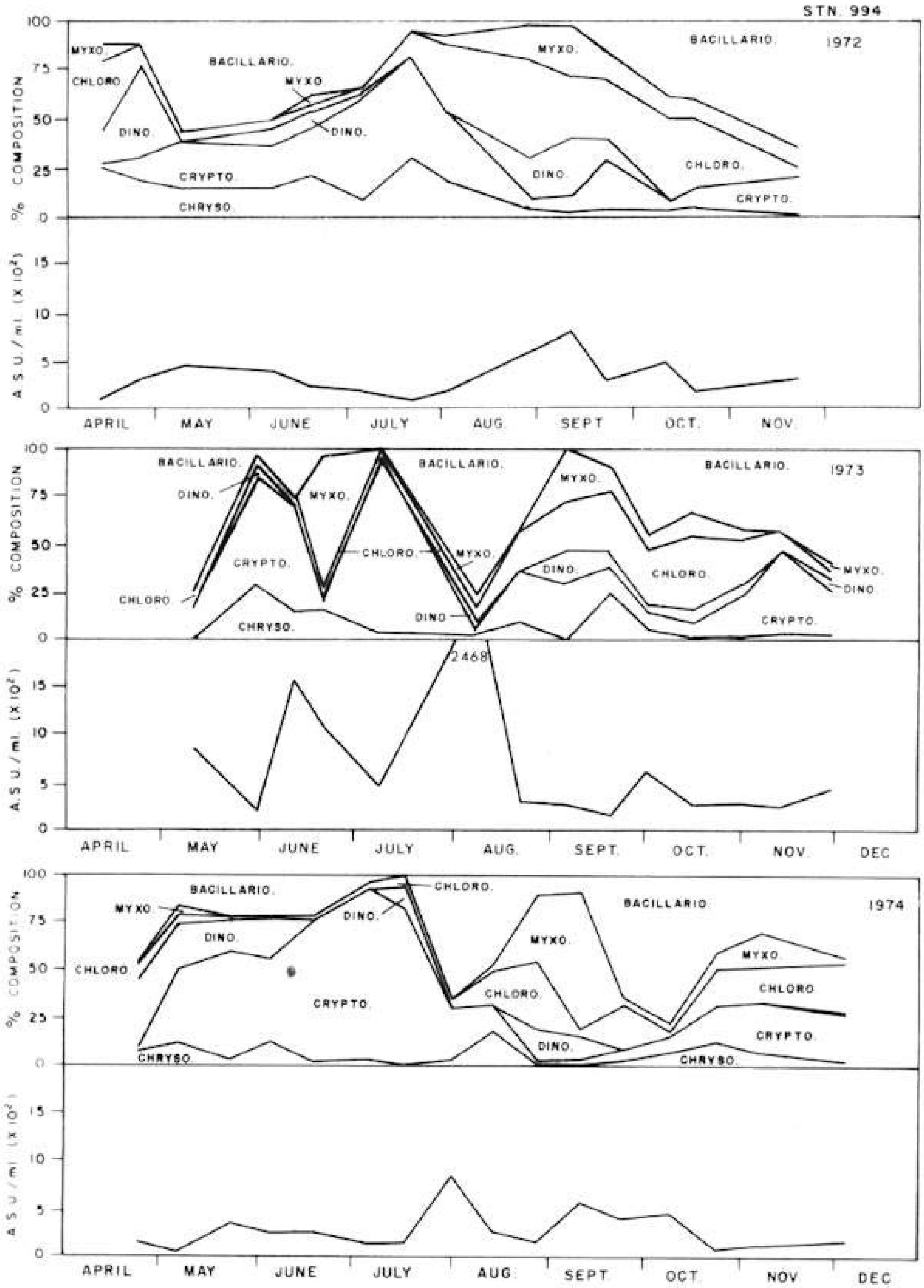

Figure 6: Seasonal changes in phytoplankton abundance (in a.s.u./ml) and species composition (%) at Station 994 in the Nanticoke area of Lake Erie. Data are presented for 1972, 1973 and 1974.

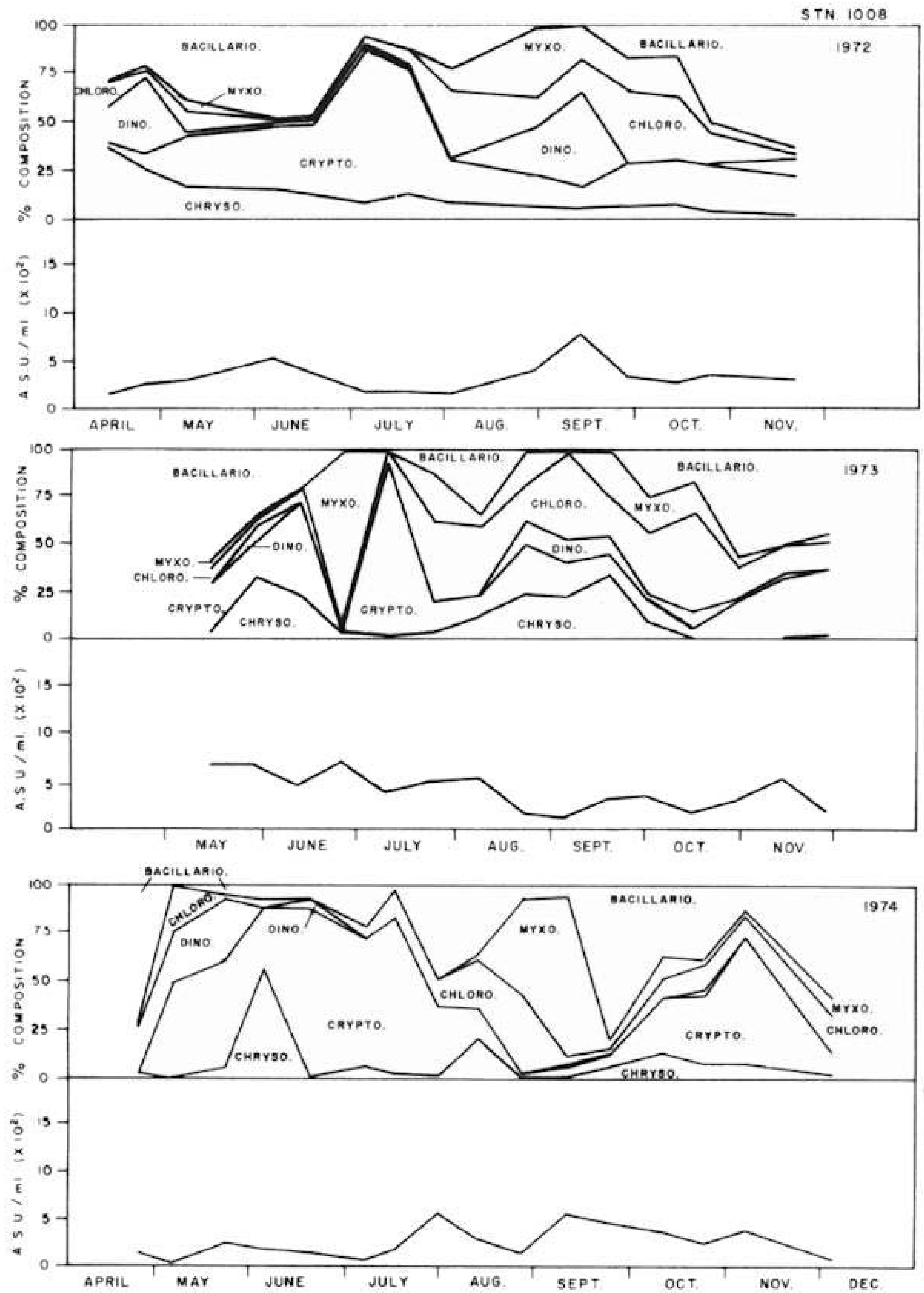

Figure 7: Seasonal changes in phytoplankton abundance (in a.s.u./ml) and species composition (%) at Station 1008 in the Nanticoke area of Lake Erie. Data are presented for 1972, 1973 and 1974.

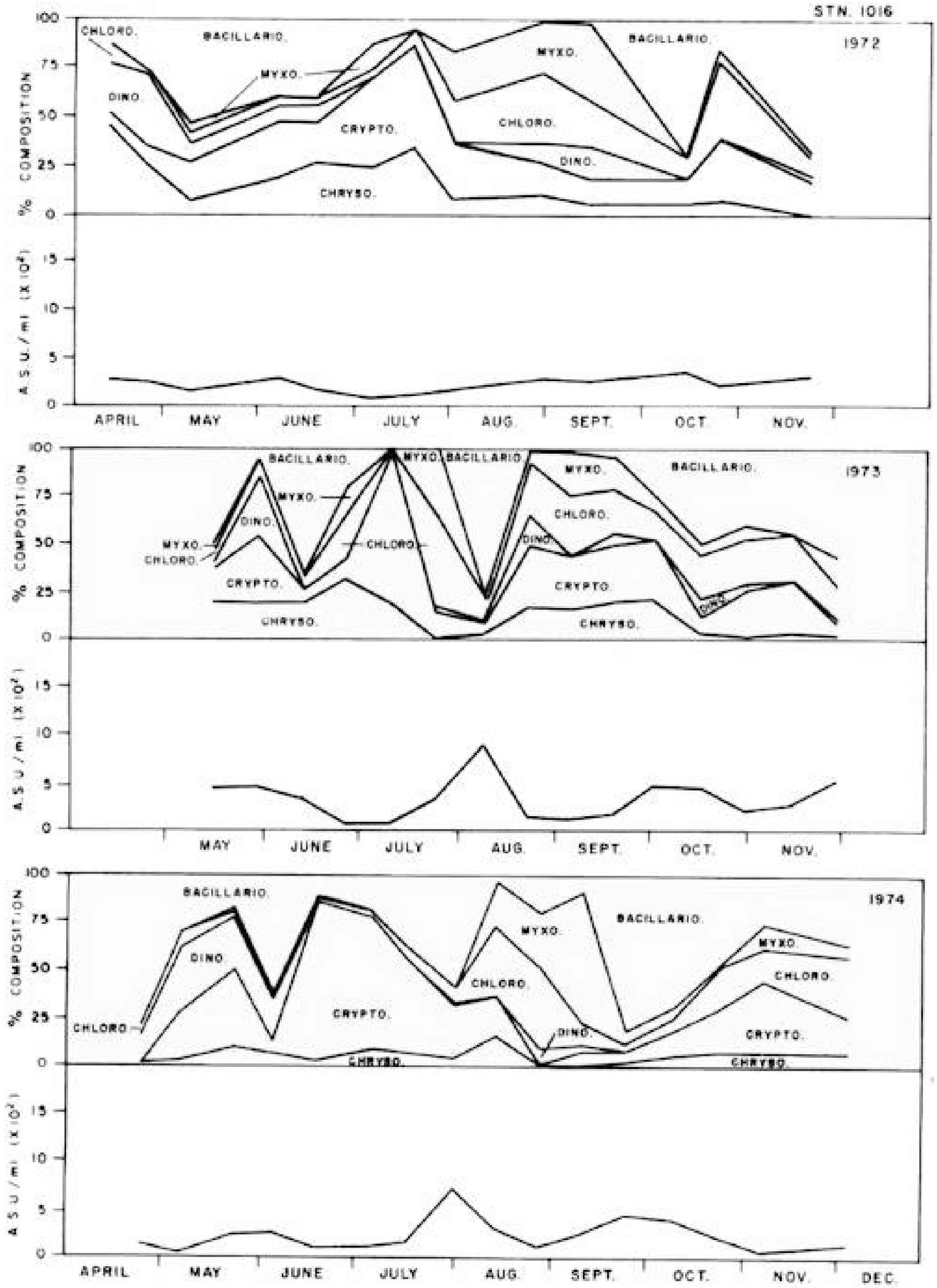

Figure 8: Seasonal changes in phytoplankton abundance (in a.s.u./ml) and species composition (%) at Station 1016 in the Nanticoke area of Lake Erie. Data are presented for 1972, 1973 and 1974.

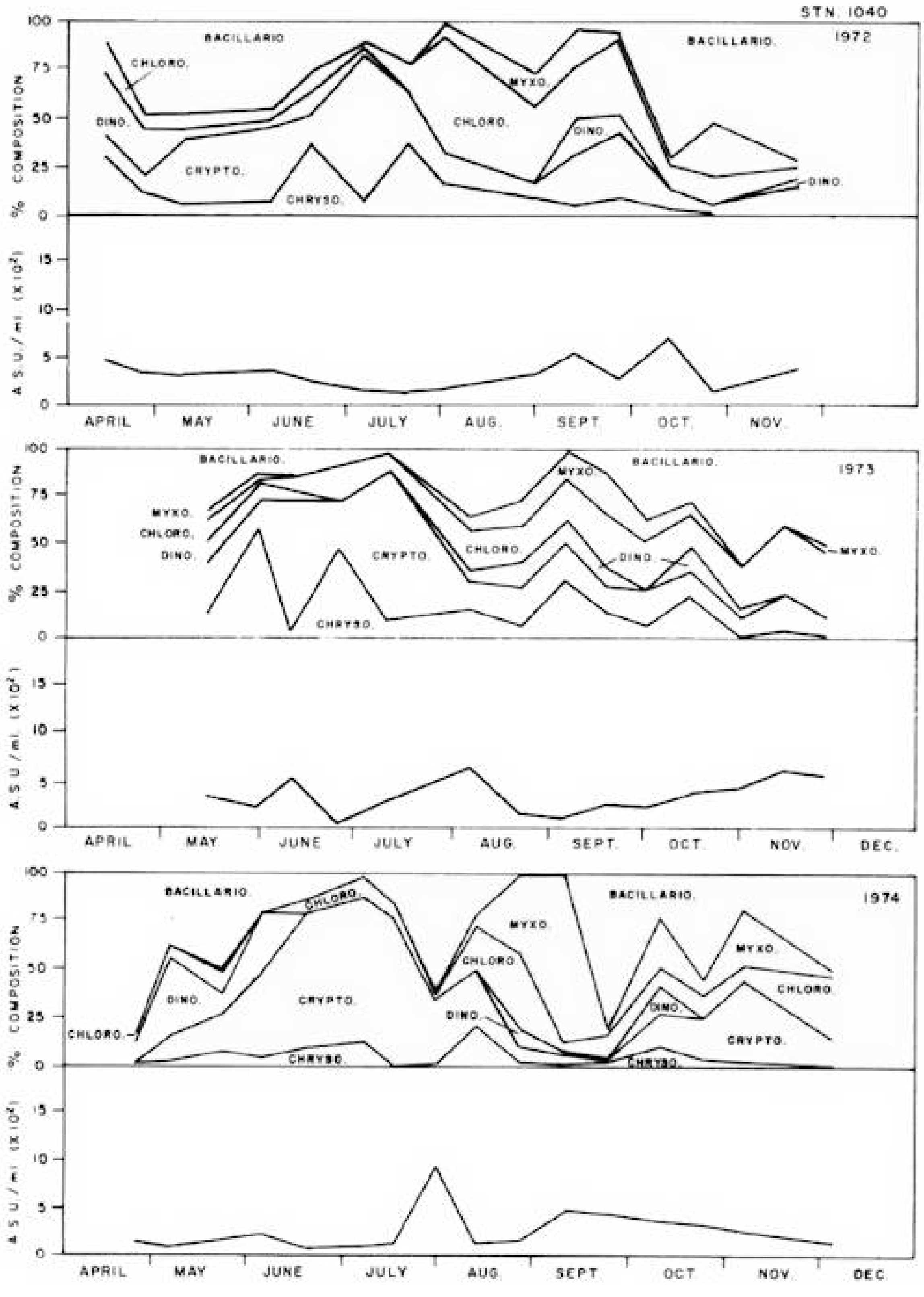

Figure 9: Seasonal changes in phytoplankton abundance (in a.s.u./ml) and species composition (%) at Station 1040 in the Nanticoke area of Lake Erie. Data are presented for 1972, 1973 and 1974.