FINAL REPORT: COASTAL ENERGY IMPACT PROGRAM

CONTRACT NUMBER 80-103

Limnological Study of Old Woman Creek National Estuarine Sanctuary for Collection of Baseline Data

OHIO DEPARTMENT OF NATURAL RESOURCES

This document was funded in part through the Coastal Zone Management Act of 1972, as amended (Coastal Energy Impact Program), provided by the U.S. Dept. of Commerce, NOAA, through the Ohio Department of Energy.

FINAL REPORT

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Limnological Study of Old Woman Creek National Estuarine Sanctuary for Collection of Baseline Data

Submitted to:

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December 30, 1981

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SUMMARY

A nineteen week study was undertaken on Old Woman Creek to provide baseline data for future environmental impact studies. Eleven sites for water analysis and phytoplankton enumeration were chosen, along with four sites for epiphyton and five sites for epilithon analysis. Many of the analysed nutrients showed a decline in concentration in the estuarine portions of the creek in rélation to the creek proper.

The plankton of the estuarine areas were dominated by the euplanktonic species. There were three distinct peaks - early April, May, and July - in the estuarine populations. The planktonic community of the creek proper was dominated by benthic species that had apparently been washed into the plankton.

The benthic algae of the estuary (epiphyton) were significantly different from the benthic algae in the creek proper (epilithon). The algae in the estuary were dominated by species that could tolerate low oxygen concentrations. The algae in the creek proper were generally dominated by algae that required high oxygen levels.

INTRODUCTION

The increasing demand for electricity has prompted construction of many new generating stations. The building and subsequent operation of such a station could cause marked changes in water quality in affected watersheds. These effects could be due to the direct utilization of surface waters for the dissipation of excess generated heat (Coutant and Pfuderer, 1974), or more indirectly through the alteration of existing drainage patterns and/or watershed (vegetative) cover profiles (Hornbeck et.al., 1970). The proposed site for Erie Two Nuclear Power Plant partially lies within the watershed of Old Woman Creek.

Estuaries and other coastal wetlands along Lake Erie have also been significantly altered in the quest for increased economic growth. Today, Ohio's shoreline is characterized by industrial, residential, and commercial development. Only a few remnants of the once-extensive estuarine areas remain. The Old Woman Creek estuary is the best remaining upland-estuary along the Ohio shoreline, and as such has been designated as a national estuarine sanctuary. This area has been left undeveloped, and currently exists in a near natural condition.

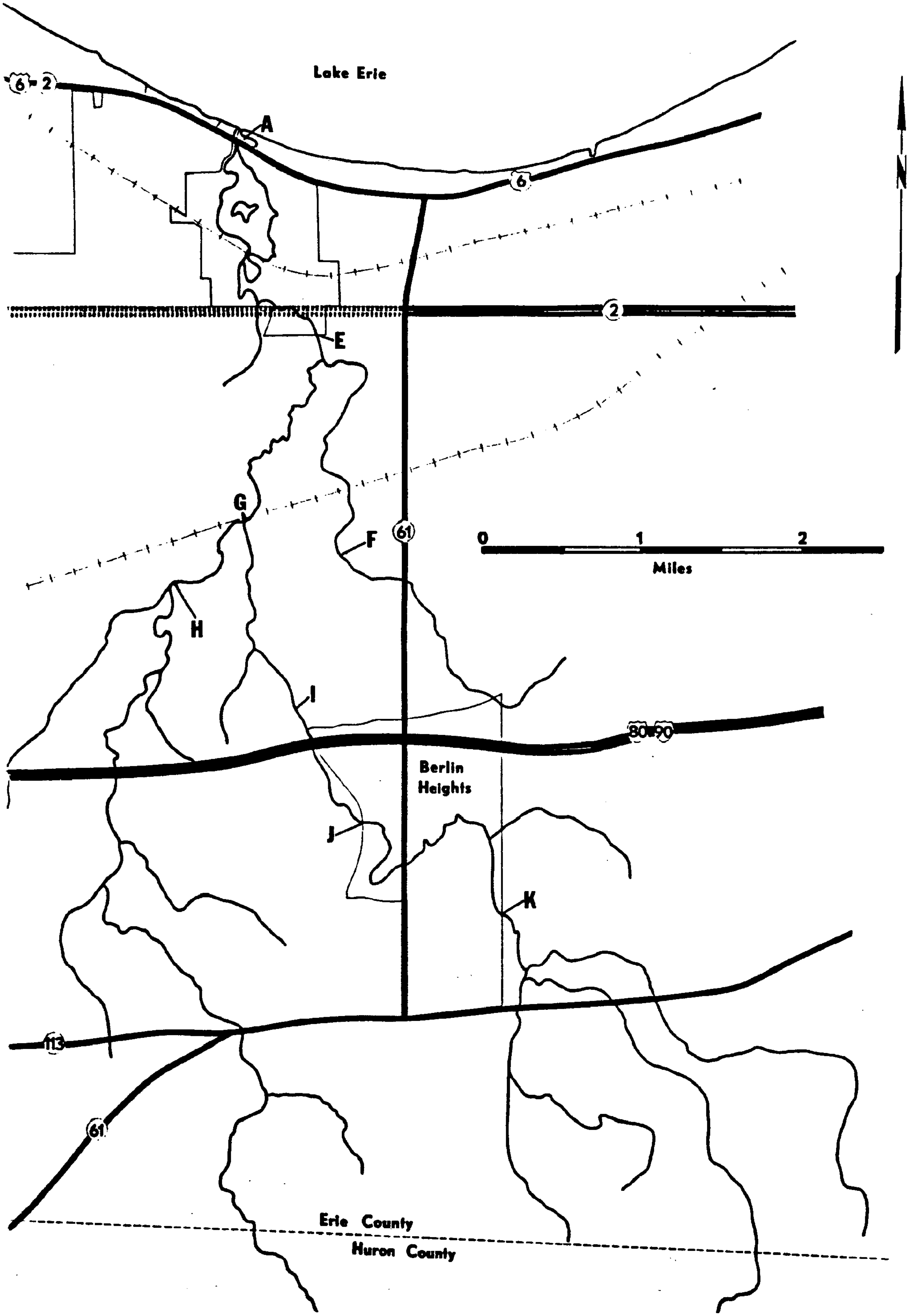
The impact of the proposed electric generating station on the water quality of Old Woman Creek and subsequently, the naturalness of the estuary, is unknown. The purpose of this study was to provide background or control data for future environmental impact studies. This study concentrated on selected chemical parameters of the water as well as both benthic and planktonic algal communities. Algae are perhaps the best biological indicators of a changing environment as they are the base of the food chain; therefore, any changes in this group could have repercussions throughout the aquatic ecosystem.

MATERIALS and METHODS

Field sampling began in late March 1981 and continued through the end of July 1981. This time period encompassed both the Spring and Summer algal communities. Water samples for both chemical analysis and phytoplankton enumeration were collected at 11 sites in both the creek proper and estuary (fig.1&2, sites A to K). Benthic algal samples were collected at 9 sites: 5 epilithon sites in the creek proper (fig.1, sites F,G,I,J,K), and 4 epiphyton sites in the estuary (fig.2, sites 1 to 4). It was necessary to sample epiphyton (algae attached to aquatic plants) in the estuary and epilithon (algae attached to rocks) in the creek proper as rocks were not readily available in the estuary and there were no beds of aquatic macrophytes in the creek proper.

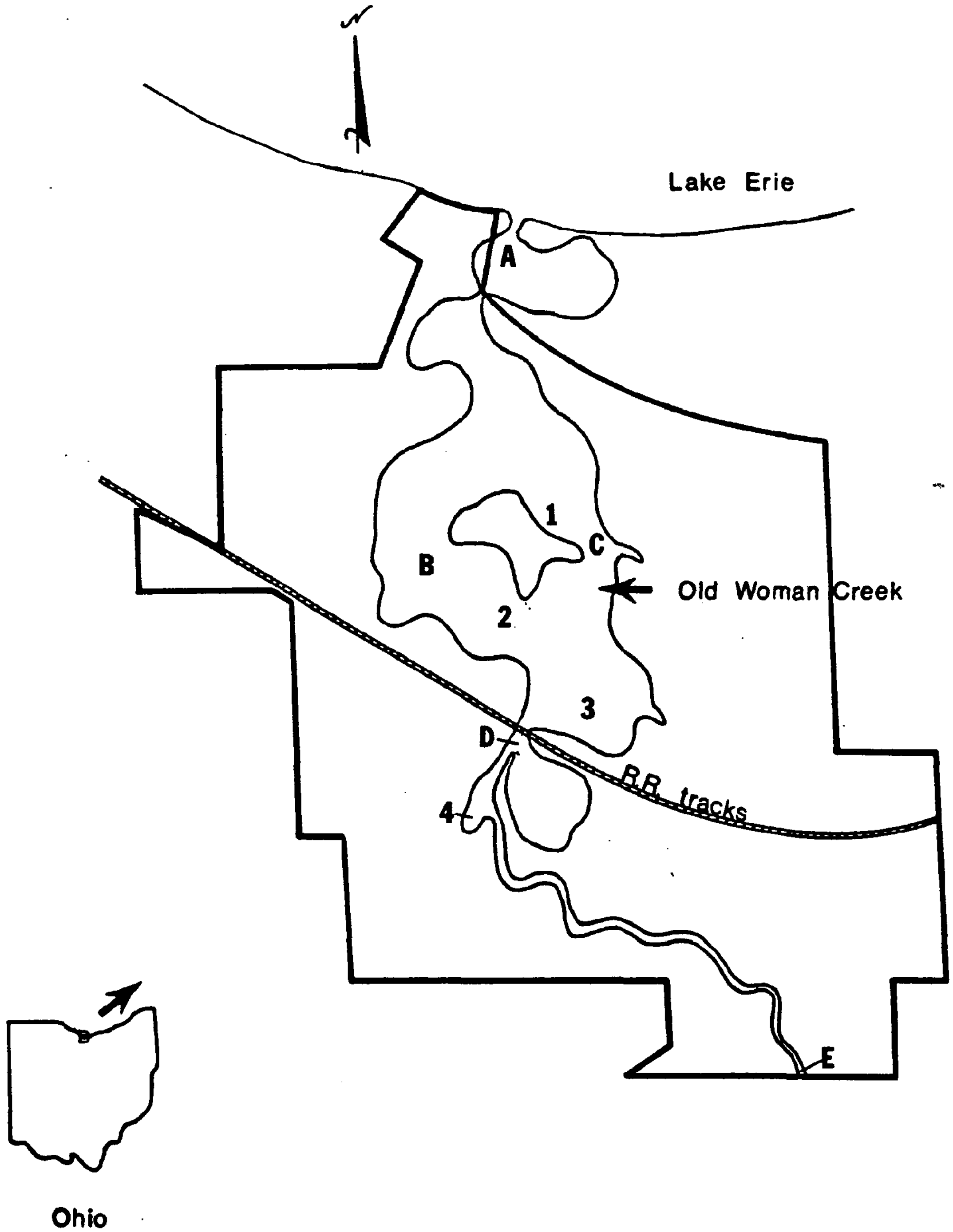
Samples for chemical analysis were collected in polyethylene bottles which had previously been rinsed with sample water. Dissolved oxygen levels, water temperature, and conductivity were determined electrometrically in the field at time of sample collection. PH and turbidity were determined electrometrically in the laboratory immediately upon return from sampling. Each sample was then filtered through GF/C filter paper to remove any suspended particles. Alkalinity, nitrite, orthophosphate (Ascorbic Acid method), silicate (Heteropoly Blue method), calcium and magnesium hardness (EDTA titration), sulfate (Turbidimetric method), and chloride (Argentometric method) were determined using methods outlined in Standard Methods, 14th ed. Nitrate concentrations were measured using the Phenoldisulfonic Acid method (Standard Methods, 12th ed.). Ammonia was determined using the proceedure described by Zadorojny et.al. (1973). Total dissolved carbon was calculated with the graph and formula presented in Mackereth (1963).

Figure 1: Map of Old Woman Creek showing location of chemistry and plankton sampling sites A, E - K, and epilithon sites F, G, I, J, & K.



Lake Erie
6
2
A
6
2
E
N
G
61
F
0
1
2
Miles
H
I
80
90
Berlin
Heights
J
K
113
61
Erie County
Huron County

Figure 2: Map of Old Woman Creek Estuarine Sanctuary showing location of chemistry and plankton sampling sites A - E and epiphyton sites 1 - 4.



Lake Erie
A
1
C
B
2
Old Woman Creek
3
D
R.R. tracks
4
E
Ohio

Unconcentrated liter water samples for phytoplankton enumeration were collected in conjunction with those for chemical analysis. The samples were transported in polythene bottles where they were poured into liter measuring cylinders. The phytoplankton were preserved and sedimented with Lugol's Iodine Solution. The phytoplankton in each liter sample were concentrated to a 10 milliliter slurry through sedimentation. A drop (.04 milliliter) was removed from the slurry, placed on a slide, covered with a coverslip, and then counted at either 750X or 480X. The number of fields counted was dependent upon phytoplankton density. The maximum number of fields counted on any slide was 500. A minimum of 100 cells or colonies of the most common species was counted per sample.

A rock was randomly selected for epilithon analysis at each site. The rock was carefully placed in a plastic bag for transportation to the laboratory, in order to minimize loss of algae. A known area of the rock's surface was scraped and then rinsed. The scrapings and washings were collected and then made up to a known volume. A portion was removed for diatom identification and enumeration while the remainder was preserved with Logol's Iodine Solution and set aside for counting. The proceedure for counting has been outlined above.

Duplicate macrophyte stems were collected at each site for epiphyton analysis. Nelumbo lutea (Willd.) Pers stems were collected at three sites (fig. 2, sites 1,2,3). Stems of Nymphaea tuberosa Paine were collected at the last site (fig.2, site 4). The sampling proceedure involved removing the floating leaf. A plastic tube was slipped over the desired portion of the stem. The stem was cut at the base of the tube and then the tube and enclosed stem were capped. At the laboratory the stem was removed from the tube and the tube was then rinsed. The stem was carefully scraped and rinsed. The scrapings and washings were combined and then made up to a known volume. A portion was removed for diatom identification and enumeration while the remainder was preserved with Lugol's Iodine Solution and set aside for counting. The counting proceedure has been outlined above.

Permanent slides were prepared from each benthic algal sample for diatom identification and enumeration. Those portions set aside for diatom analysis were treated with a sulfuric acid-potassium dichromate-hydrogen peroxide mixture to clean the frustules. The three chemicals were added in the order given. The cleaned frustules were then allowed to settle to the bottom of the beaker. The supernatent was poured off and then distilled water was added. This decanting process was continued for a minimum of 6 days to remove the acid cleaning solution. One half of a milliliter of the cleaned diatom slurry was spread onto a coverslip and allowed to dry. The coverslip was then mounted with Hyrax onto a microscope slide. The slide was then set aside for counting.

The algae were identified according to Prescott (1962). Supplimental texts for algal identification included: Taft and Taft (1971), Fott (1968), Huber-Pestalozzi (1955, 1961), and Hustedt (1930, 1949, and 1939-1966).

DESCRIPTION OF THE STUDY AREA

Old Woman Creek is but one of many small streams flowing into Lake Erie. The creek meanders 16 kilometers through portions of Huron and Erie counties before entering Lake Erie east of the city of Huron, Ohio. The entire watershed is small, encompassing approximately 80 square kilometers. The creek would be classified as a third order stream (Hynes, 1970). It has an elevation of 252 meters above sea level at its source and falls 78 meters to its mouth. The mouth is submerged and the estuarine portion of the creek extends 2.1 kilometers southward from the mouth. The location and size of the creek's mouth is continually modified by a shifting sand barrier beach. This beach frequently closes the mouth and isolates the creek from Lake Erie. The creek is shallow, often less than 0.5 meters in depth through most of its length; but it is never intermittent.

Old Woman Creek occupies a valley partially filled with glacial till. This valley may have been the preglacial course of the Huron River (Marshall, 1977). The upper portions of the creek cut through the Berea Sandstone escarpment. The lower course of the creek has cut through glacial till and lacustrian deposits down to shale bedrock.

Agriculture is the dominant industry of the watershed because of rich silt and sand loam soils and a prolonged growing season due to the proximity of Lake Erie. Agriculture has remained the major industry since the area was first settled in the early part of the nineteenth century. Berlin Heights (pop. 800) is the only urban area within the watershed. The sewage treatment plant of this town drains directly into the creek between sites I and J (fig 1).

The estuary supports a large aquatic macrophyte flora. There are extensive beds of Nelumbo lutea. Peltandra virginica (L.) Kunth, Polygonum coccineum Muhl, and Nymphaea tuberosa were also common. A comprehensive survey of the macrophytes of the estuary and surrounding uplands has been made by Marshall (1977). There were no aquatic macrophytes observed in the creek proper, with the exception of a small bed of Elodea canadensis (Michx.) Planchon at site K.

RESULTS AND DISCUSSION

Physical Conditions of the Water

Temperature- Water temperatures in Old Woman Creek varied from 4 C to 30 C during the 19 week study (fig. 3). Changes in water temperature were temporal, changing with time rather than spatial, changing from site to site on the same date. Heavy rainfall caused a temporary drop in water temperature, as was observed in mid-April and mid-June. Maximum temperatures ocurred in early July. Temperature of the water then began to decline through the remainder of the study.

Turbidity- Turbidity levels were generally higher in the estuary than in the creek proper (fig. 4). This difference corresponds to differences in water flow and then to surface area/ depth ratio. In the upper reaches of the creek the water is flowing quickly enough to prevent the build-up of silt on the bottom. The flow rate in the estuary, however, diminishes and so permits the silt to precipitate out. The surface area/ depth ratio of the estuary is very large; therefore, any wind induced turbulence will resuspend the silt into the water column. Turbidity levels at all sites increased during periods of heavy rainfall due to increased silt run-off from the watershed, as was observed in mid-June.

Chemical Conditions of the Water

Dissolved Oxygen- Oxygen saturation levels in the creek were generally around 100%, indicating equilibrium with the atmosphere (fig. 5). This is the normal state in all fast flowing creeks, except those which are heavily polluted (Hynes, 1970). The supersaturation levels recorded in mid-May resulted from high photosynthetic activity of the epilithon. Oxygen levels in the estuary were lower, frequently below 90% saturation.

Figure 3: Seasonal changes in Water Temperature from 25 March to 29 July 1981. Isotherms are expressed as degrees Centigrade.

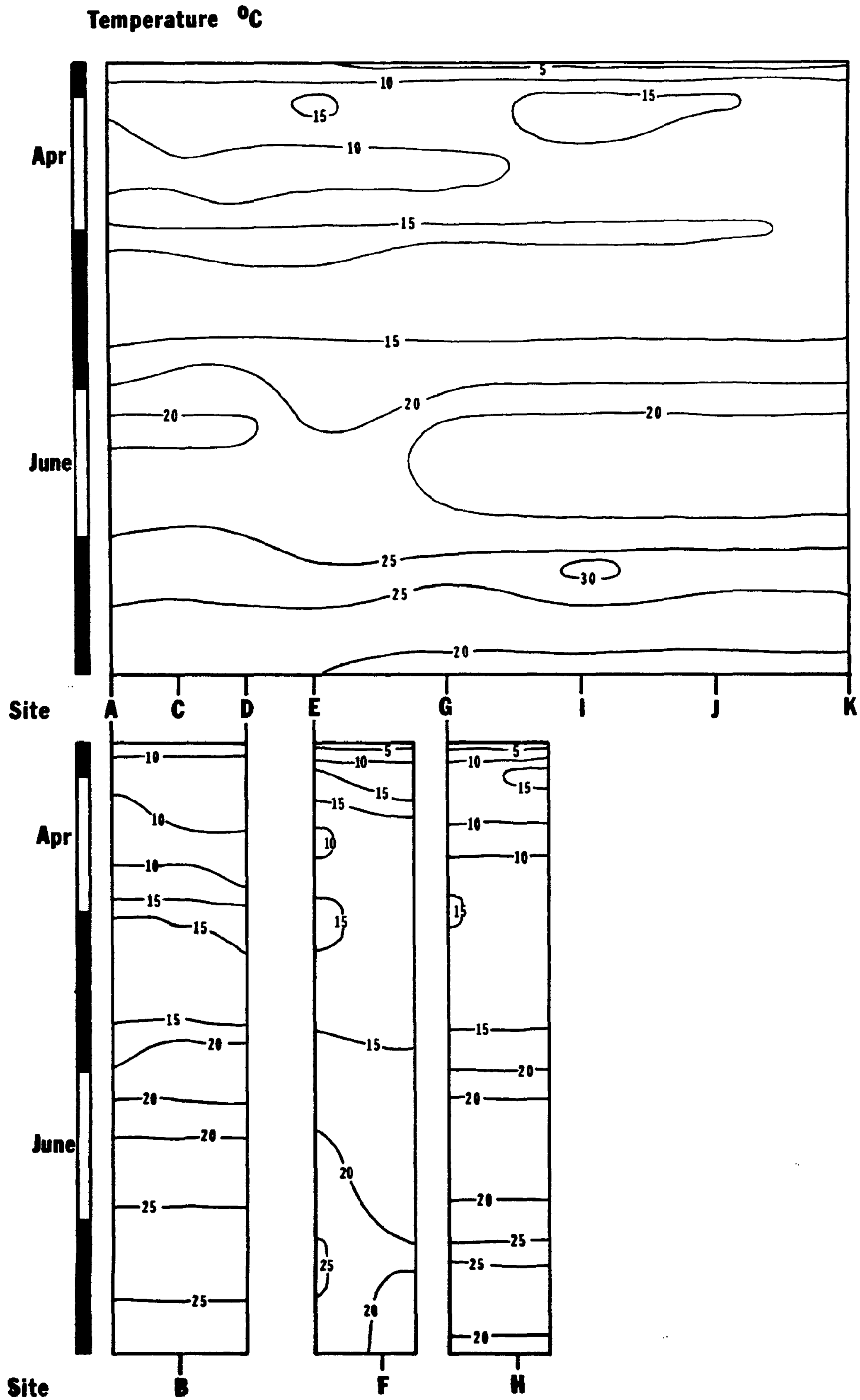

Temperature °C
Apr
June
Site
A
C
D
E
G
I
J
K
B
F
H
5
10
15
20
25
30

Figure 4: Seasonal changes in Turbidity from 25 March to 29 July 1981. Isopleths are expressed as NTU's.

Turbidity NTU

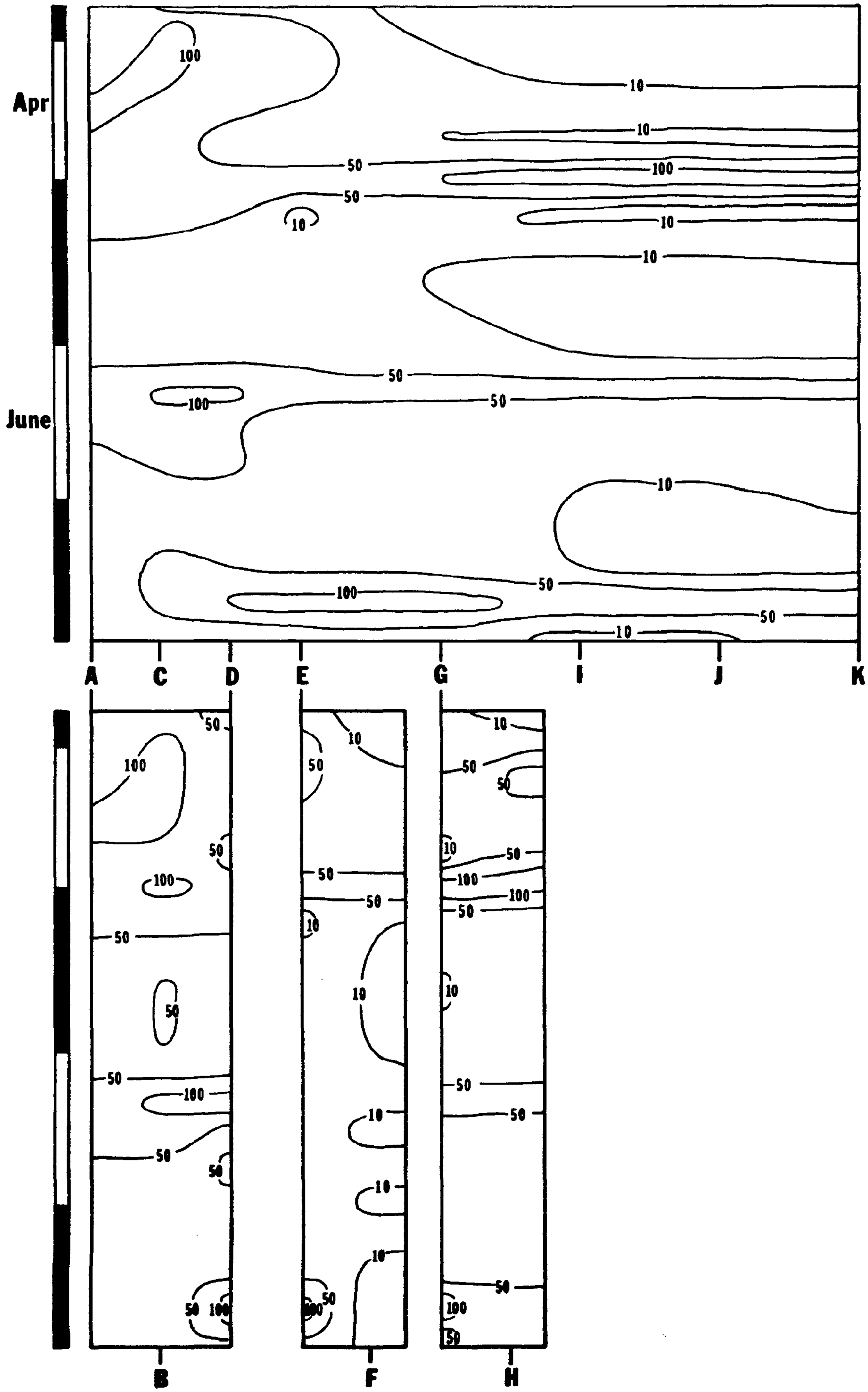
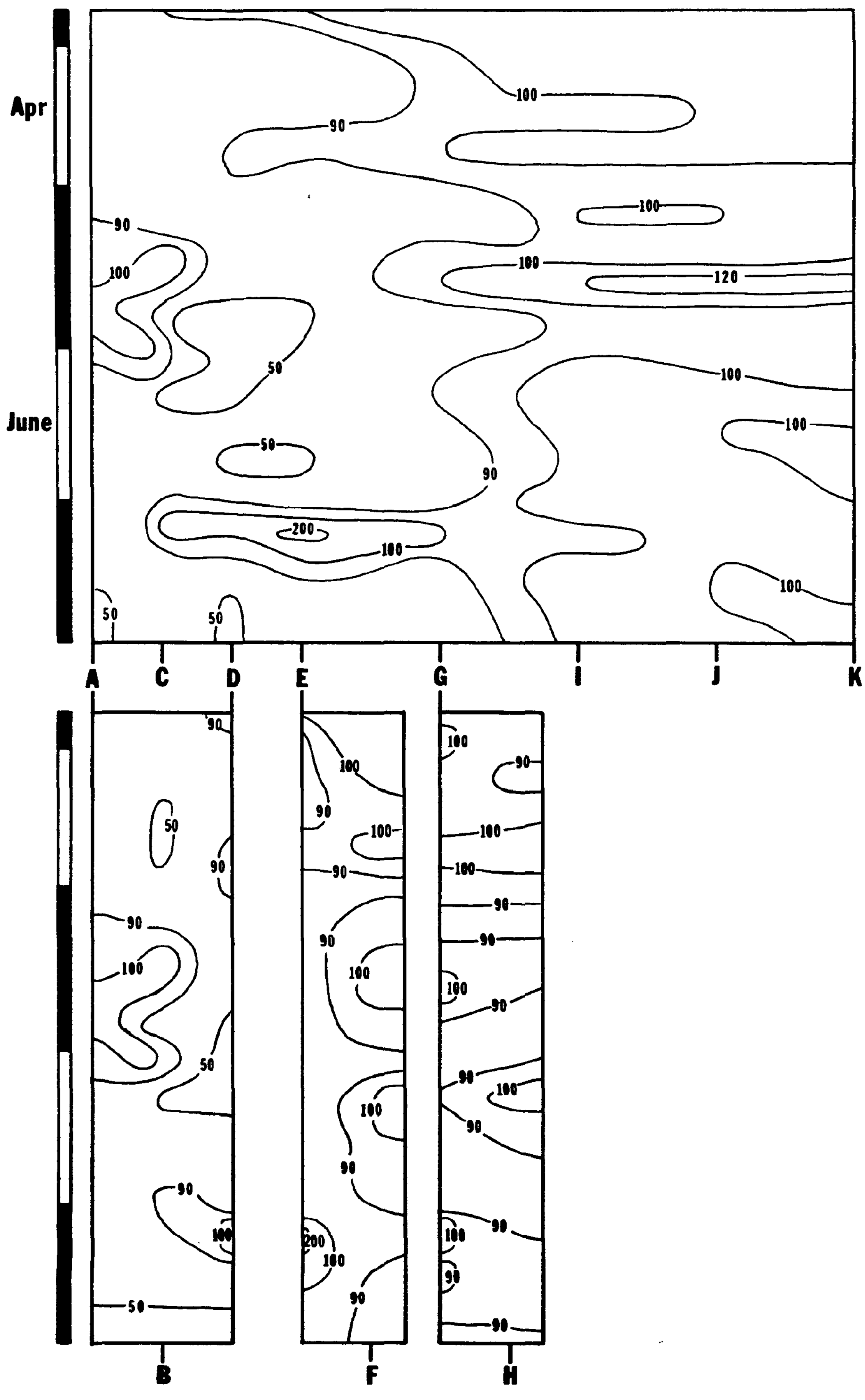


Figure 5: Seasonal changes in Dissolved Oxygen from 25 March to 29 July 1981. Isopleths are expressed as % saturation.

Dissolved Oxygen % saturation



These lower concentrations could be a result of the biological decomposition of the organic fraction of the silt as well as decreased photosynthetic activity resulting from increased turbidity (Dorris st.al.,1963). The 100% saturation levels recorded in late May corresponded to peaks in phytoplankton numbers. The very high supersaturation (200%) recorded at site E was correlated with a bloom of Rhodomonas sp. Both the supersaturated conditions and the algal bloom were confined to the upper 25 centimeters of the water column.

PH- The hydrogen ion concentration (pH) is dependent upon both biological activity and the CO -bicarbonate-carbonate system (Hutchinson, 1957). Old Woman Creek was slightly alkaline through the study, with pH levels ranging from 7.3 to 9.2 (fig. 6). PH levels were frequently higher at the mouth of the creek (site A) and at sites I and J. The higher levels at the mouth reflect the higher pH of Lake Erie (summer average 8.3-8.4). The high pH values at sites I and J can only partially be attributed to declines in CO levels caused by high photosynthetic activity. Further study is necessary to explain these higher pH values. The very high pH level at site D corresponded to the bloom of Rhodomonas sp. mentioned in the above paragraph.

Total Dissolved Carbon- There was no discernible pattern in total dissolved carbon concentrations at Old Woman Creek (fig. 7). The expected correlation between algal numbers (i.e. photosynthetic activity) and total dissolved carbon was not observed. Further study will be necessary to determine the factors influencing carbon concentrations in the water.

Conductivity- Conductivity is a measure of all ions dissolved in the water and so is an indicator of the general nutrient status of the water. Conductivity levels were lower in the estuarine portions of the

Figure 6: Seasonal changes in pH from 25 March to 29 July 1981.

PH

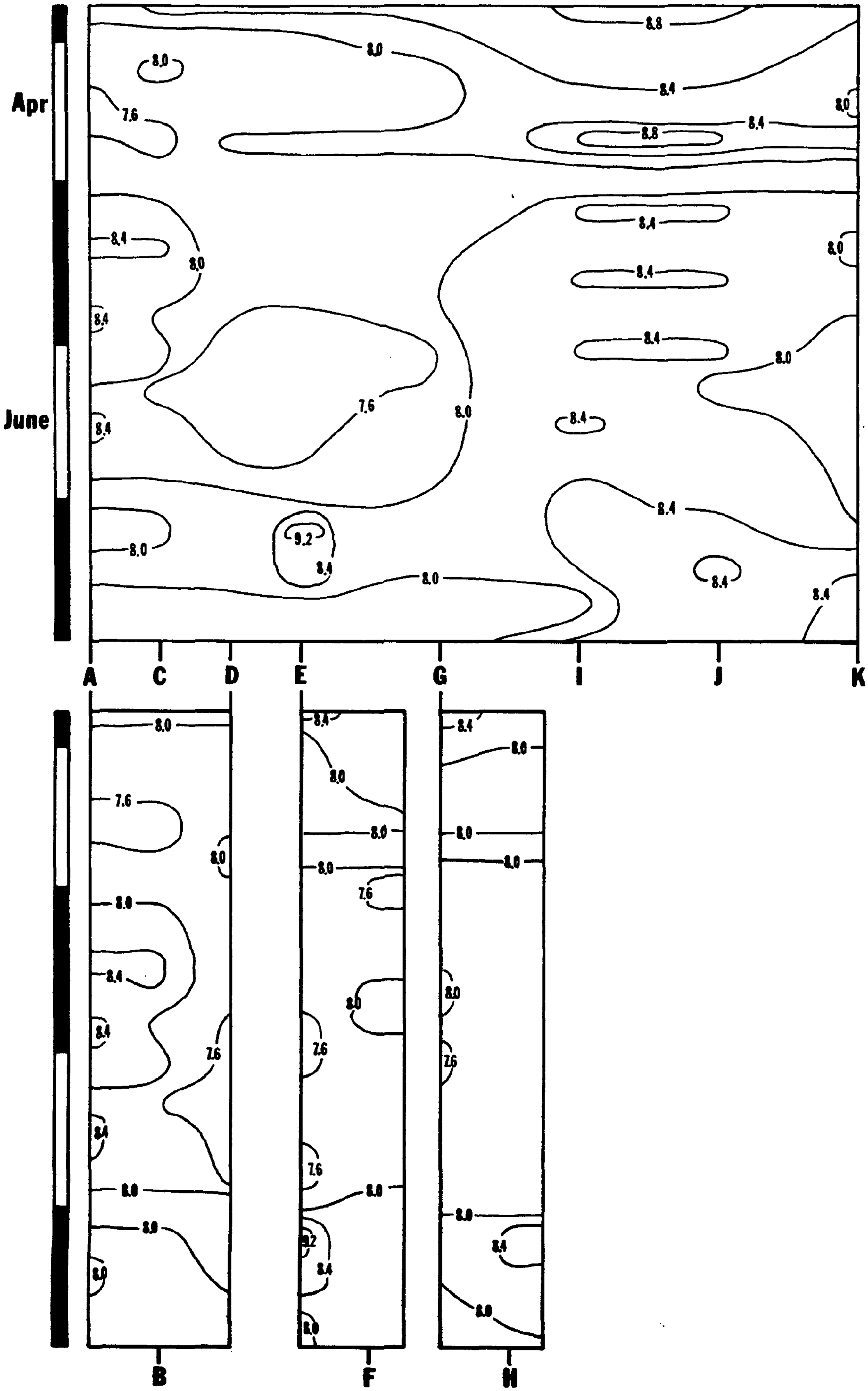
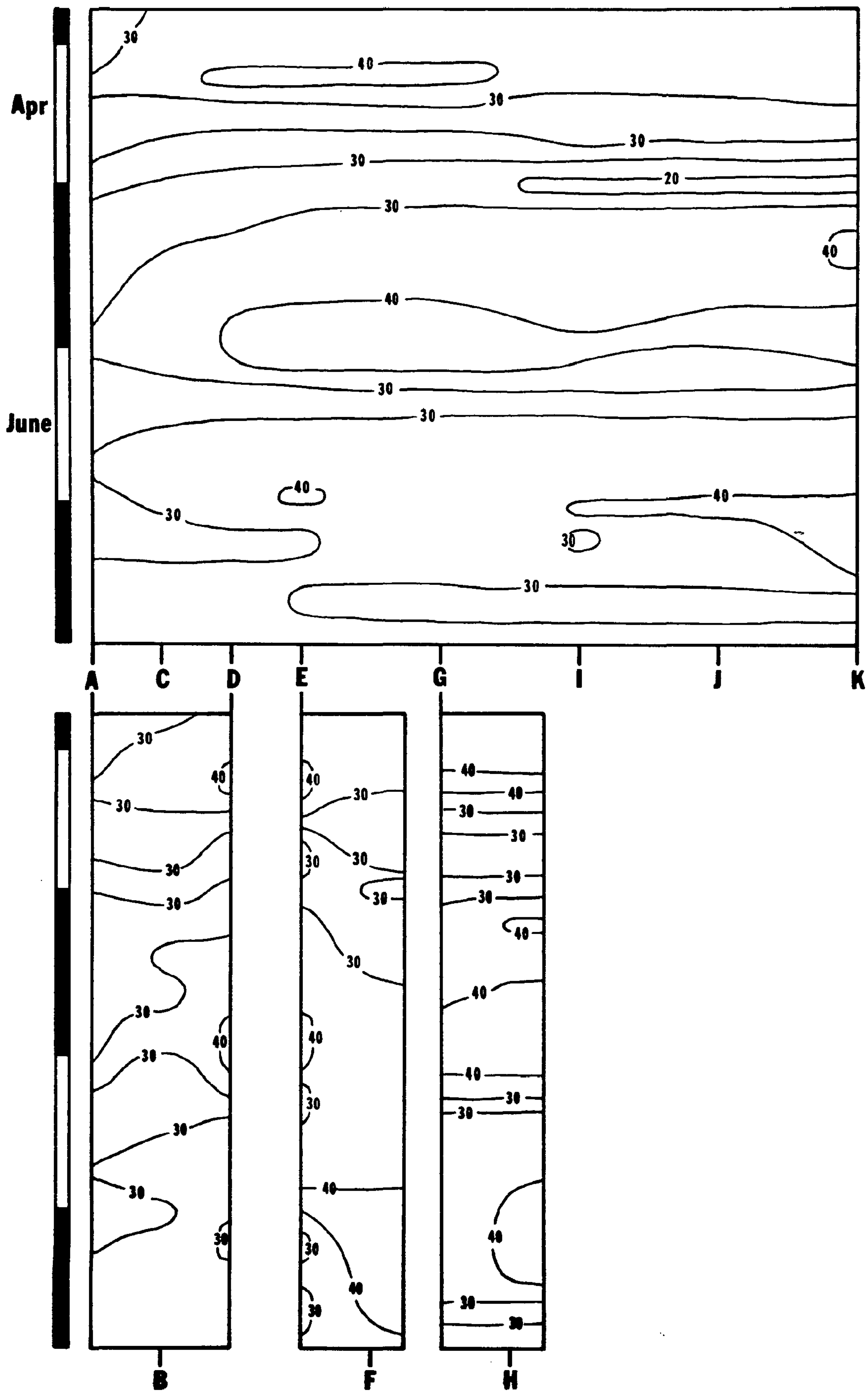


Figure 7: Seasonal changes in total Dissolved Carbon from 25 March to 29 July 1981. Isopleths are expressed as parts per million.

Total Dissolved Carbon ppm



creek than Old Woman Creek proper (fig. 8). This is a reflection of both the dilution of creek water with lake water, which has a lower conductivity value, and the cleansing of the creek water through sedimentation of the silt and nutrient uptake by the algae and aquatic macrophytes. These two factors are additive, and so it is difficult to determine the relative importance of each.

Orthophosphate- Orthophosphate concentrations were noticably lower in the estuary of Old Woman Creek than in the creek proper (fig. 9). The source of most of the orthophosphate in the creek would probably be through surface runoff, rather than from a point source (Baker and Kramer, 1973). The branch that would be directly affected by the proposed construction of the Erie 2 Power Plant had consistently lower concentrations than the other two branches. The decline in orthophosphate levels could be due to the mixing of lake and creek water. It is more probable, however, that the decline was caused by biological activity, primarily uptake by algae and aquatic macrophytes (Hutchinson, 1957).

Silicate- Silicate concentrations in the estuarine waters were lower than those of Old Woman Creek proper from late April through the duration of the study (fig. 10). One of the branches of the creek (site F) consistently had high silicate levels. The major source of silicate is the dissolution of rock containing aluminosilicate compounds (Hutchinson, 1957). Groundwater is normally the source of this silicate rich water in freshwater systems (Wetzel, 1975). Silicate is normally removed from the water column through uptake by diatoms (Hutchinson, 1957). The low concentrations in the estuary corresponded to large diatom populations in the estuarine phytoplankton. Lake Erie has a lower silicate concentration than does Old Woman Creek, so this decline in estuarine waters may also be linked

Figure 8: Seasonal changes in Conductivity from 25 March to 29 July 1981. Isopleths are expressed as micromhos.

Conductivity μmhos

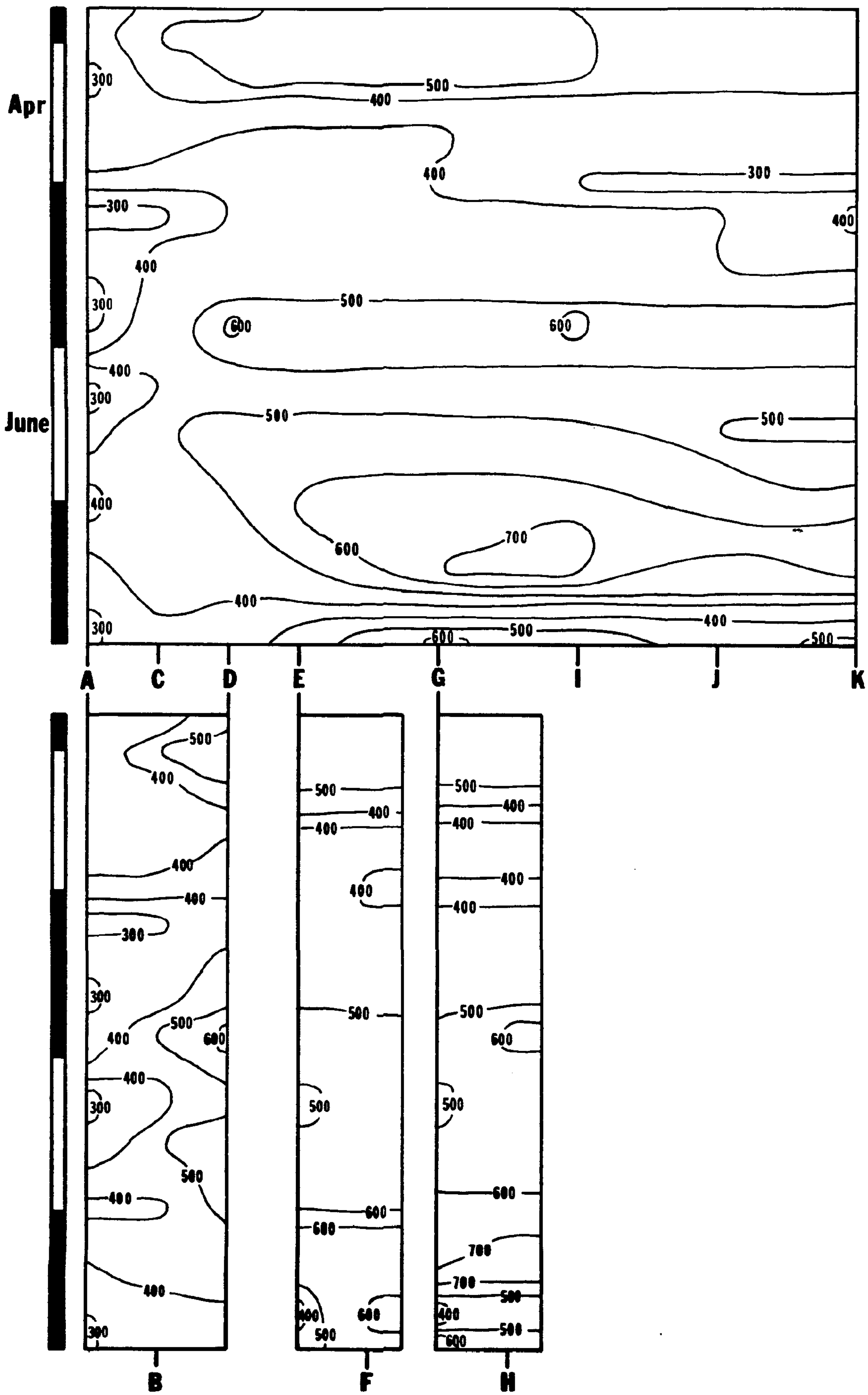


Figure 9: Seasonal changes in Orthophosphate from 25 March to 29 July 1981. Isopleths are expressed as parts per billion.

Orthophosphate ppb

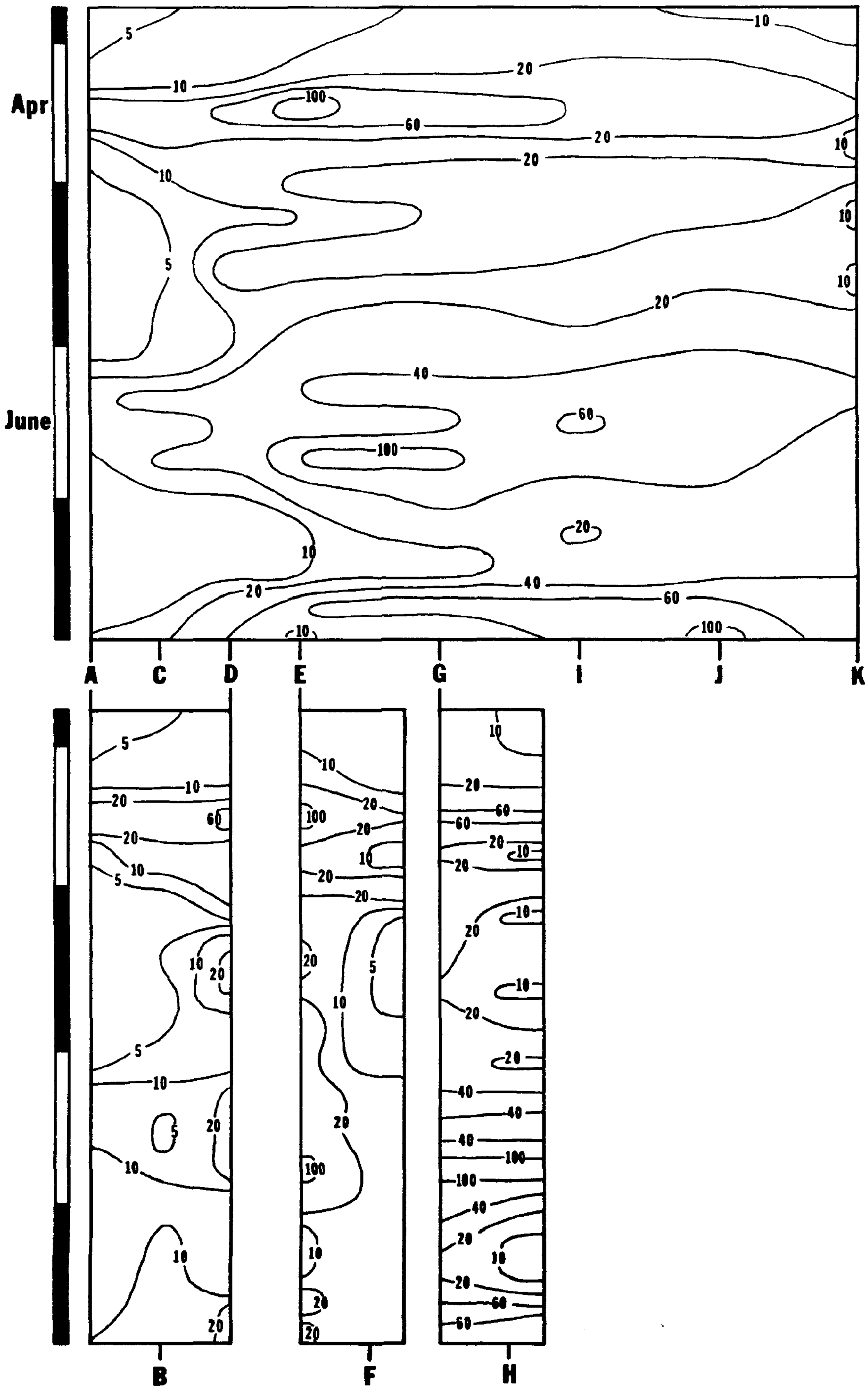
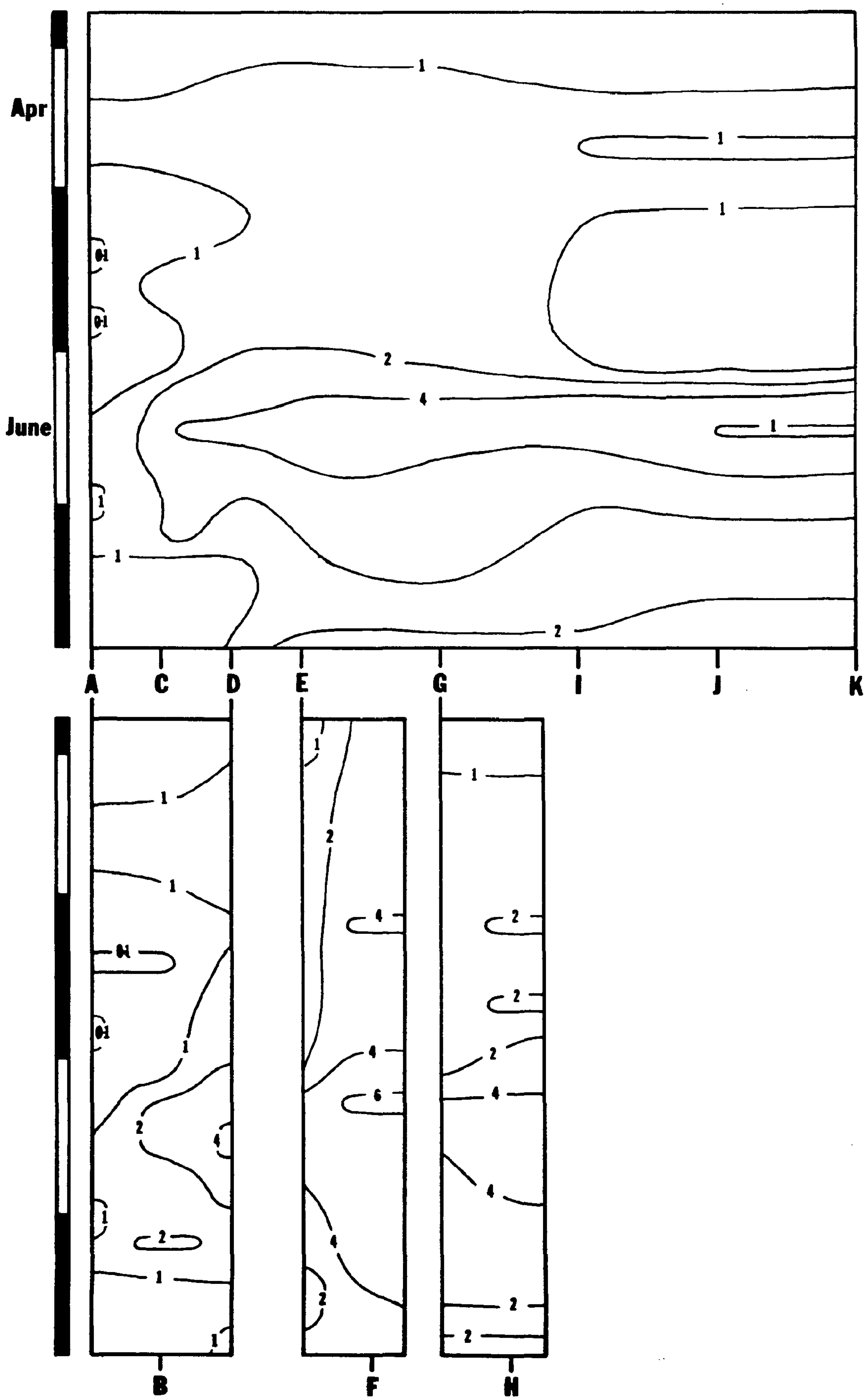


Figure 10: Seasonal changes in Silicate from 25 March to 29 July 1981. Isopleths are expressed as parts per million.

Silicate ppm



to mixing of creek water with lake water.

Nitrogen- The concentrations of the three inorganic nitrogen sources-nitrate, nitrite, and ammonia were measured during this study. The relative proportion of each of these compounds is primarily related to oxygen concentrations with high oxygen levels favoring nitrate and very low levels favoring ammonia (Mortimer, 1941-1942). In most lotic systems the presence of high nitrite and/or ammonia concentrations is indicative of pollution (Hynes, 1970).

Nitrate concentrations showed little variation through the entire length of the creek during much of the study (fig.11). The drop in nitrate in the estuarine waters in May and June coincide with large phyto-plankton populations in the estuary. This supports the contention that nitrate is the prefered nitrogen source for the algae (Wetzel, 1975). Surface runoff from agricultural lands is a major source of nitrate (Hynes, 1970), as is shown by the marked increase in nitrate concentrations during mid-June when turbidity levels were high in the creek proper.

Nitrite concentrations also showed uniform spatial distribution during most of the study (fig. 12). The marked increase in nitrite levels in mid-June corresponded to an increase in both nitrate concentrations and turbidity levels, and so would probably have also been caused by surface runoff from agricultural lands. A second increase in nitrite levels was recorded in late June and was correlated with a rise in ammonia concentrations. This increase may be due to a temporary point source pollution because the increase was confined to only one of the three branches (site H).

Ammonia concentrations also showed little spatial variation during most of the study period (fig. 13). The increase in late June corresponded to an increase in nitrite concentrations and has been discussed above.

Figure 11: Seasonal changes in Nitrate from 25 March to 29 July 1981.
Isopleths are expressed as parts per million.

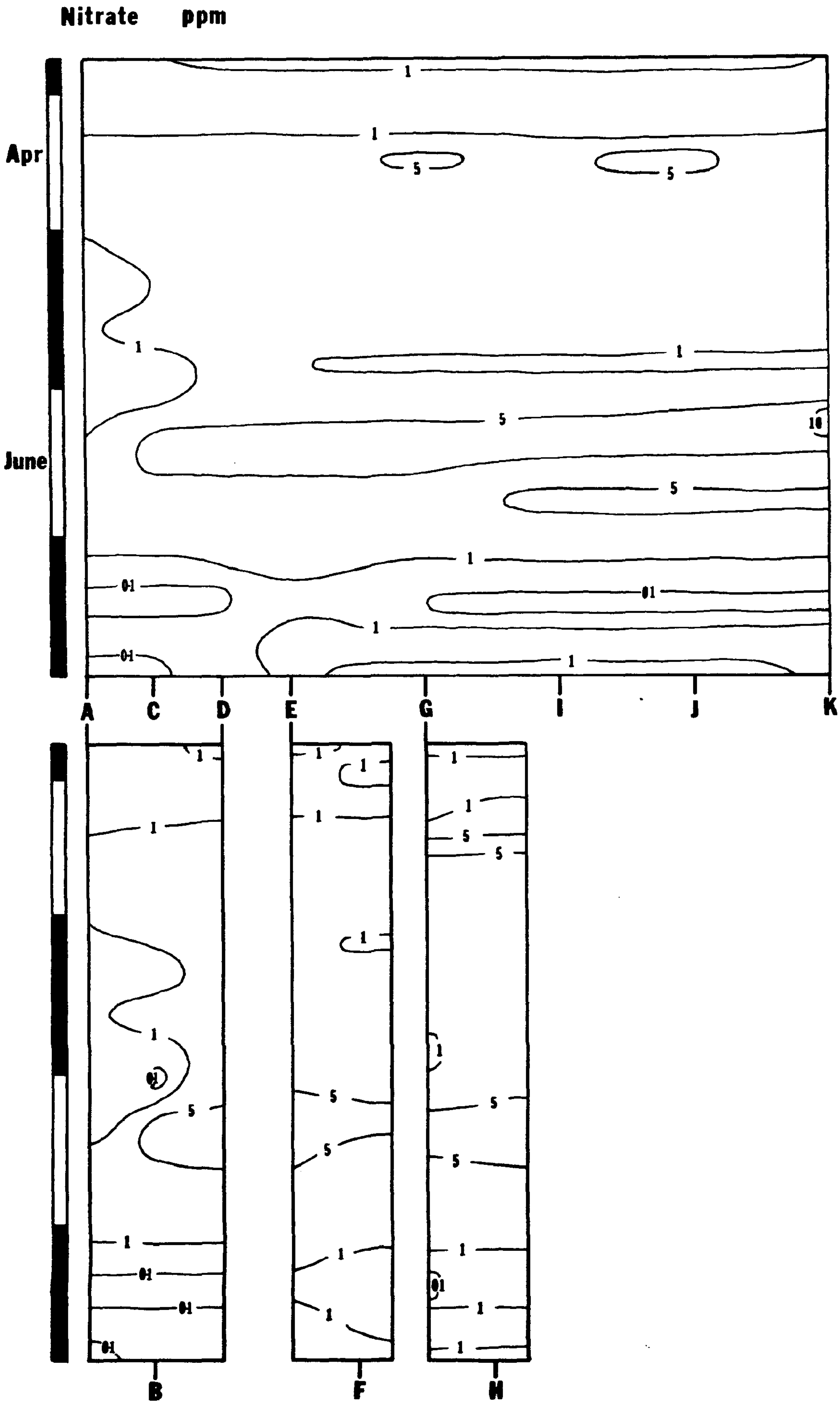

Nitrate ppm
Apr
June
A
C
D
E
G
I
J
K
B
F
H
1
5
10
0·1

Figure 12: Seasonal changes in Nitrite from March 25 to July 29 1981. Isopleths are expressed as parts per billion.

Nitrite ppb

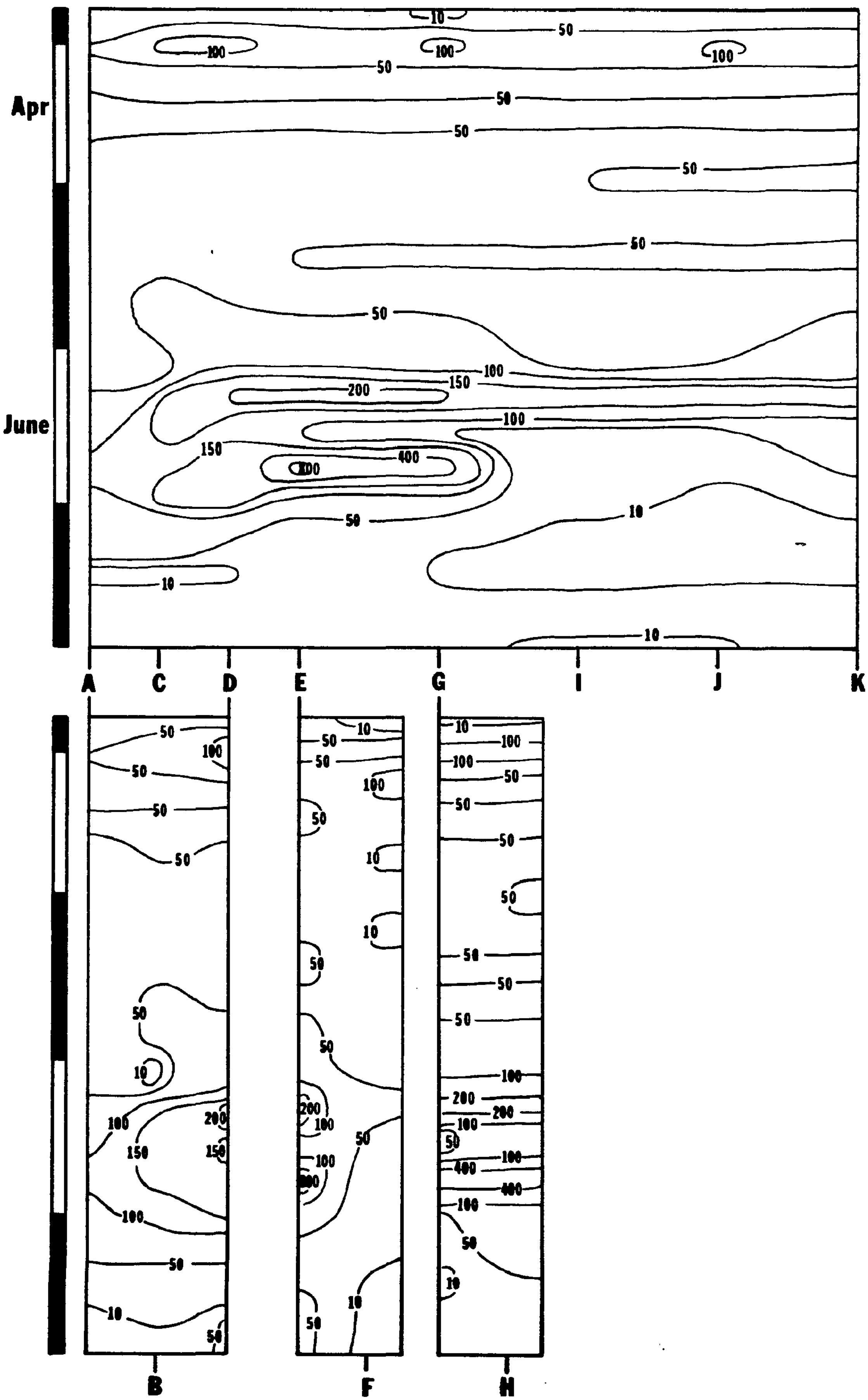
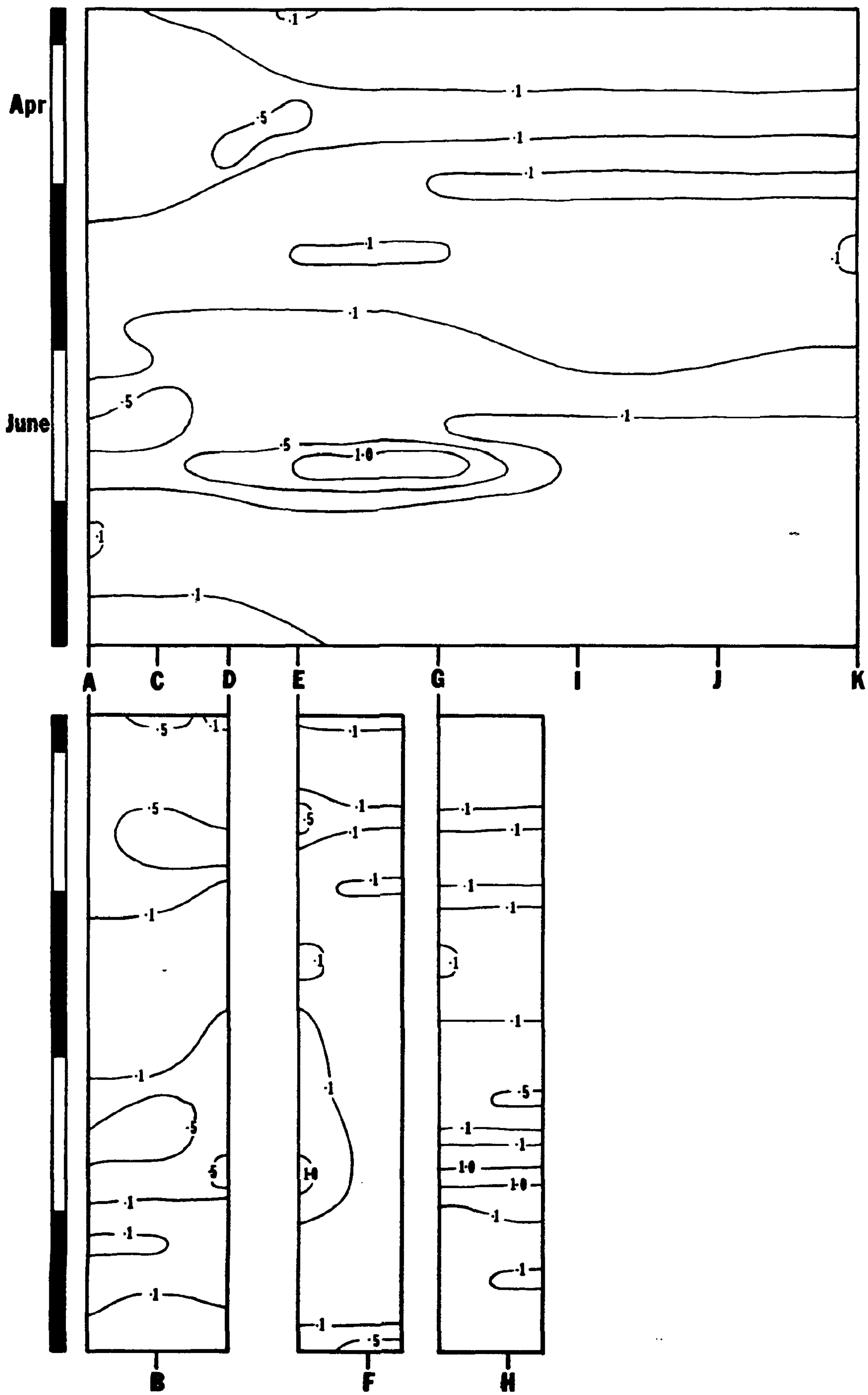

Apr
June
10
50
100
100
100
50
50
50
50
50
50
100
150
200
100
150
400
400
50
10
10
10
A
C
D
E
G
I
J
K
B
F
H

Figure 13: Seasonal changes in Ammonia from March 25 to July 29 1981. Isopleths are expressed as parts per million.

Ammonia ppm



Sulfate- Sulfate concentrations were lower in the estuarine portions of the creek than in the creek proper (fig. 14). Levels were slightly higher during the first few weeks than during the remainder of the study period. The primary source of sulfate is rainfall (Hutchinson, 1957). It is possible that the high concentrations in early Spring were due to the melting of the last remnants of the winter snow and ice; but would appear unlikely as ice breakup was several weeks prior to the commencement of this study. The cause of lower sulfate concentrations in the estuary in comparison with the creek proper is also unknown, but may, in part, be due to the dilution of creek water with lake water.

Chloride- Chloride levels also showed a slight decrease in the estuarine portions of the creek when compared to the creek proper (fig. 15). This may be due to the dilution of creek water with lake water. The high concentrations observed at site I were attributed to chlorination practices at the Berlin Heights sewage treatment plant which was located above the site. Chloride concentrations were slightly higher in the branch (site F) that would be directly affected by the Erie 2 Power Plant. Rainfall is considered to be the source of most natural chloride in a freshwater system (Hutchinson, 1957); but that would not explain the higher concentrations in the one branch.

Calcium and Magnesium- Both calcium and magnesium concentrations were lower in the estuarine protions of the creek (figs. 16 &17). Dilution of creek water with lake water may hve been the cause of this.

Figure 14: Seasonal changes in Sulfate from 25 March to 29 July 1981. Isopleths are expressed as parts per million.

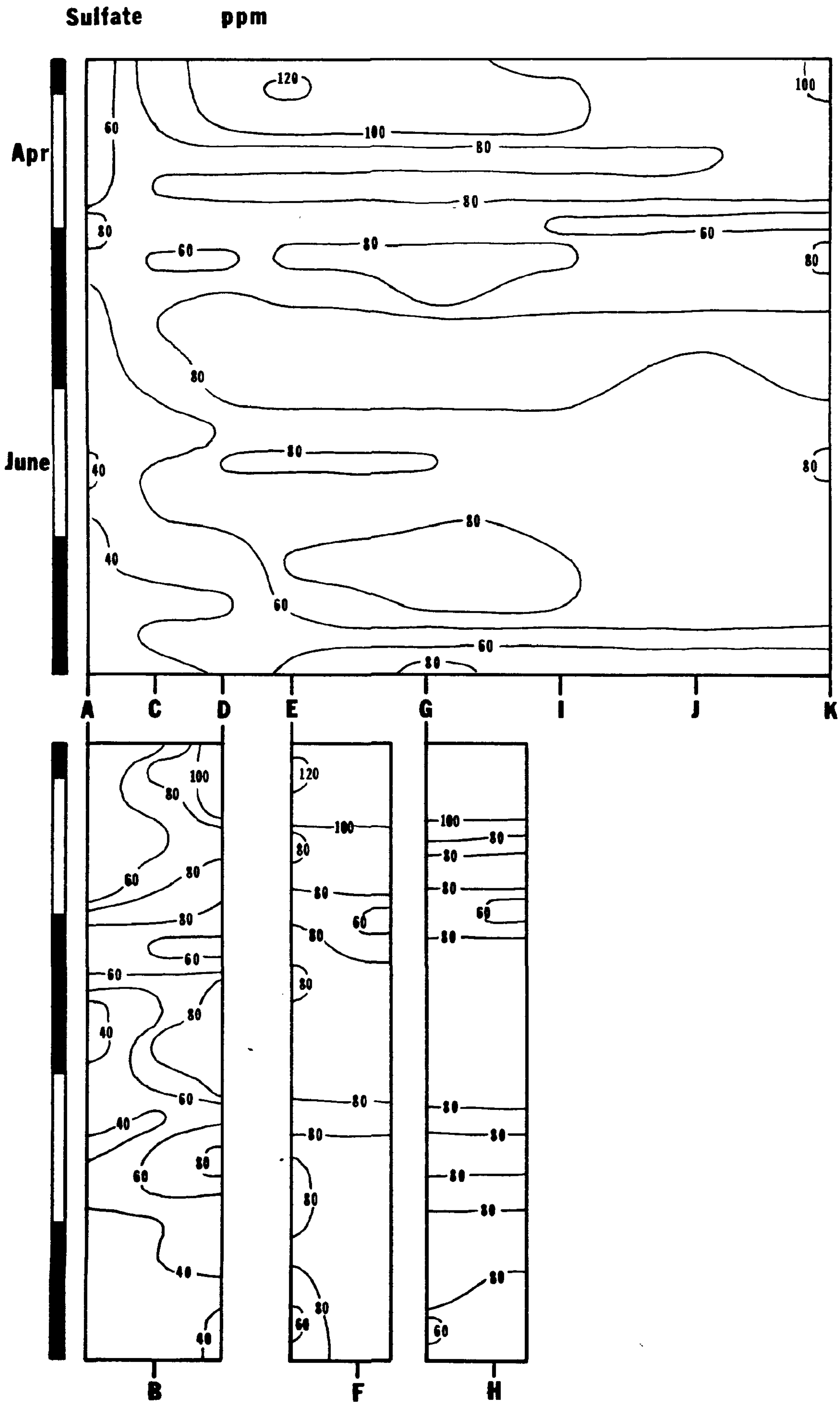

Sulfate ppm
Apr
June
A
C
D
E
G
I
J
K
B
F
H
120
100
80
60
40

Figure 15: Seasonal changes in Chloride from 25 March to 29 July 1981. Isopleths are expressed as parts per million.

Chloride ppm

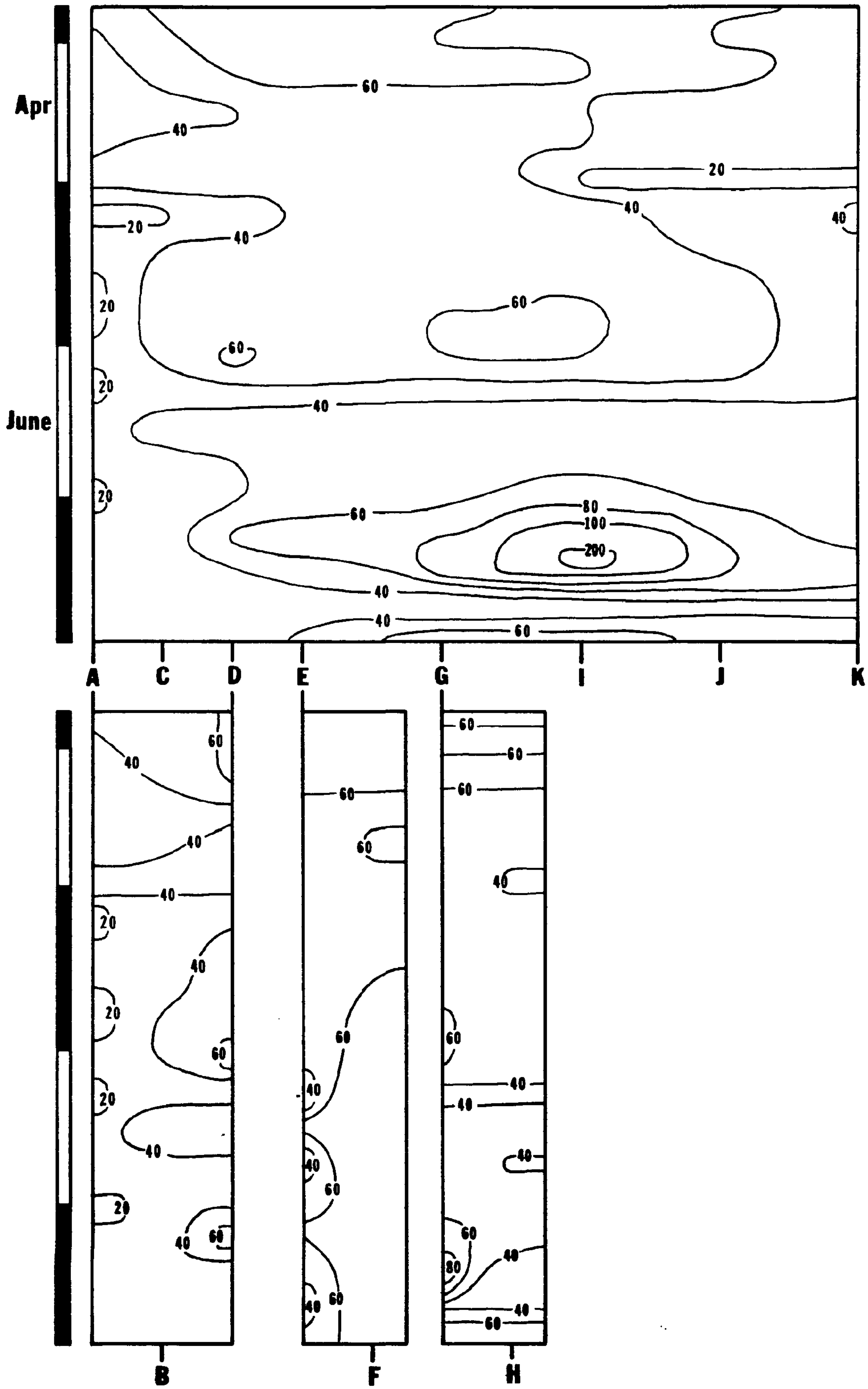


Figure 16: Seasonal changes in Calcium Hardness from 25 March to 29 July 1981.
Isopleths are expressed as parts per million.

Calcium Hardness ppm

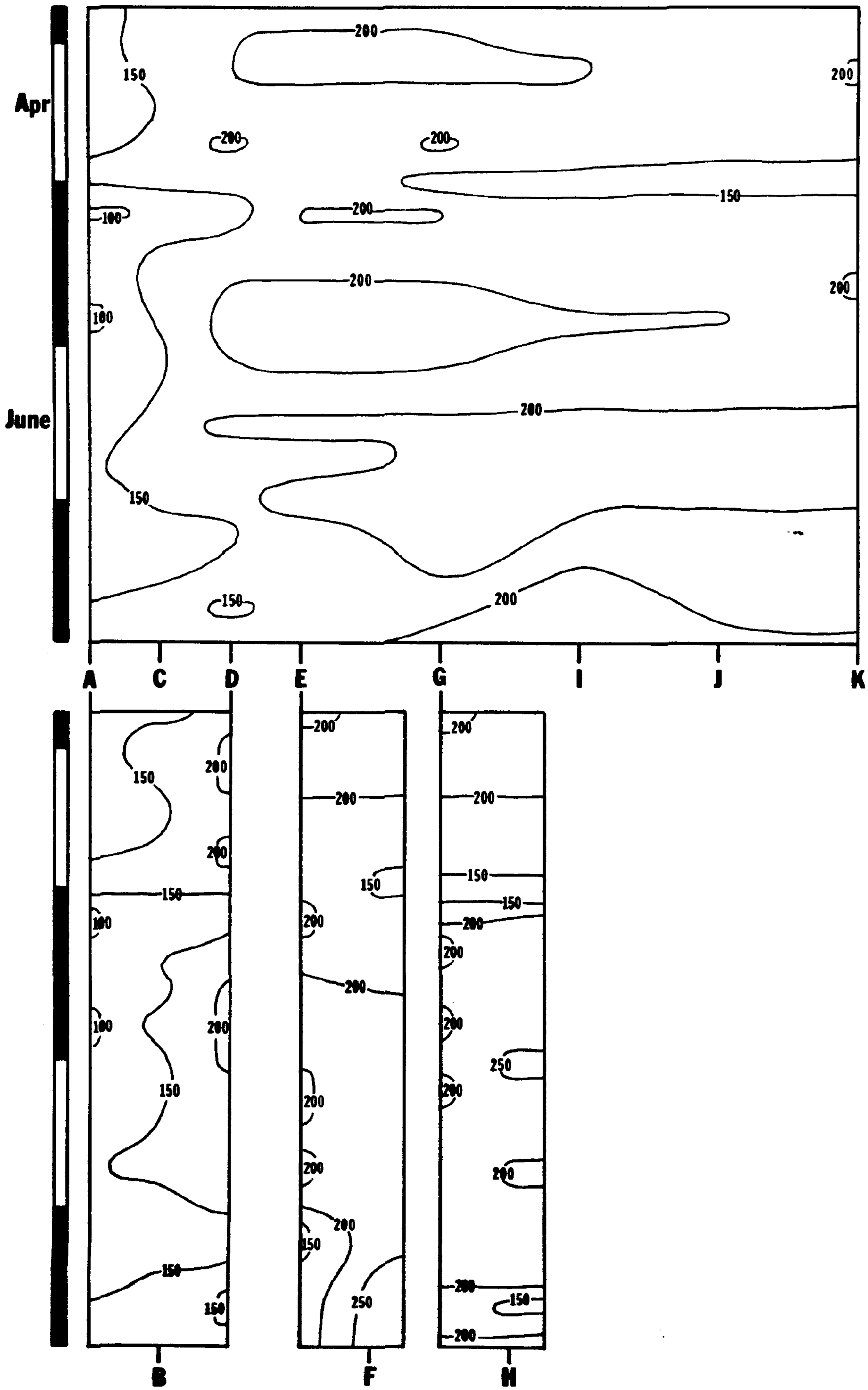
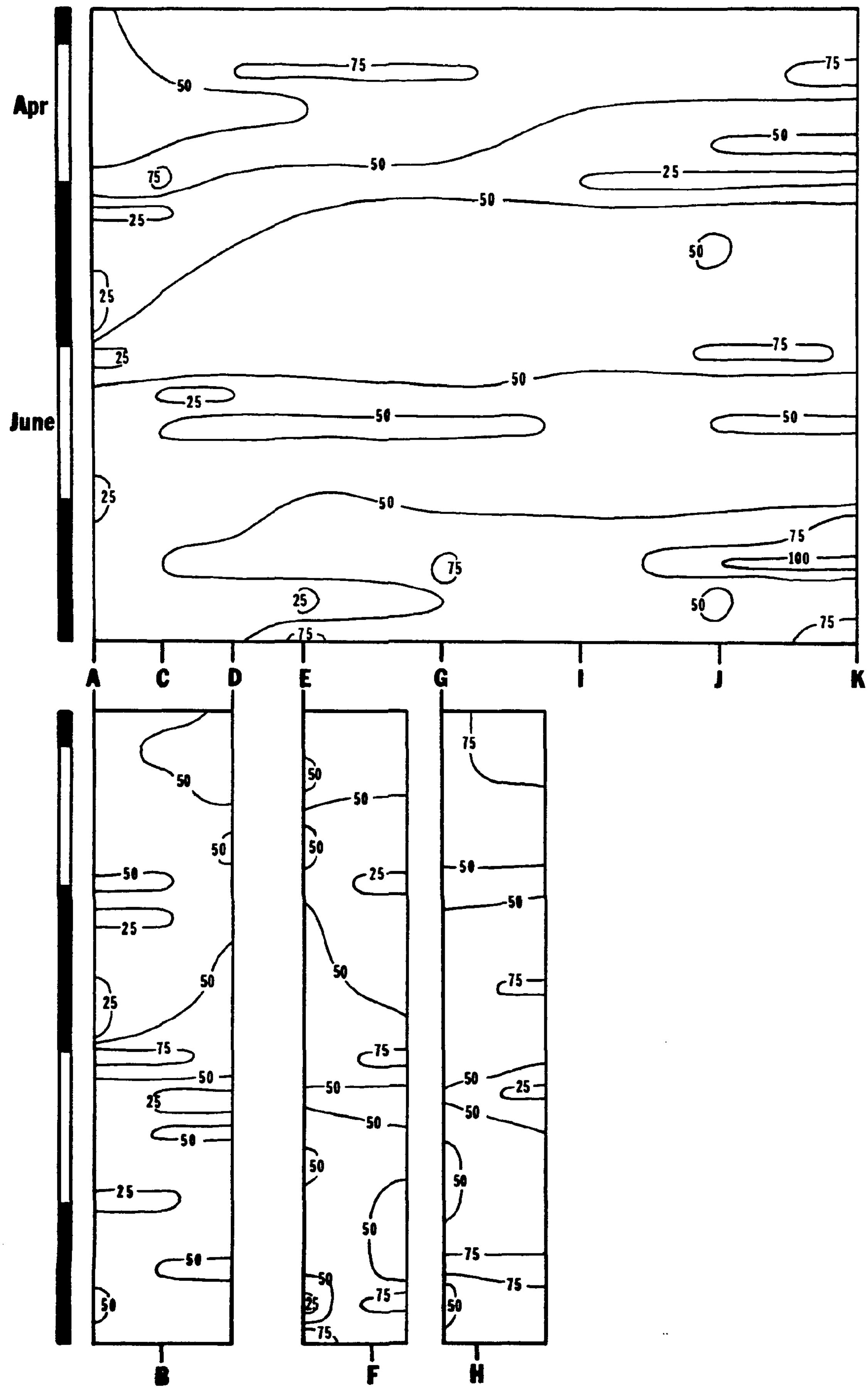


Figure 17: Seasonal changes in Magnesium Hardness from 25 March to 29 July 1981. Isopleths are expressed as parts per million.

Magnesium Hardness ppm



Algal Studies

A total of 284 algal species and varieties were recorded during this study of Old Woman Creek (table 1). Diatoms (Division Chrysophyta, Sub-Division Bacillariophyceae) were numerically the most common group at all sites.

Phytoplankton-

The phytoplankton of the estuarine portion of Old Woman Creek (fig.2, sites A,B,C) were significantly different from the phytoplankton of the creek proper (fig.1, sites F-K). The plankton of sites D and E (fig.2) were transitional between the other two populations.

The estuarine phytoplankton was dominated by euplanktonic species. There were three peaks in population numbers during the 19 week study (figs. 18,19,20). The first peak in early April was dominated by pennate diatoms, primarily *Nitzschia* spp. and *Synedra* spp. This peak was most pronounced at the mouth (site A), but was barely evident at site C. There was a large peak at all three sites during May and a smaller secondary peak in early June. Unlike the first peak, this maximum was dominated by centric diatoms, *Cyclotella* spp. and *Stephanodiscus* spp. *Cryptomonas erosa* and *Melosira distans* were also very common at this time. In mid-June population numbers dropped to very low levels at all three sites, and remained low through the end of June. The peak in July was dominated by *Melosira distans* and *Nitzschia* spp.. *Cryptomonas erosa* and *Euglena* spp. were common during the month.

The variation in peak height between sites was not unexpected. Plankton in standing water normally display a patchy distribution. This horizontal variation is often a function of wind and wind induced currents. The meteorological data necessary for determining the influence of wind on

Table 1

Species Composition of the Phytoplankton and Selected Benthic Algal Communities

Division Cyanophyta

Anabaena circinis Rabenhorst
Anabaena sp.
Aphanizomanon flos-aqua (L.) Ralfs
Aphanocapsa delicatissima West & West
Aphanocapsa elachistra West & West
Calothrix sp.
Chroococcus dispersus (V.Keissler) Lemmermann
Chroococcus minor (Kutz) Naegeli
Chroococcus minutus (Kutz) Naegeli
Gloeocapsa sp.
Lyngbya sp.
Merismopedia minima Beck
Merismopedia tenuissima Lemmermann
Oscillatoria Agardhii Gomont
Oscillatoria limosa (Roth) C.A. Agardh
Oscillatoria subbrevis Schmidle
Oscillatoria tennuis C.A. Agardh
Phormidium tenne (Menegh) Gomont

Division Chlorophyta

Actinastrum Hantzschii Lagerheim
Ankistrodesmus convolutus Corda
Ankistrodesmus faleatus (Corda) Ralfs
Ankistrodesmus faleatus var mirabilis (West & West) West
Carteria Klebsii (Dang) Dill
Characium curvatum G.M. Smith
Characium sp.
Chlamydomonas globosa Snow
Chlamydomonas sp.
Cladophora glomerata (L.) Kutzing
Closterium aciculare T. West
Cosmarium granatum de Brebisson
Cosmarium sp.
Crucigenia fenestrata Schmidle
Crucigenia quadrata Morren
Crucigenia rectangularis (A.Braun) Gay
Crucigenia tetrapedia (Kirch) West & West
Dictyosphaerium pulchellum Wood
Franceia Droescheri (Lemm) G.M. Smith
Gloeocystis gigas (Kutz) Lagerheim
Gloeocystis vesiculosa Naegeli
Golenkinia radiata (Chod.) Wille
Kirchneriella lunaris (Kirch) Moebius
Kirchneriella sp.

Lagerheimia ciliata (Lag.) Chodat
Lagerheimia genevensis var subglobosa (Lemm) Chodat
Lagerheimia quadriseta (Lemm) G.M. Smith
Micractinium pusillum Fresenius
Microspora stagnorum (Kutz) Lagerheimia
Mougeotia sp.
Oedogonium sp.
Oocystis lacustris Chodat
Oocystis parva West & West
Pandorina sp.
Pediastrum Boryanum (Turp.) Meneghini
Pediastrum duplex Meyen
Pediastrum duplex var clathratum (A.Braun) Lagerheim
Pediastrum duplex var reticulatum Legerheim
Pediastrum simplex (Meyen) Lemmermann
Pediastrum simplex var duodenarium (Bailey) Rabenhorst
Pediastrum tetras (Ehr.) Ralfs
Pediastrum tetras var tetraodon (Corda) Rabenhorst
Phacotus sp.
Protococcus viridis C.A.Agardh
Pteromonas angulosa Lemmermann
Quadrigula closterioides (Bohlin) Printz
Quadrigula lacustris (Chod.) G.M. Smith
Scenedesmus abundans (Kirch) Chodat
Scenedesmus acuminatus (Lag.) Chodat
Scenedesmus acuminatus var minor G.M.Smith
Scenedesmus armatus (Chod) G.M.Smith
Scenedesmus bijuga (Turp.) Lagerheim
Scenedesmus bijuga var alternans (Reinsch) Hansgirg
Scenedesmus denticulatus Lagerheim
Scenedesmus dimorphus (Turp.) Kutzing
Scenedesmus Lystrix Lagerheim
Scenedesmus longus var brevispina G.M.Smith
Scenedesmus opoliensis P.Richter
Scenedesmus quadricauda (Turp.) de Brebisson
Scenedesmus quadricauda var longispina (Chod.) G.M. Smith
Scenedesmus serratus (Cord.) Bohlin
Schroederia setigera (Schroder) Lemmermann
Selenastrum sp.
Sphaerellopsis sp.
Sphaerocystis Schroeteri Chodat
Spirogyra sp.
Staurastrum gracile Ralfs
Stigeoclonium sp.
Tetraedron caudatum (Corda) Hansgirg
Tetraedron minimum (A.Braun) Hansgirg
Tetraedron regulare Kutzing
Tetraedron trigonum var gracile (Reinsch) DeToni
Tetrastrum glabrum (Roll) Ahlstr & Tiff
Tetrastrum heteracanthum (Nordstedt) Chodat forma elegans
Tetrastrum punctatum (Schmidle) Ahlstr & Tiff
Tetrastrum staurogeniaeforme (Schroeder) Lemmermann
Ulothrix tenerrima (Kutz)

TABLE 1 cont'd

Division Euglenophyta

Ascoglena sp. (vaginicola ?)
Astasia sp.
Euglena acus Ehr.
Euglena gracilis Klebs
Euglena oxyuris Schmarda
Euglena oxyuris var *minor* Deflandre
Euglena sp.
Lepocinclis sp.
Phacus acuminatus Stokes
Phacus Arnoldi Swirenko
Phacus helikoides Pochmann
Phacus pseudonordstedii Pochman
Phacus sp.
Strombomonas gibberosa (Playf.) Deflandre
Trachelomonas superba (Swir) Deflandre
Trachelomonas varians (Lemm.) Deflandre
Trachelomonas volvocina Ehr
Trachelomonas sp.

Division Chrysophyta - Sub-Division Xanthophyceae

Dinobryon divergens Imhof
Dinobryon sp. (Tabellariae ?)
Ophiocytium capitatum var *longispinum* (Moebius) Lemmermann
Stipitococcus vasiformis Tiffany

Division Chrysophyta - Sub-Division Chrysophyceae

Mallomonas acaroides Perty
Synura uvella Ehr.

Division Chrysophyta - Sub-Division Bacillariophyceae

Achnanthes hungarica (Grun.) Grun.
Achnanthes lanceolata (Breb) Grun.
Achnanthes lanceolata var *dubia* Grun.
Achnanthes minutissima Kutz
Actinocyclus normanii var *subsalsa* (Juhl.-Dannf.) Hust.
Amphora ovalis var *pediculus* (Kutz) V.H.
Amphora perpusilla (Grun.) Grun
Amphora submontana Hust.
Asterionella formosa Hass.
Caloneis amphisbaena (Bory) Cl.
Caloneis bacillaris var *thermalis* (Grun.) A. Cl.
Caloneis bacillum (Grun.) Cl.
Caloneis clevei (Lagerst.) Cl.
Caloneis lewisii Patr.
Cocconeis placentula Ehr.
Cocconeis placentula var *euglypta* (Ehr.) Cl.
Cocconeis placentula var *lineata* (Erh.) V.H.

TABLE 1 cont'd

<u>Cyclotella atomus</u> Hust.
<u>Cyclotella comta</u> (Ehr.) Kutz.
<u>Cyclotella meneghiniana</u> Kutz.
<u>Cyclotella stelligera</u> (Cl. and Grun.) V.H.
<u>Cymatopleura solea</u> (Breb. and Godey) W. Sm.
<u>Cymbella minuta</u> Hilse
<u>Cymbella minuta</u> var <u>silesiaca</u> (Bleisch) Reim.
<u>Cymbella naviculiformis</u> Auersw.
<u>Cymbella tumida</u> (Breb) V.H.
<u>Cymbella turgidula</u> Grun.
<u>Cymbella ventricosa</u> Ag.
<u>Diatoma tennue</u> var <u>elongatum</u> Lyngb.
<u>Diatoma vulgare</u> Bory
<u>Eunotia arcus</u> var <u>bidens</u> Grun.
<u>Eunotia curvata</u> (Kutz) Lagerst.
<u>Eunotia curvata</u> var <u>subarcuta</u>
<u>Eunotia pectinalis</u> var <u>minor</u> (Kutz) Rabh.
<u>Fragilaria capucina</u> Desm.
<u>Fragilaria crotonensis</u> Kitton
<u>Fragilaria vaucheriae</u> (Kutz) Peters
<u>Fragilaria virescens</u> Ralfs
<u>Gomphonema acuminatum</u> Ehr.
<u>Gomphonema affine</u> Kutz.
<u>Gomphonema affine</u> var <u>elongatum</u>
<u>Gomphonema affine</u> var <u>insigne</u> (Greg) Andrews
<u>Gomphonema angustatum</u> (Kutz.) Rabh.
<u>Gomphonema angustatum</u> var <u>sarcophogus</u> (Greg.) Grun.
<u>Gomphonema gracile</u> Ehr.
<u>Gomphonema intricatum</u> Kutz.
<u>Gomphonema olivaceum</u> (Lyngh.) Kutz.
<u>Gomphonema parvulum</u> (Kutz.) Kutz.
<u>Gomphonema subclavatum</u> (Grun.) Grun.
<u>Gyrosigma scalproides</u> (Rabh.) Cl.
<u>Hantzschia amphioxys</u> (Ehr.) Grun.
<u>Melosira ambigua</u> (Grun.) O.Mull.
<u>Melosira binderana</u> Kutz.
<u>Melosira distans</u> var <u>alpigena</u> Grun.
<u>Melosira varians</u> Ag.
<u>Meridian circulare</u> (Grev.) Ag
<u>Microsphona potamus</u> Weber
<u>Navicula agnita</u> Hust.
<u>Navicula atomus</u> (Kutz.) Grun.
<u>Navicula capitata</u> Ehr.
<u>Navicula confervacea</u> (Kutz) Grun.
<u>Navicula contenta</u> var <u>biceps</u> (Arn.) Grun.
<u>Navicula cryptocephala</u> Kutz.
<u>Navicula cryptocephala</u> var <u>exilis</u>
<u>Navicula elginensis</u> (Greg.) Ralfs
<u>Navicula gregaria</u> Donk
<u>Navicula halophila</u> var <u>tenurostris</u>
<u>Navicula heufleri</u> var <u>leptocephala</u> (Breb.) Patr.
<u>Navicula hungarica</u> var <u>capitata</u> (Ehr) Cl.
<u>Navicula lanceolata</u> (Ag.) Kutz.

TABLE 1 cont'd

Navicula menisculus var upsaliensis Grun
Navicula minima var pseudofossilis
Navicula minusculoides Hust.
Navicula mutica Kutz
Navicula mutica var tropica Hust.
Navicula paucivisitata Patr.
Navicula pelliculosa Hilse
Navicula pupula Kutz
Navicula pupula var rectangularis (Greg.) Cl.
Navicula pygmaea Kutz
Navicula radiosa Kutz
Navicula radiosa var tenella (Breb) Cl. and Moll
Navicula salinarum Grun.
Navicula salinarum var intermedia (Grun.) Cl.
Navicula schroeteri var escambia (Patr.)
Navicula seminulum Grun.
Navicula splendicula Van Landingham
Navicula symmetrica Patr.
Navicula tantula Hust.
Navicula terminata Hust.
Navicula tripunctata var schizonemoides (V.H.) Patr.
Navicula tripunctata var tripunctata (O.F. Mull) Bory
Navicula vaucheriae Peterson
Navicula viridula (Kutz) Ehr.
Nitzschia actinastroides (Lemm.) Van Goor
Nitzschia acuminata (W. Sm.) Grun.
Nitzschia agnita Hust.
Nitzschia amphibia (Grun.)
Nitzschia augustata (W.Sm.) Grun.
Nitzschia capitellata Hust.
Nitzschia communis Rabh.
Nitzschia dissipata var media Grun.
Nitzschia filiformis (W. Sm.) Schutt
Nitzschia fonticola Grun.
Nitzschia frustulum (Kutz.) Grun.
Nitzschia frustulum var perminuta Grun.
Nitzschia frustulum var perpusilla (Rabh.) Grun.
Nitzschia hungarica Grun.
Nitzschia inconspicua Grun.
Nitzschia kuetzingiana Hilse
Nitzschia levidensis (W.Sm.) Grun.
Nitzschia linearis (Ag.) W. Sm.
Nitzschia palea (Kutz) W. Sm.
Nitzschia parvula var terricola Lund
Nitzschia philippinarum Hust.
Nitzschia recta Hantz.
Nitzschia romana Grun.
Nitzschia sigmoidea (Nitz.) W.Sm.
Nitzschia sinuata var tabellaria (Grun.) Grun.
Nitzschia stricta Hust.
Nitzschia subrostrata Hust.
Nitzschia tarda Hust.
Nitzschia tryblionella Hantz.

Pinnularia abaujensis var rostrata (Patr.) Patr.
Pinnularia brebissonii (Kutz.) Rabh.
Pinnularia brebissonii var diminuta (Grun.) Cl.
Pinnularia microstauron (Ehr.) Cl.
Pinnularia nodosa (Ehr.) W.Sm.
Pinnularia stomatophora (Grun.) Cl.
Pinnularia termitina (Ehr.) Patr.
Plagiotropis lepidoptera var proboscidea (Cl.) Reim.
Rhoicosphenia curvata (Kutz.) Grun.
Stauroneis anceps Ehr.
Stauroneis kriegeri Patr.
Stauroneis phoenicenteron var gracilis (Ehr.) Hust.
Stephanodiscus astraea (Ehr.) Grun.
Stephanodiscus astraea var minutula Grun.
Stephanodiscus hantzschii Grun.
Stephanodiscus subtilis (Van Goor) A.Cl.
Stephanodiscus tenuis Hust.
Surirella angusta Kutz.
Surirella ovata Kutz.
Surirella ovata var pinnata (W.Sm.) Rabh.
Surirella turgida W.Sm.
Synedra acus Kutz.
Synedra fasiculata (Ag.) Kutz.
Synedra fasiculata var truncata (Grev.) Patr.
Synedra pulchella Ralfs
Synedra pulchella var capitata
Synedra rumpens var familiaris (Kutz.) Hust.
Synedra ulna (Nitz.) Ehr.
Synedra ulna var obtusa (W.Sm.) Grun.
Tabellaria fenestrata (Lyngb.) Kutz.
Thalassiosira fluviatilis Hust.
Thalassiosira pseudonana Hasle and Heim.

Division Cryptophyta

Cryptomonas erosa Ehr.
Cryptomonas erosa var reflexa Marsson
Rhodomonas lacustris Pascher & Ruttner
Rhodomonas sp.

Division Pyrrhophyta

Ceratium hirundinella (O.F. Muell.) Dujardin
Glenodinium sp.
Gymnodinium acidotum Nygaard
Gymnodinium helveticum Penard
Gymnodinium sp.

Figure 18: Seasonal changes in population density of phytoplankton at site A from 25 March to 29 July 1981.

1 is the diatom fraction; 2 is the non-diatom fraction.

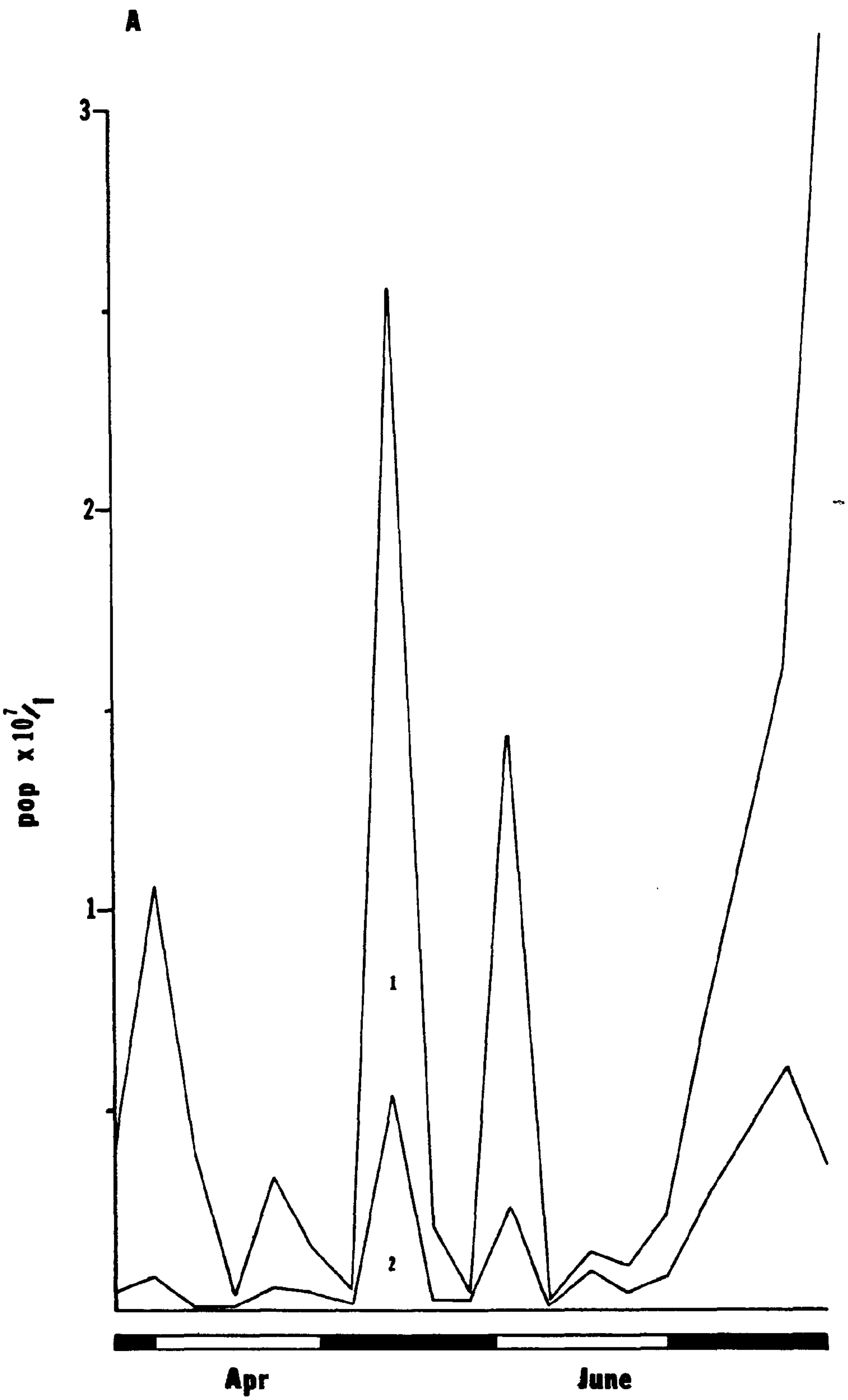

A
3
2
1
pop x 10⁷/l
1
2
Apr
June

Figure 19: Seasonal changes in population density of phytoplankton at site B from 25 March to 29 July 1981.

1 is the diatom fraction; 2 is the non-diatom fraction.

B

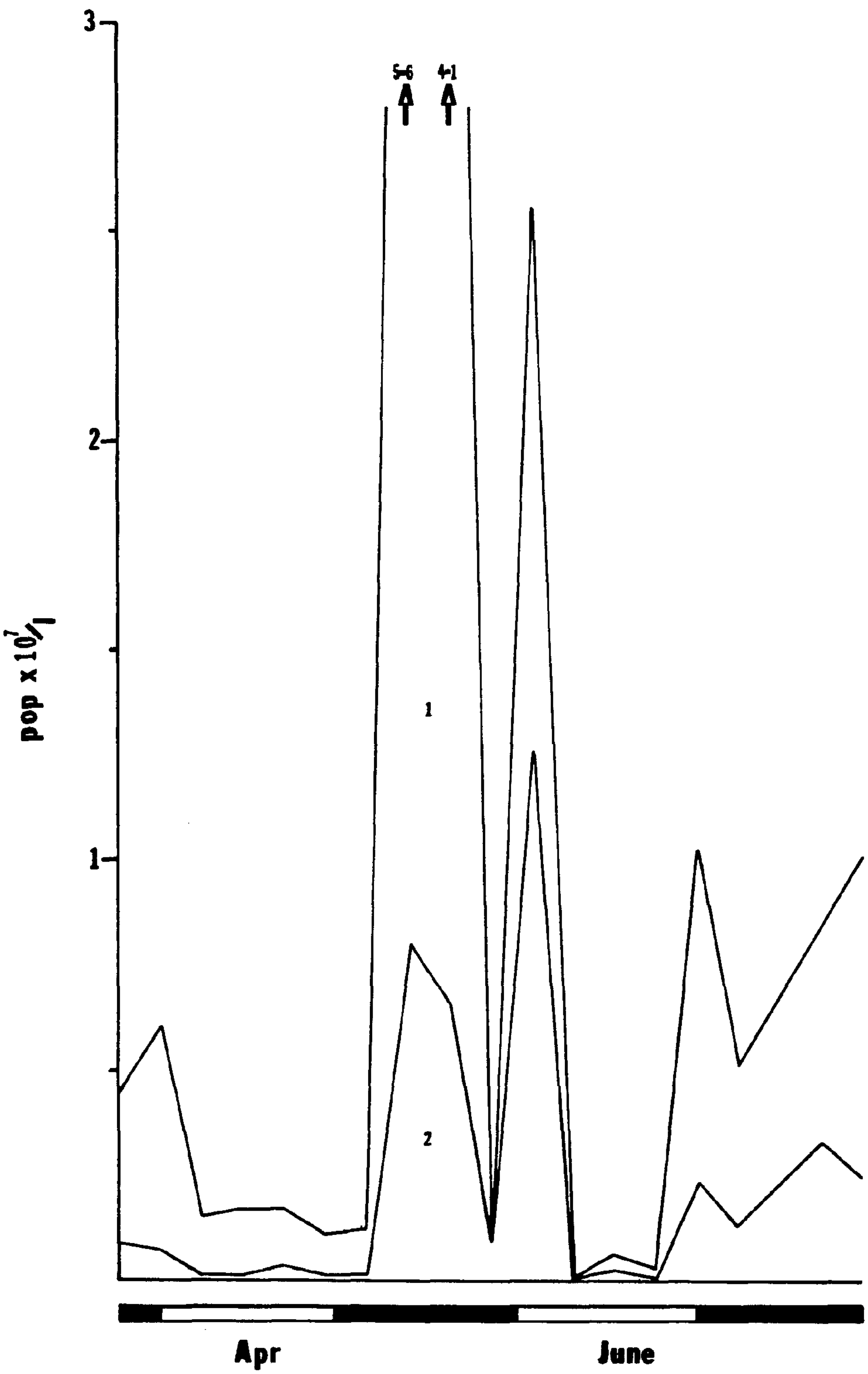
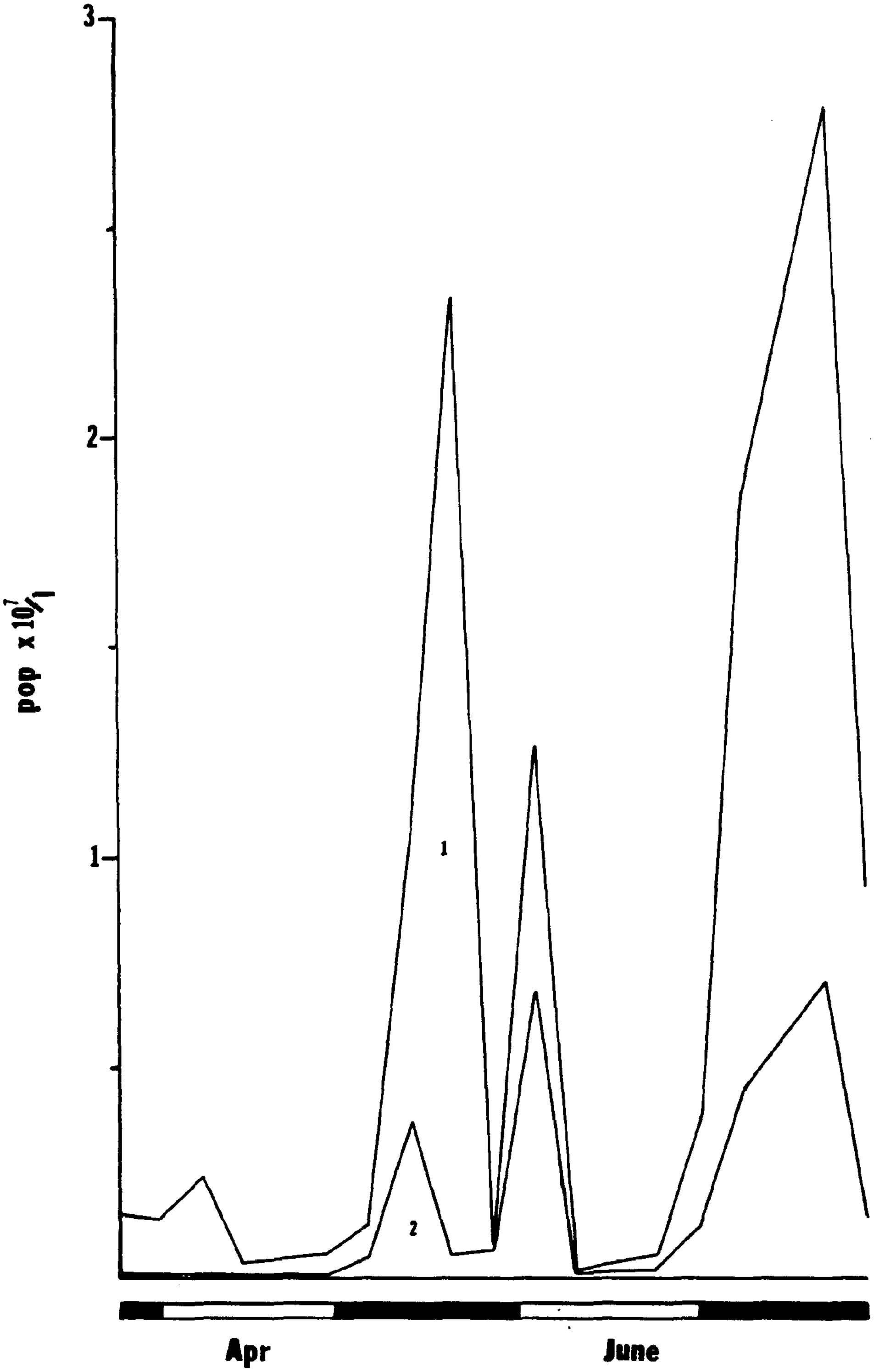


Figure 20: Seasonal changes in population density of phytoplankton at site C from 25 March to 29 July 1981.

1 is the diatom fraction; 2 is the non-diatom fraction.

c



horizontal distribution of the plankton is not available.

The large drop in the estuarine plankton populations in mid-June corresponded to high turbidity levels at all stations on the creek. As mentioned previously, high turbidity is indicative of high flow rates. This would suggest that the plankton in the estuary was flushed into Lake Erie. It is possible that other population crashes may have been the result of flushing also.

Melosira binderana is a common Spring diatom in Lake Erie (Hohn, 1969). Although this algae was never a dominant species in Old Woman Creek, it was frequently observed at site A, the mouth. It was rarely recorded at any of the other estuarine sites and was never recorded above site D. This distributional pattern would suggest that this species is not normally found in the estuary, but rather is of lake origin.

The two transitional sites (D&E) displayed varying degrees of creek and estuarine influence (figs. 21 and 22). The April and May estuarine plankton peaks were greatly reduced at site D and absent from site E. The dominant species in the abreviated peaks at site D and those in the estuarine phytoplankton were similar. Nitzschia spp. and Navicula spp. (benthic genus) were the most common algae during the first peak. The second two reduced peaks had the same dominant species observed in the estuary. During this same period, late March to mid-June, the plankton populations at site E were dominated by benthic diatoms that had apparently washed into the water column. The July peak at both the transitional sites was dominated by euplanktonic species. The peak at site D again was composed of estuarine species; Nitzschia spp., Melosira distans, Cryptomonas erosa, and Rhodomonas sp. The reduced peak at site E was dominated by Rhodomonas sp. and Euglena spp.

Figure 21: Seasonal changes in population density of phytoplankton at site D from 25 March to 29 July 1981.

1 is the diatom fraction; 2 is the non-diatom fraction.

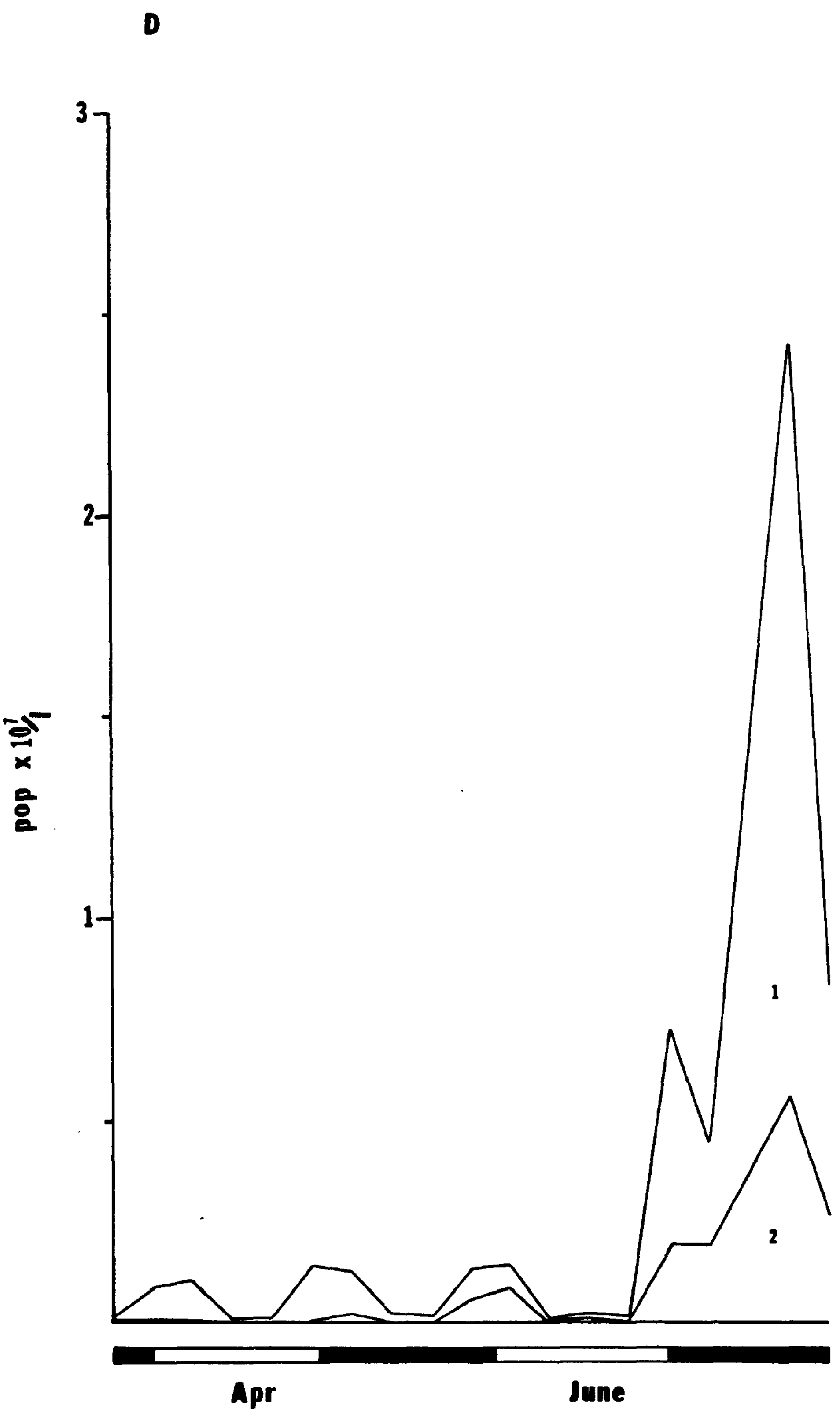
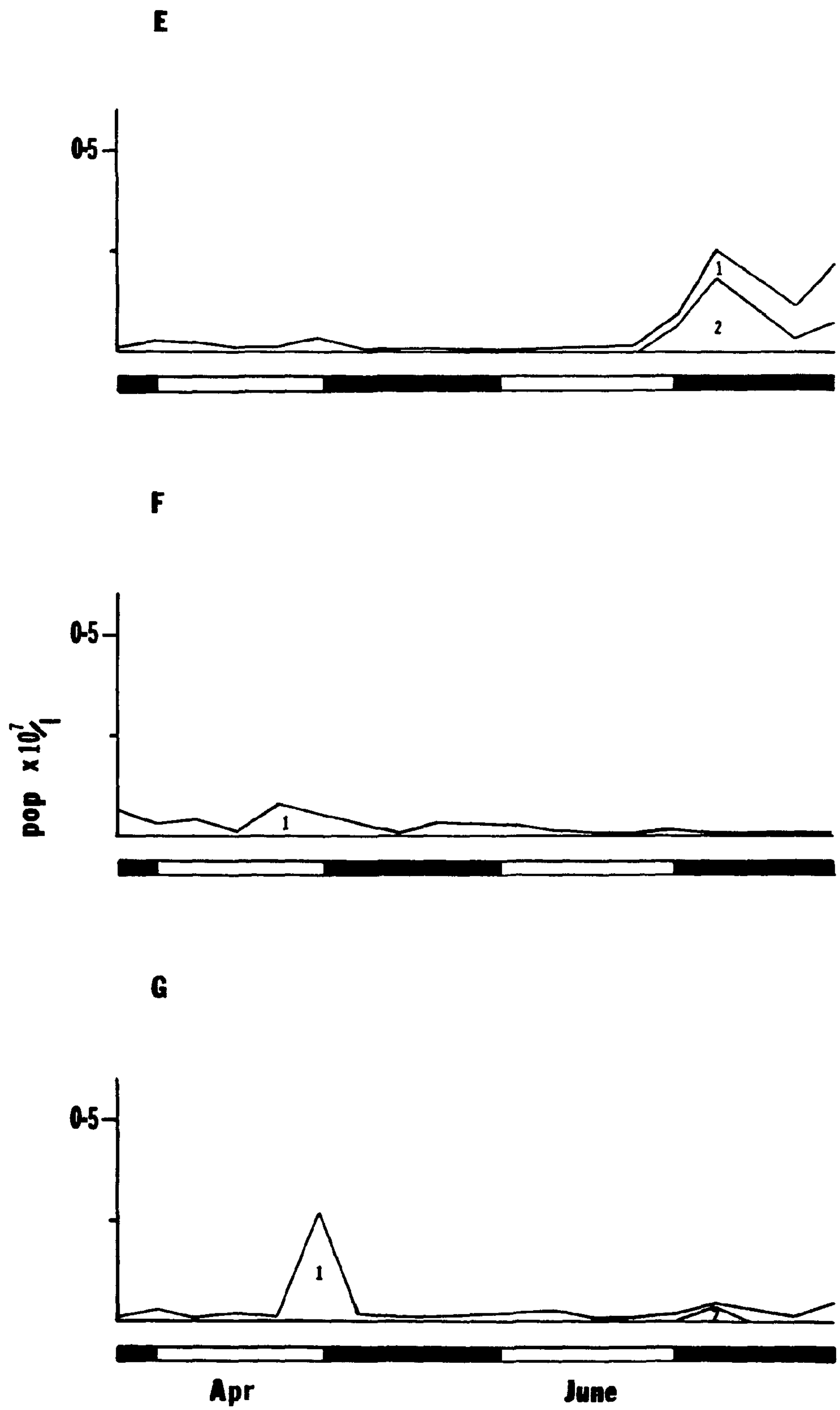

D
3
2
1
pop x 10⁷/l
1
2
Apr
June

Figure 22: Seasonal changes in the population density of phytoplankton at sites E, F, & G from 25 March to 29 July 1981. 1 is the diatom fraction; 2 is the non-distom fraction.


E
0·5
1
2
F
0·5
pop x10⁷/l
1
G
0·5
1
Apr
June

The planktonic community of the creek proper was dominated by pennate diatoms, primarily of benthic origin (figs. 22, site F & G; 23; and 24). Population numbers were very low. The only exception was at site H in early July when there was a prominent peak of Gymnodinium sp. and Cryptomonas erosa. In late April at all creek sites there was a peak observed. This peak was comprised of benthic diatoms and occurred in conjunction with high turbidity levels. This would suggest that a heavy flow dislodged benthic diatoms and temporarily suspended them in the water column.

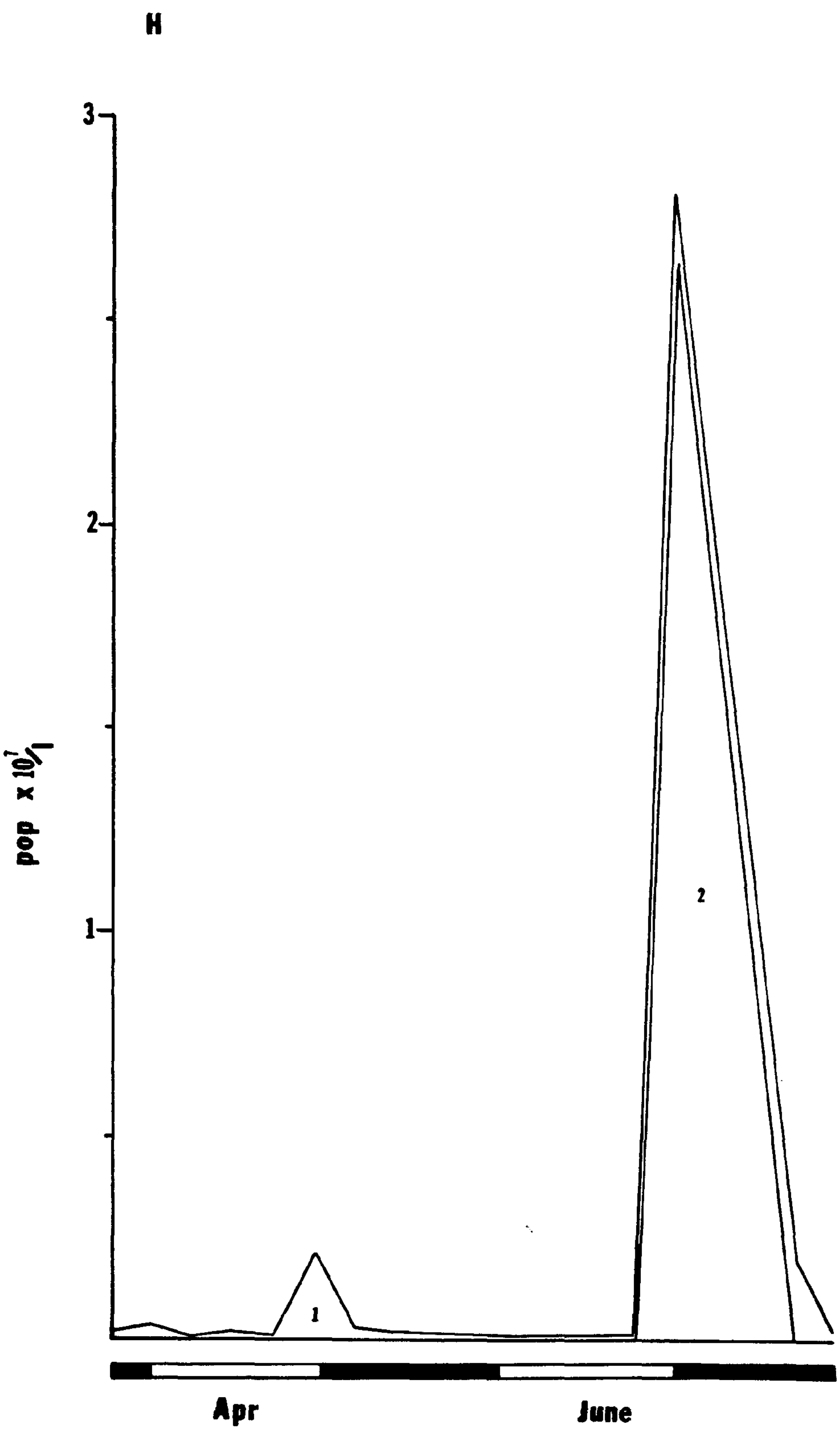
Benthic Algae- The epiphyton of the estuary was significantly different from the epilithon of Old Woman Creek. This variation was probably not due to substrate dissimilarity (macrophyte vs. rock) as first would be expected because no epiphyton - epilithon substrate affinity has been recorded from a temperate freshwater system (Klarer, 1973). Many diatoms, in fact, are classified as periphytic (Lowe, 1974) and so would be found in both epiphytic and epilithic communities. The heterogeneity between the two communities is probably related to differences in water quality between the estuary and the creek proper.

The epiphyton sampling program began on 25 March at site 1, this being the only site that had dead Nelumbo stems left from the previous growing season (fig. 25). Sampling continued on these stems until mid-April when wind induced water turbulence destroyed the stems. The epiphyton on the dead stems was dominated by Gomphonema olivaceum and Diatoma elongatum. In early April Stigeoclonium sp. joined the other species as a co-dominant.

Epiphyte sampling on the live macrophytes began after growth initiation of the host macrophytes. There was no distinct seasonal pattern in total population numbers during the sampling program (figs. 25, 26, 27, 28). However, the seasonal succession patterns were generally similar at all sites. Nitzschia spp. and Navicula spp. were the most abundant members of the

Figure 23: Seasonal changes in the population density of phytoplankton at site H from 25 March to 29 July 1981.

1 is the diatom fraction; 2 is the non-diatom fraction.



H
3
2
1
pop x 10^7/l
1
2
Apr
June

Figure 24: Seasonal changes in the population density of phytoplankton at sites I, J, & K from 25 March to 29 July 1981. 1 is the diatom fraction; 2 is the non-diatom fraction.

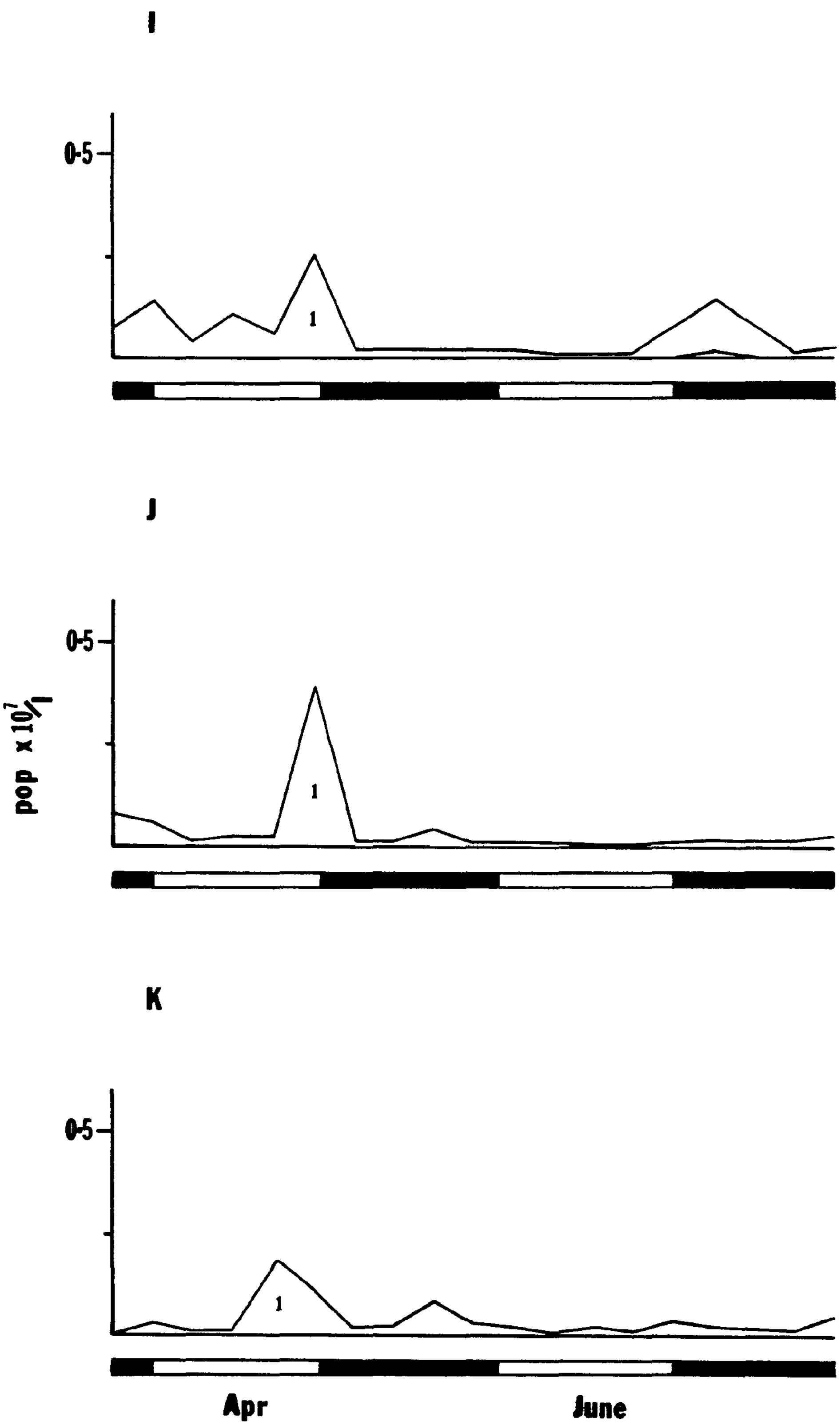

I
0·5
1
J
0·5
pop x 10^7/l
1
K
0·5
1
Apr
June

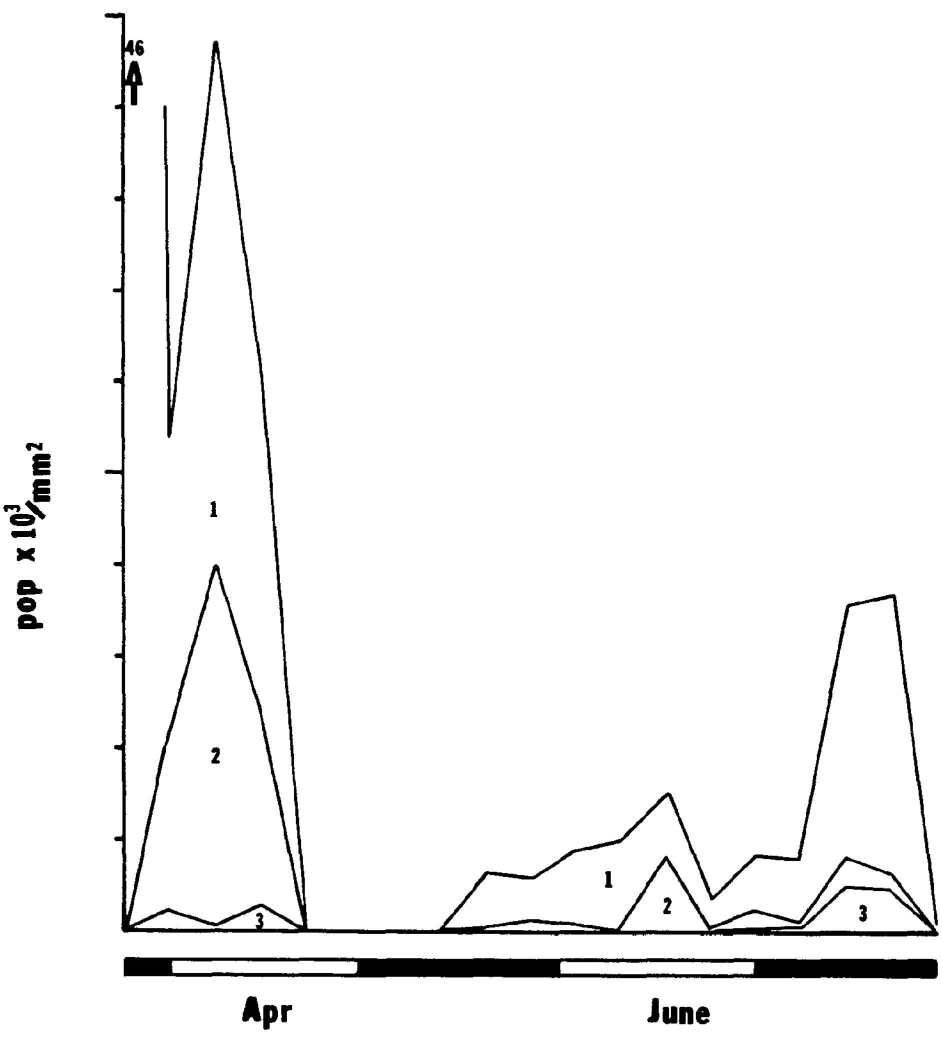
Figure 25: Seasonal changes in the Epiphyton at site 1 from 25 March to 29 July 1981.

1 is the diatom fraction; 2 is the green algal fraction; 3 is the blue-green algal fraction.

Figure 26: Seasonal changes in the Epiphyton at site 2 from 25 March to 29 July 1981.

1 is the diatom fraction; 2 is the green algal fraction; 3 is the blue-green algal fraction.

Epiphyton 1



Epiphyton 2

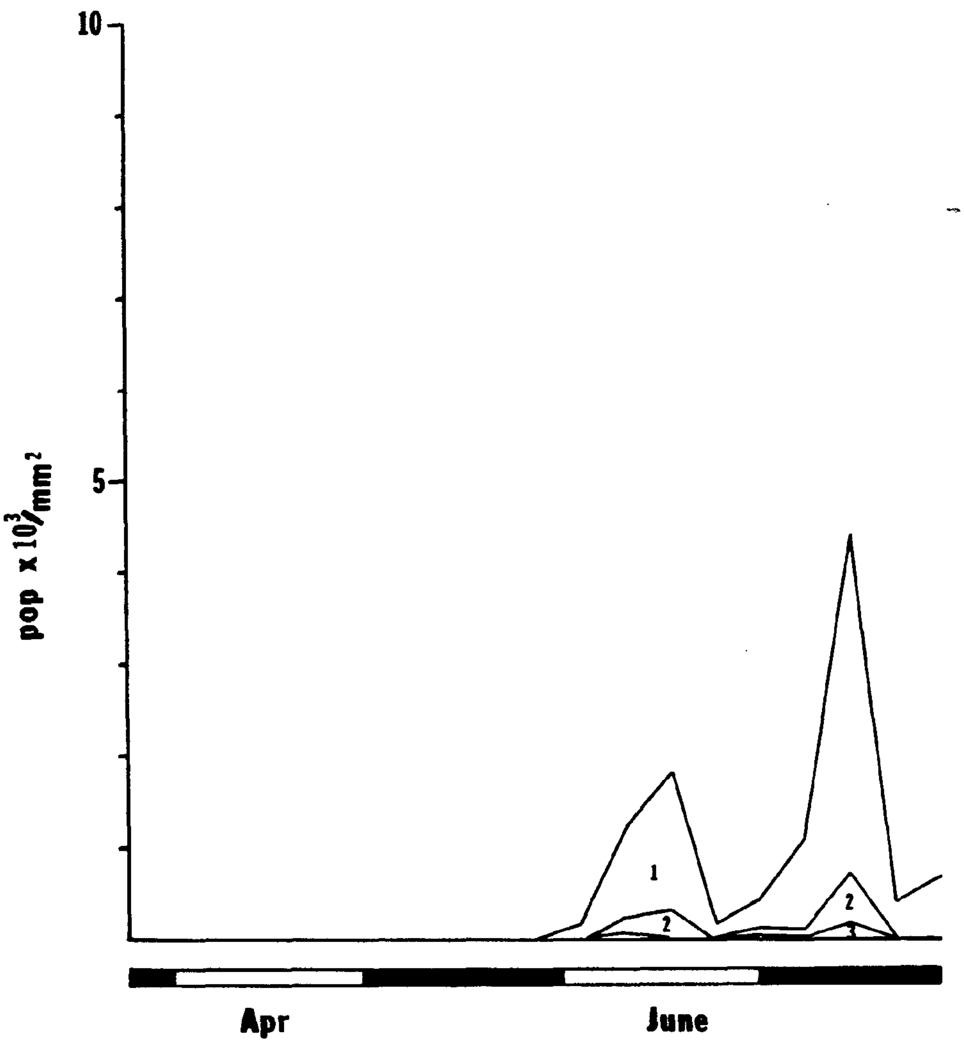


Figure 27: Seasonal changes in the Epiphyton at site 3 from 25 March to 29 July 1981.

1 is the diaton fraction; 2 is the green algal fraction; 3 is the blue-green algal fraction.

Epiphyton 3

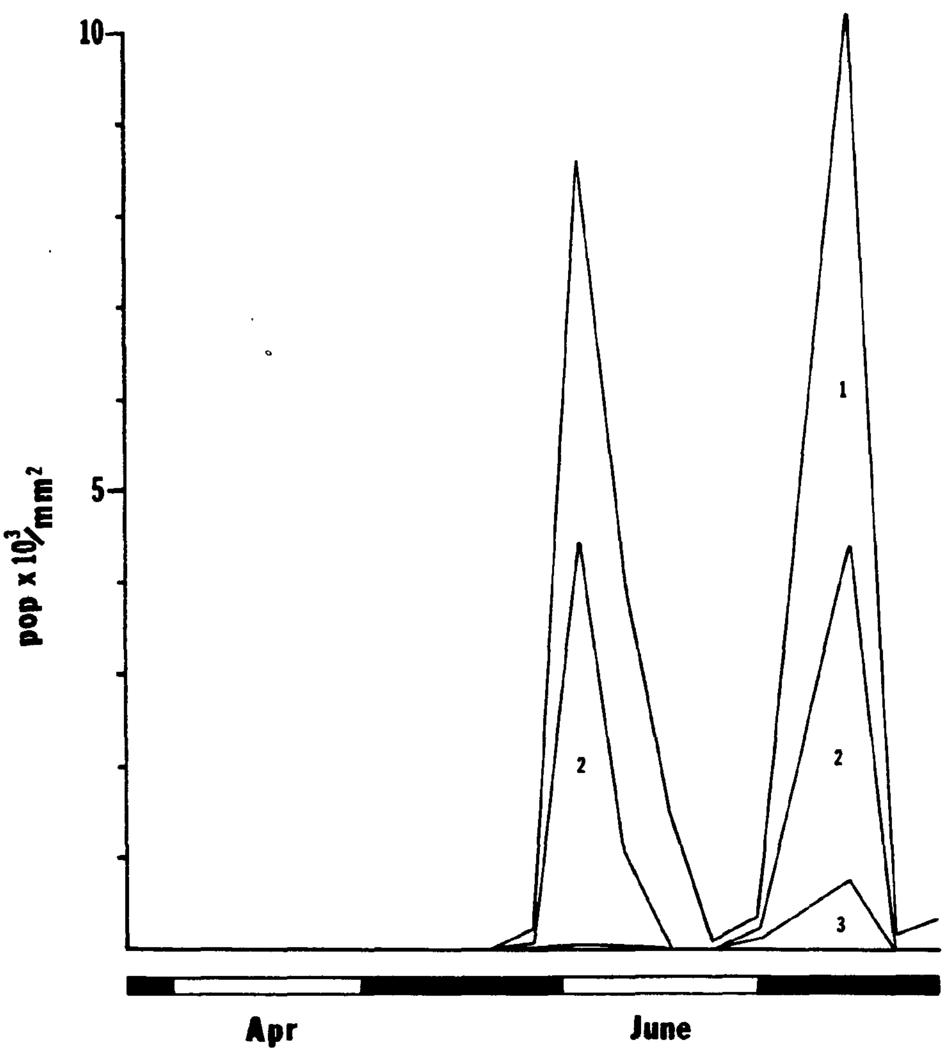
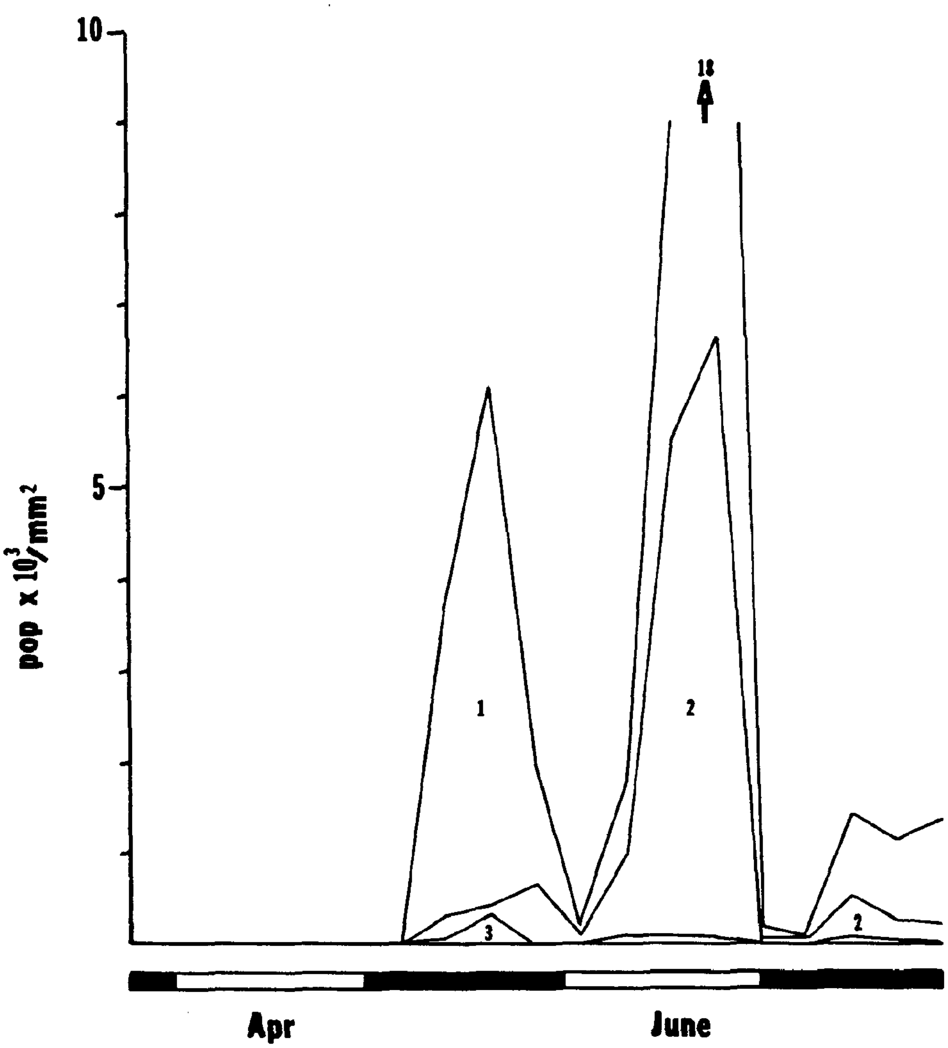


Figure 28: Seasonal changes in the Epiphyton at site 4 from 25 March to 29 July 1981.

1 is the diatom fraction; 2 is the green algal fraction; 3 is the blue-green algal fraction.

Epiphyton 4



epiphyton during May. Gomphonema parvulum assumed dominance in June and shared dominance in July with Achnanthes spp. and Nitzschia spp. Stigeoclonium sp. and Phormidium sp. were also common during June and July.

The epiphytic population at site 4 had a slightly different succession pattern during June than that outlined above. Melosira varians shared dominance with Gomphonema parvulum during this month and Oedogonium sp. and Spyrogyra sp. replaced Stigeoclonium as the most common green algae.

There was no distinct seasonal pattern in population numbers observed at the five epilithon sites (figs.29, 30, 31, 32, 33). A seasonal pattern in the algal succession, however, has emerged from this study. Gomphonema olivaceum dominated the epilithon in the early weeks of the study. During April with increasing water temperatures and light levels, Cladophora glomerata and its epiphyton, primarily Rhoicosphenia curvata and Cocconeis placentula assumed dominance. (Many of the diatoms recorded in the epilithon were technically epiphytes growing attached to Cladophora, e.g. Cocconeis placentula and Rhoicosphenia curvata.) During June Achnanthes minutissima and Nitzschia spp. became very common and often assumed numerical dominance. Nitzschia spp., Achnanthes minutissima, and Navicula spp. were the most common species during the final month of the study.

Numerically Cladophora glomerata was never a major component of the epilithon, but was a dominant species in terms of biomass, due to the large relative cell size of this alga. The results of this study were presented in terms of counts instead of biomass, because biomass tends to overestimate the importance of the large celled algae and underestimate and even mask changes in the smaller algae (Klarer, 1973).

The species composition of the epiphyton was significantly different from that of the epilithon through most of the study period. Only in

Figure 29: Seasonal changes in the Epilithon at site F from 25 March to 29 July 1981.

1 is the diatom fraction; 2 is the green algal fraction; 3 is the blue-green algal fraction.

Epilithon F

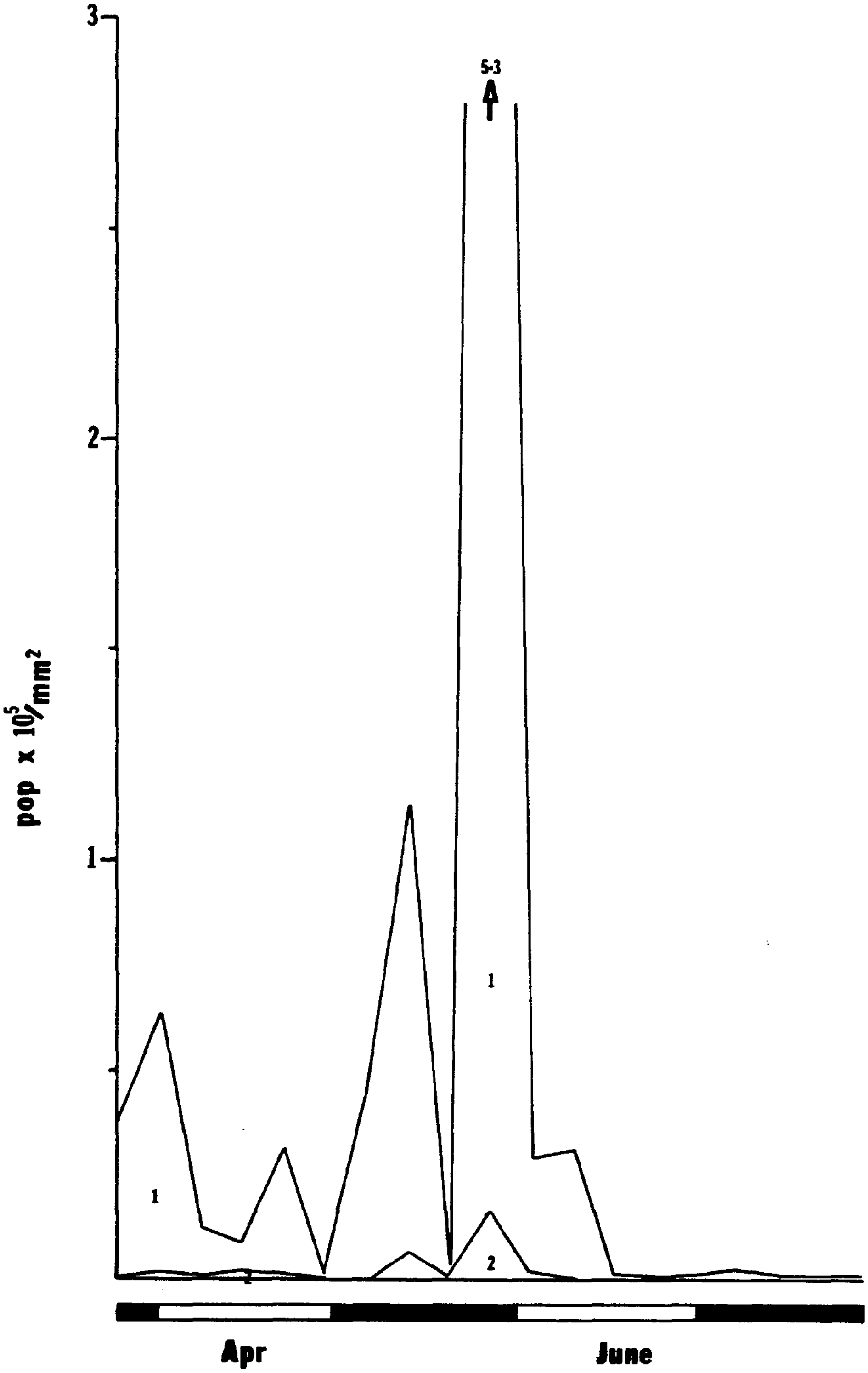


Figure 30: Seasonal changes in the Epilithon at site G from 25 March to 29 July 1981.

1 is the diatom fraction; 2 is the green algal fraction; 3 is the blue-green algal fraction.

Epilithon G

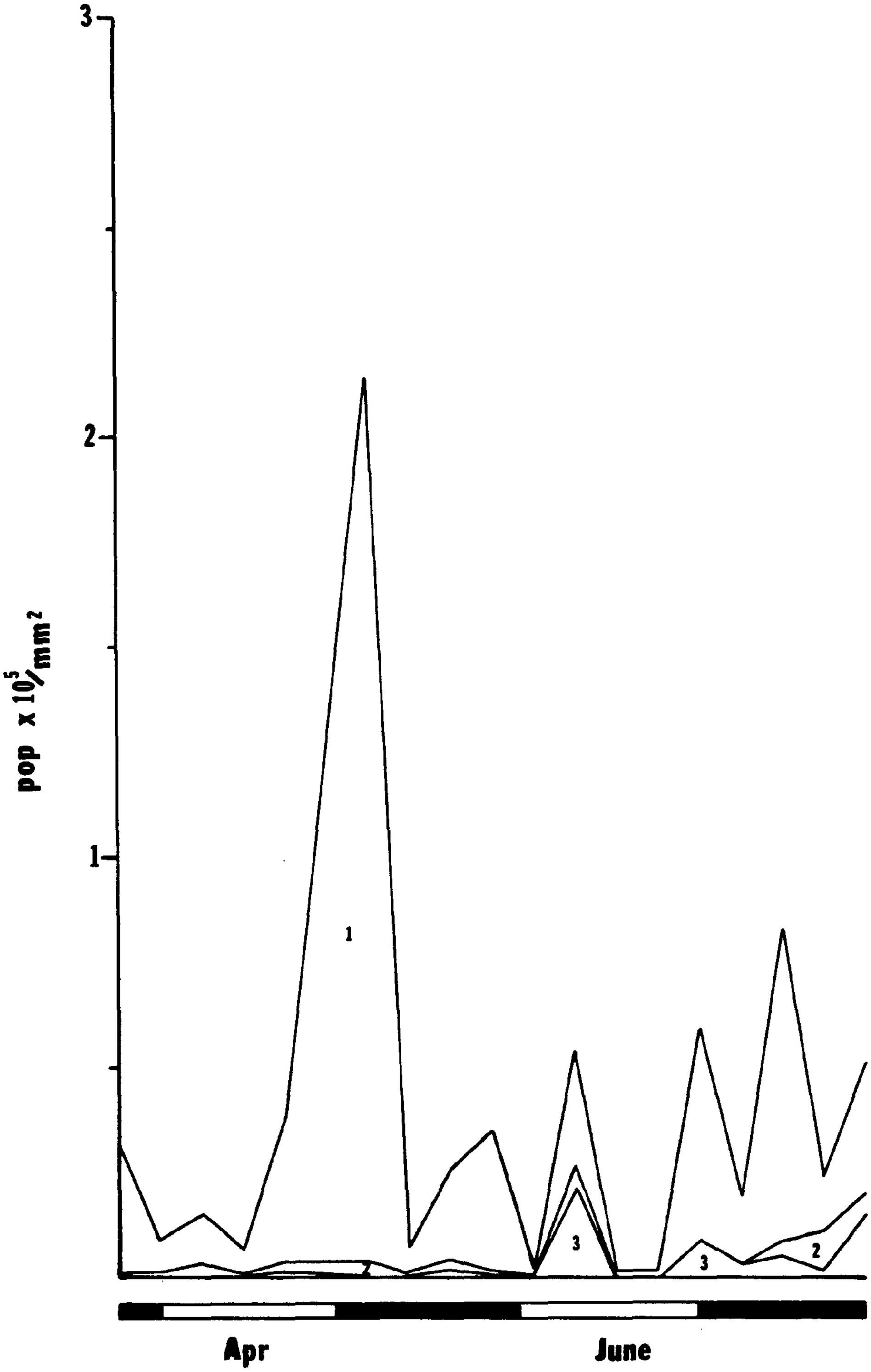


Figure 31: Seasonal changes in the Epilithon at site I from 25 March to 29 July 1981.

1 is the diatom fraction; 2 is the green algal fraction; 3 is the blue-green algal fraction.

Epilithon I

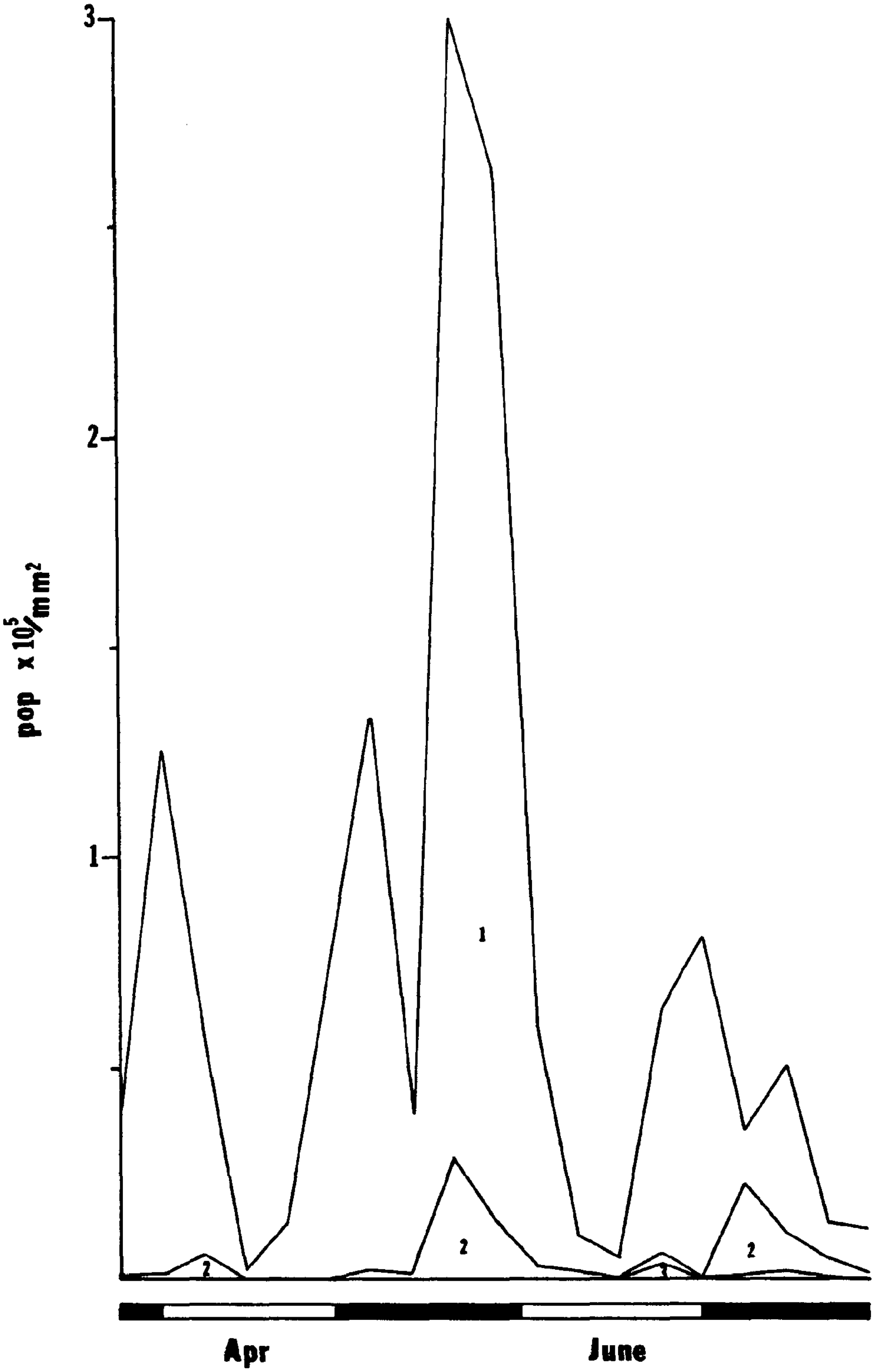


Figure 32: Seasonal changes in the Epilithon at site J from 25 March to 29 July 1981.

1 is the diatom fraction; 2 is the green algal fraction; 3 is the blue-green algal fraction.

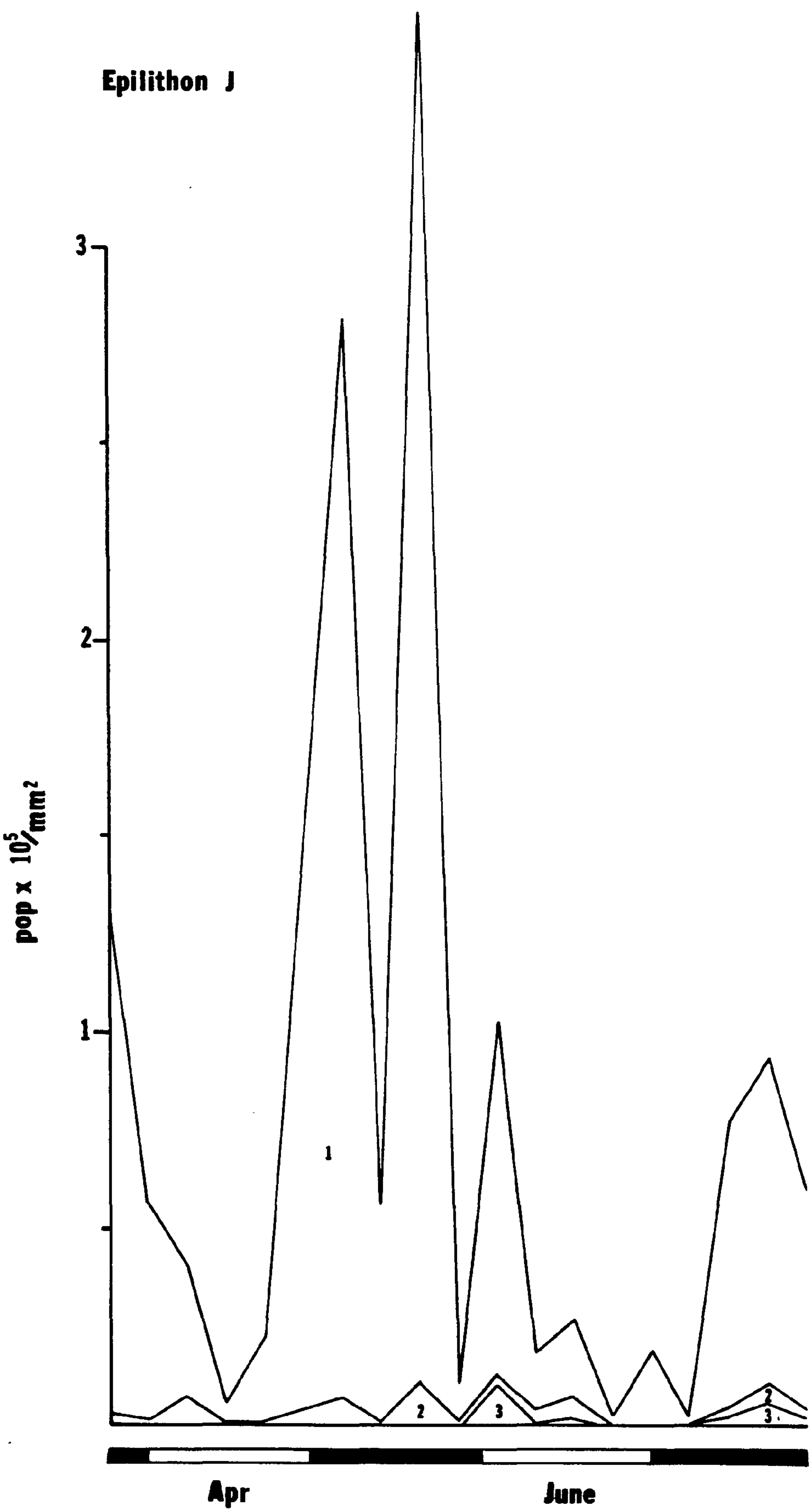
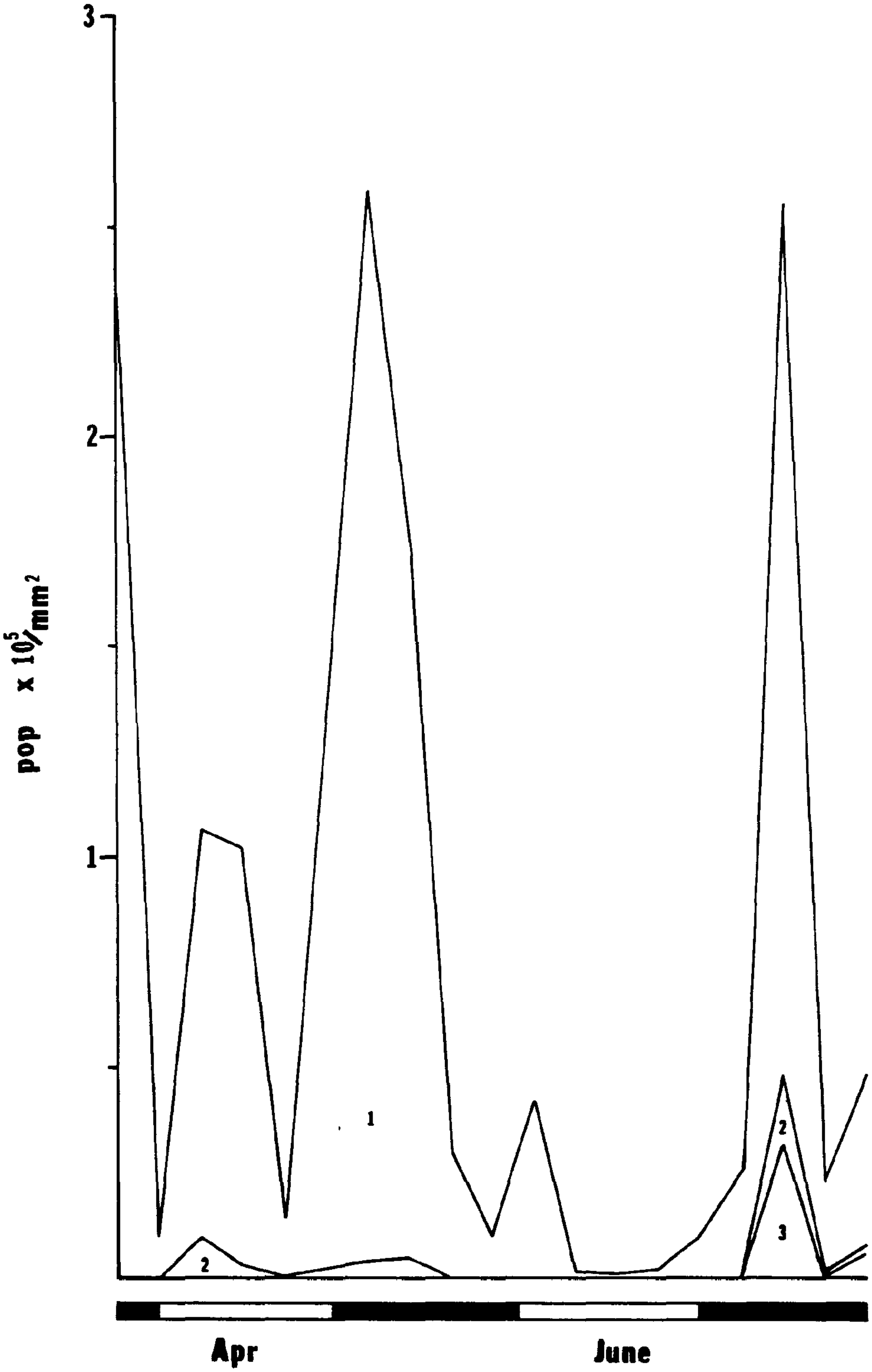

Epilithon J
3
2
1
pop x 10^5/mm^2
1
2
3
2
3
Apr
June

Figure 33: Seasonal changes in the Epilithon at site K from 25 March to 29 July 1981.

1 is the diatom fraction; 2 is the green algal fraction;

3 is the blue-green algal fraction.

Epilithon K



late March and early April, when Gomphonema olivaceum was the dominant species in both communities, did the two communities have marked similarities. Cladophora glomerata was only reported in the creek proper. This distribution would correspond to reports by previous workers (Whitton, 1970), which stated that Cladophora was restricted to running water. The filamentous algae in the estuarine benthic communities, Stigeoclonium sp., Oedogonium sp., and Spyrogyra sp., have previously been reported in standing water (lake) systems. None of these species were reported in the creek proper. The dominant algae in the creek proper included Rhoicosphenia curvata and Achnanthes minutissima, both of which are indicative of well oxygenated waters (Lowe, 1974). Gomphonema parvulum was among the dominant benthic diatoms in the estuary. This species can survive in low dissolved oxygen concentrations (Lowe,1974), as were recorded in the estuary during June and July.

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APPENDIX 1

Species List of Macroinvertebrates collected in Old Woman Creek

Species Composition of Selected Benthic Macroinvertebrate Communities

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Phylum Annelida

Branchuria sowerbyi (Beddard)
Glossiphonia sp.
Placobdella sp.
Stylodrilus heringianus (Claparede)

Phylum Arthropoda

Class Crustacea - Order Amphipoda

Hyalella azteca (Saussure)

Class Insecta - Order Plecoptera

Allocapnia recta (Claassen)
Allocapnia vivapara (Claassen)
Isoperla duplicata (Banks)
Isoperla sp.

Class Insecta - Order Ephemeroptera

Caenis simulans (McDonnough)
Ephermeralla sp.
Heptagenia pulla (Clemens)
Isonychia sicca (Walsh)
Stenonema femoratum (Say)

Class Insecta - Order Megaloptera

Sialis sp.

Class Insecta - Order Trichoptera

Cheumatopsyche sp.
Chimarra sp.
Hydropsyche sp.
Rycophila sp.

Class Insecta - Order Coleoptera

Donacia sp.
Dytiscus sp.
Elmidae sp.
Helichus sp.
Psephenus herricki (DeKay)

Class Insecta - Order Diptera

Alabesmyia parajanta (Roback)
Chaoborus sp.
Chironomus anthracinus group
Chironomus decorus (Johannsen)
Chironomus riparus group
Coelatanypus concinnsus (Coquillatt)
Criptopus tremulus group
Dictotendipes nervous (Staeger)
Endochironomus nigrans (Johannsen)
Glyptotendipes loberiferus (Say)
Labrundinia pilosilla (Loew)
Microspecta polita (Malloch)
Microtendipes caelum (Townes)
Orthocladius obumbrates (Johannsen)
Pentaneura sp.
Potthastia longimanus (Kieffer)
Probezzia sp.
Procladius subletti (Roback)
Rheotanytarus exiguncus (Bause)
Sympothastia sp.
Tanypus sp.
Tanytarsus glabrescens group
Thienamannimaya group