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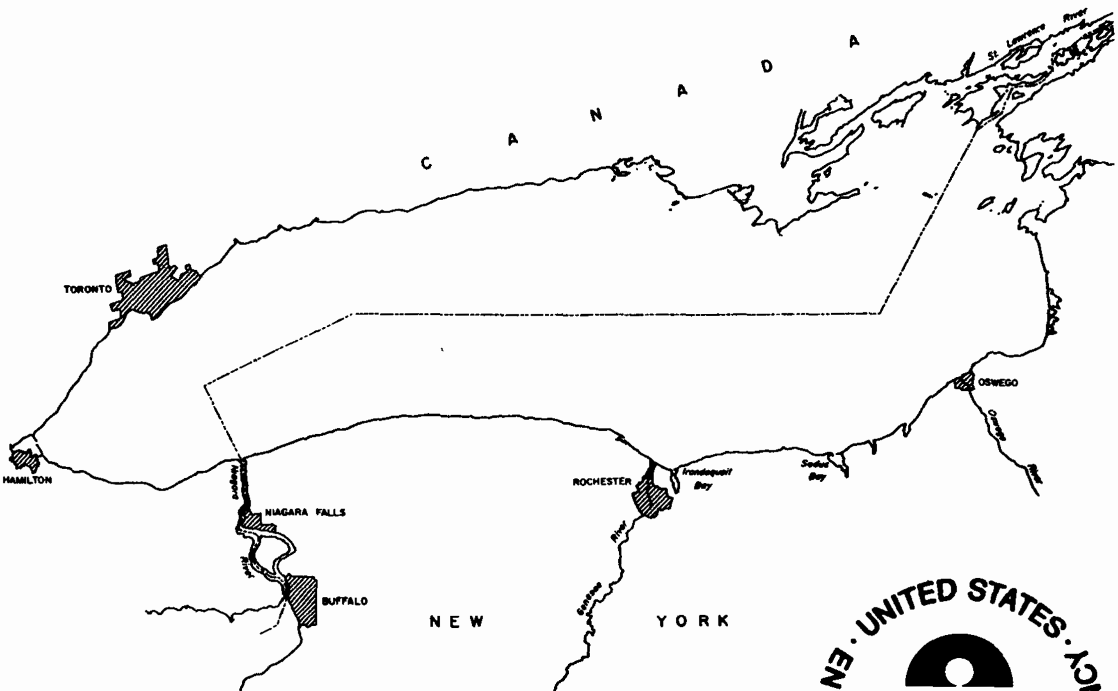
COMPREHENSIVE IFYGL MATERIALS BALANCE STUDY FOR LAKE ONTARIO BASIN

PART II



U.S. ENVIRONMENTAL PROTECTION AGENCY
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COMPREHENSIVE IFYGL MATERIALS BALANCE STUDY FOR LAKE ONTARIO
PART II

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Chapter 4

4.1 Data analysis techniques

For a comprehensive discussion of the chemical characteristics of Lake Ontario, the measurements have been grouped into 4 basic categories: (1) nutrients, (2) major ions, (3) heavy metals and (4) field measurements.

The nutrient chemistry involved variations in the concentrations of total phosphate (TP - P), total filterable phosphate (TFP - P), dissolved orthophosphate (DOP - P), nitrite-nitrate (NO2-NO3 - N), ammonia (NH3 - N), total Kjeldahl nitrogen (TKN - N), organic nitrogen (ON - N), total nitrogen (TN - N), total organic carbon (TOC) and silica (SiO2). Included as major ions are sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), sulfate (SO4), and fluoride (F). Manganese (Mn), iron (Fe), nickel (Ni), copper (Cu), zinc (Zn), and cadmium (Cd) are the heavy metals. The quantities pH, dissolved oxygen and total alkalinity were obtained as field measurements. The water temperatures were improperly measured and so have not been reported.

Variations of the chemical concentrations and field measurements are, of course, a very complex matter. Statistics for each of the cruises are provided in Tables 4.1a through 4.1k. In order to ascertain some basic trends in these variations, histograms for the measurements of each substance for each cruise have been obtained (the "a" series of figures for each substance). The "b" series show the lake surface concentrations map. The variations in mean concentration with depth are presented in the "a" series of tables (beginning with Table 4.2a). Depth-time isopleths of concentration have been determined in the figures labeled "c". Horizontal variations are presented in figures "d" (north-south variations), "e" (middle lake-offshore variations), and the "b" series of tables (east-west variations). Figures "f" and "g" show the mean monthly surface and bottom concentrations and where possible compare these with those reported by Shiomi and Chawla (1970) which spanned the period April 1969 through March 1970. In addition, a calculation of the mass of each substance contained in the lake at the time of each cruise has been made. The total masses together with the masses of each of the horizontal sublayers into which the lake was divided are presented in the tables "c" beginning with 4.2c. A summary of the total masses for each cruise has been provided in Table 4.26. The masses of each substance in the upper 20 meter "eutrophic zone" appear in Table 4.25.

Before continuing with the discussion of the individual substances, the analysis procedures previously listed will be described. Contours of constant surface concentrations have been plotted for those substances for which data were obtained from at least 25 (0 to 2 meters) sampling stations. Using the SYMAP computer contouring package (Dudnik 1971) together with a digitized map of the shoreline of Lake Ontario, contours for each substance on each cruise have been drawn.

The variations of the mean concentrations of each of the substances with depth were obtained from the SPLOTCH (Boyce 1973) computer program. The program interpolates vertically to fill gaps in the missing data and then layer mean concentrations are obtained by dividing the calculated layer masses by the layer volumes.

In order to determine the general east-west trends in the concentration variations, the lake is split into sections which run perpendicular to the lake in a roughly north-south direction, see Figure 4.1. The concentrations of each substance measured at all stations within each section have been averaged and are listed in the tables designated "b".

North-south variations in the concentrations of each substance are obtained by dividing the lake into sections which are perpendicular to the lake surface in a generally east to westerly direction. Stations in each section are indicated in Figure 4.2. Averages were obtained for the north, central and southern sections. These mean values have been plotted in the "d" series of figures.

For the comparison of middle lake and offshore mean concentrations the lake has been divided as indicated in Figure 4.3. The field year variations of the mean middle lake and mean offshore concentrations have been plotted in the "e" series of the figures.

Lake mass contents of the nutrients, major ions and heavy metals have been calculated by means of a numerical integration of the product of the substance concentration and the volume element associated with that concentration over the entire lake.

The bottom surface contours and the lake shoreline have been digitized for an accurate volume determination of Lake Ontario. The integrations were performed by means of the SPLOTCH (Boyce 1973) computer program which divided the lake into layers and obtained the mass of each substance in each of the layers. These layer masses together with the total mass of each substance are listed in the "c" series of tables with the totals summarized in Table 4.26.

4.2 Nutrients

TOTAL PHOSPHATE

The means, standard deviations, maximum and minimum concentration measurements of total phosphate are presented in Tables 4.1a - 4.1k for each of the 11 materials balance cruises. For each of the cruises, a total phosphate histogram has been drawn in Fig 4.4a. These are generally somewhat skewed toward lower values.

Computer surface concentration maps of TP are provided in Fig 4.4b for cruises 4(Jul 10-14, 1972), 5(Aug 21-25, 1972), 6(Oct 30-Nov 2, 1972), 7(Nov 27-Dec 2, 1972), 9(Mar 18-23, 1973), 10(Apr 24-30, 1973) and 11(Jun 11-15, 1973). Insufficient surface concentration data was available in the case of the other cruises. The pattern roughly appears to be characterized by higher south shore concentrations in the mid summer (cruise 4) followed by a propagation of higher concentrations northward (cruises 5 and 6). The surface concentration became fairly uniform with the onset of winter (cruise 7). During 1973, the cycle of higher concentration on the south shore in the early spring (cruise 9) which later migrating northward in summer (cruises 10 and 11) was repeated.

The variations of the mean concentration with depth were provided in Table 4.2a. The early May (cruise 1) concentrations were fairly uniform with depth at about .010 mg/l. By mid May (cruise 2) the concentrations were higher throughout the lake with the highest levels in the depth range 30-100 meters. The spring turnover appeared to have occurred between these two cruises. The mid June (cruise 3) concentrations showed a similar distribution to that of the previous cruise. By middle July (cruise 4) there was a definite negative gradient of the concentration with depth. In mid August (cruise 5) the upper 20 meters concentrations had decreased while the concentrations in the 30-150 meter depths have increased. The fall overturn seemed to have homogenized the concentration by November (cruise 6). Generally December, February, March and April (cruises 7,8,9, and 10) are fairly uniform with depth. Between cruises 10 and 11 (later April and mid-June) there was the spring turnover with maximum concentrations again in the middle levels. Fig 4.4c illustrates these seasonal variations of concentration with depth.

Fig 4.4d, which shows the north to south variation of the mean total phosphate concentrations, demonstrates a rather well defined north to south positive gradient with central lake values running generally lower than either the north or south shore areas. The offshore-middle lake variation is further illustrated in Fig 4.4e where offshore values slightly exceed those of the middle lake. Table 4.2b shows no enduring bias throughout the field year (each segment showed a mean over the field year of about .018 mg/l). Cruises 1,2,6,8,9 and 11 exhibited an increase from east to west while the opposite trend was noted in cruises 3, 4 and 10 data. Cruises 5 and 7 showed increased concentrations in the central portion.

Fig 4.4f compares the mean surface concentrations of total phosphate as measured by Shiomi and Chawla (1970) in 1969-70 with the IFYGL study. The Shiomi and Chawla values averaged about 1.4 times those of the IFYGL study in 1972-73. The comparison of the bottom concentrations, Fig 4.4g, also showed uniformly higher values in the Shiomi-Chawla study.

Table 4.25 shows the field year variation of total of total phosphate in the top 20 meter "eutrophic zone". The mass peaked in the spring-summer and early winter periods. The component layers and total mass contents of TP for the lake are listed in Table 4.2c. A summary of the total mass content for each cruise is provided in Table 4.26.

TOTAL FILTERABLE PHOSPHATES

Tables 4.1a-4.1k provide the means, standard deviations, maximum and minimum concentration measurements of total filterable phosphate for each of the cruises. A total filterable phosphate histogram is also included for each of the cruises in Fig 4.5a. The histograms, like those for total phosphate, are generally skewed somewhat toward lower values.

Computer surface concentration maps are included as Fig

4.5b. Sufficient surface concentration data existed to produce maps for cruises 2(May 25-19, 1972), 3(Jun 12-16, 1972), 4(Jul 10-14, 1972), 5(Aug 21-25, 1972), 6(Oct 30-Nov 2, 1972), 7(Nov 27-Dec 2, 1972), 8(Feb 5-9, 1973) and 11(Jun 11-15, 1973). Higher concentrations were noted off the mouth of the Niagara River and also the eastern central portion of the lake in May 1972. By mid June the portions of these higher concentration areas near shore have been depleted. The higher concentration regions were once more quite extensive, reaching across the lake from Breeze-Hamlin (U.S.) to Colbourg (Canada) and from the Oswego to Black River mouths (U.S.) to the Coleborne to Prince Edward Point (Canada) area in July. In August the overall surface concentrations were reduced, with patches of moderate concentrations at points along the southern shore and off Toronto. The early November cruise showed increased surface concentrations of total filterable phosphate with higher concentration patches along the shoreline. The December cruise found a more uniform lake surface with only very small areas of enhanced concentrations at the mouths of the Niagara, Genesee and St. Lawrence Rivers. The general level of the surface total filterable phosphate had greatly increased by February with heavy concentrations extending from the Niagara River mouth to Toronto, from the north central shore into the lake and along the shore near the mouth of the Black River. During June the surface mean concentration was again reduced with patches of moderate concentration at various shore locations and a north-south strip which extended from the Sodus Bay area (U.S.) up to the

Colbourne-Salmon Point area (Canada).

Table 4.3a provides a synopsis of the variation of total filterable phosphate with depth. Throughout May (cruise 1 and 2) the concentrations remained fairly uniform at all depths of the lake. By mid June (cruise 3) the upper 40 meters were depleted while the lower levels had been enhanced. This situation persisted into July (cruise 4). The August cruise (cruise 5) showed a general reduction of total filterable phosphate at all depths. At the beginning of November (cruise 6) the concentrations were somewhat increased but fairly uniform with depth. The concentration remained much the same into December (cruise 7). February (cruise 8) saw greatly enhanced concentrations with a positive depth gradient; this picture persisted into March (cruise 9). The highest concentrations of the field year were observed in April (cruise 10) at which time the variation with depth was extremely slight. By June (cruise 11) the upper levels were again experiencing depletion. This field year variation in total filterable phosphate concentration, shown in Fig 4.5d, indicated that lower concentration levels persisted throughout the field year in the northern part of the lake as compared with the central and southern portions. The central and southern portions showed the same mean value over the field year, however, the concentrations in the central lake exceed northern and southern in the spring while the southern concentrations were dominant in the summer, fall and winter seasons.

The offshore-middle lake variation is further illustrated in

Fig 4.5e where off-shore concentrations were greater in summer and winter. Springs of 1972 and 1973 both showed higher middle lake values. Table 4.3b shows no particular east-west trend in the total filterable phosphate data.

Figs 4.5f and 4.5g show the mean surface and bottom variation of total filterable phosphate throughout the field year. Both showed the same basic structure with winter spring maxima and generally lower values in the summer and fall.

Table 4.25 shows the field year variation of total filterable phosphate in the upper 20 meter eutrophic zone. This quantity also peaked in the winter-spring period. Table 4.3c lists the component layers and total mass contents of TFP for the lake. A summary of the total mass content for each cruise is provided in Table 4.26.

DISSOLVED ORTHOPHOSPHATE

For each of the materials balance cruises, the means, standard deviations, maximum and minimum dissolved orthophosphate concentrations are listed in Tables 4.1a - 4.1k. Fig 4.6a provides the histograms for the DOP concentrations determined for each of the cruises. The histograms are generally quite broad and skewed toward lower values in the summer and fall while the winter and early spring saw higher concentrations.

Computer surface maps of dissolved orthophosphate are shown in Fig. 4.6b. Sufficient surface data was available for the construction of maps only for cruises 5 (Aug. 21-25, 1972), 6 (Oct. 30 - Nov. 2, 1972), 7 (Nov. 27 - Dec. 2, 1972), 8 (Feb. 5-9, 1973), 9 (Mar. 18-23, 1973) and 11 (June 11-15, 1973).

August 1972 was characterized by low uniform concentrations. From November to March there were some isolated coastal patches of higher concentrations superimposed on generally low lake wide concentrations. The concentrations were universally low again by June.

The variation of dissolved orthophosphate with depth is included as Table 4.4a. In mid-May the concentrations were higher near the surface and declined with increasing depth. Uniformly low DOP concentrations were observed in June. By July and August the upper levels were still low, however, the concentrations at the lower levels had increased. The concentrations began to rise also at higher levels in the lake during November and December so that the overall lake wide concentrations were moderate. Early February saw a decline at the greatest depths but no change at shallower depths. In mid-March the DOP was again beginning to be depleted. June was characterized by decreased concentrations in the shallower portions of the lake. The field year depth variation of dissolved orthophosphate is further illustrated in Fig 4.6c.

Fig. 4.6d shows the north-south distribution of dissolved orthophosphate in the lake. On the average, the northern concentrations were the lowest but increased considerably in the central lake and increased slightly more in the south part of the lake. The offshore-middle lake variations are specifically presented in Fig. 4.6e where it is shown that the middle concentrations exceeded those of the offshore region, except in mid-winter. From Table 4.4b, the east-west variations indicated a trend of increasing dissolved orthophosphate concentrations from the eastern to the western end of the lake.

Figs. 4.6f and 4.6g show the surface and bottom concentrations of dissolved orthophosphate. Both had low concentrations in the summer-fall period and peaks in the winter.

Table 4.25 lists the field year variation of DOP in the upper 20 meter "eutrophic zone". The lake mass content of DOP peaked in the winter-spring period. The component layers and total mass content of dissolved orthophosphate for the lake are listed in Table 4.4c. A summary of the total mass content for each cruise is provided in Table 4.26.

NITRITE-NITRATE

Given in Tables 4.1a-4.1k are the means, standard deviations, maximum and minimum concentration measurements of nitrite-nitrate for each of the 11 cruises. A nitrite-nitrate histogram is also included for each cruise in Fig 4.7a. In each case, the histogram is skewed toward lower values.

Fig 4.7b shows a computer mapping of the surface concentration data for each of the 11 cruises. In early May (cruise 1) high concentrations existed in the western and central portions of the lake surface which by mid May (cruise 2) were somewhat reduced in magnitude. Concentrations in the eastern end of the lake had become large. High concentrations were also characteristic of the western and central lake into June (cruise 3) but the eastern concentrations were lower once again. With the exception of small areas the nitrite-nitrate concentrations were quite low during July and August (cruise 4 and 5). The concentration level of the entire lake was increased with the greatest increases having occurred along the western end and the southern shore by early November (cruise 6). In early December (cruise 7), the south-western shore concentrations were reduced as compared with the previous month. February, March and into May (cruises 8, 9 and 10) showed a fairly uniform high concentration level for the whole lake with slightly higher concentrations along the southwestern shore. By mid-June (cruise 11) the concentration levels were generally reduced except near the mouths of the major tributaries.

The variations of the mean concentration of nitrite-nitrate with depth has been included as Table 4.5a. During May (cruises 1 and 2) the concentrations were high at all depths but generally increased with depth. Depletion of nitrite-nitrate throughout the lake to a near uniform moderate level occurred in June (cruise 3). This uniformity may have been the result of the spring overturn mixing. The July cruise (4) found further depletion of nitrite-nitrate in the upper 20 meters while at greater depths the concentrations had increased. Reductions of concentration throughout the lake characterized August (cruise 5). By November (cruise 6) the mean concentration in the upper 20 meters of the lake again began to increase while at greater depths concentrations continued to decrease. A decrease in concentrations throughout the lake occurred in December (cruise 7) but by February (cruise 8) and through March (cruise 9) this trend had been entirely reversed with a near uniform concentration at all depths. The late April (cruise 10) and June (cruise 11) data showed a general depletion. During June concentrations near the lake bottom grew. Fig 4.7c is a graphic presentation of the variations with depth over the field year.

North-south variations in nitrite-nitrate shown in Fig 4.7d indicate lower concentration levels persisted through the field year in the northern part of the lake. The central lake concentrations are largest in the spring and summer 1972 but remained about equal with the southern portion of the lake during the remainder of the field year. Fig 4.7e for the offshore-middle lake comparison of mean concentrations of nitrite-nitrate showed the middle lake concentration to exceeded those of the offshore area throughout the year except during the winter. The east-west concentration variation of the mean concentrations are listed in Table 4.5b. Generally the concentrations at the western end of the lake exceeded those at the eastern end except in June and December when the opposite situation existed.

The mean surface concentration of nitrite-nitrate measured in 1969-70 and reported by Shiomi and Chawla (1970) are compared with the IFYGL data in Fig 4.7f. Both studies found the same structure of variation by the late summer-fall values in the IFYGL study are considerably lower than in the Shiomi and Chawla study. Fig 4.7g compares the bottom concentrations determined in the same two studies. Both showed a near constant level throughout the field year.

Table 4.2b illustrates the field year variation of total filterable phosphate in the upper 20 meter "eutrophic zone". The mass peaked in the springs of both 1972 and 1973. The component layers and total mass contents of nitrite-nitrate for the lake are listed in Table 4.5c. A summary of the total mass contents for each cruise is provided in Table 4.26.

AMMONIA

Means, standard deviations, maximum and minimum concentration measurements of ammonia are provided in Tables 4.1a-4.1k for each of 11 cruises. Fig 4.8a includes a histogram for each of the cruises. Cruises 1 and 2 showed a nearly constant value throughout the lake while the remainder showed a generally rather broad distribution in concentration values.

Computer maps of ammonia surface concentrations are provided in Fig 4.8b for cruises 3(Jun 12-16, 1972), 4(Jul 10-14, 1972), 5(Aug 21-25, 1972), 6(Oct 27-Nov 2, 1972), 7(Nov 27-Dec 2, 1972), 8(Feb 5-9, 1973), 9(Mar 18-23, 1973) and 11(Jun 11-15, 1973). Insufficient surface concentrations existed for the other cruises to make possible the calculation of computer maps. June 1972 was characterized by generally low levels of ammonia except immediately adjacent to Toronto, the Niagara River mouth and at the east end of the lake where moderate concentrations were noted. By July 1972 the ammonia concentration level of the lake had increased with wide north-south strips of higher concentration connecting the Niagara River mouth to Toronto and another running from Rochester to Oswego almost across the lake. The August cruise found quite similar surface ammonia concentration picture. At the beginning of November overall ammonia had increased with higher levels typical of the entire western half of the lake as well as a north-south strip crossing from Rochester to Prince Edward Point.

The ammonia concentration was greatly reduced throughout the lake by December. By February areas of higher ammonia concentrations had developed adjacent to Toronto, the Niagara River mouth and the Rochester area. From late March into June the ammonia concentrations were moderately low.

The variation of ammonia with depth is illustrated in Table 4.6a. In late spring the concentration dropped off with depth. During the summer there was a build up of the ammonia in the deeper lake waters until by August ammonia levels were fairly uniform with depth. This situation persisted until spring 1973; see Fig. 4.8c.

Presented in Fig. 4.8d is the north-south variation of ammonia The southern ammonia concentrations consistently exceeded both northern and central mean concentrations. The northern lake ammonia concentrations ran slightly in excess of the central lake throughout the field year. This offshore versus middle lake variation is demonstrated explicitly in Fig. 4.8e. Except for May 1972 when a uniform ammonia concentration throughout the lake was determined, the offshore concentrations consistently surpassed thos of the middle lake. In the east-west variation, Table 4.6b, the middle lake mean concentrations continued to be lower than either those in the eastern or western ends of the lake. The western end of the lake did however, tend to contain higher ammonia concentrations than the eastern except during the late fall when the two are comparable.

Figs. 4.8f and 4.8g show the mean surface and bottom variations of ammonia throughout the field year as compared with data obtained data obtained in 1969-1970 and reported by Shiomi and Chawla (1970). The IFYGL surface values average about half the values obtained in the other study but show a summer-fall peak which was absent in the Shiomi-Chawla study. For the bottom concentrations the two studies indicated closely related structures and ranges of value. The late summer-fall peak was evident in both studies. In the IFYGL analysis, high values were maintained even into the winter. Spring minima were characteristic of both studies.

The field year variation of ammonia in the upper 20 meters "eutrophic" zone is shown in Table 4.25. July through August were characterized by the highest ammonia content while the minimum ammonia content appeared in early spring. Component layers and total mass contents of ammonia for the lake are listed in Table 4.6c. A summary of the total mass content for each cruise is provided in Table 4.26.

TOTAL KJELDAHL NITROGEN

Provided in Tables 4.1a-4.1k are the means, standard deviations, maximum and minimum concentration measurements of Total Kjeldahl nitrogen for each of the cruises in Fig 4.9a. The summer and fall cruises showed considerably broader ranges of concentrations than during the rest of the year.

Computer maps of the lake surface concentrations are included as Fig 4.9b. Sufficient surface concentration data existed only for cruises 2(May 15-19, 1972), 3(Jun 12-16, 1972), 4(Jul 10-14, 1972), 5(Aug 21-25, 1972), 6(Oct 30-Nov 2, 1972), 7(Nov 27-Dec 2, 1972), 8(Feb 5-9, 1973) and 11 (Jun 11-15, 1973) for the map production. The surface concentrations were generally moderate through May and June 1972 with increased levels which developed during July. Concentration levels, then once again, began to subside in August and continued to do so through February 1973. The February values are uniformly low throughout the lake. By June 1973 the map showed the same sort of higher concentrations that had been observed the previous June.

The variation of total Kjeldahl nitrogen with depth is provided in Table 4.7a. Generally the concentrations decreased with depth during the field year although during the winter-spring 1973 period the decrease with depth was rather small. This variation is graphically demonstrated in Fig. 4.9c.

North-south variations in total Kjeldahl nitrogen shown in Fig 4.9d revealed the north and south mean concentrations to be quite close, however, the south peaked slightly before the north. Also the central lake was consistently lower than either the north or south means. The offshore-middle lake variation is further illustrated in Fig 4.9e where the offshore values ran consistenly higher than the middle lake. Both showed simultaneous maxima and minima. Table 4.7b provides the east-west variations. It is apparent from the table that the eastern end of the lake displayed generally higher concentrations than the western end. Both were higher than the central lake concentrations.

Fig 4.9f and 4.9g display the mean surface and bottom concentration variations of total Kjeldahl nitrogen during the field year. Both surface and bottom mean concentrations exhibited the same type of variation with summer-fall peaks and winter-spring troughs.

Table 4.25 lists the field year variation of total Kjeldahl nitrogen in the upper 20 meter "eutrophic zone". This quantity peaked in July 1972 and reached its minimum in March 1973. Component layers and total mass contents of total Kjeldahl nitrogen for the lake are listed in Table 4.7c. A summary of the total mass content for each cruise is provided in Table 4.26.

ORGANIC NITROGEN

The histograms for each of the cruises appear in Fig. 4.10a. During the field year, the width of the distribution of values varied considerably with a maximum during the summer. Late spring and into summer was a period of maximum mean values.

The variation of organic nitrogen with depth is included as Table 4.8a. Generally, the organic nitrogen concentrations decreased with depth in the lake except in the fall when the reverse occurred. The field year variation of organic nitrogen with depth is further illustrated in Fig. 4.10c.

Horizontal variations are provided by Fig. 4.10d (north-south variation), 4.10e (offshore-middle variation) and Table 4.8b (east-west variations). Organic nitrogen appeared to exist at the highest concentrations in the northern segment of the lake, with the southern mean concentrations somewhat lower and the central concentration still lower. The offshore-middle lake variations show consistently higher offshore than middle lake mean concentrations. Also there were generally higher concentrations in the eastern than in the western ends of the lake.

Figs. 4.10f and 4.10g show that the surface and bottom mean concentrations were structurally similar with summer maxima and winter-early spring minima. The surface means, however, generally exceeded the bottom means which is to be expected from Table 4.8a.

The component layers and the total mass content of organic nitrogen in the lake are listed in Table 4.8c.

TOTAL NITROGEN

The histograms for total nitrogen as determined for each of the cruises are provided in Fig. 4.11a. Over the field year the width of the distribution of total nitrogen measurements varied from quite broad in the summer and fall of 1972 to very narrow in the winter. Variation in the cruise mean values ranged from a high of .48 mg/l in summer 1972 to a low of .27 mg/l in fall 1972.

Table 4.9a, provides the mean concentrations for the study of the variation of total nitrogen with depth. Both spring 1972 and 1973 showed a decrease of total nitrogen with depth while a general increase was noted throughout the remainder of the field year. See also Fig. 4.11c.

Provided in Fig. 4.11d is a plot of the north-south variation of total nitrogen. There were no major north-south variations, however, the concentrations in the northern segment of the lake were slightly lower than either the central or southern mean concentrations. Offshore-middle lake variations are provided in Fig. 4.11e. Again, the variations were not great but during the spring and summer, the middle lake values exceeded the offshore concentrations while in winter the situation was reversed. With regard to the east-west variations, mean total nitrogen concentrations decreased from west to east in the lake; see Table 4.9b.

Fig. 4.11f and 4.11g provide the surface and bottom mean nitrogen concentrations throughout the field year. While the surface concentrations showed a seasonal variation, the bottom concentration variation seemed to show no such definite pattern. Instead, it appeared to be a statistical variation about a uniform mean level.

Table 4.9c provides a listing of the component layers and total mass of total nitrogen in the lake.

TOTAL ORGANIC CARBON

Tables 4.1a-4.1k provide the means, standard deviations, maximum and minimum total organic carbon concentrations for each of the materials balance cruises. The histograms for each cruise appear in Fig. 4.12a and have distributions which are fairly broad and show seasonal variation in the mean value.

Computer surface maps of total organic carbon are shown in Fig. 4.12b. Sufficient surface data existed for the construction of maps only for cruises 2(May 15-19, 1972), 3(Jun 12-16, 1972), 4(Jul 10-14, 1972) 5(Aug 21-25, 1972), 6(Oct 30-Nov 2, 1972), 8(Feb 5-9, 1973), 9(Mar 18-23, 1973) and 11(Jun 11-15, 1973). In May the TOC concentrations were moderately low except for a few isolated patches at somewhat higher concentrations. The general concentration level of the lake had risen by June and continued to do so in July especially in the eastern and southern parts of the lake. There was a reduction in the overall concentration level of the lake in August. The concentrations were moderately low through the winter and into the following spring. A build up was apparent again at the time of the June cruise as the seasonal cycle began to repeat.

The variation of total organic carbon with depth is related in Table 4.10a. An examination of the table shows that the total organic carbon concentrations decreased with increasing depth except in the late fall-winter period when the situation was reversed. The field year depth variation of total organic carbon is further illustrated in Fig. 4.12c.

Fig. 4.12d shows the north-south distribution of total organic carbon mean concentrations in the lake. Central concentrations average lower than either the northern or southern segments. The latter two showed the same mean values. Offshore areas dominatedthe concentration picture in the late winter-spring period while the late summer-fall and early winter found the central concentrations to be highest. See also Fig. 4.12e. From Table 4.10b, the east-west variation determinations indicated a generally higher eastern lake TOC concentration than that in the western end of the lake. The centbal lake mean concentration was higher than either the eastern or the western.

Figs. 4.12f and 4.12g illustrate the mean surface and lake bottom concentration variations of total organic carbon. Both are characterized by summer peaks and mid winter lows at the same times of year and with nearly the same magnitudes.

The field year variation of TOC in the upper 20 meter "eutrophic zone" is shown in Table 4.25. This mass content also peaked in the summer. The component layers and total mass content of total organic carbon for the lake are listed in Table 4.10c. A summary of the total mass content for each cruise is supplied in Table 4.26.

SILICA

Provided in Tables 4.1a-4.1k are the means, standard deviations, maximum and minimum silica concentrations for each of the cruises. The histograms for each cruise appear in Fig. 4.13a. A fairly broad distribution of values is characteristic of the entire field year.

Silica computer surface maps are shown in Fig. 4.13b. There was sufficient surface data to produce maps for all 11 cruises from May 1, 1972 through June 15, 1973. In May the general concentration levels of the lake were moderately low and decreased still further in June. A build up of silica in the eastern half of the lake and off Toronto was apparent in July. The increase continued in August and moderate levels were observed throughout the lake even into February. By the end of April both the east and west ends of the lake were depleted to low levels. In June the sizes of these low concentration regions had grown.

The variation of silica with depth is included as Table 4.11a. From the table it is apparent that the silica concentrations near the surface were greater than those near the bottom, however, the maximum values were achieved at intermediate levels. This situation prevailed throughout the field year except the early May and early November cruises. See also Fig. 4.13c.

From an examination of Fig. 4.13d, there were no distinct north-south variations. On the average, the north and south segments of the lake have similar means, although the central lake mean silica concentration was higher. The offshore-middle lake variation is illustrated specifically in Fig. 4.13e. It shows that the middle lake values usually exceeded the offshore values except in the fall when the situation was reversed. In the east-west variations, see Table 4.14b, it appears that the eastern concentrations were on the average somewhat smaller than either the western or central values. The latter two quantities had nearly equal mean values.

Figs. 4.13f and 4.13g provide a comparison of the mean lake surface and bottom concentrations as obtained in this study (1972-1973) with those observed in the Shiomi and Chawla (1970) study (1969-1970). Both figures show the IFYGL concentrations to have exceeded the Shiomi and Chawla values. The IFYGL surface data appears to have peaked in the fall whereas the Shiomi and Chawla data peak occurred in mid winter. The structure of the bottom data from the two studies is quite similar with definite seasonal variations less distinguishable.

Table 4.25 shows the field year variation of silica in the upper 20 meter "eutrophic zone". The silica mass content of this layer of the lake peaked in the spring. Component layers and the total mass content of silica in the lake are listed in Table

4.11c. A summary of the total mass content for each cruise is provided in Table 4.26.

4.3 Major Ions

SODIUM

Tables 4.1a-4.1k contain the means, standard deviations, maximum and minimum sodium concentrations for each of the materials balance cruises. The distributions of the sodium concentration measurements, shown in the cruise histograms, Fig. 4.14a, are quite narrow with a mean that varied only slightly throughout the field year.

Computer maps of sodium surface concentration are provided in Fig. 4.14b. Sufficient surface data were available for the calculation of the maps for all cruises except the first. The results show that the surface concentrations ran almost uniformly in the 13 to 14 mg/l range without regard for season.

Examination of Table 4.12a, indicates that the sodium concentrations were rather uniform with depth. See also Fig. 4.14c. In the analysis of the horizontal variations of the sodium concentration no patterns of either north-south or offshore-middle lake variation were apparent, see Figs. 4.14d and 4.14e. Even the east-west variation, Table 4.12b, showed little variation in the sodium concentration.

Figs. 4.14f and 4.14g show the near constancy of both the mean surface and mean bottom sodium concentrations which are also about equal in magnitude.

Table 4.25 provides a listing of the sodium content of the upper 20 meter "eutrophic zone" during the field year. As would be expected, it remained rather uniform. The component layer masses and the total mass content of sodium in the lake are shown in Table 4.12c. A summary of the total mass content for each cruise is provided in Table 4.26.

POTASSIUM

Means, standard deviations, maximum and minimum potassium concentrations for each of the cruises are listed in Tables 4.1a-4.1k. Rather narrow distributions and nearly uniform means were characteristic of the histograms for potassium; see Fig. 4.15a.

Potassium surface concentration computer maps are provided in Fig. 4.15b for all cruises except the first and so span the period from May 15, 1972 to June 15, 1973. Spring and early summer 1972 showed fairly uniform moderate concentrations which steadily increased into the winter. By February 1973 and on through June the concentrations had returned to the moderate levels of the previous spring.

Analysis of Table 4.13a, shows that the potassium concentrations were quite uniform with depth in the upper 100 meters of the lake. At greater depths the concentrations were usually somewhat lower. See also Fig. 4.15c. Just as in the case of sodium no significant horizontal variations in potassium were observed in either the north-south means, Fig. 4.15d, or the offshore-middle lake variation, Fig. 4.15e. Even the east-west variations, Table 4.13b, indicated little variability in the mean potassium concentrations.

Provided in Table 4.25 is a listing of the potassium content of the upper 20 meter "eutrophic zone" during the field year. These values were quite uniform with a maximum variation of 20%. The component layers and the total mass content of potassium in the lake are shown in Table 4.13c. A summary of the total mass content for each cruise is provided in Table 4.26.

CALCIUM

For each of the cruises the means, standard deviations, maximum and minimum calcium concentrations are listed in Tables 4.1a-4.1k. The calcium histograms show a rather narrow distribution of values and a nearly uniform mean; see Fig. 4.16a.

Calcium surface concentration maps are provided for all cruises except 1(May 1-5, 1972) and 10(Apr 24-30, 1973) and appear in Fig. 4.16b. The surface concentrations typically ranged between 36 and 40 mg/l but higher values were noted during May and June 1972.

A uniformity of the calcium concentrations with depth can be noted from Table 4.14a. At depths greater than 100 meters there was some drop in the concentrations. See also Fig. 4.16c for a graphic presentation of the calcium variation with depth. The horizontal variations as provided in the north-south means, Fig. 4.16d, the offshore-middle lake means, Fig. 4.16e and the east-west means in Table 4.14b, show a near uniform calcium concentration. Figs. 4.16f and 4.16g indicate also uniform mean lake surface and bottom concentrations throughout the period of study.

The calcium content of the upper 20 meter "eutrophic zone" exhibited a maximum variation of 15% from the mean; see Table

4.25. Component layer masses and the total mass content of calcium in the lake are listed in Table 4.14c. A summary of the total mass content for each cruise is included in Table 4.26.

MAGNESIUM

Means, standard deviations, maximum and minimum magnesium concentrations for each of the cruises are listed in Tables 4.1a-4.1k. With the exception of cruise 2(May 15-19, 1972) the distributions of values are quite narrow and the means fairly constant as shown in the histograms, Fig. 4.17a.

The computer magnesium surface concentration maps, included as Fig. 4.17b, are for all cruises except 1(May 1-5, 1972) and 10(Apr 24-30, 1973). Surface concentrations typically ranged from 7 to 10 mg/l with only summer concentrations running at the upper end of the interval.

Table 4.15a shows a reasonable uniformity of the magnesium concentration with depth in the upper 100 meters of the lake. At greater depths the concentrations are generally lower. See also Fig. 4.17c for a graphic presentation of the depth variation over the field year.

The north-south variations of magnesium concentrations are shown in Fig. 4.17d. Through most of the year the concentration of southern segment of the lake slightly exceeded those of the northern and central portions. A similar result, indicating slightly greater offshore than middle lake mean concentrations, appears in Fig. 4.17e. Table 4.15b shows no strong east to west variations.

The lake mean surface and bottom variations of magnesium are presented in Fig. 4.17f and 4.17g. Both figures show a prominent dip in the summer-fall 1972 mean concentrations and an otherwise uniform level.

Table 4.25 provides a listing of the magnesium content of the upper 20 meter "eutrophic zone" which shows the same structure as the surface concentrations. Component layer masses and the total mass content of magnesium in the lake are shown in Table 4.15c. A summary of the total mass content for each cruise is provided in Table 4.26.

SULFATE

Tables 4.1a-4.1k provide the means, standard deviations, maximum and minimum sulfate concentrations for the materials balance cruises. The distributions of the sulfate measurements for each of the cruises is shown in the histograms, Fig. 4.18a. These histograms indicate a rather narrow distribution of values and a nearly uniform mean for all of the cruises.

Computer maps of sulfate surface concentrations are provided in Fig. 4.18b for cruises 6(Oct 30-Nov 2, 1972), 7(Nov 27-Dec 2, 1972), 8(Feb 5-9, 1973), 9(Mar 18-23, 1973), 10(Apr 24-30, 1973) and 11 (Jun 11-15, 1973). The sulfate surface concentration distributions were fairly uniform in the range 25 to 30 mg/l except during cruise 7 when the lower limit of the range reached 20 mg/l.

Examination of Table 4.16a shows that the sulfate concentrations were rather uniform with depth. See also Fig. 4.18c. In the analysis of the horizontal variations of sulfate concentrations no strong patterns of either north-south or offshore-middle lake variations were noted in Figs. 4.18d and 4.18e, respectively. Even the east-west variation Table 4.16b, showed very little sulfate variation. The near constancy and equality of both the mean surface and mean bottom sulfate concentrations are illustrated in Figs. 4.18f and 4.18g.

Table 4.25 provides a listing of the sulfate content of the upper 20 meter "eutrophic zone". As would be expected, it remained rather uniform. The component layer masses and the total mass content of sulfate in the lake are listed in Table 4.16c. A summary of the total mass content for each cruise is provided in Table 4.26.

FLUORIDE

For the fluoride measurements made on each of the materials balance cruises, means standard deviations, maximum and minimum concentration values are listed in Table 4.1a-4.1k. The distributions of the fluoride measurements, shown in the cruise histograms, Fig. 4.19a, are quite broad with considerable variation in the mean values.

Computer maps of fluoride surface concentrations are provided for all cruises except 2(May 15-19, 1972) and 8(Feb 5-9,1973) and appear in Fig. 4.19b. Throughout most of the field year fluoride concentrations lay in the range .06-.18 mg/l with a predominancy in the .06-.12 mg/l subrange.

From Table 4.17a, the variation of fluoride with depth does not appear to be significant. See also Fig. 4.19c for the field year variation with depth of the mean fluoride concentrations.

As indicated in Figs. 4.19d and 4.19e, the north-south and offshore-middle lake variations seemed to be essentially absent for fluoride. However, Table 4.17b does show a monotonic decline in fluoride concentrations from west to east in the lake. Fig. 4.19f and 4.19g provide lake mean surface and bottom concentrations. Both figures show similar values and a slow variation over the field year period.

Provided in Table 4.25 is the listing of the fluoride content of the upper 20 meter "eutrophic zone" which indicated a maximum in the spring-summer period. The component layer masses and the total mass content of fluoride in the lake are shown in Table 4.17c. A summary of the total mass content for each cruise is provided in Table 4.26.

4.4 Heavy Metals

MANGANESE

Provided in Tables 4.1a-4.1k are the individual cruise means, standard deviations, maximum and minimum manganese concentrations. Manganese histograms show a fairly broad distribution of values and varying mean values; see Fig. 4.20a.

Computer manganese surface concentrations are shown in Fig. 4.20b. Sufficient surface data exists to produce maps only for cruises 3(Jun 12-16, 1972), 5(Aug 21-25, 1972), 7 (Nov 27-Dec 2, 1972), 9(Mar 18-23, 1973), 10(Apr 24-30, 1973) and 11(Jun 11-15, 1973). The June 1972 cruise showed a general low concentration level. By August the mean concentration was somewhat increased with heavy concentrations in the eastern end of the lake. The western half of the lake showed moderately low concentrations while in the eastern half the concentrations had increased at the time of the December cruise. During March and April 1973 the general level of concentrations rose steadily over those that had been observed during the winter. By June, the manganese had again dropped. Chau et al. (1970) found similar surface variations in their manganese surface data. However, their measurements were uniformly lower than those of the present study. Table 4.18a shows little variation in the manganese concentration with depth. Chau et al. (1970) found a similar result.

Because of so little data, the horizontal variations in manganese concentrations in the lake are difficult to access. No definite north-south or offshore-middle lake variations were determined. From Table 4.18b, this also seemed to be the case with regard to east-west variations.

Based on Table 4.25 which shows the variation of manganese in the upper 20 meter "eutrophic zone", it appears that the manganese content varied by a factor of two during the field year. The component layers and the total mass content of manganese in the lake are listed in Table 4.18c. A summary of the total mass content for each cruise is provided in Table 4.26.

IRON

Tables 4.1a-4.1k contain the individual cruise means, standard deviations, maximum and minimum iron concentrations. The histograms for each cruise show consistently wide distributions of iron concentrations with mean values ranging from .04-.06 mg/l; see Fig. 4.21a.

Iron surface concentration maps are provided in Fig. 4.21b. They are generally characterized by concentration levels in the range .03-.06 mg/l with isolated shore patches in the .06-.09 mg/l range. This situation is quite similar to that found by Chau et al. (1970) in their summer study of Lake Ontario.

The variation of the mean iron concentrations with depth seemed to be quite small; see Table 4.19a. Chau et al. (1970) found a definite increase with depth. Basic horizontal variations are difficult to determine because of the relatively small data base. However, it appears that no strong north-south, offshore-middle, or east-west (Table 4.19b) variations can be ascertained.

Examination of Table 4.25 shows no particular seasonal variation in the iron content of the upper 20 meter "eutrophic zone" in the lake. The component layers and the total mass content of iron in the lake are listed in Table 4.19c. A summary of the total iron content for each cruise is included in Table 4.26.

NICKEL

The means, standard deviations, maximum and minimum nickel concentrations on each of the materials cruises are provided in Tables 4.1a-4.1k. Fig. 4.22a includes the nickel histograms for each of the cruises. These histograms show a fairly narrow distribution of concentration measurements with mean values in the range of .009-.014 mg/l.

Nickel surface concentration maps for cruises 7(Nov 27-Dec 2, 1972), 9(Mar 18-23, 1973), 10(Apr 24-30, 1973) and 11(Jun 11-15, 1973) are presented in Fig. 4.22b. Concentrations typically ranged from .008-.020 mg/l but during August reached .020-.030 mg/l. These levels are significantly higher than .001-.003 mg/l average nickel concentrations reported by Chau et al. (1970).

Examination of Table 4.20a indicates a general decrease in the nickel concentration with depth. This decrease was not noted by Chawla et al. (1970) who found no distinct variation with depth. Both studies found no strong horizontal variations in the nickel concentration (east-west variations in Table 4.20b).

On the basis of Table 4.25, there seemed to be a fairly broad variation in the mass content of the upper 20 meter "eutrophic zone" with a maximum during the spring time. The component layers and the total nickel mass content of the lake are listed in Table 4.20c. A summary of the total mass content for each cruise is provided in Table 4.26.

ZINC

The means, standard deviations, maximum and minimum zinc concentrations for each of the cruises is presented in Tables 4.1a-4.1k. Zinc histograms for these cruises show rather broad distributions of measurements with means ranging between .005-.020 mg/l; see Fig. 4.23a.

Surface concentration maps of zinc are included in Fig. 4.23b. These figures show considerable variation in the zinc content near the lake surface. Typically the background concentrations ran in the .007-.014 mg/l range with isolated patches reaching as high as .035 mg/l. Although, it is not entirely clear due to the extent of the data base, it appears that the summer concentrations may have been the highest. Zinc surface concentrations measured in this study compare very closely with those measured by Chau et al. (1970) who found a complex structure with values generally in range .005-.030 mg/l.

The mean zinc concentrations at successive depths, which are listed in Table 4.21a, indicated no significant variation of these concentrations with depth. Chawla et al. (1970) reported the same result. Likewise, no strong horizontal variations of the zinc concentration were noted; see Table 4.21b.

Table 4.25 also indicates relatively high summer zinc content of the upper 20 meter "eutrophic zone". The component layers and the total mass content of zinc in the lake are listed in Table 4.21c. A summary of the total zinc content for each cruise is provided in Table 4.26.

CADMIUM

Cadmium concentrations were obtained only during cruise 3 (Jun 12-16, 1972). The cruise mean, standard deviation, maximum and minimum cadmium concentrations are provided in Table 4.1c.

Insufficient surface concentration measurements made it impossible to obtain a surface concentration map for cadmium. The mean cadmium concentrations showed no variation with depth on the cruise. Chawla et al. (1970) reported the same result. There was not enough data for the determination of any horizontal variations in the cadmium concentrations.

Table 4.25 contains the cadmium content in the upper 20 meter "eutrophic zone" as obtained on cruise 3. The total cadmium content for this cruise of the lake is shown in Table

4.26.

4.5 Field Measurements

pH

For each of the materials balance cruises, the means, standard deviation, maximum and minimum pH measurements are listed in Tables 4.1a-4.1k. Fig. 4.24a provides the histograms for the pH values determined on each of the cruises. The May histograms are quite narrow while in June the distribution of values had increased. With the approach of fall and winter there was a larger number of low pH values.

The computer surface maps of pH values are shown in Fig. 4.24b. Sufficient surface data permitted the construction of maps only for cruises 3(Jun 12-16, 1972), 4(Jul 10-14, 1972), 5(Aug 21-25, 1972), 6(Oct 30-Nov 2, 1972), 7(Nov 27-Dec 2, 1972), 9(Mar 18-23, 1973), 10(Apr 24-30, 1973) and 11(Jun 11-15, 1973). June 1972 showed generally high values of pH particularly along the coast running from the mouth of the Niagara River around the western end of the lake and on past Toronto to about Coleborne as in the very eastern end of the lake. High pH levels were in evidence also in July with large areas around the periphery of the lake showing the high values. The highest overall pH measurements were obtained in August with the largest pH determination obtained in the western tip of the lake and the entire eastern half of the lake. In November and December the pH values were considerably reduced throughout the whole lake. The March 1973 cruise found the coastal area pH levels had increased.

By June the levels were quite high particularly in the eastern end of the lake.

The variation of pH values with depth is included as Table 4.22a. Usually the pH values declined with depth during the field year with means of: 8.5 for 0-10 meters, 8.3 for 20-30 meters and 8.24 for 100-150 meters. The field year depth variation of pH is further illustrated in Fig. 4.24c.

Fig. 4.24d shows the north-south distribution of pH values in the lake. The northern section of the lake exhibited the highest pH measurements with the southern and central portions at slightly lower values. In the case of each of the 3 lake sections, the spring-summer pH values were generally higher with fall levels reaching a minimum. The offshore-middle lake variations are further demonstrated in Fig. 4.24e where offshore pHs were greater than middle values from May through November 1972 and approximately equal from November to December 1972.

East-west variations shown in Table 4.22b shows a fairly consistent lower central measurements but the eastern and western concentration are about the same.

The mean lake surface and bottom variations of pH during the field year are presented in Fig. 4.24f and 4.24g, respectively. Surface values showed a seasonal cycle of high summer measurements and winter lows while the bottom values appear to be 180 degrees out of phase.

DISSOLVED OXYGEN

Tables 4.1a-4.1k provide the means, standard deviations, maximum and minimum concentration measurements of dissolved oxygen for each of the cruises. A dissolved oxygen histogram is also included for each of the cruises in Fig. 4.25a. A broad range of values was evident from May through August 1972. By November the distribution had narrowed considerably and remained so into February.

Computer surface dissolved oxygen concentration maps are included for curises 3(Jun 12-16, 1972), 4(Jul 10-14, 1972), 5(Aug 21-25, 1972), 6(Oct 30-Nov 2, 1972), 7(Nov 17-Dec 2, 1972), 8(Feb 5-9, 1973), and 11(Jun 11-15, 1973) in Fig. 4.25b. June 1972 showed the highest overall level of concentrations. Highest dissolved oxygen concentrations were noted in the western end of the lake and adjacent to the north central shore. In July the concentration level was reduced but quite varied over the lake surface. A further drop occurred in August, however, the level of variation were quite small. During November and December the dissolved oxygen began to increase again to a moderate uniform level. Except for the development of high concentrations at isolated shore points, the February 1973 dissolved oxygen was still moderate. By June the high concentrations had been depleted.

Table 4.23a provides the data concerning the variation of dissolved oxygen with depth. During May a build up to a uniformly high level of dissolved oxygen throughout the lake had occurred. These were the highest levels which were observed in the study. In June there was a depletion of the DO, particularly in the upper layers. The July and August cruises found increasing depletion at all levels. By November and in December and on into February higher concentrations developed first at greater depths and later near the surface. A uniformly high level had been reach throughout the lake by March. From April into June DO depletion was again observed. The field year depth variation of dissolved oxygen is illustrated in Fig. 4.25c.

North-south variations in DO shown in Fig. 4.25d indicate that the northern and central means were nearly identical through the period of study while the southern mean was lower than the other two in the spring-early summer 1972 period and higher in the winter. The offshore-middle lake variation is presented in Fig. 4.25e. With the exception of February 1973, the measurements showed the offshore dissolved oxygen concentration to be consistently lower than the middle lake. From Table 4.23b, the east-west variations of dissolved oxygen concentration showed the central concentrations to be typically slightly higher than the western and eastern lake segment concentration. Eastern concentrations were usually somewhat higher than the western values.

Figs. 4.25f and 4.25g illustrate the mean surface and lake bottom variations of dissolved oxygen during the field year. The surface values were high in spring, dropped to a minimum in late summer which was followed by a winter recovery. The bottom concentrations appeared to have the same structure.

TOTAL ALKALINITY

Means, standard deviations, maximum and minimum measurements of total alkalinity are included in Tables 4.1a-4.1k. Histograms for each of the cruises are provided in Fig. 4.26a. Except for the first cruise, the distributions of values are fairly narrow. However, as the year advanced from spring to winter, progressively higher value of total alkalinity were reported.

Fig. 4.26b shows the computer total alkalinity measurement maps which could be constructed. There was sufficient surface data only in the cases of cruises 3(Jun 12-16, 1972), 4(Jul 10-14, 1972), 5(Aug 21-25, 1972), 6(Oct 30-Nov 2, 1972), and 7(Nov 27-Dec 2, 1972). During June the surface total alkalinity values were generally moderate with some isolated near shore patches at lower values. In July measurements were low and fairly uniform over the lake surface. In August the general level of the total alkalinity rose to a moderate level with north to south bands of lower concentrations across the middle lake and the eastern end. Moderate levels prevailed into November with the development of higher concentrations around the mouth of the Niagara River. In December more extensive bands of higher total alkalinity concentrations were in evidence.

The variation of total alkalinity with depth is documented in Table 4.24a. In mid May the measurements are uniform with depth. By June the upper 10 meter values were reduced somewhat while at greater depths the concentrations remained constant at the level of the previous month. The total alkalinity was reduced at all depths in July, however, there was a positive gradient with increasing depth. August values were all increased considerably over the previous month but still showed the same increase with depth. At the beginning of November the concentration had not changed very much, but by December the values were uniform with depth and the highest measured during the field year, see Fig. 4.26c.

The north-south variations in total alkalinity which appear in Fig. 4.26d indicate that the southern mean remained lower than the northern or central values in the spring and summer but higher in the fall-winter period. The northern and central segments of the lake showed comparable total alkalinity levels through July. After this time the central levels were high and remained rather uniform from fall into winter. Presented in Fig. 4.26e is the offshore-middle lake total alkalinity variation. Throughout the field year the middle lake values ran somewhat higher than the offshore values. The east-west variations, see Table 4.24b, indicate the lowest level of total alkalinity was measured in the eastern end of the lake and the highest in the central lake. The western end was almost as high as the central lake.

Figs. 4.26f and 4.26g illustrate the mean surface and bottom variations of total alkalinity. The surface values showed a seasonal decline of the total alkalinity in the late summer-fall period while the bottom values are reasonably uniform with time.

Table 4.1a Statistics - Cruise 1 - May 1-5, 1972

Parameter	Units	Number	Mean	Stand. Dev.	Maximum	Minimum
Dis. Oxygen	mg/l	21	12.8	3.33	14.8	1.52
pH	SU	136	8.28	.174	8.66	7.60
NH3	mg/l N	198	.005	.001	.015	.004
NO2-NO3	mg/l N	197	.411	.363	3.10	.070
Total Phos.	mg/l P	208	.011	.004	.042	.006
TFP	mg/l P	177	.010	.005	.033	.002
DOP	mg/l P	185	.001	.001	.005	.000
T. Org. Carbon	mg/l	55	2.42	.494	4.00	1.40
Calcium	mg/l	38	37.4	.985	39.2	33.4
Magnesium	mg/l	38	7.54	.155	8.16	7.30
Sodium	mg/l	38	12.9	.284	13.5	12.4
Potassium	mg/l	38	1.50	.139	2.01	1.21
Fluoride	mg/l	188	.050	.040	.120	.009
Silica	mg/l	190	.702	.671	6.30	.005

Table 4.1b Statistics - Cruise 2 - May 15-19, 1972

Parameter	Units	Number	Mean	Stand. Dev.	Maximum	Minimum
Dis. Oxygen	mg/l	98	13.3	2.15	14.8	1.54
pH	SU	174	8.43	.255	9.10	7.90
Total Alka.	mg/l	179	95.4	8.84	116.	10.0
NH3	mg/l N	193	.005	.001	.009	.005
TKN	mg/l N	257	.170	.060	.520	.035
NO2-NO3	mg/l N	190	.360	.406	3.00	.020
Total Phos.	mg/l P	180	.013	.014	.100	.001
TFP	mg/l P	232	.008	.004	.029	.001
DOP	mg/l P	95	.003	.006	.050	.002
T. Org. Carbon	mg/l	268	2.89	.850	6.40	1.60
Calcium	mg/l	186	41.1	3.84	48.0	29.0
Magnesium	mg/l	187	7.87	.957	10.1	4.80
Sodium	mg/l	186	12.9	.957	16.8	11.5
Potassium	mg/l	186	1.42	.132	2.30	1.18
Fluoride	mg/l	150	.052	.006	.075	.015
Silica	mg/l	192	.468	.297	1.70	.010

Table 4.1c Statistics - Cruise 3 - June 12-16, 1972

Parameter	Units	Number	Mean	Stand. Dev.	Maximum	Minimum
Dis. Oxygen	mg/l	465(	12.5	1.93	15.0	1.51
pH	Su	460	8.55	.497	11gfF	
Total Alka.	mg/l	460	95.3	9.41	115.	.006
NH3	mg/l N	443	.013	.010	.100	.005
TKN	mg/l N	453	.176	.050	.395	.016
NO2-NO3	mg/l N	442	.289	.394	3.00	.020
Total Phos.	mg/l P	391	.015	.009	.063	.002
TFP	mg/l P	421	.007	.005	.050	.002
DOP	mg/l P	445	.001	.001	.008	.001
T. Org. Carbon	mg/l	174	3.56	1.33	8.80	1.30
Calcium	mg/l	92	39.4	2.73	46.7	32.5
Magnesium	mg/l	93	7.91	.738	8.70	5.03
Sodium	mg/l	93	13.0	.614	15.4	11.5
Potassium	mg/l	93	1.43	.081	1.80	1.27
Fluoride	mg/l	443	.111	.046	.270	.101
Silica	mg/l	441	.434	2.63	47.0	.050
Cadmium	ug/l	64	7.07	7.38	50.0	4.00
Chromium	ug/l	64	10.6	8.07	41.5	1.00
Iron	ug/l	53	63.2	31.0	170.	11.0
Manganese	ug/l	53	2.62	2.04	13.0	1.00
Nickel	ug/l	64	32.8	19.1	61.5	4.00
Zinc	ug/l	64	22.8	27.4	222.	5.00

Table 4.1d Statistics - Cruise 4 - July 10-14, 1972

Parameter	Units	Number	Mean	Stand. Dev.	Maximum	Minimum
Dis. Oxygen	mg/l	461	10.9	2.05	15.0	1.52
pH	SU	451	8.35	.349	9.20	7.50
Total Alka.	mg/l	616	85.0	10.1	101.	17.0
NH3	mg/l N	331	.025	.036	.630	.004
TKN	mg/l N	352	.230	.121	.770	.020
NO2-NO3	mg/l N	331	.236	.251	3.78	.015
Total Phos.	mg/l P	356	.017	.012	.095	.004
TFP	mg/l P	438	.011	.013	.240	.003
DOP	mg/l P	193	.002	.001	.009	.001
T. Org. Carbon	mg/l	135	4.43	2.13	12.6	2.20
Calcium	mg/l	111	38.1	3.37	47.8	31.0
Magnesium	mg/l	111	7.98	.731	8.61	3.32
Sodium	mg/l	111	13.9	1.29	17.5	4.14
Potassium	mg/l	111	1.47	.163	2.1	1.19
Fluoride	mg/l	329	.116	.057	.359	.040
Silica	mg/l	329	.669	.512	3.01	.037

Table 4.1e Statistics - Cruise 5 - August 21-25, 1972

Parameter	Units	Number	Mean	Stand. Dev.	Maximum	Minimum
Dis. Oxygen	mg/l	439	9.73	1.13	14.7	6.20
pH	SU	465	8.21	.456	9.00	2.10
Total Alka.	mg/l	466	96.5	9.16	119.	10.0
NH3	mg/l N	392	.023	.020	.088	.001
TKN	mg/l N	372	.190	.145	1.46	.010
NO2-NO3	mg/l N	418	.178	.271	1.98	.003
Total Phos.	mg/l P	429	.018	.010	.120	.004
TFP	mg/l P	310	.007	.005	.039	.001
DOP	mg/l P	287	.003	.002	.018	.001
T. Org. Carbon	mg/l	155	3.61	1.02	11.0	1.80
Calcium	mg/l	128	37.9	4.47	44.8	.340
Magnesium	mg/l	127	5.62	1.48	7.72	3.35
Sodium	mg/l	127	12.8	.793	14.7	10.2
Potassium	mg/l	127	1.63	.107	1.96	1.43
Fluoride	mg/l	434	.088	.025	.164	.002
Silica	mg/l	355	.670	.553	3.00	.001
Iron	ug/l	78	57.2	35.7	167.	3.50
Manganese	ug/l	78	3.11	1.20	8.00	1.00
Nickel	ug/l	77	21.3	10.2	38.0	5.00
Zinc	ug/l	77	13.1	10.3	58.0	3.50

Table 4.1f Statistics - Cruise 6 - October 30-November 2, 1972

Parameter	Units	Number	Mean	Stand. Dev.	Maximum	Minimum
Dis. Oxygen	mg/l	471	11.5	.767	13.4	1.78
pH	SU	484	8.40	.232	10.0	6.90
Total Alka.	mg/l	483	100.	9.98	124.	70.0
NH3	mg/l N	290	.022	.017	.082	.001
TKN	mg/l N	379	.163	.085	.460	.005
NO2-NO3	mg/l N	408	.213	.136	1.43	.003
Total Phos.	mg/l P	439	.017	.013	.170	.001
TFP	mg/l P	440	.010	.007	.112	.002
DOP	mg/l P	324	.004	.003	.018	.001
T. Org. Carbon	mg/l	102	3.39	1.43	7.80	1.00
Calcium	mg/l	130	37.5	1.98	41.5	32.5
Magnesium	mg/l	129	7.59	.333	8.60	6.75
Sodium	mg/l	129	13.5	.504	14.5	12.3
Potassium	mg/l	129	1.54	.073	1.92	1.37
Sulfate	mg/l	425	26.6	3.32	38.0	11.0
Fluoride	mg/l	426	.095	.034	.200	.010
Silica	mg/l	324	.653	.596	5.90	.100

Table 4.1g Statistics - Cruise 7 - November 27-December 1, 1972

Parameter	Units	Number	Mean	Stand. Dev.	Maximum	Minimum
Dis. Oxygen	mg/l	275	12.4	.342	13.8	11.6
pH	SU	422	8.14	.320	8.80	3.00
Total Alka.	mg/l	422	101.	10.5	124.	12.0
NH3	mg/l N	226	.011	.017	.251	.001
TKN	mg/l N	278	.103	.045	.230	.010
NO2-NO3	mg/l N	399	.177	.060	.396	.006
Totam Phos.	mg/l P	210	.025	.006	.045	.003
TFP	mg/l P	385	.008	.003	.022	.002
DOP	mg/l P	288	.004	.003	.018	.001
Calcium	mg/l	104	38.4	.810	40.2	35.6
Magnesium	mg/l	104	7.70	.151	8.24	7.19
Sodium	mg/l	104	13.1	.402	14.0	11.8
Potassium	mg/l	104	1.87	.120	2.42	1.69
Sulfate	mg/l	383	24.0	3.61	32.0	13.0
Fluoride	mg/l	395	.091	.030	.180	.030
Silica	mg/l	186	.445	.318	1.40	.100
Iron	ug/l1	88	40.6	22.8	134.	13.0
Manganese	ug/l	91	3.67	1.38	14.0	1.00
Nickel	ug/l	91	9.43	2.22	26.0	5.00
Zinc	ug/l	91	13.2	6.43	57.0	4.00

Table 4.1h Statistics - Cruise 8 - February 5-9, 1973

Parameter	Units	Number	Mean	Stand. Dev.	Maximum	Minimum
Dis. Oxygen	mg/l	162	12.6	1.47	16.6	10.2
NH3	mg/l N	60	.012	.012	.057	.001
TKN	mg/l N	80	.099	.021	.140	.060
NO2-NO3	mg/l N	96	.267	.026	.331	.172
Total Phos.	mg/l P	128	.018	.005	.041	.009
TFP	mg/l P	100	.017	.004	.040	.011
DOP	mg/l P	98	.007	.002	.014	.002
TOC	mg/l	115	1.97	1.19	7.70	.400
Calcium	mg/l	111	38.9	1.03	42.6	36.1
Magnesium	mg/l	111	7.67	.181	8.89	7.33
Sodium	mg/l	111	12.9	.447	16.7	11.7
Potassium	mg/l	111	1.44	.081	1.74	1.32
Sulfate	mg/l	97	28.0	1.88	31.0	24.0
Silica	mg/l	98	.709	.169	1.10	.400
Iron	ug/l	31	49.0	40.6	155.	12.0
Manganese	ug/l	31	2.48	3.40	20.0	1.00
Nickel	ug/l	31	13.8	.821	16.0	12.0
Zinc	ug/l	31	5.00	5.87	22.0	1.00

Table 4.11 Statistics - Cruise 9 - March 18-23, 1973

Parameter	Units	Number	Mean	Stand. Dev.	Maximum	Minimum
Dis. Oxygen	mg/l	66	12.8	.490	13.6	11.2
pH	SU	129	8.45	.189	9.10	8.10
NH3	mg/l N	66	.009	.006	.024	.001
TKN	mg/l N	84	.113	.040	.220	.050
NO2-NO3	mg/l N	104	.281	.048	.500	.148
Total Phos.	mg/l P	128	.020	.011	.102	.007
DOP	mg/l P	97	.005	.002	.011	.001
T. Org. Carbon	mg/l	117	2.74	.976	7.80	1.10
Calcium	mg/l	117	38.1	1.23	40.7	27.8
Magnesium	mg/l	117	7.49	.151	7.97	7.08
Sodium	mg/l	117	13.1	.290	14.4	12.4
Potassium	mg/l	117	1.36	.105	2.12	1.29
Sulfate	mg/l	104	26.9	1.36	31.0	22.0
Fluoride	mg/l	106	.129	.018	.180	.080

Table 4.1j Statistics - Cruise 10 - April 24-30, 1973

Parameter	Units	Number	Mean	Stand. Dev.	Maximum	Minimum
Dis. Oxygen	mg/l	51	11.6	.800	15.0	10.6
pH	SU	237	8.28	.159	8.66	7.06
NH3	mg/l N	243	.014	.009	.118	.001
NO2-NO3	mg/l N	244	.249	.051	.506	.053
Total Phos.	mg/l P	247	.019	.009	.094	.008
TFP	mg/l P	244	.018	.014	.216	.007
DOP	mg/l P	231	.007	.005	.065	.001
TOC	mg/l	92	2.58	.930	5.30	1.20
Sulfate	mg/l	241	26.5	2.78	32.0	5.00
Fluoride	mg/l	246	.108	.023	.180	.030
Silica	mg/l	218	.520	.267	1.20	.076
Iron	ug/l	91	55.3	32.4	163.	7.00
Manganese	ug/l	91	5.42	1.31	10.0	3.00
Nickel	ug/l	92	9.12	3.42	19.0	1.00
Zinc	ug/l	89	5.82	2.95	19.0	2.00

Table 4.1k Statistics - Cruise 11 - June 11-15, 1973

Parameter	Units	Number	Mean	Stand. Dev.	Maximum	Minimum
Dis. Oxygen	mg/l	324	11.8	.896	14.0	9.20
pH	SU	323	8.59	.296	9.56	7.76
NH3	mg/l N	203	.014	.013	.115	.001
TKN	mg/l N	248	.142	.053	.350	.040
NO2-NO3	mg/l N	286	.184	.093	.556	.028
Total Phos.	mg/l P	341	.019	.013	.147	.005
TFP	mg/l P	278	.010	.004	.032	.004
DOP	mg/l P	197	.004	.003	.019	.001
T. Org. Carbon	mg/l	129	3.98	1.11	7.10	2.10
Calcium	mg/l	130	38.0	2.34	50.4	33.0
Mangesium	mg/l	130	7.39	.174	8.14	6.97
Sodium	mg/l	130	13.2	.472	15.0	11.9
Potassium	mg/l	130	1.49	.115	2.30	1.29
Sulfate	mg/l	283	25.6	1.20	31.0	23.0
Fluoride	mg/l	285	.124	.023	.230	.060
Silica	mg/l	282	.405	.245	1.10	.100
Iron	ug/l	127	41.2	24.8	168.	11.0
Manganese	ug/l	128	2.46	1.18	10.0	1.00
Nickel	ug/l	128	9.62	1.95	17.0	5.00
Zinc	ug/l	128	16.3	6.91	47.0	6.00

Table 4.2a Variations of Mean Measurements with Depth for Total Phosphate (milligrams per liter)

Cruise	0-10	10-15	15-20	20-30	30-40
	layers (meters)				
1	.012	.012	.011	.011	.010
2	.015	.015	.017	.017	.019
3	.016	.016	.015	.013	.015
4	.023	.020	.020	.016	.015
5	.020	.015	.015	.015	.018
6	.018	.016	.019	.017	.017
7	.009	.026	.026	.025	.024
8	.018	.017	.017	.016	.016
9	.020	.020	.020	.018	.017
10	.020	.021	.022	.020	.019
11	.024	.021	.019	.018	.021

Cruise	40-50	50-100	100-150	150-bottom
	layers (meters)			
1	.011	.011	.008	.007
2	.021	.021	.011	.005
3	.018	.018	.012	.009
4	.016	.018	.015	.011
5	.018	.018	.017	.009
6	.017	.021	.018	.009
7	.025	.025	.024	.020
8	.016	.016	.013	---
9	.017	.017	.014	---
10	.020	.021	.024	---
11	.022	.022	.018	---

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.2b Variations of Mean Measurements from West to East for Total Phosphate (milligrams per liter)

	Station Numbers				
Cruise	West 1-12	14-35	36-59	60-78	East 79-105
1	.014	.010	.010	.010	.011
2	.020	.021	.016	.013	.018
3	.013	.016	.016	.017	.015
4	.015	.015	.018	.020	.019
5	.017	.016	.022	.015	.019
6	.021	.021	.015	.016	.016
7	.022	.027	.023	.022	.025
8	---	.027	.023	.022	.020
9	.022	.022	.018	.017	.019
10	.017	.017	.020	.022	.019
11	.020	.022	.021	.021	.017

Table 4.2c Mass Determination - Layers and Total
for Total Phosphate
(metric tons)

Cruises	layers (meters) 0-10	10-15	15-20	20-30	30-40
1	2.1067E3	9.4804E2	8.3481E2	1.5506E3	1.4197E3
2	2.5217E3	1.2633E3	1.3494E3	2.5403E3	2.6202E3
3	2.8133E3	1.2711E3	1.1430E3	1.9312E3	2.0676E3
4	3.8418E3	1.5917E3	1.5690E3	2.4019E3	2.0959E3
5	3.3593E3	1.2336E3	1.1526E3	2.1566E3	2.4231E3
6	3.0714E3	1.3241E3	1.4397E3	2.5034E3	2.2779E3
7	1.5259E4	2.0976E3	2.0162E3	3.6950E3	3.2959E3
8	3.0631E3	1.3889E3	1.3068E3	2.3232E3	2.1184E3
9	3.3600E3	1.6127E3	1.5269E3	1.5880E3	2.3206E3
10	3.4385E3	1.6980E3	1.6952E3	2.9582E3	2.5871E3
11	4.1475E3	1.6954E3	1.4618E3	2.5718E3	2.7903E3

Cruises	layers (meters) 40-50	50-100	100-150	150-bottom	Total
1	1.3051E3	5.1581E3	2.5891E3	9.4304E3	1.6861E4
2	2.5414E3	9.8895E3	3.4907E3	5.2424E3	2.6953E4
3	2.1821E3	8.6851E3	3.9072E3	1.1280E3	2.5138E4
4	1.9927E3	8.3431E3	4.8560E3	1.3660E3	2.8087E4
5	2.2828E3	8.6076E3	5.3198E3	1.2728E3	2.7821E4
6	2.1571E3	1.0011E4	5.5601E3	9.7482E3	2.9444E4
7	3.0768E3	1.2050E4	7.5310E3	---	3.7864E4
8	1.9488E3	7.6138E3	4.0346E3	---	2.2385E4
9	2.1281E3	8.1518E3	4.3342E3	3.2812E2	2.6424E4
10	2.4098E3	1.0157E4	7.5892E3	2.3855E3	3.4942E4
11	2.6752E3	1.0576E4	1.9763E3	2.9600E3	2.7923E4

Table 4.3a Variations of Mean Measurements with Depth for Total Filterable Phosphate (milligrams per liter)

Cruise	layers (meters) 0-10	10-15	15-20	20-30	30-40
1	.010	.011	.012	.013	.011
2	.010	.008	.008	.009	.010
3	.008	.007	.008	.008	.009
4	.010	.010	.011	.009	.011
5	.006	.006	.006	.007	.008
6	.010	.009	.009	.010	.009
7	.008	.008	.008	.008	.008
8	.018	.017	.017	.016	.016
9	.013	.015	.015	.019	.014
10	.019	.018	.019	.019	.020
11	.010	.010	.009	.011	.013

Cruise	layers (meters) 40-50	50-100	100-150	150-bottom
1	.012	.013	.010	.013
2	.011	.011	.006	.006
3	.011	.011	.008	.010
4	.012	.014	.011	.009
5	.010	.011	.008	.008
6	.010	.011	.013	.008
7	.008	.010	.007	.005
8	.016	.017	.015	---
9	.012	.013	.018	.007
10	.020	.021	.019	---
11	.014	.014	.015	---

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.3b Variations of Mean Measurements from West to East for Total Filterable Phosphate (milligrams per liter)

Cruise	West 1-12	14-35	36-59	60-78	East 79-105
	Station Numbers				
1	.011	.011	.011	.011	.006
2	---	.009	.008	.009	.008
3	.007	.008	.008	.007	.007
4	.014	.009	.011	.011	.009
5	.007	.008	.006	.007	.008
6	.014	.010	.008	.011	.009
7	.008	.008	.008	.008	.008
8	.020	.017	.016	.018	.016
9	---	---	---	---	---
10	.017	.017	.020	.022	.019
11	.012	.011	.010	.011	.008

Table 4.3c Mass Determination - Layers and Total for Total Filterable Phosphate (metric tons)

Cruises	layers (meters) 0-10	10-15	15-20	20-30	30-40
1	1.7313E3	8.9662E2	9.2788E2	1.8704E3	1.4774E3
2	1.7263E3	6.5887E2	6.2909E2	1.3249E3	1.3238E3
3	1.3551E3	5.9893E2	5.8888E2	1.1054E3	1.1633E3
4	1.7575E3	7.7696E2	8.7261E2	1.3155E3	1.4230E3
5	1.1094E3	4.8900E2	4.9997E2	1.0126E3	1.0798E3
6	1.7456E3	7.4151E2	6.7897E2	1.3941E3	1.2779E3
7	1.4141E3	6.7759E2	6.2611E2	1.1287E3	1.0311E3
8	2.9970E3	1.3514E3	1.2917E3	2.3595E3	2.1711E3
9	2.2852E3	1.1737E3	1.1910E3	2.7284E3	1.8629E3
10	3.2448E3	1.4716E3	1.4367E3	2.8350E3	1.6557E3
11	1.6867E3	8.0130E2	7.2554E2	1.5832E3	1.7477E3

Cruises	layers (meters) 40-50	50-100	100-150	150-bottom	Total
1	1.4774E3	6.3346E3	3.1793E3	1.6136E3	1.9571E4
2	1.3411E3	5.1421E3	1.9727E3	5.6691E2	1.4711E4
3	1.3233E3	5.1688E3	2.5148E3	1.3365E3	1.5164E4
4	1.5219E3	6.4305E3	3.4872E3	1.0928E3	1.8711E4
5	1.1790E3	5.1026E3	2.6186E3	1.0569E3	1.4149E4
6	1.2171E3	5.3904E3	4.2168E4	9.3050E2	1.7689E4
7	9.4311E2	4.5114E3	2.2874E3	3.7410E3	1.3145E4
8	2.0255E3	8.2074E3	4.6283E3	---	2.5082E4
9	1.5335E3	6.3939E3	5.6899E3	6.9219E2	2.5702E4
10	2.4809E3	9.8468E3	5.8823E3	1.5188E3	3.1384E4
11	1.7079E3	6.8149E3	1.6474E3	7.2040E2	1.7435E4

Table 4.4a Variations of Mean Measurements with Depth for Dissolved Orthorphosphate (milligrams per liter)

Cruise	0-10	10-15	15-20	20-30	30-40
	layers (meters)				
1	.002	.002	.002	.002	.001
2	.006	.005	.007	.004	.004
3	.002	.002	.002	.002	.002
4	.002	.002	.002	.002	.003
5	.002	.002	.002	.002	.003
6	.004	.003	.003	.004	.004
7	.004	.004	.004	.004	.003
8	.007	.008	.008	.008	.008
9	.005	.005	.005	.006	.006
10	.006	.006	.007	.007	.008
11	.003	.003	.003	.004	.005

Cruise	40-50	50-100	100-150	150-bottom
	layers (meters)			
1	.002	.002	.001	.002
2	.004	.005	.003	.002
3	.002	.003	.002	.002
4	.003	.004	.005	.004
5	.003	.005	.004	.002
6	.004	.005	.005	.004
7	.003	.004	.003	.004
8	.008	.007	.005	---
9	.006	.006	.004	---
10	.008	.008	.006	---
11	.005	.006	.005	---

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.4b Variations of Mean Measurements from West to East for Dissolved Orthophosphate (milligrams per liter)

Cruise	West 1-12	14-35	36-59	60-78	East 79-105
1	.002	.002	.002	.001	.001
2	---	.003	.006	.004	.007
3	.003	.002	.002	.002	.002
4	.002	.003	.002	.002	.002
5	.002	.003	.002	.002	.003
6	.006	.004	.003	.003	.003
7	.005	.004	.004	.003	.003
8	.008	.008	.006	.009	.006
9	.006	.004	.005	.005	.003
10	.006	.007	.006	.008	.006
11	.005	.004	.003	.004	.002

Station Numbers spans columns 1-12 through 79-105.

Table 4.4c Mass Determination - Layers and Total for Dissolved Orthophosphate (metric tons)

Cruises	0-10	10-15	15-20	20-30	30-40
	layers (meters)				
1	2.6437E2	1.2270E2	1.2135E2	2.2350E2	2.0023E2
2	9.8553E2	4.3506E2	5.2106E2	6.0641E2	5.4379E2
3	3.8293E2	1.7256E2	1.5708E2	3.1844E2	2.7908E2
4	3.0082E2	1.5343E2	1.5039E2	3.2439E2	3.6608E2
5	3.5616E2	1.6563E2	1.8449E2	3.6143E2	3.5790E2
6	6.8068E2	2.7030E2	2.6089E2	5.3375E2	4.8058E2
7	6.1297E2	3.3188E2	3.2774E2	5.6230E2	4.3411E2
8	1.2730E3	6.3031E2	6.1064E2	1.1395E3	1.0498E3
9	8.1296E2	3.9541E2	3.8900E2	8.2251E2	7.6919E2
10	1.0348E3	5.1194E2	5.1123E2	1.0657E3	1.0204E3
11	4.4435E2	2.3395E2	2.6223E2	5.1419E2	6.1454E2

Cruises	40-50	50-100	100-150	150-bottom	Total
	layers (meters)				
1	2.2287E2	7.5321E2	4.7093E2	2.2512E2	2.6054E3
2	5.1559E2	2.1705E3	9.1544E2	2.1575E2	7.0418E3
3	2.6861E2	1.1874E3	5.1845E2	2.1451E2	3.5007E3
4	3.6890E2	1.7643E3	1.4305E3	3.6698E2	5.3558E3
5	4.0587E2	2.1566E3	1.2173E3	2.6423E2	5.4716E3
6	4.4597E2	2.2433E3	1.7172E3	3.4981E2	7.0165E3
7	3.9616E2	1.7895E3	1.0855E3	3.6407E2	6.0097E3
8	9.5698E2	3.4558E3	1.7292E3	---	1.0878E4
9	7.2637E2	2.7937E3	1.2424E3	1.0758E2	8.0761E3
10	9.2530E2	3.6978E3	2.0329E3	5.3525E2	1.1338E4
11	6.1552E2	2.7302E3	5.7162E2	7.9000E1	5.9945E3

Table 4.5a Variations of Mean Measurements with Depth for Nitrite-Nitrate (milligrams per liter)

Cruise	0-10	10-15	15-20	20-30	30-40
	layers (meters)				
1	.379	.413	.430	.488	.537
2	.316	.373	.329	.330	.352
3	.269	.234	.273	.262	.238
4	.192	.240	.250	.481	.489
5	.107	.111	.173	.297	.321
6	.209	.223	.221	.199	.232
7	.179	.183	.184	.194	.201
8	.277	.274	.275	.271	.268
9	.345	.363	.360	.399	.383
10	.262	.262	.269	.264	.259
11	.118	.157	.195	.241	.248

Cruise	40-50	50-100	100-150	150-bottom
	layers (meters)			
1	.452	.539	.735	.276
2	.305	.358	.479	.279
3	.261	.282	.216	.278
4	.490	.565	.412	.206
5	.305	.354	.268	.209
6	.256	.249	.214	.179
7	.207	.210	.210	.117
8	.272	.279	.258	.196
9	.376	.369	.243	.261
10	.265	.268	.197	---
11	.243	.258	.280	---

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.5b Variations of Mean Measurements from West to East for Nitrite-Nitrate (milligrams per liter)

Cruise	West 1-12	14-35	36-59	60-78	East 79-105
	Station Numbers				
1	.433	.384	.531	.484	.222
2	---	.360	.324	.388	.257
3	.219	.202	.279	.290	.232
4	.259	.343	.259	.399	.265
5	.169	.210	.180	.177	.154
6	.324	.255	.184	.209	.171
7	.192	.190	.185	.186	.138
8	---	.189	.185	.187	.204
9	.309	.274	.282	.283	.252
10	.266	.245	.250	.257	.228
11	.186	.171	.208	.198	.153

Table 4.5c Mass Determination - Layers and Total
for Nitrite-Nitrate
(metric tons)

Cruises	layers (meters) 0-10	10-15	15-20	20-30	30-40
1	6.4679E4	3.3327E4	3.3225E4	7.1074E4	7.2639E4
2	5.4013E4	3.0085E4	2.5464E4	4.8130E4	4.7701E4
3	4.5855E4	1.8884E4	2.1069E4	3.8223E4	3.2173E4
4	3.2930E4	2.6978E4	1.9331E4	7.0060E4	6.6140E4
5	1.8279E4	8.9653E3	1.3338E4	4.3322E4	4.3419E5
6	3.5698E4	1.8018E4	1.7085E5	2.8933E4	3.1436E4
7	3.0540E4	1.4754E4	1.4242E4	2.8217E4	2.7222E4
8	4.7289E4	2.2122E4	2.1285E4	3.9413E4	3.6233E4
9	5.8862E4	2.9328E4	2.7860E4	5.8112E4	5.1906E4
10	4.4659E4	2.1151E4	2.0785E4	3.8521E4	3.5122E4
11	2.0145E4	1.2653E4	1.5090E4	3.5141E4	3.3556E4

Cruises	layers (meters) 40-50	50-100	100-150	150-bottom	Total
1	5.5768E4	2.5773E5	2.3353E5	3.5557E4	8.5795E5
2	3.7658E4	1.6983E5	1.5214E5	2.8508E4	5.9432E5
3	3.2225E4	1.3413E5	6.8665E4	3.5595E4	4.2698E5
4	6.0490E4	2.6820E5	1.3097E5	2.0352E4	7.0170E5
5	3.7642E4	1.6827E5	8.5167E4	2.6715E4	4.4533E5
6	3.1569E4	1.1815E5	6.7893E4	2.1344E4	3.7181E5
7	2.5602E4	9.9938E4	6.6645E4	1.4006E4	3.2218E5
8	3.3591E4	1.3326E5	8.1913E4	2.5177E4	4.4123E5
9	4.6419E4	1.7647E5	7.7257E4	2.4210E4	5.5186E5
10	3.2711E4	1.2836E5	6.2546E4	2.5831E4	4.0983E5
11	3.0023E4	1.2273E5	3.2633E4	---	3.0237E5

Table 4.6a Variations of Mean Measurements with Depth for Ammonia (milligrams per liter)

Cruise	layers (meters) 0-10	10-15	15-20	20-30	30-40
1	---	---	---	---	---
2	---	---	---	---	---
3	.007	.013	.014	.015	.013
4	.027	.026	.027	.024	.026
5	.021	.030	.034	.026	.013
6	.021	.025	.028	.026	.026
7	.010	.009	.009	.011	.011
8	.009	.008	.008	.006	.006
9	.006	.006	.006	.006	.007
10	.014	.013	.013	.012	.013
11	.010	.014	.016	.013	.013

Cruise	layers (meters) 40-50	50-100	100-150	150-bottom
1	---	---	---	---
2	---	---	---	---
3	.014	.013	.011	.008
4	.025	.022	.015	.012
5	.012	.015	.015	.023
6	.026	.023	.012	.006
7	.015	.011	.007	.004
8	.006	.004	.003	.001
9	.009	.008	.005	.002
10	.013	.011	.008	---
11	.009	.009	.011	---

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.6b Variations of Mean Measurements from West to East for Ammonia (milligrams per liter)

Cruise	West 1-12	14-35	36-59	60-78	East 79-105
	Station Numbers				
1	---	---	---	---	---
2	---	---	---	---	---
3	.017	.014	.011	.014	.013
4	.037	.022	.021	.024	.027
5	.034	.030	.023	.017	.021
6	.024	.019	.021	.019	.028
7	.009	.010	.010	.013	.013
8	.015	.013	.005	.018	.011
9	.010	.010	.010	.008	.005
10	.013	.015	.016	.012	.012
11	.012	.014	.017	.011	.016

Table 4.6c Mass Determination - Layers and Total for Ammonia (metric tons)

Cruises	0-10	10-15	15-20	20-30	30-40
	layers (meters)				
1	---	---	---	---	---
2	---	---	---	---	---
3	2.1627E3	1.0266E3	1.0496E3	2.1448E3	1.8121E3
4	4.6518E3	2.0598E3	2.0777E3	3.4807E3	3.5260E3
5	3.6186E3	2.3996E3	2.6217E3	3.7392E3	1.7979E3
6	3.4992E3	1.9953E3	2.1549E3	3.8077E3	3.5848E3
7	1.7603E3	7.4326E2	6.9333E2	1.6300E3	1.7486E3
8	1.4558E3	6.8319E2	6.5148E2	9.3600E2	7.8102E2
9	1.0005E3	5.1242E2	5.0041E2	8.5950E2	9.7402E2
10	2.4137E3	1.0665E3	9.8011E2	1.7117E3	1.7064E3
11	1.7301E3	1.1431E3	1.2548E3	1.9043E3	1.7803E3

Cruises	40-50	50-100	100-150	150-bottom	Total
	layers (meters)				
1	---	---	---	---	---
2	---	---	---	---	---
3	1.7861E3	5.9562E3	3.4911E3	1.0126E3	2.0448E4
4	3.0324E3	1.0653E4	4.9192E3	1.1596E3	3.5929E4
5	1.4680E3	7.1816E3	4.6864E3	2.9171E3	3.0459E4
6	3.1774E3	1.0967E4	3.8431E3	6.0551E2	3.3787E5
7	1.8639E3	5.0328E3	2.2045E3	3.6125E2	1.6189E4
8	7.2999E2	1.9527E3	8.8324E2	1.9023E2	8.2708E3
9	1.0503E3	3.6602E3	1.6454E3	2.0099E2	1.0415E4
10	1.5739E3	5.3033E3	2.6954E3	1.9017E2	1.7642E4
11	1.0565E3	4.3858E3	1.2763E3	4.1698E3	1.8701E4

Table 4.7a Variations of Mean Measurements with Depth for Total Kjeldahl Nitrogen (milligrams per liter)

Cruise	0-10	10-15	15-20	20-30	30-40
1	---	---	---	---	---
2	.187	.200	.179	.164	.161
3	.204	.186	.181	.170	.151
4	.288	.247	.225	.215	.198
5	.236	.215	.212	.174	.162
6	.168	.167	.170	.178	.173
7	.111	.108	.111	.121	.119
8	.102	.094	.100	.094	.090
9	.116	.115	.110	.116	.109
10	.085	.086	.081	.073	.067
11	.170	.164	.144	.122	.116

Cruise	40-50	50-100	100-150	150-bottom
1	---	---	---	---
2	.162	.178	.229	.243
3	.160	.167	.171	.115
4	.199	.206	.236	.123
5	.164	.152	.113	.108
6	.160	.171	.159	.074
7	.111	.102	.079	.060
8	.091	.092	.056	---
9	.106	.122	.098	.118
10	.072	.078	.073	---
11	.108	.107	.116	---

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.7b Variations of Mean Measurements from West to East for Total Kjeldahl Nitrogen (milligrams per liter)

	Station Numbers				
Cruise	West 1-12	14-35	36-59	60-78	East 79-105
1	---	---	---	---	---
2	---	.168	.164	.212	.147
3	.162	.169	.180	.186	.175
4	.229	.291	.192	.216	.260
5	.232	.213	.156	.198	.182
6	.125	.165	.168	.154	.177
7	.095	.095	.094	.121	.114
8	.094	.106	.086	.111	.097
9	.134	.111	.087	.114	.091
10	.071	.080	.082	.082	.095
11	.151	.156	.125	.134	.152

Table 4.7c Mass Determination - Layers and Total for Total Kjeldahl Nitrogen (metric tons)

Cruises	0-10	10-15	15-20	20-30	30-40
	layers (meters)				
1	---	---	---	---	---
2	3.1884E4	1.6127E4	1.3811E4	2.3860E4	2.1779E4
3	3.4890E4	1.5044E4	1.3977E4	2.4715E4	2.0501E4
4	4.9159E4	1.9934E4	1.7413E4	3.1360E4	2.6779E4
5	4.0357E4	1.7369E4	1.6402E4	2.5364E4	2.1905E4
6	2.8638E4	1.3437E4	1.3115E4	2.5978E4	1.3463E4
7	1.8877E4	8.6832E3	8.5799E3	1.7570E4	1.6109E4
8	1.7476E4	7.6168E3	7.7285E3	1.3482E4	1.2120E4
9	1.9854E4	9.2848E3	8.4812E4	1.6925E4	1.4790E4
10	1.4503E4	6.9090E3	6.2472E3	1.0599E4	9.1126E3
11	2.9087E4	1.3227E4	1.1121E4	1.7736E4	1.5684E4

Cruises	40-50	50-100	100-150	150-bottom	Total
	layers (meters)				
1	---	---	---	---	---
2	2.0028E4	8.4361E4	7.2639E4	2.4876E4	3.1025E5
3	1.9741E4	7.9147E4	5.4446E4	1.4755E4	2.7730E5
4	2.4519E4	9.7734E4	7.4896E4	1.5533E4	3.5761E5
5	2.0273E4	7.2231E4	3.5869E4	1.3896E4	2.6380E5
6	1.9710E4	8.1072E4	5.0435E4	7.1057E4	2.6324E5
7	1.3649E4	4.8301E4	2.5143E4	6.7476E3	1.6427E5
8	1.1184E4	4.3972E4	1.7894E4	---	---
9	1.3035E4	5.8216E4	3.1261E4	1.0962E4	1.8343E5
10	8.9079E3	3.7505E4	2.3044E4	3.5182E3	1.2171E5
11	1.3310E4	5.0884E4	1.3510E4	---	1.6461E5

Table 4.8a Variations of Mean Measurements with Depth for Organic Nitrogen (milligrams per liter)

Cruise	0-10	10-15	15-20	20-30	30-40
	layers (meters)				
1	---	---	---	---	---
2	.181	.195	.174	.159	.156
3	.197	.173	.167	.155	.138
4	.261	.221	.198	.191	.172
5	.215	.185	.179	.148	.149
6	.147	.142	.142	.152	.147
7	.101	.099	.102	.110	.108
8	.093	.086	.092	.088	.084
9	.110	.109	.104	.110	.102
10	.071	.073	.068	.061	.054
11	.160	.150	.128	.109	.103

Cruise	40-50	50-100	100-150	150-bottom
	layers (meters)			
1	---	---	---	---
2	.157	.172	.224	.237
3	.146	.154	.160	.107
4	.174	.184	.221	.111
5	.152	.137	.098	.085
6	.134	.148	.147	.068
7	.096	.091	.072	.056
8	.085	.088	.053	---
9	.097	.114	.093	.116
10	.059	.067	.065	---
11	.099	.098	.105	---

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.8b Variations of Mean Measurements from West to East for Organic Nitrogen (milligrams per liter)

	Station Numbers				
Cruise	West 1-12	14-35	36-59	60-78	East 79-105
1	---	---	---	---	---
2	---	.163	.159	.207	.142
3	.145	.155	.169	.172	.162
4	.192	.269	.171	.192	.233
5	.198	.183	.133	.181	.161
6	.101	.146	.147	.135	.149
7	.086	.085	.084	.108	.101
8	.079	.093	.081	.093	.086
9	.124	.101	.077	.106	.086
10	.058	.065	.066	.070	.083
11	.139	.142	.108	.123	.136

Table 4.8c Mass Determination - Layers and Total for Organic Nitrogen (metric tons)

Cruises	0-10	10-15	15-20	20-30	30-40
	layers (meters)				
1	---	---	---	---	---
2	3.0944E4	1.5719E4	1.3403E4	2.3097E4	2.1065E4
3	3.2727E4	1.4017E4	1.2927E4	2.2570E4	1.8689E4
4	4.4507E4	1.7874E4	1.5335E4	2.7879E4	2.3253E4
5	3.6738E4	1.4969E4	1.3780E4	2.1625E4	2.0107E4
6	2.5139E4	1.1442E4	9.3073E3	2.2170E4	1.9878E4
7	1.7117E4	7.9400E3	7.8866E3	1.5940E4	1.4360E4
8	1.6020E4	6.9340E3	7.0770E3	1.2546E4	1.1339E4
9	1.8854E4	8.7720E3	8.4312E4	1.6066E4	1.3815E4
10	1.2089E4	5.8430E3	5.2671E3	8.8873E3	8.9420E4
11	2.7357E4	1.2084E4	9.8662E3	1.5832E4	1.3904E4

Cruises	40-50	50-100	100-150	150-bottom	Total
	layers (meters)				
1	---	---	---	---	---
2	1.9375E4	8.1714E4	7.1124E4	2.4214E4	3.0148E5
3	1.7955E4	7.3191E4	5.0955E4	1.3742E4	1.5685E5
4	2.1487E4	8.7081E4	6.9977E4	1.4373E4	3.2168E5
5	1.8805E4	6.5049E4	3.1183E4	1.0979E4	1.3334E5
6	1.6533E4	7.0105E4	4.6592E4	7.0451E4	---
7	1.1785E4	4.3268E4	2.2939E4	6.7115E4	1.4808E5
8	1.0454E4	4.2019E4	1.7011E4	---	---
9	1.1985E4	5.4556E4	2.9616E4	1.0761E4	1.7301E5
10	7.3340E3	3.2202E4	2.0349E4	3.4992E4	1.0407E5
11	1.2254E4	4.6498E4	1.2234E4	---	1.4591E5

Table 4.9a Variations of Mean Measurements with Depth for Total Nitrogen (milligrams per liter)

Cruise	layers (meters) 0-10	10-15	15-20	20-30	30-40
1	---	---	---	---	---
2	.503	.573	.508	.494	.513
3	.473	.420	.454	.432	.389
4	.480	.487	.475	.696	.687
5	.343	.326	.385	.453	.483
6	.377	.390	.391	.377	.405
7	.290	.291	.295	.315	.320
8	.379	.368	.375	.365	.358
9	.461	.478	.470	.515	.492
10	.347	.348	.350	.337	.326
11	.288	.321	.339	.363	.364

Cruise	layers (meters) 40-50	50-100	100-150	150-bottom
1	---	---	---	---
2	.467	.536	.708	.522
3	.421	.449	.387	.393
4	.689	.771	.648	.329
5	.469	.506	.381	.317
6	.416	.420	.373	.253
7	.318	.312	.289	.177
8	.363	.371	.314	---
9	.482	.491	.341	.196
10	.337	.346	.270	---
11	.351	.365	.396	---

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.9b Variations of Mean Measurements from West to East for Total Nitrogen (milligrams per liter)

	Station Numbers				
Cruise	West 1-12	14-35	36-59	60-78	East 79-105
1	---	---	---	---	---
2	---	.528	.488	.600	.404
3	.381	.371	.459	.476	.407
4	.488	.634	.451	.615	.525
5	.401	.423	.336	.375	.336
6	.449	.420	.352	.363	.348
7	.287	.295	.279	.307	.252
8	---	.295	.271	.298	.301
9	.443	.385	.369	.397	.343
10	.337	.325	.332	.339	.323
11	.337	.327	.333	.332	.305

Table 4.9c - Mass Determination - Layers and Total for Total Nitrogen (metric tons)

Cruises	layers (meters) 0-10	10-15	15-20	20-30	30-40
1	---	---	---	---	---
2	8.5897E4	4.6212E4	3.9275E4	7.1990E4	6.9480E4
3	8.0745E4	3.3928E4	3.5046E4	6.2938E4	5.2674E4
4	8.2089E4	4.6912E4	3.6744E4	3.1431E4	9.2919E4
5	5.8636E4	2.6334E4	2.9740E4	6.8686E4	4.5610E5
6	6.4336E4	3.1455E4	1.8396E5	5.4911E4	5.4899E4
7	4.9417E4	2.3437E4	2.2822E4	4.5787E4	4.3331E4
8	6.4765E4	2.9739E4	9.8571E4	5.2895E4	4.8353E4
9	7.8716E4	3.8613E4	1.1267E4	7.5037E4	6.6696E4
10	5.9162E4	2.8060E4	2.7032E4	4.9120E4	4.4235E4
11	4.9232E4	2.5880E4	2.6211E4	5.2877E4	4.9240E4

Cruises	layers (meters) 40-50	50-100	100-150	150-bottom	Total
1	---	---	---	---	---
2	5.7686E4	2.5419E5	2.2478E5	5.3384E4	9.0457E5
3	5.1966E4	2.1328E5	1.2311E5	5.0350E4	7.0428E5
4	8.5009E4	3.6593E5	2.0587E5	3.5885E4	1.0593E6
5	5.7915E4	2.4050E5	1.2104E5	4.0611E4	7.0913E5
6	5.1279E4	1.9922E5	1.1833E5	9.2401E4	6.3505E5
7	3.9251E4	1.4824E5	9.1788E4	2.0754E4	4.8645E5
8	4.4775E4	1.7723E5	9.9807E4	---	---
9	5.9454E4	2.3469E5	1.0852E5	3.5172E4	7.3529E5
10	4.1619E4	1.6587E5	8.5590E4	2.9349E4	5.3154E5
11	4.3333E4	1.7361E5	4.6143E4	---	4.6698E5

Table 4.10a Variations of Mean Measurements with Depth for Total Organic Carbon (milligrams per liter)

	layers (meters)				
Cruise	0-10	10-15	15-20	20-30	30-40
1	2.82	2.48	2.49	2.33	2.56
2	3.05	3.03	3.11	2.74	2.71
3	3.79	3.74	3.86	3.76	3.72
4	4.58	4.62	4.67	4.72	4.86
5	3.97	3.76	3.76	3.75	3.72
6	3.98	3.80	3.85	4.21	4.87
7	---	---	---	---	---
8	2.26	2.26	2.16	2.09	1.72
9	2.81	2.78	2.82	2.77	2.70
10	2.86	2.94	2.93	3.02	2.91
11	4.34	4.36	4.20	4.20	4.01

	layers (meters)			
Cruise	40-50	50-100	100-150	150-bottom
1	2.70	2.61	2.43	---
2	2.75	2.82	2.18	---
3	3.76	3.82	2.98	---
4	5.05	5.35	4.08	---
5	3.78	3.73	3.34	---
6	4.21	4.59	4.79	---
7	---	---	---	---
8	1.61	1.87	1.71	---
9	2.77	3.08	2.13	---
10	2.95	2.91	1.88	---
11	3.93	3.84	3.75	---

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.10b Variations of Mean Measurements from West to East for Total Organic Carbon (milligrams per liter)

	Station Numbers				
Cruise	West 1-12	14-35	36-59	60-78	East 79-105
1	---	---	---	---	---
2	---	3.09	3.08	2.58	2.80
3	3.86	4.68	3.49	2.87	3.54
4	4.13	4.65	5.49	3.42	4.18
5	3.84	3.65	3.97	3.33	3.37
6	3.14	3.19	3.54	4.68	2.60
7	---	---	---	---	---
8	1.94	1.97	1.82	1.96	2.08
9	2.94	2.30	2.98	2.61	3.01
10	2.77	2.78	2.46	2.37	2.27
11	3.53	3.70	3.94	4.10	4.45

Table 4.10c Mass Determination - Layers and Total for Total Organic Carbon (metric tons)

Cruises	0-10	10-15	15-20	20-30	30-40
	layers (meters)				
1	4.8180E6	2.0046E6	1.9259E5	3.3961E5	3.4601E5
2	5.2028E5	2.4457E5	2.4033E5	3.9923E5	3.6716E5
3	6.4687E5	3.0173E5	2.9841E5	5.4823E5	5.0292E5
4	7.8152E5	3.7297E5	3.6105E5	6.8754E5	6.5844E5
5	---	---	---	---	---
6	6.7899E5	3.0699E5	2.9785E5	6.1298E5	6.5880E5
7	---	---	---	---	---
8	3.8527E5	1.8201E5	1.660E5	3.0379E5	2.3325E5
9	4.7920E5	2.2471E5	2.1777E5	4.0392E5	3.6583E5
10	4.8881E5	2.3711E5	2.2653E5	4.3965E5	3.9433E5
11	7.4132E5	3.521E5	3.2443E5	6.1244E5	5.4319E5

Cruises	40-50	50-100	100-150	150-bottom	Total
	layers (meters)				
1	3.3360E5	1.2470E6	7.7323E5	2.3063E5	4.1462E6
2	3.4014E5	1.3408E6	6.9290E5	1.1575E5	4.2716E6
3	4.6391E5	1.8159E6	9.4748E5	1.6618E5	5.6926E6
4	6.2313E5	2.5412E6	1.2964E6	2.4430E5	7.5721E6
5	---	---	---	---	---
6	5.2012E5	2.1792E6	1.5220E6	4.4425E5	7.2444E6
7	---	---	---	---	---
8	1.9893E5	8.9238E5	5.4316E5	---	2.9104E6
9	3.4174E5	1.4717E6	6.7777E5	4.8922E4	4.2861E6
10	3.6476E5	1.3929E6	5.9671E5	1.4052E5	4.2826E6
11	4.8579E5	1.8233E6	4.3803E3	1.1050E5	5.4311E6

Table 4.11a Variations of Mean Measurements with Depth for Silica (milligrams per liter)

Cruise	0-10	10-15	15-20	20-30	30-40
	layers (meters)				
1	.911	.805	.855	.768	.785
2	.481	.544	.550	.710	.628
3	.573	.511	.948	.770	.276
4	.695	.724	.689	.702	.742
5	.675	.645	.723	.793	.676
6	.700	.738	.674	.648	.488
7	.489	.532	.545	.484	.443
8	.729	.765	.781	.764	.736
9	.491	.500	.501	.531	.521
10	.606	.580	.593	.631	.642
11	.397	.310	.400	.416	.476

Cruise	40-50	50-100	100-150	150-bottom
	layers (meters)			
1	.819	1.11	.754	1.28
2	.563	.549	.307	.248
3	.298	.311	.316	.208
4	.745	.770	.795	.339
5	.627	.728	.637	.459
6	.541	.624	.569	.324
7	.380	.384	.478	.273
8	.740	.765	.585	---
9	.528	.550	.518	---
10	.681	.721	.532	---
11	.561	.660	.672	---

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Tables 4.11b Variations of Mean Measurements from West to East for Silica (milligrams per liter)

Cruise	West 1-12	14-35	36-59	60-78	East 79-105
	Station Numbers				
1	.720	.789	.620	.114	.196
2	---	.501	.487	.548	.381
3	.225	.252	.106	.269	.196
4	.540	.643	.772	.659	.788
5	.628	.665	.727	.694	.604
6	.889	.566	.612	.551	.763
7	.346	.515	.444	.428	.459
8	.622	.717	.693	.755	.738
9	---	---	---	---	---
10	.530	.483	.536	.584	.437
11	.411	.339	.415	.456	.415

Table 4.11c Mass Determination - Layers and Total for Silica (metric tons)

Cruises	0-10	10-15	15-20	20-30	30-40
	layers (meters)				
1	1.5542E5	6.4993E4	6.6091E4	1.1190E5	1.0625E5
2	8.2013E4	4.3928E4	4.2490E4	9.6063E4	7.7524E4
3	9.7765E4	4.1225E4	7.3308E4	1.1223E5	3.7408E4
4	1.1865E5	5.8381E4	5.3271E4	1.0229E5	1.0042E5
5	1.1521E5	5.2025E4	5.5892E4	1.1552E5	9.1532E4
6	1.1942E5	5.9531E4	5.2107E4	9.4439E4	6.6093E4
7	8.3431E4	4.2959E4	4.2146E4	7.0548E4	5.9911E4
8	1.2442E5	6.1704E4	6.0404E4	1.1126E5	9.9697E4
9	8.3726E4	4.0338E4	3.8751E4	7.7424E4	7.0573E4
10	1.0333E5	4.6836E4	4.5877E4	9.1943E4	8.6924E4
11	6.7696E4	2.4980E4	3.0919E4	6.0575E4	6.4404E4

Cruises	40-50	50-100	100-150	150-bottom	Total
	layers (meters)				
1	1.0118E5	5.3242E5	2.3952E5	1.6500E5	1.5433E6
2	6.9578E4	2.6065E5	9.7539E4	2.5306E4	7.9653E5
3	3.6813E4	1.4758E5	1.0027E5	2.6498E4	6.7331E5
4	9.2013E4	3.6545E5	2.5241E5	3.4949E4	1.1865E6
5	7.7440E4	3.4571E5	2.0246E5	5.8625E4	1.1148E6
6	6.6549E4	2.9613E5	1.8062E5	3.8838E4	9.7657E5
7	4.6972E4	1.8218E5	1.5189E5	---	6.8355E5
8	9.1402E4	3.6567E5	1.8596E5	---	1.1038E6
9	6.5243E4	2.6316E5	1.6446E5	1.4119E4	8.2007E5
10	8.4052E4	3.4462E5	1.6906E5	4.3942E4	1.0309E6
11	6.9322E4	3.1350E5	7.8374E4	9.200E3	7.1069E5

Table 4.12a Variations of Mean Measurements with Depth for Sodium (milligrams per liter)

Cruise	0-10	10-15	15-20	20-30	30-40
	layers (meters)				
1	13.5	13.6	13.7	13.3	13.1
2	13.5	13.5	13.4	13.3	13.1
3	13.8	13.9	14.0	13.8	13.6
4	14.8	14.7	14.7	14.4	14.0
5	13.5	13.4	13.4	13.2	13.1
6	14.1	14.2	14.2	14.0	13.9
7	13.8	13.7	13.8	13.6	13.4
8	13.5	13.4	13.5	13.4	13.3
9	13.8	13.7	13.8	13.6	13.5
10	---	---	---	---	---
11	13.9	13.9	13.9	13.7	13.6

Cruise	40-50	50-100	100-150	150-bottom
	layers (meters)			
1	13.3	13.7	11.9	10.3
2	13.3	13.7	12.8	12.2
3	13.8	14.2	11.7	10.1
4	14.3	15.0	12.7	10.9
5	13.3	13.9	11.9	12.8
6	14.1	14.5	12.8	10.8
7	13.6	14.1	12.0	10.3
8	13.5	13.9	11.8	9.4
9	13.7	14.1	12.0	---
10	---	---	---	---
11	13.8	14.2	12.0	11.3

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.12b Variations of Mean Measurements from West to East for Sodium (milligrams per liter)

Cruise	West 1-12	14-35	36-59	60-78	East 79-105
1	---	---	---	---	---
2	---	12.5	12.7	12.9	13.3
3	12.9	13.0	12.9	13.1	13.2
4	14.2	13.1	13.8	14.0	14.5
5	12.7	12.5	12.6	13.1	13.2
6	13.5	13.2	13.7	13.6	13.5
7	13.2	12.9	13.0	13.2	13.2
8	13.1	12.7	12.7	13.1	13.0
9	13.3	13.1	12.5	13.2	13.1
10	---	---	---	---	---
11	13.1	13.2	13.1	13.3	13.2

Table 4.12c Mass Determination - Layers and Total for Sodium
(metric tons)

	layers (meters)				
Cruises	0-10	10-15	15-20	20-30	30-40
1	2.3081E6	1.0946E6	1.0562E6	1.9342E6	1.7682E6
2	2.3075E6	1.0882E6	1.0391E6	1.9331E6	1.7767E6
3	2.3578E6	1.1187E6	1.0799E6	2.0147E6	1.8468E6
4	2.5179E6	1.1837E6	1.1366E6	2.0965E6	1.8906E6
5	2.3000E6	1.0794E6	1.0371E6	1.9273E6	1.7693E6
6	2.4124E6	1.1431E6	1.0997E6	2.0454E6	1.8775E6
7	2.3557E6	1.1079E6	1.0653E6	1.9841E6	1.8199E6
8	2.2962E6	1.0849E6	1.0440E6	1.9500E6	1.7968E6
9	2.3549E6	1.1088E6	1.0678E6	1.9857E6	1.8279E6
10	---	---	---	---	---
11	2.3769E6	1.1180E6	1.0764E6	2.0023E6	1.8395E6

	layers (meters)				
Cruises	40-50	50-100	100-150	150-bottom	Total
1	1.6406E6	6.5684E6	3.7851E6	1.3251E6	2.1488E6
2	1.6401E6	6.5192E6	4.0727E6	1.24612E6	2.1671E7
3	1.7043E6	6.7529E6	3.7222E6	1.2985E6	2.1903E7
4	1.7652E6	7.1306E6	4.0426E6	1.3677E6	2.3160E7
5	1.6394E6	6.5960E6	3.7853E6	1.2706E6	2.1417E7
6	1.7354E6	6.8940E6	4.0262E6	1.3085E6	2.2621E7
7	1.6823E6	6.6974E6	3.8211E6	1.1311E6	2.1858E7
8	1.6661E6	6.6336E6	3.7611E6	1.2083E6	2.1487E7
9	1.6912E6	6.7342E6	3.8259E6	8.9796E5	2.1900E7
10	---	---	---	---	---
11	1.7035E6	6.7426E6	3.8040E6	1.3035E6	2.1984E7

Table 4.13a Variations of Mean Measurements with Depth for Potassium (milligrams per liter)

Cruise	layers (meters) 0-10	10-15	15-20	20-30	30-40
1	1.54	1.55	1.59	1.55	1.45
2	1.48	1.49	1.50	1.48	1.47
3	1.52	1.52	1.52	1.49	1.48
4	1.56	1.55	1.57	1.54	1.50
5	1.71	1.69	1.69	1.67	1.64
6	1.62	1.60	1.61	1.59	1.59
7	1.95	1.93	1.93	1.90	1.87
8	1.50	1.50	1.51	1.50	1.48
9	1.41	1.40	1.41	1.39	1.37
10	---	---	---	---	---
11	1.58	1.60	1.60	1.58	1.56

Cruise	layers (meters) 40-50	50-100	100-150	150-bottom
1	1.53	1.57	1.36	1.43
2	1.49	1.53	1.32	1.83
3	1.49	1.54	1.31	1.08
4	1.51	1.54	1.30	1.11
5	1.66	1.68	1.46	1.23
6	1.61	1.67	1.40	1.15
7	1.90	1.96	1.70	1.41
8	1.51	1.53	1.30	1.06
9	1.39	1.43	1.22	---
10	---	---	---	---
11	1.58	1.65	1.39	1.21

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.13b Variations of Mean Measurements from West to East for Potassium (milligrams per liter)

Cruise	West 1-12	14-35	36-59	60-78	East 79-105
1	---	---	---	---	---
2	---	1.43	1.39	1.45	1.41
3	1.47	1.40	1.42	1.42	1.48
4	1.56	1.40	1.51	1.52	1.40
5	1.63	1.59	1.63	1.64	1.63
6	1.54	1.55	1.50	1.57	1.54
7	1.90	1.89	1.83	1.88	1.86
8	1.43	1.45	1.41	1.44	1.45
9	1.44	1.34	1.32	1.37	1.33
10	---	---	---	---	---
11	1.47	1.46	1.49	1.55	1.46

Station Numbers

Table 4.13c Mass Determination - Layers and Total for Potassium (metric tons)

Cruises	layers (meters) 0-10	10-15	15-20	20-30	30-40
1	2.6252E5	1.2477E5	1.2274E5	2.2604E5	1.9642E5
2	2.5343E5	1.2043E5	1.1602E5	2.1525E5	1.9846E5
3	2.5943E5	1.2229E5	1.1728E5	2.1763E5	1.9969E5
4	2.6656E5	1.2517E5	1.2103E5	2.2464E5	2.0309E5
5	2.9195E5	1.3657E5	1.3082E5	2.4263E5	2.2212E5
6	2.7590E5	1.2942E5	1.2476E5	2.3223E6	2.1568E5
7	3.3364E5	1.5561E5	1.4924E5	2.7624E5	2.5377E5
8	2.5649E5	1.2116E5	1.1678E5	2.1784E5	2.0066E5
9	2.4138E5	1.1307E5	1.0887E5	2.0227E5	1.8595E5
10	---	---	---	---	---
11	2.6956E5	1.2879E5	1.2345E5	2.3033E5	2.1168E5

Cruises	layers (meters) 40-50	50-100	100-150	150-bottom	Total
1	1.8844E5	7.5214E5	4.3343E5	1.8416E5	2.4915E6
2	1.8393E5	7.2832E5	4.1972E5	1.8730E5	2.4311E6
3	1.8443E5	7.3151E5	4.1577E5	2.3870E5	2.3875E6
4	1.8641E5	7.3237E5	4.1412E5	1.4017E5	2.4163E6
5	2.0487E5	7.9777E5	4.6394E5	1.5682E5	2.6491E6
6	1.9907E6	7.9335E5	4.4631E5	1.3954E5	2.5647E6
7	2.3515E5	9.3055E5	5.3910E5	1.5500E5	3.0548E6
8	1.8598E5	7.3351E5	4.1315E5	1.3631E5	2.3871E6
9	1.7206E5	6.8360E5	3.8771E5	8.8997E4	2.2242E6
10	---	---	---	---	---
11	1.9547E5	7.8187E5	4.4014E5	1.3934E5	2.5225E6

Table 4.14a Variations of Mean Measurements with Depth for Calcium (milligrams per liter)

Cruise	0-10	10-15	15-20	20-30	30-40
	layers (meters)				
1	38.7	38.7	38.9	37.4	36.4
2	43.4	43.7	43.2	42.2	41.5
3	41.8	41.3	41.5	41.0	40.4
4	40.1	39.6	39.7	39.2	39.0
5	39.4	39.7	40.5	39.4	37.9
6	39.2	39.1	39.3	38.9	38.3
7	40.3	40.3	40.6	40.0	39.7
8	40.8	40.6	40.9	40.3	39.9
9	40.0	39.9	40.1	39.6	39.2
10	---	---	---	---	---
11	39.8	40.1	40.2	39.3	---

Cruise	40-50	50-100	100-150	150-bottom
	layers (meters)			
1	38.3	40.2	34.4	28.9
2	41.8	44.2	40.5	44.7
3	40.9	42.5	36.8	30.1
4	39.6	40.8	34.0	27.0
5	38.2	39.1	33.4	32.2
6	39.0	40.2	34.7	30.5
7	40.3	41.5	35.3	29.2
8	40.5	41.6	35.7	28.9
9	39.8	41.0	34.9	---
10	---	---	---	---
11	39.7	41.3	35.3	30.9

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.14b Variations of Mean Measurements from West to East for Calcium (milligrams per liter)

	Station Numbers				
Cruise	West 1-12	14-35	36-59	60-78	East 79-105
1	---	---	---	---	---
2	---	37.5	41.5	43.1	42.7
3	39.6	37.9	39.0	39.8	41.1
4	39.5	37.7	38.0	38.2	37.9
5	39.7	38.8	39.0	37.0	37.3
6	37.8	37.1	38.1	37.2	36.9
7	38.4	38.5	38.5	38.7	38.0
8	38.8	38.7	39.2	39.1	38.7
9	38.9	38.0	38.3	38.0	37.4
10	---	---	---	---	---
11	37.2	38.0	39.4	37.3	38.1

Table 4.14c Mass Determination - Layers and Total for Calcium (metric tons)

Cruises	0-10	10-15	15-20	20-30	30-40
	layers (meters)				
1	6.6115E6	3.1211E6	3.0072E6	5.4530E6	4.9685E6
2	7.4091E6	3.5264E6	3.3416E6	6.1544E6	5.6155E6
3	7.1361E6	3.3350E6	3.2124E6	5.9737E6	5.4671E6
4	6.8360E6	3.1949E6	3.0708E6	5.7165E6	5.2762E6
5	6.7174E6	3.2055E6	3.1332E6	5.7428E6	5.1265E6
6	6.6856E6	3.1560E6	3.0354E6	5.6717E6	5.10807E6
7	6.8784E6	3.2543E6	3.1352E6	5.8286E6	5.3676E6
8	6.9656E6	3.2801E6	3.1601E6	5.8730E6	5.4034E6
9	6.8271E6	3.2199E6	3.1016E6	5.7740E6	5.3104E6
10	---	---	---	---	---
11	6.7963E6	3.2365E6	3.1095E6	5.7277E6	5.2814E6

Cruises	40-50	50-100	100-150	150-bottom	Total
	layers (meters)				
1	4.7241E6	1.9215E7	1.0940E7	3.7171E6	6.1779E7
2	5.1555E6	2.0980E7	1.2853E7	4.5654E6	6.9775E7
3	5.0512E6	2.0177E7	1.1688E7	3.8560E6	6.5918E7
4	4.8835E6	1.9368E7	1.0812E7	3.4038E6	6.2633E7
5	4.7150E6	1.8571E7	1.0586E7	4.0979E6	6.1938E7
6	4.8176E6	1.9083E7	1.1029E7	3.6921E7	6.2587E7
7	4.9716E6	1.9721E7	1.1213E7	3.2089E6	6.4127E7
8	4.9989E6	1.9882E7	1.1343E7	3.7218E6	6.4769E7
9	4.9194E6	1.9617E7	1.1085E7	2.5597E6	6.3572E7
10	---	---	---	---	---
11	4.8999E6	1.9614E7	1.1219E7	3.6800E6	6.3614E7

Table 4.15a Variations of Mean Measurements with Depth for Magnesium (milligrams per liter)

Cruise	0-10	10-15	15-20	20-30	30-40
	layers (meters)				
1	8.06	8.03	8.05	8.05	7.96
2	8.31	8.18	8.09	8.03	8.01
3	8.33	8.33	8.42	8.39	8.41
4	8.47	8.40	8.46	8.45	8.37
5	5.96	5.82	5.79	5.76	5.67
6	7.99	7.97	8.05	7.94	7.91
7	8.05	8.04	8.07	7.95	7.87
8	8.05	8.04	8.09	7.99	7.88
9	7.83	7.80	7.85	7.74	7.67
10	---	---	---	---	---
11	7.77	7.73	7.75	7.62	7.55

Cruise	40-50	50-100	100-150	150-bottom
	layers (meters)			
1	7.98	8.10	6.90	5.77
2	8.11	8.09	7.67	8.10
3	8.53	8.86	7.68	6.28
4	8.50	8.76	7.52	6.23
5	5.71	6.22	4.94	6.38
6	8.06	8.15	6.98	5.72
7	8.00	8.25	7.06	5.83
8	7.98	8.19	7.07	5.61
9	7.79	8.00	6.80	---
10	---	---	---	---
11	7.66	7.96	6.78	6.18

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.15b Variations of Mean Measurements from West to East for Magnesium (milligrams per liter)

Cruise	West 1-12	14-35	36-59	60-78	East 79-105
1	---	---	---	---	---
2	---	6.99	8.09	8.21	8.24
3	7.98	8.01	7.99	8.13	7.36
4	8.37	7.85	7.92	7.86	8.09
5	5.07	5.06	4.81	6.68	6.11
6	7.61	7.53	7.58	7.59	7.75
7	7.73	7.71	7.68	7.72	7.67
8	7.60	7.68	7.73	7.69	7.68
9	7.60	7.53	7.38	7.52	7.41
10	---	---	---	---	---
11	7.29	7.36	7.46	7.39	7.40

Table 4.15c Mass Determination - Layers and Total for Magnesium
(metric tons)

Cruises	0-10	10-15	15-20	20-30	30-40
		layers (meters)			
1	1.3762E6	6.4772E5	6.2237E5	1.1722E6	1.0777E6
2	1.4176E6	6.6000E5	6.2521E5	1.1693E6	1.0844E6
3	1.4219E6	6.7188E5	6.5123E5	1.2228E6	1.1378E6
4	1.4453E6	6.7771E5	6.5437E5	1.2316E6	1.1332E6
5	1.0172E6	4.6934E5	4.4757E5	8.3872E5	7.6729E5
6	1.3642E6	6.4303E5	6.2221E5	1.1572E6	1.0708E6
7	1.3746E6	6.4864E5	6.2420E5	1.1588E6	1.0652E6
8	1.3745E6	6.4868E5	6.2516E5	1.1634E6	1.0674E6
9	1.3371E6	6.2929E5	6.0669E5	1.1279E6	1.0388E6
10	---	---	---	---	---
11	1.3254E6	6.2379E5	5.9902E5	1.1106E6	1.0217E6

Cruises	40-50	50-100	100-150	150-bottom	Total
		layers (meters)			
1	9.8560E5	3.8715E6	2.1922E6	7.4293E5	1.2693E7
2	1.0017E6	3.8436E6	2.4380E6	8.2771E5	1.3100E7
3	1.0529E6	4.2060E6	2.4398E6	8.0367E5	1.3613E7
4	1.0495E6	4.1598E6	2.3896E6	7.8606E5	1.3527E7
5	7.0482E5	2.9557E6	1.5685E6	6.3150E5	9.4071E6
6	9.9536E5	3.8719E6	2.2187E6.	6.9470E5	1.2680E7
7	9.8752E5	3.9159E6	2.2437E6	6.4094E5	1.2769E7
8	9.8586E5	3.9164E6	2.2454E6	7.2225E5	1.2776E7
9	9.6196E5	3.8278E6	2.1607E6	5.0104E5	1.2418E7
10	---	---	---	---	---
11	9.4641E5	3.7817E6	2.1532E6	7.1340E5	1.2285E7

Table 4.16a Variations of Mean Measurements with Depth for Sulfate (milligrams per liter)

Cruise	0-10	10-15	15-20	20-30	30-40
	layers (meters)				
1	---	---	---	---	---
2	---	---	---	---	---
3	---	---	---	---	---
4	---	---	---	---	---
5	---	---	---	---	---
6	28.4	27.1	26.9	28.0	27.9
7	25.0	25.3	25.1	25.5	25.2
8	29.6	29.6	29.7	29.2	28.8
9	28.7	28.1	28.2	27.9	27.8
10	28.0	28.0	28.2	27.5	27.5
11	26.9	27.1	27.2	26.5	26.3

Cruise	40-50	50-100	100-150	150-bottom
	layers (meters)			
1	---	---	---	---
2	---	---	---	---
3	---	---	---	---
4	---	---	---	---
5	---	---	---	---
6	27.6	27.9	22.1	16.2
7	25.7	25.2	22.6	11.6
8	29.1	28.8	25.0	---
9	28.1	27.8	25.2	---
10	27.6	27.5	25.1	---
11	26.9	26.3	30.7	---

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.16b Variations of Mean Measurements from West to East for Sulfate (milligrams per liter)

	Station Numbers				
Cruise	West 1-12	14-35	36-59	60-78	East 79-105
1	---	---	---	---	---
2	---	---	---	---	---
3	---	---	---	---	---
4	---	---	---	---	---
5	---	---	---	---	---
6	26.7	26.8	26.5	27.1	25.8
7	24.8	24.5	24.1	23.3	23.2
8	27.5	28.4	27.5	28.6	27.8
9	27.2	26.9	27.3	27.1	26.0
10	26.8	25.6	26.4	27.1	26.7
11	25.6	25.7	25.9	25.5	25.4

Table 4.16c Mass Determination - Layers and Total for Sulfate
(metric tons)

Cruises	layers (meters) 0-10	10-15	15-20	20-30	30-40
1	---	---	---	---	---
2	---	---	---	---	---
3	---	---	---	---	---
4	---	---	---	---	---
5	---	---	---	---	---
6	4.8448E6	2.1836E6	2.0779E6	4.0855E6	3.7730E6
7	4.2616E6	2.0440E6	1.9418E6	3.7099E6	3.4148E6
8	5.0564E6	2.3876E6	2.2945E6	4.2539E6	3.8983E6
9	4.7910E6	2.2680E6	2.1802E6	4.0674E6	3.7596E6
10	4.7740E6	2.2567E6	2.1788E6	4.0002E6	3.7243E6
11	4.5899E6	2.1896E6	2.1002E6	3.8666E6	3.5560E6

Cruises	layers (meters) 40-50	50-100	100-150	150-bottom	Total
1	---	---	---	---	---
2	---	---	---	---	---
3	---	---	---	---	---
4	---	---	---	---	---
5	---	---	---	---	---
6	3.4030E6	1.3228E7	7.0240E6	1.9105E6	4.2706E7
7	3.1672E6	1.1878E7	7.1830E6	---	3.7750E7
8	3.5942E6	1.4146E7	7.9310E6	---	4.3663E7
9	3.4752E6	1.3964E7	8.0100E6	6.5786E5	4.3321E7
10	3.4055E6	1.3544E7	7.9863E6	1.9337E6	4.3819E7
11	3.3270E6	1.3703E7	3.3208E6	3.3900E5	3.6687E7

Table 4.17a Variations of Mean Measurements
with Depth for Fluoride
(milligrams per liter)

Cruise	layers (meters) 0-10	10-15	15-20	20-30	30-40
1	.055	.054	.055	.066	.068
2	.053	.055	.055	.054	.054
3	.115	.111	.115	.109	.109
4	.113	.120	.123	.115	.109
5	.089	.096	.100	.099	.094
6	.103	.095	.099	.105	.102
7	.097	.096	.098	.096	.100
8	---	---	---	---	---
9	.143	.142	.141	.139	.138
10	.110	.111	.110	.109	.110
11	.127	.130	.131	.135	.129

Cruise	layers (meters) 40-50	50-100	100-150	150-bottom
1	.057	.062	.060	.008
2	.054	.057	.055	.028
3	.106	.113	.105	.073
4	.113	.120	.125	.061
5	.088	.104	.095	.091
6	.097	.105	.095	.053
7	.103	.098	.090	.068
8	---	---	---	---
9	.140	.140	.113	---
10	.111	.116	.094	---
11	.129	.134	.137	---

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.17b Variations of Mean Measurements from West to East for Fluoride (milligrams per liter)

	Station Numbers				
Cruise	West 1-12	14-35	36-59	60-78	East 79-105
1	.048	.061	.070	.036	.030
2	---	.051	.054	.054	.051
3	.120	.130	.116	.083	.109
4	.146	.137	.131	.083	.085
5	.095	.085	.086	.088	.088
6	.117	.114	.093	.086	.082
7	.102	.087	.095	.101	.080
8	---	---	---	---	---
9	.122	.125	.135	.132	.131
10	.105	.106	.104	.110	.115
11	.128	.129	.121	.120	.121

Table 4.17c Mass Determination - Layers and Total for Fluoride
(metric tons)

	layers (meters)				
Cruises	0-10	10-15	15-20	20-30	30-40
1	9.3836E3	4.3540E3	4.2391E3	9.5528E3	9.2198E4
2	9.1145E3	4.4540E3	4.2724E3	7.8549E3	7.3705E3
3	1.9619E4	8.9180E3	8.8636E3	1.5928E4	1.4802E4
4	1.9247E4	9.6793E3	9.5089E3	1.6788E4	1.4697E4
5	1.5235E4	7.7337E3	7.7060E3	1.4403E4	1.2791E4
6	1.7545E4	7.6833E3	7.6203E3	1.5332E4	1.3804E4
7	1.6548E4	7.7139E3	7.5390E3	1.4032E4	1.3560E4
8	---	---	---	---	---
9	2.4364D4	1.1429E4	1.0923E4	2.0228E4	1.8716E4
10	1.8697E4	8.9528E3	8.5350E3	1.5864E4	1.4849E4
11	2.1761E4	1.0507E4	1.0162E4	1.9630E4	1.7504E4

	layers (meters)				
Cruises	40-50	50-100	100-150	150-bottom	Total
1	7.0178E3	2.9600E4	1.9013E4	1.0939E3	9.3479E4
2	6.6956E3	2.6982E4	1.7384E4	2.8561E3	8.7164E4
3	1.3126E4	5.3545E4	3.3316E4	9.3145E3	1.7746E5
4	1.3941E4	5.7182E4	3.9624E4	6.0226E3	1.8853E5
5	1.0877E4	4.9171E4	3.0084E4	1.1643E4	1.5975E5
6	1.1922E4	4.9984E4	3.0303E4	6.3952E3	1.6104E5
7	1.2659E4	4.6475E4	2.8541E4	---	1.4795E5
8	---	---	---	---	---
9	1.7229E4	6.6787E4	3.5817E4	2.8749E3	2.0905E5
10	1.3678E4	5.5280E4	2.9778E4	8.0293E3	1.7371E5
11	1.5921E4	6.3521E4	1.6009E4	2.1880E3	1.7520E5

Table 4.18a Variations of Mean Measurements with Depth for Manganese (milligrams per liter)

Cruise	layers (meters) 0-10	10-15	15-20	20-30	30-40
1	---	---	---	---	---
2	---	---	---	---	---
3	.003	.003	.003	.003	.003
4	---	---	---	---	---
5	.003	.003	.003	.003	.003
6	---	---	---	---	---
7	---	---	---	---	---
8	---	---	---	---	---
9	.005	.004	.005	.004	.004
10	.005	.006	.006	.006	.008
11	.003	.002	.002	.002	.002

Cruise	layers (meters) 40-50	50-100	100-150	150-bottom
1	---	---	---	---
2	---	---	---	---
3	.003	.003	.002	.002
4	---	---	---	---
5	.003	.003	.003	.002
6	---	---	---	---
7	---	---	---	---
8	---	---	---	---
9	.004	.003	.003	---
10	.008	.012	.005	---
11	.002	.002	.002	.002

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.18b Variations of Mean Measurements from West to East for Manganese (milligrams per liter)

Cruise	West 1-12	14-35	36-59	60-78	East 79-105
1	---	---	---	---	---
2	---	---	---	---	---
3	---	---	---	---	---
4	---	---	---	---	---
5	---	---	---	---	---
6	---	---	---	---	---
7	.003	.004	.003	.004	.005
8	---	---	---	---	---
9	.005	.007	.005	.006	.006
10	.005	.005	.013	.006	.006
11	.003	.003	.002	.003	.002

Table 4.18c Mass Determination - Layers and Total for Manganese
(metric tons)

Cruises	0-10	10-15	15-20	20-30	30-40
1	---	---	---	---	---
2	---	---	---	---	---
3	4.8019E2	2.2122E2	2.3197E2	4.2580E2	3.7370E2
4	---	---	---	---	---
5	5.8274E2	2.4608E2	2.2936E2	4.8666E2	4.2842E2
6	---	---	---	---	---
7	6.1377E2	2.8012E2	2.6273E2	4.7584E2	3.9413E2
8	---	---	---	---	---
9	8.0215E2	3.8487E2	3.7470E2	5.8141E2	5.2119E2
10	9.3006E2	4.6207E2	4.5972E2	9.1050E2	1.0248E3
11	4.3765E2	1.7556E2	1.5357E2	2.8417E2	2.5931E2

Cruises	40-50	50-100	100-150	150-bottom	Total
1	---	---	---	---	---
2	---	---	---	---	---
3	3.2942E2	1.3796E3	6.1515E2	1.9047E2	4.3487E3
4	---	---	---	---	---
5	4.0232E2	1.4524E3	9.2099E2	1.7148E2	5.0395E3
6	---	---	---	---	---
7	3.6722E2	1.2350E3	1.2532E3	1.4929E2	5.3589E3
8	---	---	---	---	---
9	4.8286E2	1.6237E3	9.1121E2	3.2269E2	6.1563E3
10	1.0274E3	5.8212E3	1.4323E3	4.4784E2	1.2519E4
11	2.4601E3	1.0569E3	5.6775E2	2.7155E2	3.4564E3

Table 4.19a Variations of Mean Measurements with Depth for Iron (milligrams per liter)

Cruise	0-10	10-15	15-20	20-30	30-40
	layers (meters)				
1	---	---	---	---	---
2	---	---	---	---	---
3	.068	.071	.071	.069	.067
4	---	---	---	---	---
5	.074	.061	.056	.053	.051
6	---	---	---	---	---
7	---	---	---	---	---
8	---	---	---	---	
9	.084	.078	.079	.070	.065
10	.048	.050	.049	.047	.052
11	.047	.033	.032	.030	.032

Cruise	40-50	50-100	100-150	150-bottom
	layers (meters)			
1	---	---	---	---
2	---	---	---	---
3	.065	.058	.060	.041
4	---	---	---	---
5	.053	.042	.042	.034
6	---	---	---	---
7	---	---	---	---
8	---	---	---	---
9	.063	.067	.049	---
10	.056	.073	.044	.020
11	.039	.041	.040	.085

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.19b Variations of Mean Measurements from West to East for Iron (milligrams per liter)

	Station Numbers				
	West				East
Cruise	1-12	14-35	36-59	60-78	79-105
1	---	---	---	---	---
2	---	---	---	---	---
3	---	---	---	---	---
4	---	---	---	---	---
5	---	---	---	---	---
6	---	---	---	---	---
7	.035	.030	.034	.053	.053
8	---	---	---	---	---
9	---	---	---	---	---
10	.044	.057	.092	.053	.059
11	.078	.048	.036	.044	.053

Table 4.19c Mass Determination - Layers and Total for Iron (metric tons)

	layers (meters)				
Cruises	0-10	10-15	15-20	20-30	30-40
1	---	---	---	---	---
2	---	---	---	---	---
3	1.1689E4	5.6949E3	5.4533E3	1.0002E4	9.0888E3
4	---	---	---	---	---
5	1.2647E4	4.9559E3	4.3578E3	7.7391E3	6.8934E3
6	---	---	---	---	---
7	6.4481E3	2.8651E3	2.6528E3	4.8317E3	4.3263E3
8	---	---	---	---	---
9	1.4290E4	6.2880E3	6.1138E3	1.0356E4	8.7918E3
10	8.2609E3	3.9992E4	3.7997E3	6.8537E3	7.1044E3
11	8.3028E3	2.6286E3	2.4930E3	4.4245E3	4.2986E3

	layers (meters)				
Cruises	40-50	50-100	100-150	150-bottom	Total
1	---	---	---	---	---
2	---	---	---	---	---
3	8.0550E3	2.7398E4	1.8968E4	3.4284E3	1.0160E5
4	---	---	---	---	---
5	6.5076E3	1.9991E4	1.3472E4	2.5611E3	8.0949E4
6	---	---	---	---	---
7	4.0251E3	1.6061E4	7.1754E3	7.6044E2	5.0784E4
8	---	---	---	---	---
9	7.8329E3	3.1962E4	1.5557E4	1.3171E4	1.2091E5
10	6.9501E3	3.4789E4	1.3976E4	2.5369E3	8.8283E4
11	4.1688E3	1.9589E4	1.2568E4	1.0594E4	6.8974E4

Table 4.20a Variations of Mean Measurements with Depth for Nickel (milligrams per liter)

Cruise	layers (meters) 0-10	10-15	15-20	20-30	30-40
1	---	---	---	---	---
2	---	---	---	---	---
3	---	---	---	---	---
4	---	---	---	---	---
5	.027	.030	.031	.068	.085
6	---	---	---	---	---
7	---	---	---	---	---
8	---	---	---	---	---
9	.015	.016	.016	.015	.015
10	.009	.009	.009	.010	.010
11	.011	.010	.010	.010	.010

Cruise	layers (meters) 40-50	50-100	100-150	150-bottom
1	---	---	---	---
2	---	---	---	---
3	---	---	---	---
4	---	---	---	---
5	.106	.117	.049	.023
6	---	---	---	---
7	---	---	---	---
8	---	---	---	---
9	.016	.015	.015	---
10	.010	.012	.010	.014
11	.010	.010	.010	.014

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.20b Variations of Mean Measurements from West to East for Nickel (milligrams per liter)

	Station Numbers				
Cruise	West 1-12	14-35	36-59	60-78	East 79-105
1	---	---	---	---	---
2	---	---	---	---	---
3	---	---	---	---	---
4	---	---	---	---	---
5	---	---	---	---	---
6	---	---	---	---	---
7	.010	.010	.009	.010	.010
8	---	---	---	---	---
9	.010	.015	.017	.012	.017
10	.008	.007	.011	.010	.008
11	.009	.010	.010	.010	.011

Table 4.20c Mass Determination - Layers and Totals for Nickel (metric tons)

Cruises	0-10	10-15	15-20	20-30	30-40
	layers (meters)				
1	---	---	---	---	---
2	---	---	---	---	---
3	---	---	---	---	---
4	---	---	---	---	---
5	4.6936E3	2.3891E3	2.4095E3	9.8942E3	1.1458E4
6	---	---	---	---	---
7	2.6535E3	1.2680E3	1.2329E3	2.2065E3	2.3941E3
8	---	---	---	---	---
9	2.5392E3	1.2675E3	1.2312E3	2.2545E3	2.0910E3
10	1.5846E3	7.6176E2	7.2725E2	1.3948E3	1.3145E3
11	1.8602E3	7.8130E2	7.3847E2	1.3923E3	1.2912E3

Cruises	40-50	50-100	100-150	150-bottom	Total
	layers (meters)				
1	---	---	---	---	---
2	---	---	---	---	---
3	---	---	---	---	---
4	---	---	---	---	---
5	1.2605E4	5.5742E4	1.5677E4	1.7606E3	1.1786E5
6	---	---	---	---	---
7	2.0560E3	7.1734E3	2.3281E3	2.1784E3	2.1989E4
8	---	---	---	---	---
9	1.9392E3	7.2634E3	4.6514E3	6.1684E2	2.4127E4
10	1.2519E3	5.6254E3	3.0373E3	1.1701E3	1.6874E4
11	1.2071E3	4.8498E3	3.1798E3	1.7523E3	1.7080E4

Table 4.21a Variations of Mean Measurements with Depth for Zinc (milligrams per liter)

Cruise	layers (meters) 0-10	10-15	15-20	20-30	30-40
1	---	---	---	---	---
2	---	---	---	---	---
3	.025	.026	.026	.025	.022
4	---	---	---	---	---
5	.016	.015	.016	.036	.044
6	---	---	---	---	---
7	---	---	---	---	---
8	---	---	---	---	---
9	.013	.013	.013	.014	.014
10	.006	.006	.007	.007	.007
11	.020	.017	.017	.016	.017

Cruise	layers (meters) 40-50	50-100	100-150	150-bottom	
1	---	---	---	---	---
2	---	---	---	---	
3	.023	.024	.017	.011	
4	---	---	---	---	
5	.054	.066	.030	.017	
6	---	---	---	---	
7	---	---	---	---	
8	---	---	---	---	
9	.013	.012	.009	---	
10	.008	.009	.006	.002	
11	.019	.022	.018	.042	

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.21b Variations of Mean Measurements from West to East for Zinc (milligrams per liter)

Cruise	West 1-12	14-35	36-59	60-78	East 79-105
1	---	---	---	---	---
2	---	---	---	---	---
3	---	---	---	---	---
4	---	---	---	---	---
5	---	---	---	---	---
6	---	---	---	---	---
7	.012	.018	.015	.014	.013
8	---	---	---	---	---
9	.012	.012	.007	.017	.009
10	.007	.006	.009	.006	.009
11	.025	.018	.018	.026	.013

Table 4.21c Mass Determination - Layers and Totals for Zinc
(metric tons)

Cruises	0-10	10-15	15-20	20-30	30-40
	layers (meters)				
1	---	---	---	---	---
2	---	---	---	---	---
3	4.2548E3	2.0748E3	2.0251E3	3.6771E3	3.0443E3
4	---	---	---	---	---
5	2.6999E3	1.2418E3	1.2472E3	5.2215E3	5.9845E3
6	---	---	---	---	---
7	4.9135E3	2.1950E3	2.0912E3	4.4787E3	5.3271E3
8	---	---	---	---	---
9	2.2566E3	1.0617E3	1.0318E3	2.0580E3	1.8297E3
10	9.7534E2	5.2021E2	5.2919E2	1.0426E3	1.0031E3
11	3.4072E3	1.3859E3	1.2785E3	2.3802E3	2.2390E3

Cruises	40-50	50-100	100-150	150-bottom	Total
	layers (meters)				
1	---	---	---	---	---
2	---	---	---	---	---
3	2.8077E3	1.1163E4	5.4418E3	1.3381E3	3.5841E4
4	---	---	---	---	---
5	6.7244E3	3.1286E4	9.6052E3	1.2995E3	6.6222E4
6	---	---	---	---	---
7	4.5048E3	1.7268E4	1.1304E4	1.3960E3	5.6558E4
8	---	---	---	---	---
9	1.6303E3	5.5959E3	2.7904E3	1.3822E3	2.0121E4
10	1.0029E3	4.3522E3	1.9149E3	2.9510E2	1.1637E4
11	2.2858E3	1.0633E4	5.7656E3	5.1634E3	3.4623E4

Table 4.22a Variations of Mean Measurements with Depth for pH

	layers (meters)				
Cruise	0-10	10-15	15-20	20-30	30-40
1	8.31	8.32	8.37	8.28	8.18
2	8.53	8.38	8.31	8.34	8.29
3	8.67	8.60	8.55	8.50	8.47
4	8.69	8.42	8.19	8.14	8.10
5	8.69	8.26	8.03	7.93	7.95
6	8.44	8.43	8.42	8.40	8.37
7	8.09	8.08	8.15	8.20	8.18
8	---	---	---	---	---
9	8.45	8.47	8.51	8.46	8.33
10	8.31	8.32	8.31	8.30	8.24
11	8.79	8.64	8.49	8.43	8.42

	layers (meters)			
Cruise	40-50	50-100	100-150	150-bottom
1	8.19	8.20	8.14	8.10
2	8.27	8.33	8.29	8.55
3	8.38	8.36	8.35	8.38
4	8.04	8.05	8.05	8.06
5	7.97	7.96	7.95	7.85
6	8.31	8.28	8.30	8.46
7	8.13	8.15	8.15	8.18
8	---	---	---	---
9	8.37	8.42	8.40	8.47
10	8.22	8.21	8.21	8.19
11	8.42	8.45	8.53	8.77

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.22b Variations of Mean Measurements from West to East for pH

Cruise	West 1-12	14-35	36-59	60-78	East 79-105
	Station Numbers				
1	8.22	8.18	8.19	8.30	8.44
2	---	8.35	8.38	8.34	8.75
3	8.84	8.50	8.61	8.34	8.57
4	8.38	8.31	8.35	8.33	8.39
5	8.20	8.20	8.21	8.28	8.24
6	8.49	8.48	8.47	8.41	8.16
7	8.16	8.19	8.17	7.92	8.12
8	---	---	---	---	---
9	---	---	---	---	---
10	---	---	---	---	---
11	---	---	---	---	---

Table 4.23a Variations of Mean Measurements with Depth for Dissolved Oxygen (milligrams per liter)

	layers (meters)				
Cruise	0-10	10-15	15-20	20-30	30-40
1	10.1	11.4	14.1	14.0	13.8
2	13.9	13.7	13.5	13.6	13.5
3	12.3	12.3	12.4	12.6	12.6
4	11.2	11.1	10.8	10.5	10.9
5	10.0	9.7	9.2	9.5	9.9
6	11.4	11.3	11.4	11.5	11.3
7	12.4	12.4	12.4	12.4	12.4
8	12.9	12.9	12.6	12.5	13.0
9	12.8	12.7	12.9	13.0	12.9
10	11.8	12.0	9.9	9.6	9.1
11	12.0	12.0	11.7	11.7	11.8

	layers (meters)			
Cruise	40-50	50-100	100-150	150-bottom
1	13.6	13.8	12.7	11.2
2	13.5	13.5	13.5	13.6
3	12.6	12.6	12.9	12.9
4	11.0	10.9	11.0	11.2
5	10.2	10.2	10.1	9.5
6	11.4	11.9	12.3	12.4
7	12.5	12.6	12.6	12.5
8	13.1	12.2	12.0	11.9
9	12.8	12.7	12.9	12.7
10	9.3	10.5	11.2	11.1
11	11.8	11.7	11.6	11.8

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.23b Variations of Mean Measurements from West to East for Dissolved Oxygen (milligrams per liter)

	Station Numbers				
Cruise	West 1-12	14-35	36-59	60-78	East 79-105
1	---	---	---	---	---
2	---	---	14.0	11.5	13.6
3	12.3	12.2	12.5	13.1	12.1
4	11.3	10.9	11.2	10.8	10.6
5	9.8	9.8	9.7	9.8	9.6
6	12.1	11.7	11.5	11.4	11.1
7	12.4	12.4	12.5	12.5	11.9
8	12.4	12.4	11.7	11.9	13.9
9	---	---	---	---	---
10	---	---	---	---	---
11	---	---	---	---	---

Table 4.24a Variations of Mean Measurements with Depth for Total Alkalinity (milligrams per liter)

Cruise	0-10	10-15	15-20	20-30	30-40
1	---	---	---	---	---
2	97.1	95.7	96.3	97.4	96.7
3	93.8	96.5	96.9	97.0	96.3
4	82.1	84.4	85.9	86.8	87.1
5	93.6	94.5	95.8	98.3	100.2
6	97.0	97.7	98.4	97.1	96.8
7	101.9	101.9	101.0	100.0	99.9
8	---	---	---	---	---
9	---	---	---	---	---
10	---	---	---	---	---
11	---	---	---	---	---

Cruise	40-50	50-100	100-150	150-bottom
1	---	---	---	---
2	96.5	96.7	96.8	97.7
3	95.8	96.0	95.2	98.0
4	87.7	87.1	88.4	88.2
5	100.9	101.7	102.1	97.2
6	97.6	99.6	102.2	104.6
7	99.7	100.6	101.3	101.6
8	---	---	---	---
9	---	---	---	---
10	---	---	---	---
11	---	---	---	---

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 4.24b Variation of mean measurments from West to East for Total Alkalinity (milligrams per liter)

Cruise	West 1-12	14-35	36-59	60-78	East 79-105
	Station Numbers				
1	---	---	---	---	---
2	---	90.3	95.7	97.4	96.7
3	95.0	94.6	96.4	92.4	97.7
4	86.8	85.9	87.6	84.6	79.9
5	98.4	99.2	98.5	93.2	93.4
6	99.3	103.5	96.1	96.3	95.5
7	100.2	99.6	103.0	109.0	97.2
8	---	---	---	---	---
9	---	---	---	---	---
10	---	---	---	---	---
11	---	---	---	---	---

Table 4.25 Lake Ontario - Upper 20 Meter Chemical Masses
(metric tons)

	May 1-5 1972 Cr. 1	May 15-19 1972 Cr. 2	Jun 12-16 1972 Cr. 3	Jul 10-14 1972 Cr. 4	Aug 21-25 1972 Cr. 5	Oct 30-Nov 2 1972 Cr. 6
TP	3.80E3	5.13E3	5.23E3	7.08E3	5.75E3	5.84E3
TFP	3.56E3	3.01E3	2.54E3	3.41E3	2.10E3	3.17E3
DOP	5.08E2	1.94E3	7.13E2	6.05E2	7.00E2	1.21E3
NO2-NO3	1.31E5	1.10E5	8.58E4	7.92E4	4.90E4	7.08E4
NH3	---	---	4.24E3	8.79E3	8.64E3	7.65E3
TKN	---	6.18E4	6.39E4	8.05E4	---	5.52E4
TOC	8.75E5	1.01E6	1.25E6	1.52E6	---	1.20E6
SO4	---	---	---	---	---	9.11E6
SiO2	2.87E5	1.68E5	2.12E5	2.30E5	2.23E5	2.31E5
F	1.80E4	1.78E4	3.74E4	3.84E4	3.07E4	3.28E4
K	5.10E5	4.89E5	4.09E5	5.13E5	5.59E5	5.30E5
Na	4.40E6	4.43E6	4.50E6	4.84E6	4.42E6	4.00E6
Ca	1.27E7	1.43E7	1.37E7	1.31E7	1.31E7	1.29E7
Mg	2.65E6	2.70E6	2.75E6	2.78E6	1.93E6	2.63E6
Mn	---	---	9.33E2	---	1.00E3	---
Fe	---	---	2.28E4	---	2.20E4	---
Zn	---	---	8.35E3	---	5.19E3	---
Ni	---	---	---	---	9.40E3	---
Cd	---	---	1.11E4	---	---	---

	Nov 27-Dec 2 1972 Cr. 7	Feb 5-9 1973 Cr. 8	Mar 19-23 1973 Cr. 9	Apr 24-30 1973 Cr. 10	Jun 11-15 1973 Cr. 11
TP	7.32E3	5.70E3	6.59E3	[illegible]	7.30E3
TFP	2.72E3	5.44E3	4.05E3	[illegible]	3.21E3
DOP	1.27E3	1.37E3	1.60E3	2.00E3	9.60E2
NO2-NO3	5.95E4	2.08E4	1.10E5	[illegible]	4.79E4
NH3	3.20E3	2.79E3	2.01E3	4.40E3	4.13E3
TKN	[illegible]	---	[illegible]	2.77E4	5.34E4
TOC	---	7.34E5	6.22E5	[illegible]	1.42E6
SO4	8.25E6	9.78E6	[illegible]	[illegible]	8.89E6
SiO2	[illegible]	1.47E5	[illegible]	[illegible]	[illegible]
F	[illegible]	---	[illegible]	[illegible]	[illegible]
K	[illegible]	[illegible]	[illegible]	---	5.92E5
Na	[illegible]	[illegible]	[illegible]	---	4.57E6
Ca	[illegible]	[illegible]	[illegible]	---	1.31E7
Mg	[illegible]	[illegible]	[illegible]	---	[illegible]
Mn	---	---	1.50E3	1.85E3	7.67E2
Fe	---	---	[illegible]	1.01E4	1.32E4
Zn	---	---	[illegible]	[illegible]	6.07E3
Ni	---	---	[illegible]	[illegible]	[illegible]
Cd	---	---	---	---	---

Table 4.26 Lake Ontario - Chemical Total Mass Determination

	May 1-5 1972 Cr. 1	May 15-19 1972 Cr. 2	Jun 12-16 1972 Cr. 3	Jul 10-14 1972 Cr. 4	Aug 21-25 1972 Cr. 5	Oct 30-Nov 2 1972 Cr. 6
TP	1.69E4	2.70E4	2.51E4	2.81E4	2.78E4	2.94E4
TFP	1.96E4	1.47E4	1.52E4	1.87E4	1.41E4	1.77E4
POP	2.61E3	7.04E3	3.50E3	5.36E3	5.47E3	7.02E3
NO2-NO3	8.58E5	5.94E5	4.27E5	7.02E5	4.45E5	3.72E5
NH3	---	---	2.04E4	3.59E4	3.05E4	3.38E4
TKN	---	3.10E5	1.77E5	3.57E5	---	2.63E5
TOC	4.15E6	4.27E6	5.69E6	7.57E6	---	1.24E7
SO4	---	---	---	---	---	---
SiO2	1.54E6	7.97E5	6.73E5	1.19E6	1.11E6	9.77E5
F	9.35E4	8.72E4	1.77E5	1.89E5	1.00E5	1.61E5
K	2.49E6	2.43E6	2.39E6	2.42E6	2.65E6	2.56E6
Na	2.15E7	2.17E7	2.19E7	2.32E7	2.14E7	2.26E7
Ca	6.18E7	6.98E7	6.59E7	6.26E7	6.19E7	6.20E7
Mg	1.27E7	1.31E7	1.30E7	1.35E7	9.41E6	1.27E7
Mn	---	---	4.35E3	---	5.04E3	---
Fe	---	---	1.02E5	---	8.09E4	---
Zn	---	---	3.58E4	---	6.02E4	---
Ni	---	---	---	---	1.18E5	---
Cd	---	---	1.17E5	---	---	---

	Nov 27-Dec 2 1972 Cr. 7	Feb 5-9 1973 Cr. 8	Mar 18-23 1973 Cr. 9	Apr 24-30 1973 Cr. 10	Jun 11-15 1973 Cr. 11
TP	3.79E4	2.39E4	2.64E4	3.49E4	2.79E4
TFP	1.31E4	2.51E4	2.57E4	3.14E4	1.74E4
POP	6.01E3	1.09E4	8.08E3	1.13E4	5.99E3
NO2-NO3	3.22E5	4.41E5	5.52E5	4.10E5	3.62E5
NH3	1.62E4	8.27E3	1.04E4	1.76E4	1.87E4
TKN	1.64E5	---	1.83E5	1.22E5	1.65E5
TOC	---	2.91E6	4.29E6	4.28E6	5.43E6
SO4	3.78E7	4.37E7	4.33E7	4.38E7	3.67E7
SiO2	6.84E5	1.10E6	8.92E5	1.03E6	7.11E5
F	1.48E5	---	2.09E5	1.74E5	1.75E5
K	3.05E6	2.39E6	2.22E6	---	2.52E6
Na	2.19E7	2.15E7	2.19E7	---	2.20E7
Ca	6.41E7	6.48E7	6.36E7	---	6.36E7
Mg	1.28E7	1.28E7	1.24E7	---	1.23E7
Mn	---	---	6.16E3	1.24E4	3.46E3
Fe	---	---	1.21E5	8.63E4	6.90E4
Zn	---	---	2.03E4	1.16E4	3.46E4
Ni	---	---	2.41E4	1.69E4	1.71E4
Cd	---	---	---	---	---

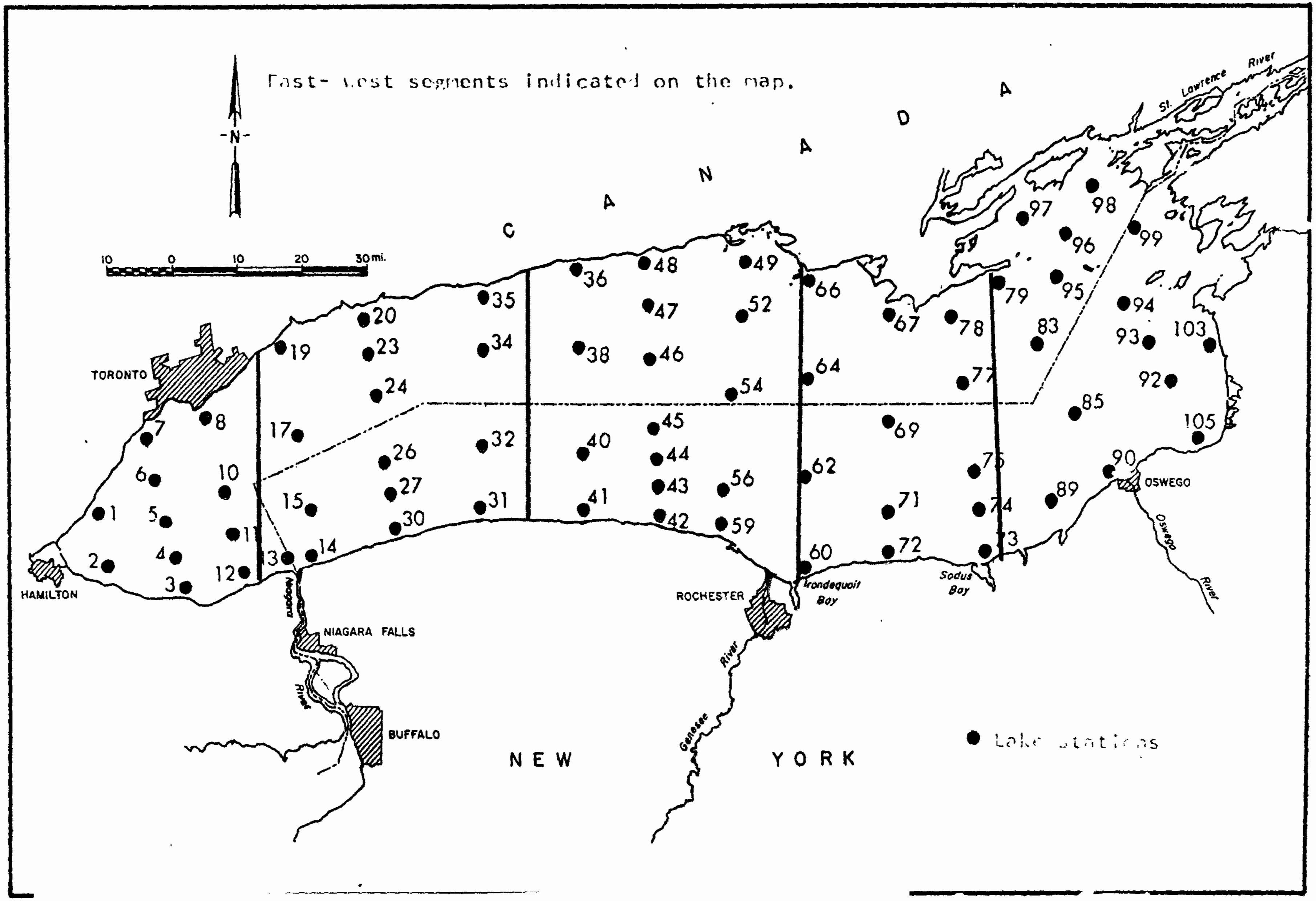

Figure 4.1 Map for East-West Chemical Variations in Lake Ontario

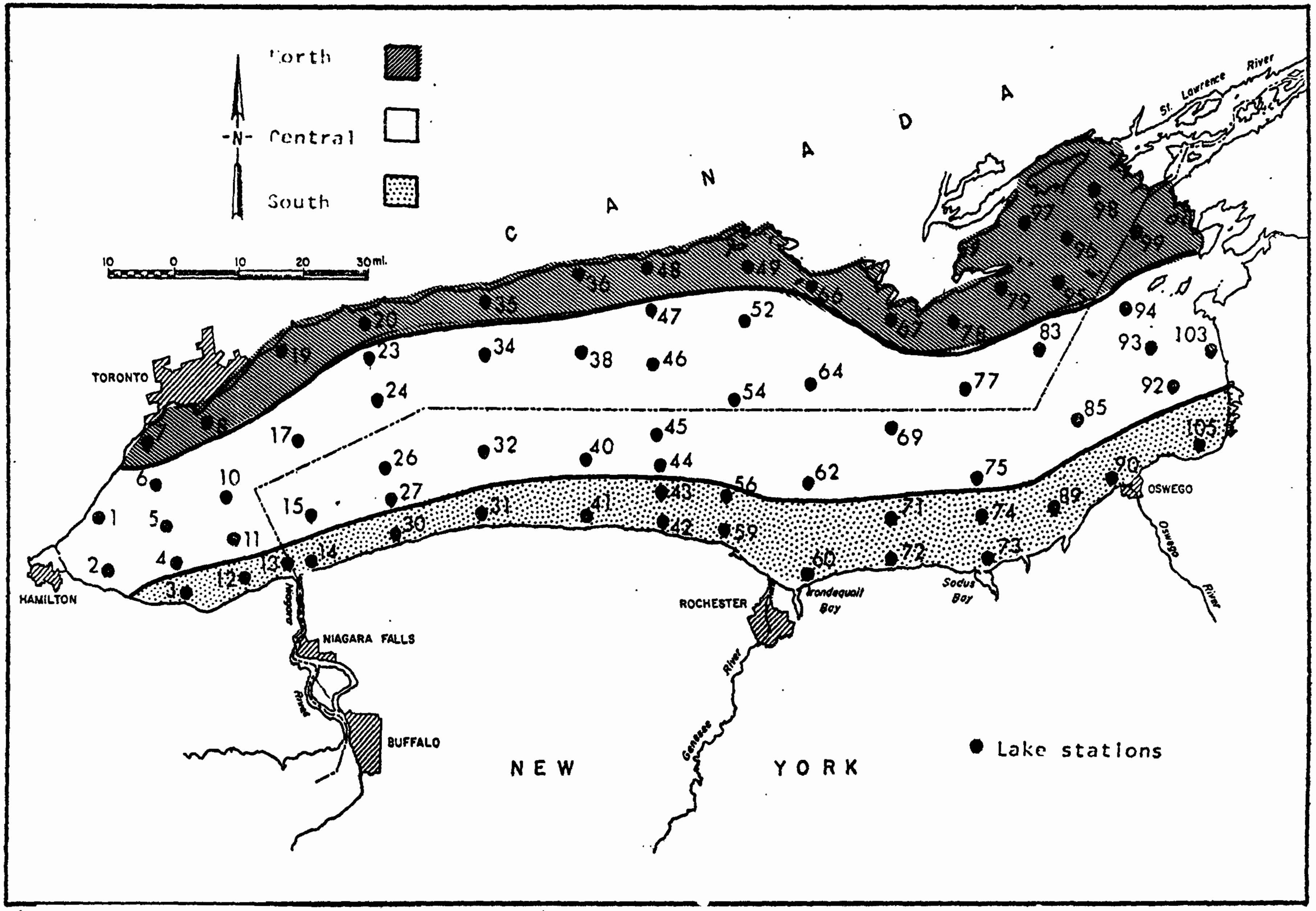

Figure 4.2 Map for North-South Chemical Variatins in Lake Ontario

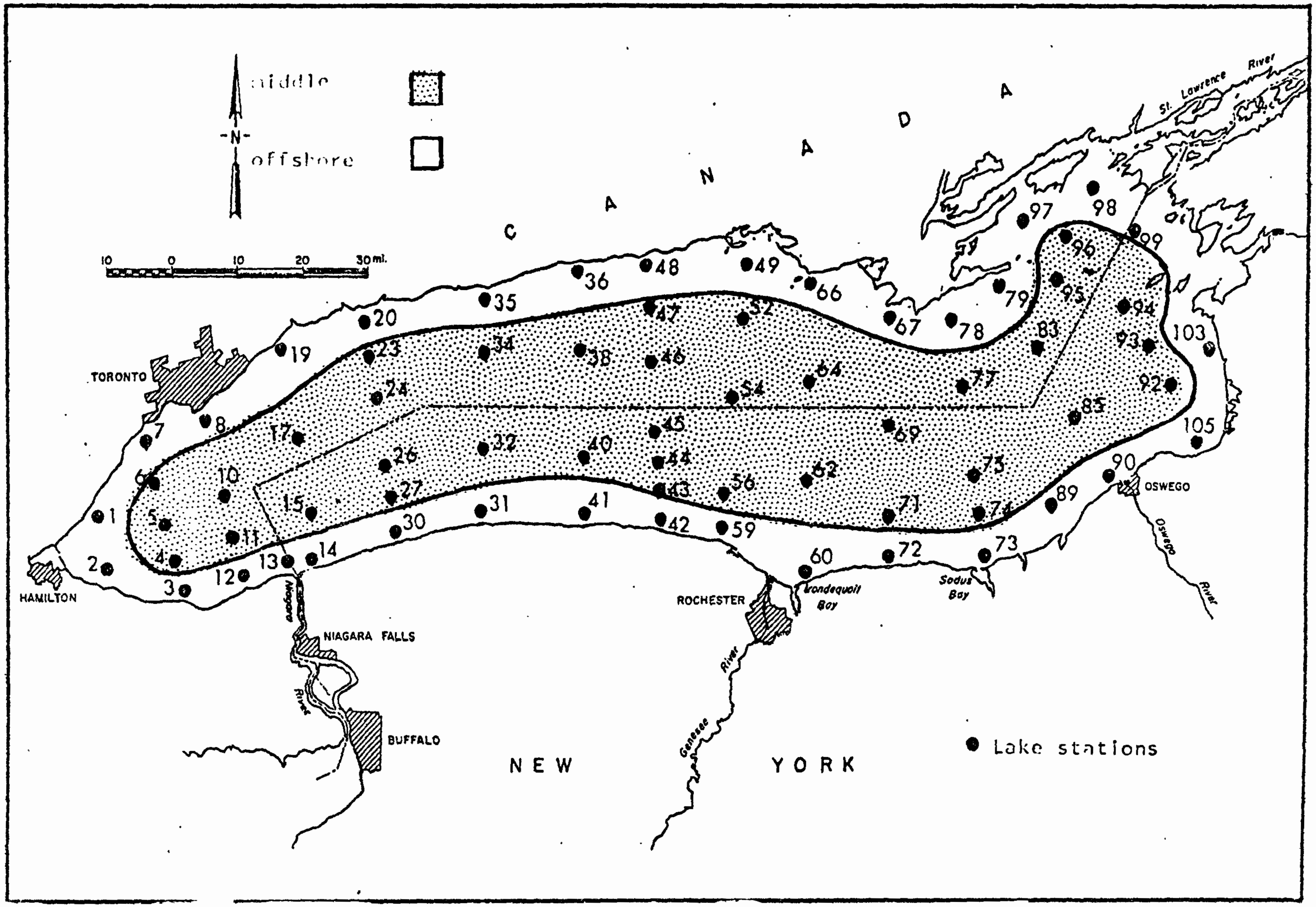

Figure 4.3 Map for Middle Lake-Offshore Chemical Variations in Lake Ontario

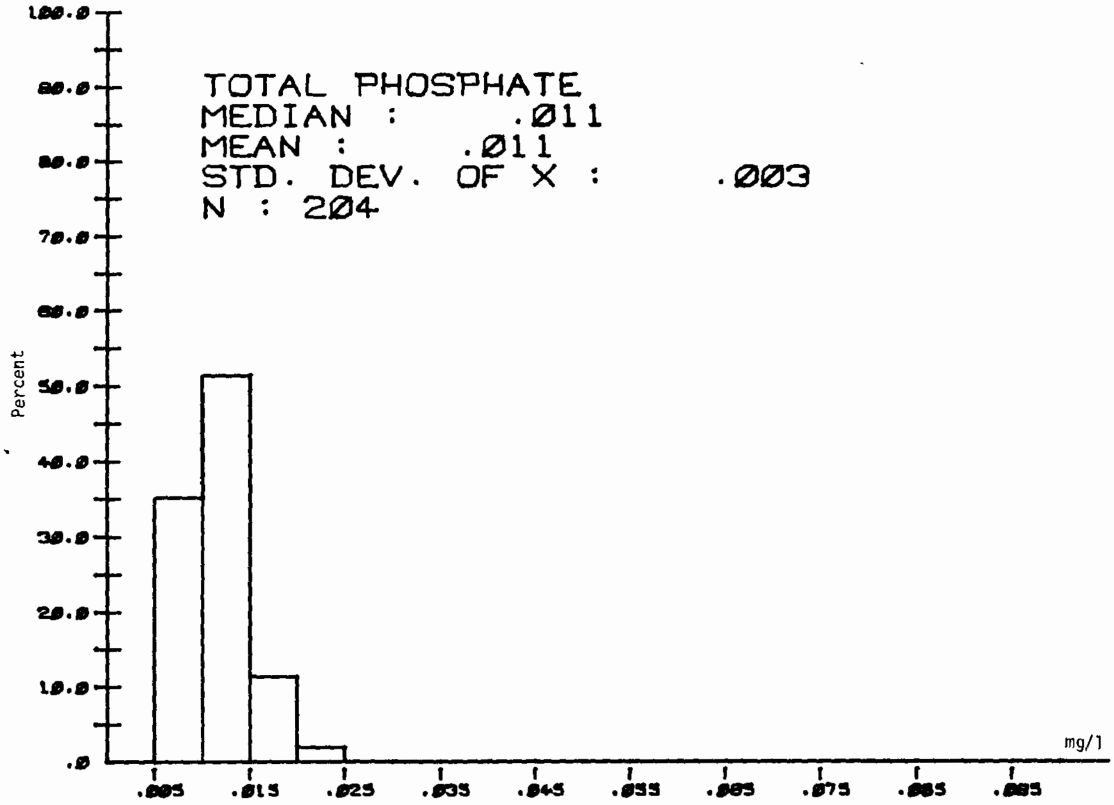

Figure 4.4a Histograms for Total Phosphate - Cruise 1

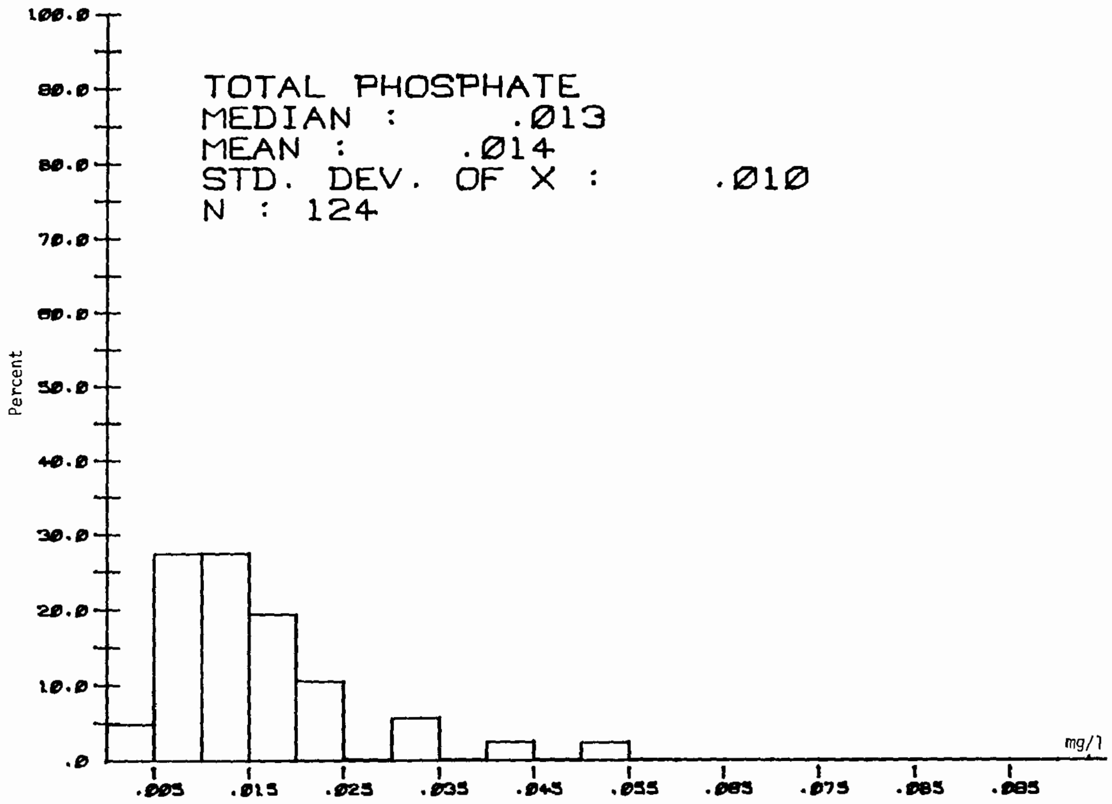

Figure 4.4a Histograms for Total Phosphate - Cruise 2

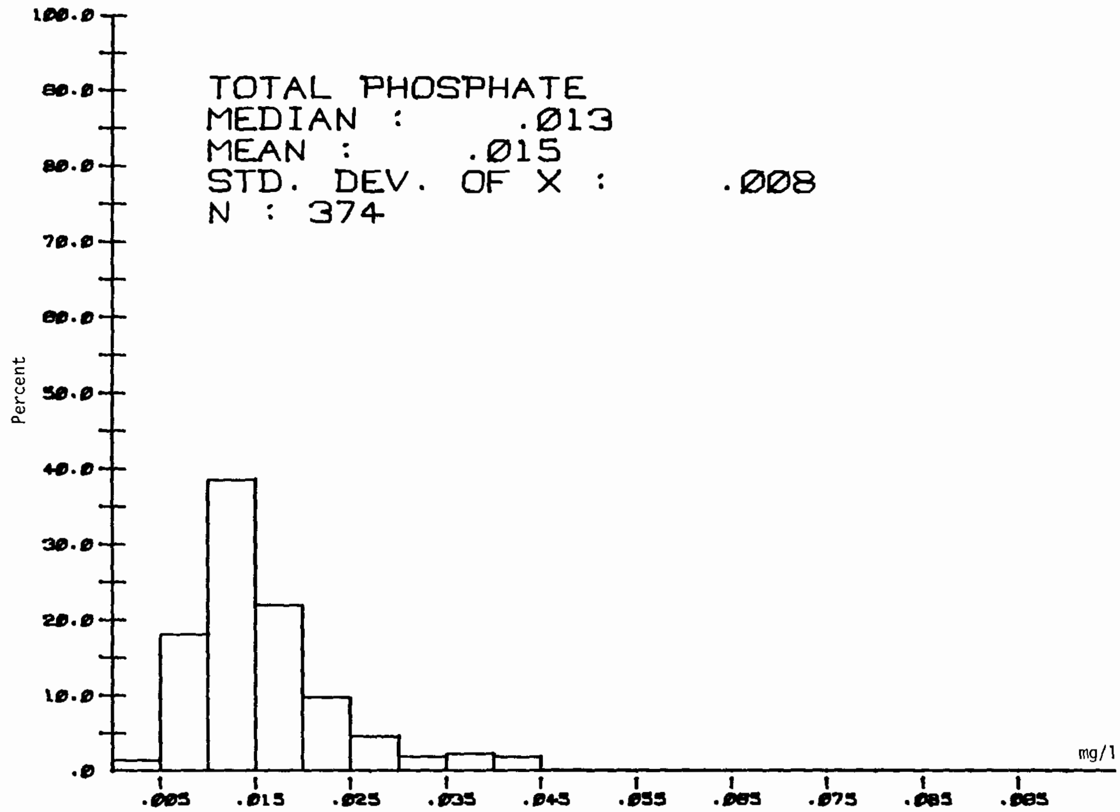

Figure 4.4a Histograms for Total Phosphate - Cruise 3

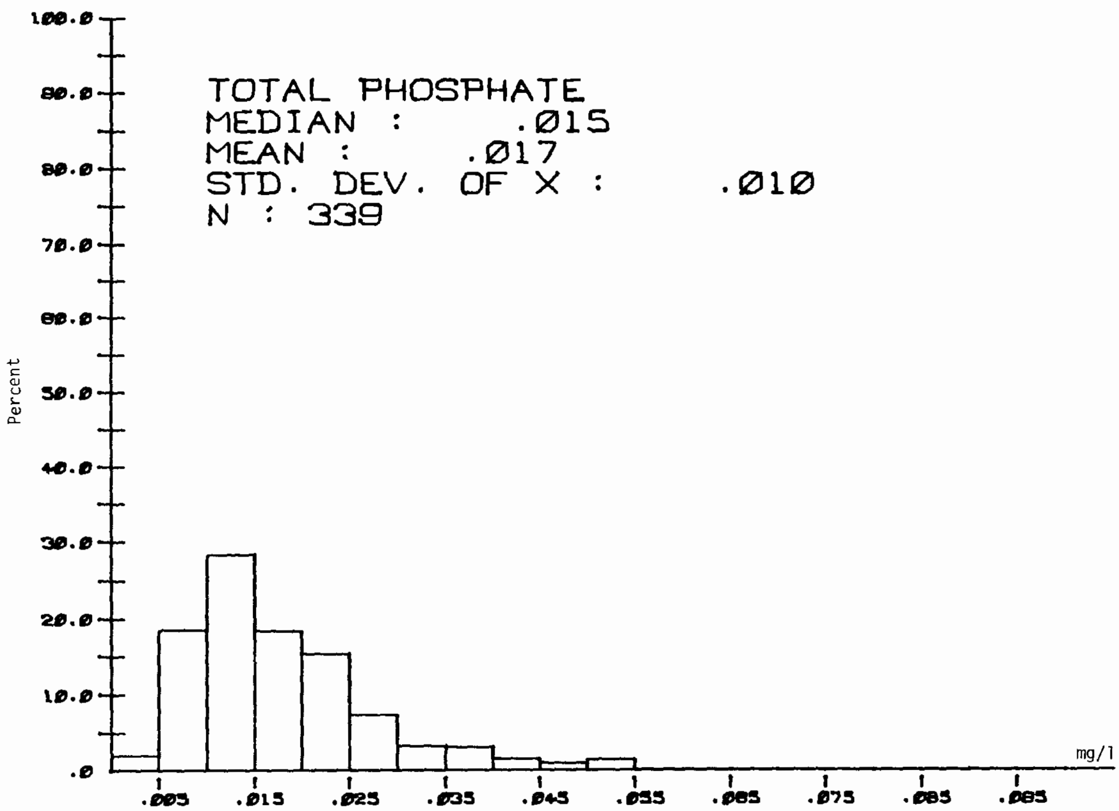

Figure 4.4a Histograms for Total Phosphate - Cruise 4

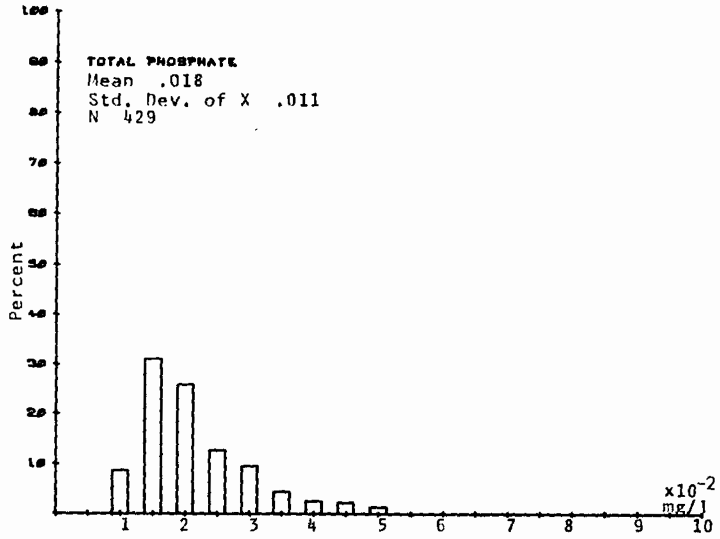

Figure 4.4a Histograms for Total Phosphate - Cruise 5

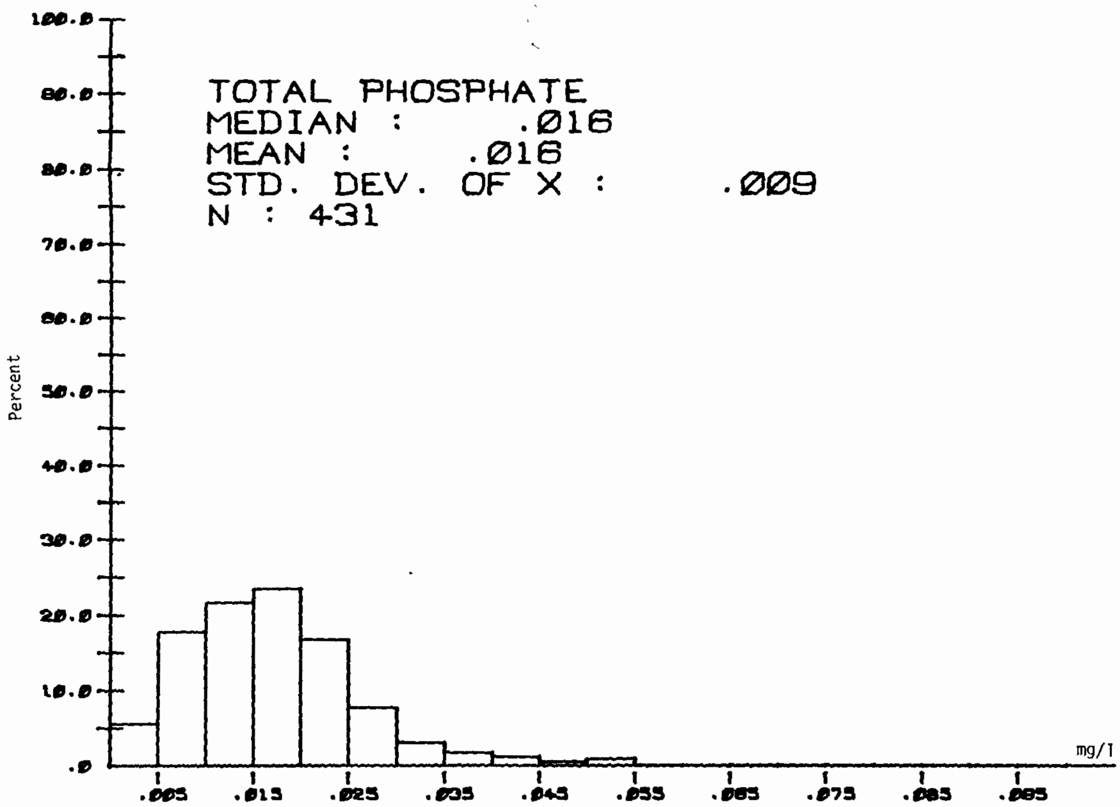

Figure 4.4a Histograms for Total Phosphate - Cruise 6

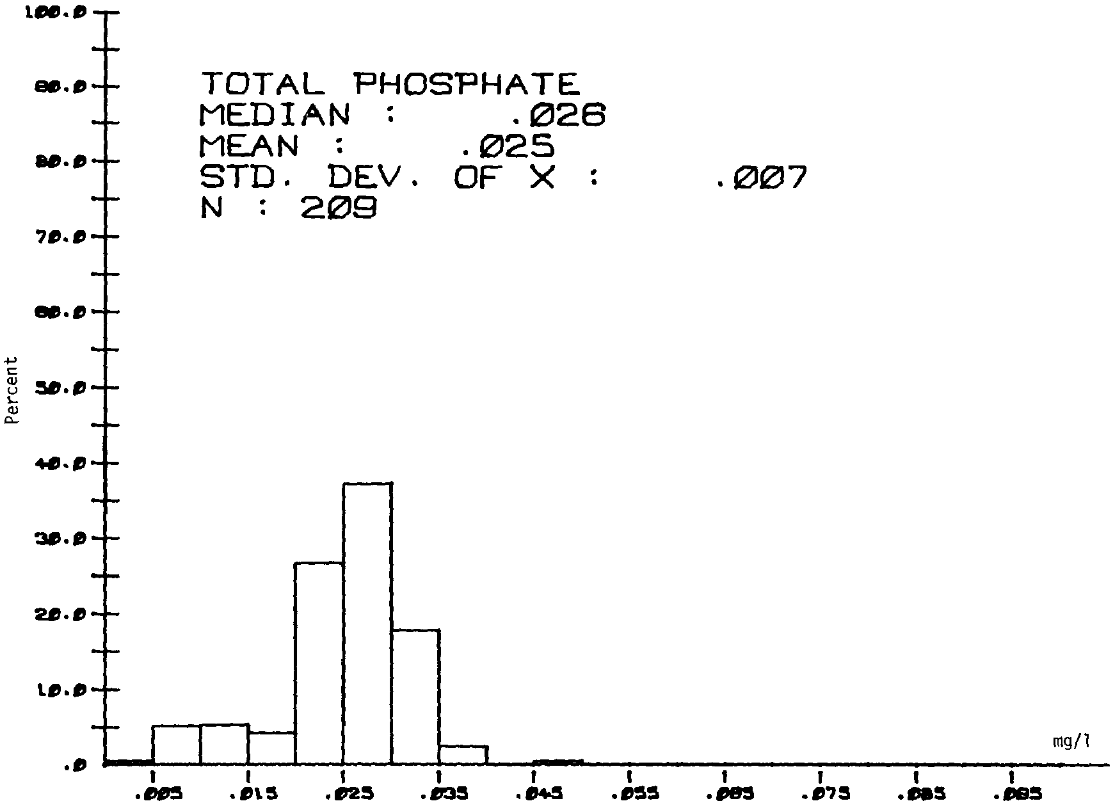

Figure 4.4a Histograms for Total Phosphate - Cruise 7

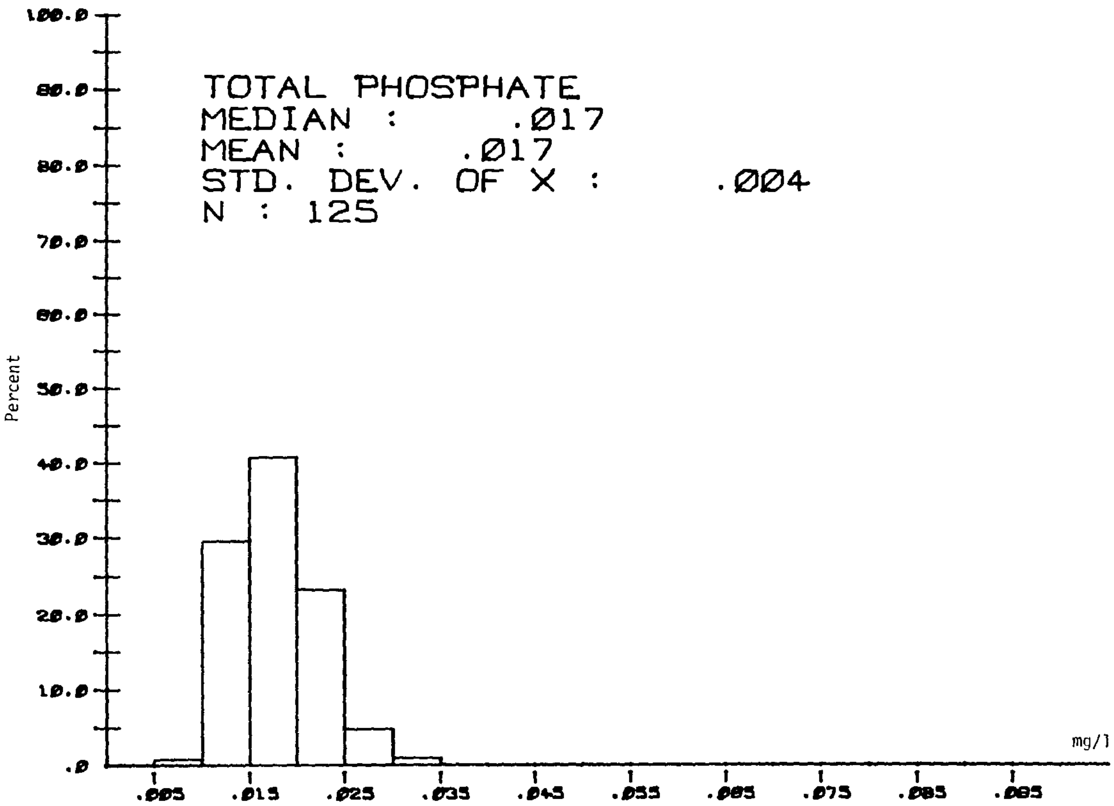

Figure 4.4a Histograms for Total Phosphate - Cruise 8

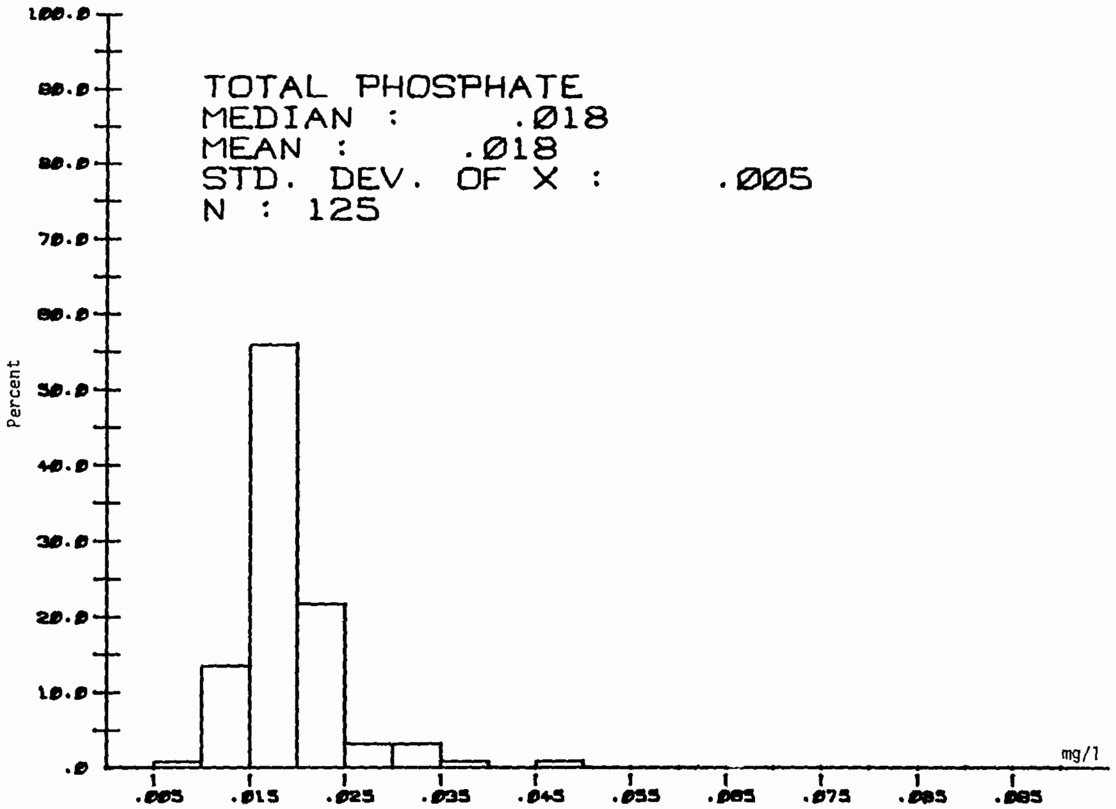

Figure 4.4a Histograms for Total Phosphate - Cruise 9

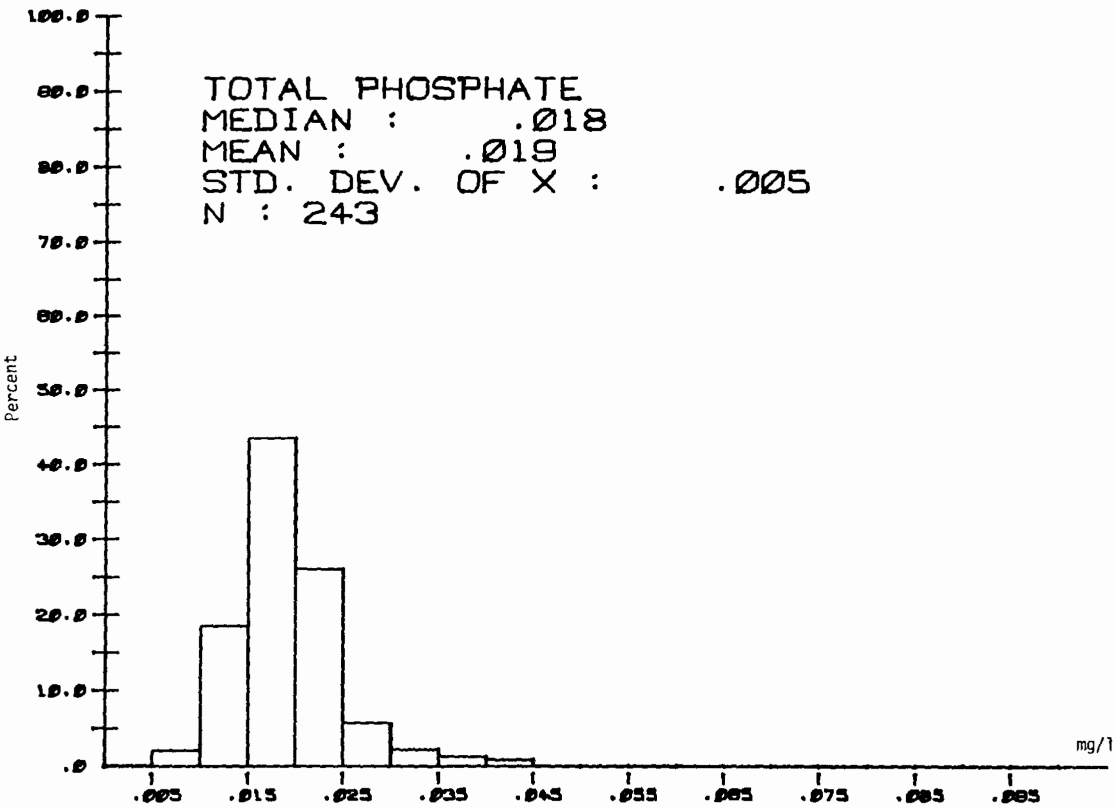

Figure 4.4a Histograms for Total Phosphate - Cruise 10

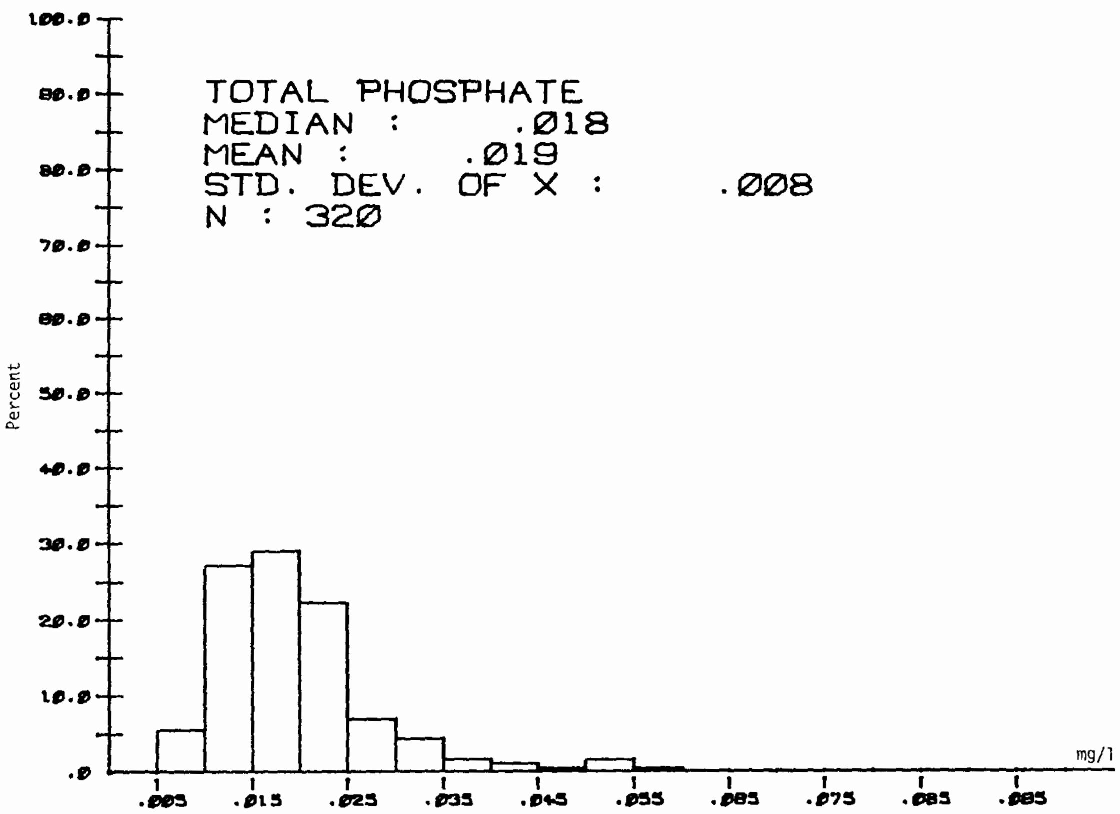

Figure 4.4a Histograms for Total Phosphate - Cruise 11

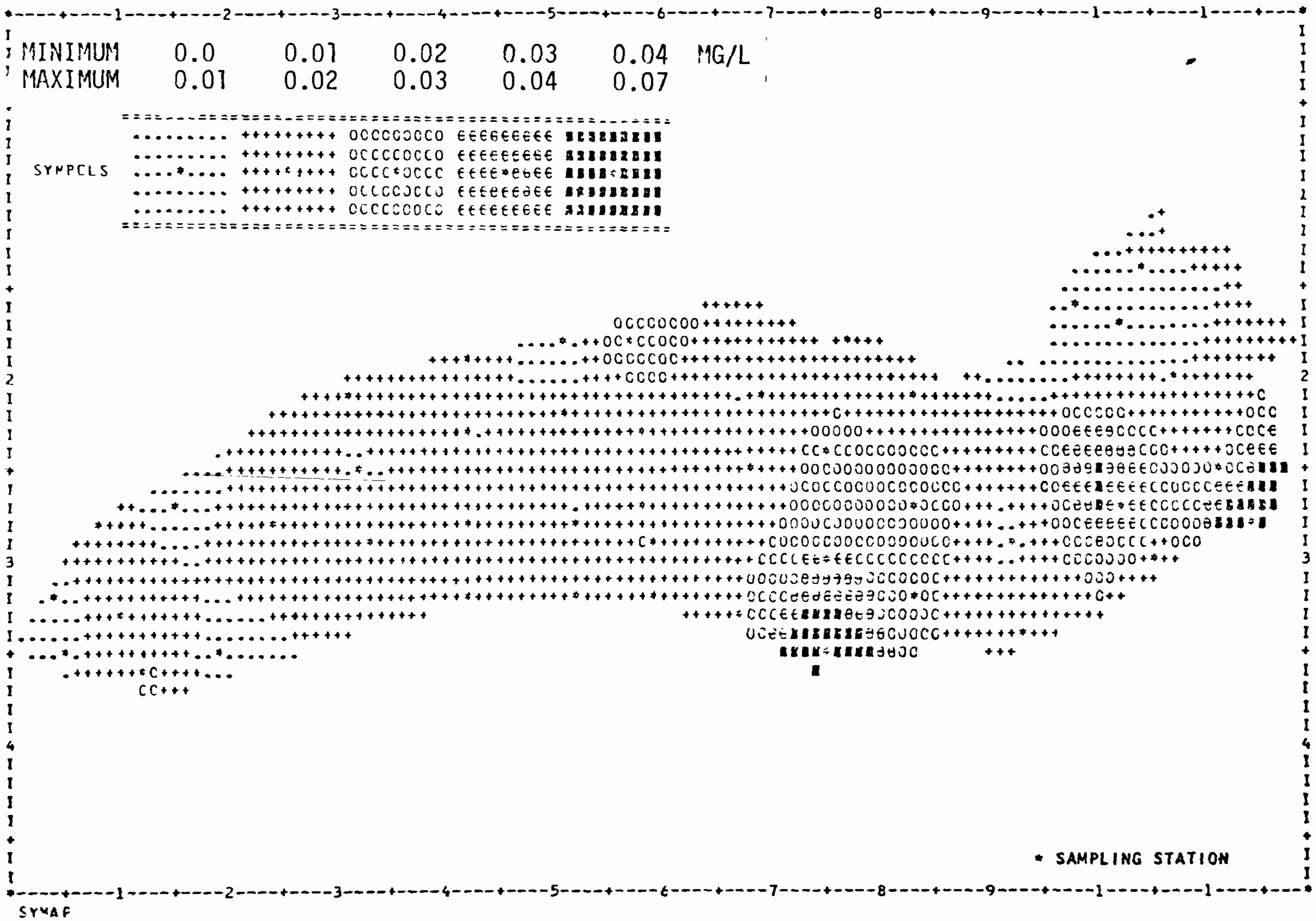

Figure 4.4b Contours of Constant Surface Total Phosphate

Cruise Number 3: June 12, 1972 to June 16, 1972

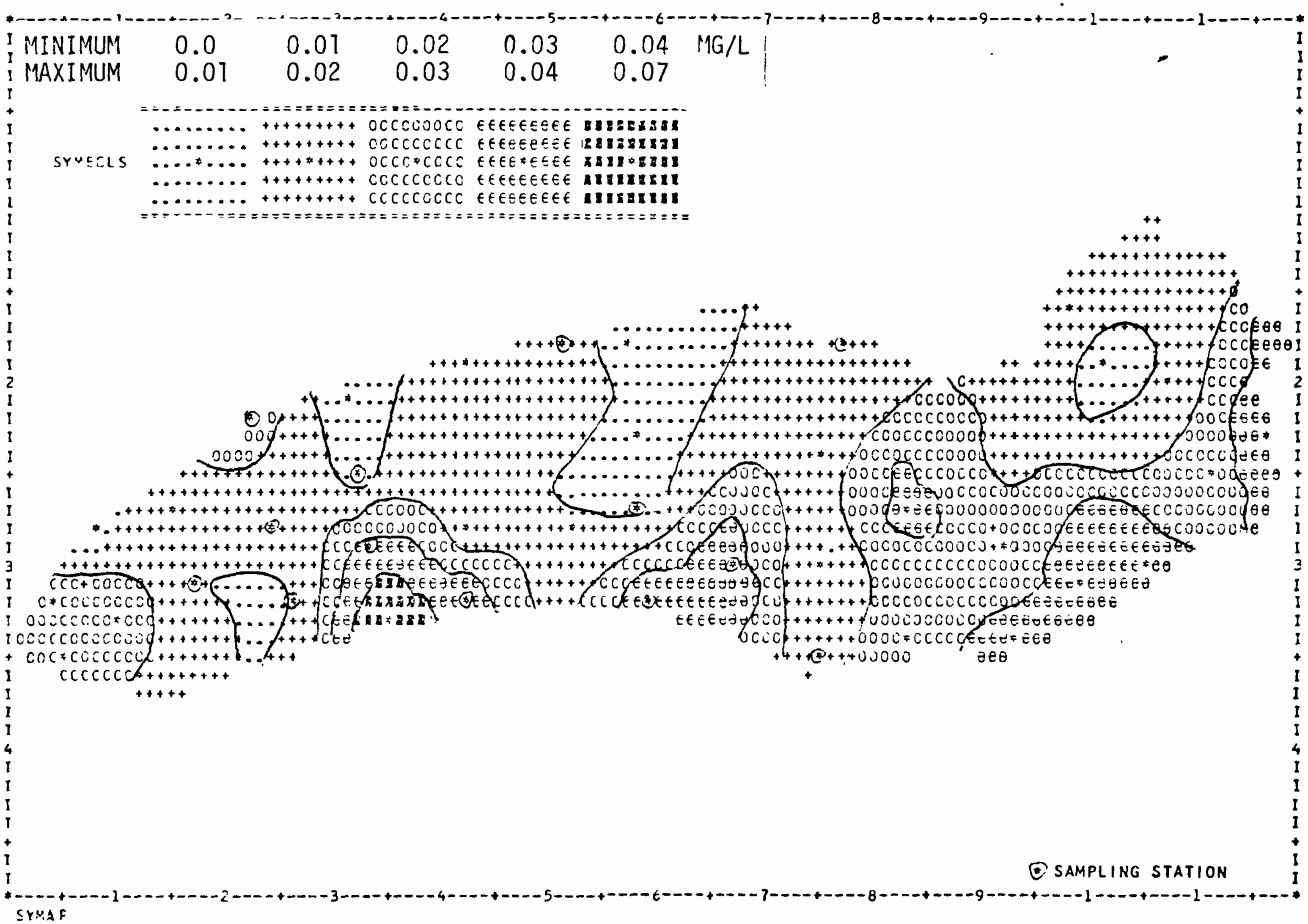

Figure 4.4b Contours of Constant Surface Total Phosphate
Cruise Number 4: July 10, 1972 to July 14, 1972

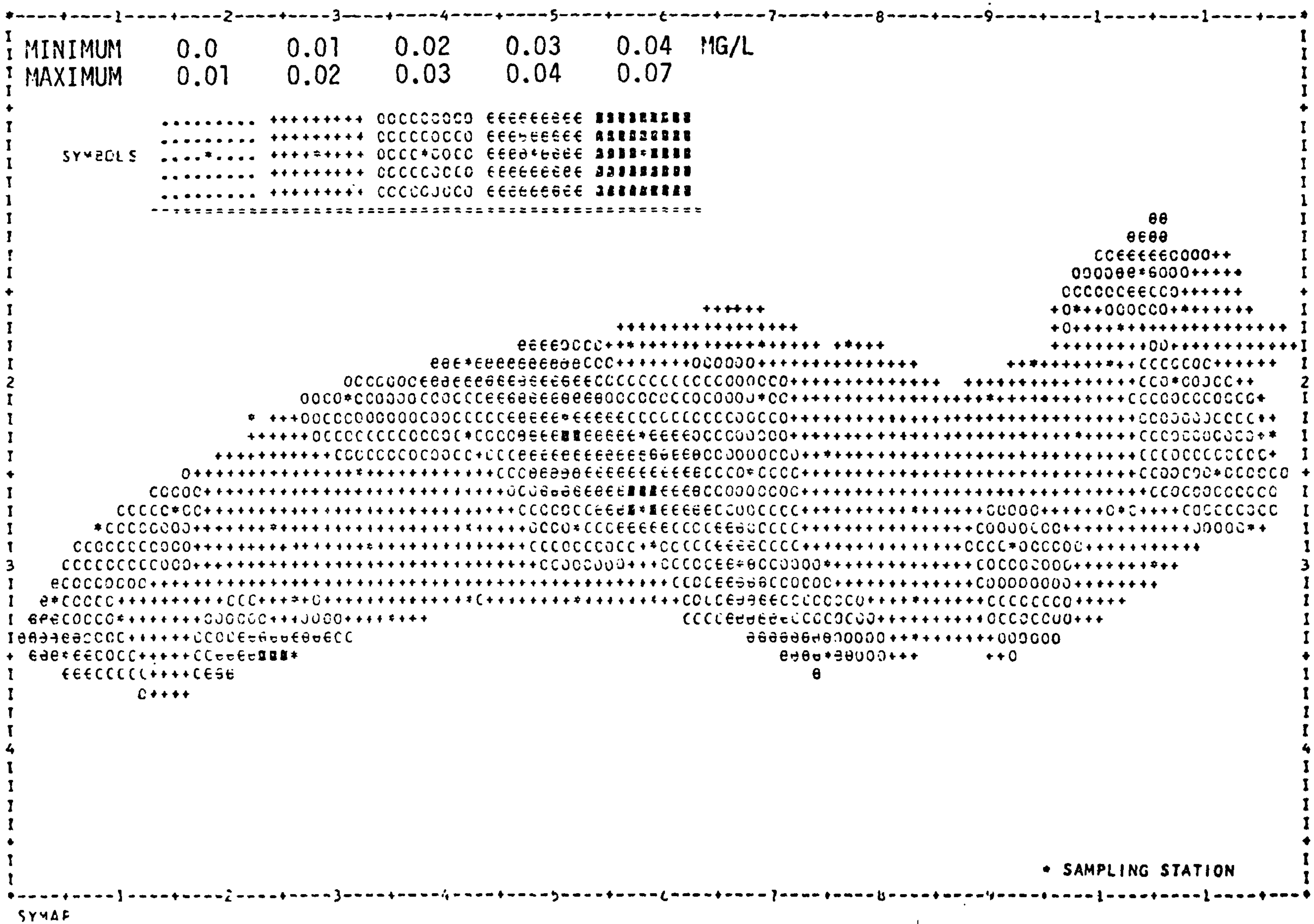

Figure 4.4b Contours of Constant Surface Total Phosphate
Cruise Number 5: August 21, 1972 to August 25, 1972

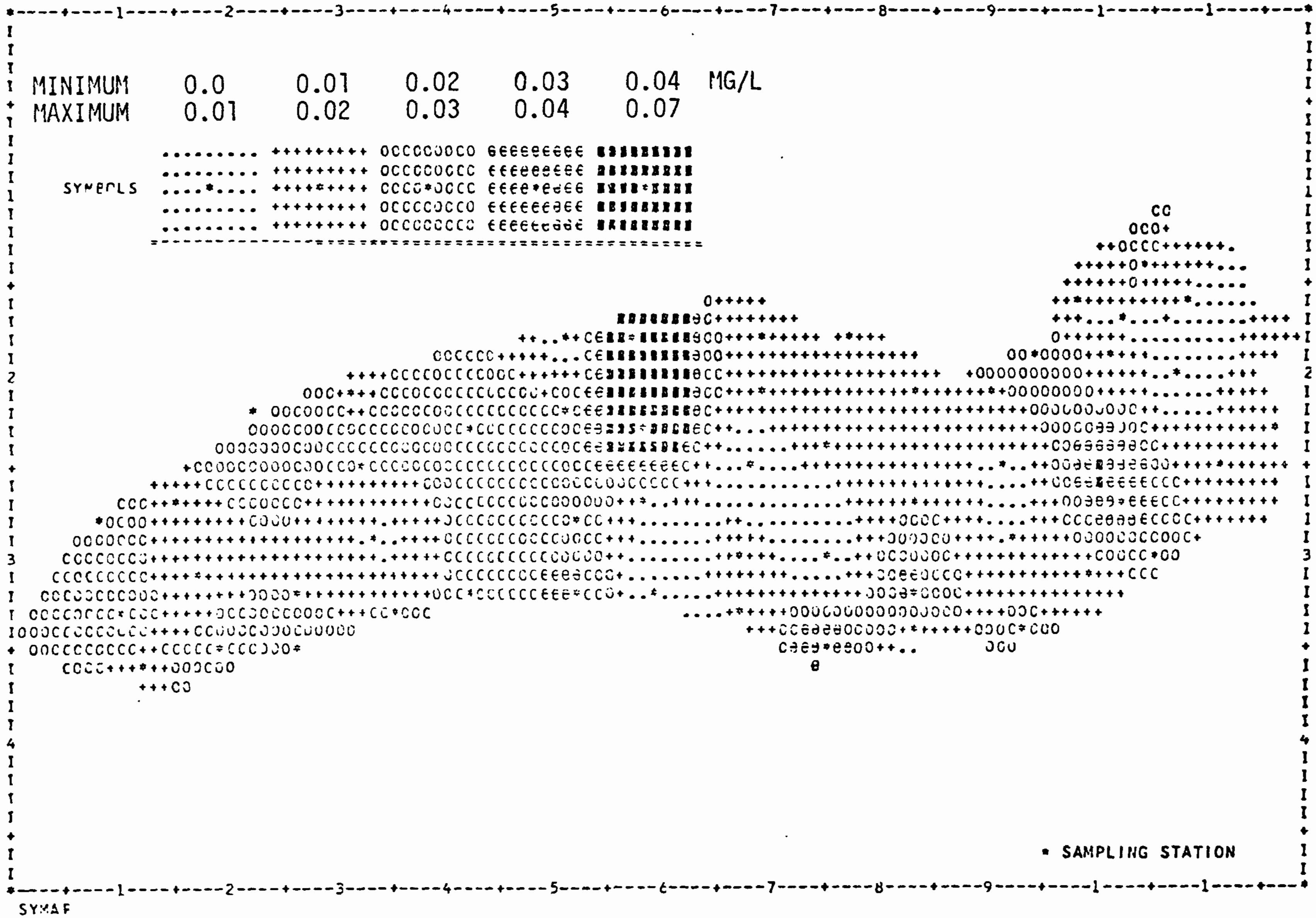

Figure 4.4b Contours of Constant Surface Total Phosphate

Crusie Number 6: Ocotober

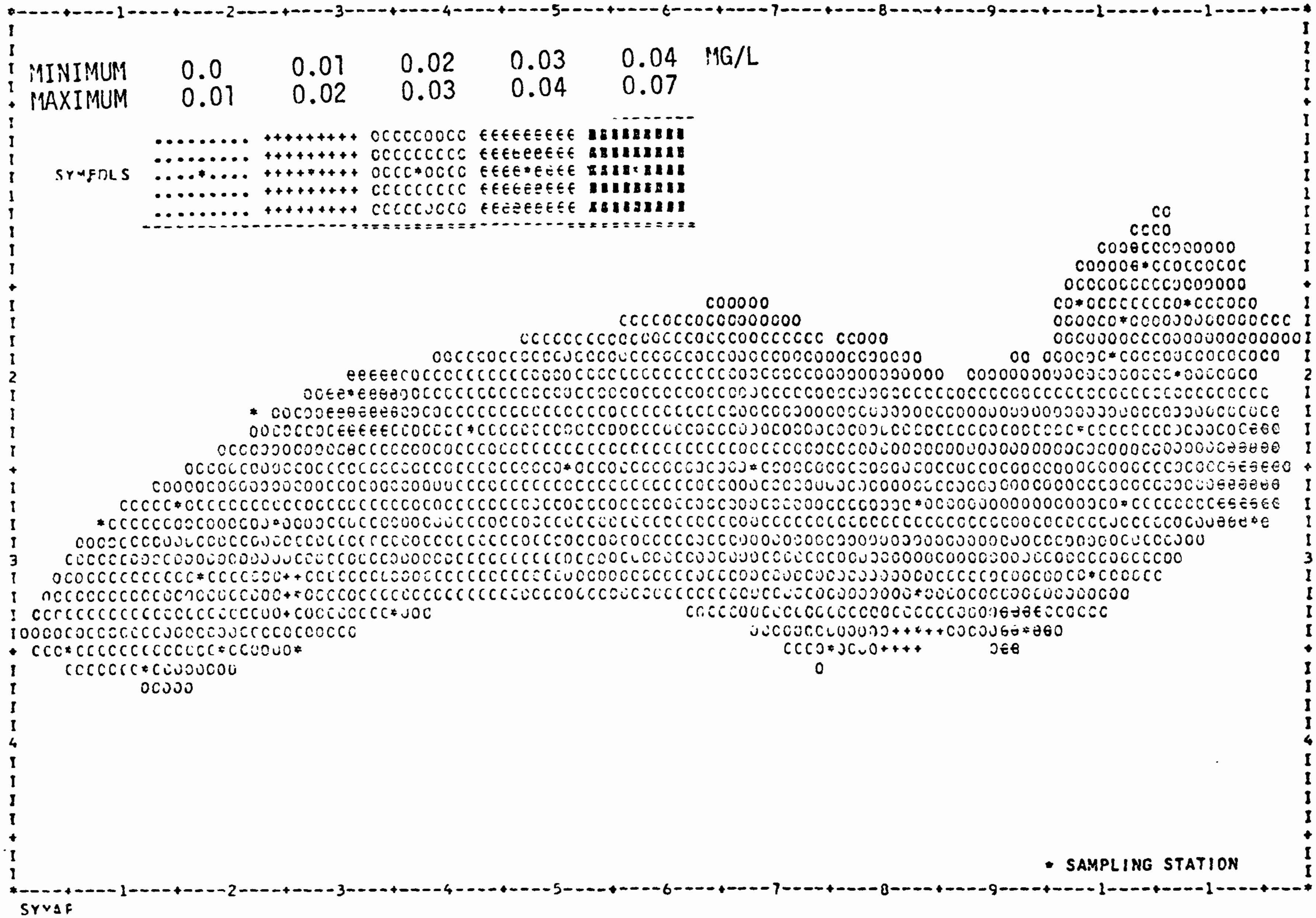

Figure 4.4b Contours of Constant Surface Total Phosphate
Cruise Number 7: November 27, 1972 to December 2, 1972

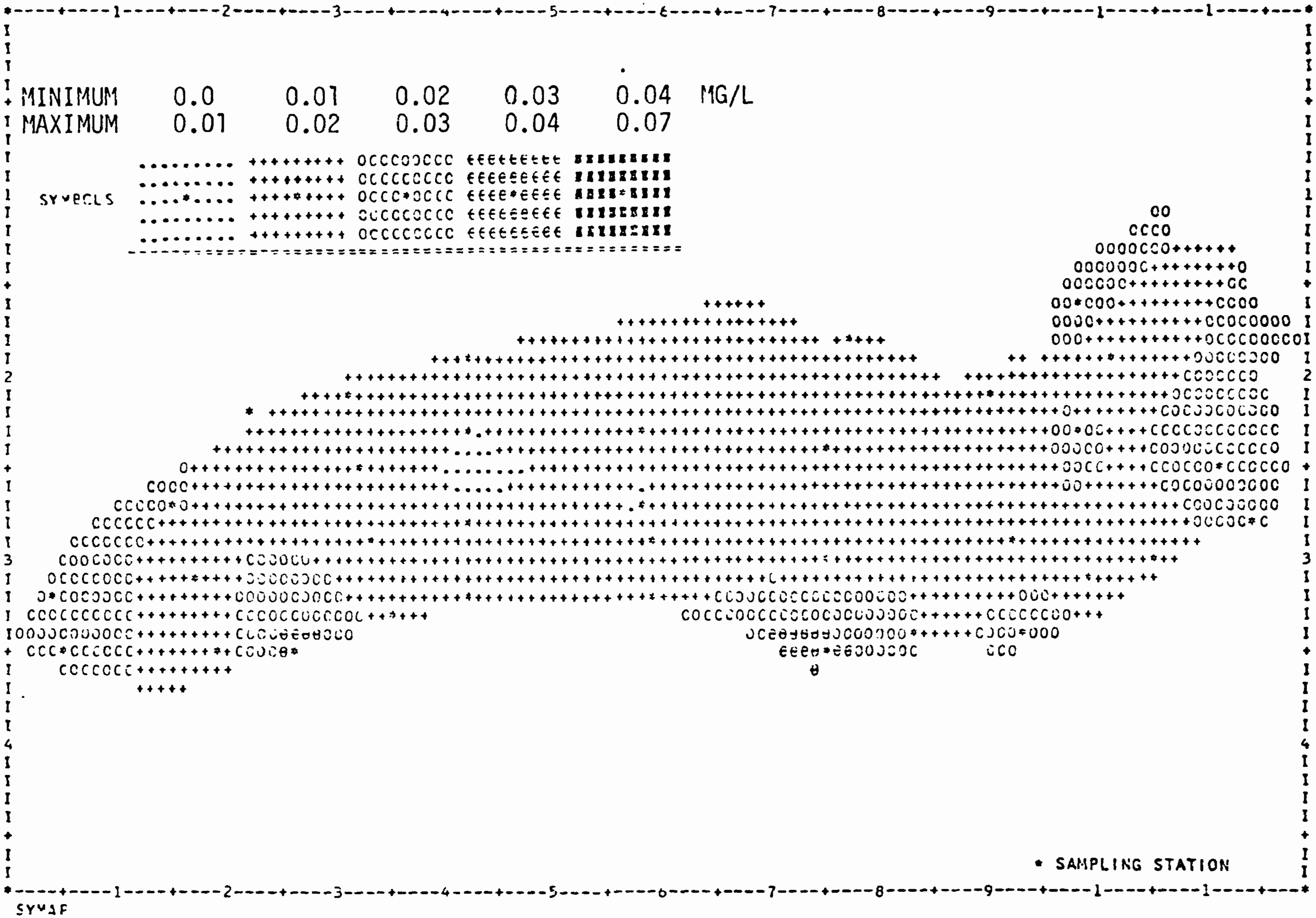

Figure 4.4b Contours of Constant Surface Total Phosphate
Cruise Number 8: February 5, 1973 to February 9, 1973

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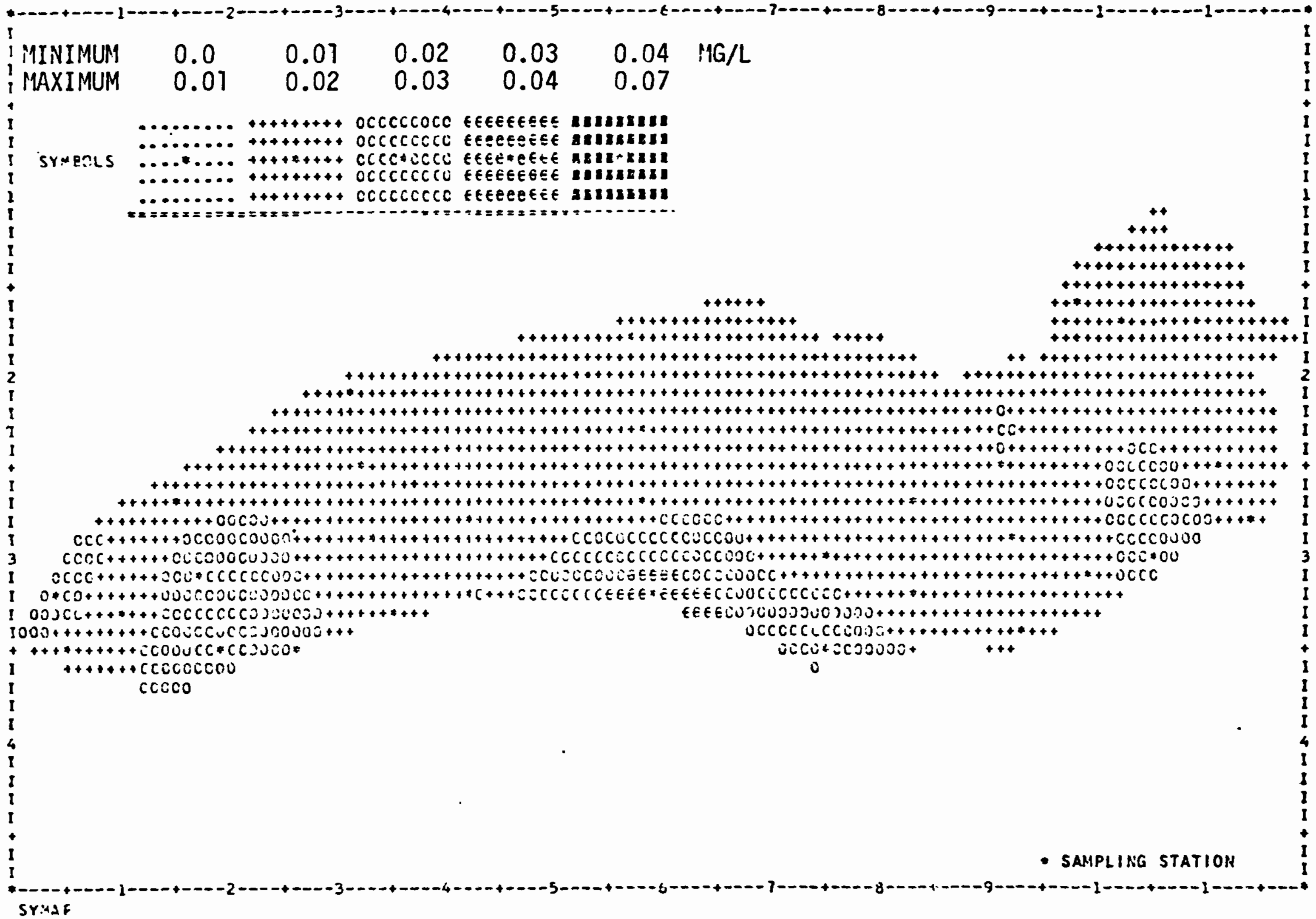


Figure 4.4b Contours of Constant Surface Total Phosphate

Crusie Number 9: March 18, 1973 to March 23, 1973

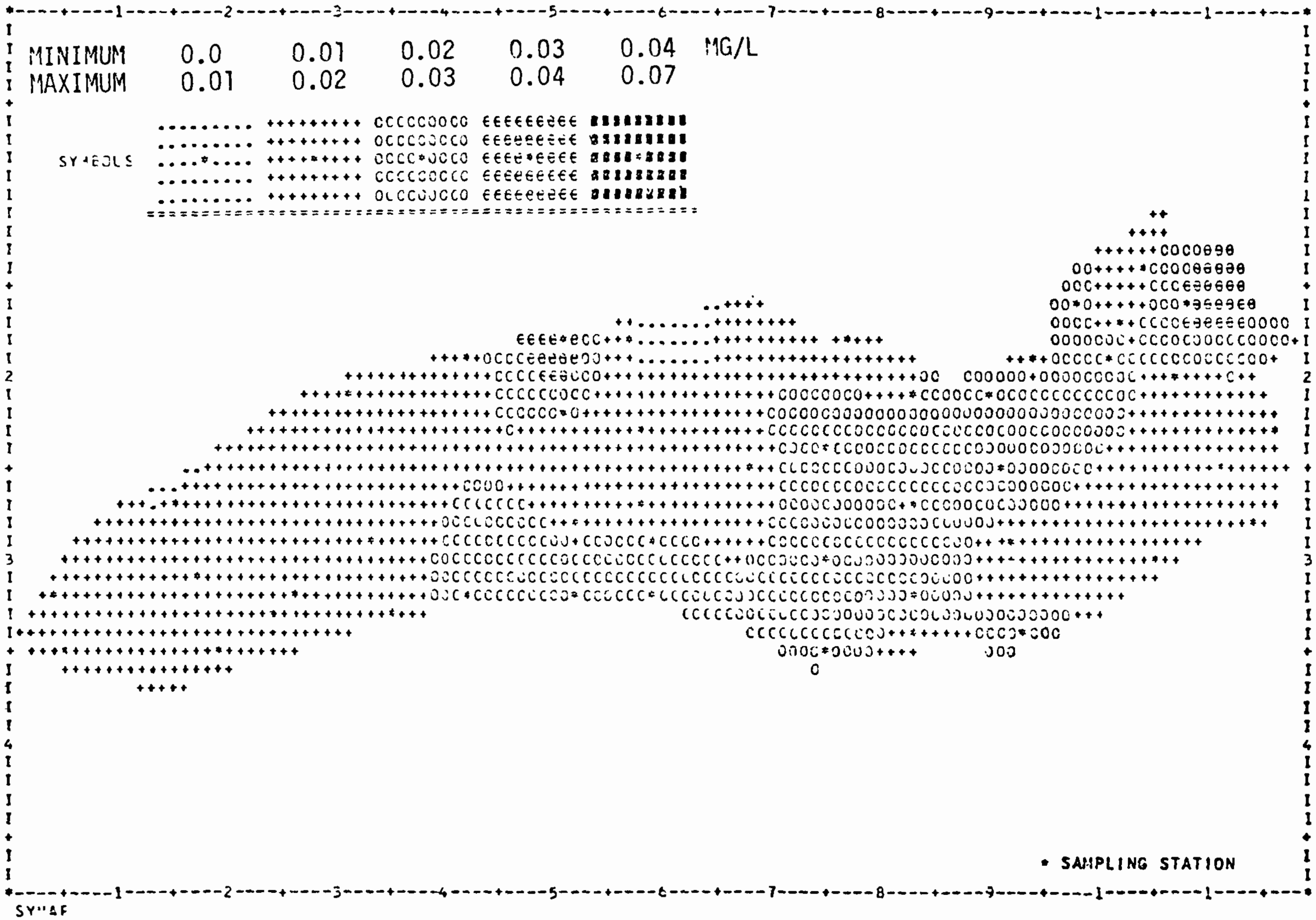


Figure 4.4b Contours of Constant Surface Total Phosphate

Cruise Number 10: April 24, 1973 to April 30, 1973

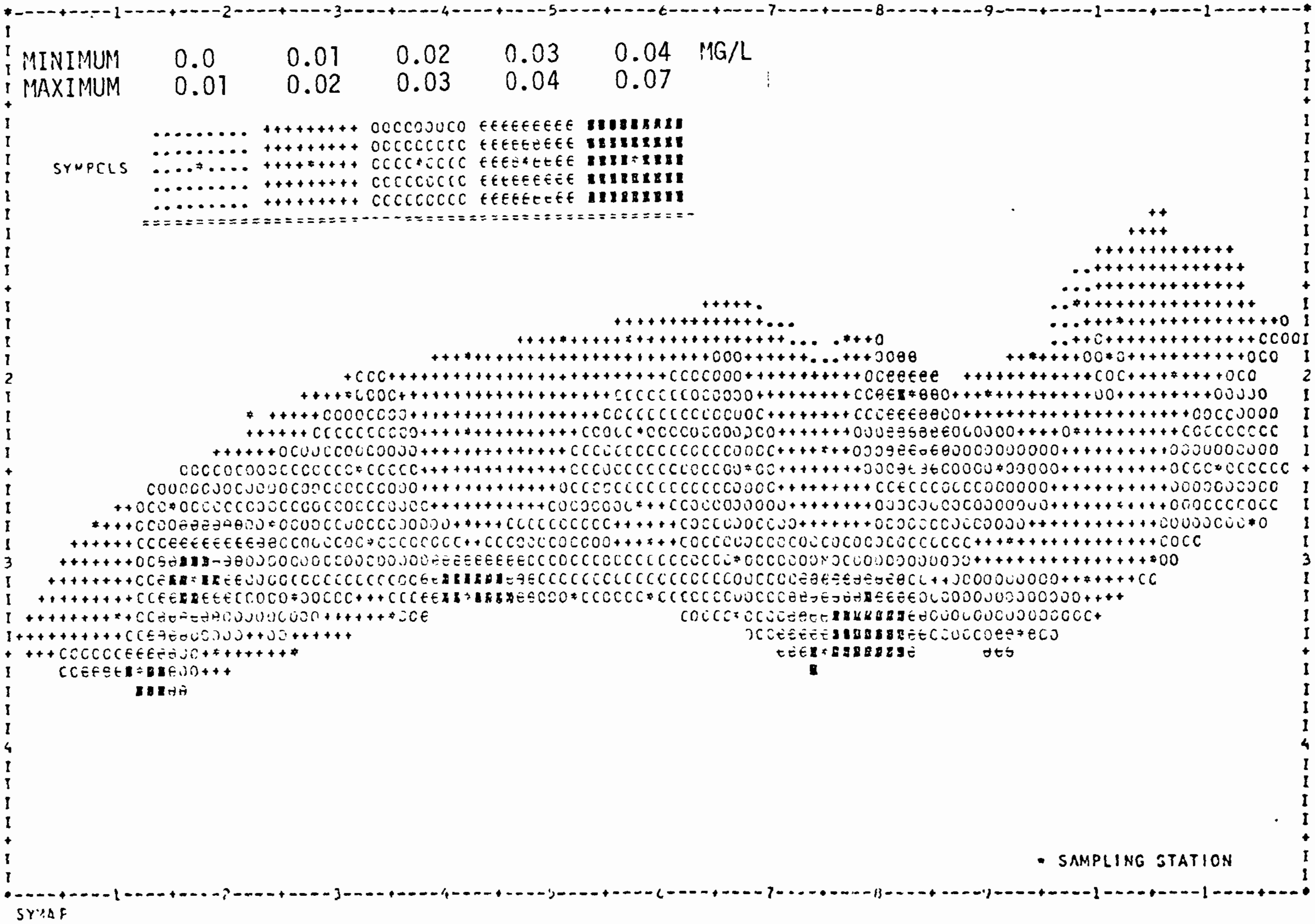


Figure 4.4b Contours of Constant Surface Total Phosphate
Cruise Number 11: June 11, 1973 to June 15, 1973

MG/L					
MINIMUM	0.00	0.01	0.015	0.02	0.025
MAXIMUM	0.01	0.015	0.02	0.025	0.03

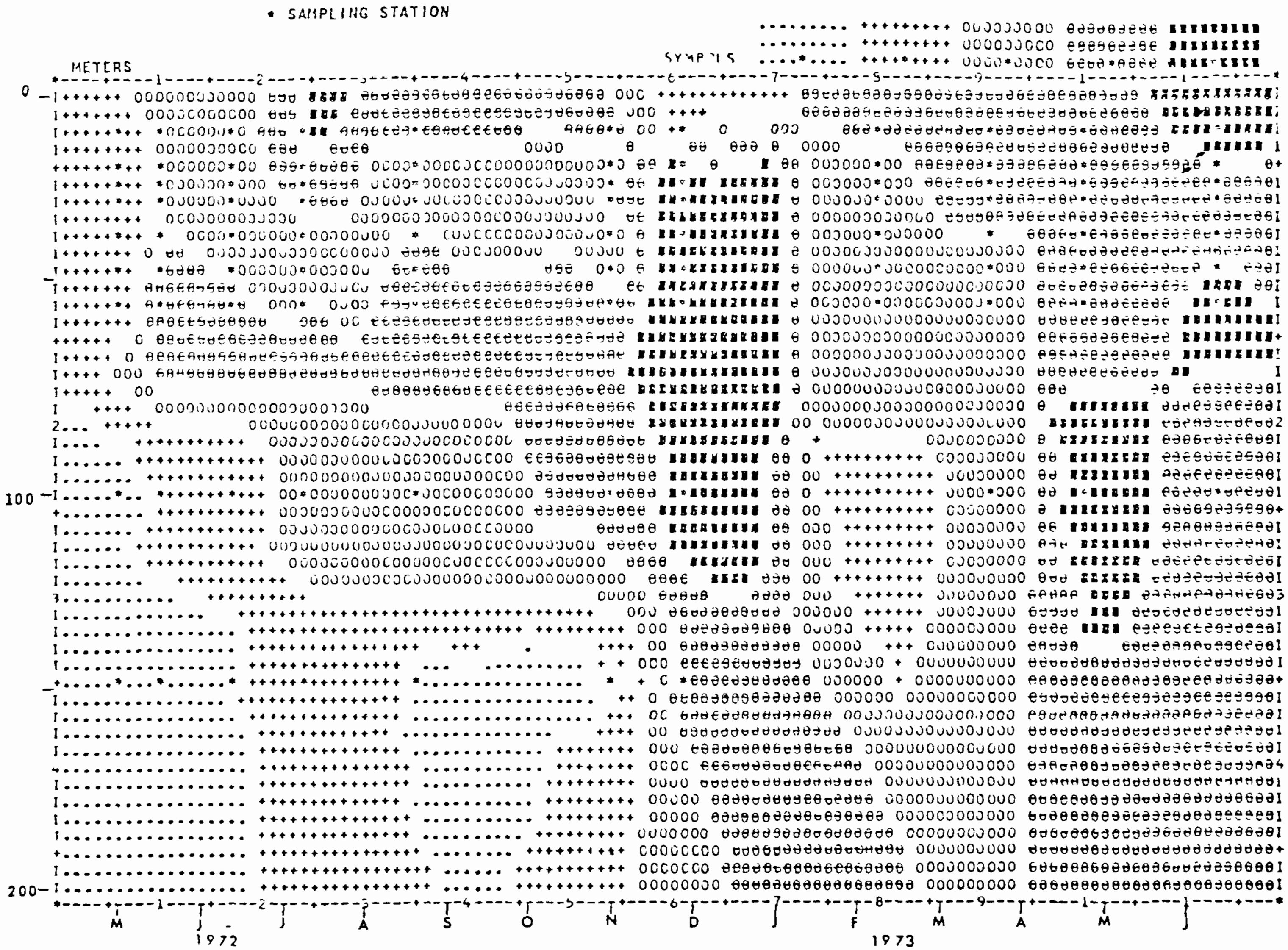


Figure 4.4c Depth Versus Time Contours of Constant Total Phosphate

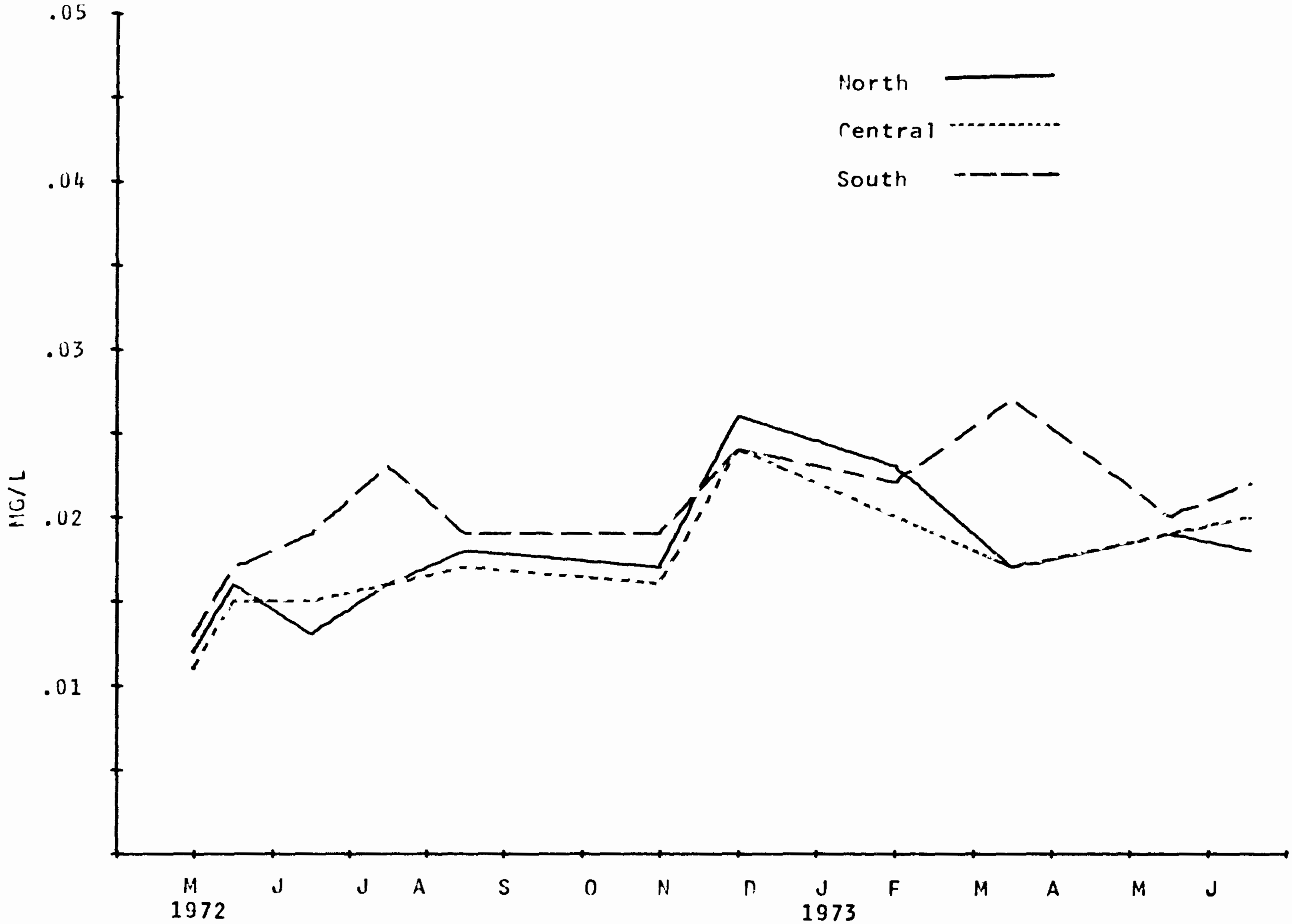


Figure 4.4d North-south variation of total phosphate

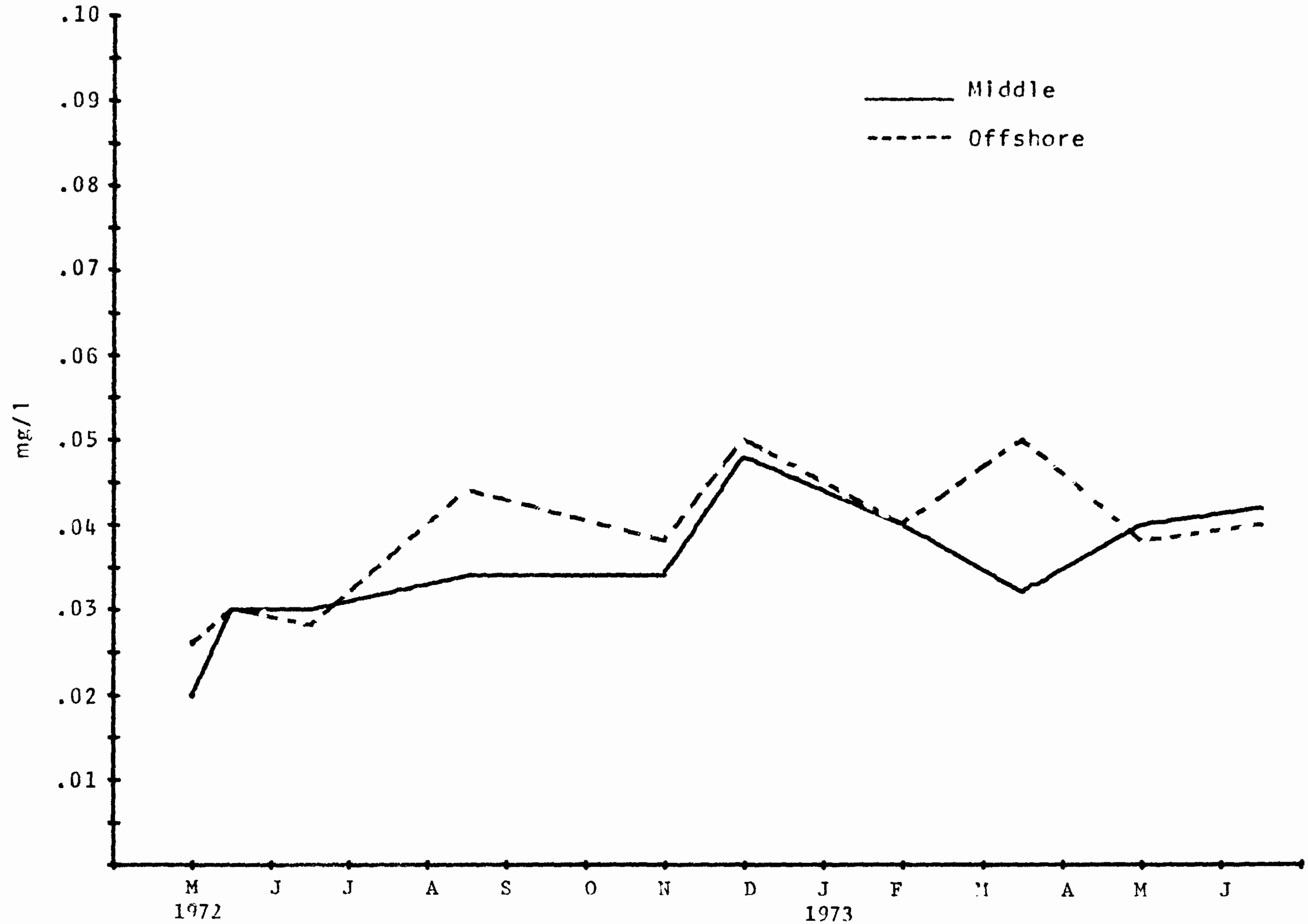


Figure 4.4e Middle Lake-Offshore Variation of Mean Total Phosphate Concentration

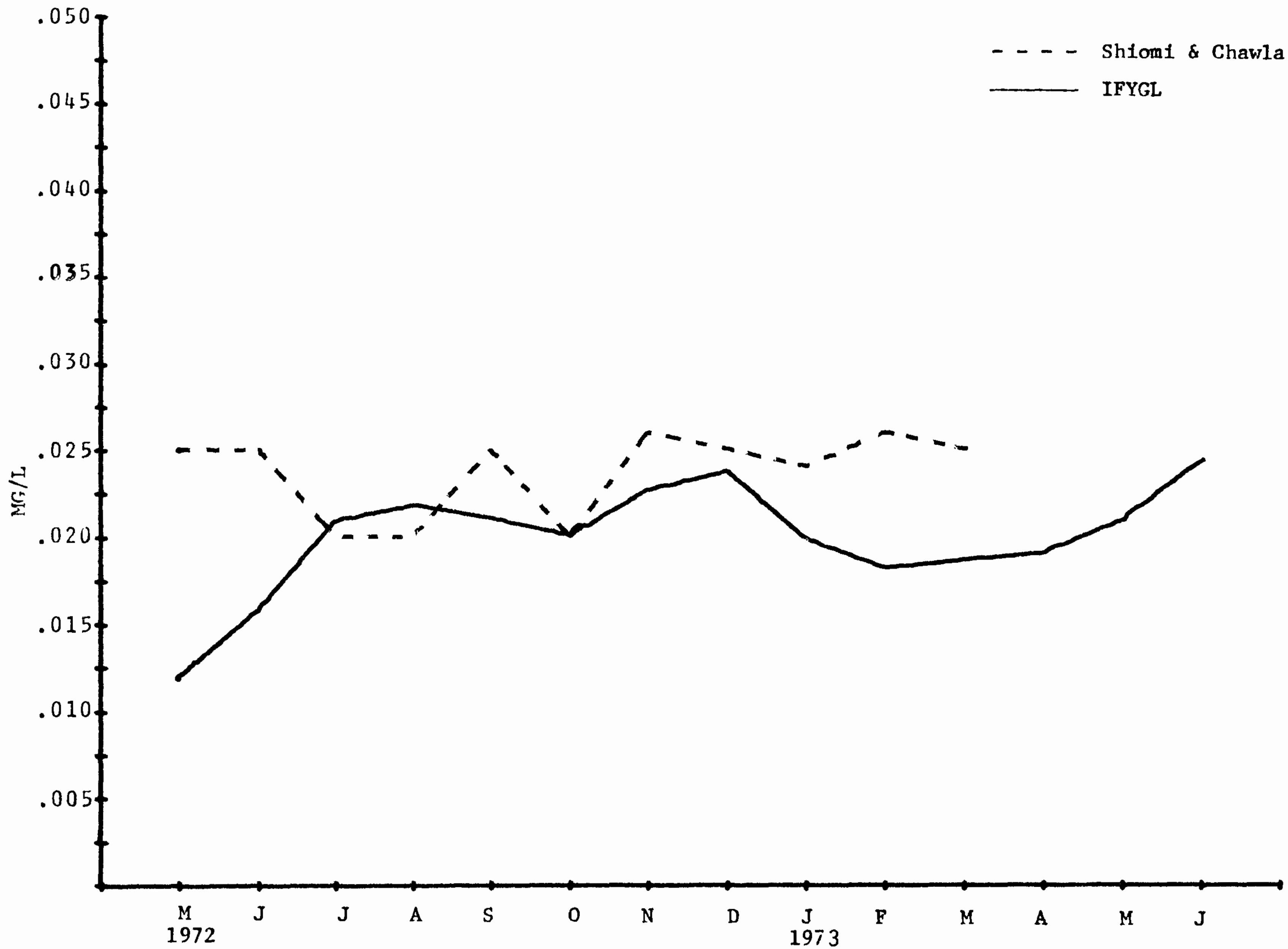


Figure 4.4f Mean surface variation of Total Phosphate concentration during the field year.

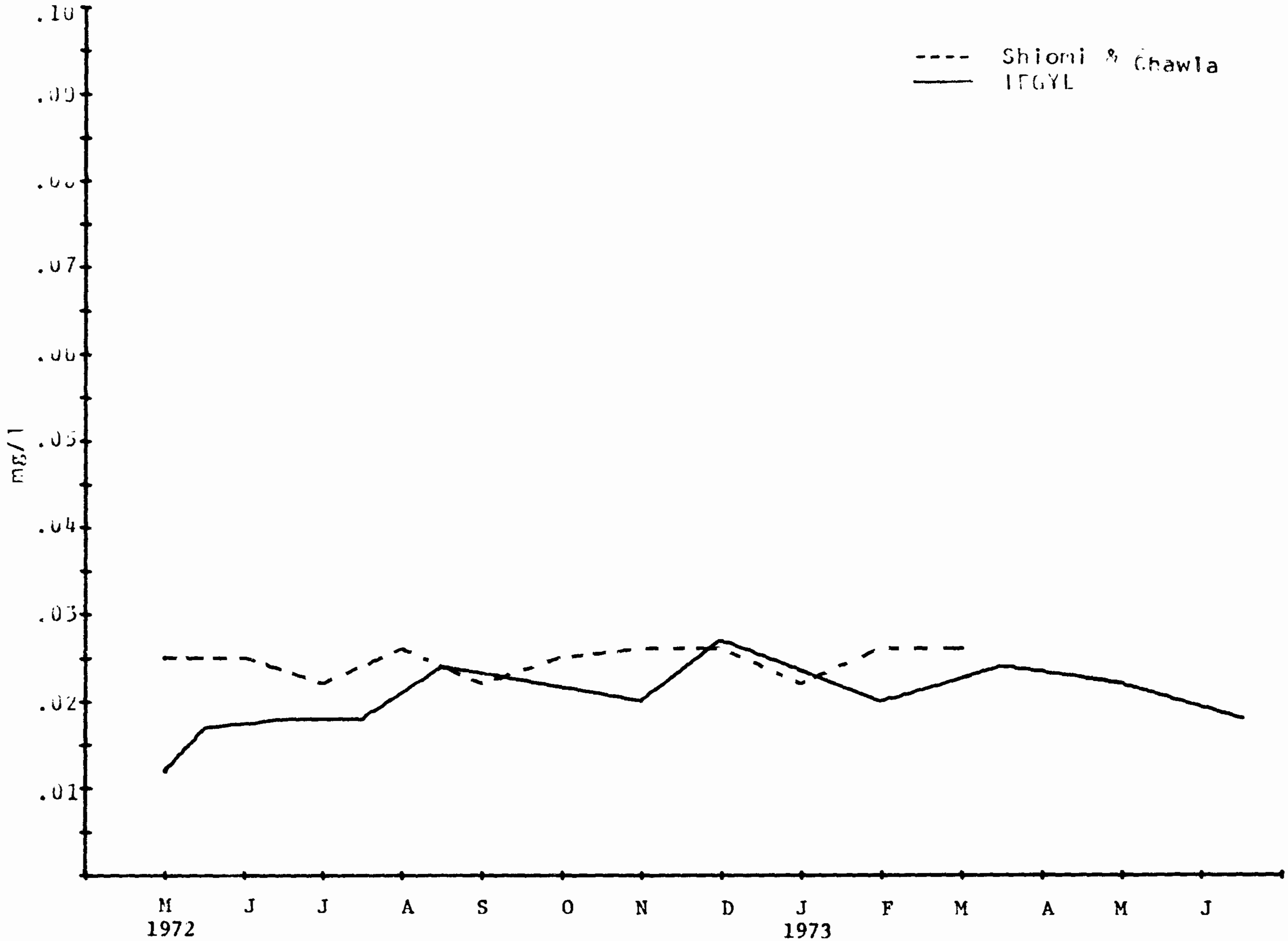


Figure 4.4g Mean Bottom Variations of Total Phosphate Concentration During the Field Year

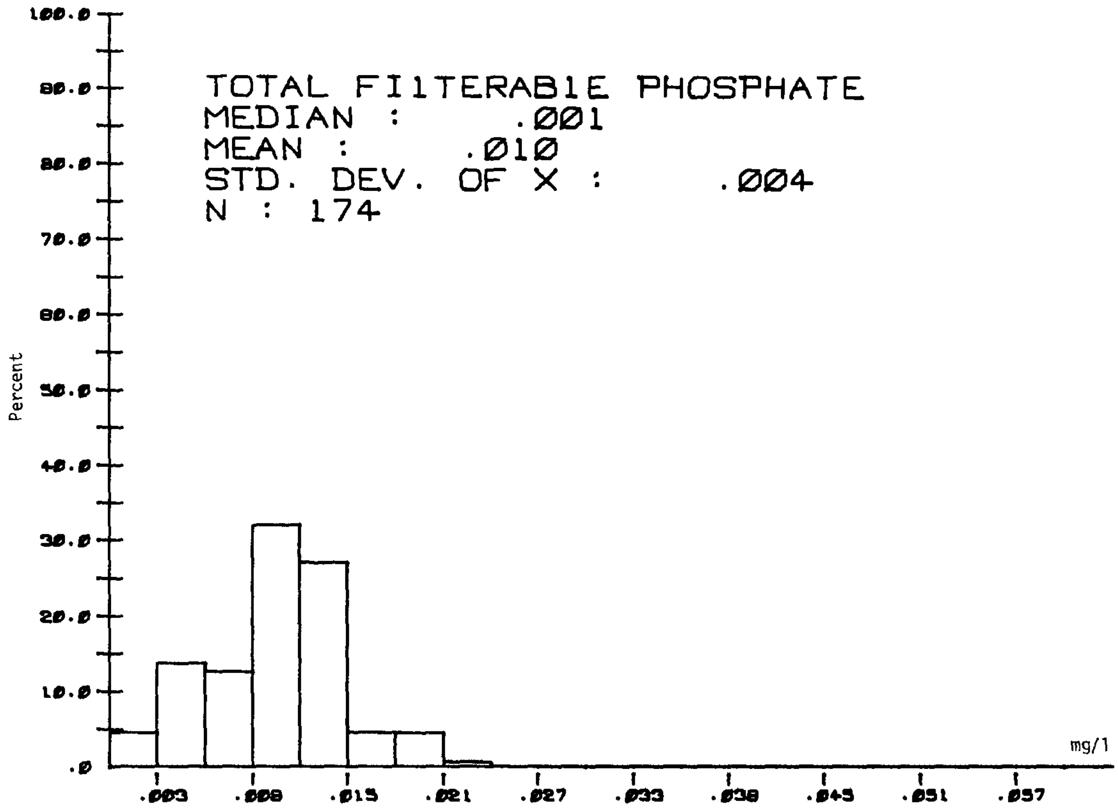


Figure 4.5a Histograms for Total Filterable Phosphate
Cruise 1

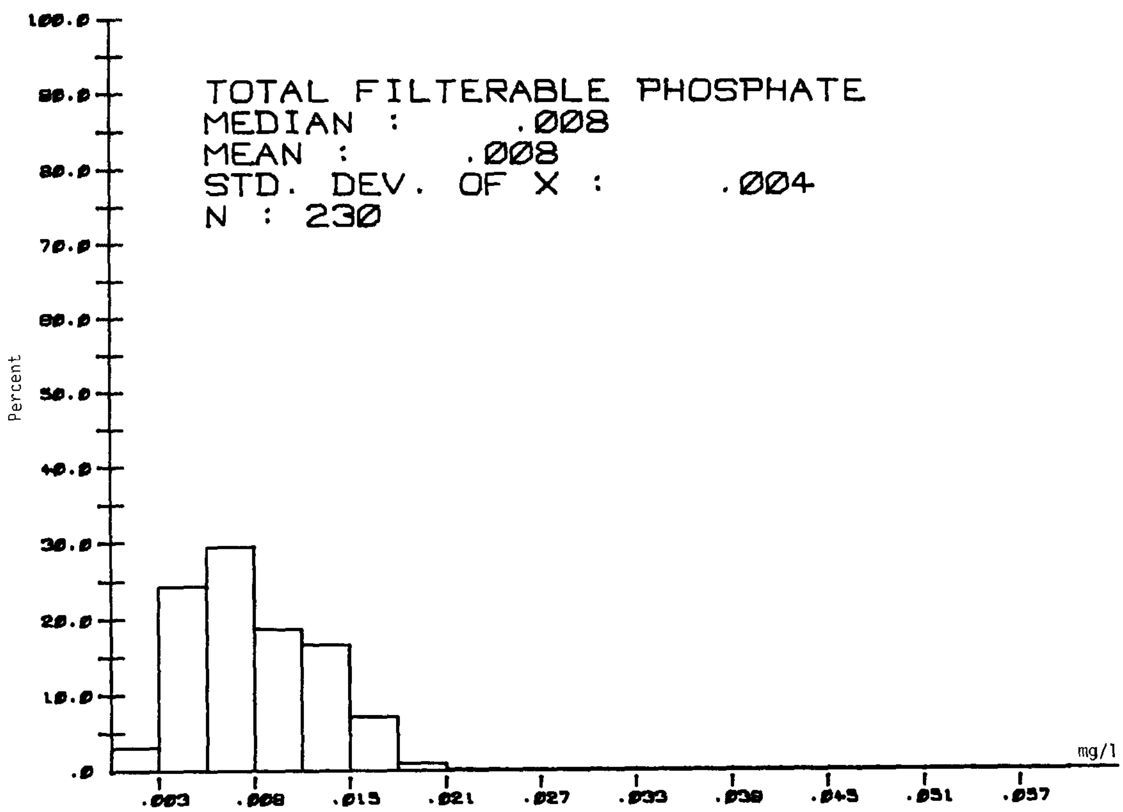


Figure 4.5a Histograms for Total Filterable Phosphate
Cruise 2

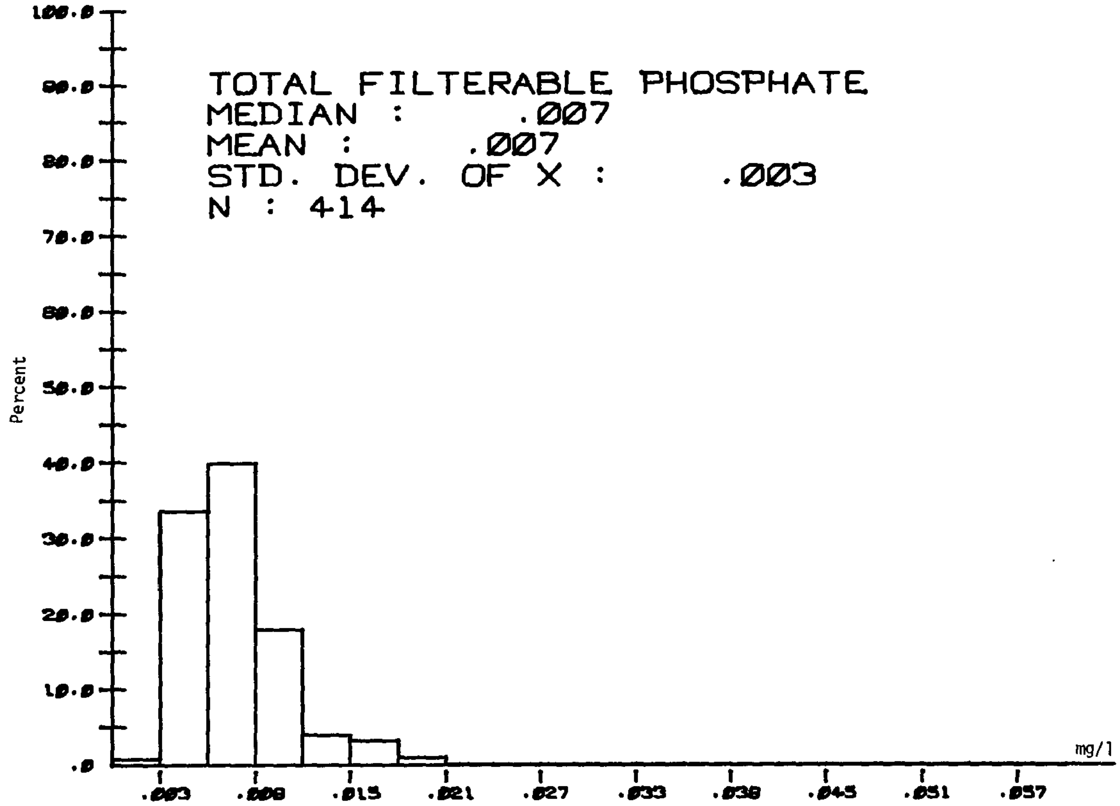


Figure 4.5a Histograms for Total Filterable Phosphate - Cruise 3

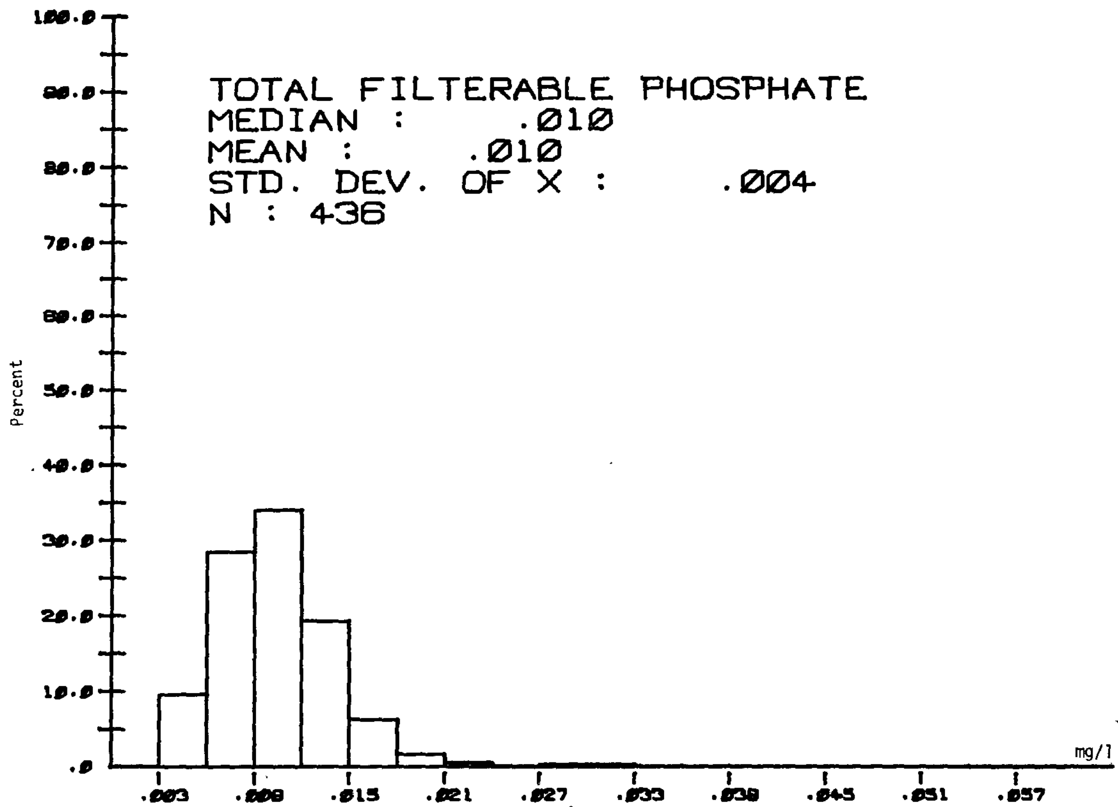


Figure 4.5a Histograms for Total Filterable Phosphate - Cruise 4

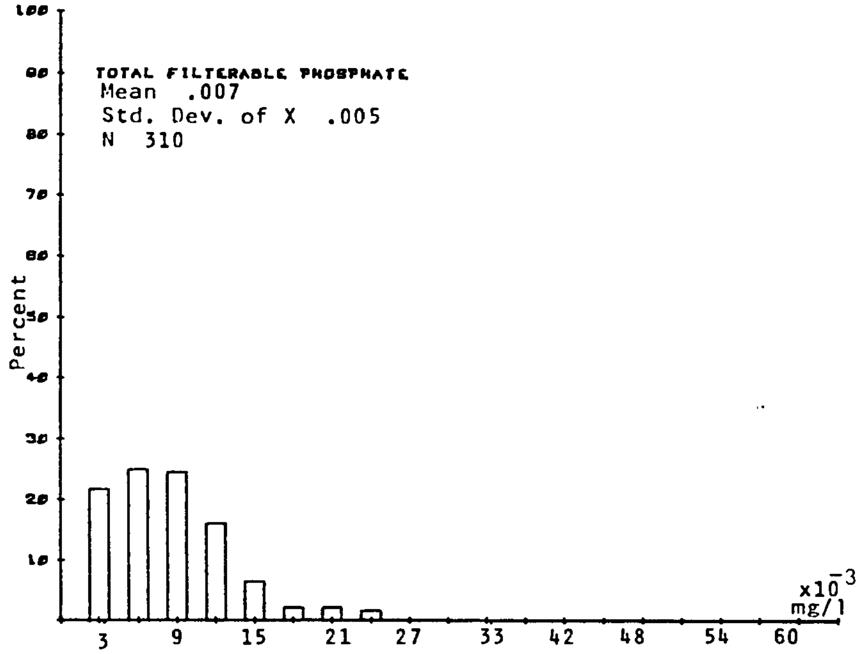


Figure 4.5a Histograms for Total Filterable Phosphate - Cruise 5

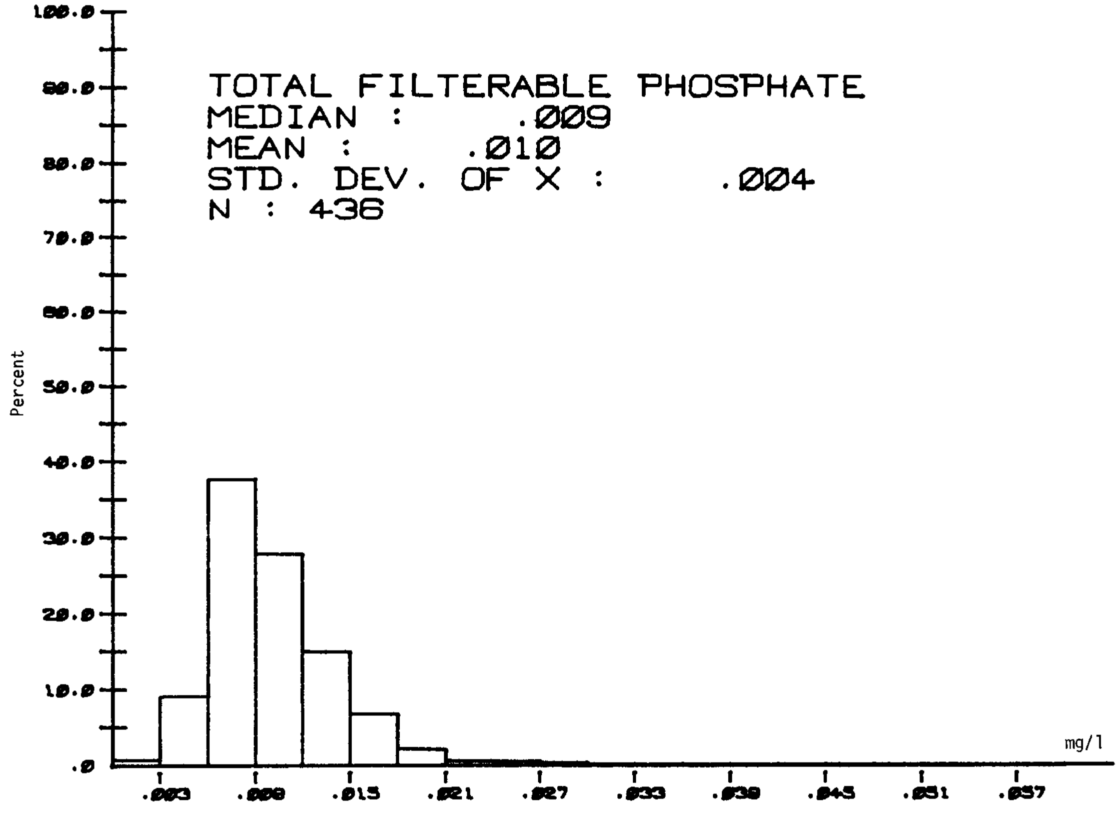


Figure 4.5a Histograms for Total Filterable Phosphate - Cruise 6

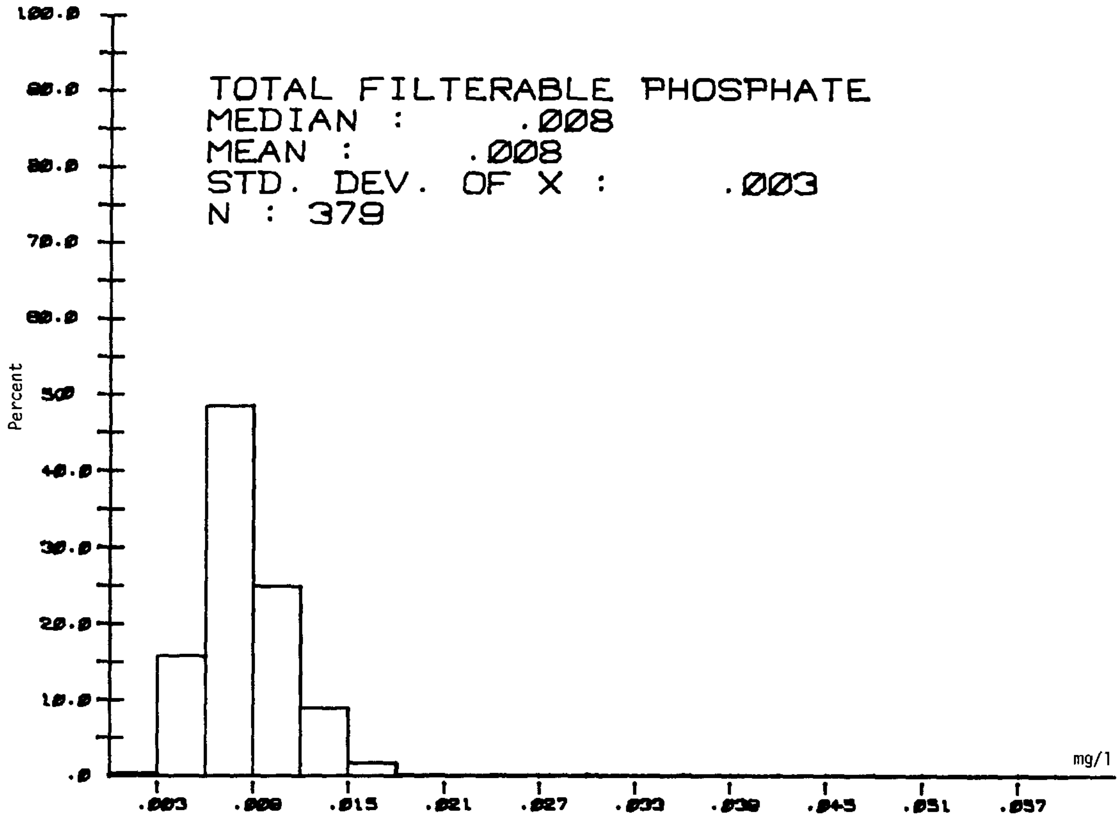


Figure 4.5a Histograms for Total Filterable Phosphate - Cruise 7

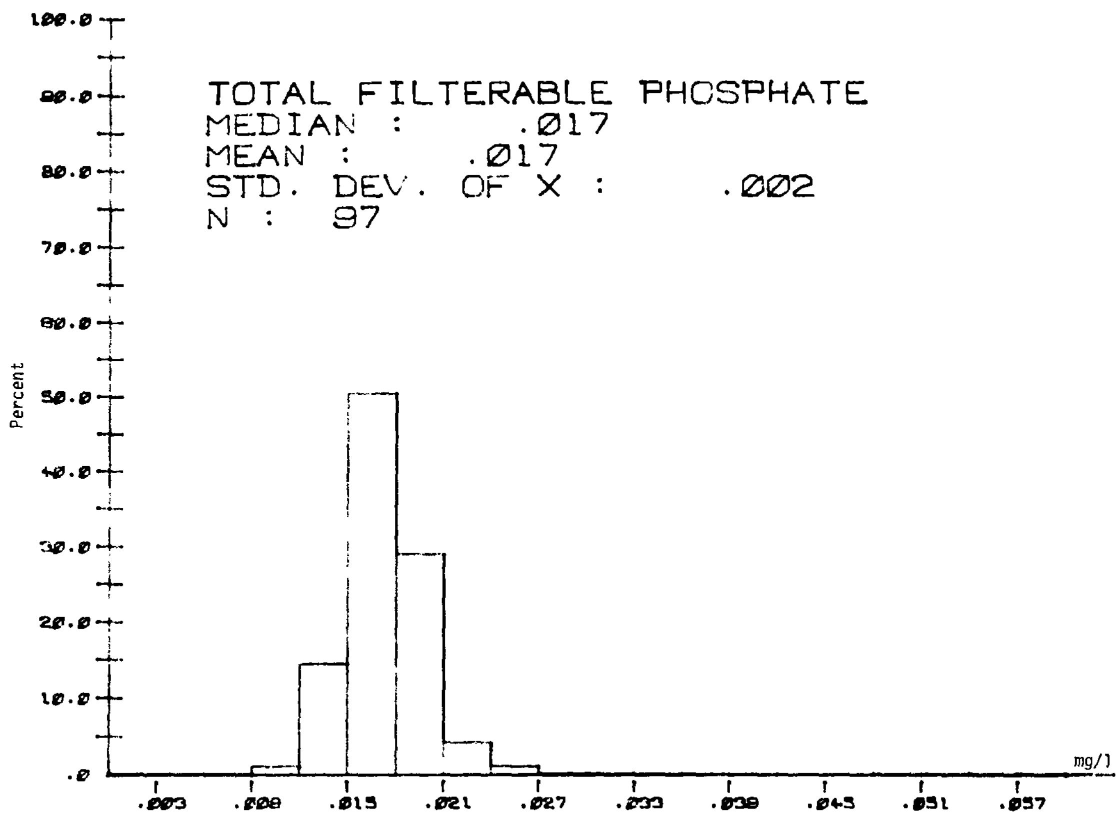


Figure 4.5a Histograms for Total Filterable Phosphate - Cruise 8

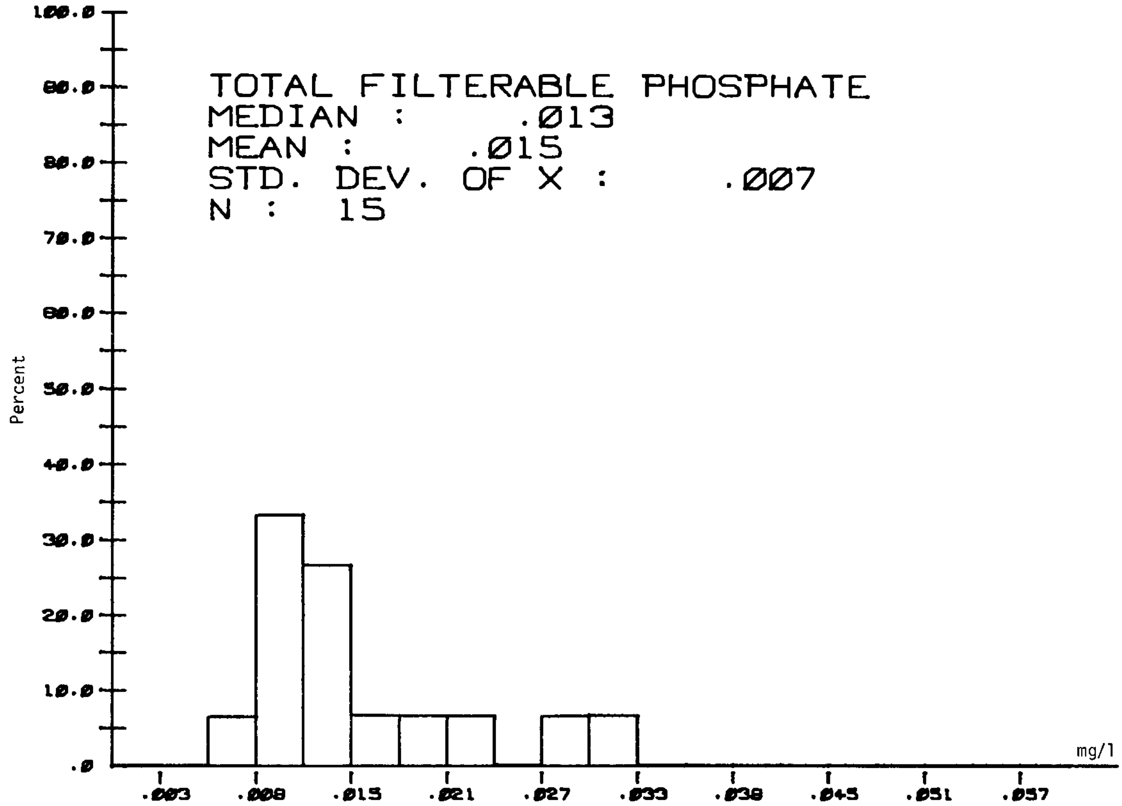


Figure 4.5a Histograms for Total Filterable Phosphate - Cruise 9

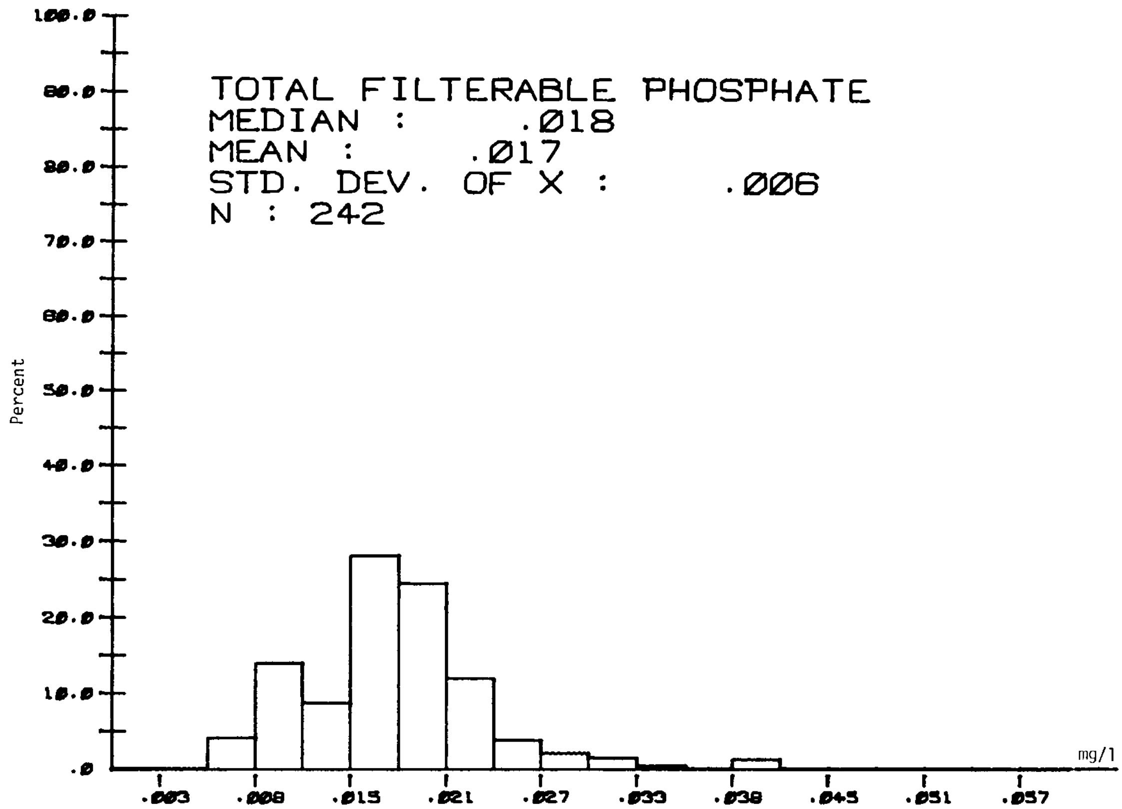


Figure 4.5a Histograms for Total Filterable Phosphate - Cruise 10

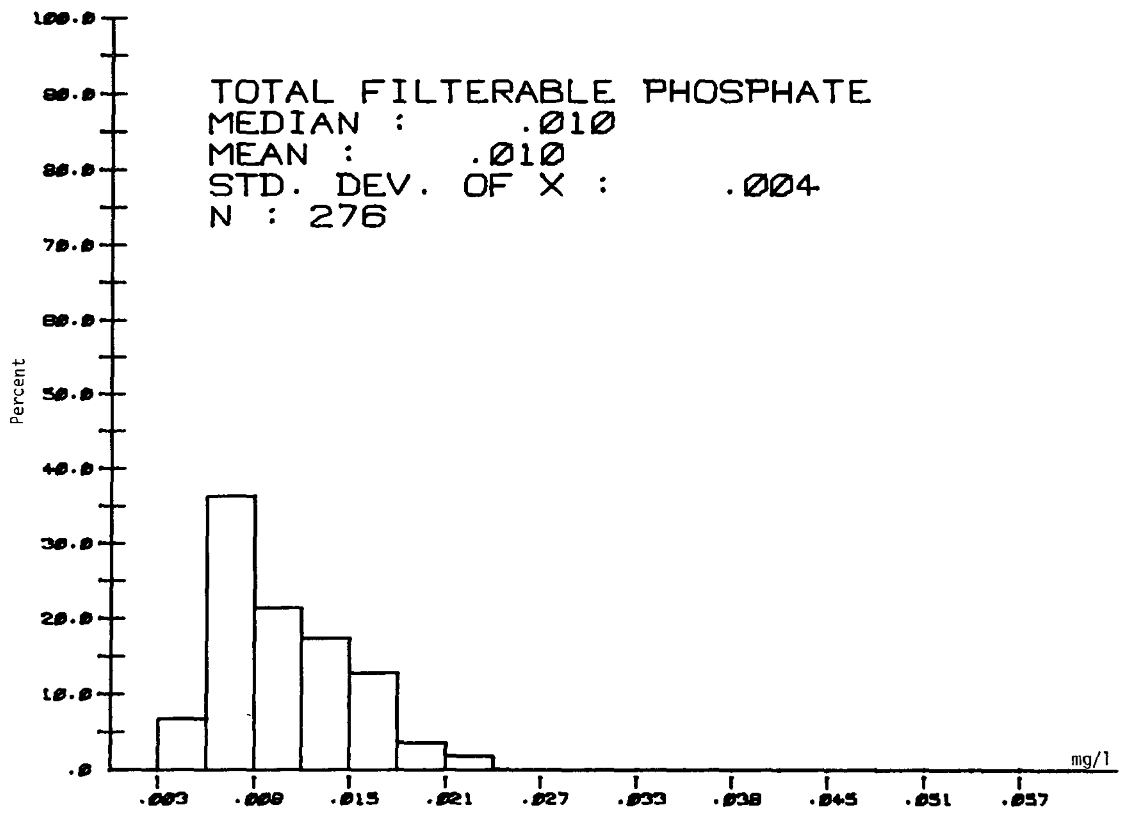


Figure 4.5a Histograms for Total Filterable Phosphate - Cruise 11

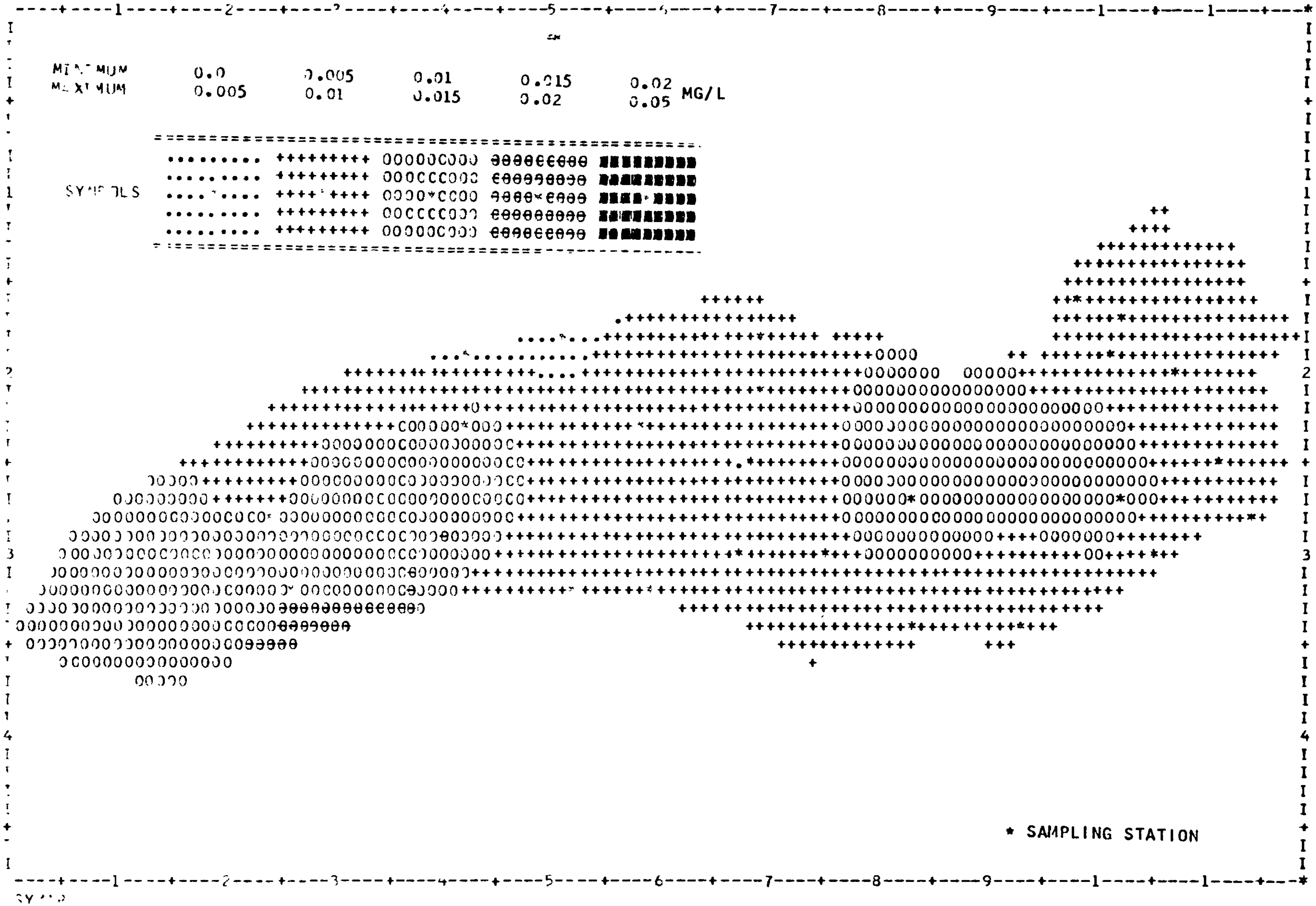


Figure 4.5b Contours of Constant Surface Total Filterable Phosphate

CRUISE NUMBER 2: MAY 15, 1972 TO MAY 19, 1972

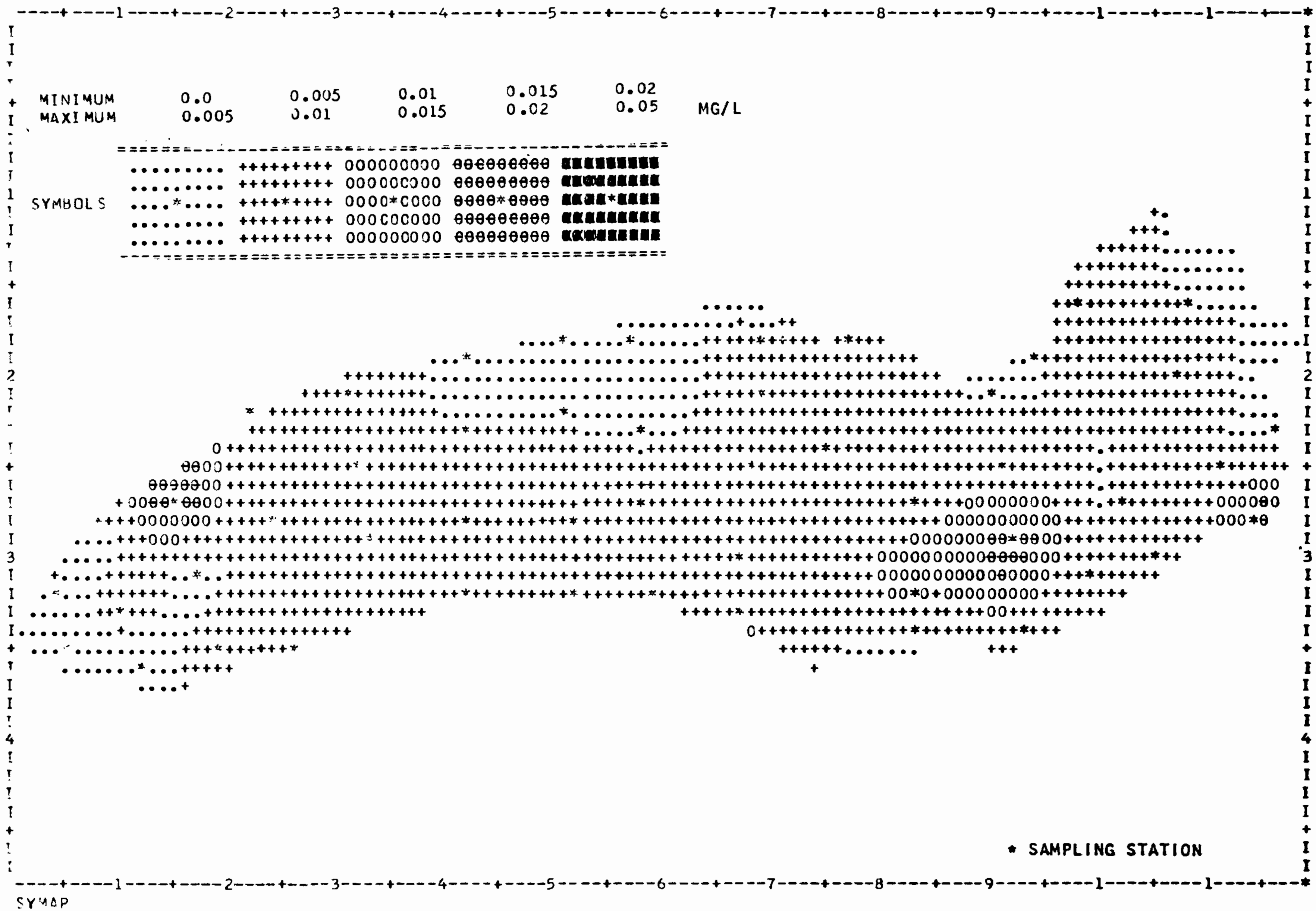


Figure 4.5b Contours of Constant Surface Total Filterable Phosphate

CRUISE NUMBER 3: JUNE 12, 1972 TO JUNE 16, 1972

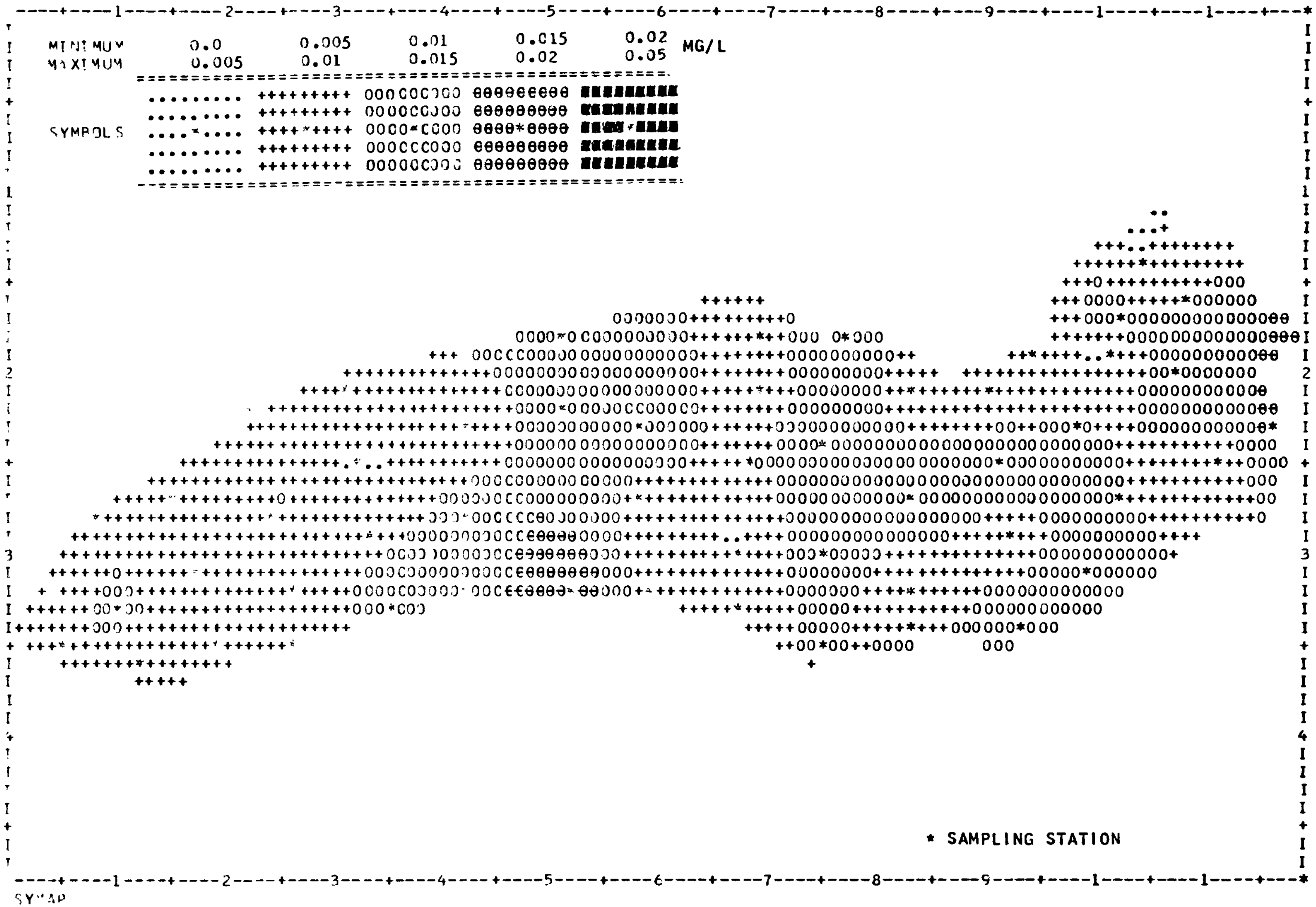


Figure 4.5b Contours of Constant Surface Total Filterable Phosphate

CRUISE NUMBER 4: JULY 10, 1972 TO JULY 14, 1972

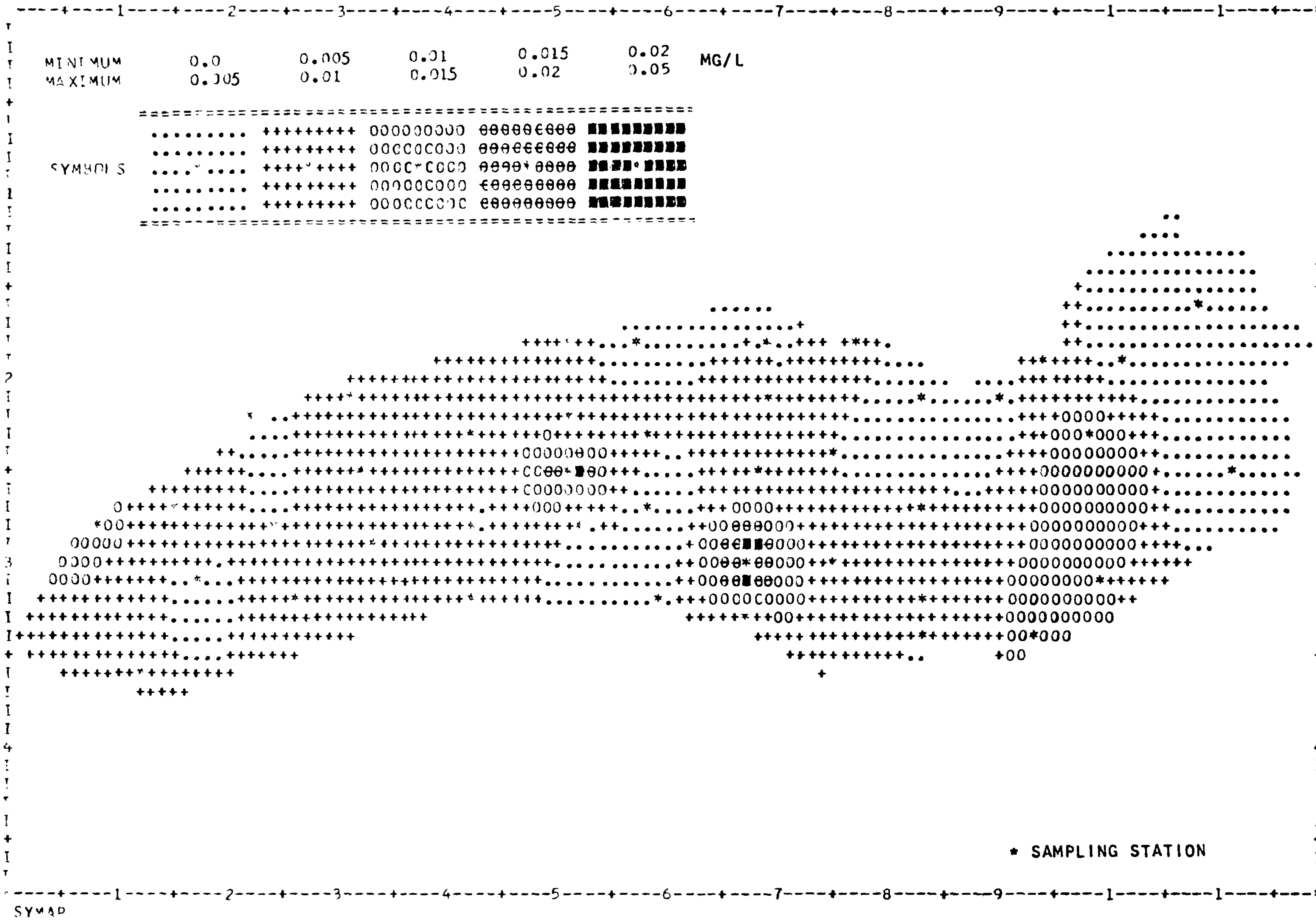


Figure 4.5b Contours of Constant Surface Total Filterable Phosphate

CRUISE NUMBER 5: AUGUST 21, 1972 TO AUGUST 25, 1972

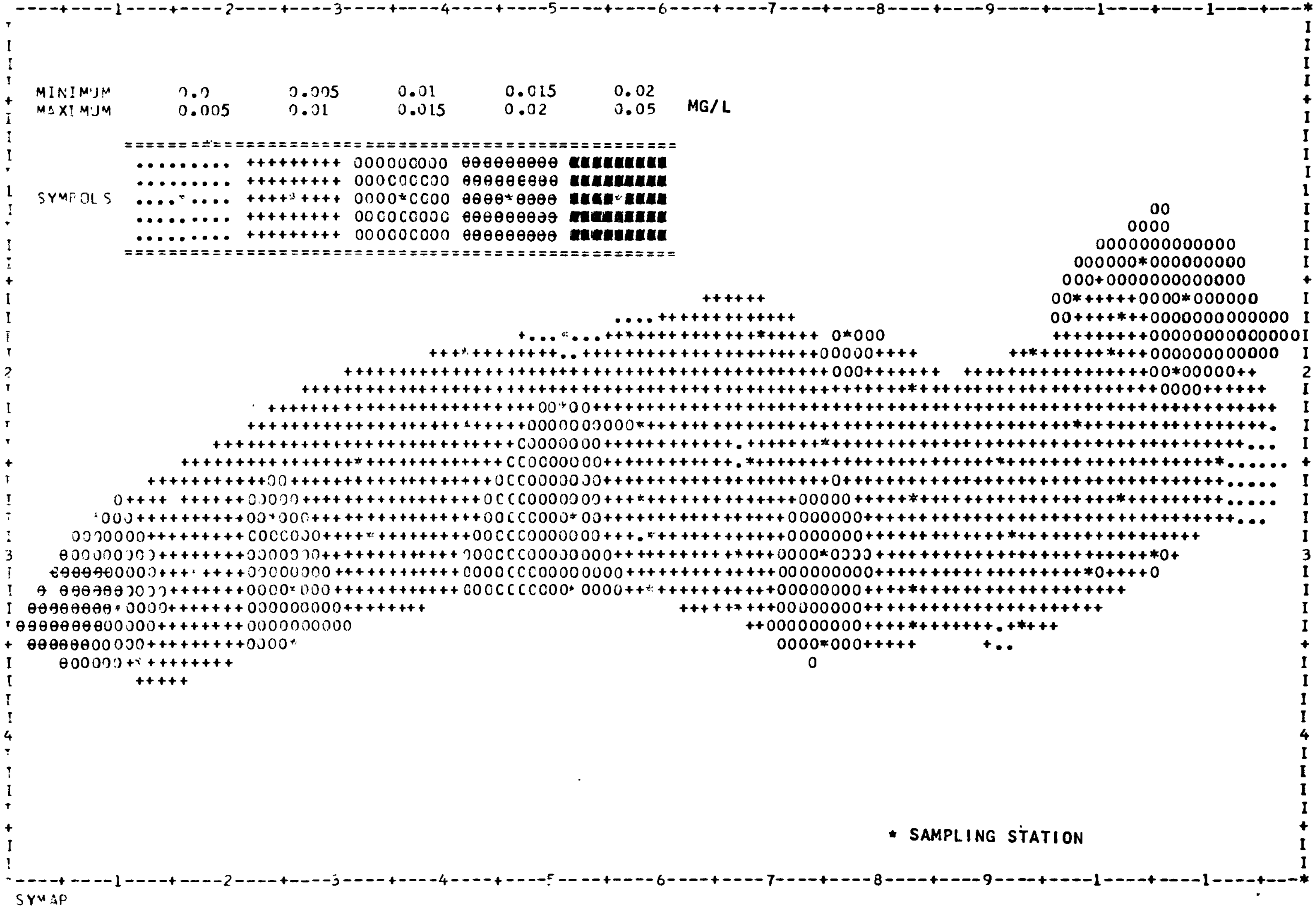


Figure 4.5b Contours of Constant Surface Total Filterable Phosphate

CRUISE NUMBER 6: OCTOBER 30, 1972 TO NOVEMBER 3, 1972

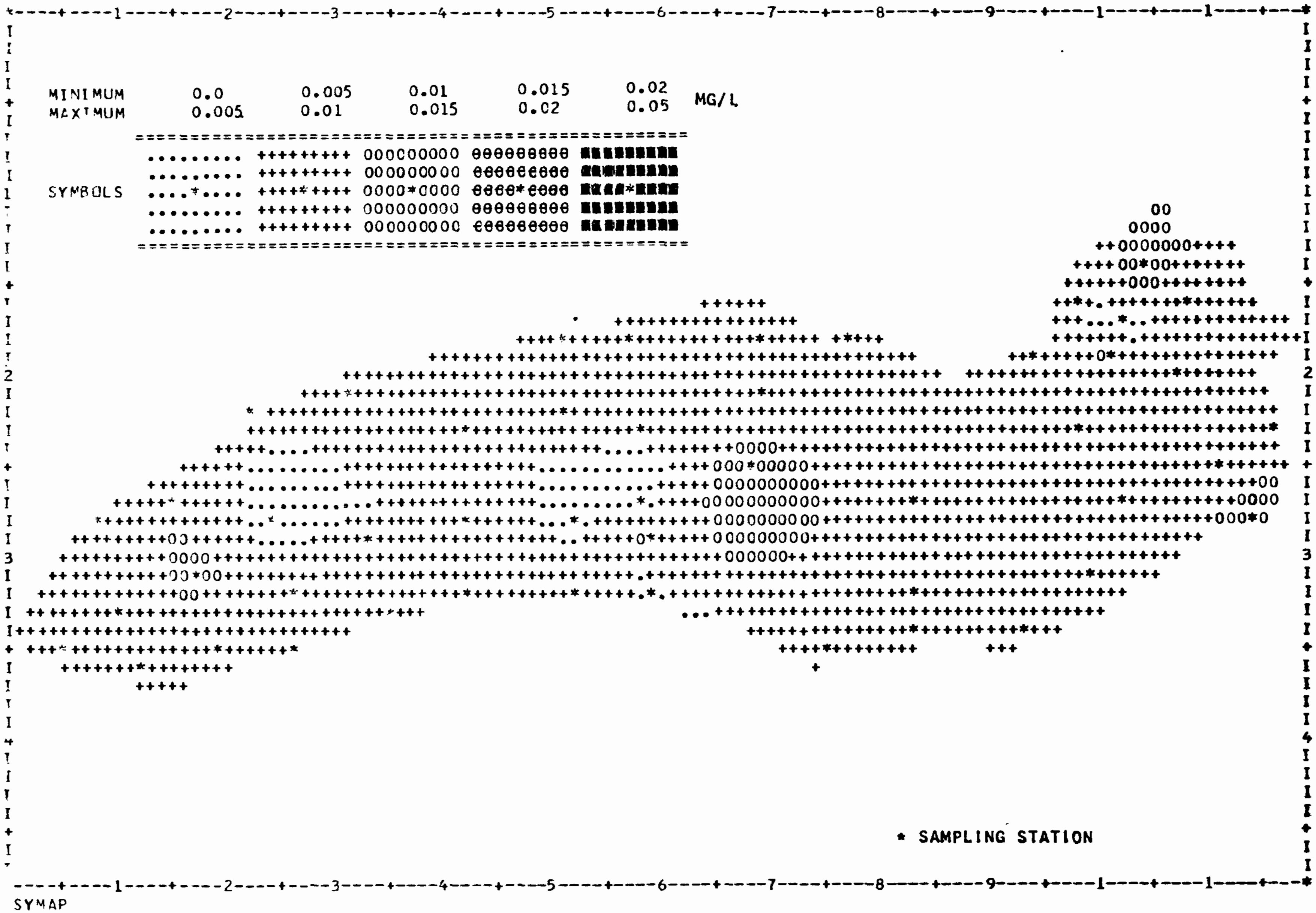


Figure 4.5b Contours of Constant Surface Total Filterable Phosphate

CRUISE NUMBER 7: NOVEMBER 27, 1972 TO DECEMBER 2, 1972

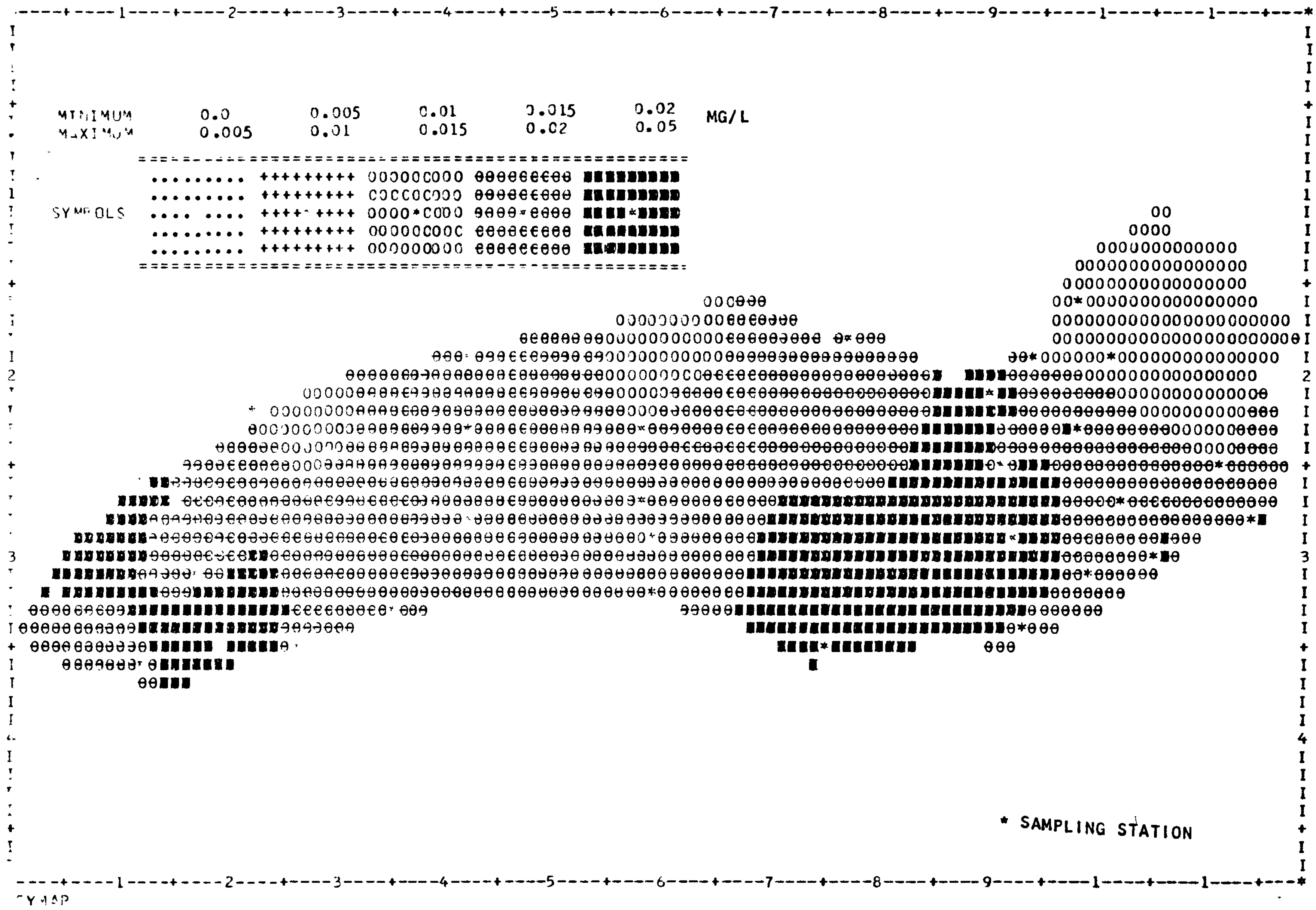


Figure 4.5b Contours of Constant Surface Total Filterable Phosphate

FEBRUARY 5, 1973 TO FEBRUARY 9, 1973

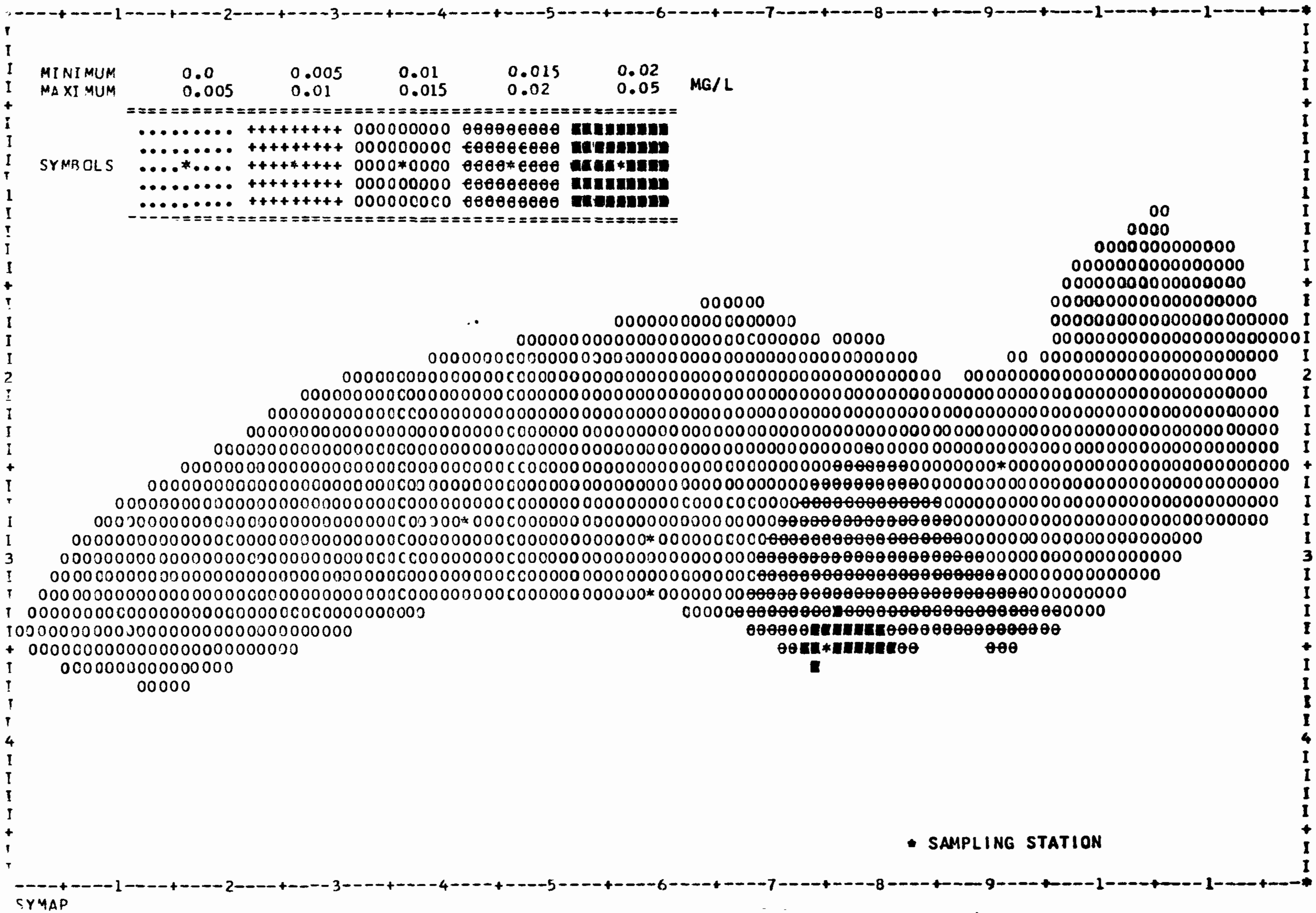


Figure 4.5b Contours of Constant Surface Total Filterable Phosphate

CRUISE NUMBER 9: MARCH 18, 1973 TO MARCH 23, 1973

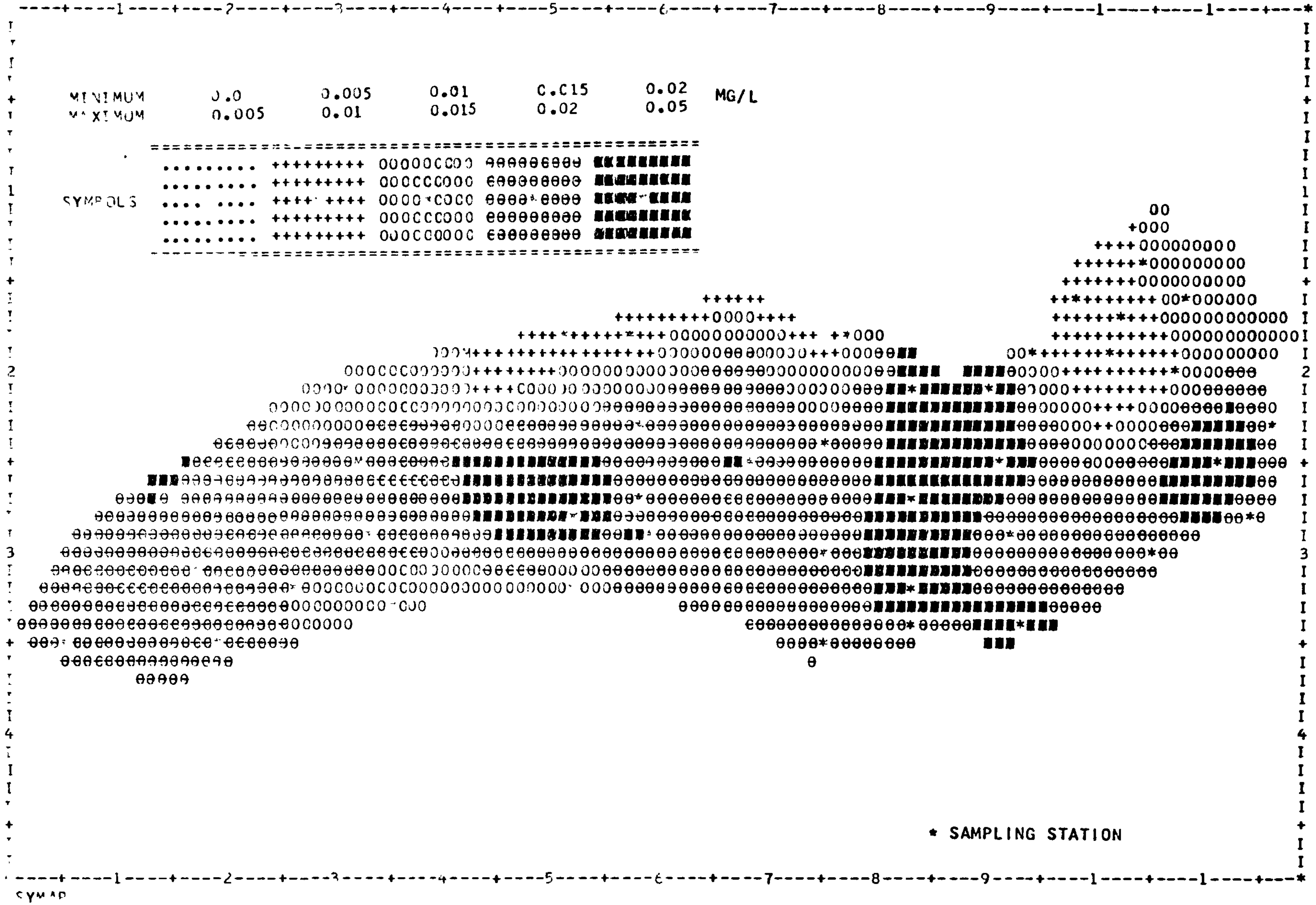


Figure 4.5b Contours of Constant Surface Total Filterable Phosphate

CRUISE NUMBER 10: APRIL 24, 1973 TO APRIL 30, 1973

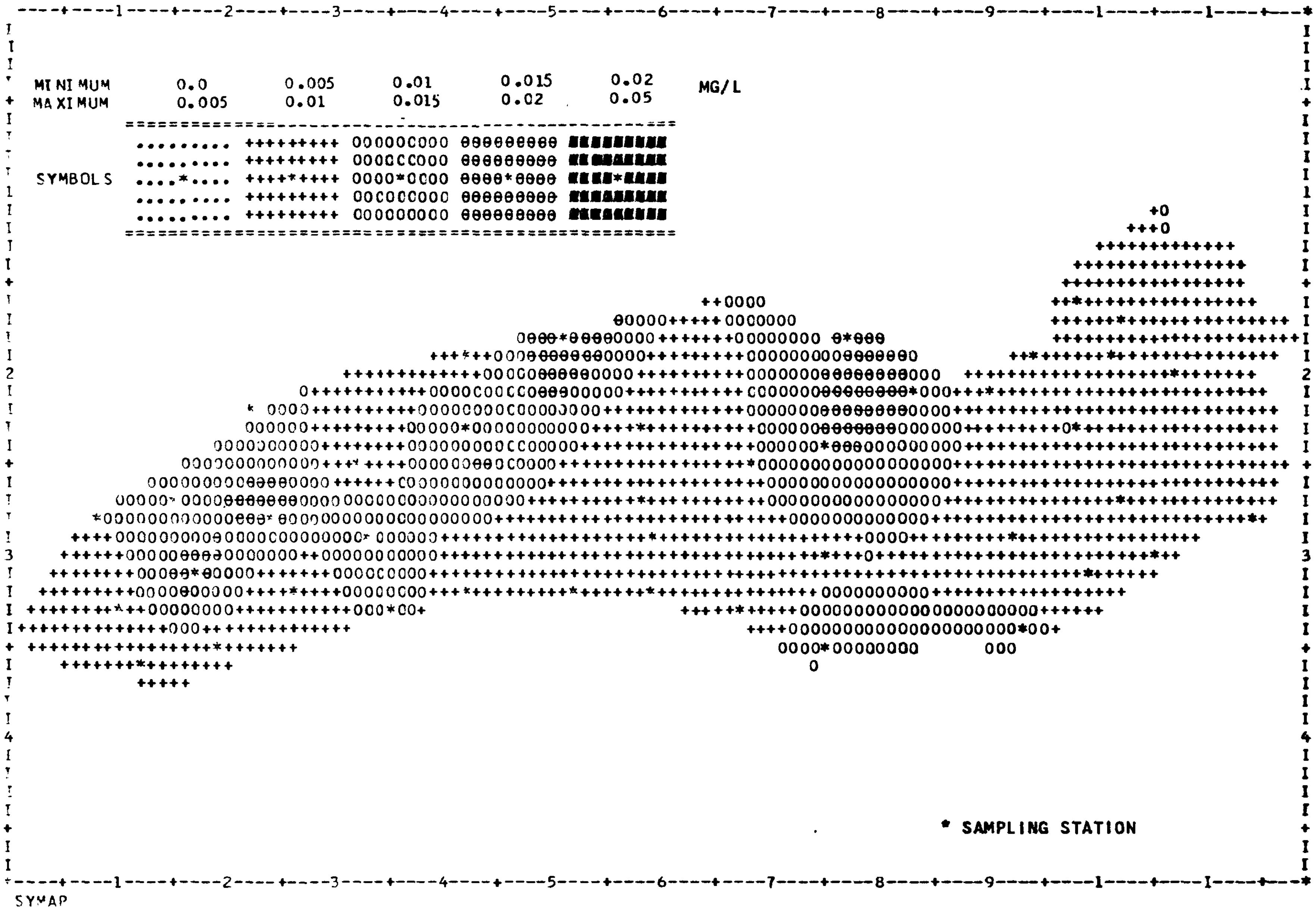


Figure 4.5b Contours of Constant Surface Total Filterable Phosphate

CRUISE NUMBER 11: JUNE 11, 1973 TO JUNE 15, 1973

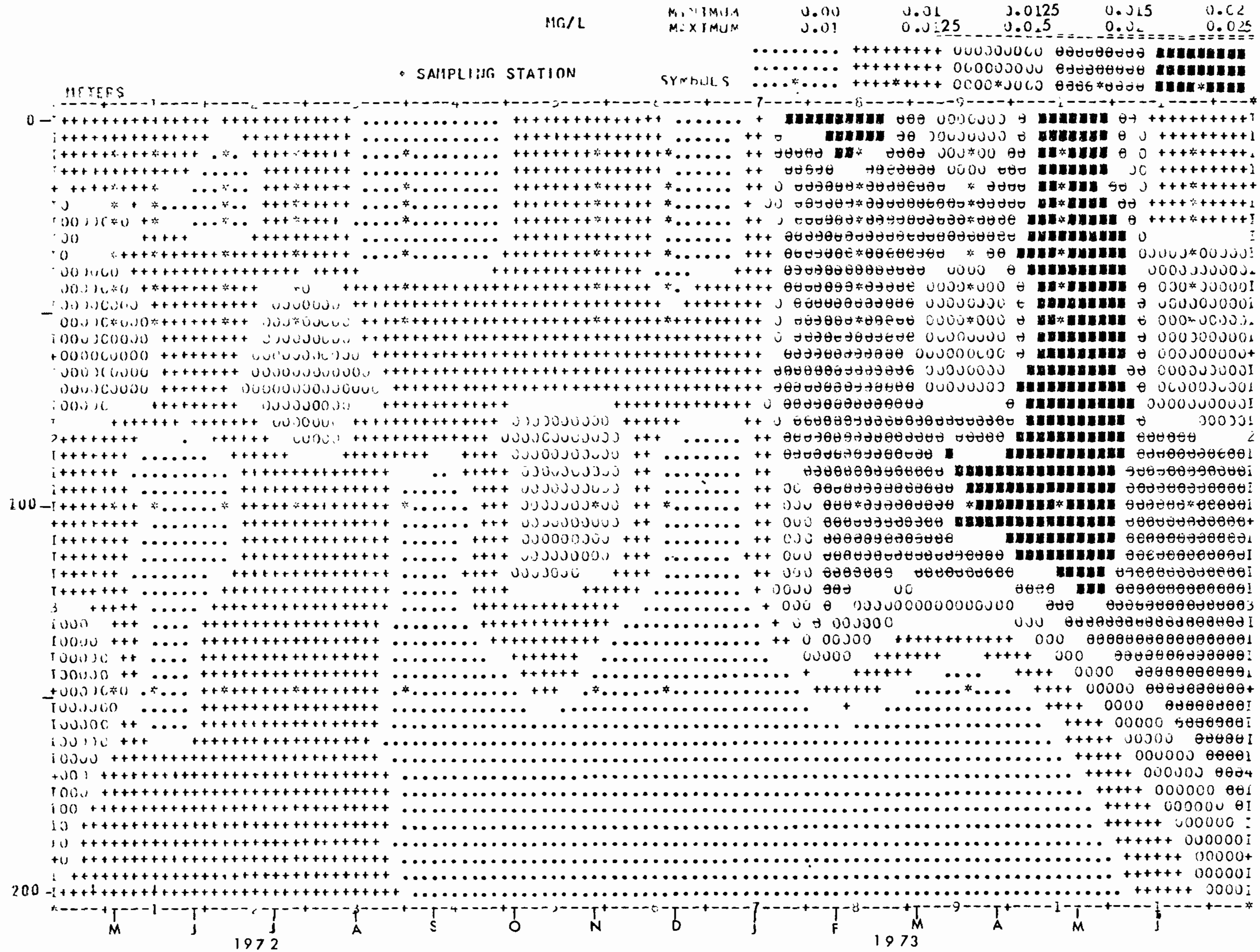


Figure 4.5c Depth Versus Time Contours of Constant Total Filterable Phosphate

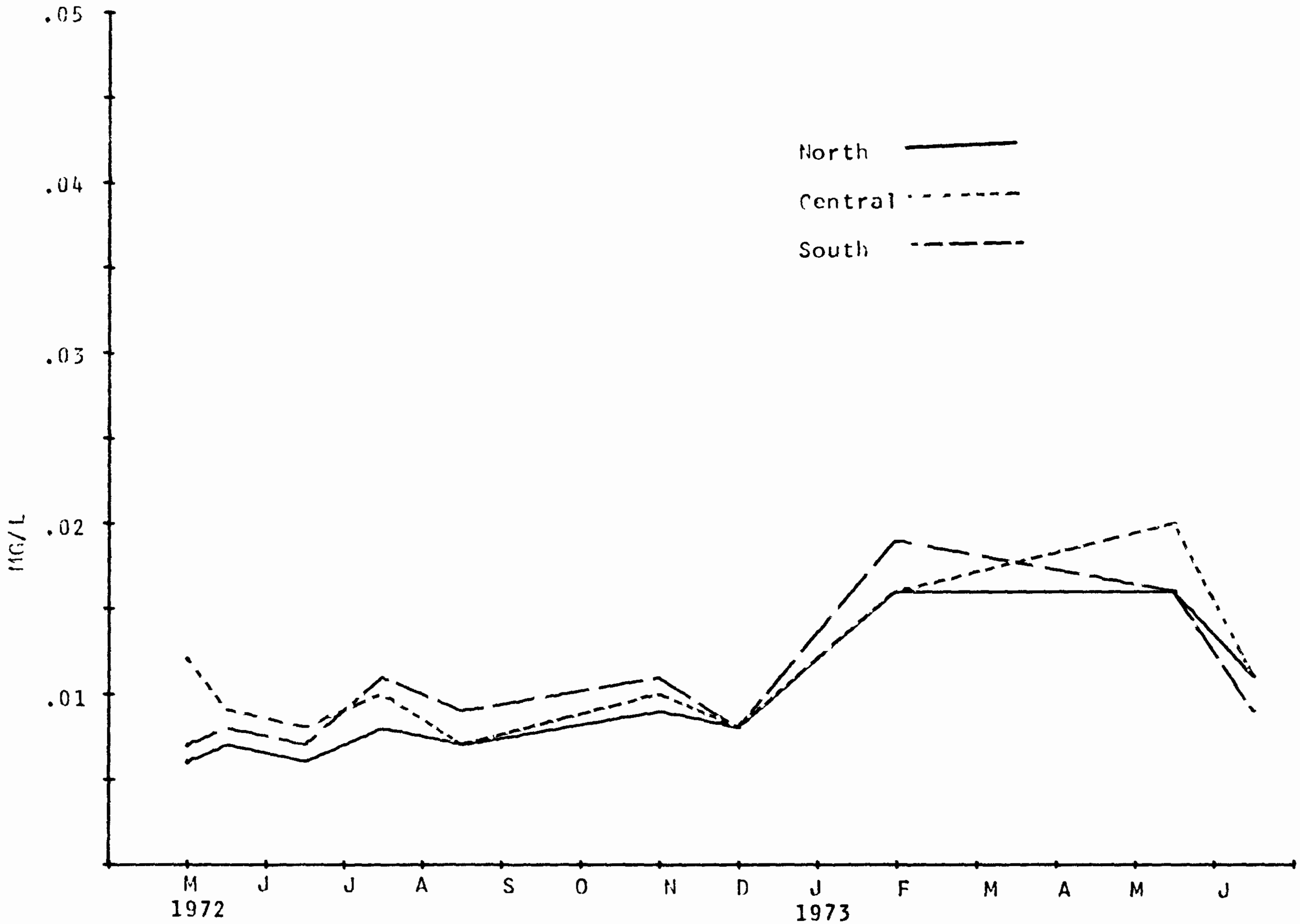


Figure 4.5d Norh-south variation of total filterable phosphate

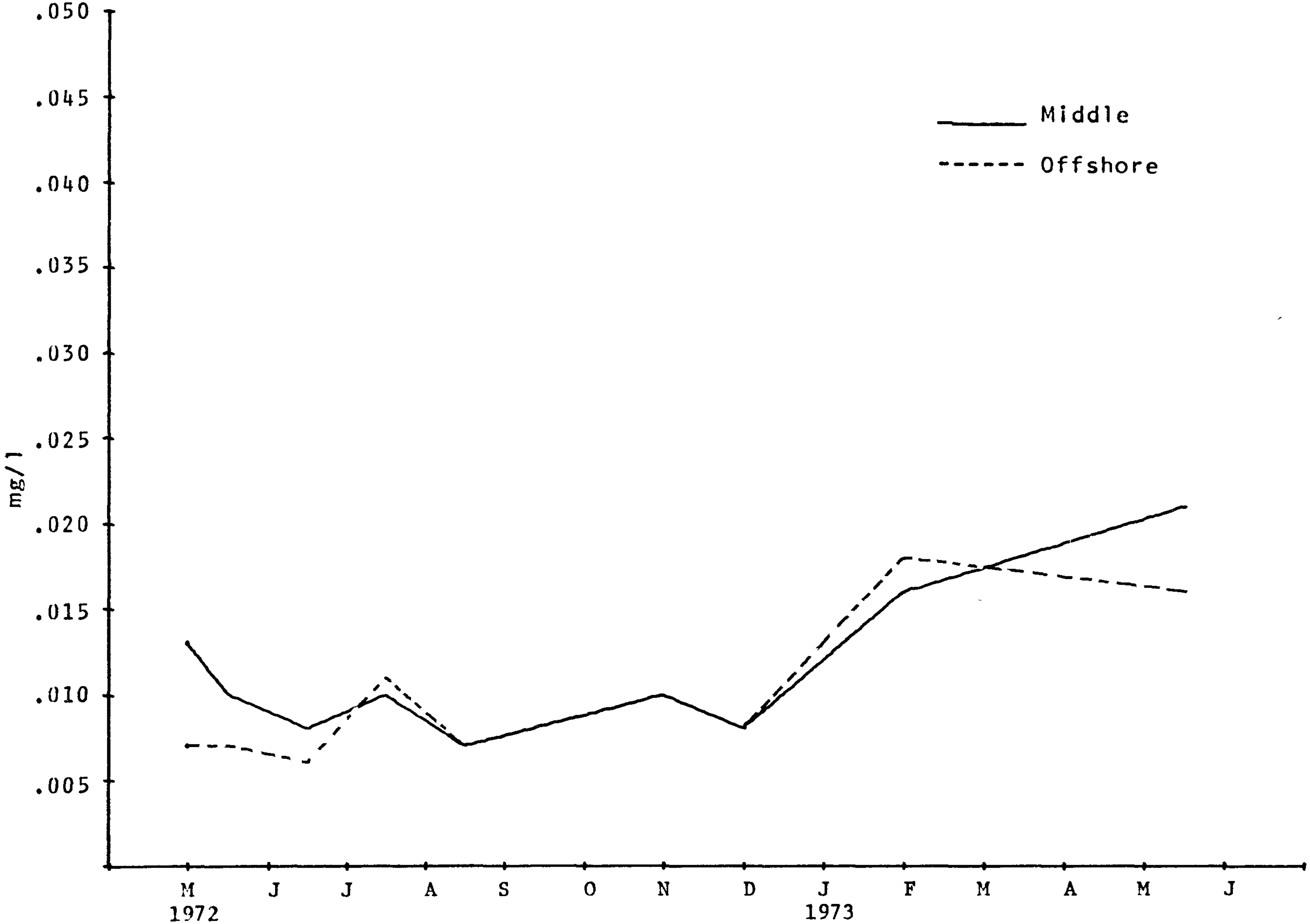


Figure 4.5e Middle Lake-Offshore Variations of Mean Total Filterable Phosphate Concentration

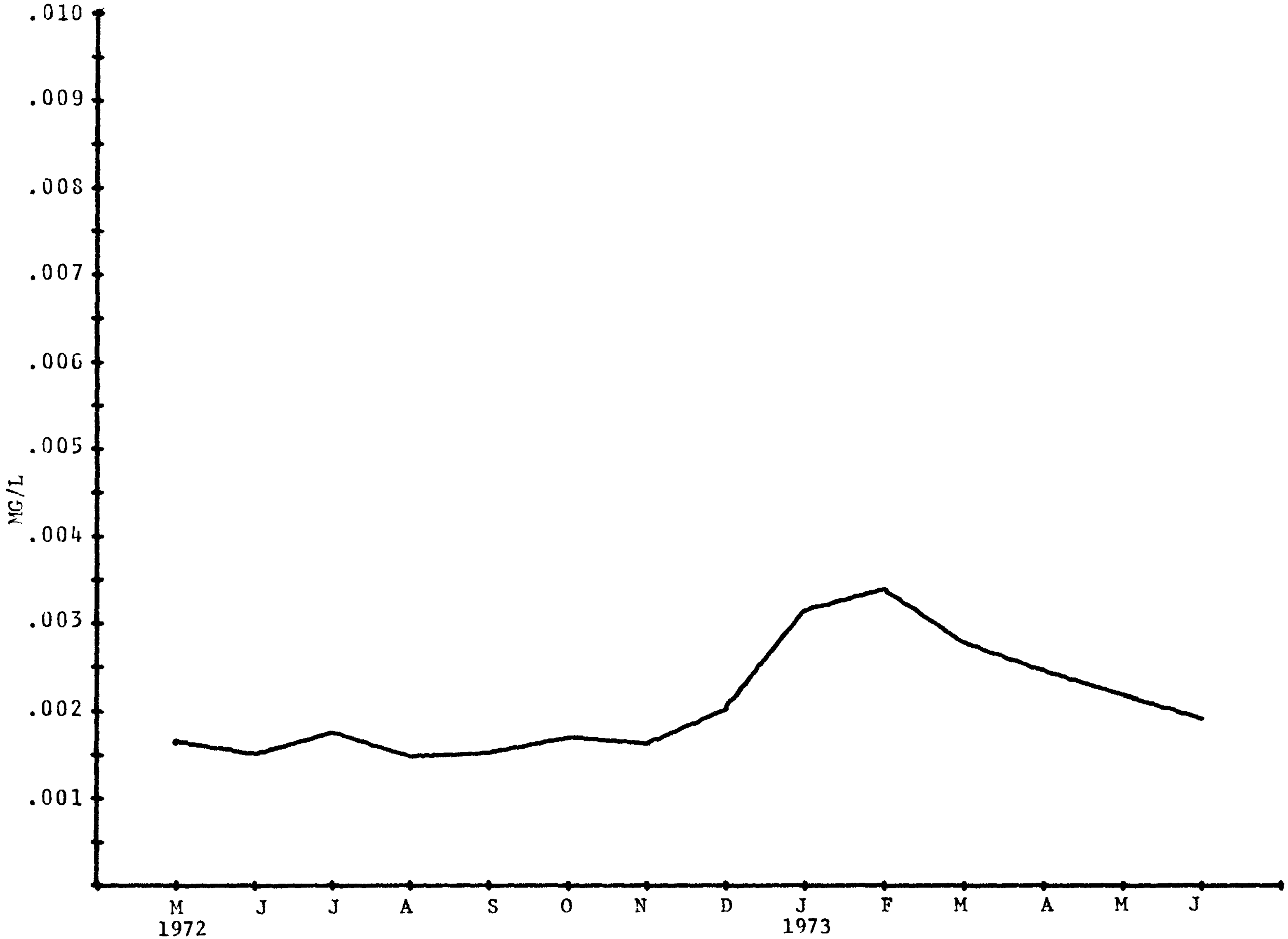


Figure 4.5f Mean surface variation of Total Filterable Phosphate concentration during the field year.

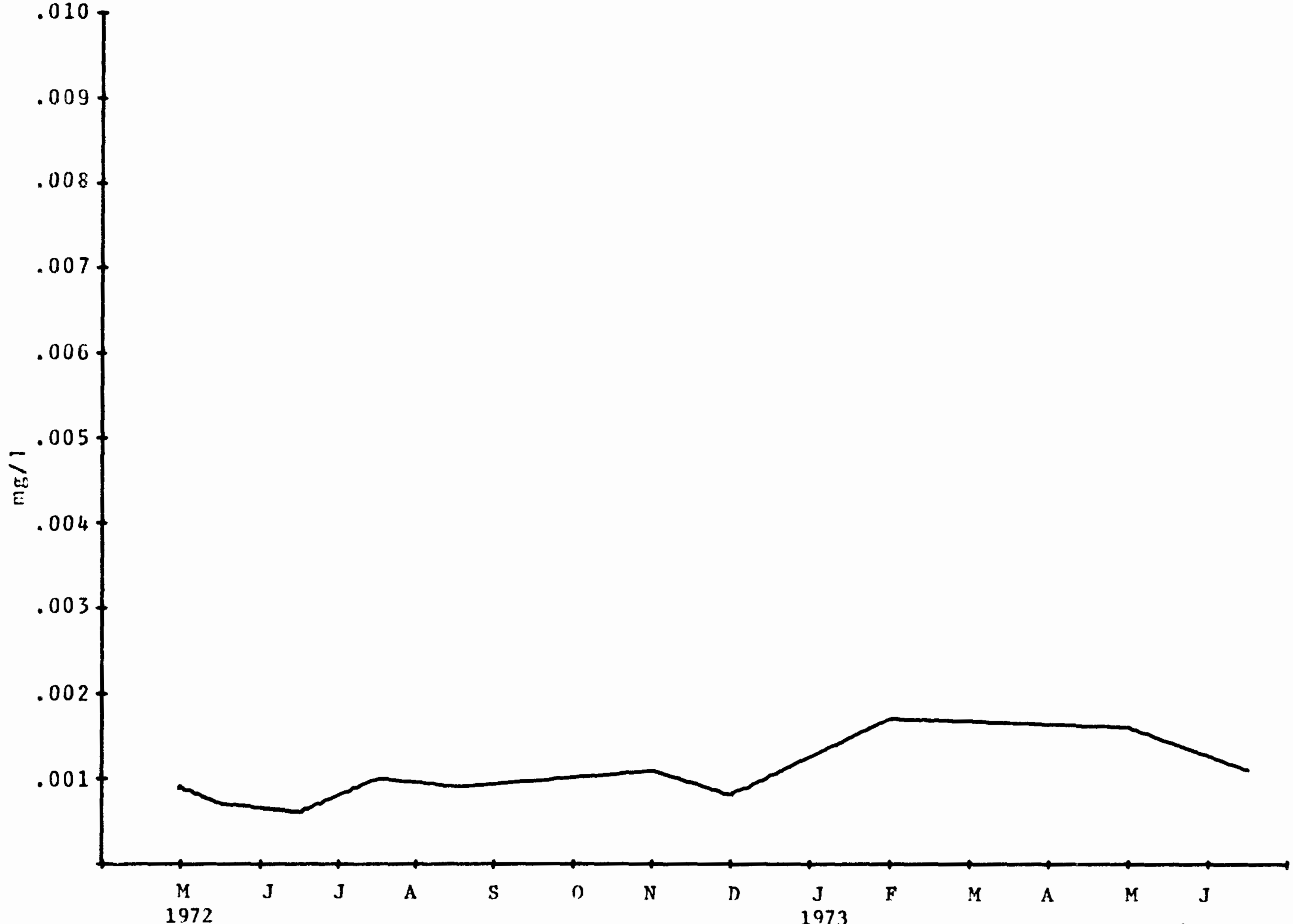


Figure 4.5g Mean Bottom Variation of Total Filterable Phosphate Concentration During the Field Year

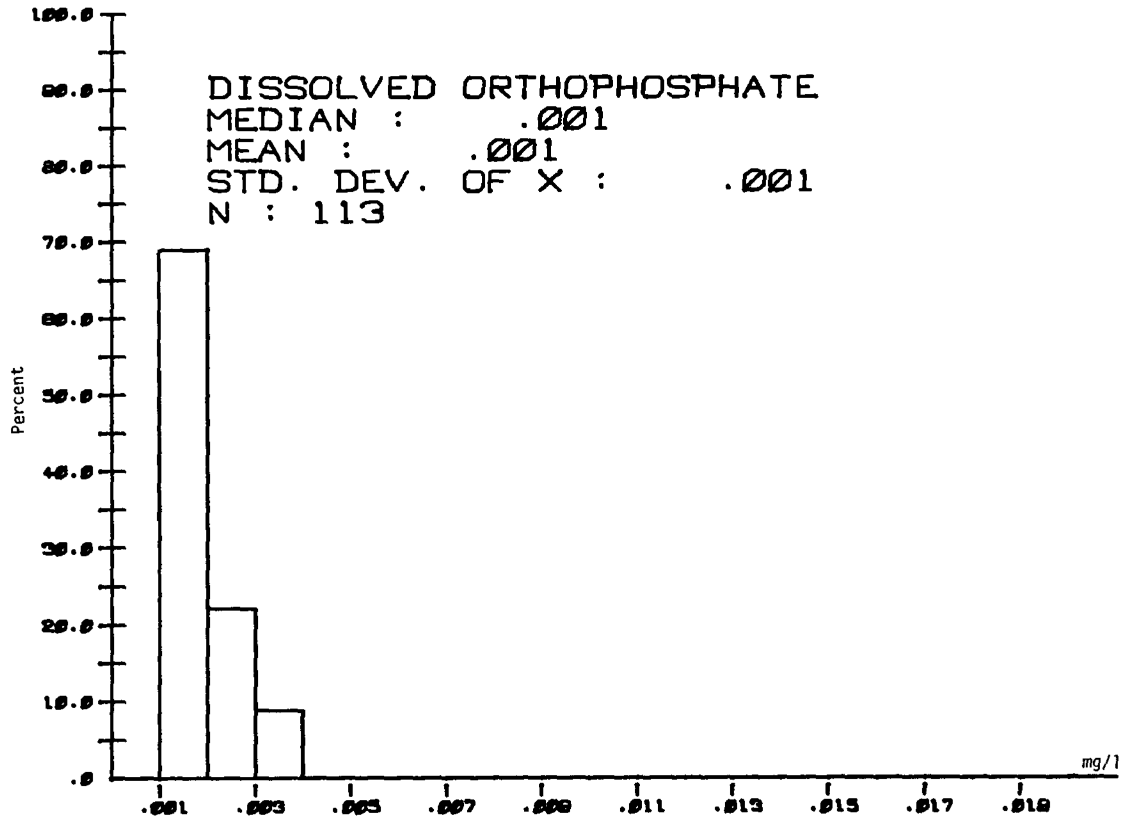


Figure 4.6a Histograms for Dissolved Orthophosphate - Cruise 1

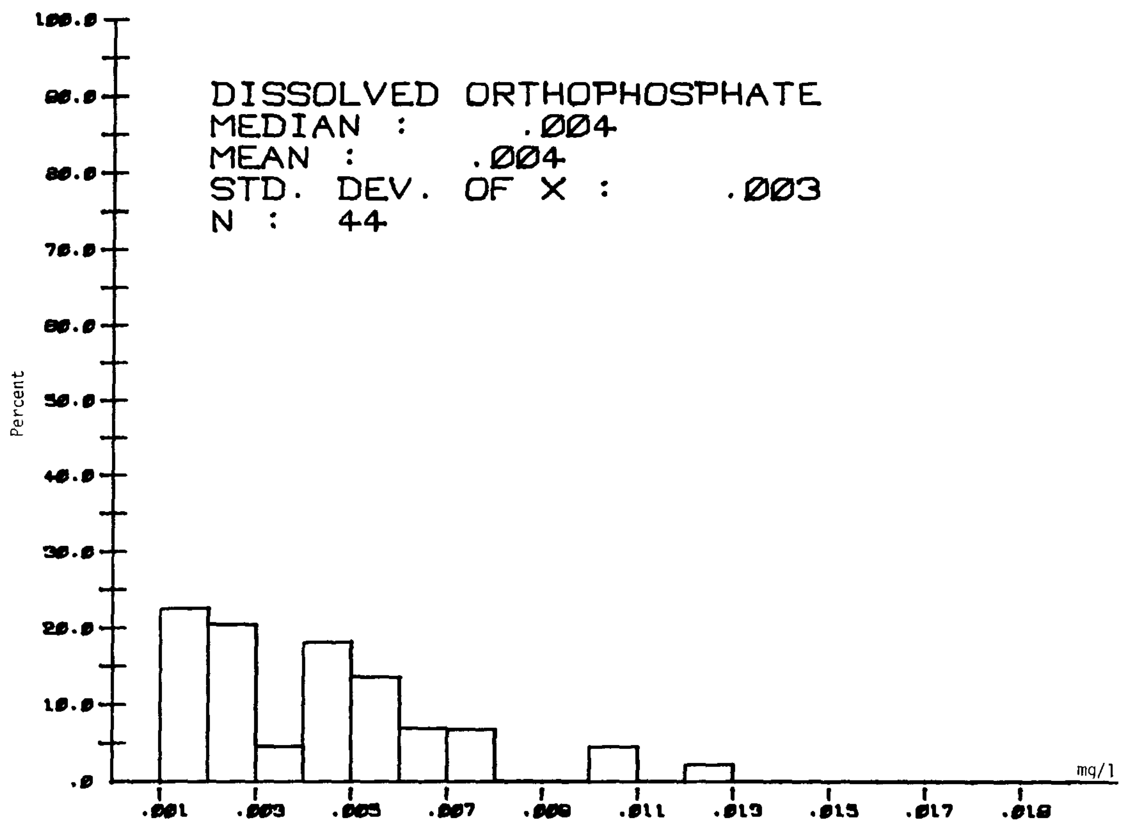


Figure 4.6a Histograms for Dissolved Orthophosphate - Cruise 2

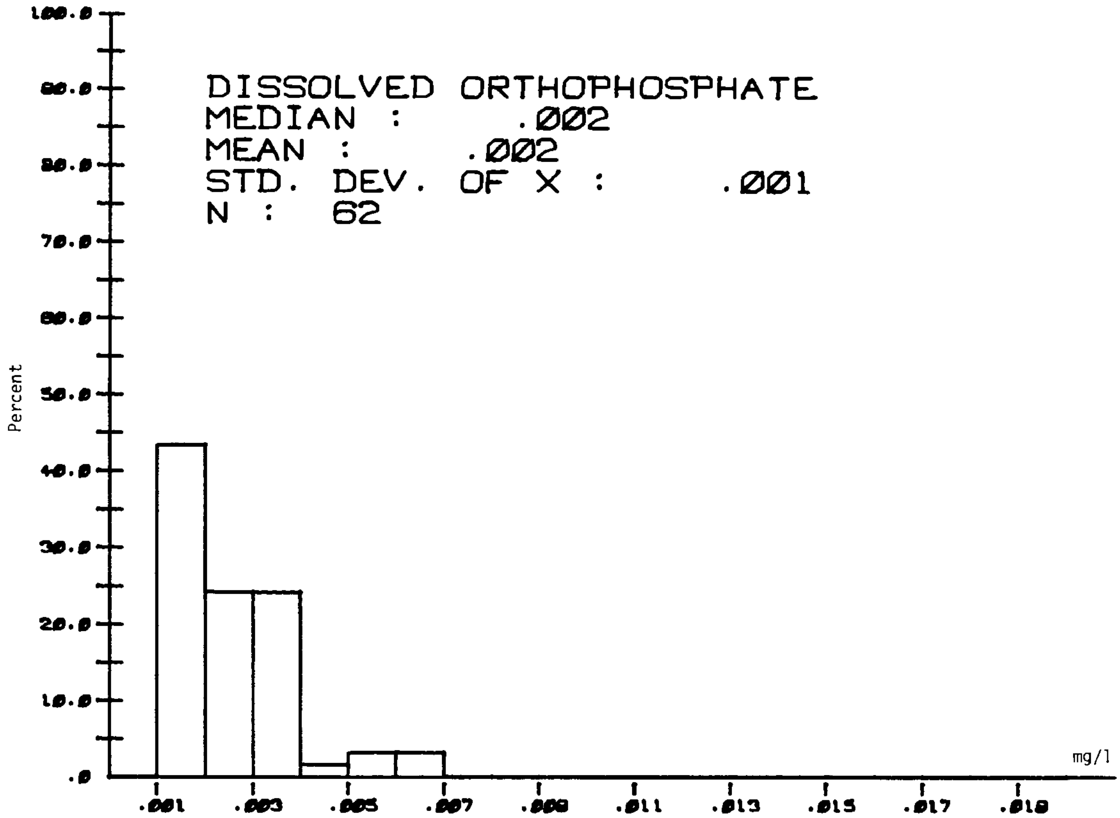


Figure 4.6a Histograms for Dissolved Orthophosphate - Cruise 3

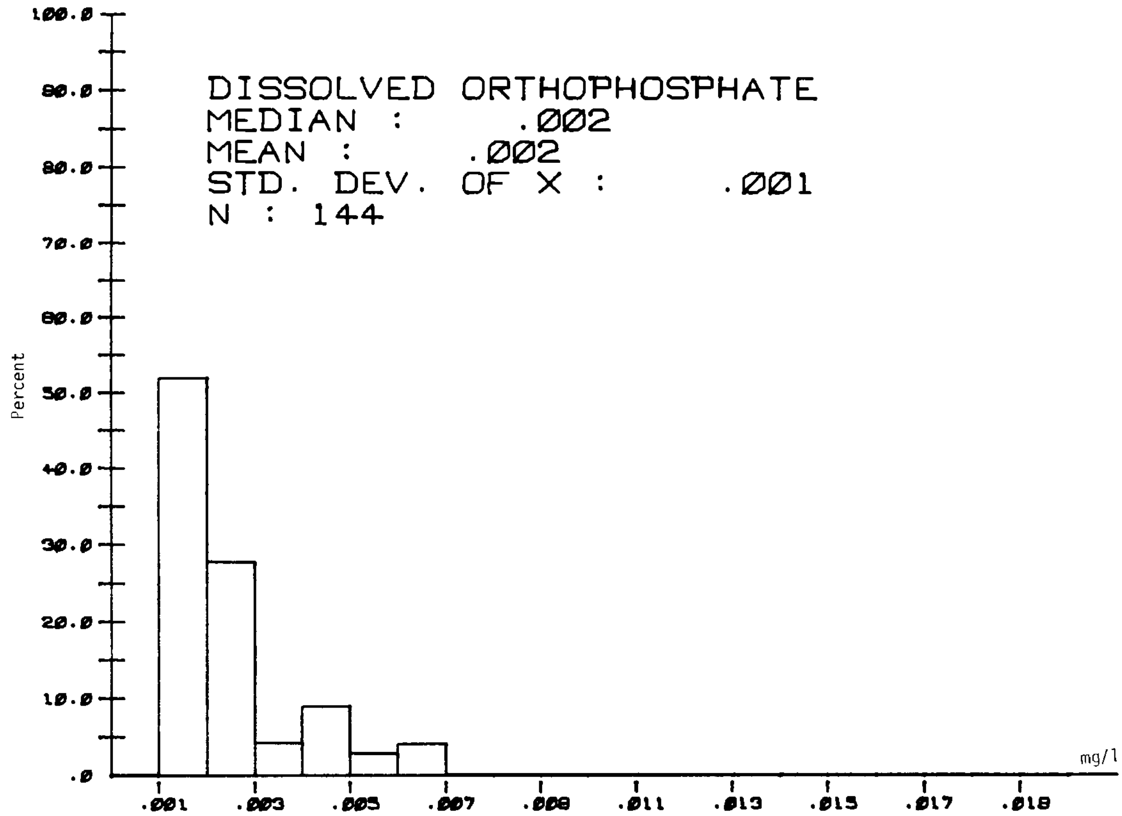


Figure 4.6a Histograms for Dissolved Orthophosphate - Cruise 4

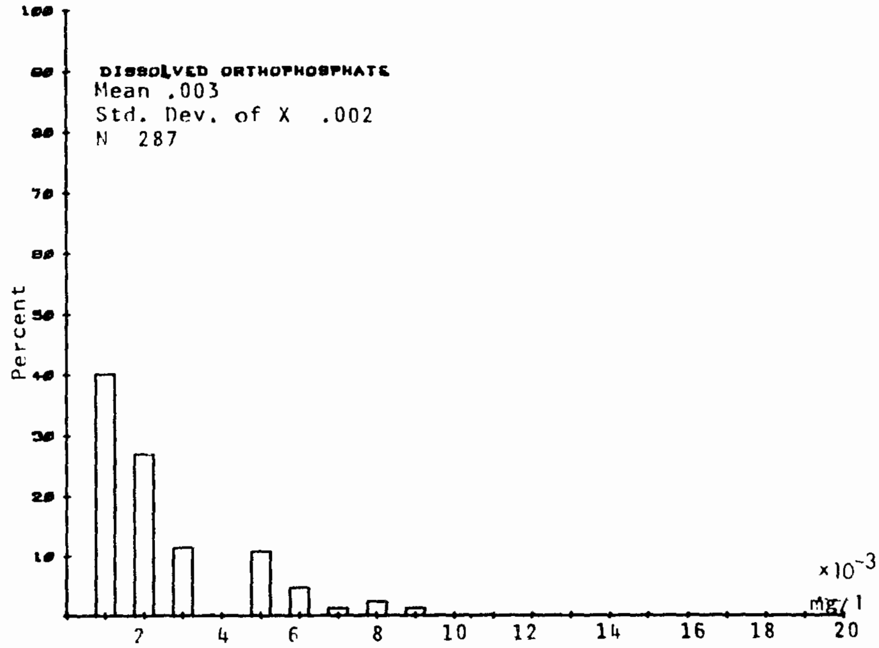


Figure 4.6a Histograms for Dissolved Orthophosphate - Cruise 5

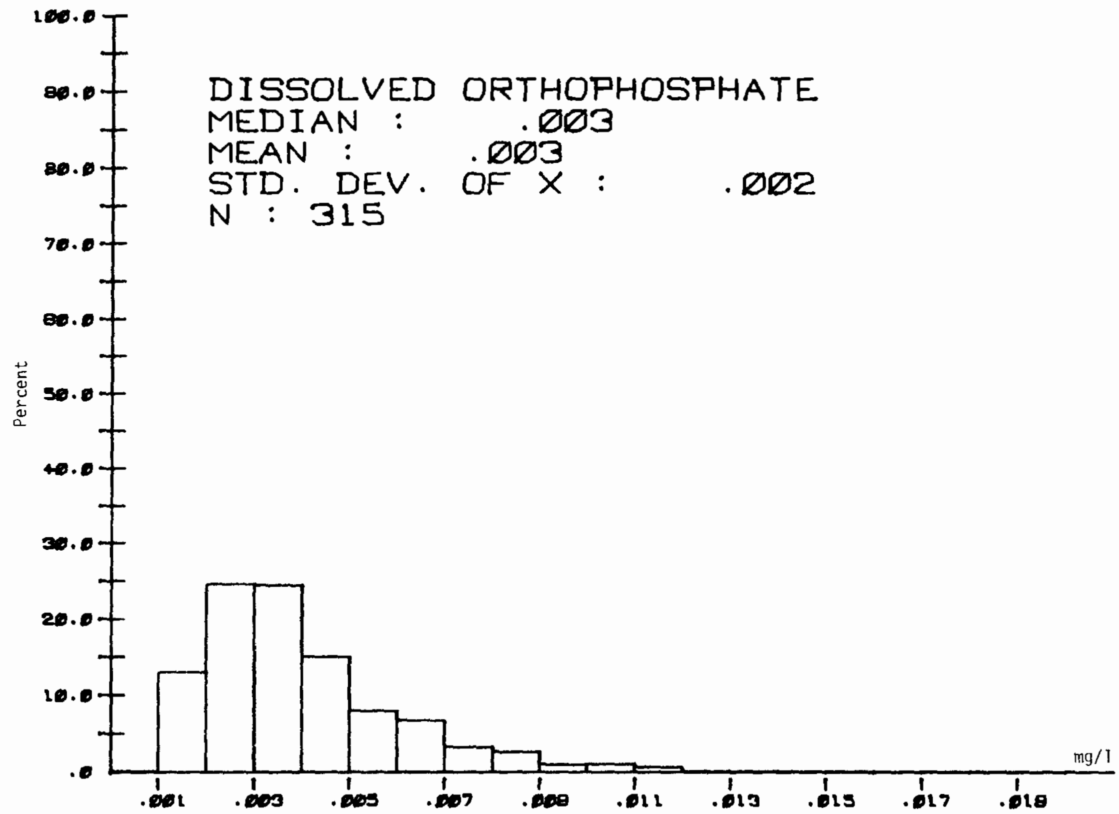


Figure 4.6a Histograms for Dissolved Orthophosphate - Cruise 6

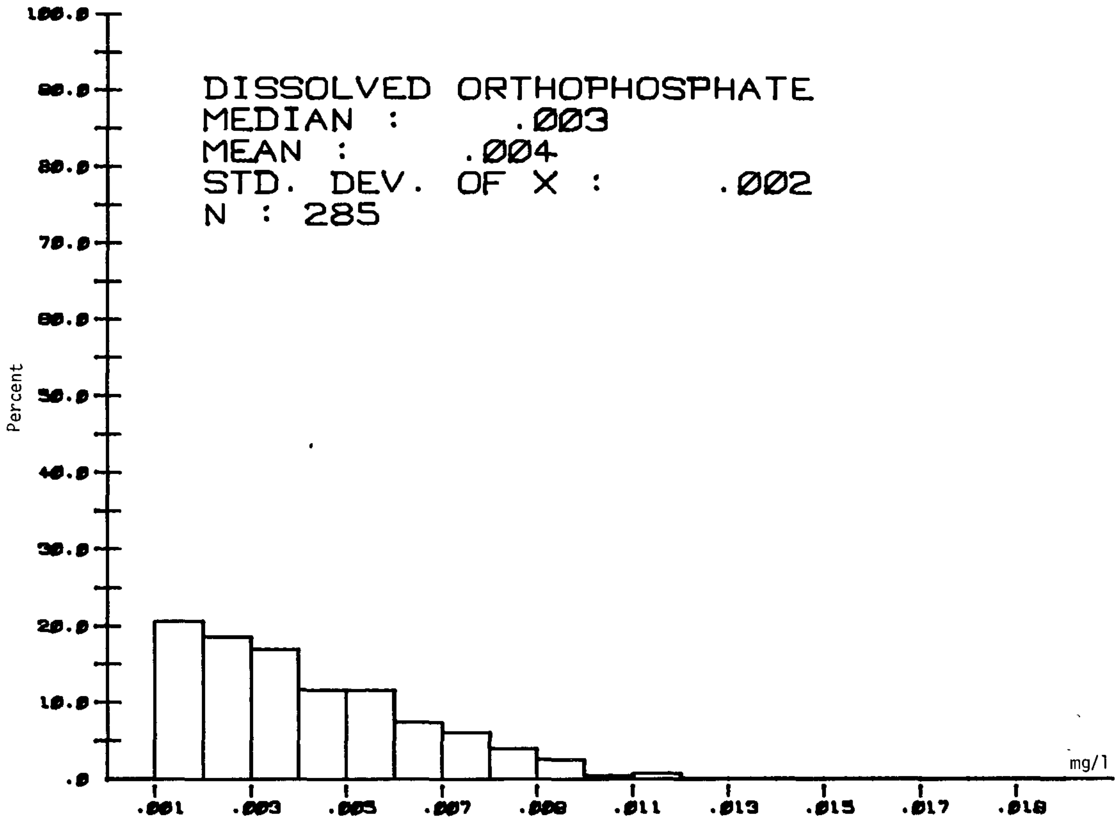


Figure 4.6a Histograms for Dissolved Orthophosphate - Cruise 7

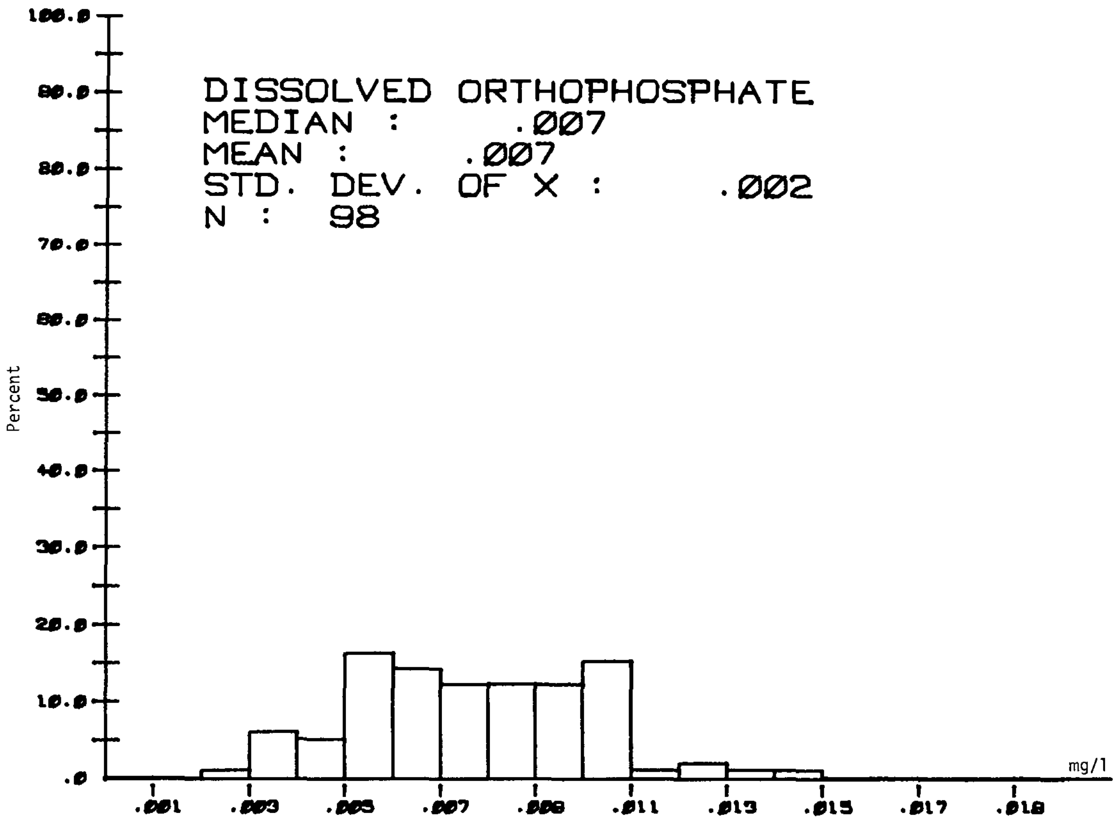


Figure 4.6a Histograms for Dissolved Orthophosphate - Cruise 8

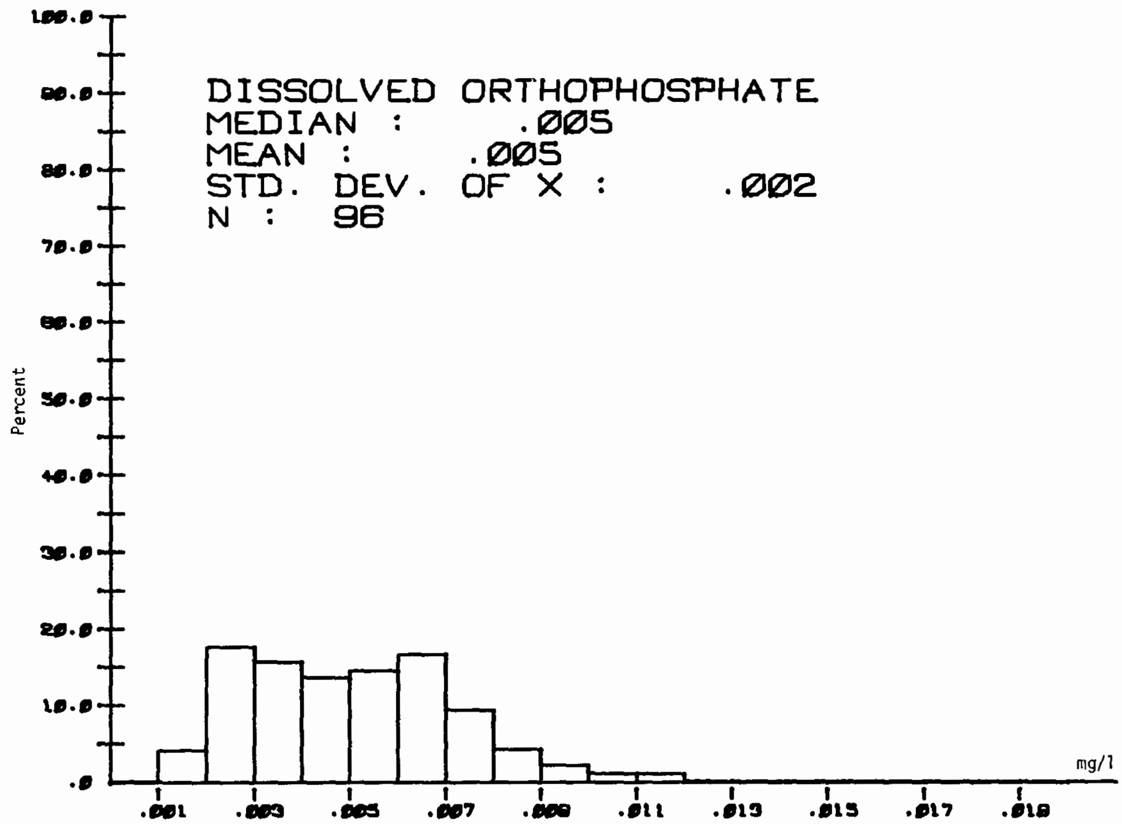


Figure 4.6a Histograms for Dissolved Orthophosphate - Cruise 9

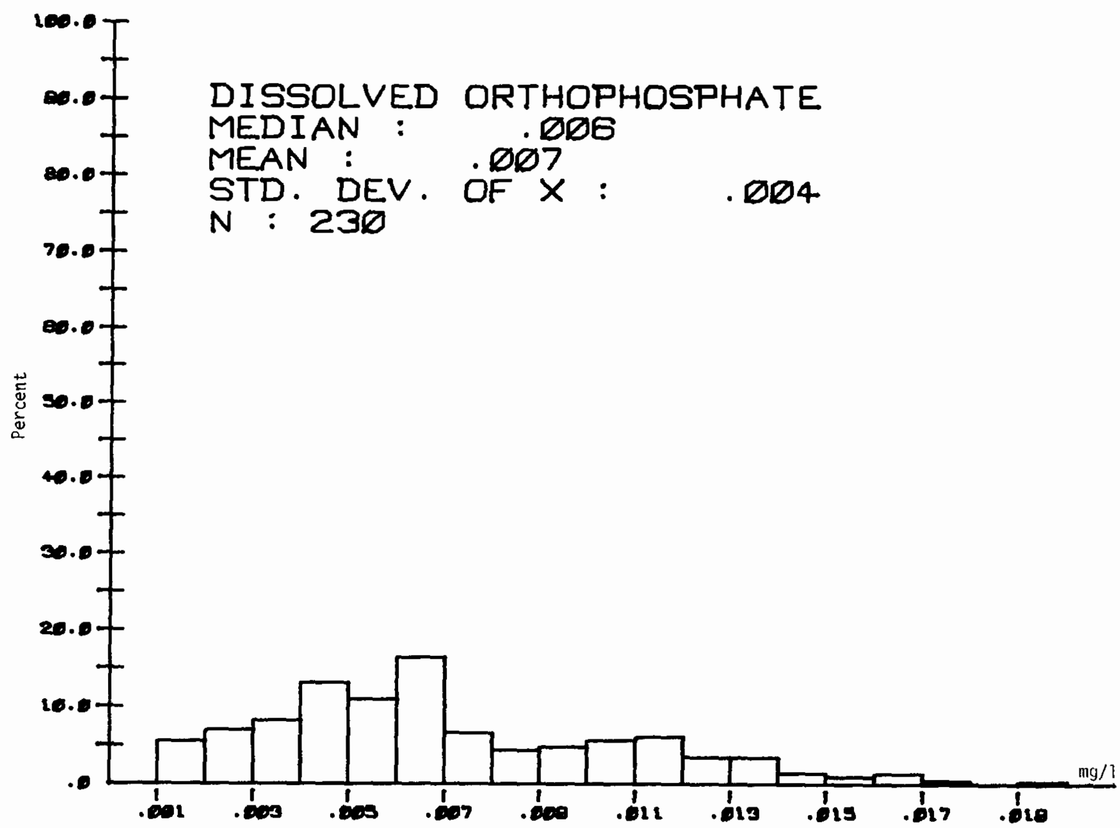


Figure 4.6a Histograms for Dissolved Orthophosphate - Cruise 10

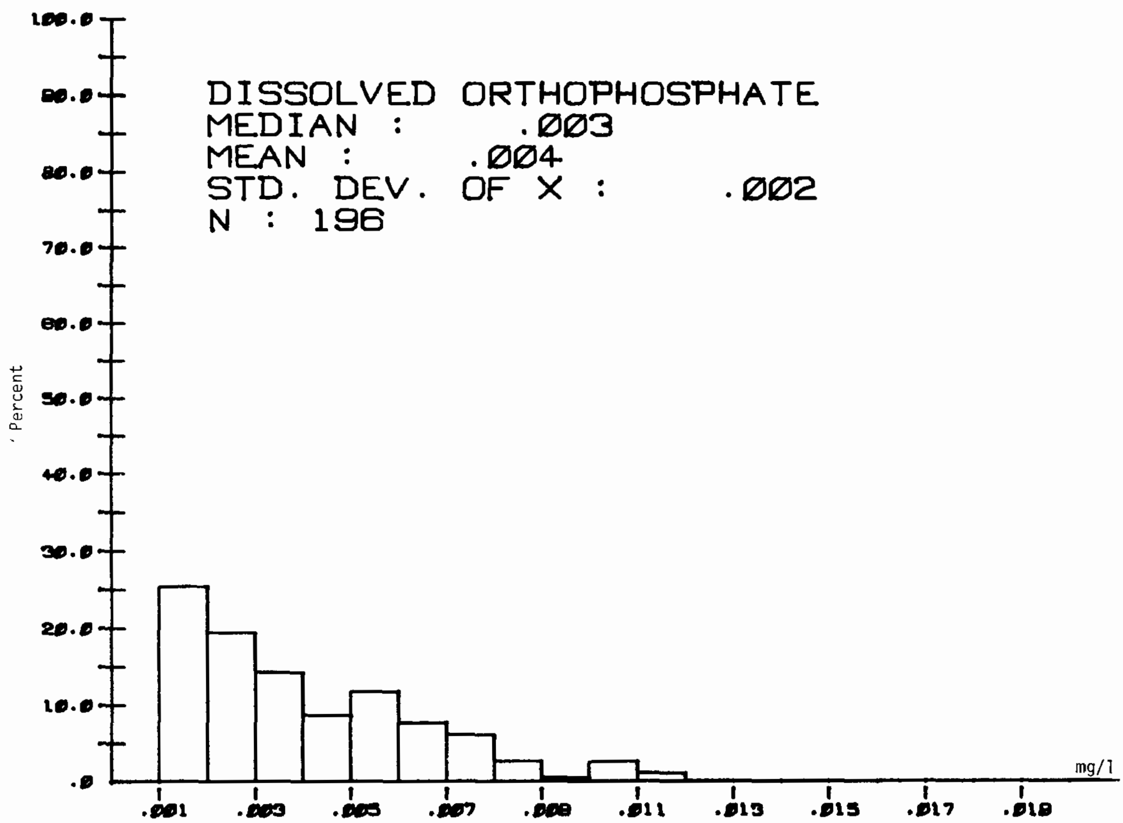


Figure 4.6a Histograms for Dissolved Orthophosphate - Cruise 11

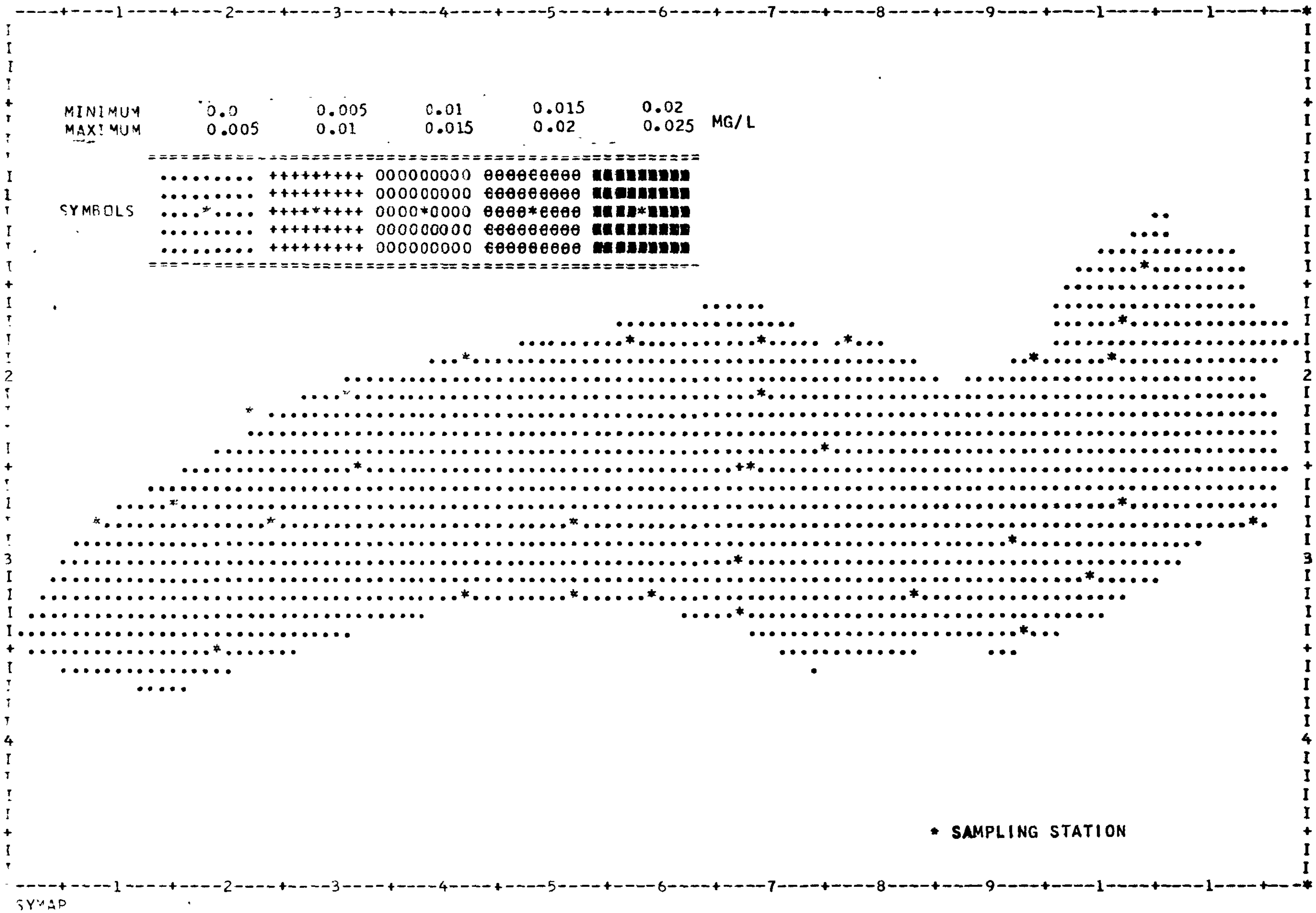


Figure 4.6b Contours of Constant Surface Dissolved Orthophosphate

CRUISE NUMBER 5: AUGUST 21, 1972 TO AUGUST 25, 1972

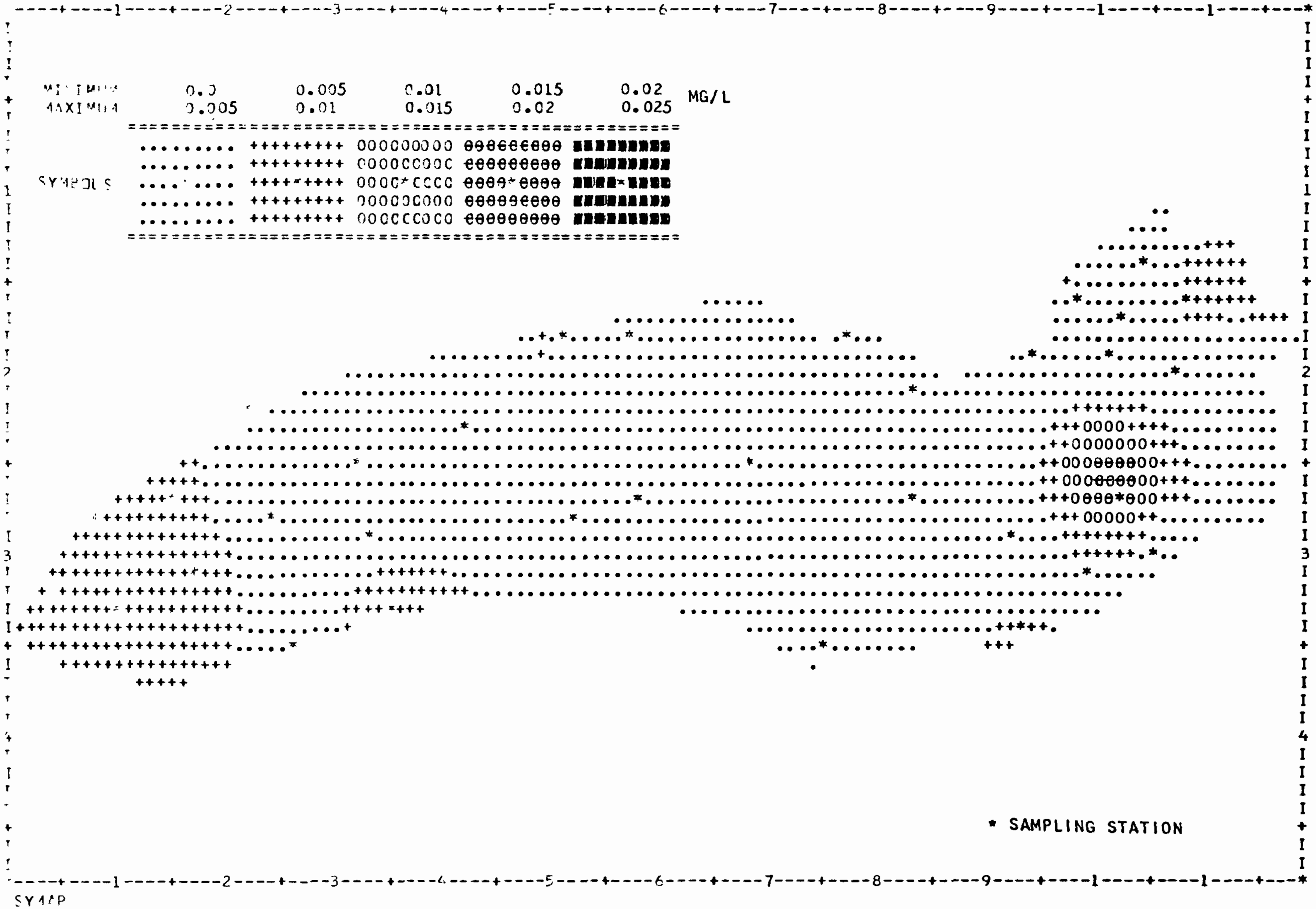


Figure 4.6b Contours of Constant Surface Dissolved Orthophosphate

CRUISE NUMBER 6: OCTOBER 30, 1972 TO NOVEMBER 3, 1972

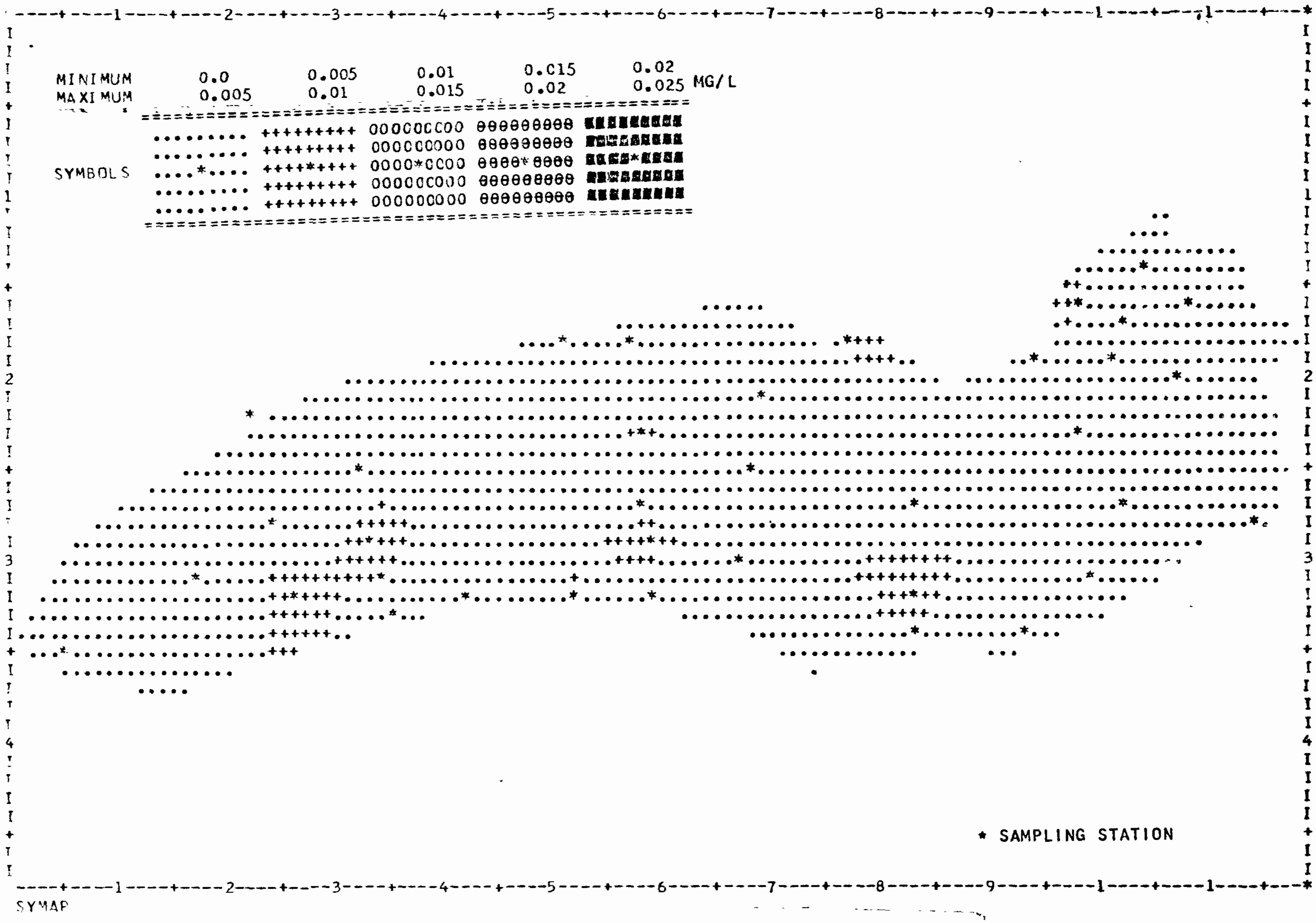


Figure 4.6b Contours of Constant Surface Dissolved Orthophosphate

CRUISE NUMBER 7: NOVEMBER 27, 1972 TO DECEMBER 2, 1972

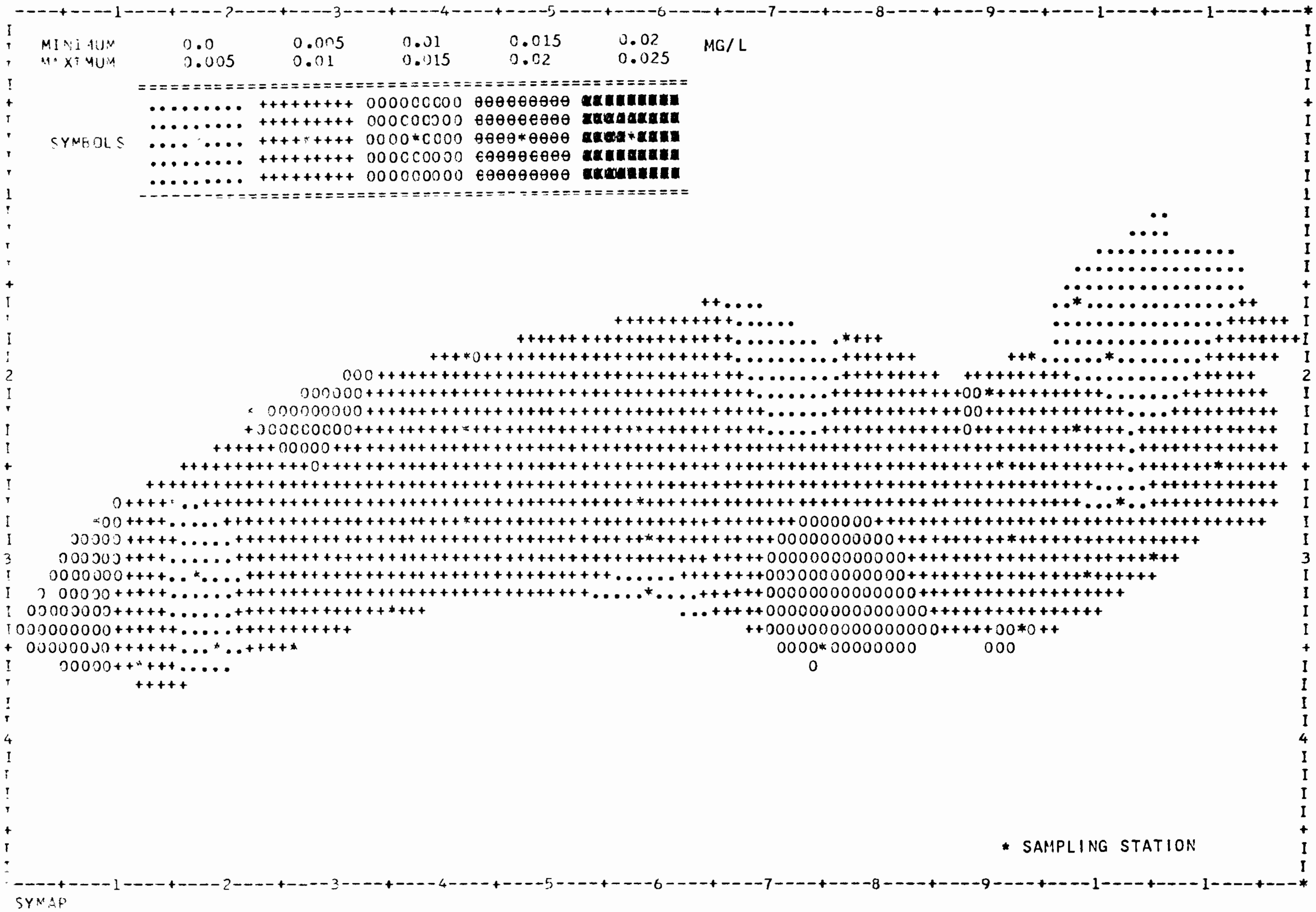
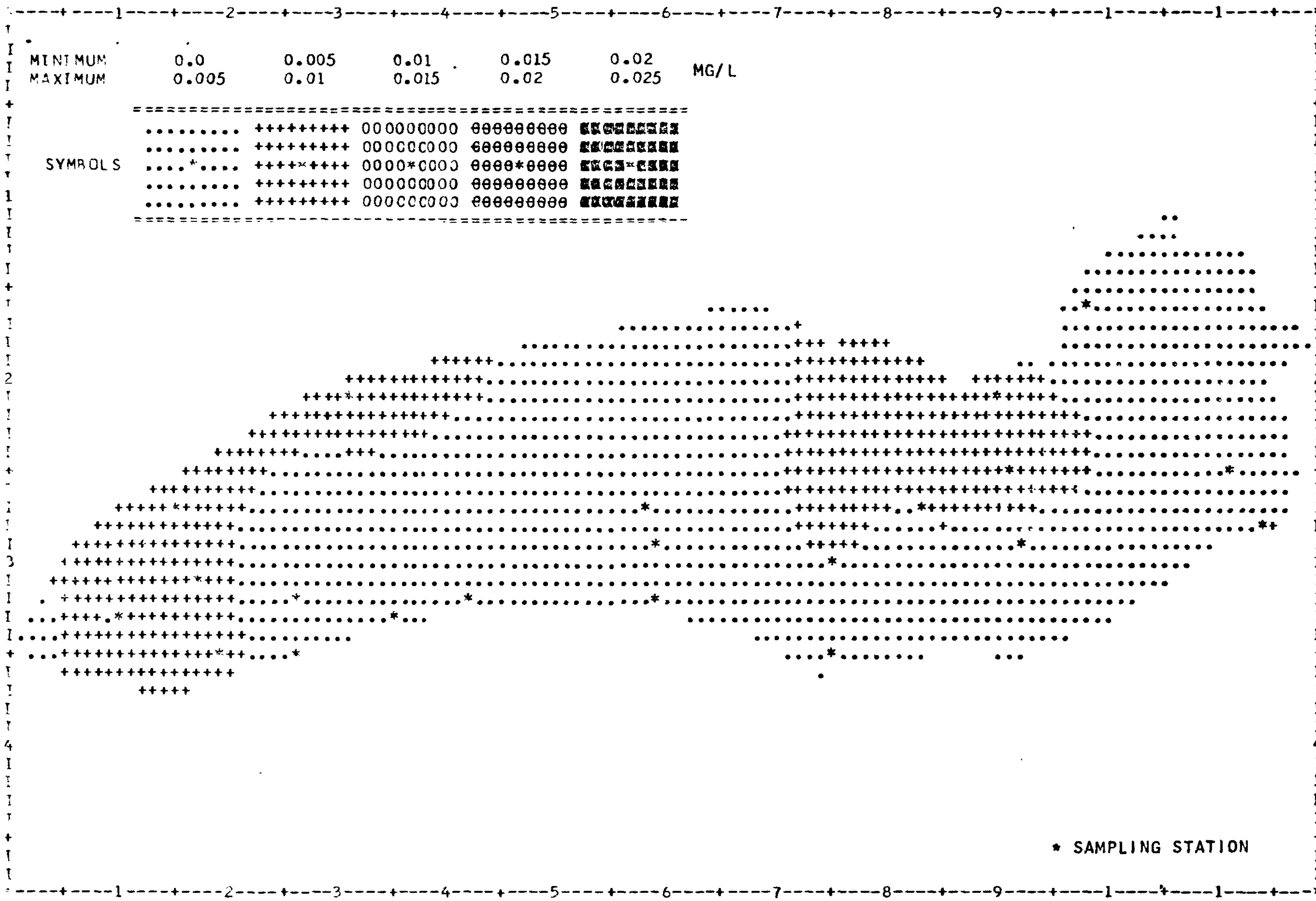


Figure 4.6b Contours of Constant Surface Dissolved Orthophosphate

CRUISE NUMBER 3: FEBRUARY 5, 1973 TO FEBRUARY 9, 1973



SYMAP

Figure 4.6b Contours of Constant Surface Dissolved Orthophosphate

CRUISE NUMBER 9: MARCH 18, 1973 TO MARCH 23, 1973

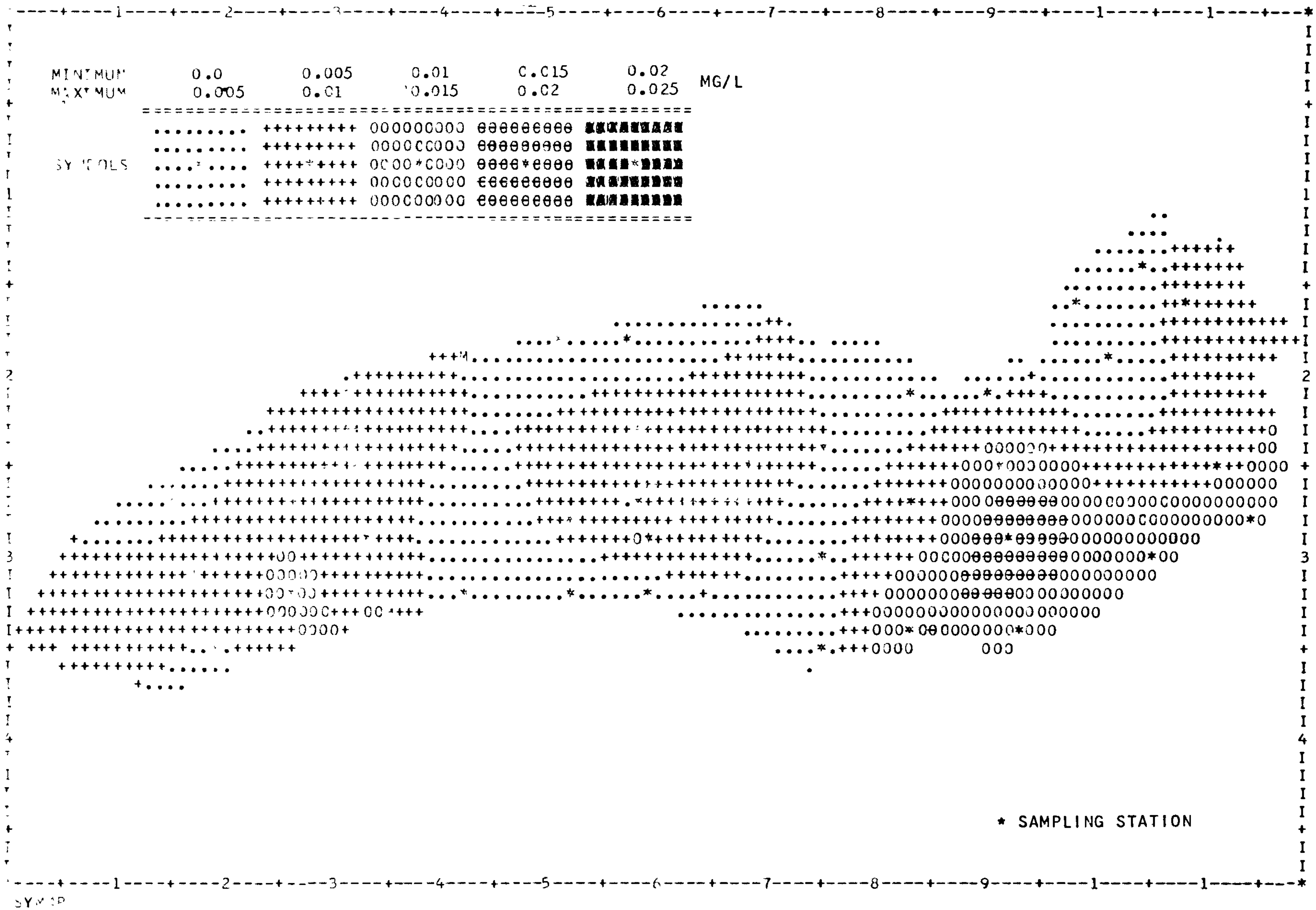


Figure 4.6b Contours of Constant Surface Dissolved Orthophosphate

CRUISE NUMBER 10: APRIL 24, 1973 TO APRIL 30, 1973

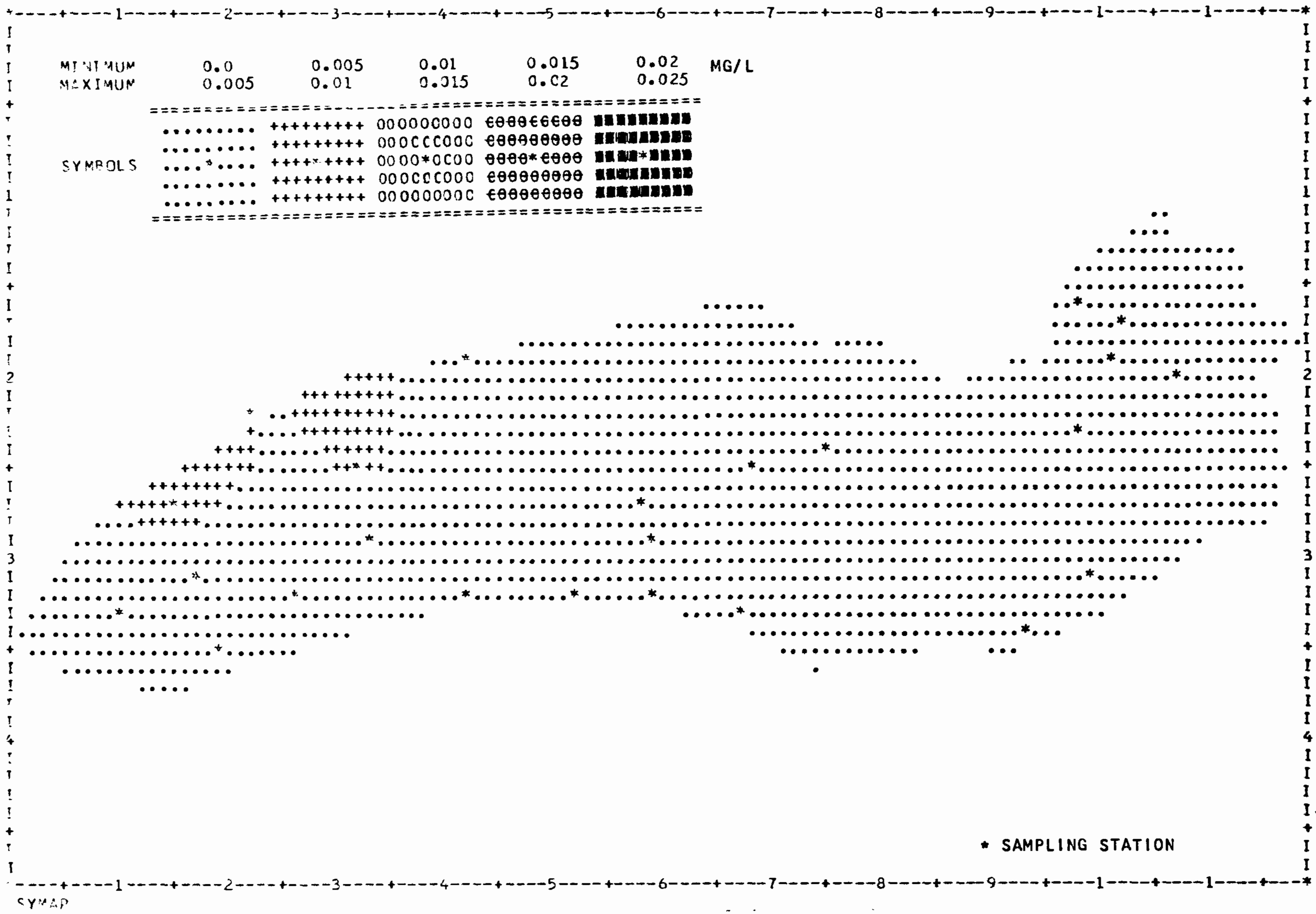


Figure 4.6b Contours of Constant Surface Dissolved Orthophosphate

CRUISE NUMBER 11: JUNE 11, 1973 TO JUNE 15, 1973

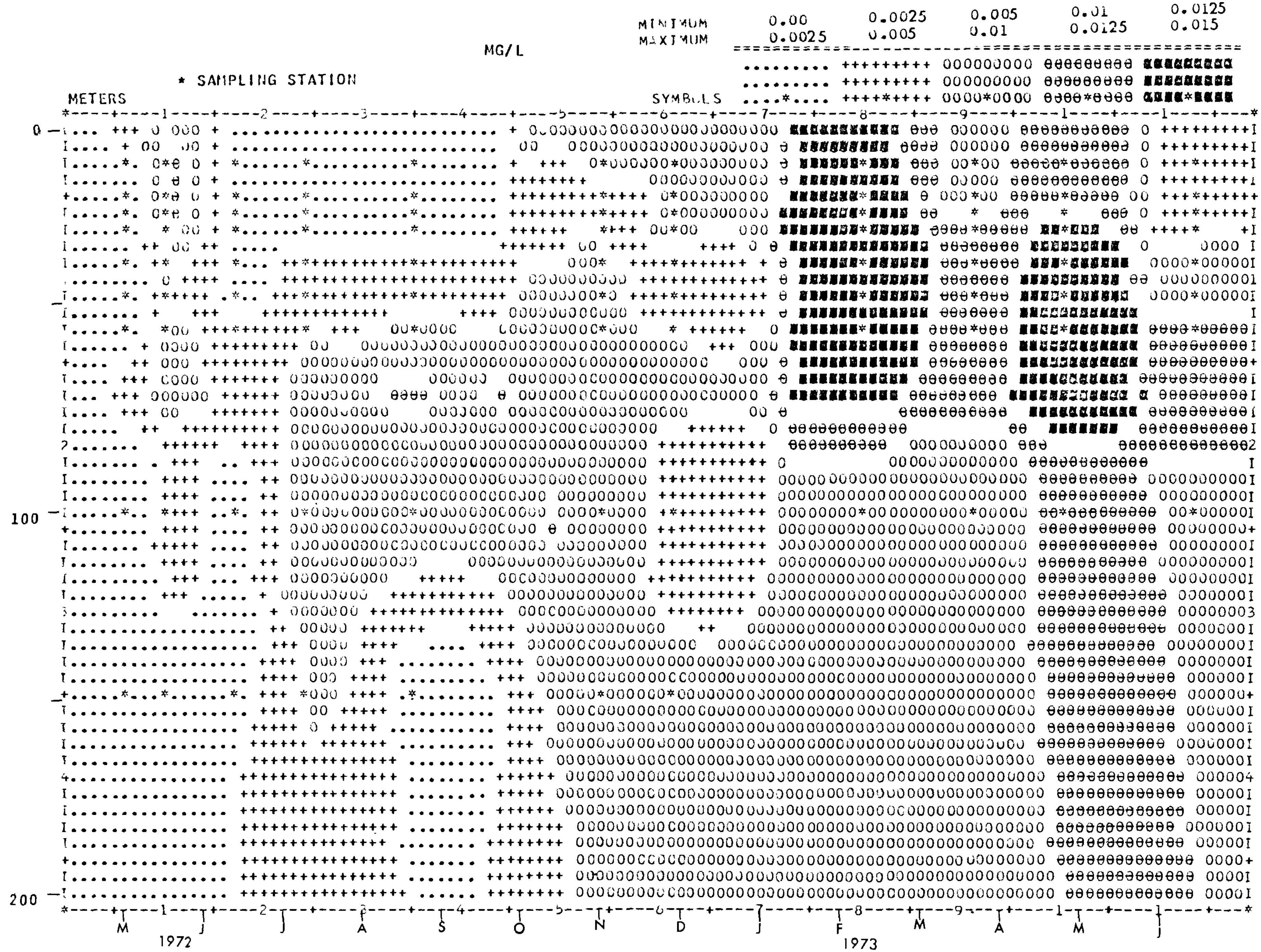


Figure 4.6c Depth Versus Time Contours of Constant Dissolved Orthophosphate

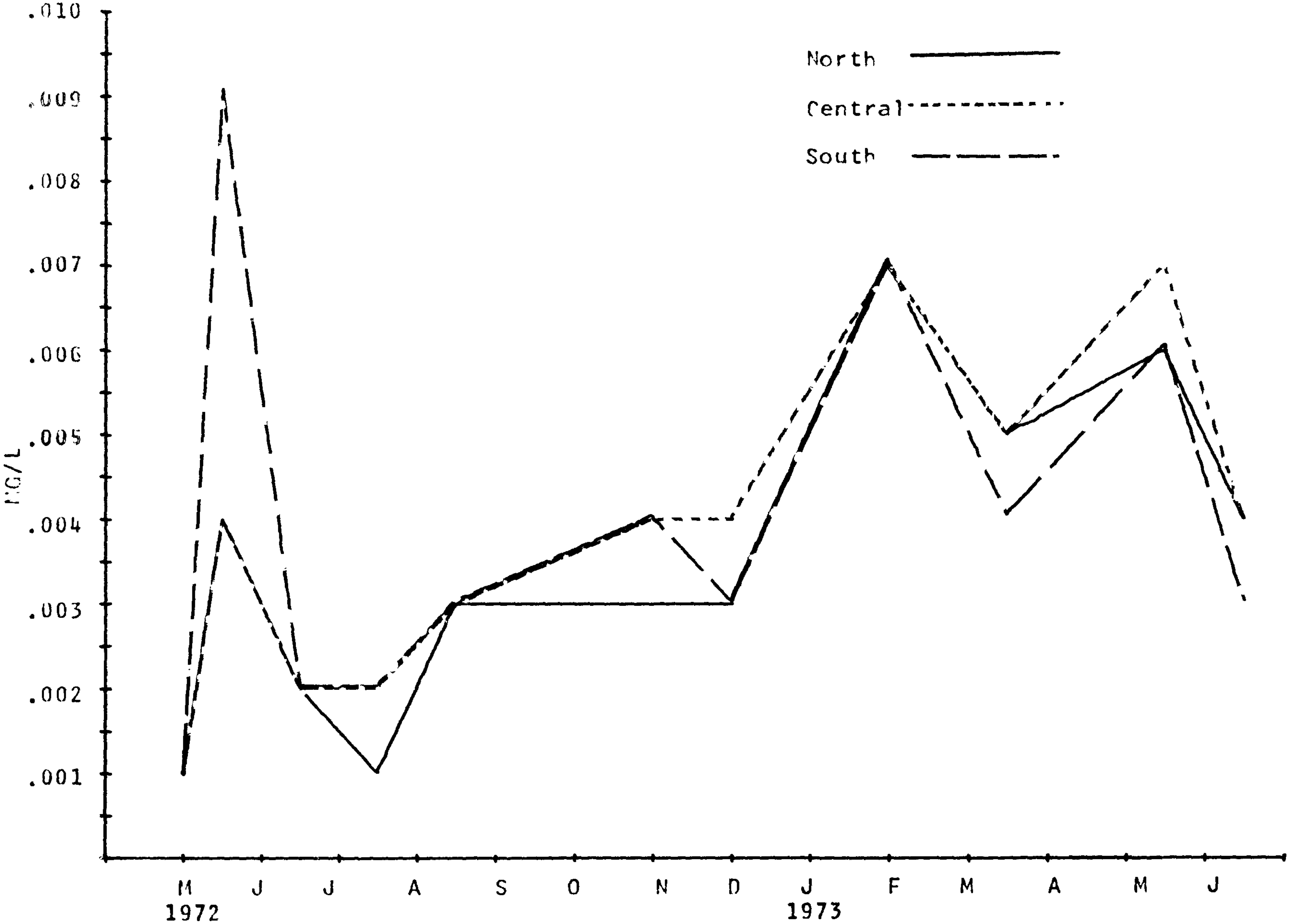


Figure 4.6d North-south variation of dissolved orthophosphate

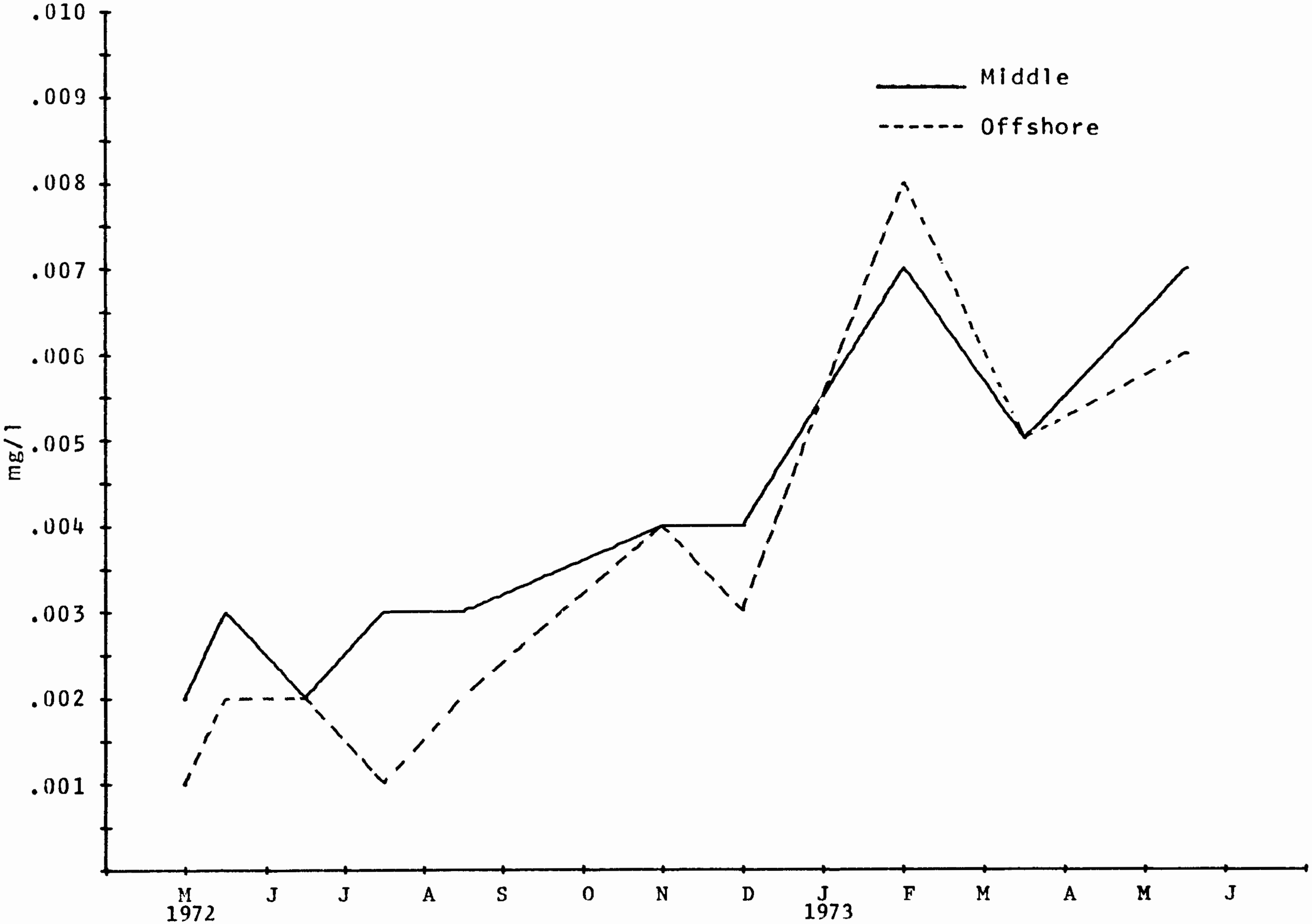


Figure 4.6e Middle Lake-Offshore Variations of Mean Dissolved Orthophosphate Concentration

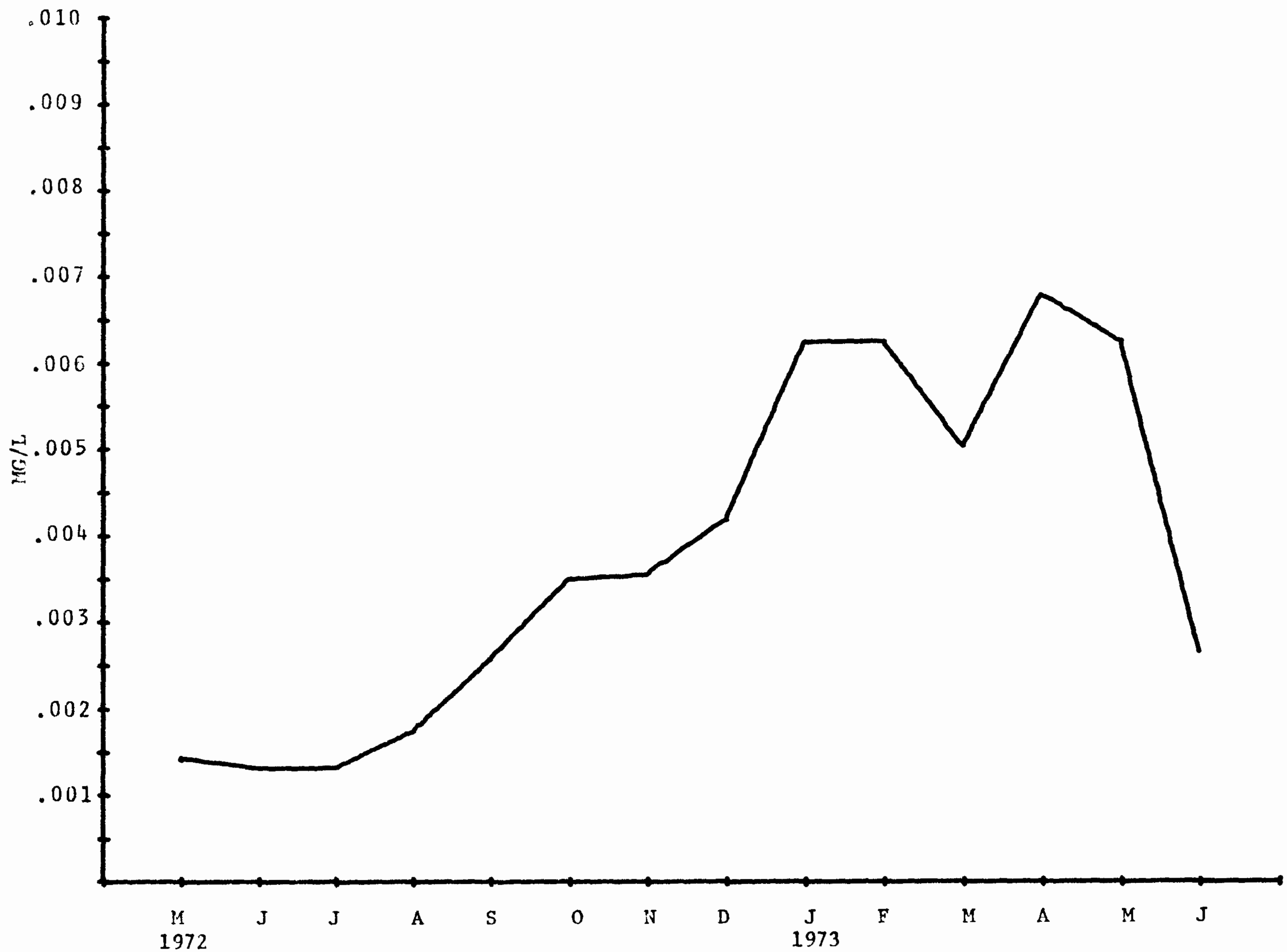


Figure 4.6f Mean surface variation of Dissolved Orthophosphate concentration during the field year.

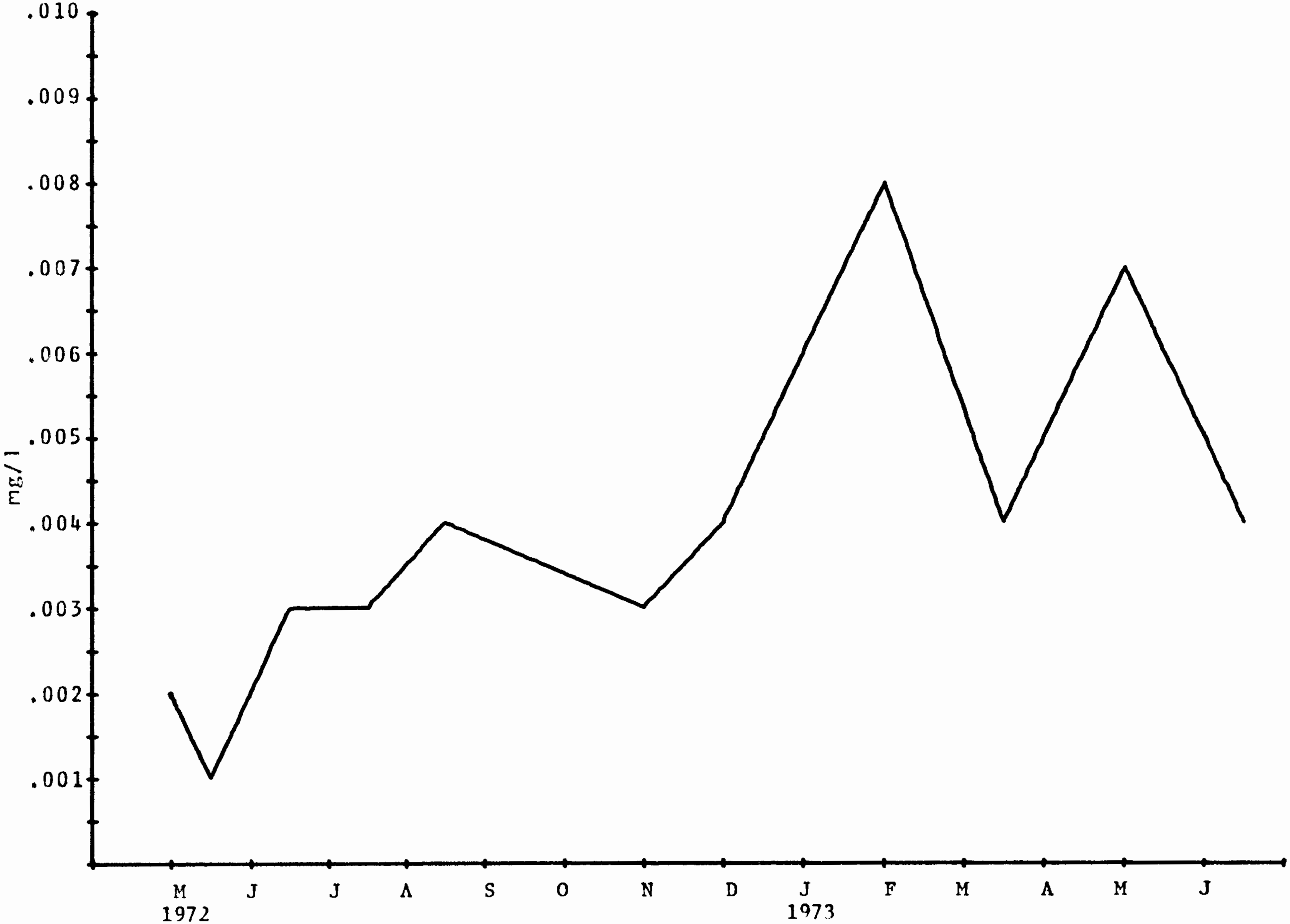


Figure 4.6g Mean Botton Variation of Dissolved Orthophosphate Concentration During the Field Year

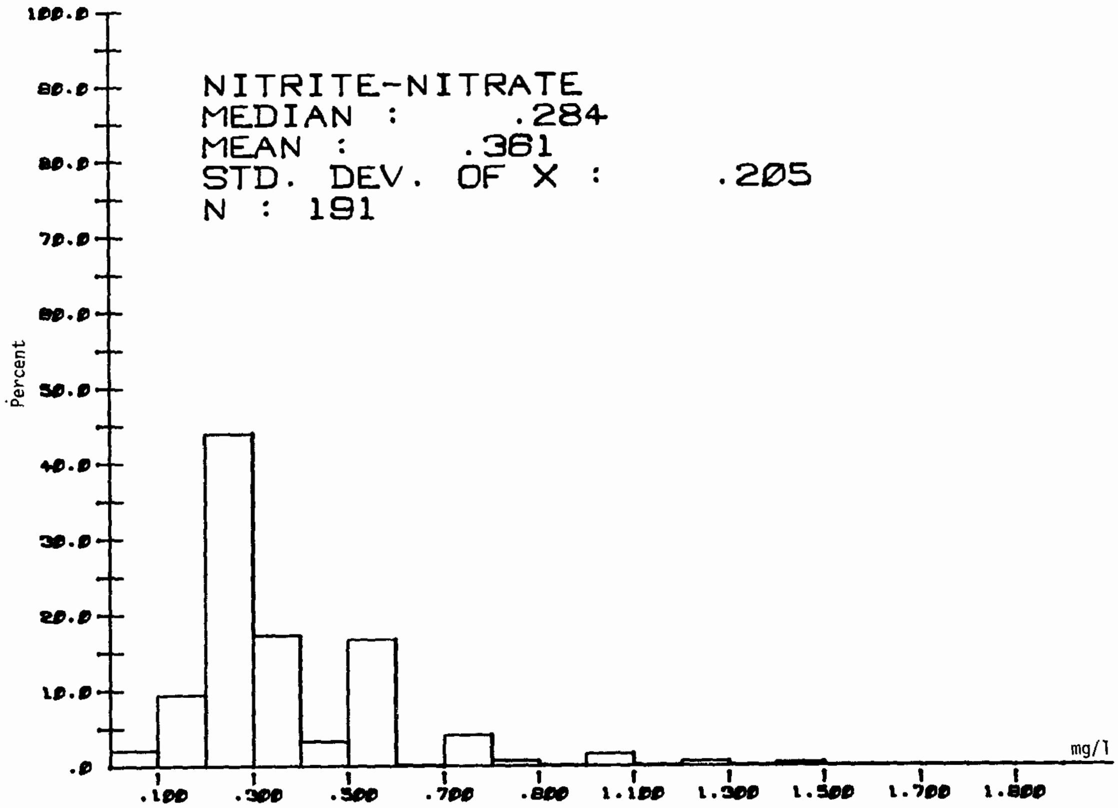


Figure 4.7a Histograms for Nitrite-Nitrate - Cruise 1

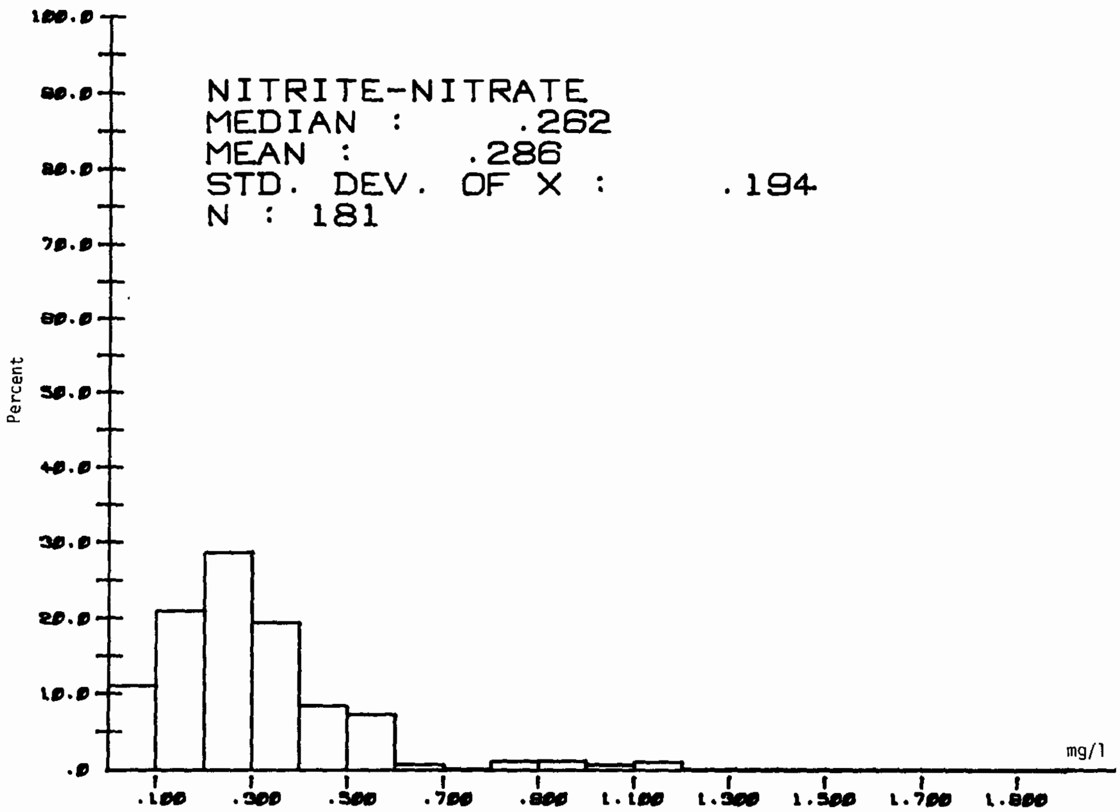


Figure 4.7a Histograms for Nitrite-Nitrate - Cruise 2

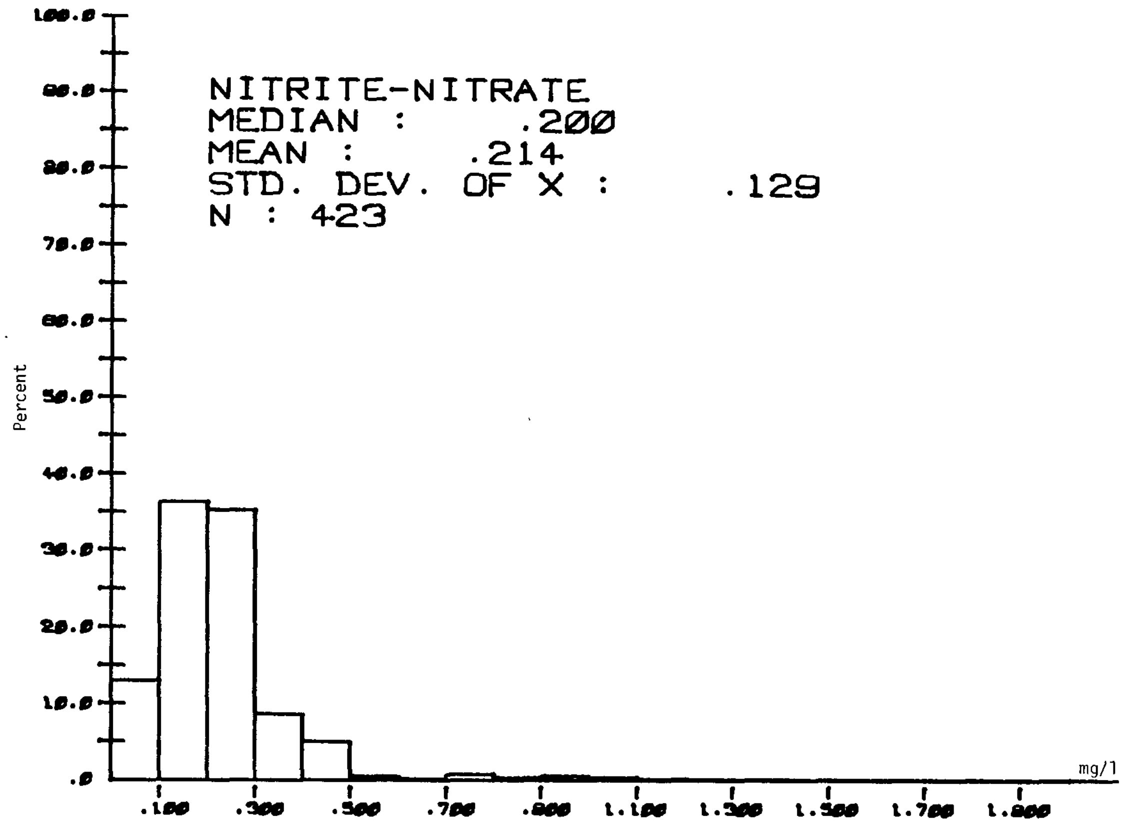


Figure 4.7a Histograms for Nitrite-Nitrate - Cruise 3

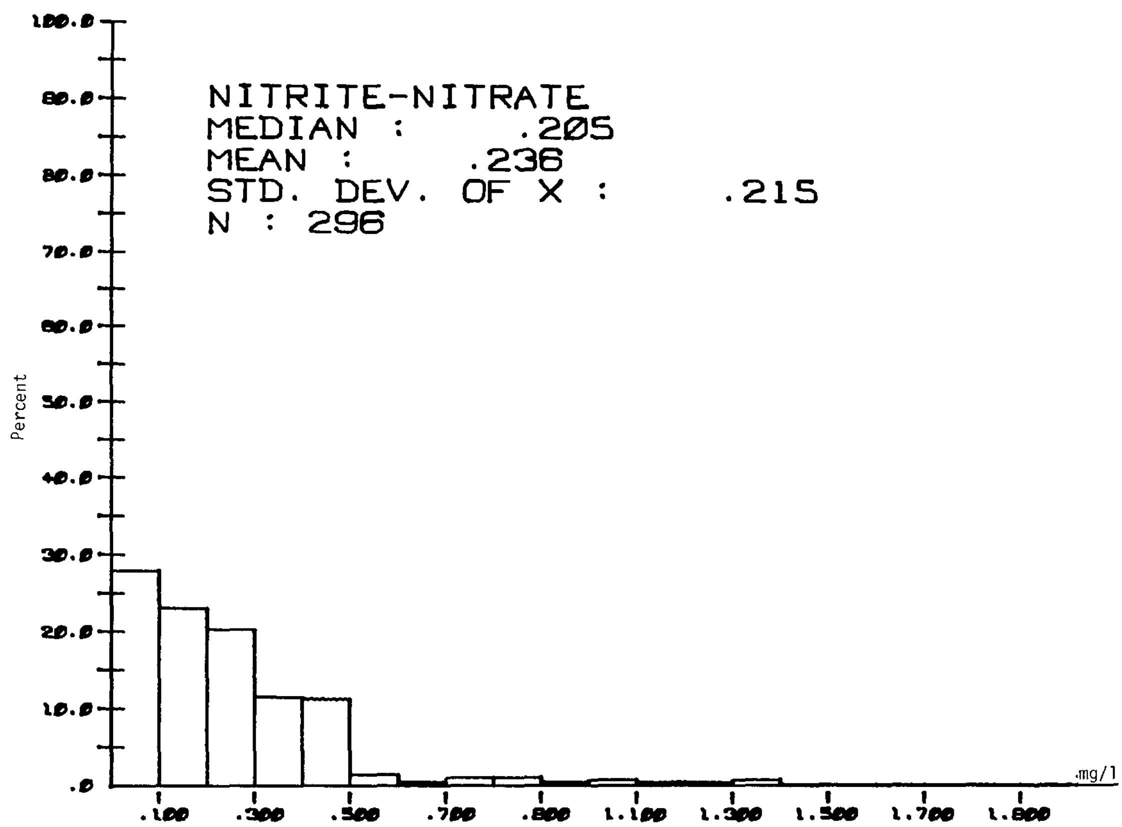


Figure 4.7a Histograms for Nitrite-Nitrate - Cruise 4

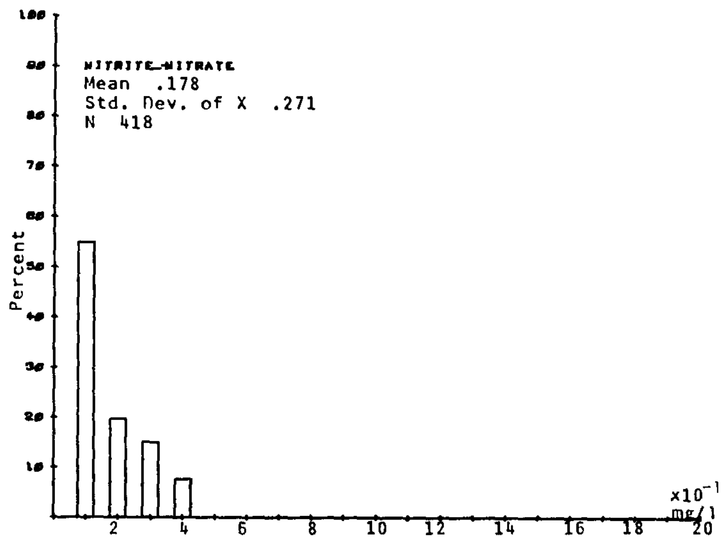


Figure 4.7a Histograms for Nitrite-Nitrate - Cruise 5

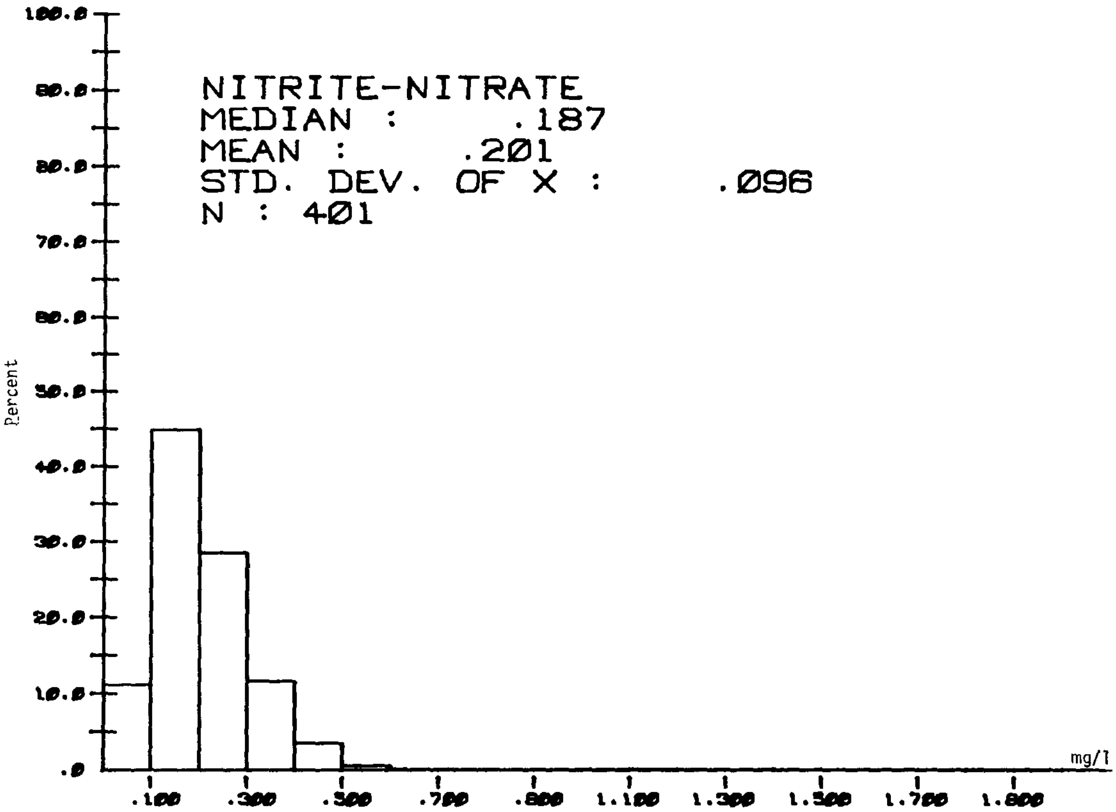


Figure 4.7a Histograms for Nitrite-Nitrate - Cruise 6

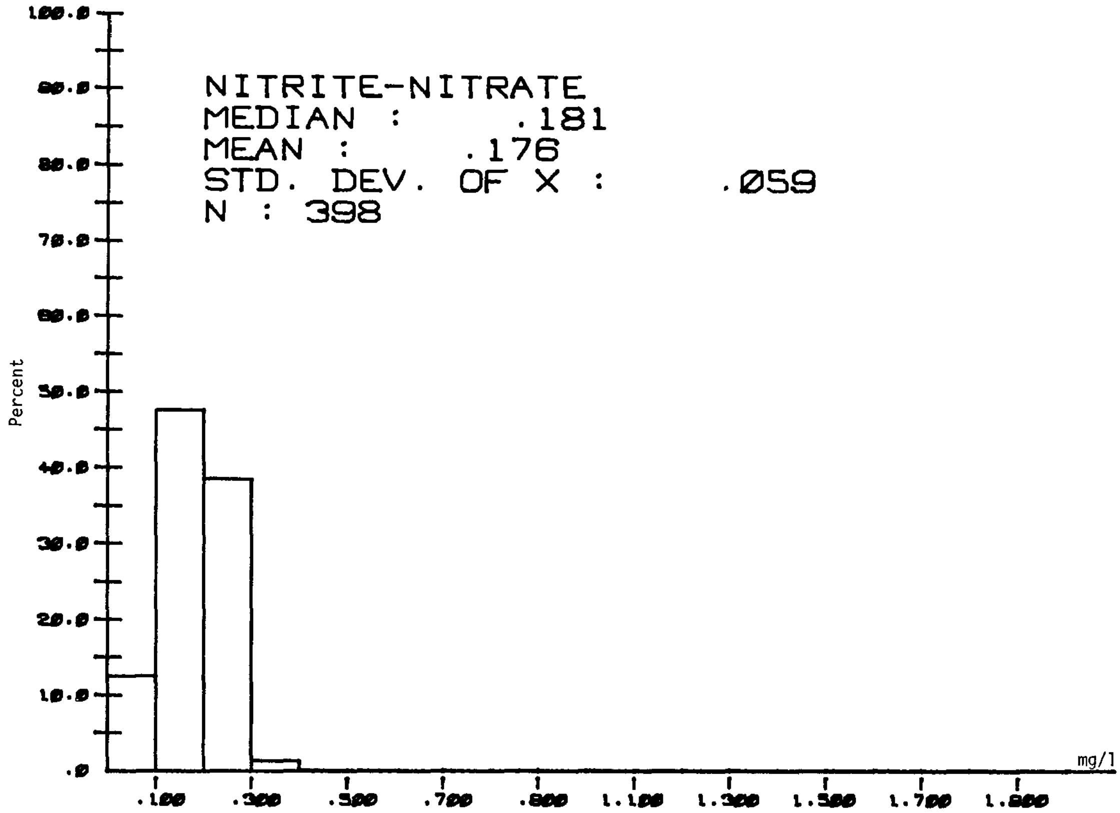


Figure 4.7a Histograms for Nitrite-Nitrate - Cruise 7

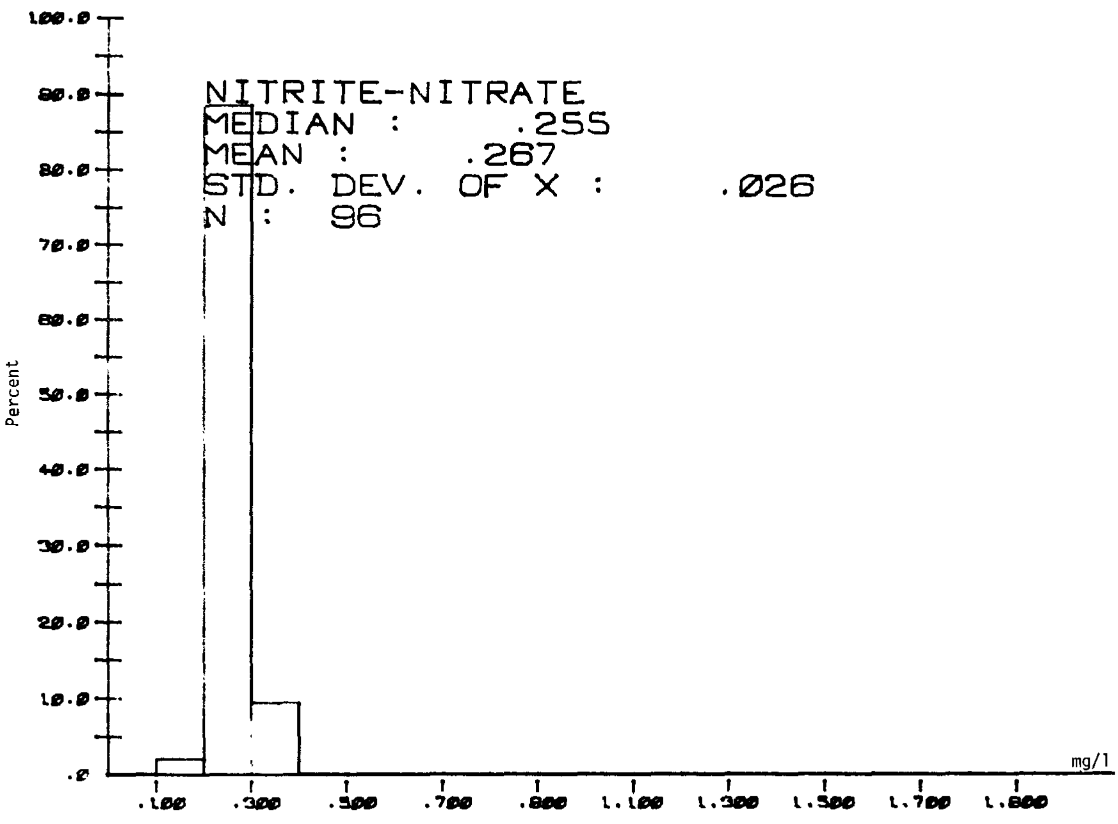


Figure 4.7a Histograms for Nitrite-Nitrate - Cruise 8

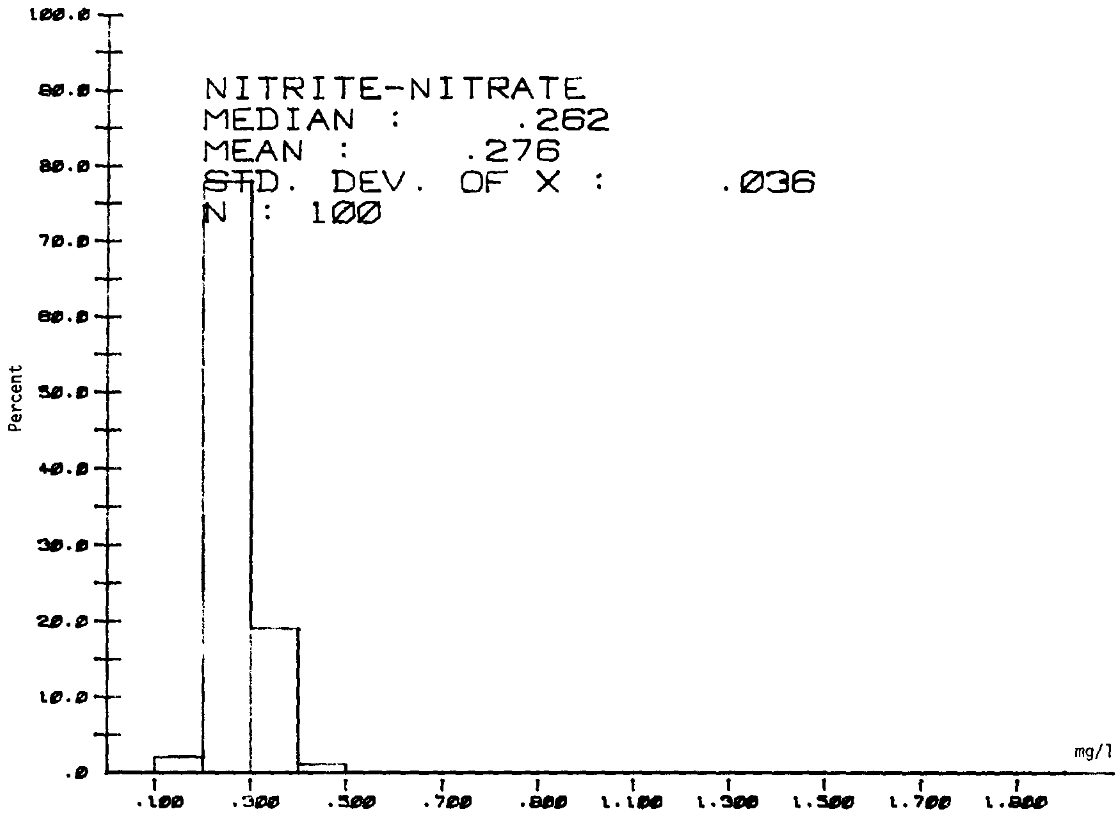


Figure 4.7a Histograms for Nitrite-Nitrate - Cruise 9

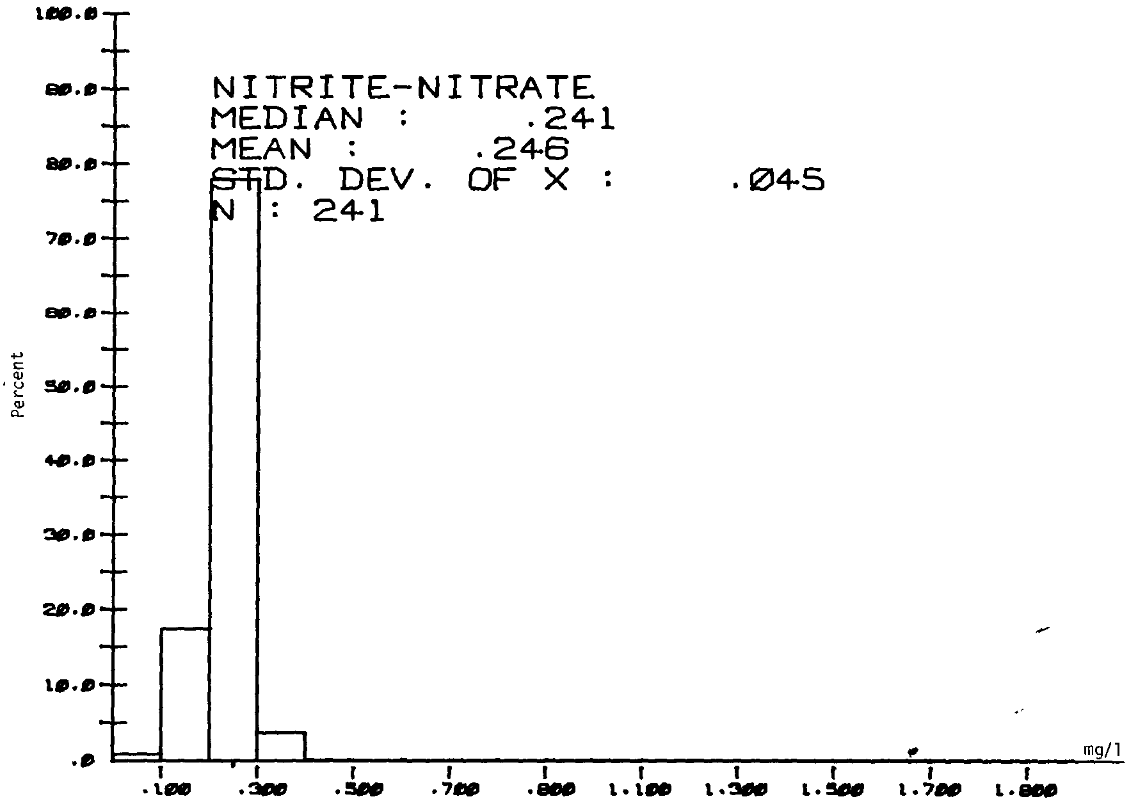


Figure 4.7a Histograms for Nitrite-Nitrate - Cruise 10

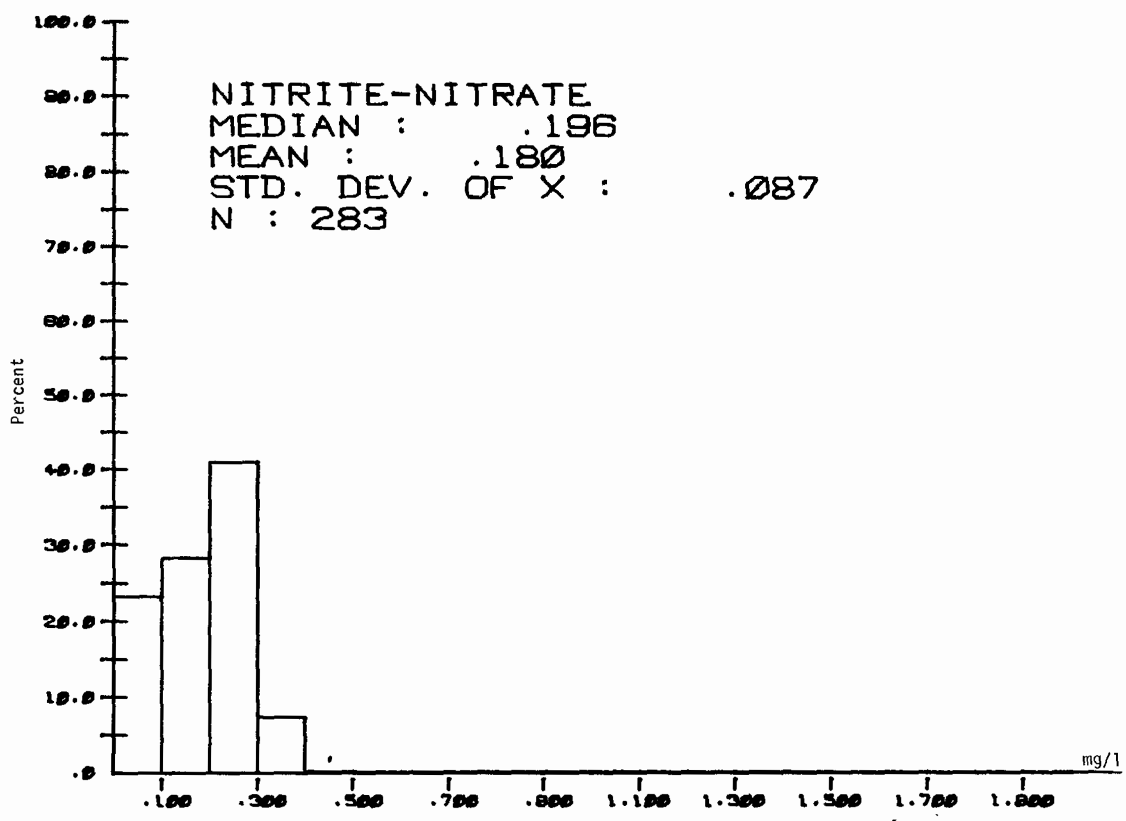


Figure 4.7a Histograms for Nitrite-Nitrate - Cruise 11

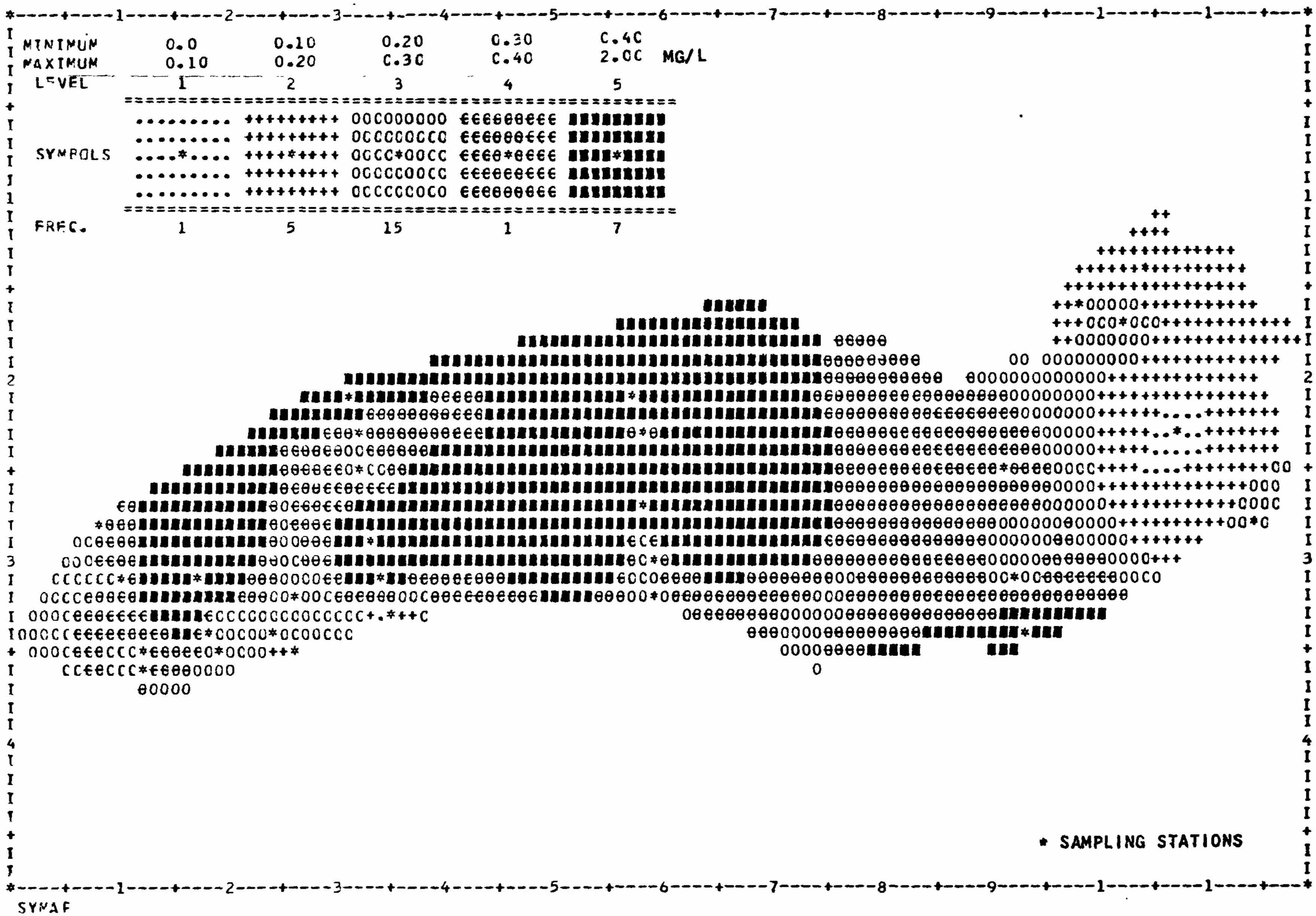


Figure 4.7b Contours of Constant Surface Nitrite-Nitrate

CRUISE NUMBER 1: MAY 1, 1972 TO MAY 5, 1972

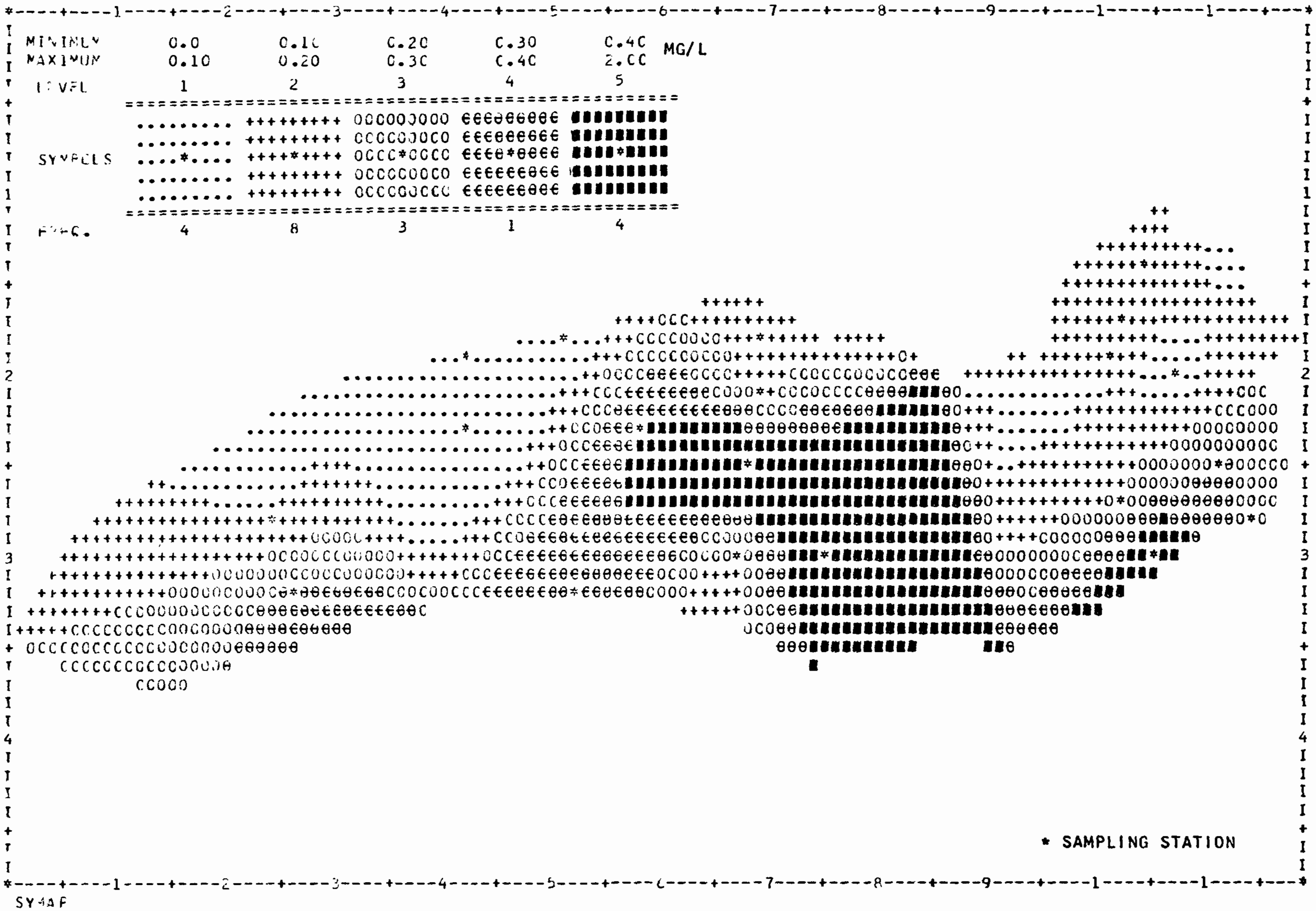


Figure 4.7b Contours of Constant Surface Nitrite-Nitrate

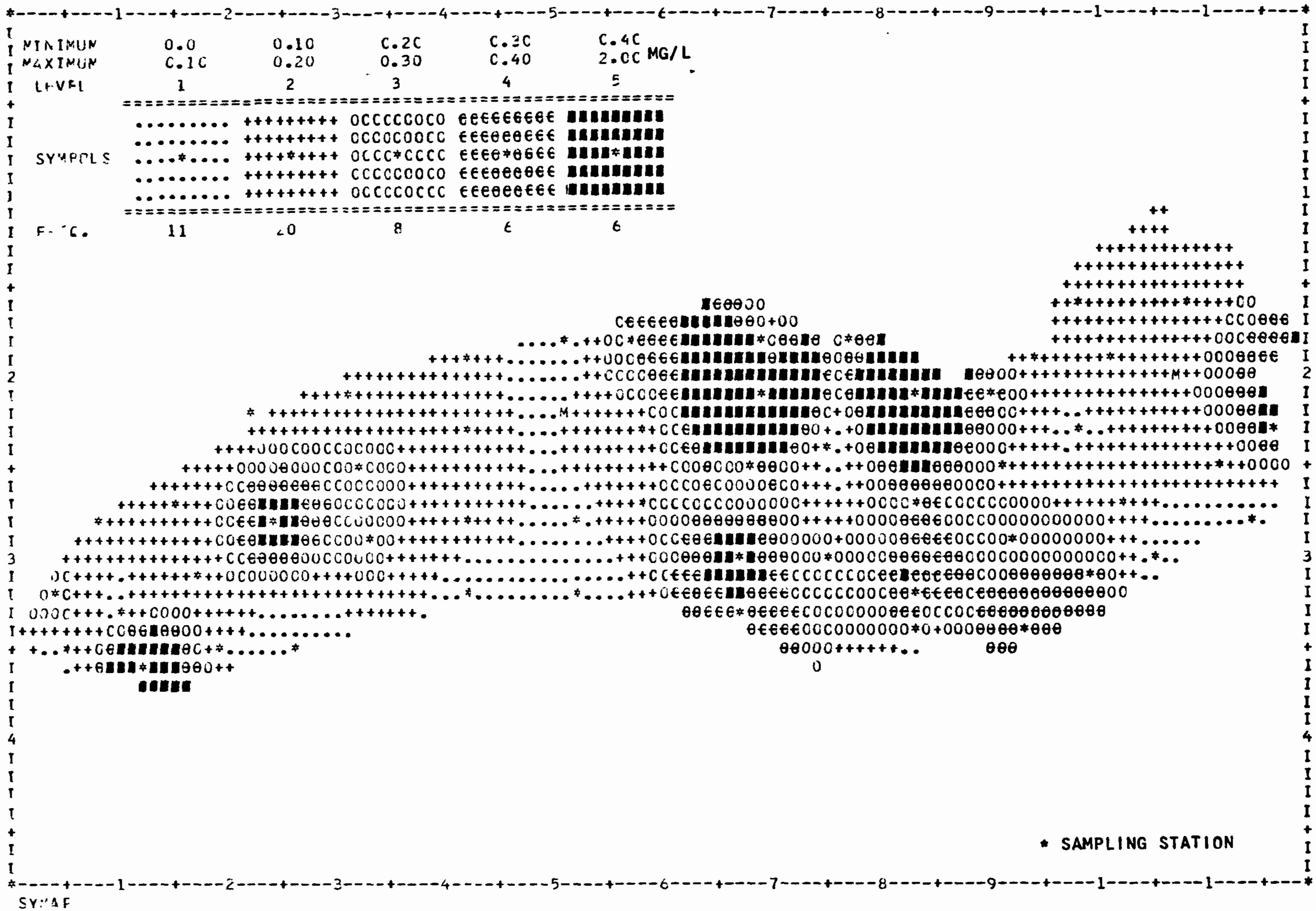


Figure 4.7b Contours of Constant Surface Nitrite-Nitrate

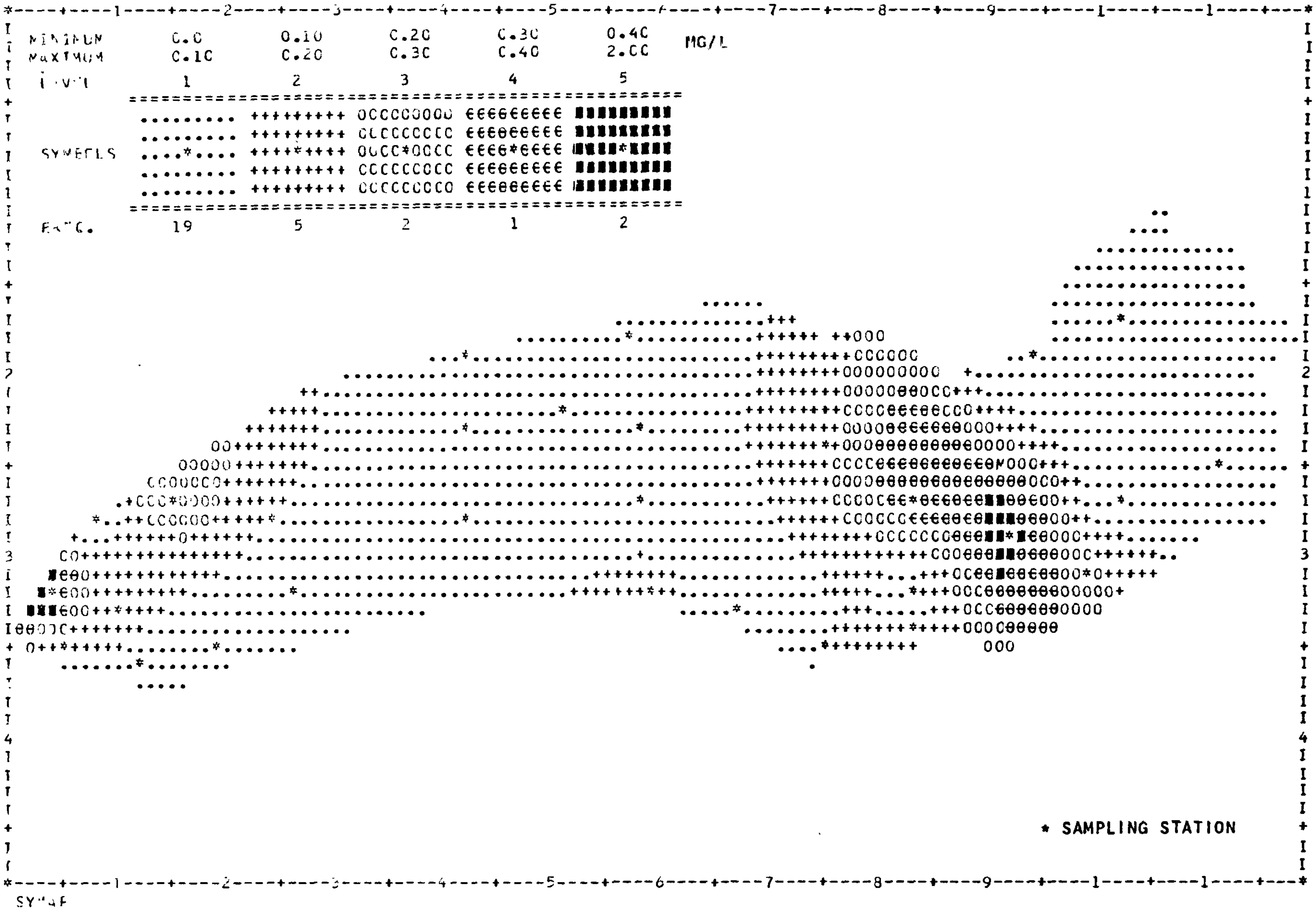


Figure 4.7b Contours of Constant Surface Nitrite-Nitrate

CRUISE NUMBER 4: JULY 10, 1972 TO JULY 14, 1972

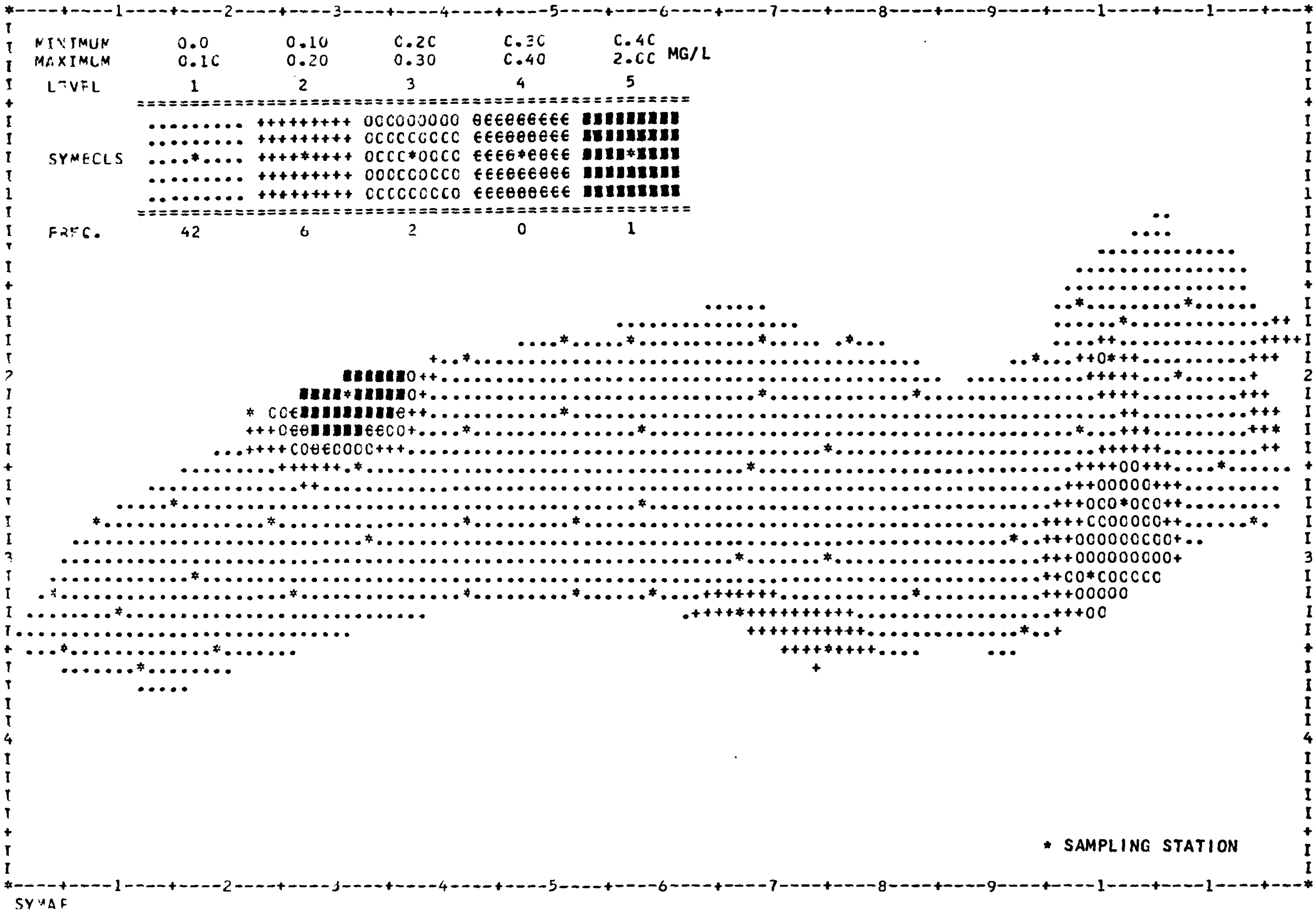


Figure 4.7b Contours of Constant Surface Nitrite-Nitrate

CRUISE NUMBER 5: AUGUST 21, 1972 TO AUGUST 25, 1972

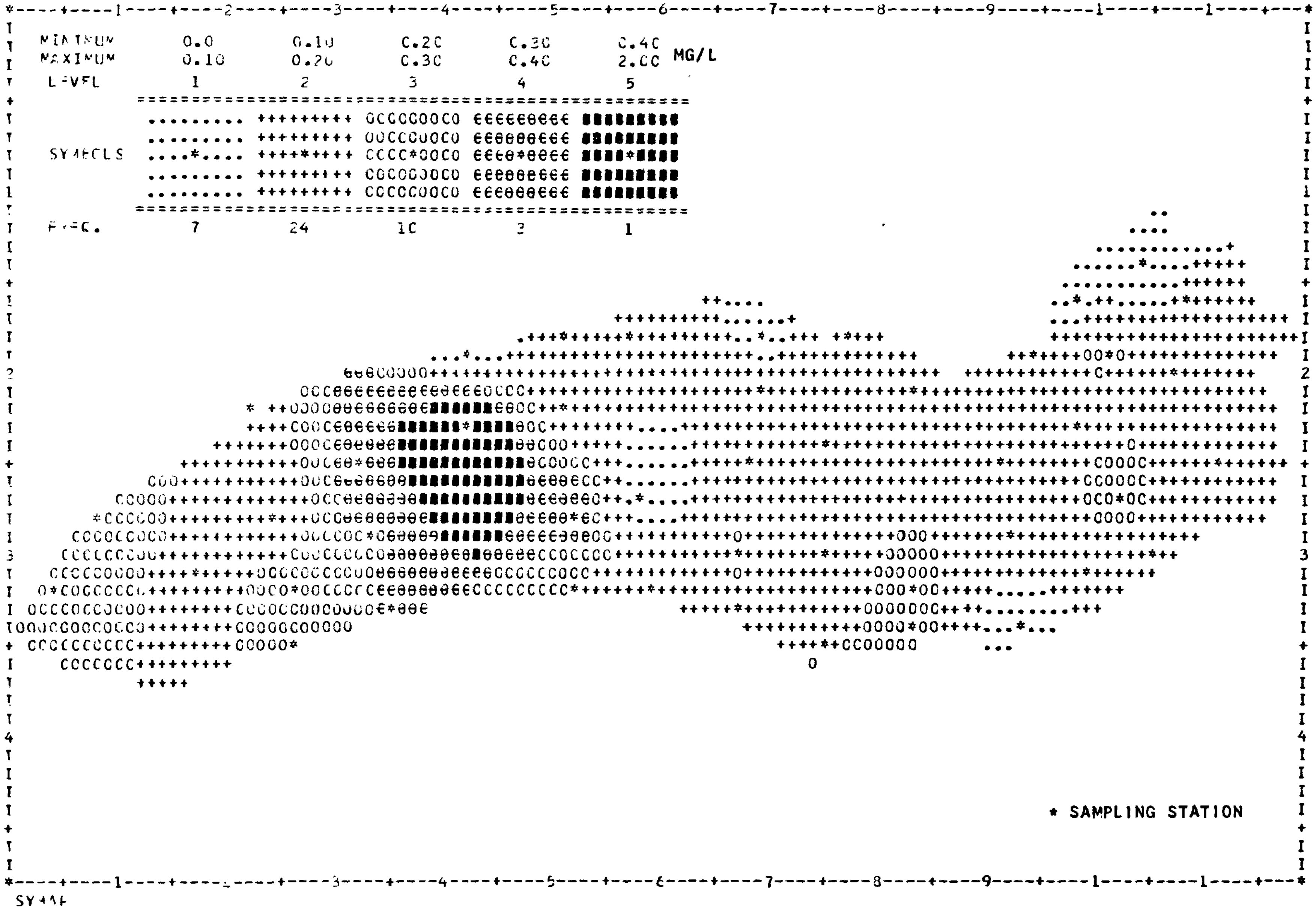


Figure 4.7b Contours of Constant Surface Nitrite-Nitrate

CRUISE NUMBER 6: OCTOBER 30, 1972 TO NOVEMBER 3, 1972

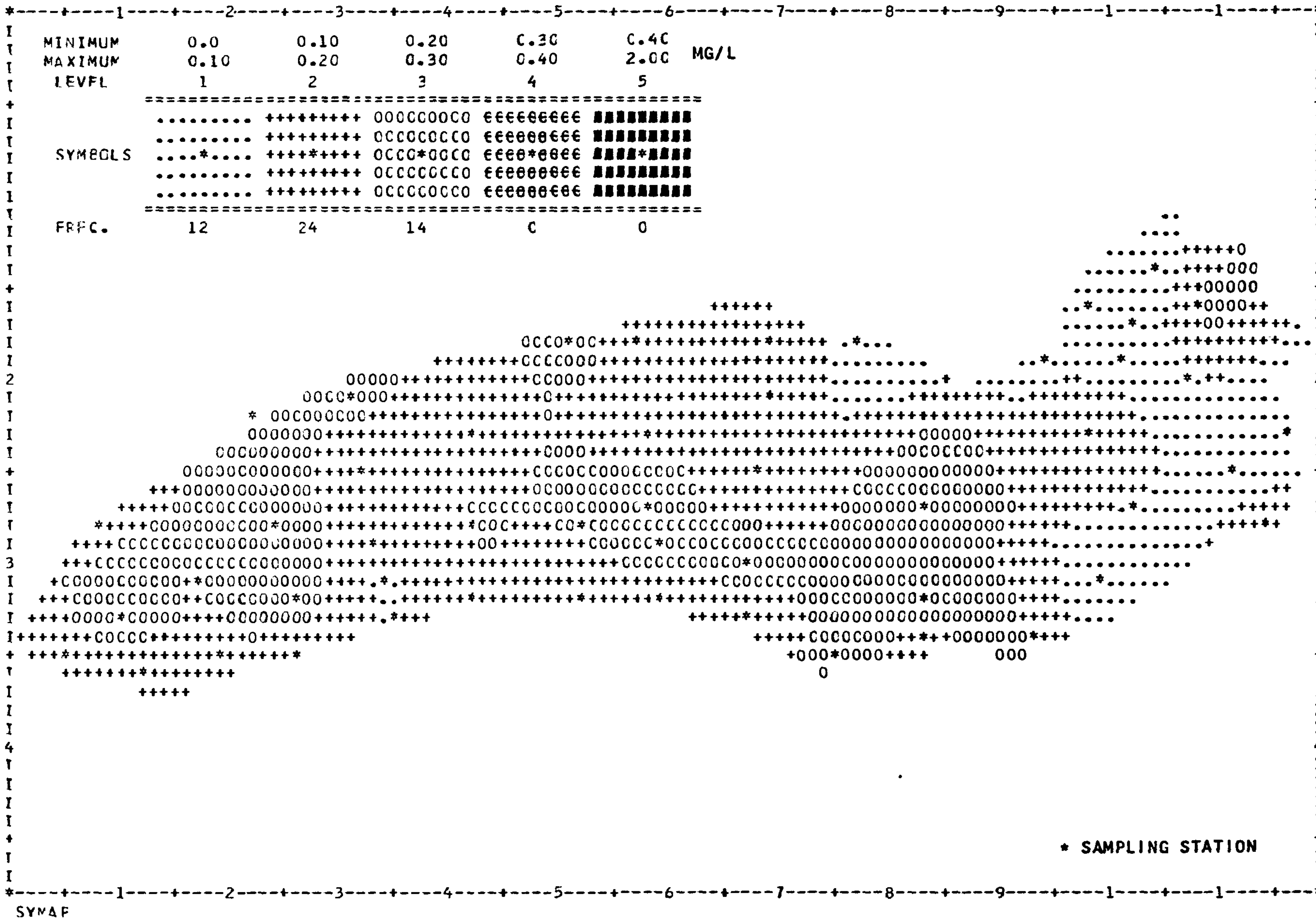


Figure 4.7b Contours of Constant Surface Nitrite-Nitrate

CRUISE NUMBER 7: NOVEMBER 27, 1972 TO DECEMBER 2, 1972

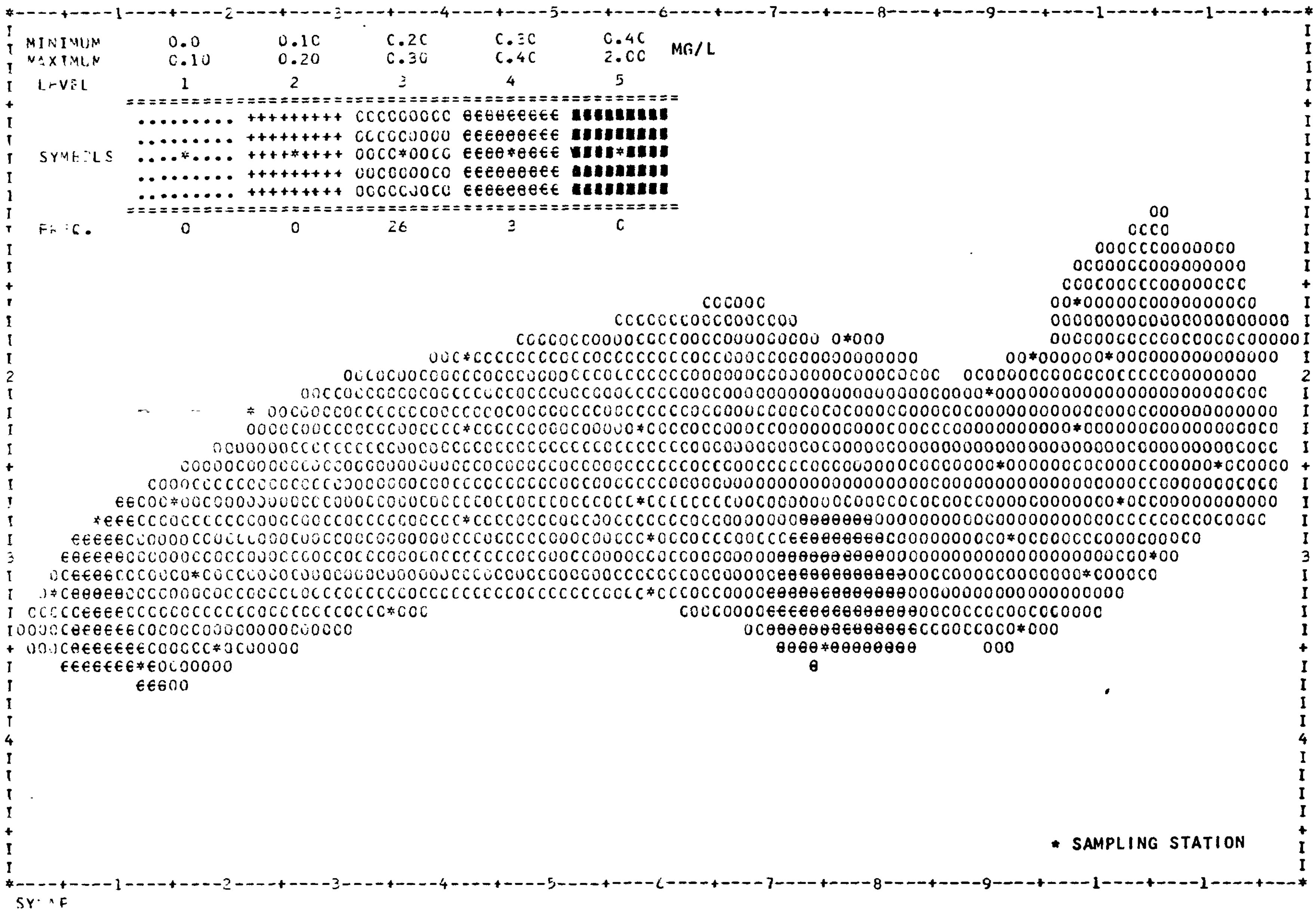
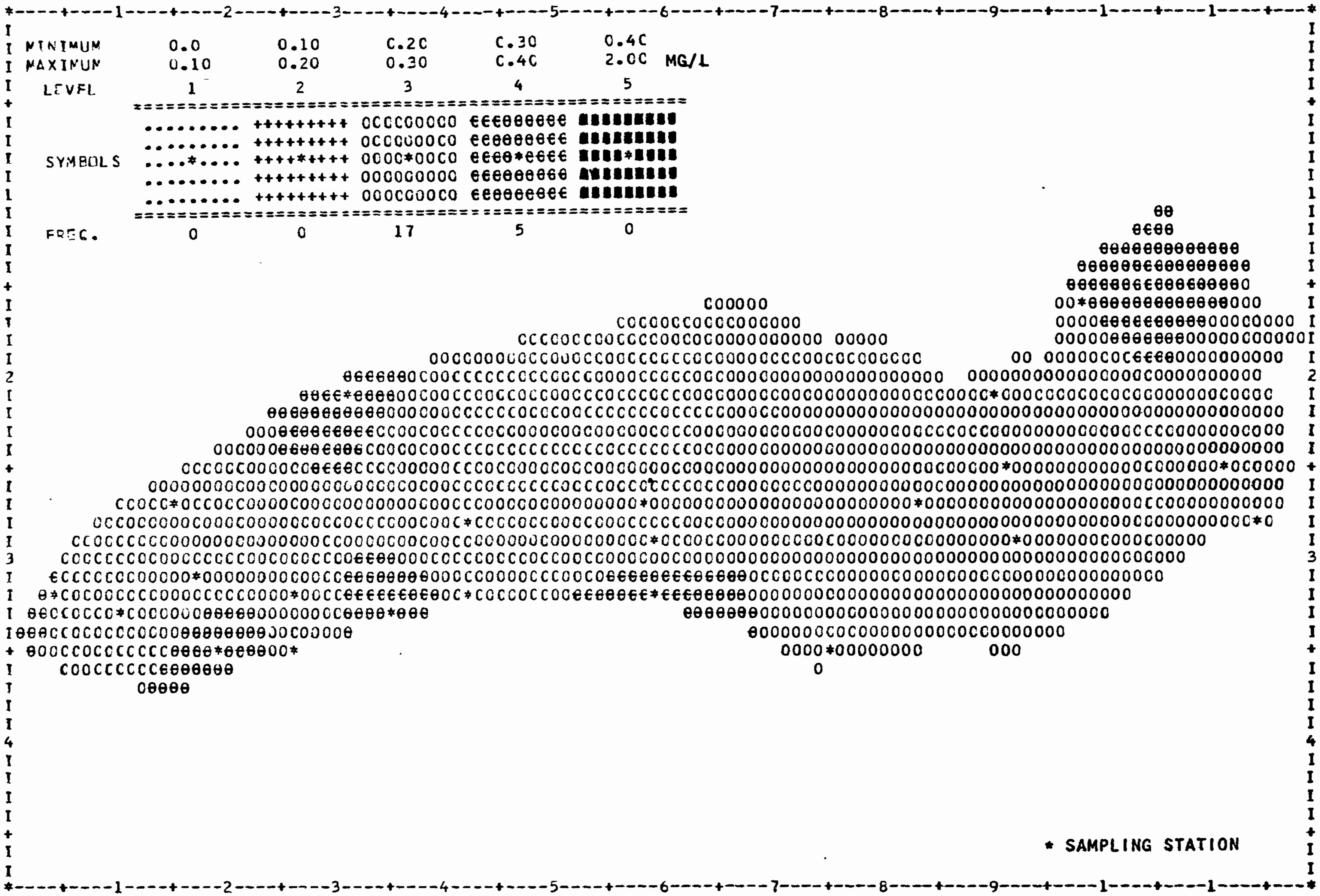


Figure 4.7b Contours of Constant Surface Nitrite-Nitrate

CRUISE NUMBER 6: FEBRUARY 5, 1973 TO FEBRUARY 9, 1973



SYMAP

Figure 4.7b Contours of Constant Surface Nitrite-Nitrate

CRUISE NUMBER 9: MARCH 18, 1973 TO MARCH 23, 1973

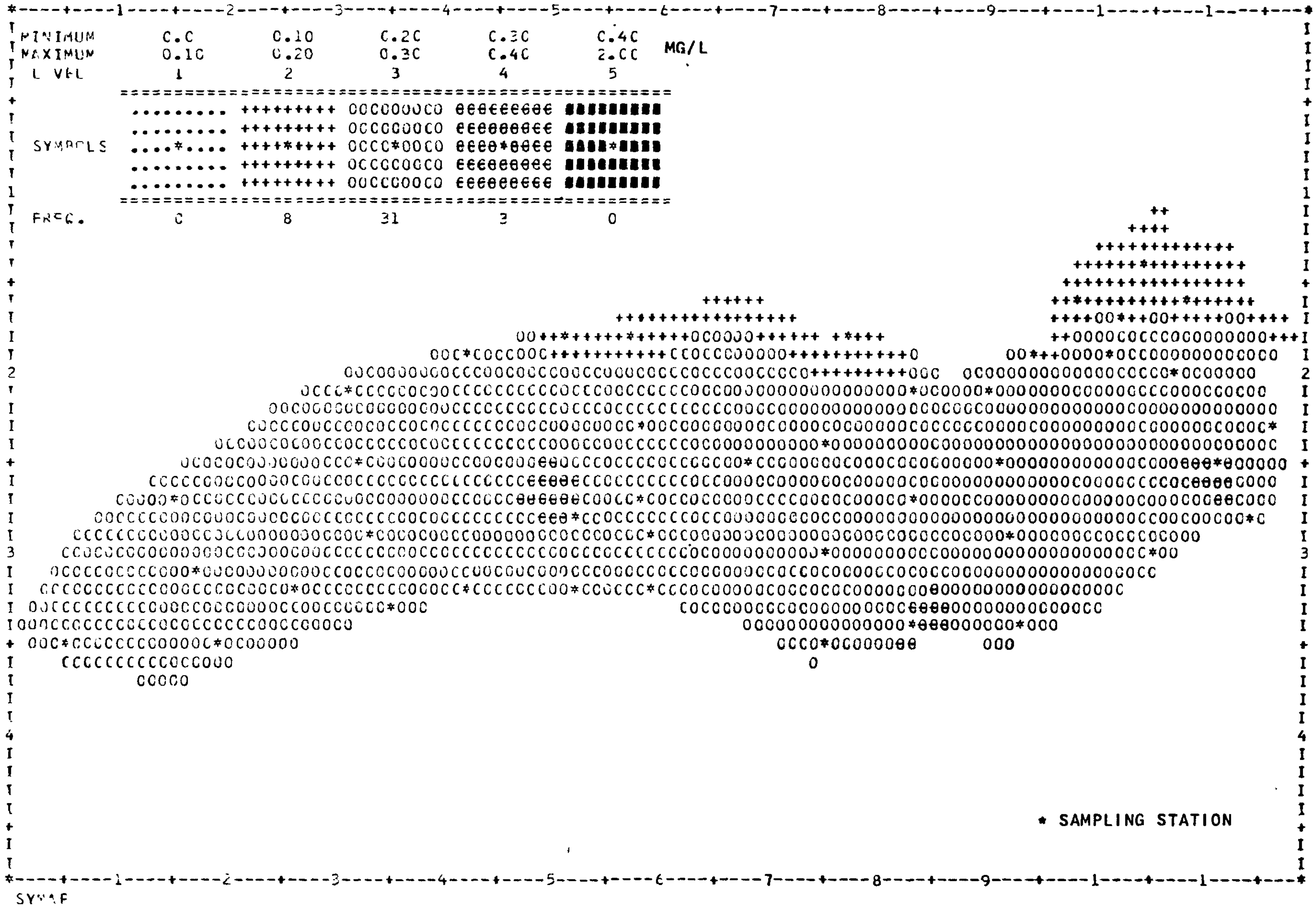


Figure 4.7b Contours of Constant Surface Nitrite-Nitrate

CRUISE NUMBER 10: APRIL 24, 1973 TO APRIL 30, 1973

MINIMUM	0.0	0.10	0.20	0.30	0.40	MG/L
MAXIMUM	0.10	0.20	0.30	0.40	2.00	
LEVEL	1	2	3	4	5	
SYMBOLS	....	+++++++++	000000000	θθθθθθθθθ	███████	
FREQ.	21	8	6	5	1	

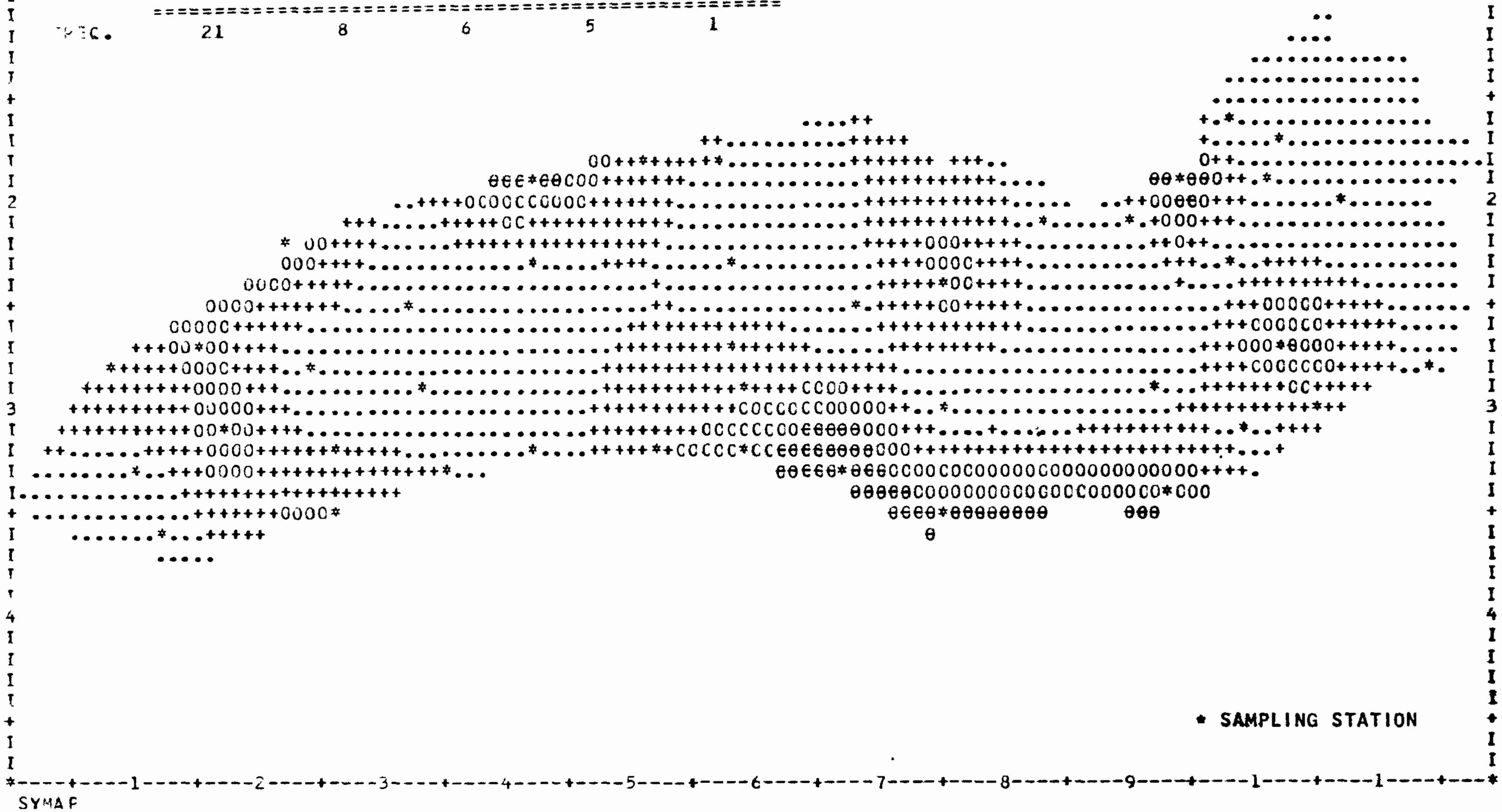


Figure 4.7b Contours of Constant Surface Nitrite-Nitrate

CRUISE NUMBER 11: JUNE 11, 1973 TO JUNE 15, 1973

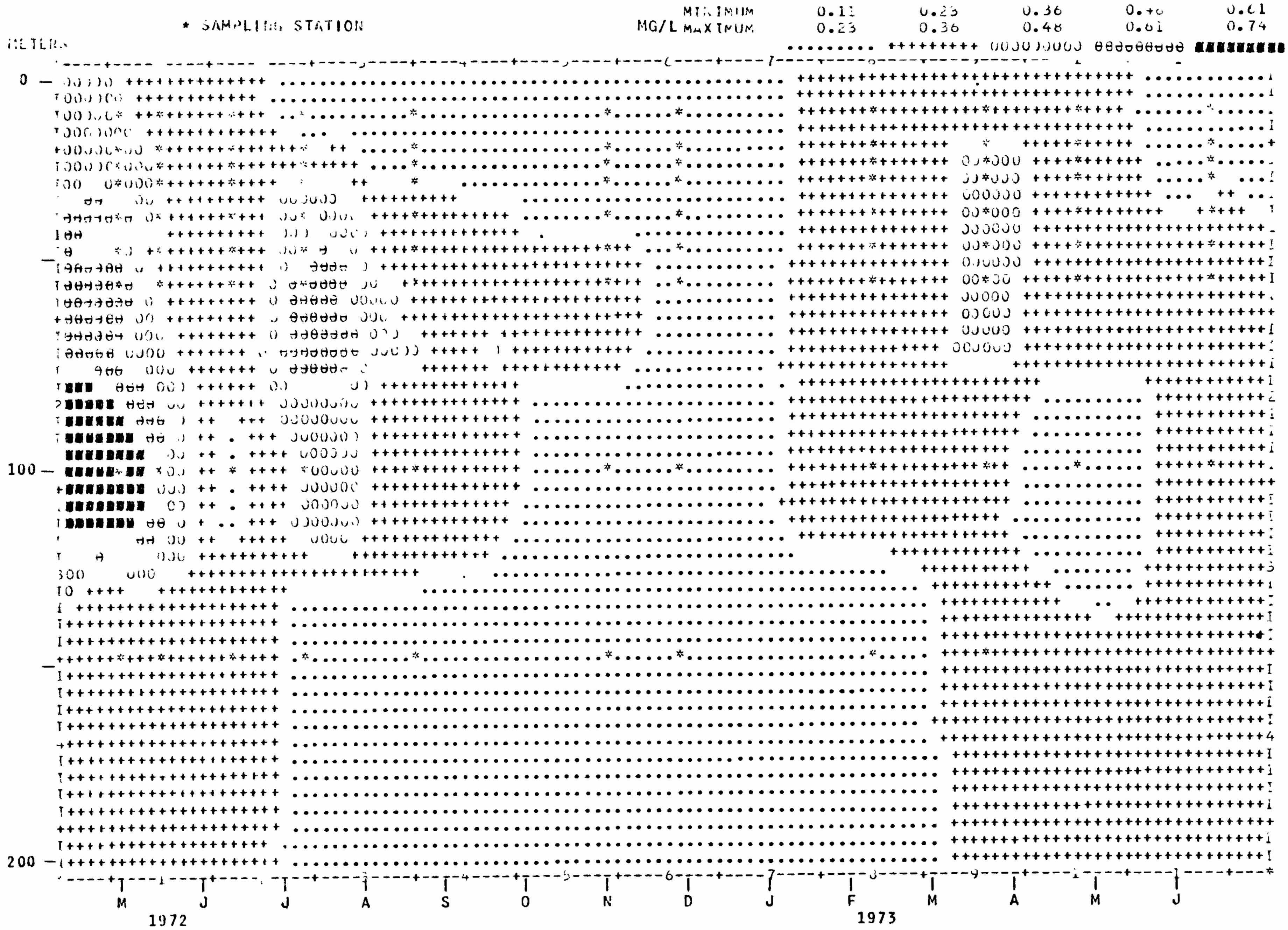


Figure 4.7c Depth Versus Time Contours of Nitrite-Nitrate

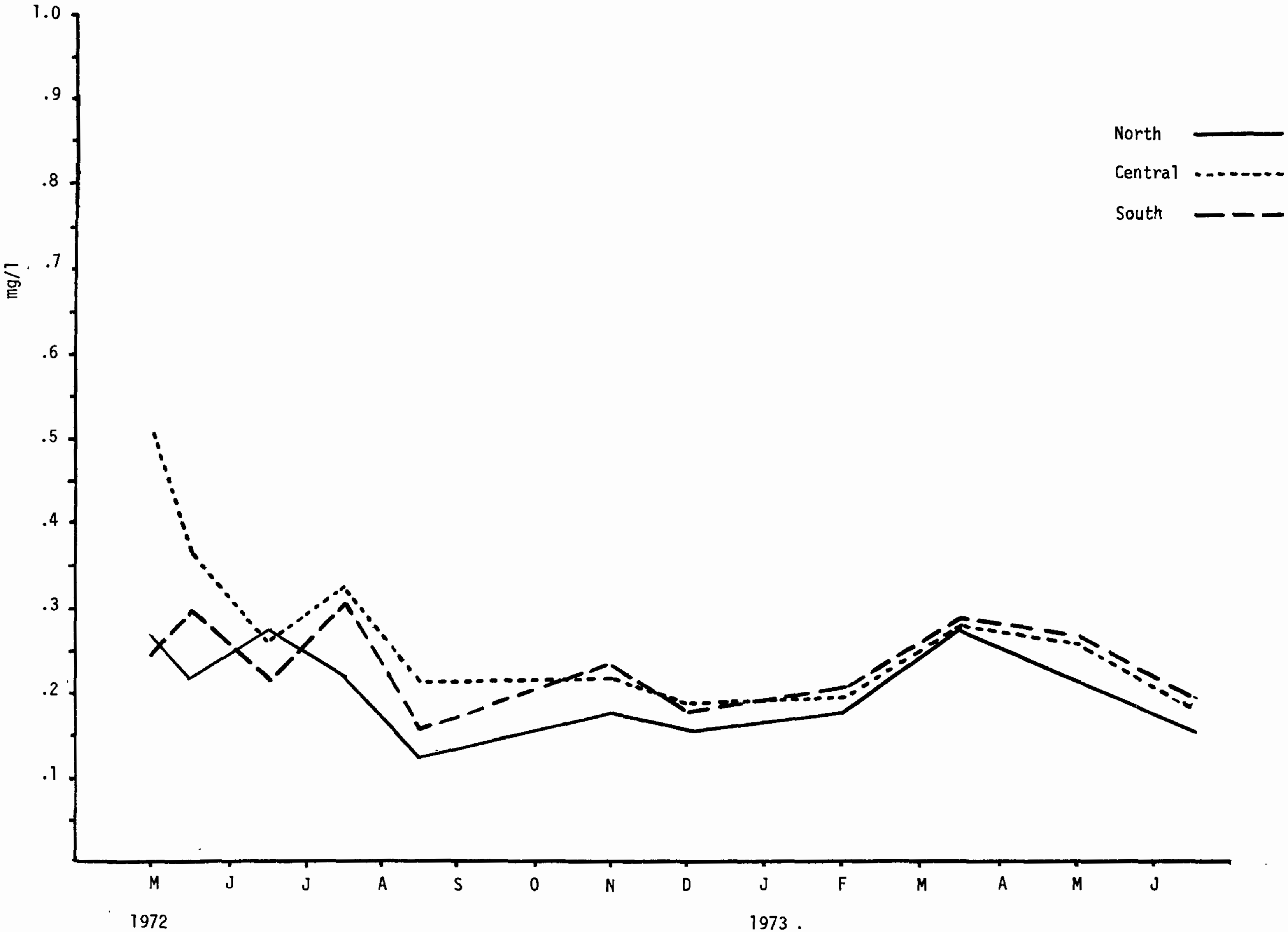


Figure 4.7d North-South Variation of Mean Nitrite-Nitrate During the Field Year

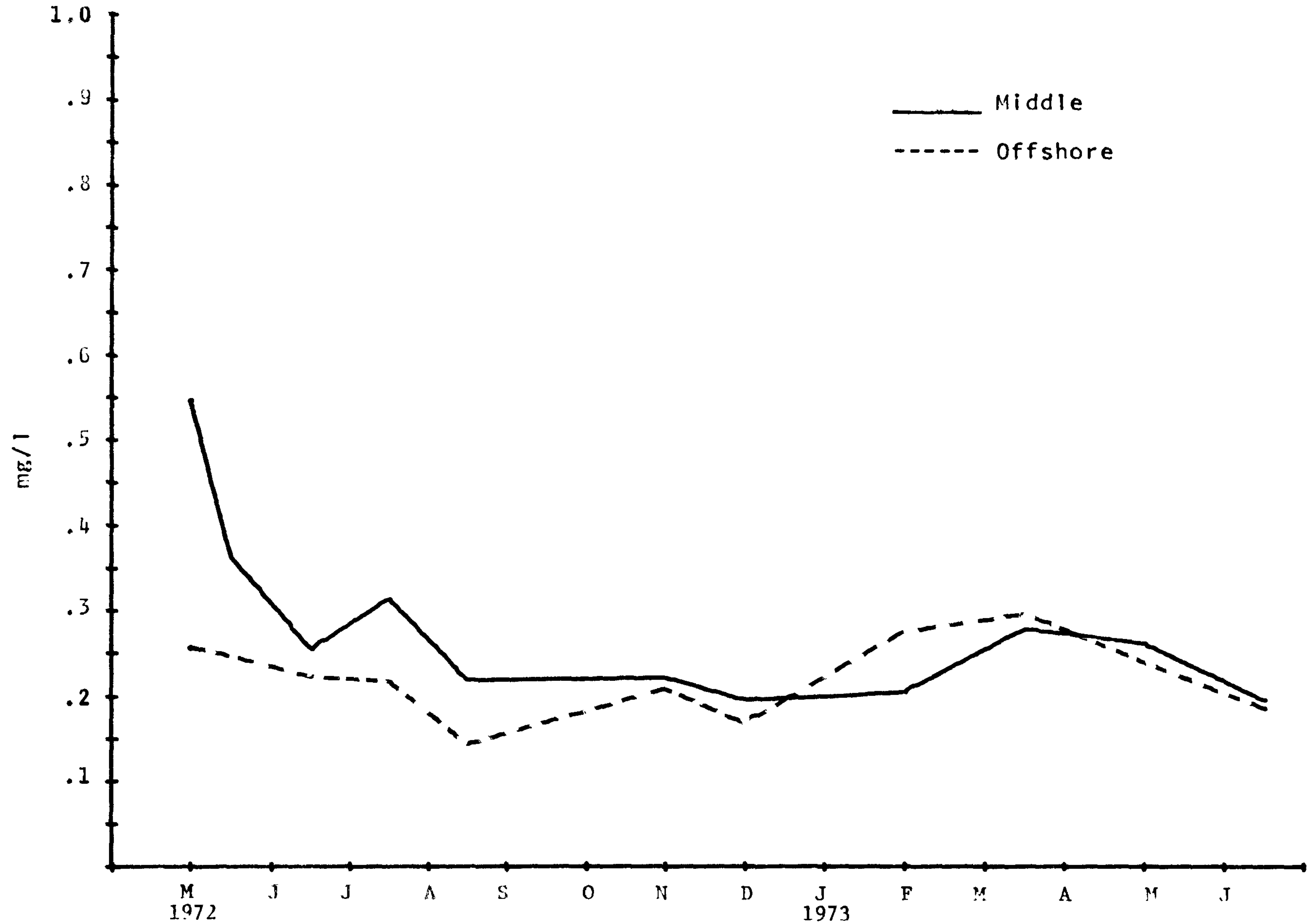


Figure 4.7e Middle Lake-Offshore Variations of Mean Nitrite-Nitrate Concentration

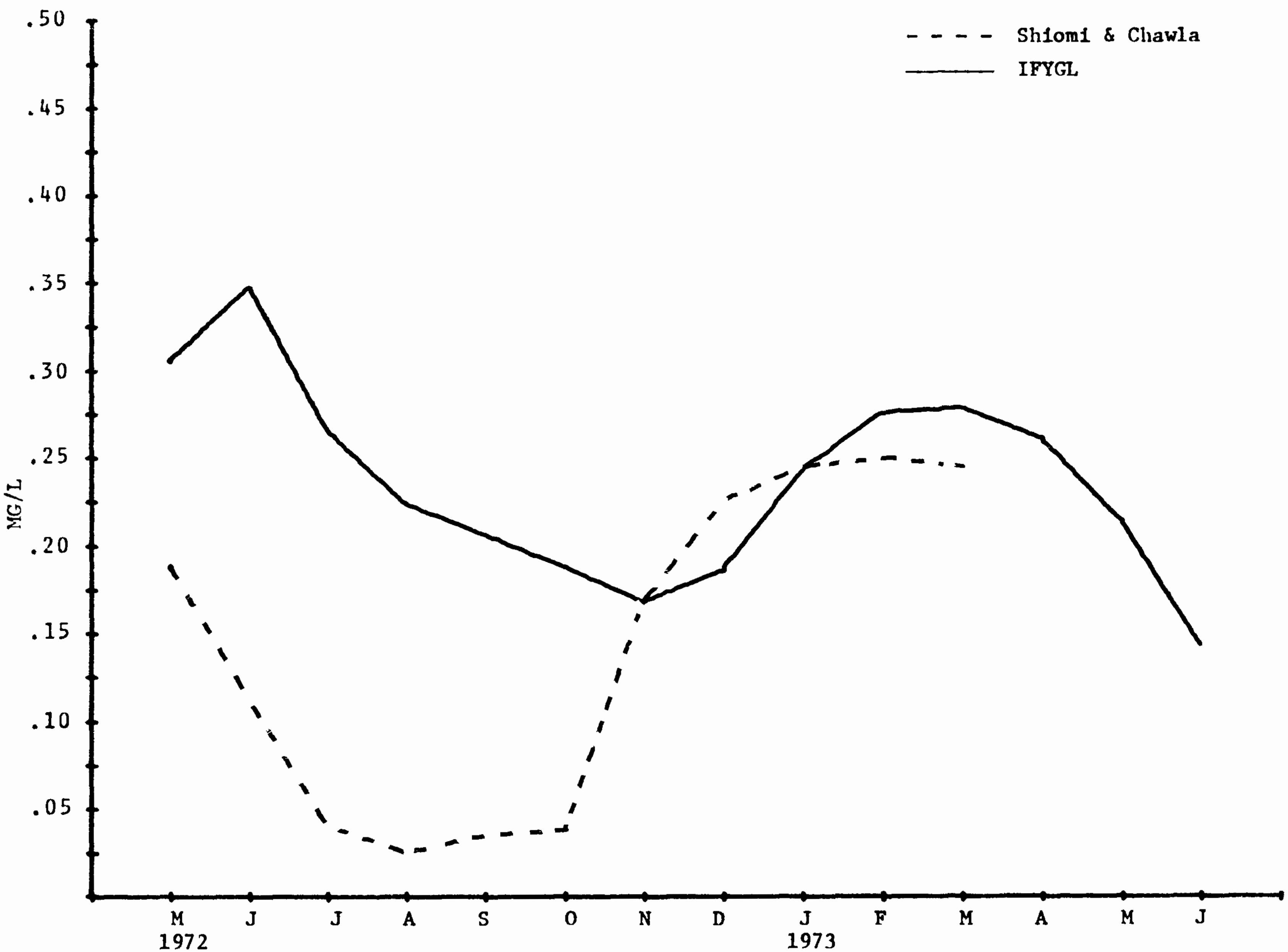


Figure 4.7f Mean surface variations of Nitrite-Nitrate concentration during the field year.

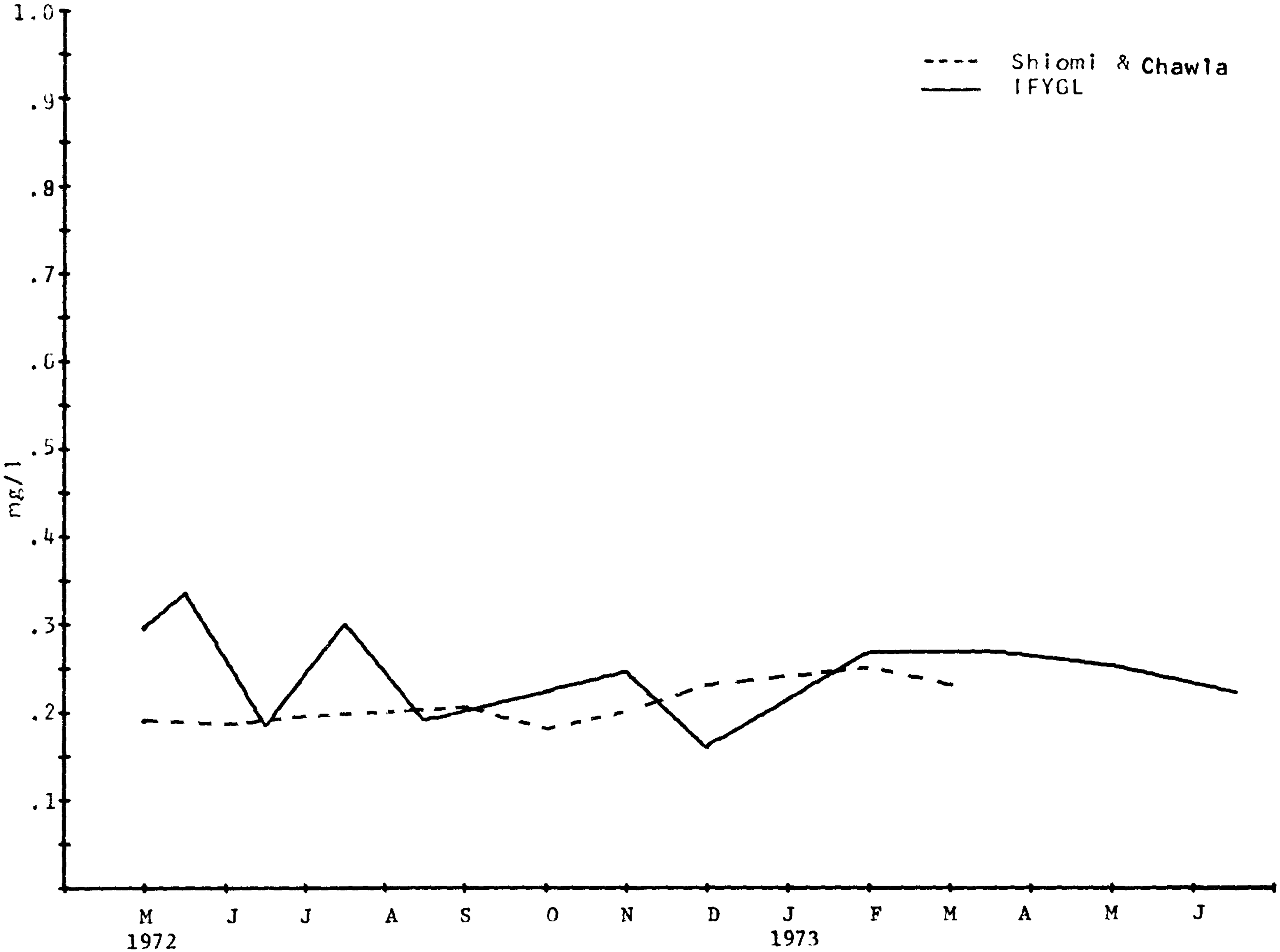


Figure 4.7g Mean Bottom Variation of Nitrite-Nitrate Concentration During the Field Year

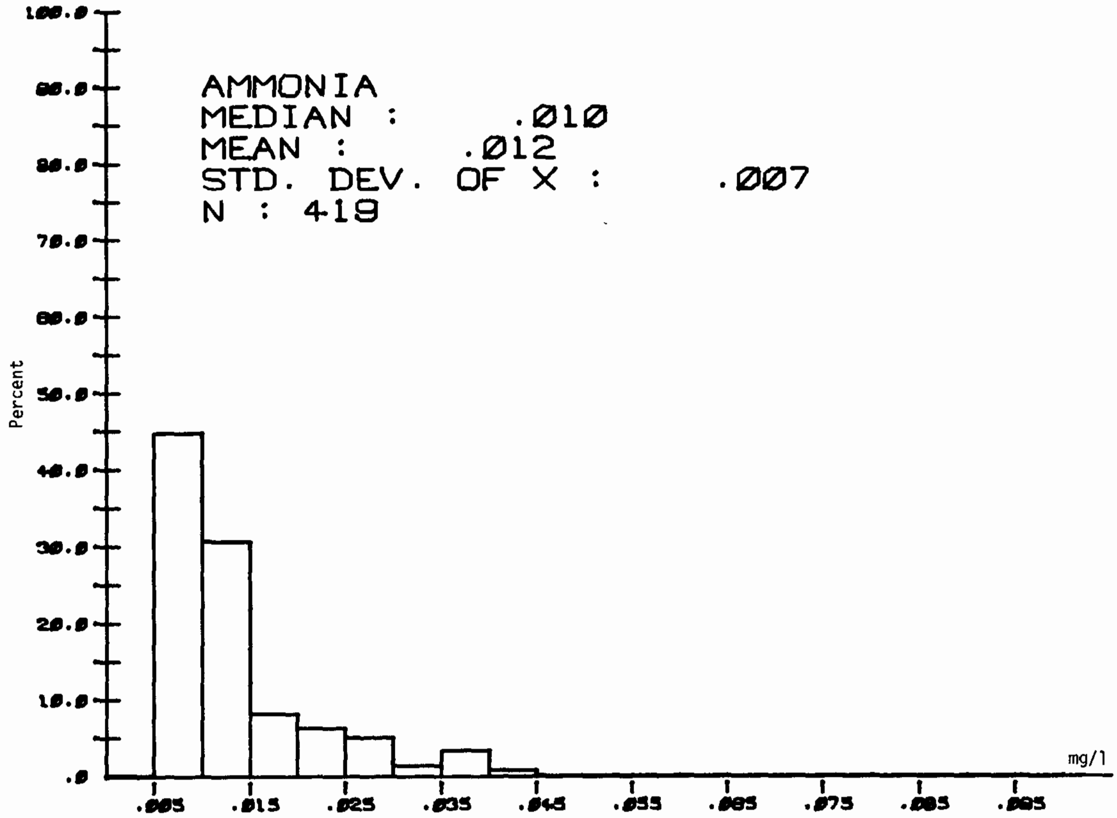


Figure 4.8a Histograms for Ammonia - Cruise 3

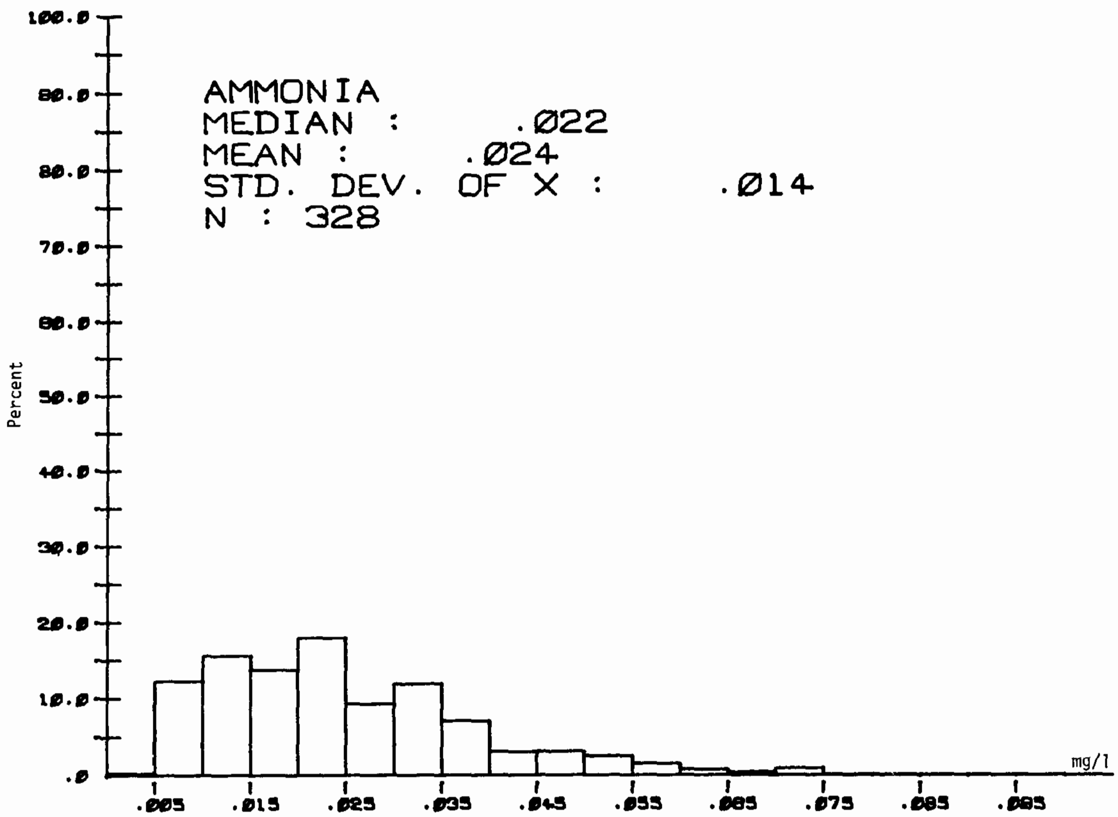


Figure 4.8a Histograms for Ammonia - Cruise 4

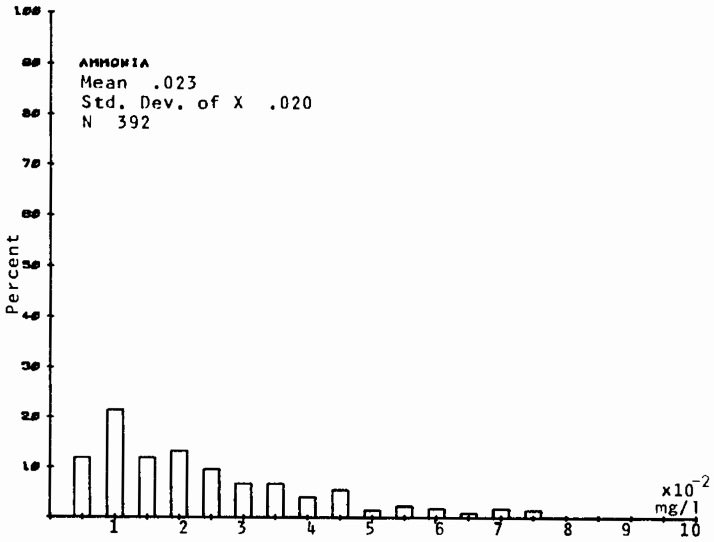


Figure 4.8a Histograms for Ammonia - Cruise 5

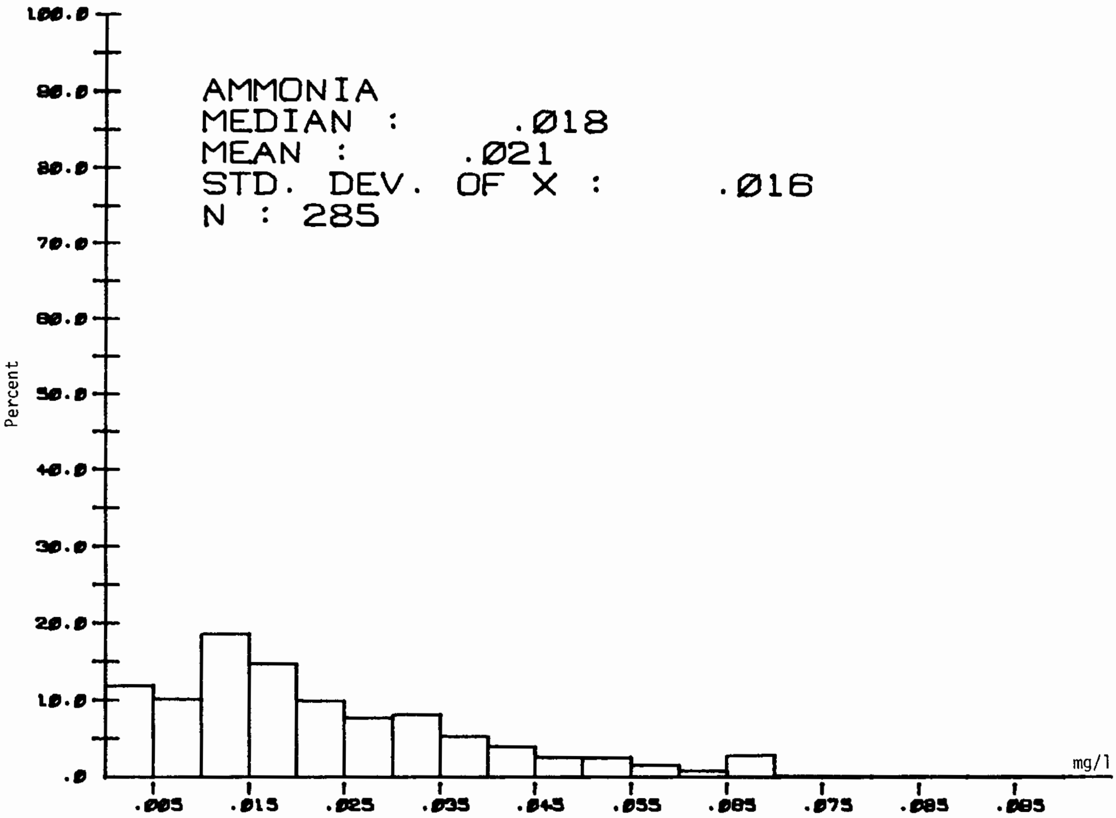


Figure 4.8a Histograms for Ammonia - Cruise 6

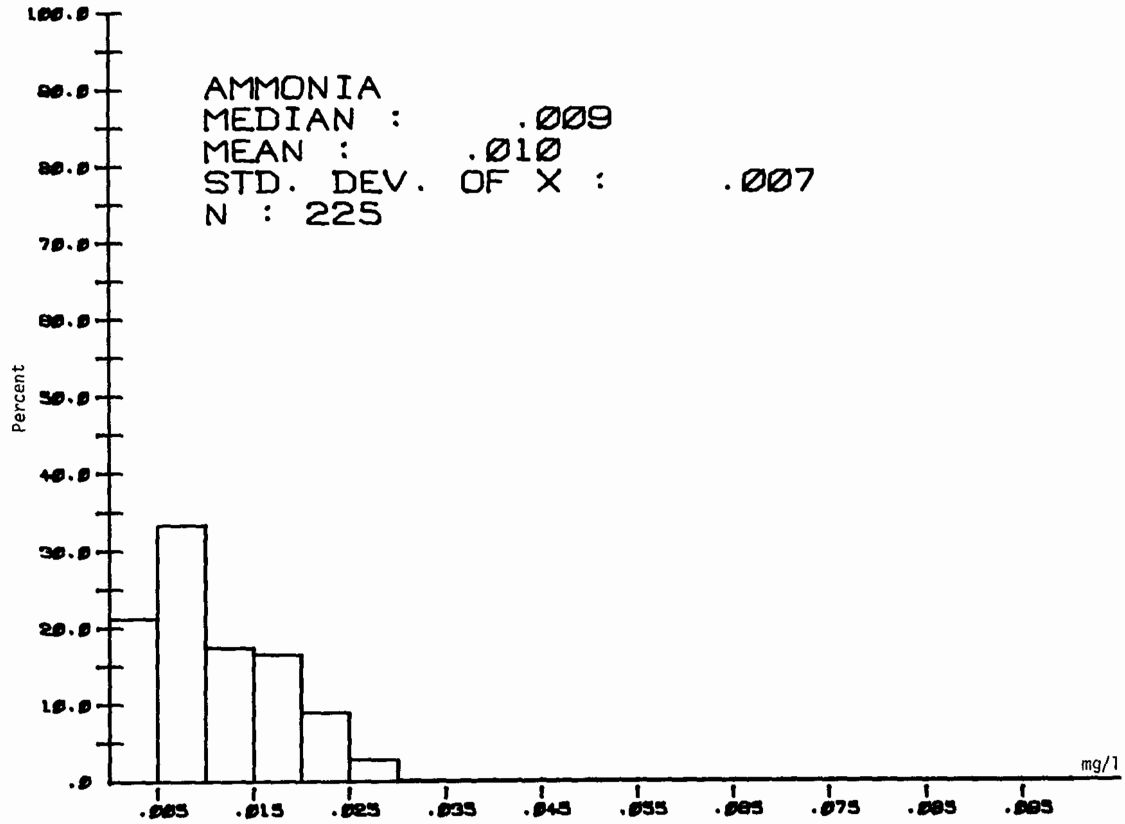


Figure 4.8a Histograms for Ammonia - Cruise 7

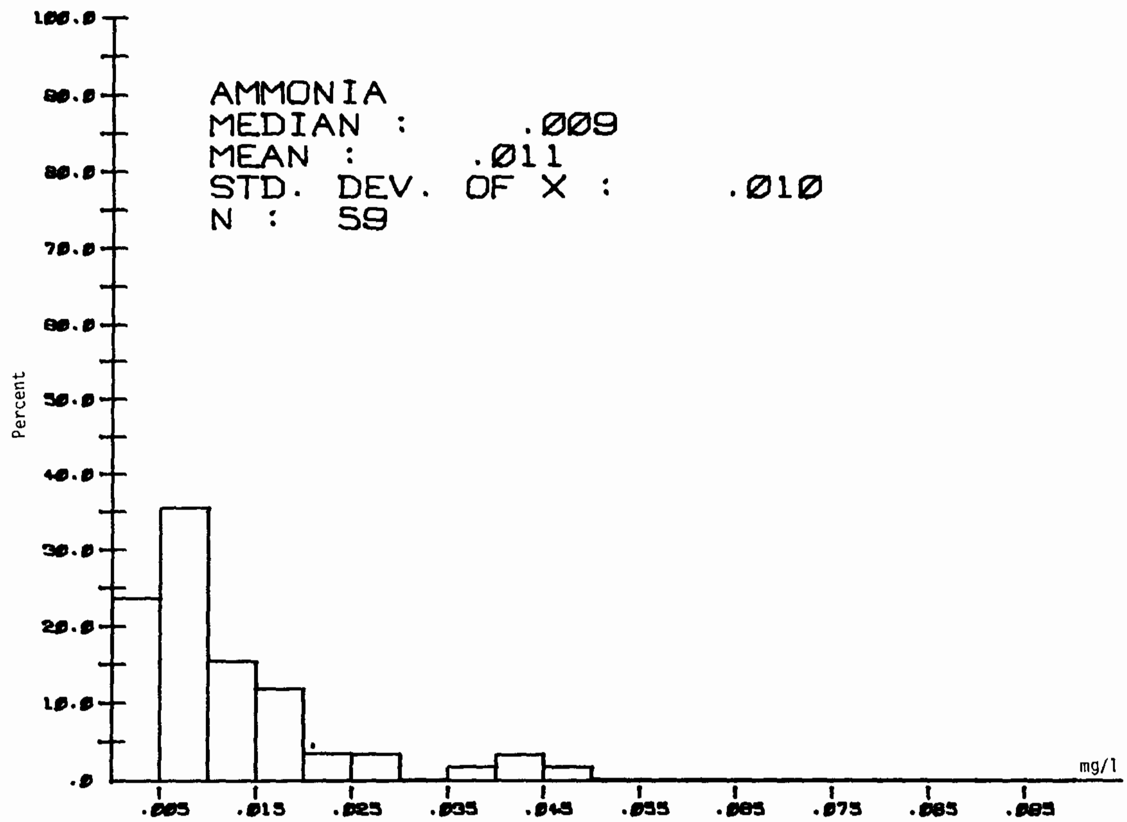


Figure 4.8a Histograms for Ammonia - Cruise 8

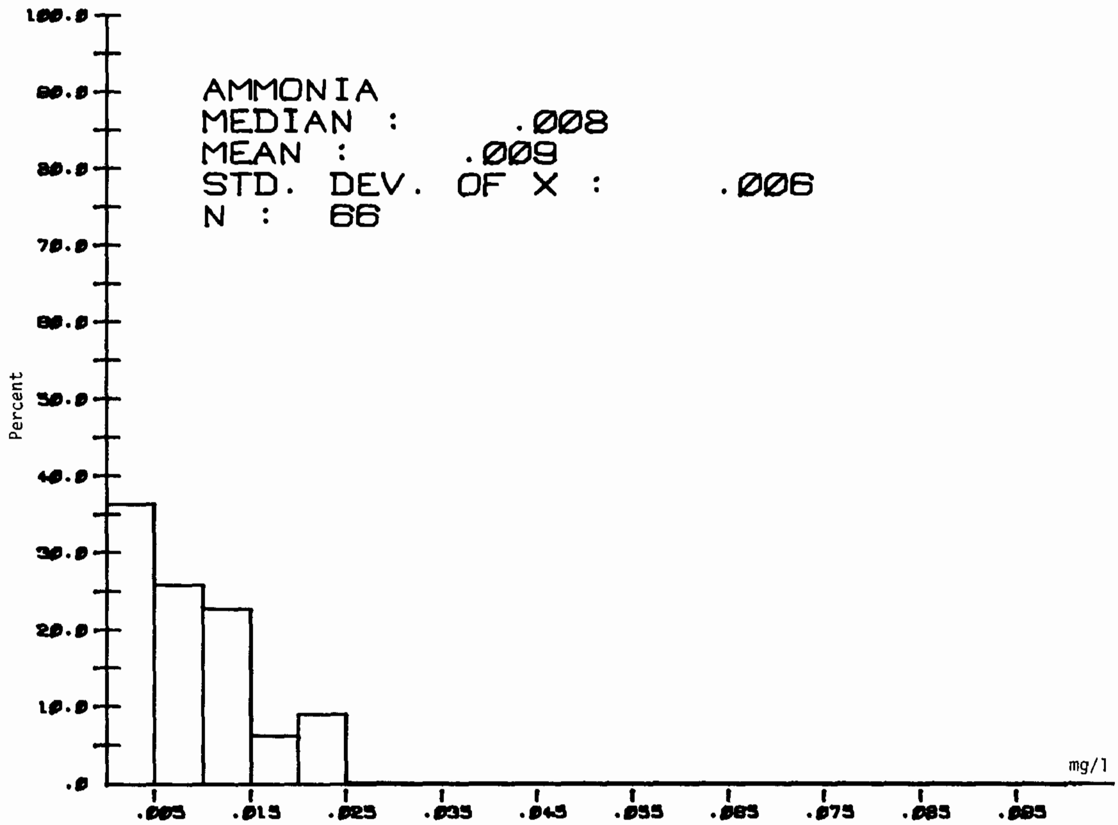


Figure 4.8a Histograms for Ammonia - Cruise 9

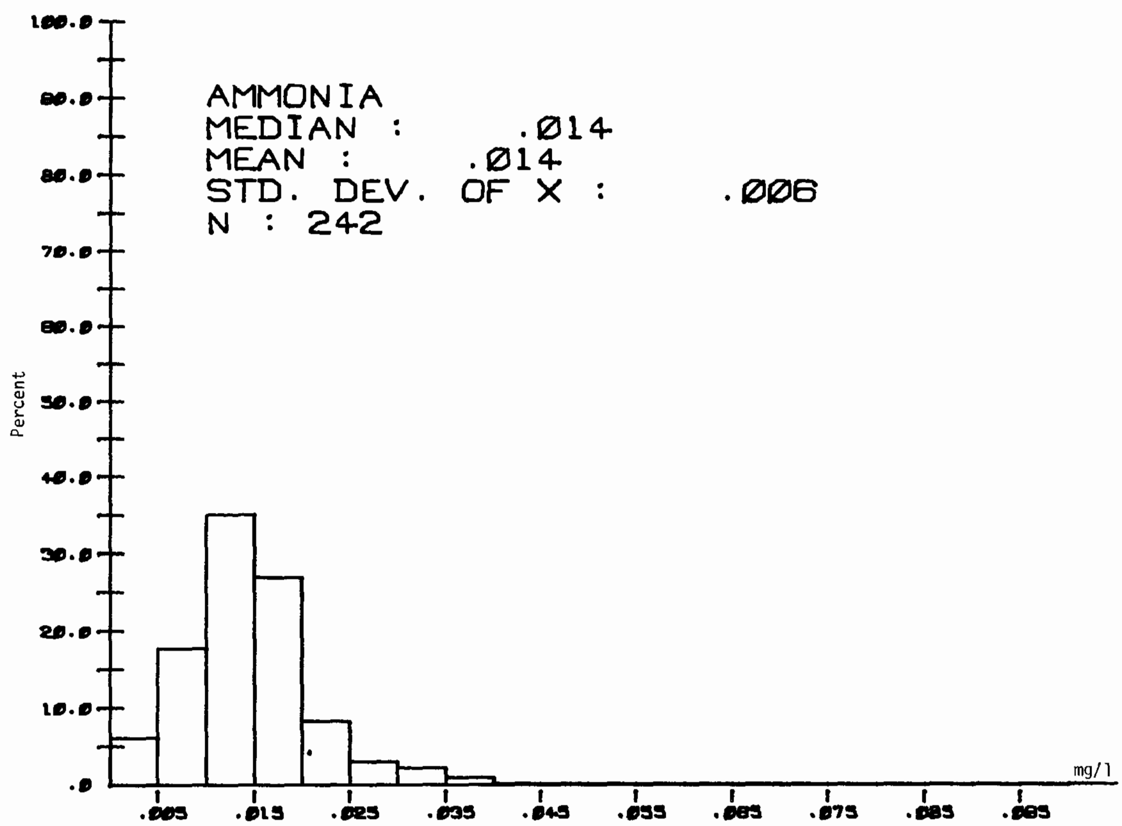


Figure 4.8a Histograms for Ammonia - Cruise 10

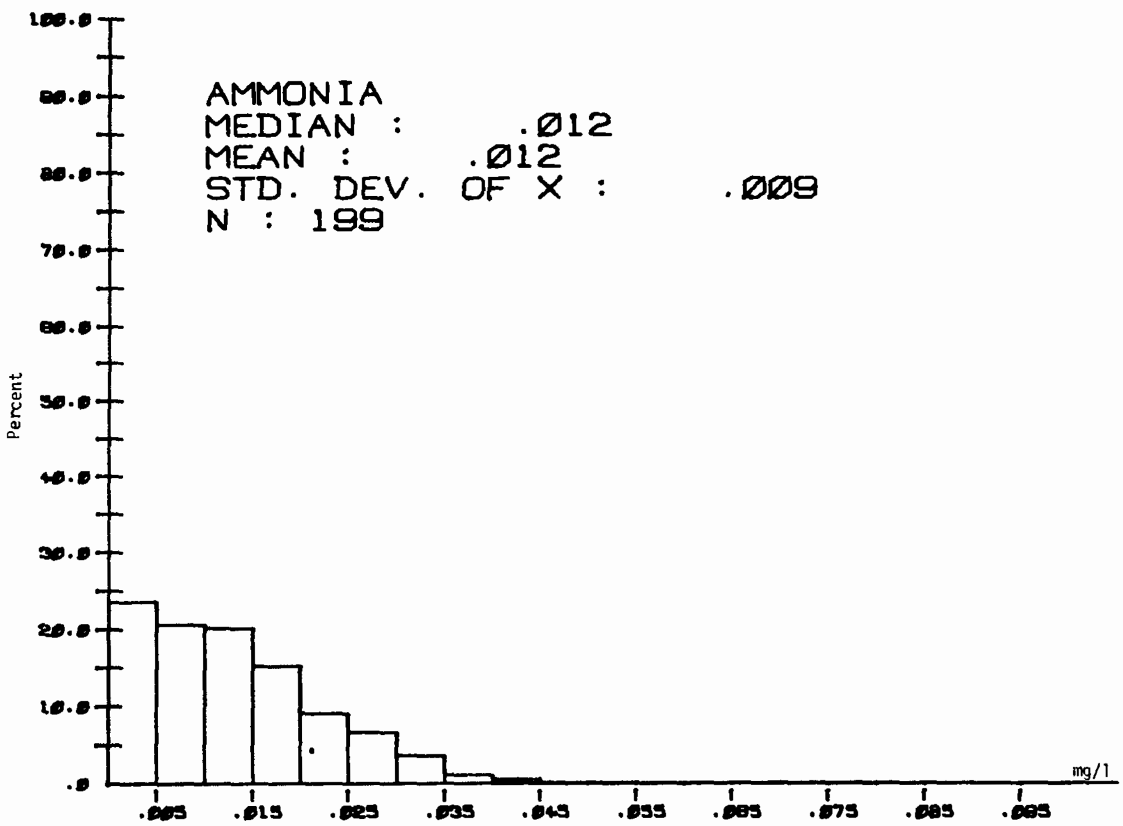


Figure 4.8a Histograms for Ammonia - Cruise 11

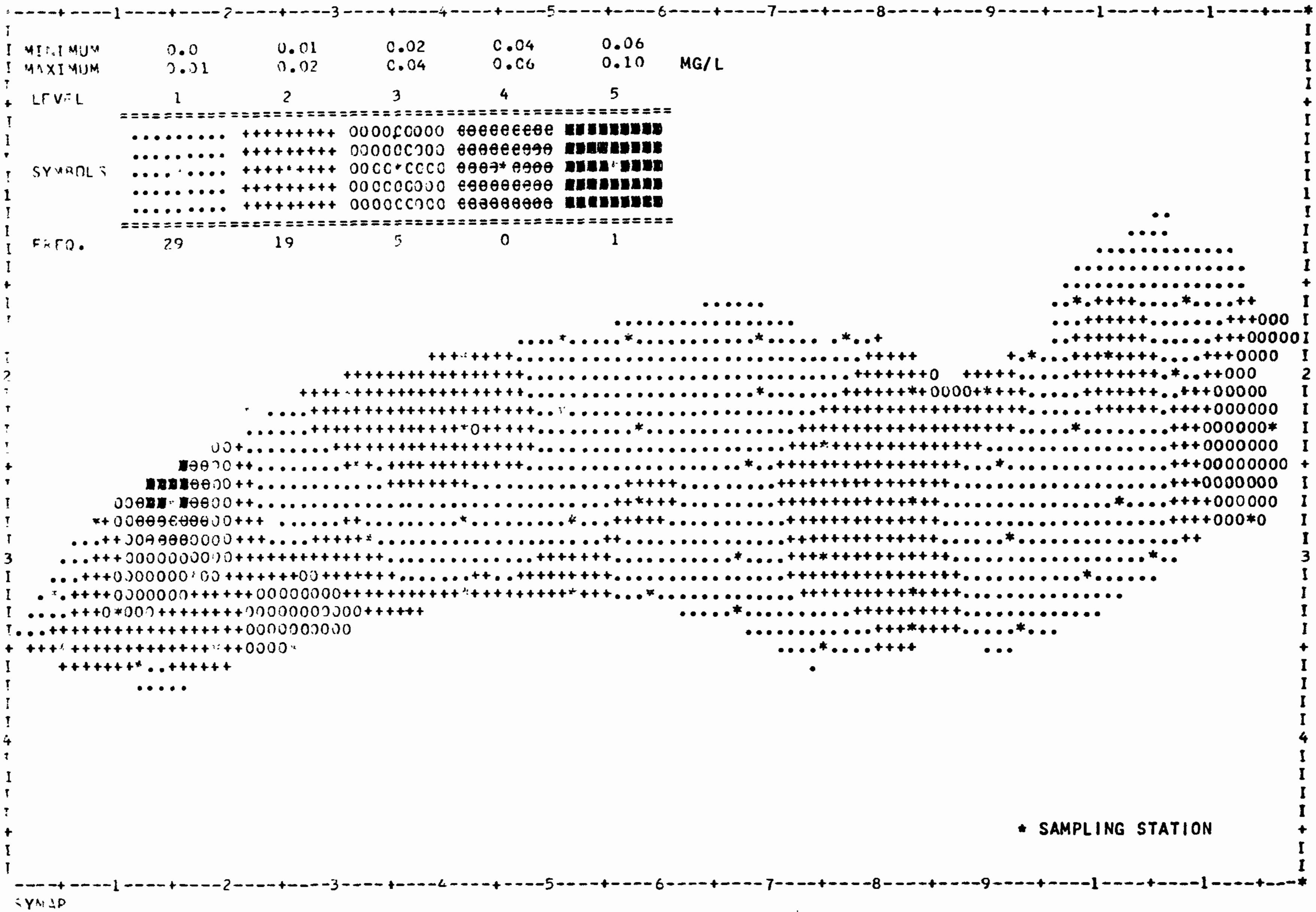


Figure 4.8b Contours of Constant Surface Ammonia

CRUISE NUMBER 3: JUNE 12, 1972 TO JUNE 16, 1972

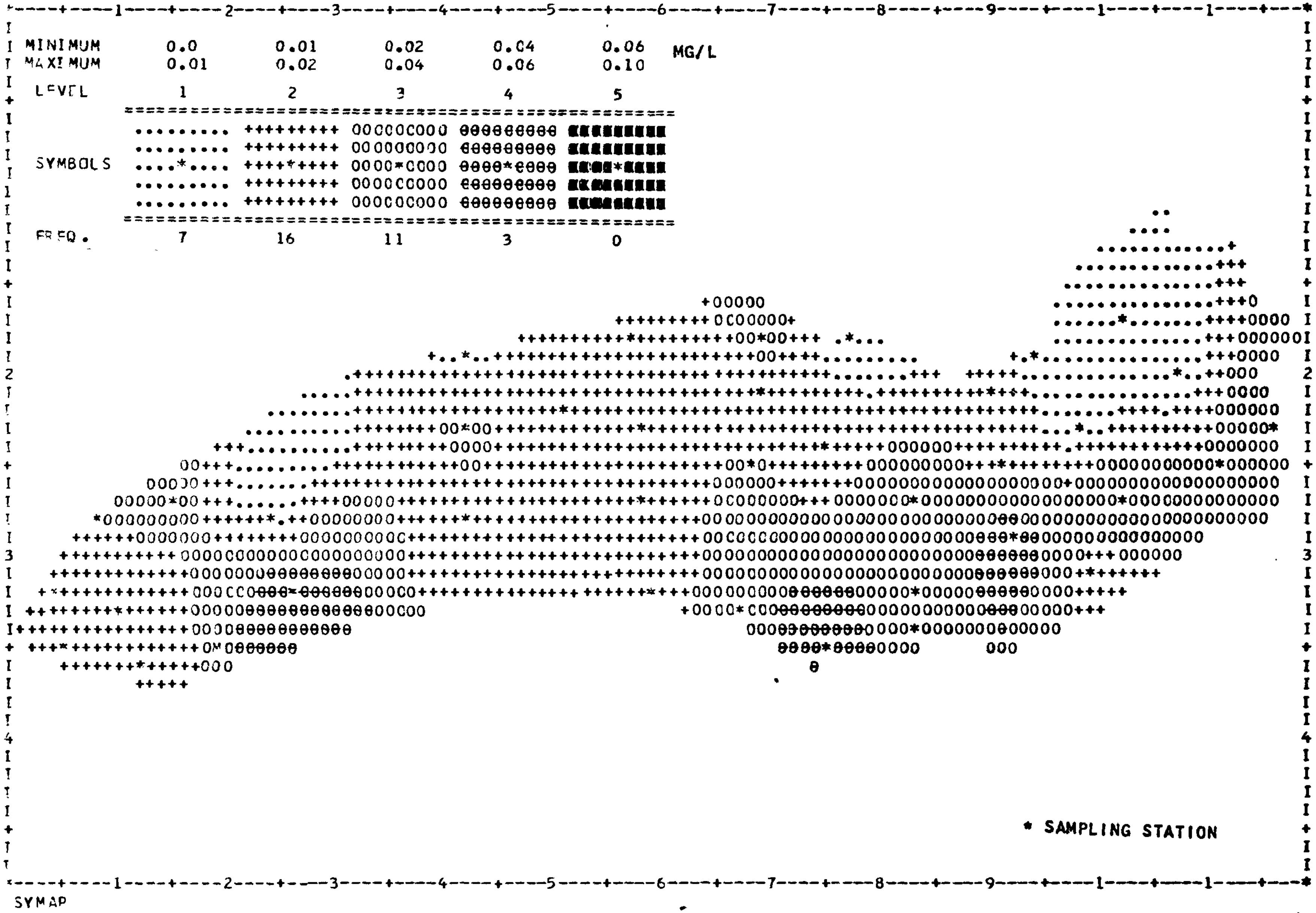


Figure 4.8b Contours of Constant Surface Ammonia

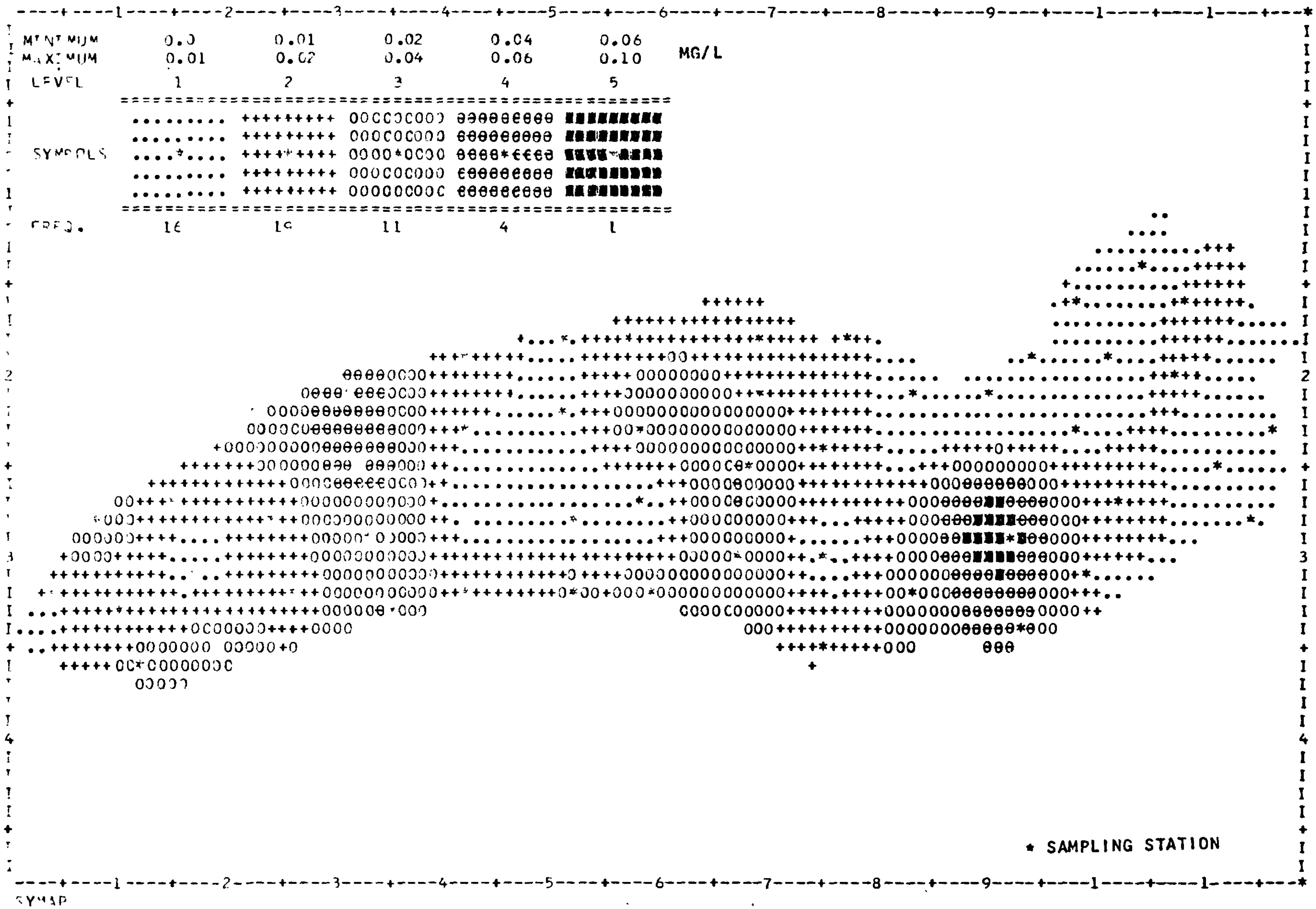


Figure 4.8b Contours of Constant Surface Ammonia

CRUISE NUMBER 5: AUGUST 21, 1972 TO AUGUST 25, 1972

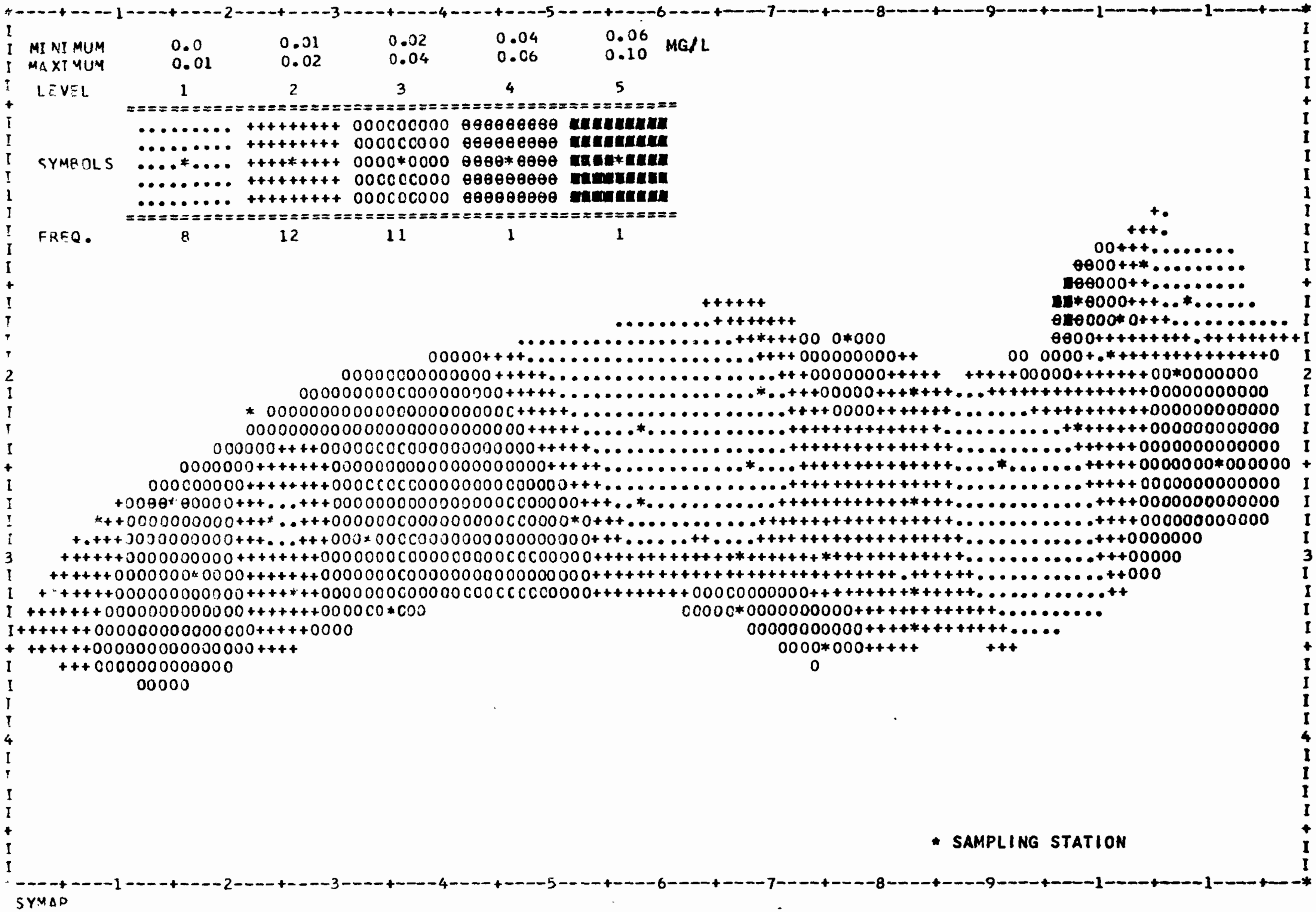


Figure 4.8b Contours of Constant Surface Ammonia

CRUISE NUMBER 6: OCTOBER 30, 1972 TO NOVEMBER 3, 1972

LEVEL	1	2	3	4	5	
MINIMUM	0.0	0.01	0.02	0.04	0.06	
MAXIMUM	0.01	0.02	0.04	0.06	0.10	MG/L
SYMBOLS	....	+++++++++	000000000	eeeeeeeee	■■■■■■■■■	
FREQ.	15	9	4	0	0	

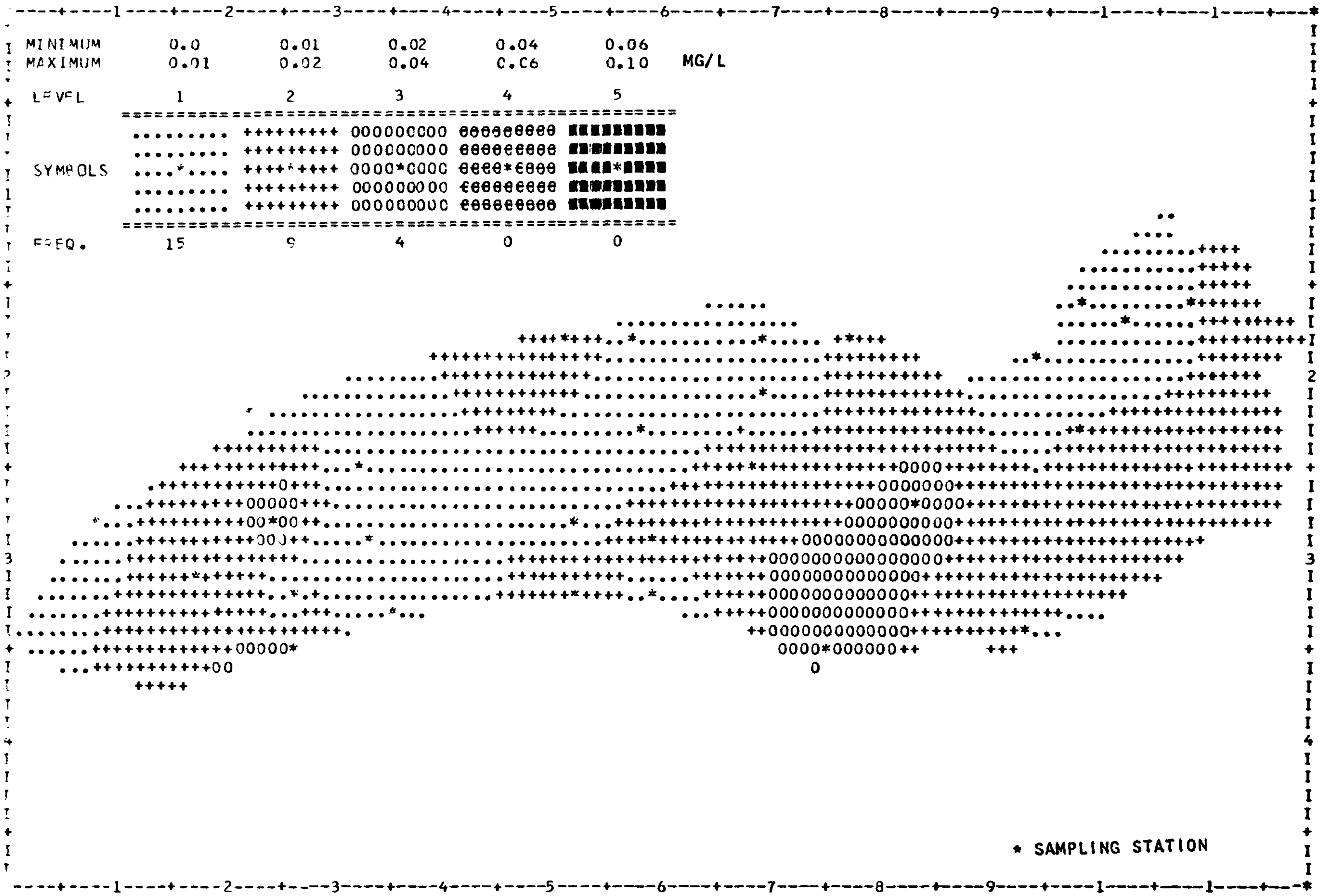


Figure 4.8b Contours of Constant Surface Ammonia

CRUISE NUMBER 7: NOVEMBER 27, 1972 TO DECEMBER 2, 1972

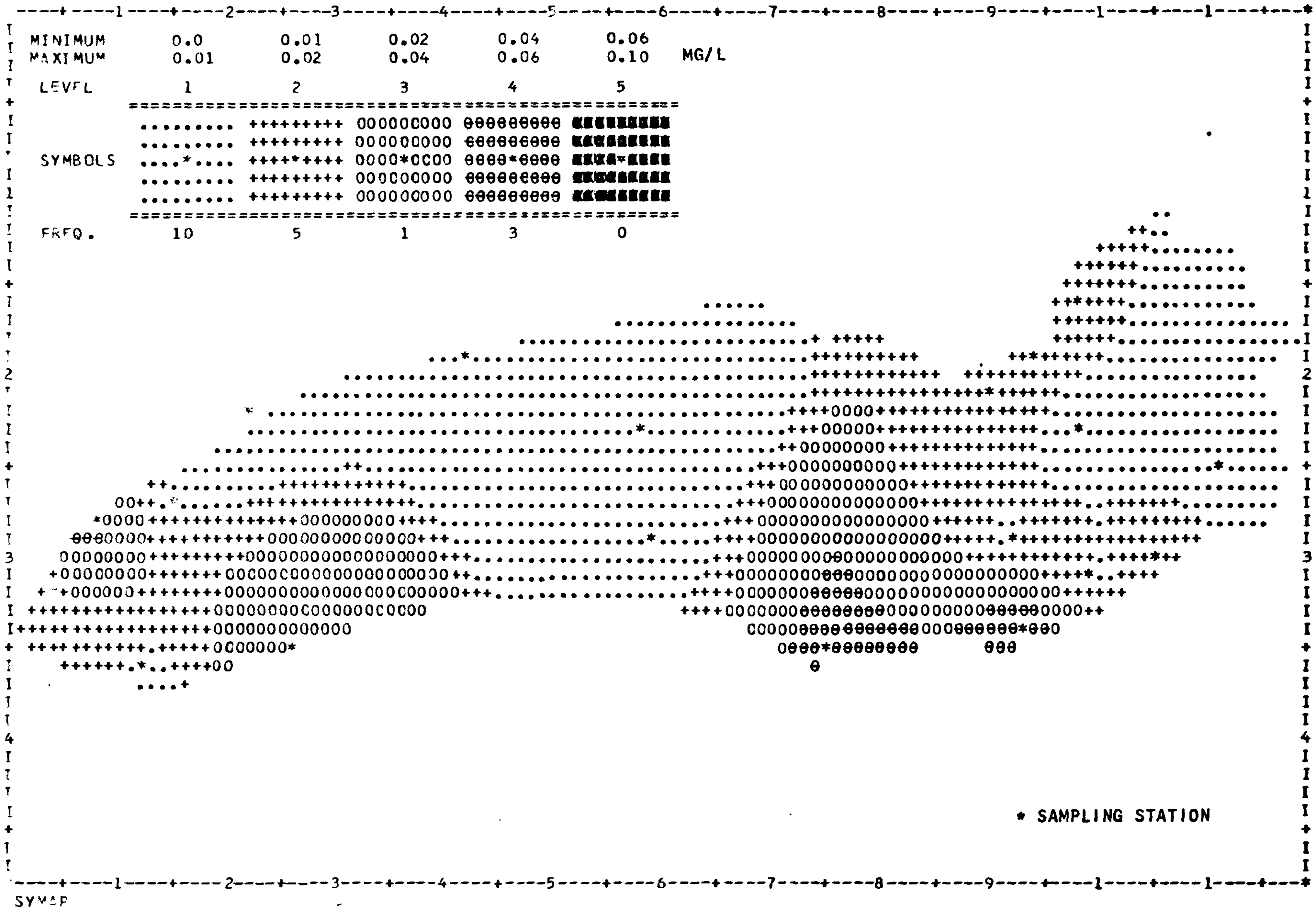


Figure 4.8b Contours of Constant Surface Ammonia

CRUISE NUMBER 8: FEBRUARY 5, 1973 TO FEBRUARY 9, 1973

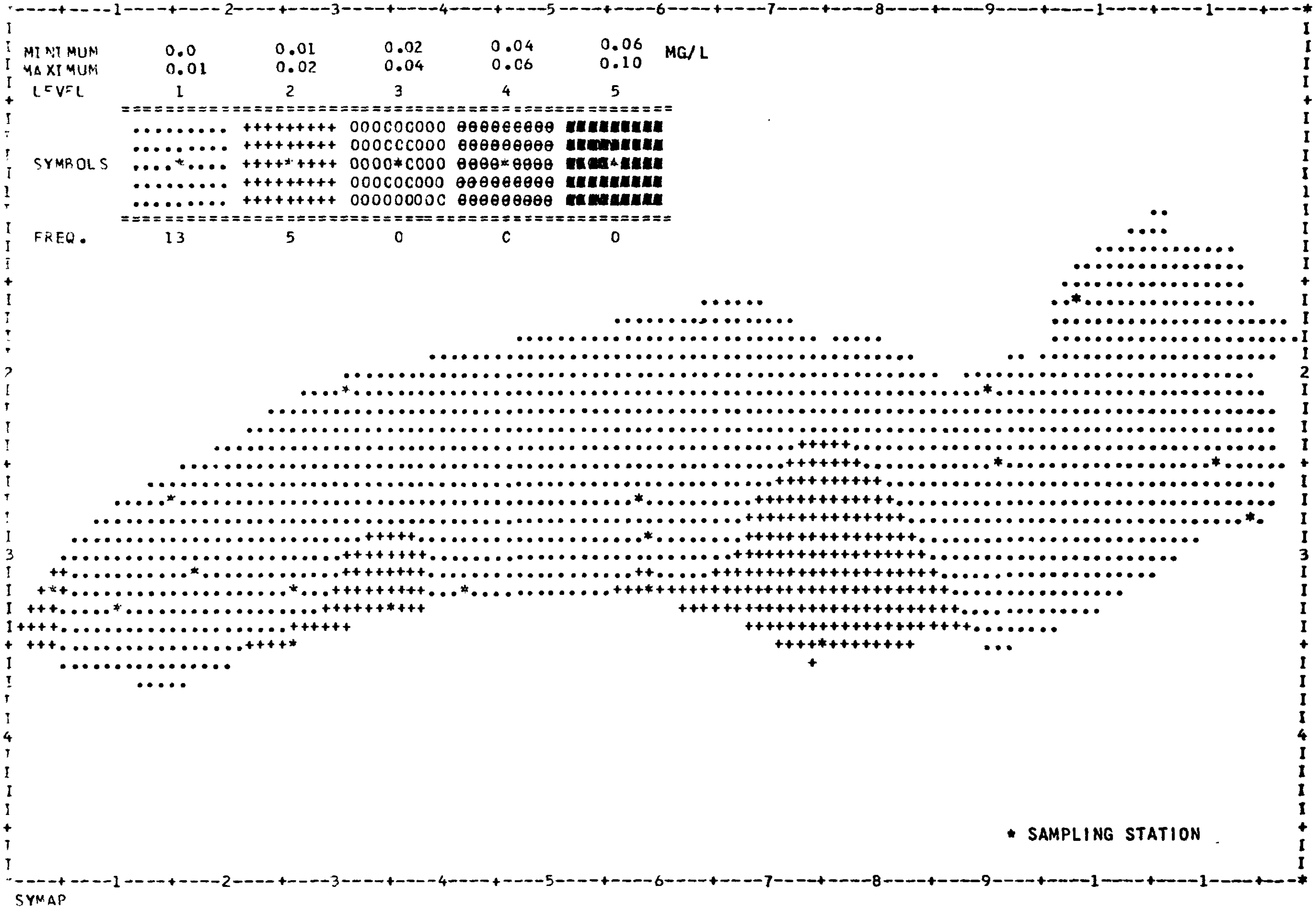


Figure 4.8b Contours of Constant Surface Ammonia

CRUIS⁼ NUMBEF 9: MARCH 18, 1973 TC MARCH 23, 1973

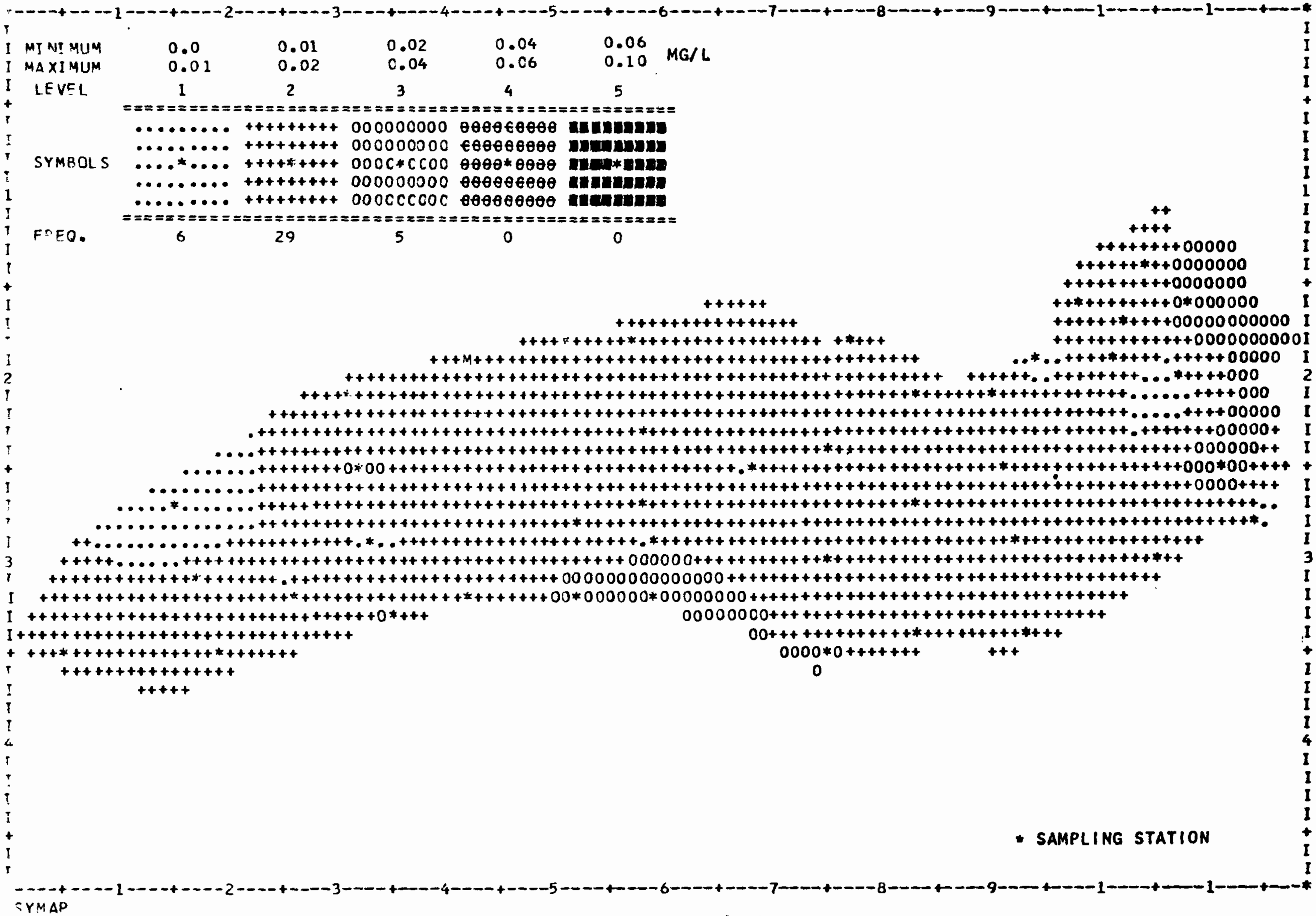


Figure 4.8b Contours of Constant Surface Ammonia

CRUISE NUMBER 10: APRIL 24, 1973 TO APRIL 30, 1973

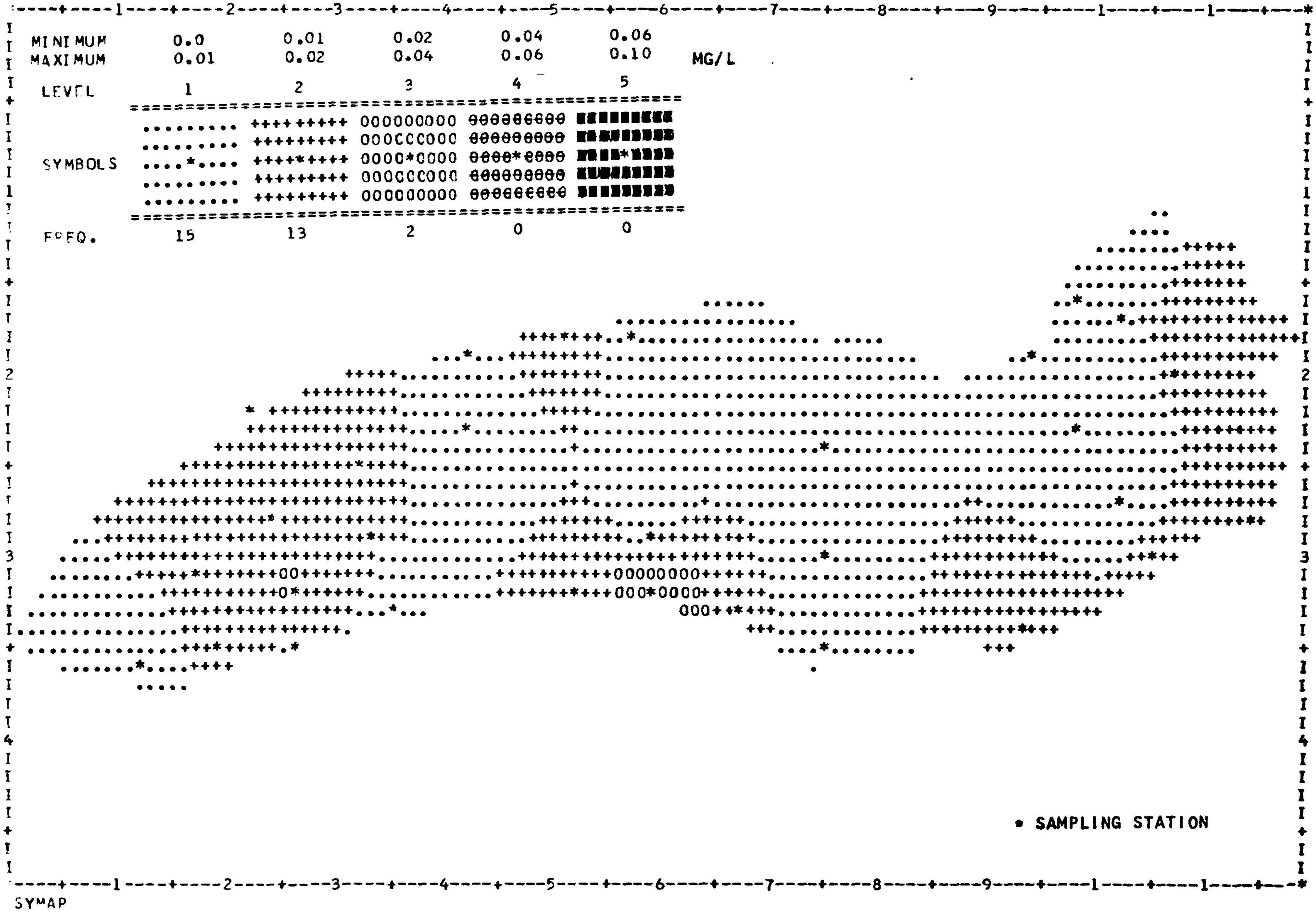


Figure 4.8b Contours of Constant Surface Ammonia

CRUISE NUMBER 11: JUNE 11, 1973 TO JUNE 15, 1973

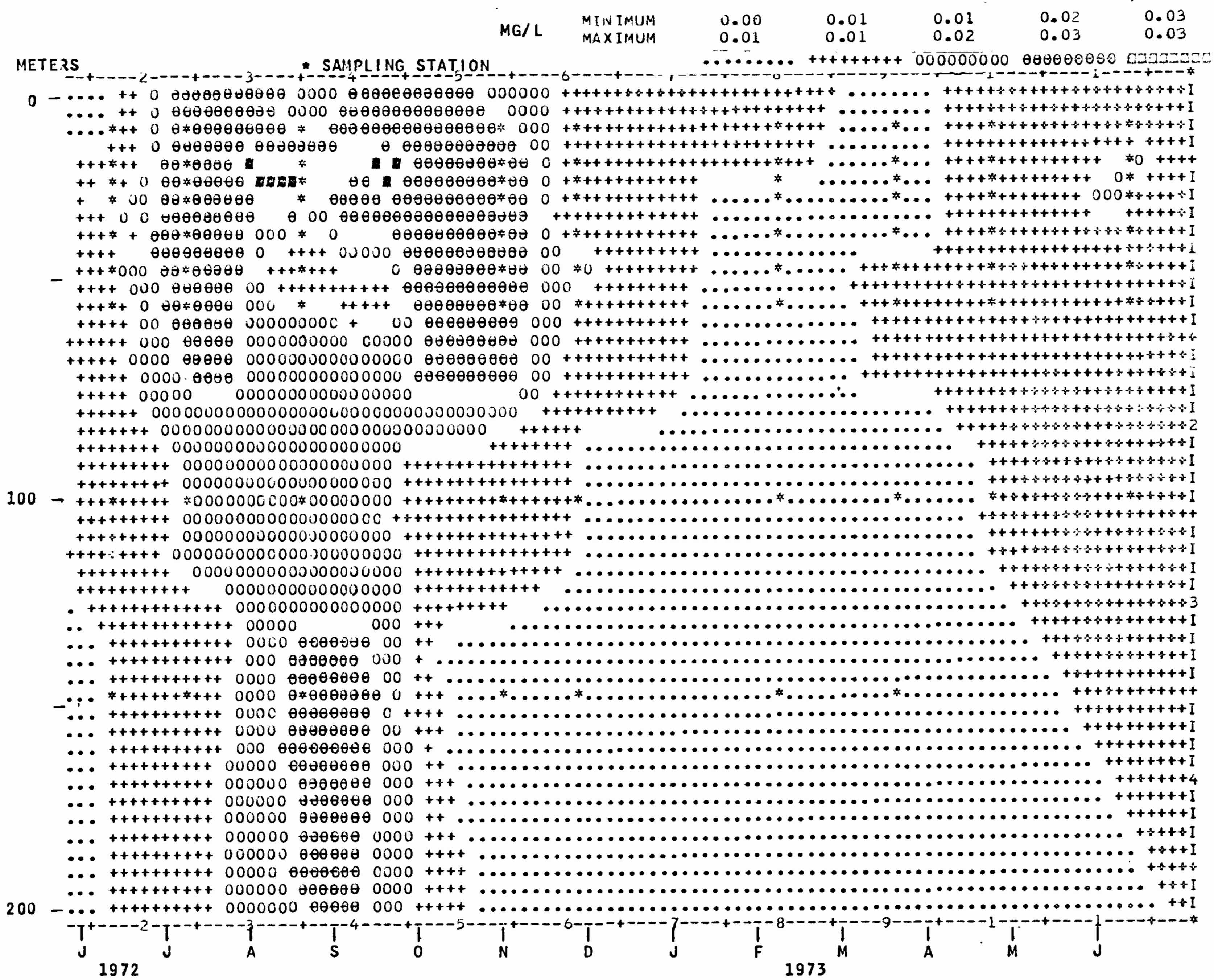


Figure 4.8c Depth Versus Time Contours of Ammonia

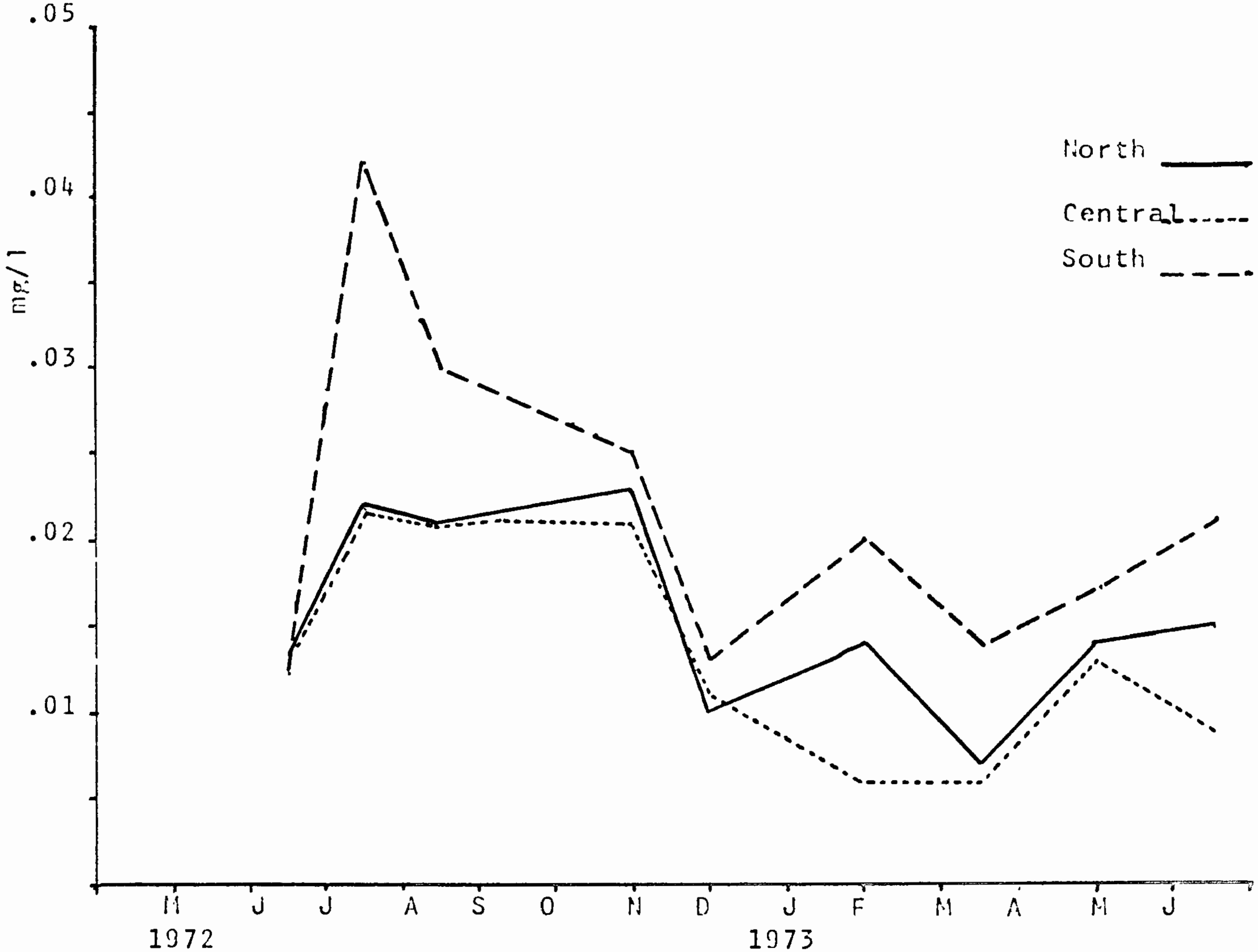


Figure 4.8d North-south Variation of Mean Ammonia
During the Field Year

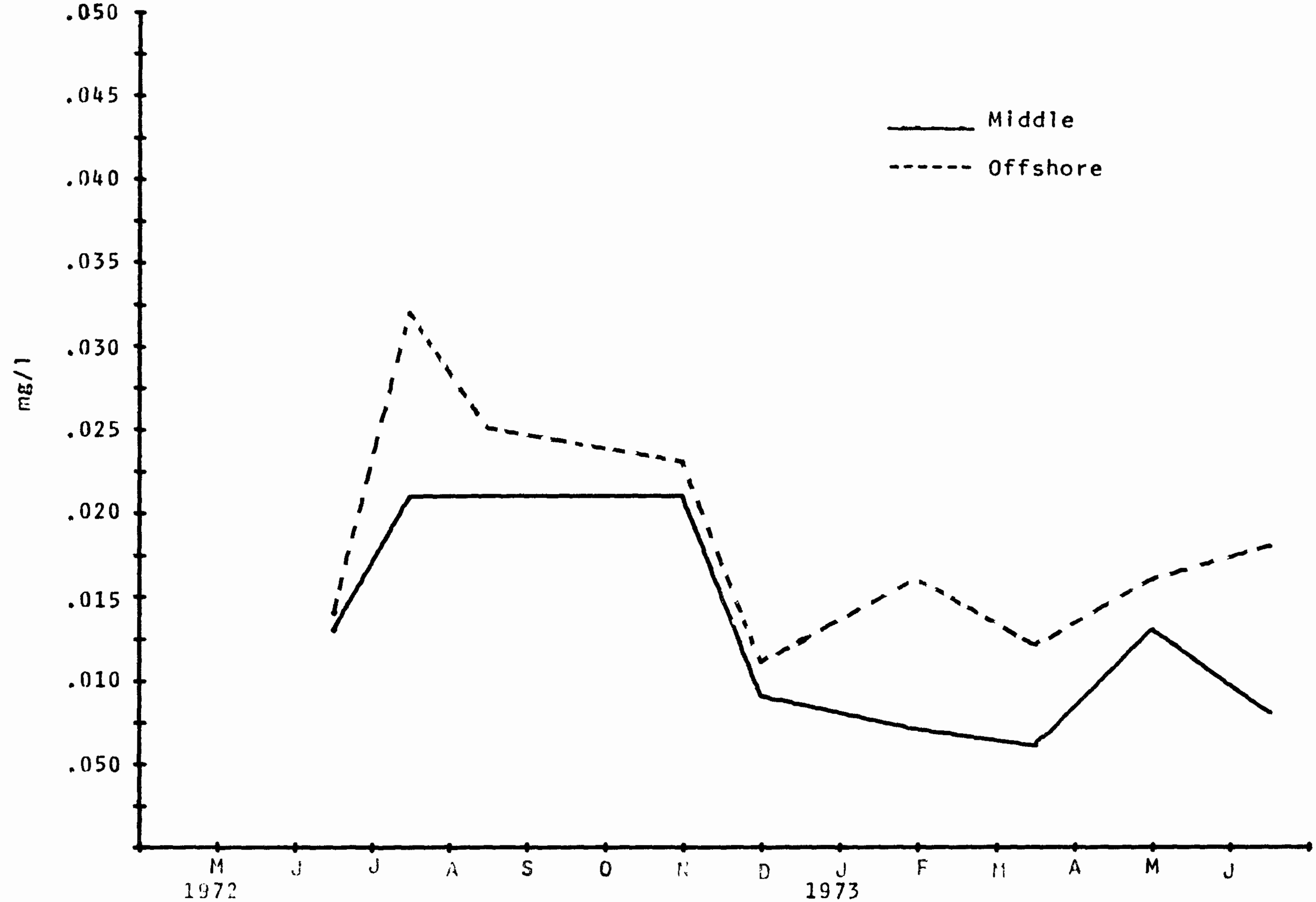


Figure 4.8e Middle Lake-Offshore Variations of Mean Ammonia Concentration

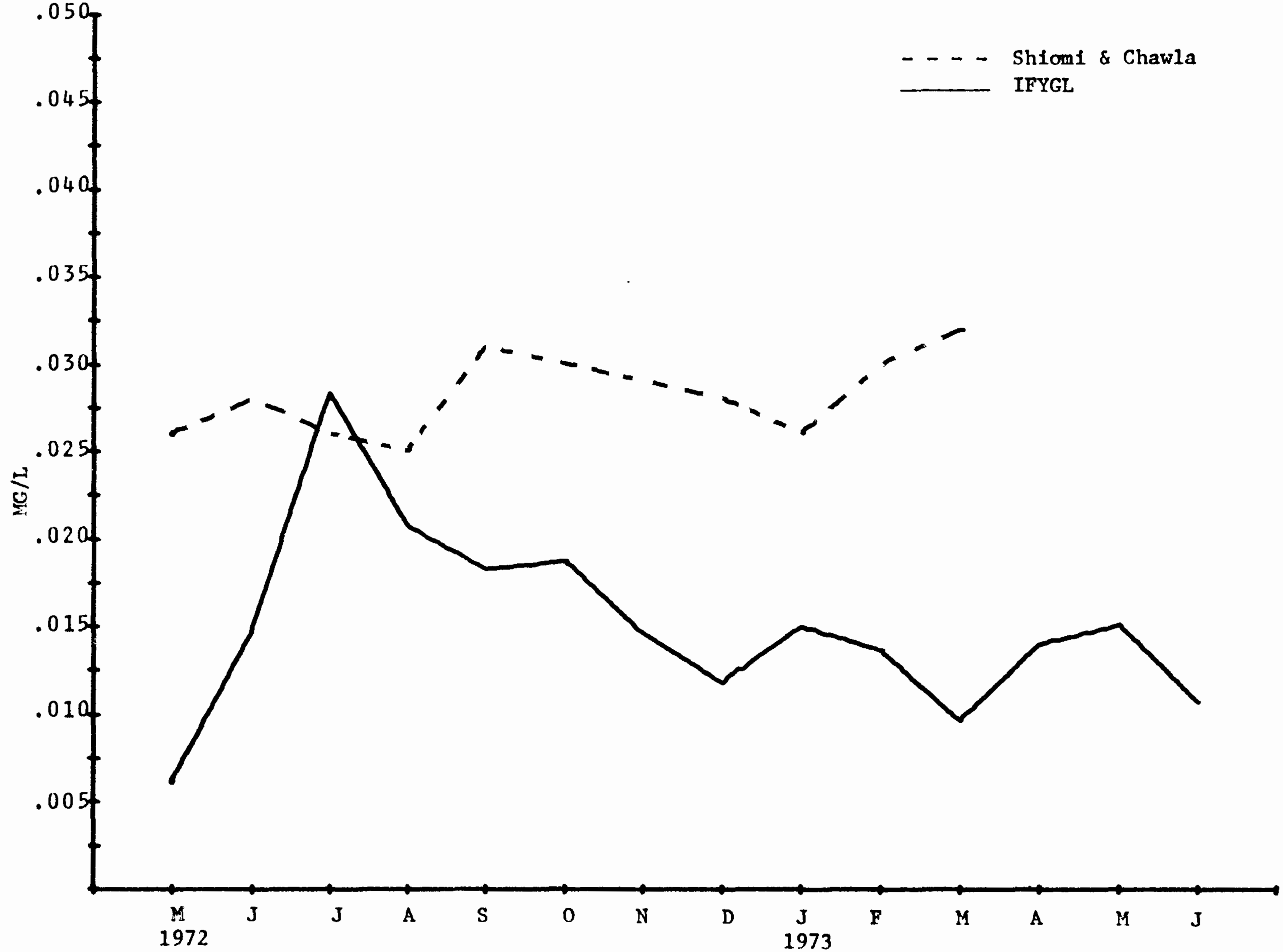


Figure 4.8f Mean surface variation of ammonia concentration during the field year.

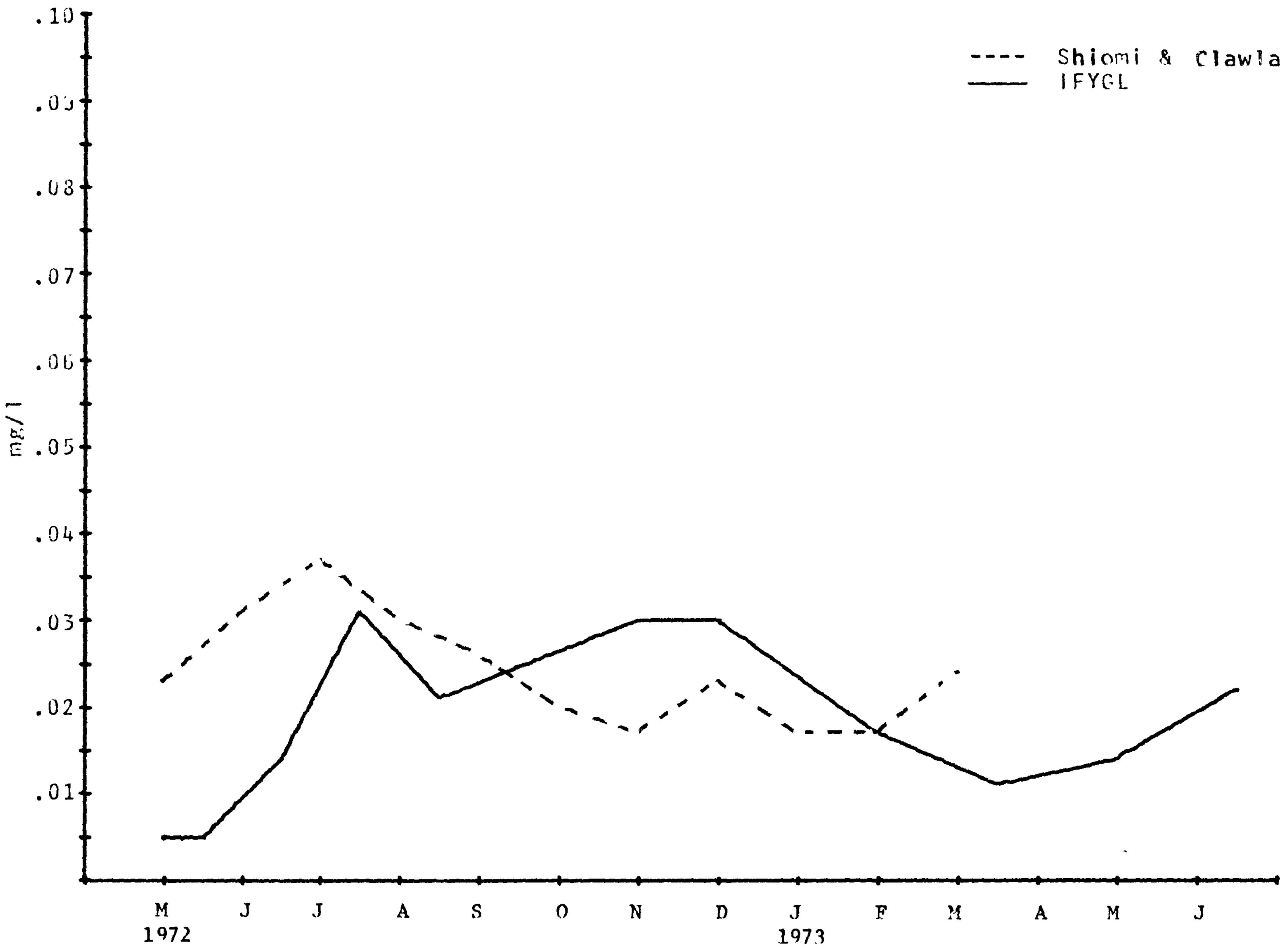


Figure 4.8g Mean Bottom Variation of Ammonia Concentration
During the Field Year

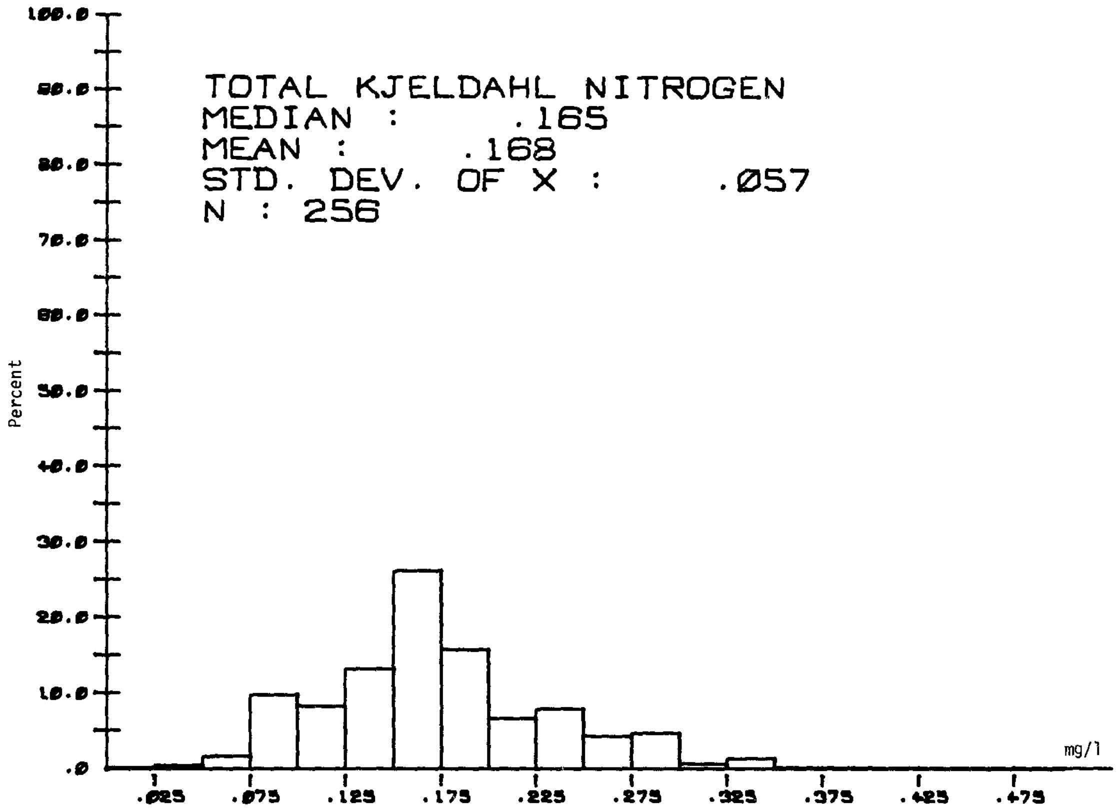


Figure 4.9a Histograms for Total Kjeldahl Nitrogen - Cruise 2

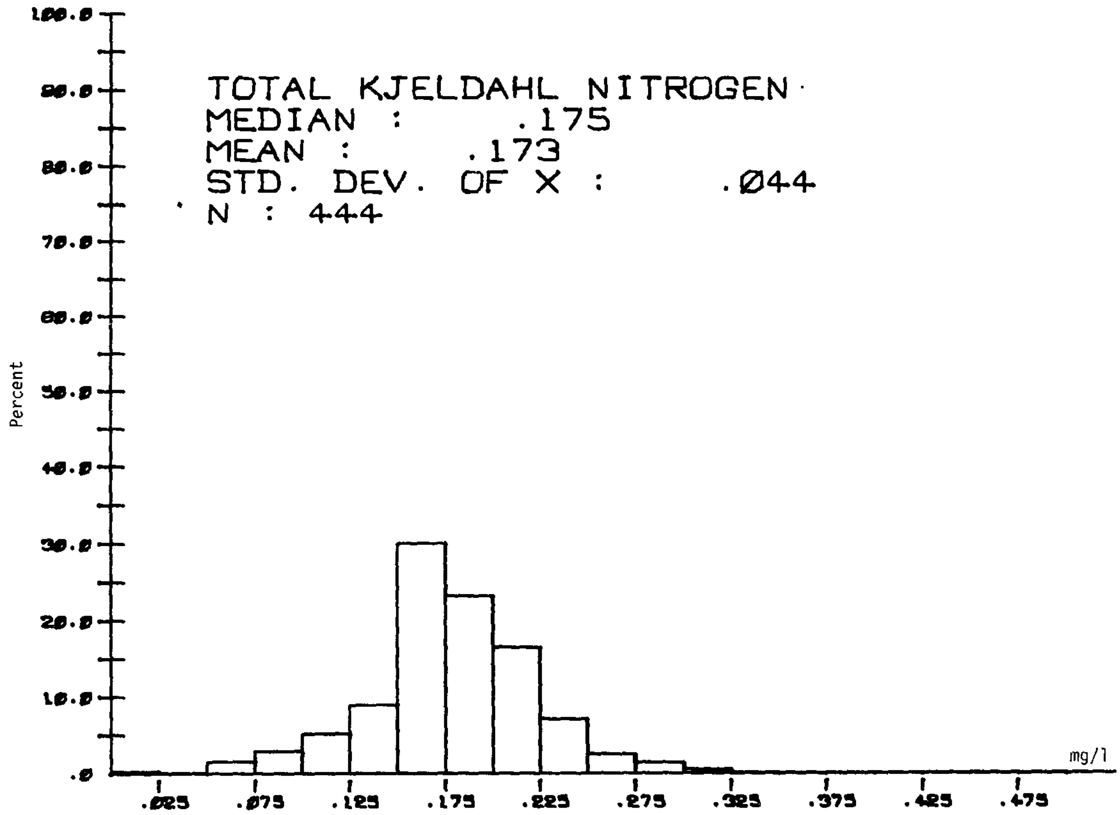


Figure 4.9a Total Kjeldahl Nitrogen - Cruise 3

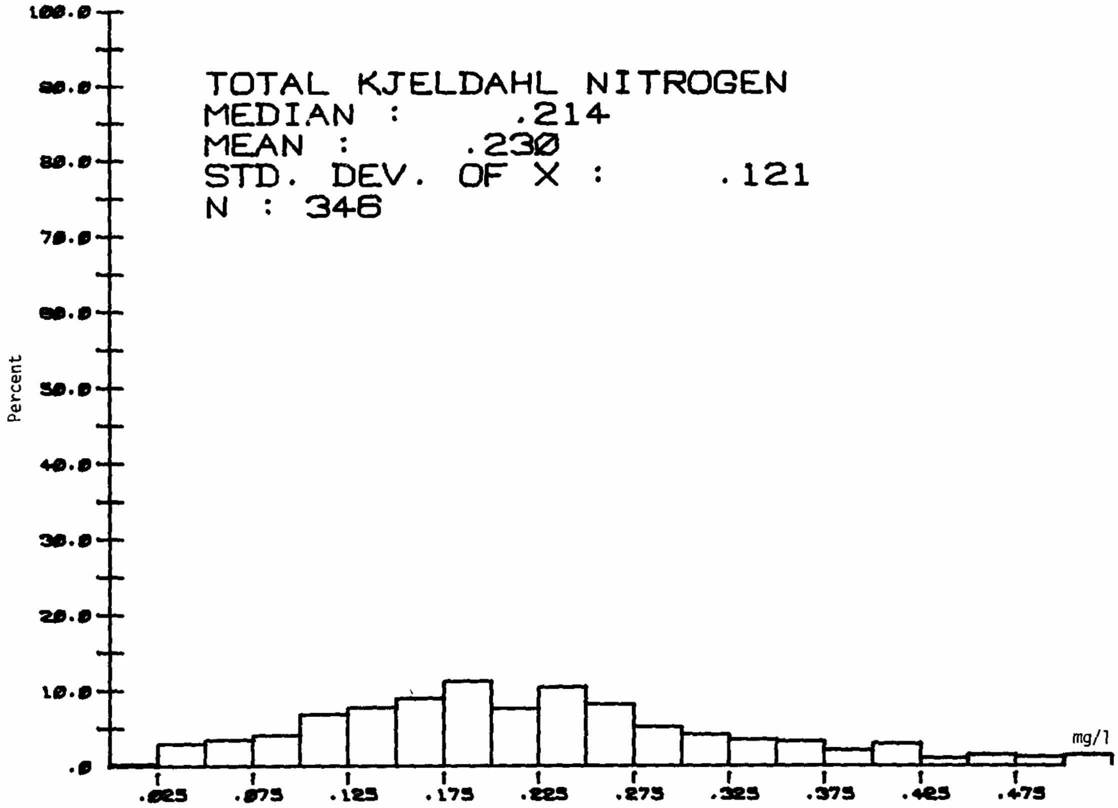


Figure 4.9a Histograms for Total Kjeldahl Nitrogen - Cruise 4

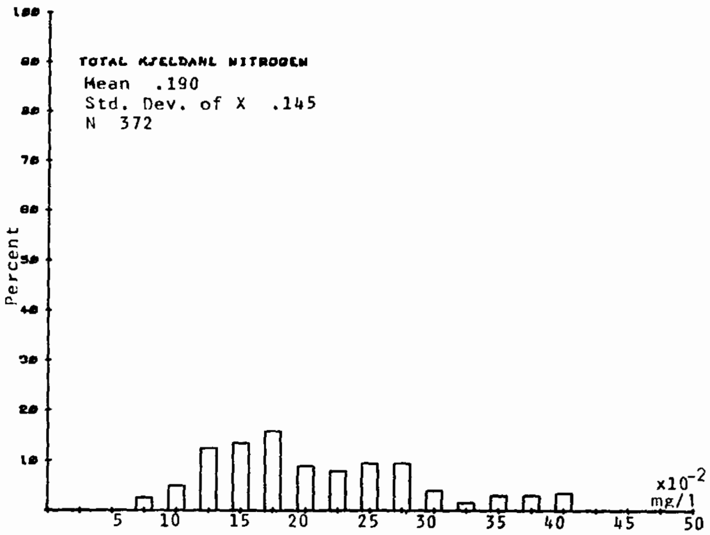


Figure 4.9a Histograms for Total Kjeldahl Nitrogen - Cruise 5

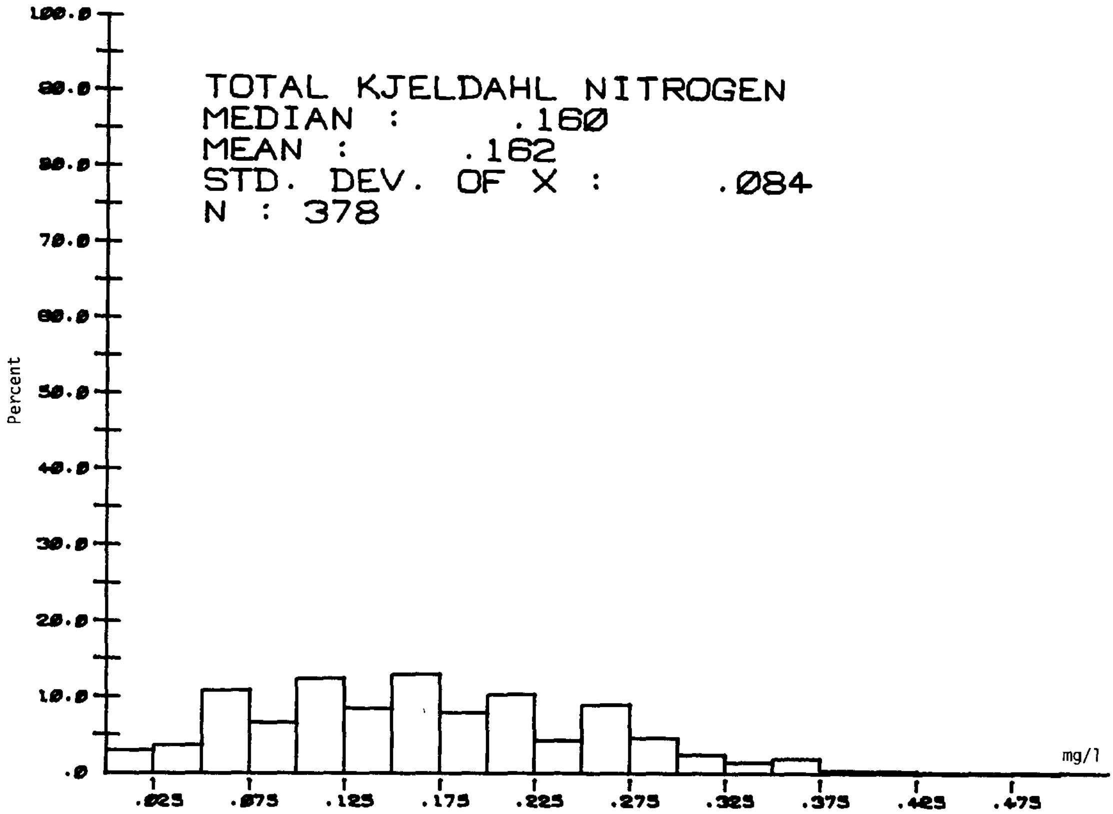


Figure 4.9a Histograms for Total Kjeldahl Nitrogen - Cruise 6

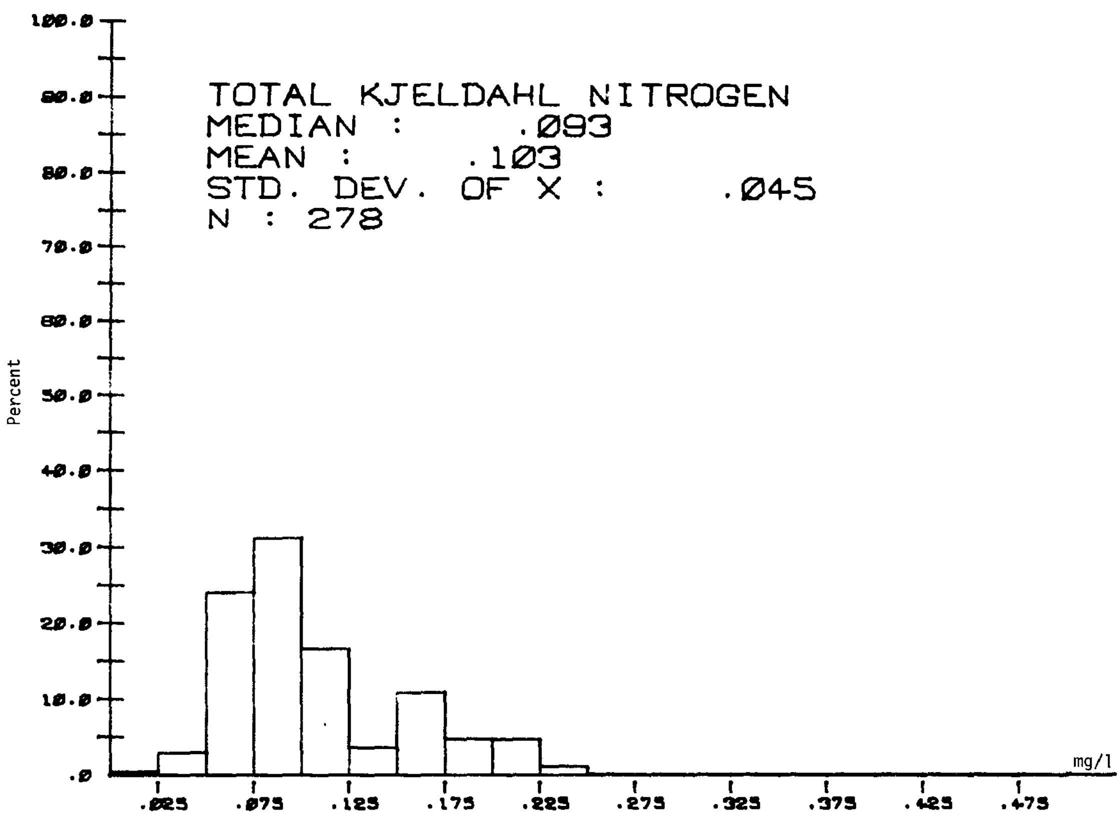


Figure 4.9a Histograms for Total Kjeldahl Nitrogen - Cruise 7

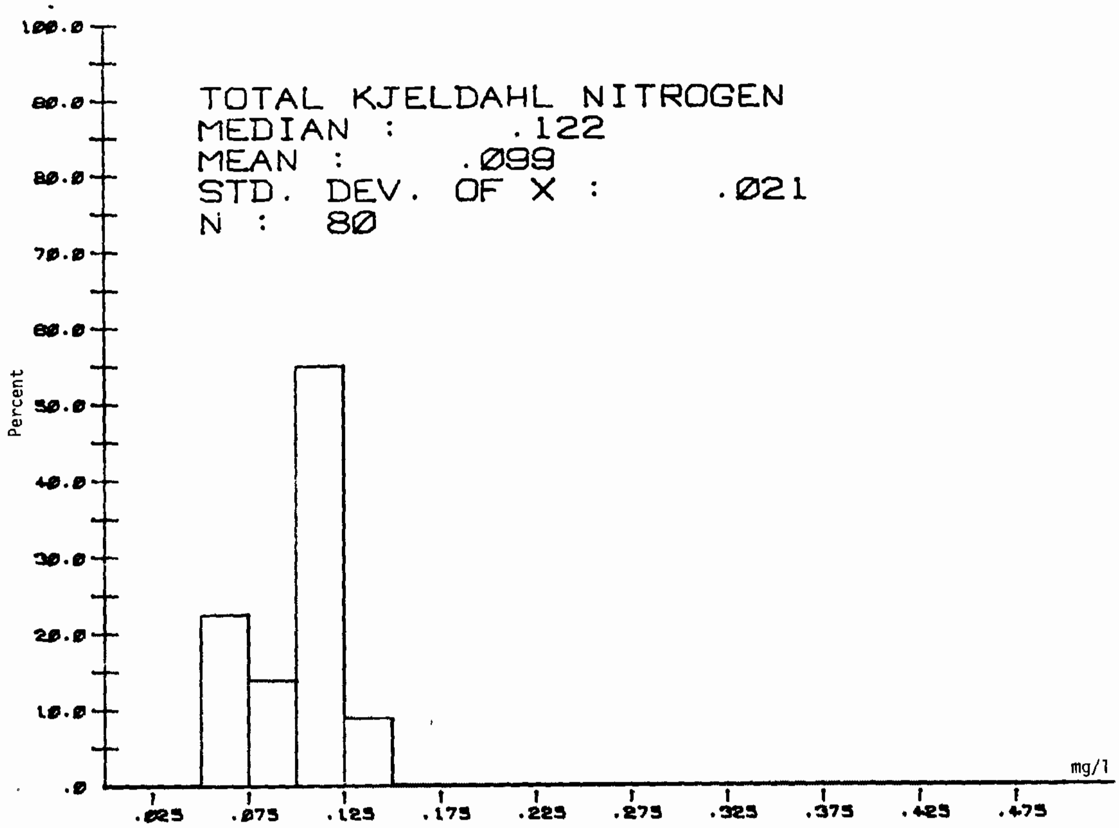


Figure 4.9a Histograms for Total Kjeldahl Nitrogen - Cruise 8

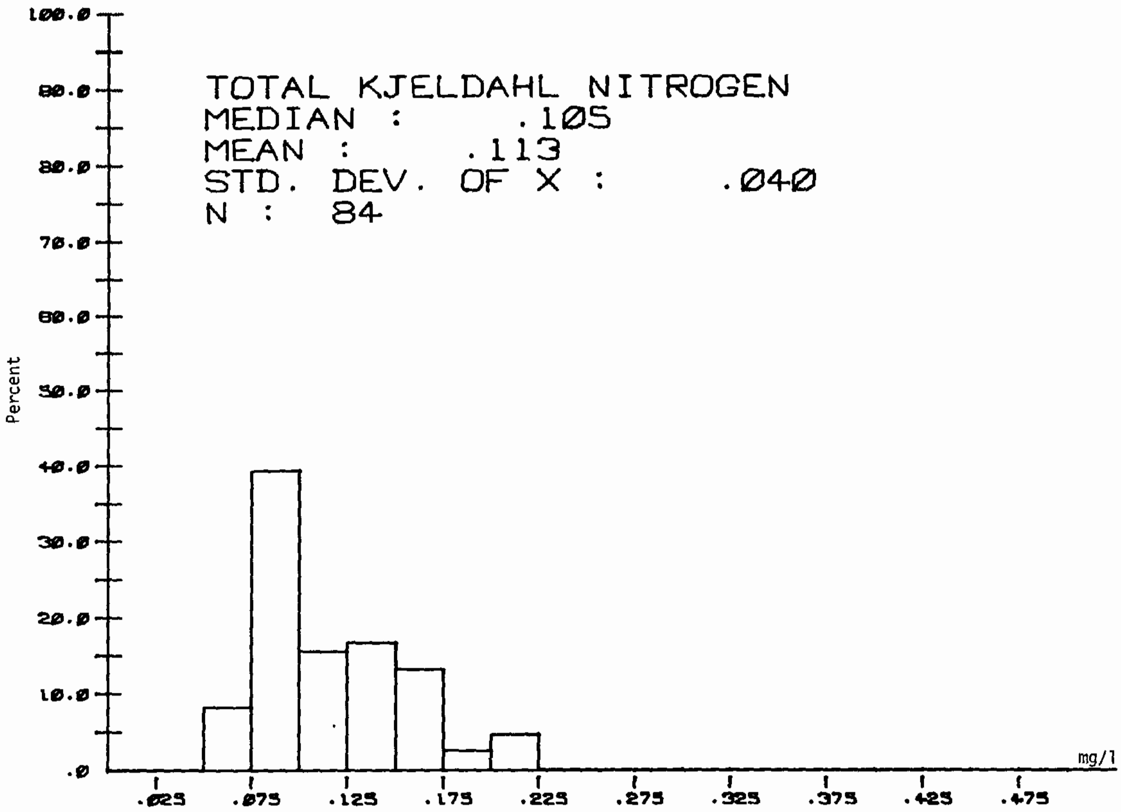


Figure 4.9a Histograms for Total Kjeldahl Nitrogen - Cruise 9

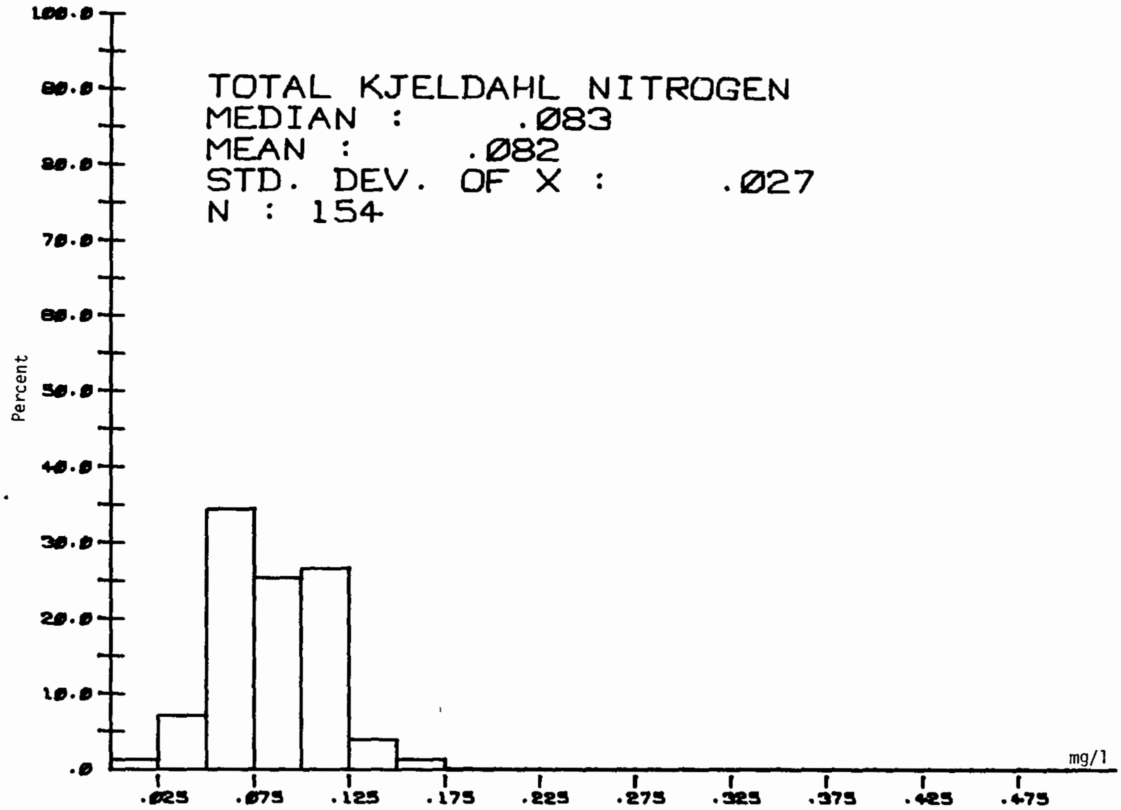


Figure 4.9a Histograms for Total Kjeldahl Nitrogen - Cruise 10

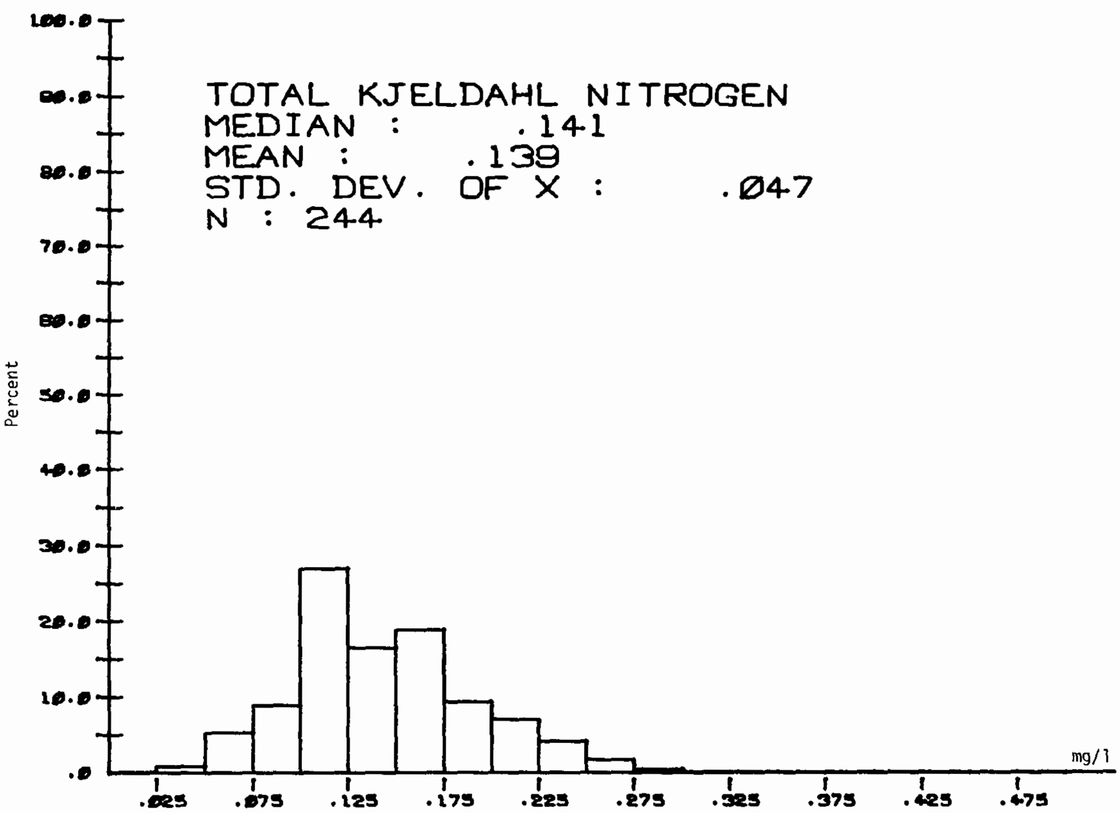


Figure 4.9a Histograms for Total Kjeldahl Nitrogen - Cruise 11

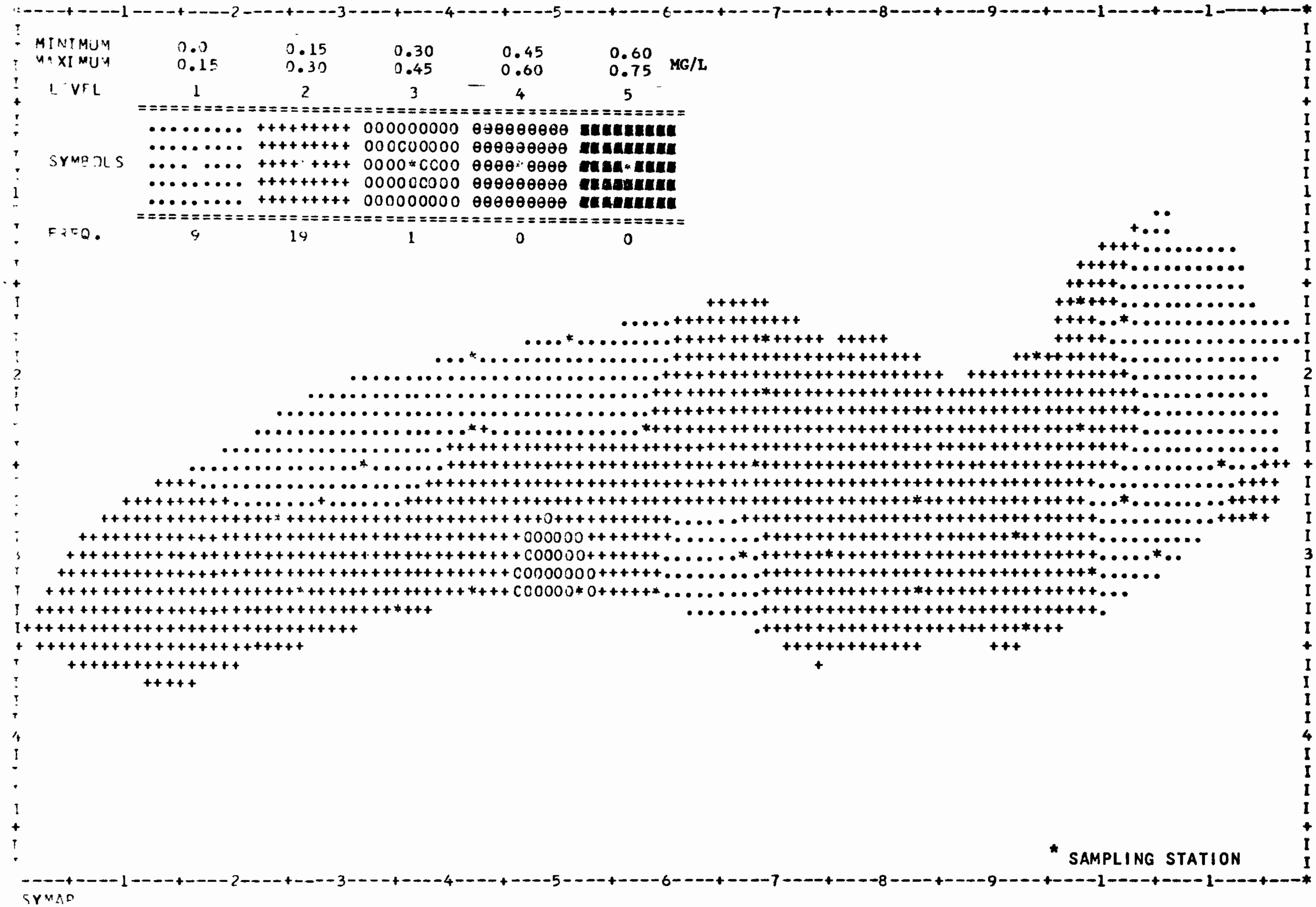


Figure 4.9b Contours of Constant Surface Total Kjeldahl Nitrogen

CRUISE NUMBER 2: MAY 15, 1972 TO MAY 19, 1972

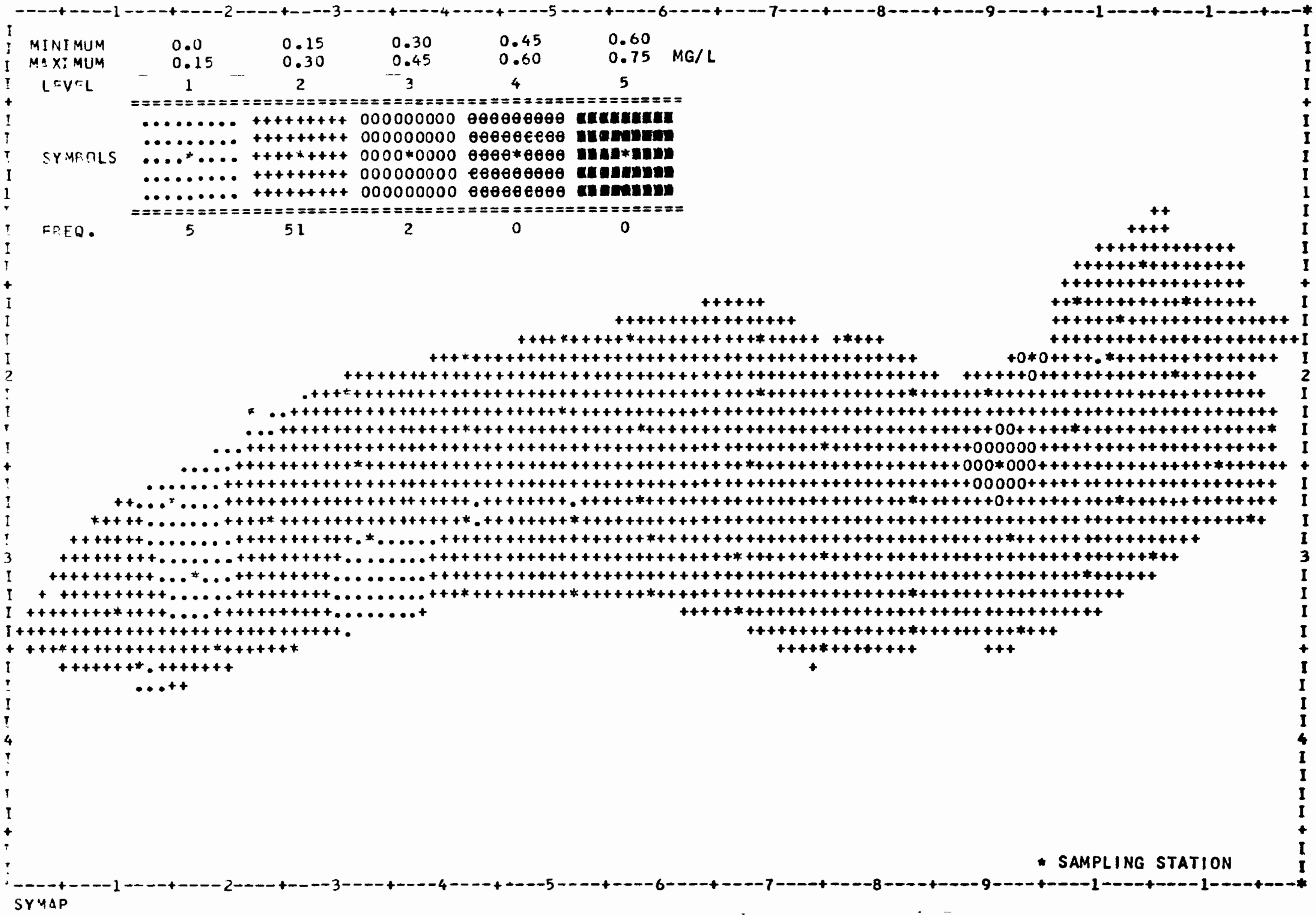


Figure 4.9b Contours of Constant Surface Total Kjeldahl Nitrogen

CRUISE NUMBER 3: JUNE 12, 1972 TO JUNE 16, 1972

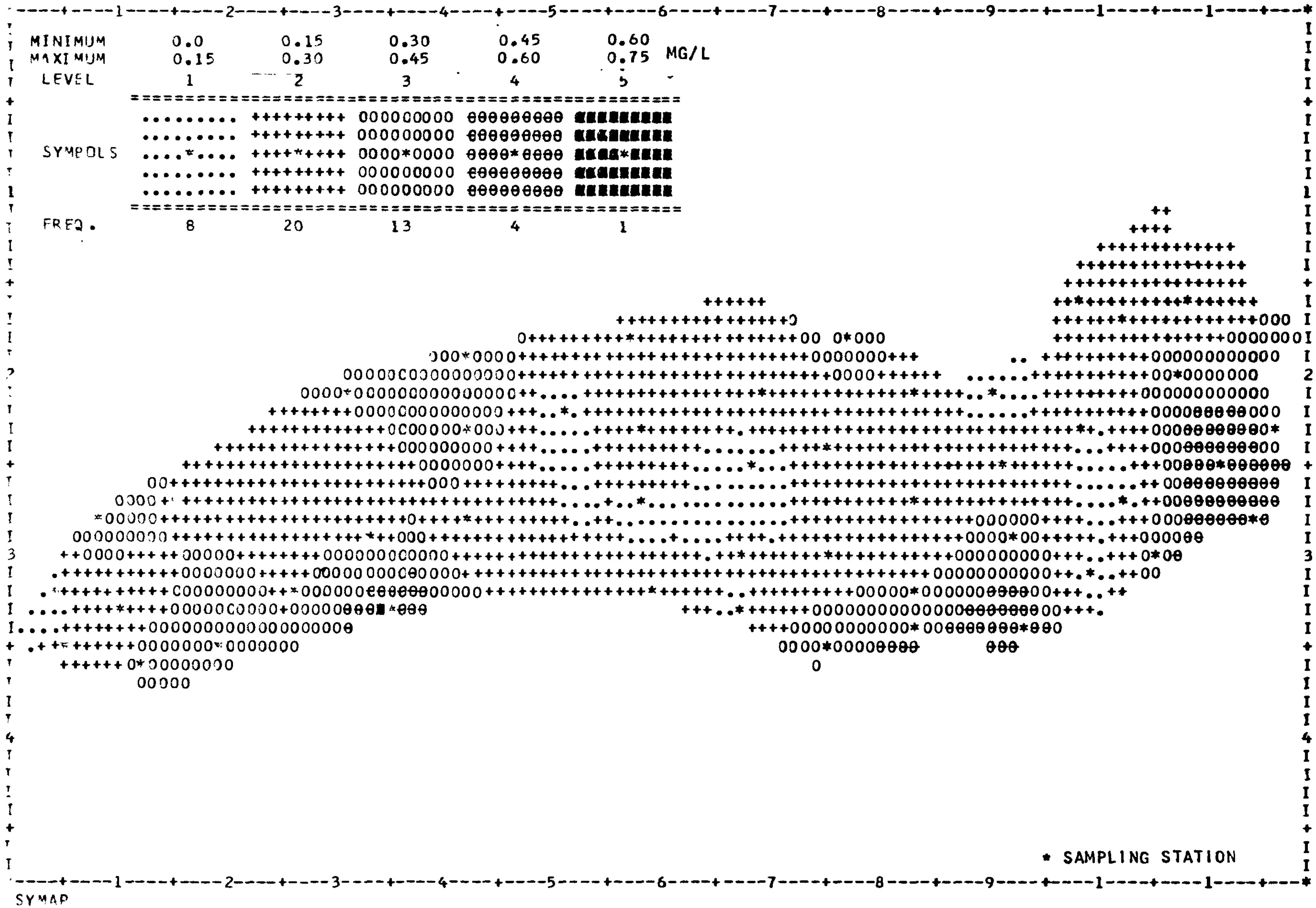


Figure 4.9b Contours of Constant Surface Total Kjeldahl Nitrogen

CRUISE NUMBER 4: JULY 10, 1972 TO JULY 14, 1972

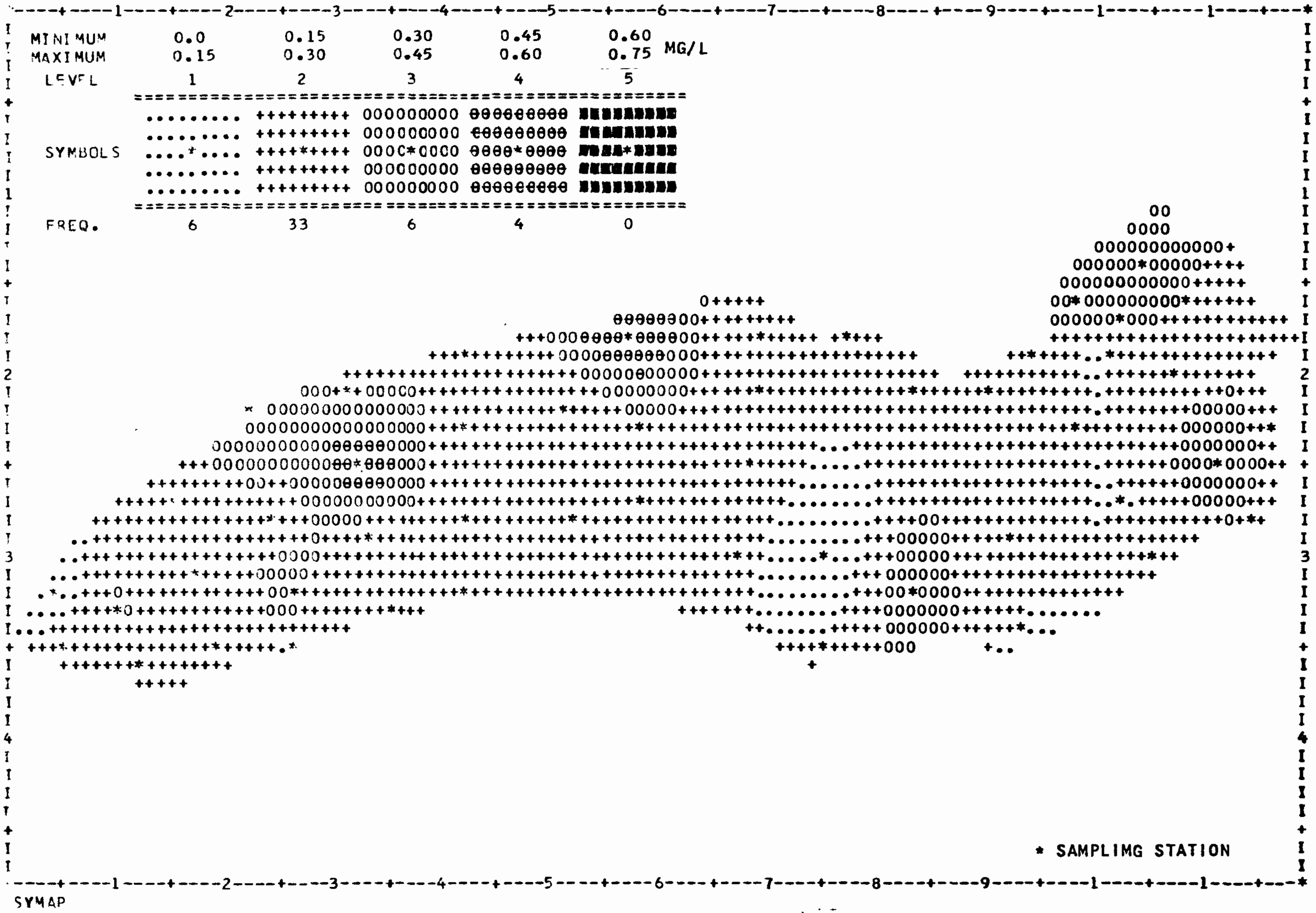
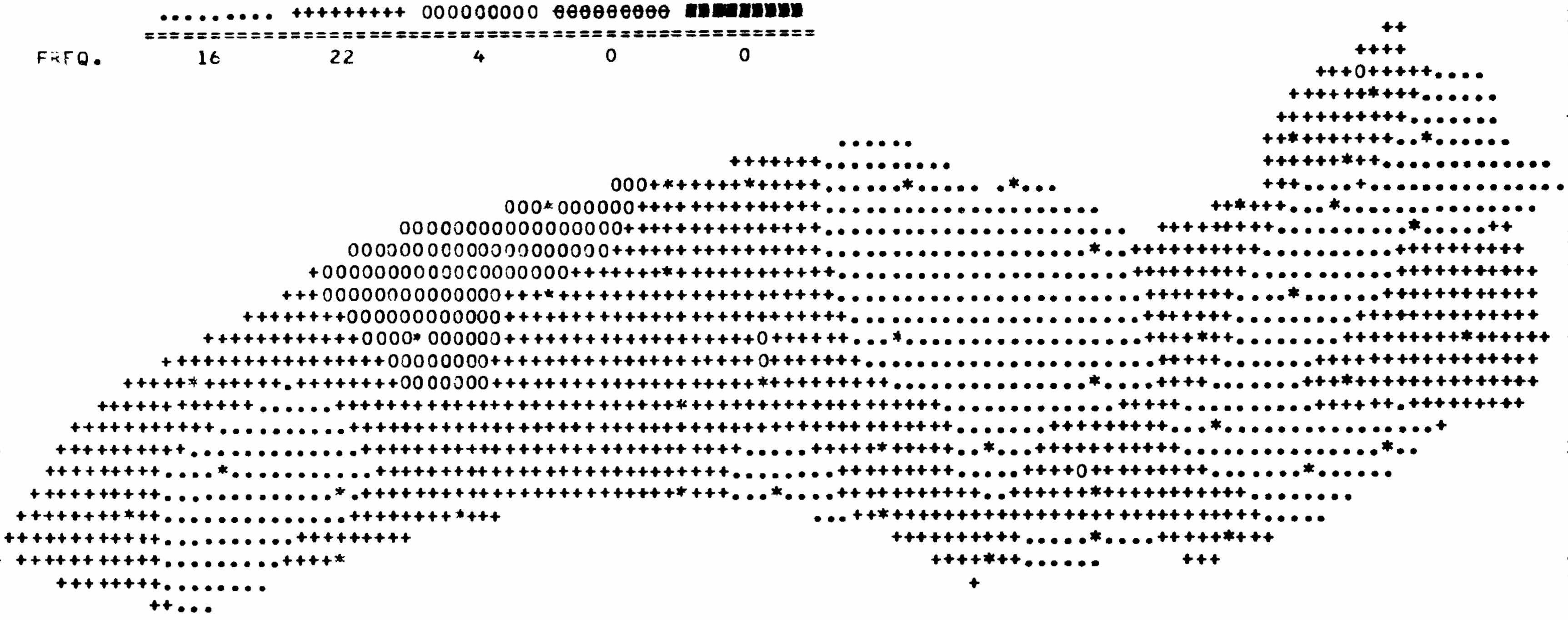


Figure 4.9b Contours of Constant Surface Total Kjeldahl Nitrogen

CRUISE NUMBER 5: AUGUST 21, 1972 TO AUGUST 25, 1972

	Level 1	Level 2	Level 3	Level 4	Level 5	
MINIMUM	0.0	0.15	0.30	0.45	0.60	
MAXIMUM	0.15	0.30	0.45	0.60	0.75	MG/L
LEVEL	1	2	3	4	5	
SYMBOLS	....*....	++++*++++	0000*0000	θθθθ*θθθθ	████*████	
FREQ.	16	22	4	0	0	



SYMAP

Figure 4.9b Contours of Constant Surface Total Kjeldahl Nitrogen

CRUISE NUMBER 6: OCTOBER 30, 1972 TO NOVEMBER 3, 1972

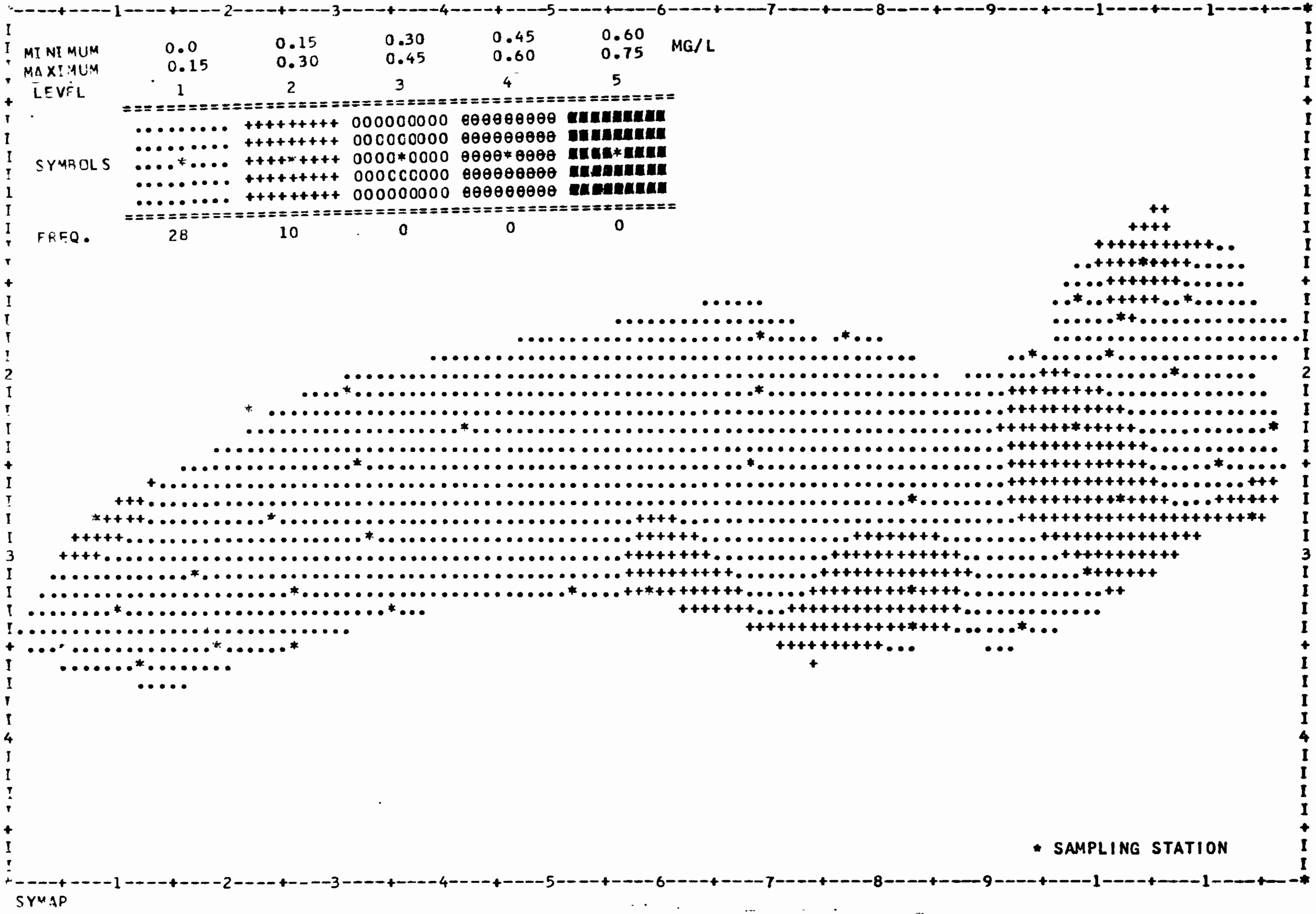


Figure 4.9b Contours of Constant Surface Total Kjeldahl Nitrogen

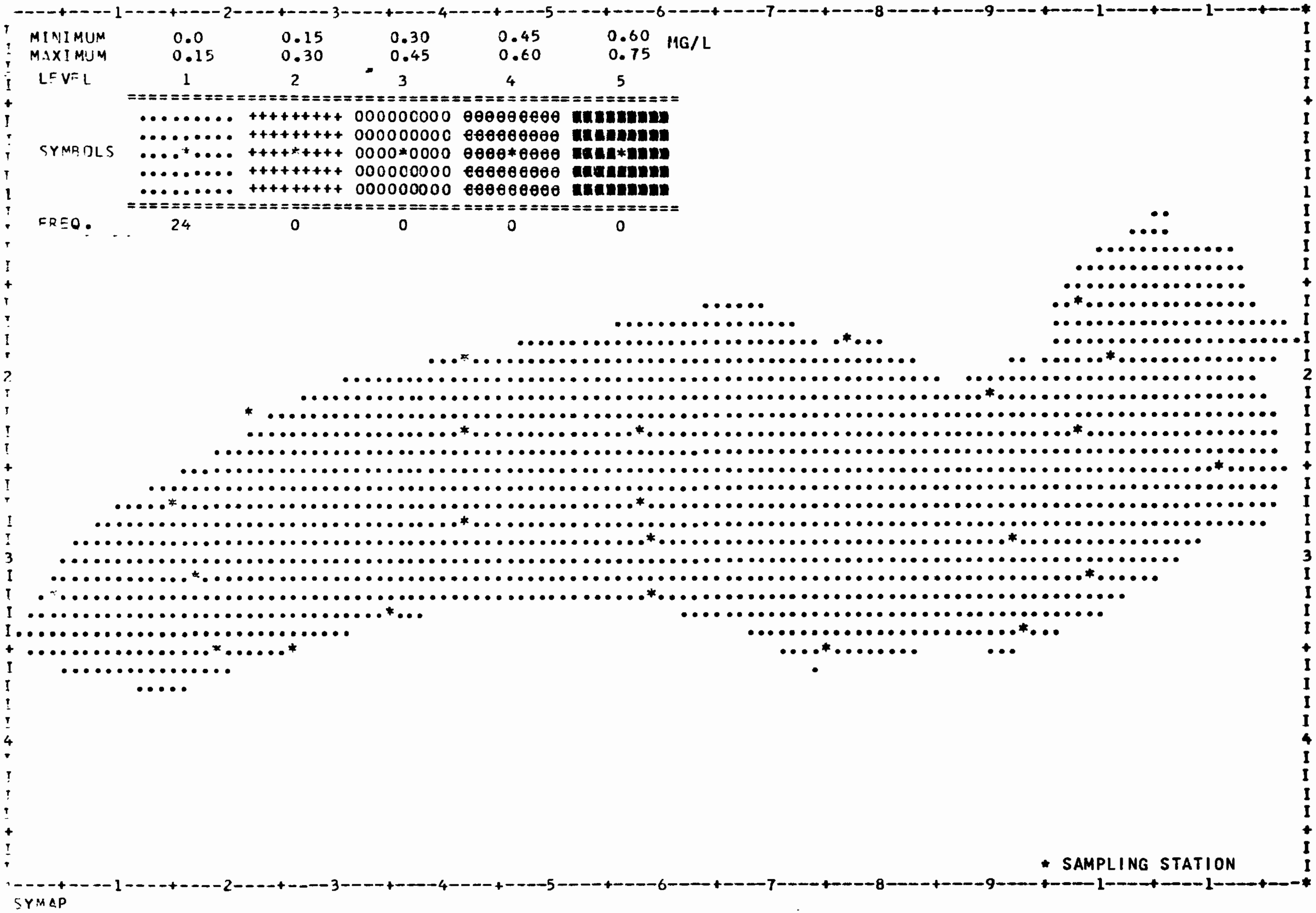


Figure 4.9b Contours of Constant Surface Total Kjeldahl Nitrogen

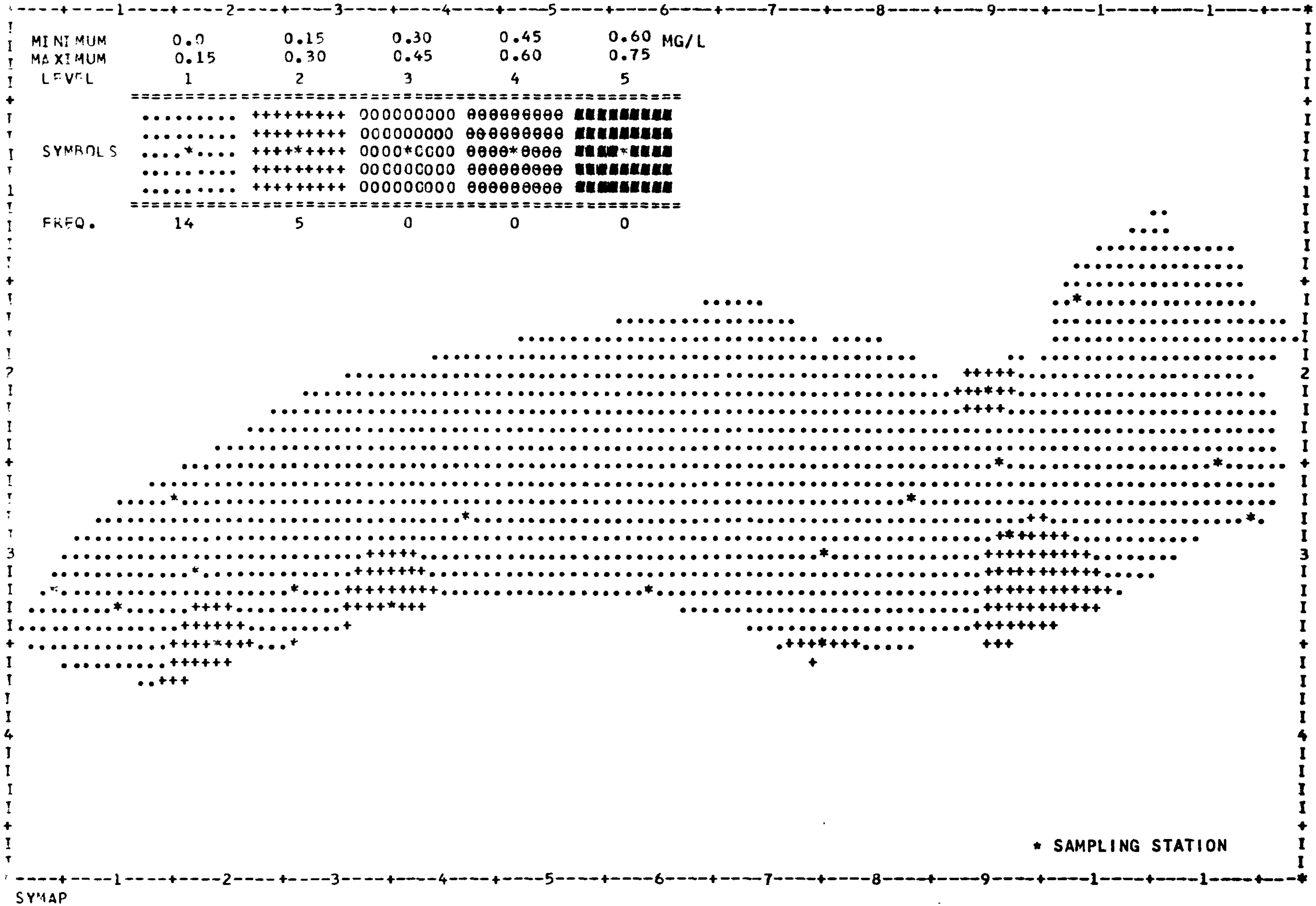
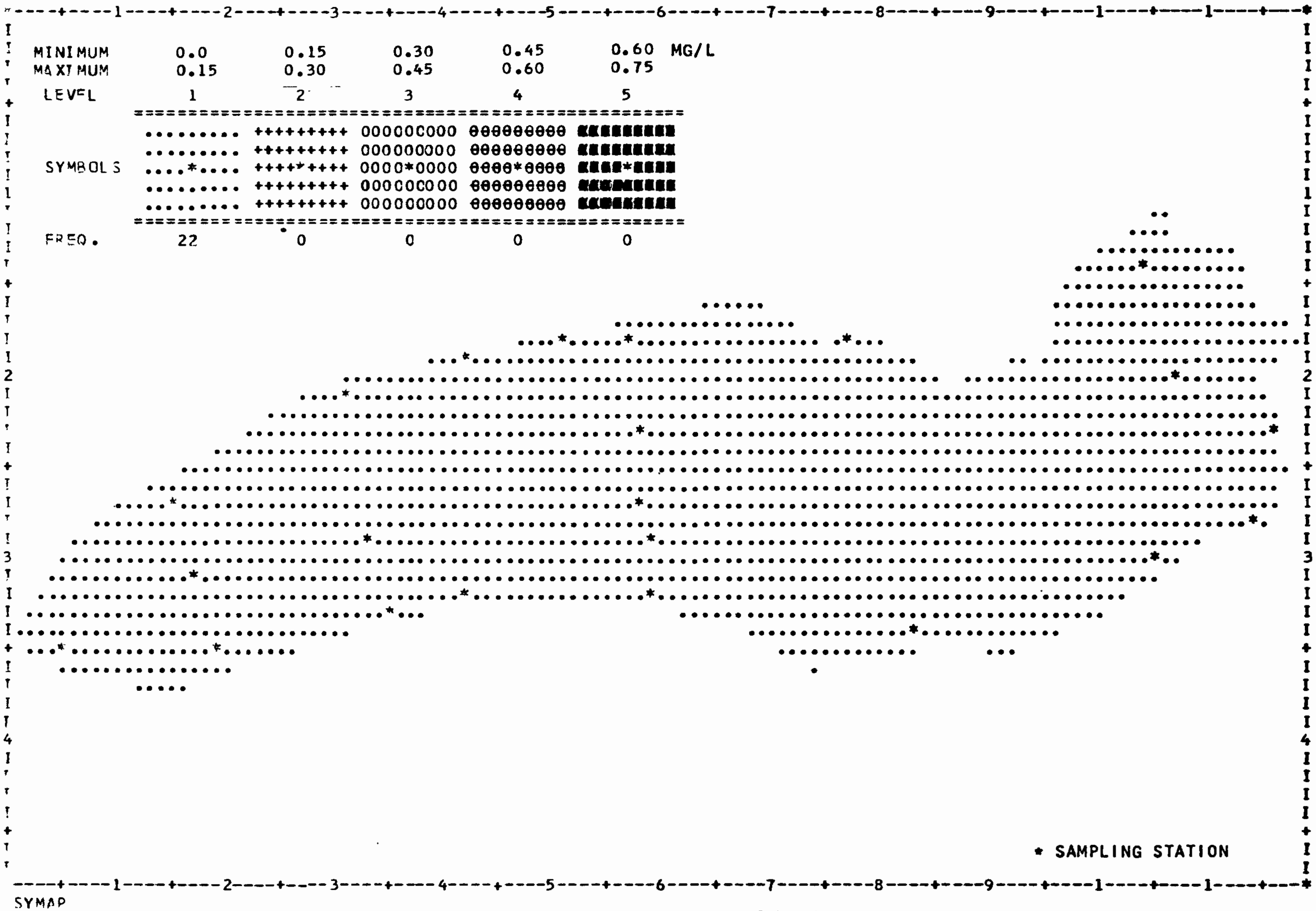


Figure 4.9b Contours of Constant Surface Total Kjeldahl Nitrogen

CRUISE NUMBER 9: MARCH 18, 1973 TO MARCH 23, 1973



MINIMUM	0.0	0.15	0.30	0.45	0.60 MG/L
MAXIMUM	0.15	0.30	0.45	0.60	0.75
LEVEL	1	2	3	4	5
SYMBOLS	....	+++++++++	000000000	θθθθθθθθθ	■■■■■■■■■
	....	+++++++++	000000000	θθθθθθθθθ	■■■■■■■■■
	....*....	++++*++++	0000*0000	θθθθ*θθθθ	■■■■*■■■■
	....	+++++++++	000000000	θθθθθθθθθ	■■■■■■■■■
	....	+++++++++	000000000	θθθθθθθθθ	■■■■■■■■■
FREQ.	22	0	0	0	0

Figure 4.9b Contours of Constant Surface Total Kjeldahl Nitrogen

CRUISE NUMBER 10: APRIL 24, 1973 TO APRIL 30, 1973

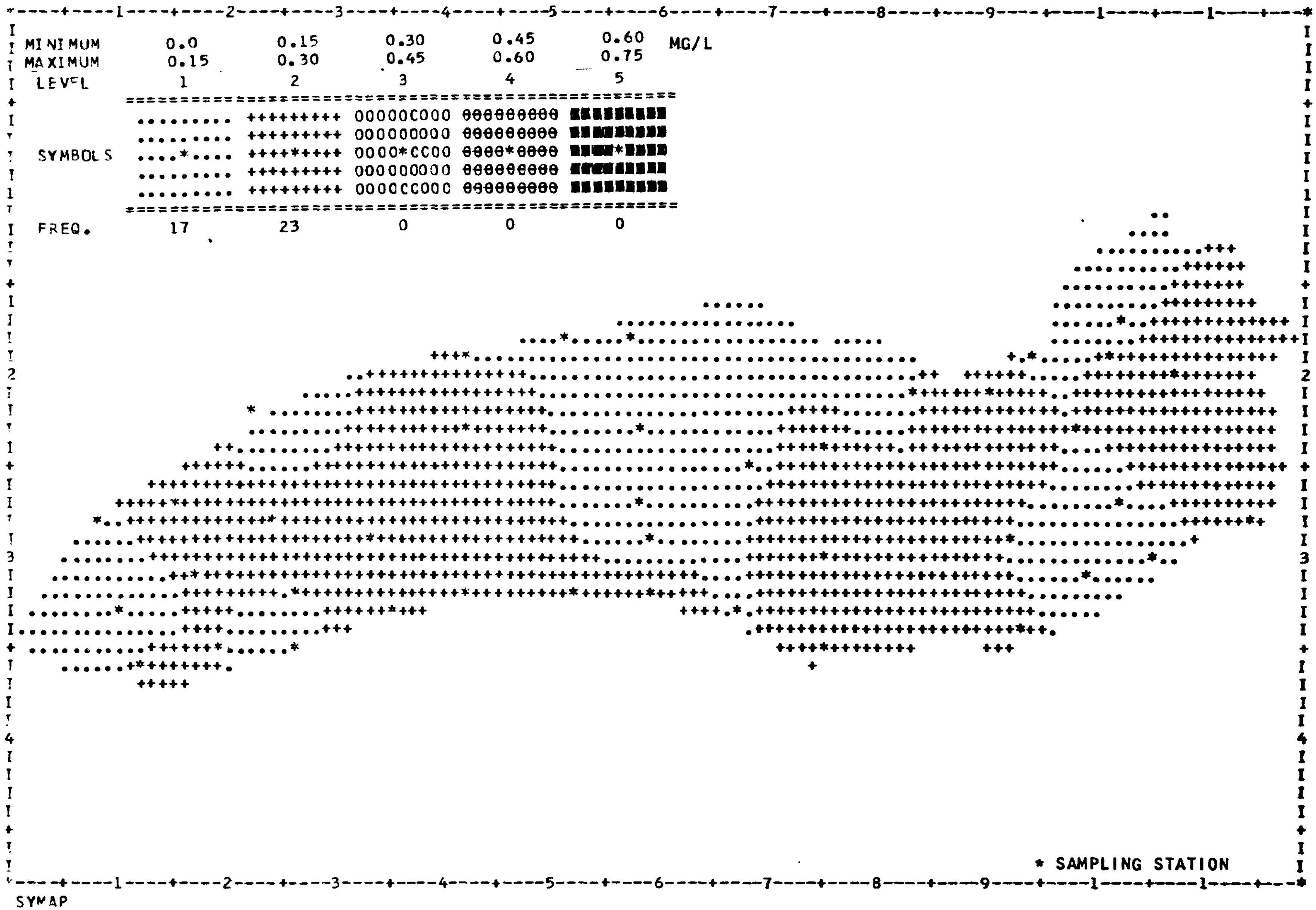


Figure 4.9b Contours of Constant Surface Total Kjeldahl Nitrogen

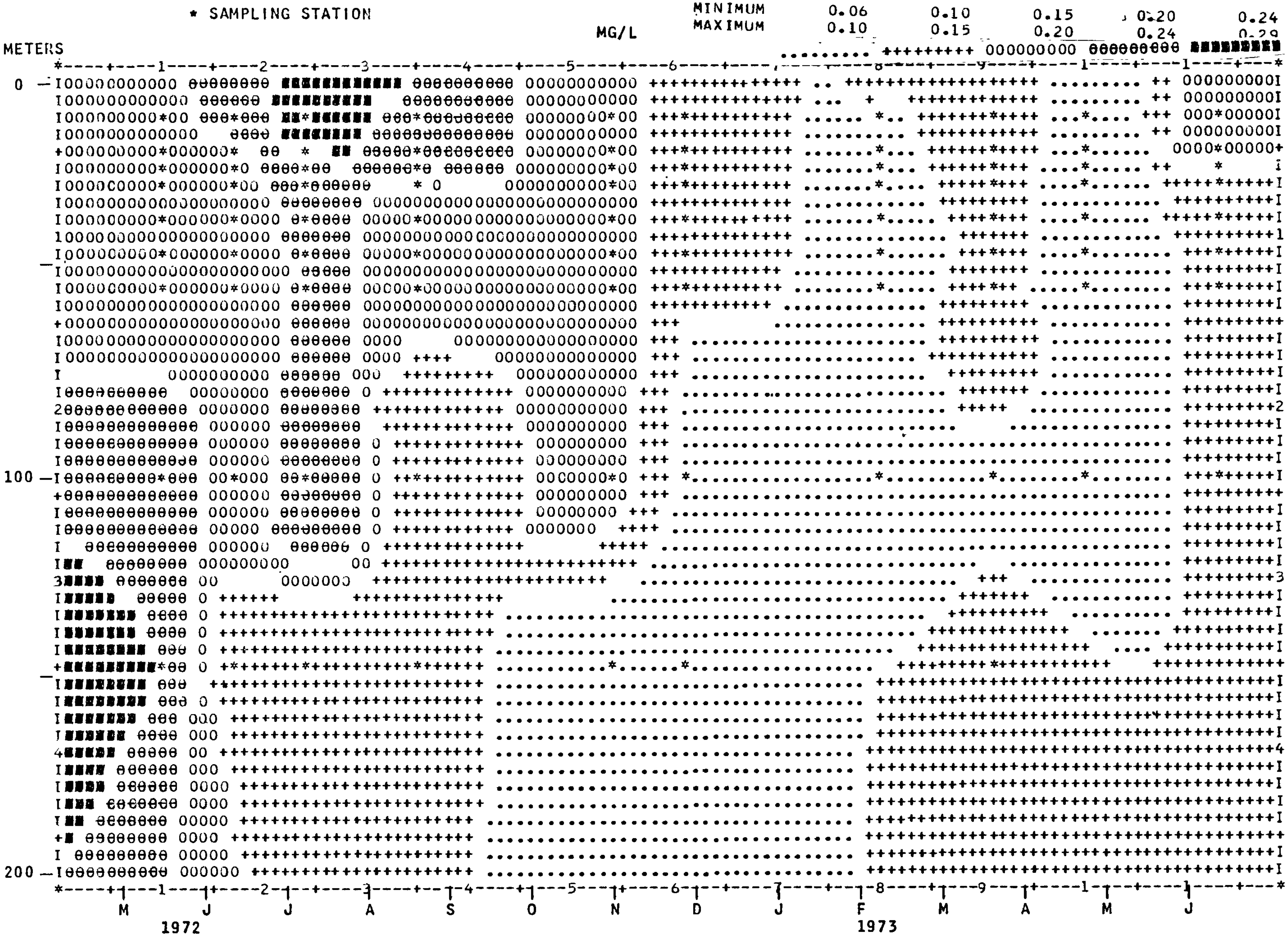


Figure 4.9c Depth Versus Time Contours of Constant Total Kjeldahl Nitrogen

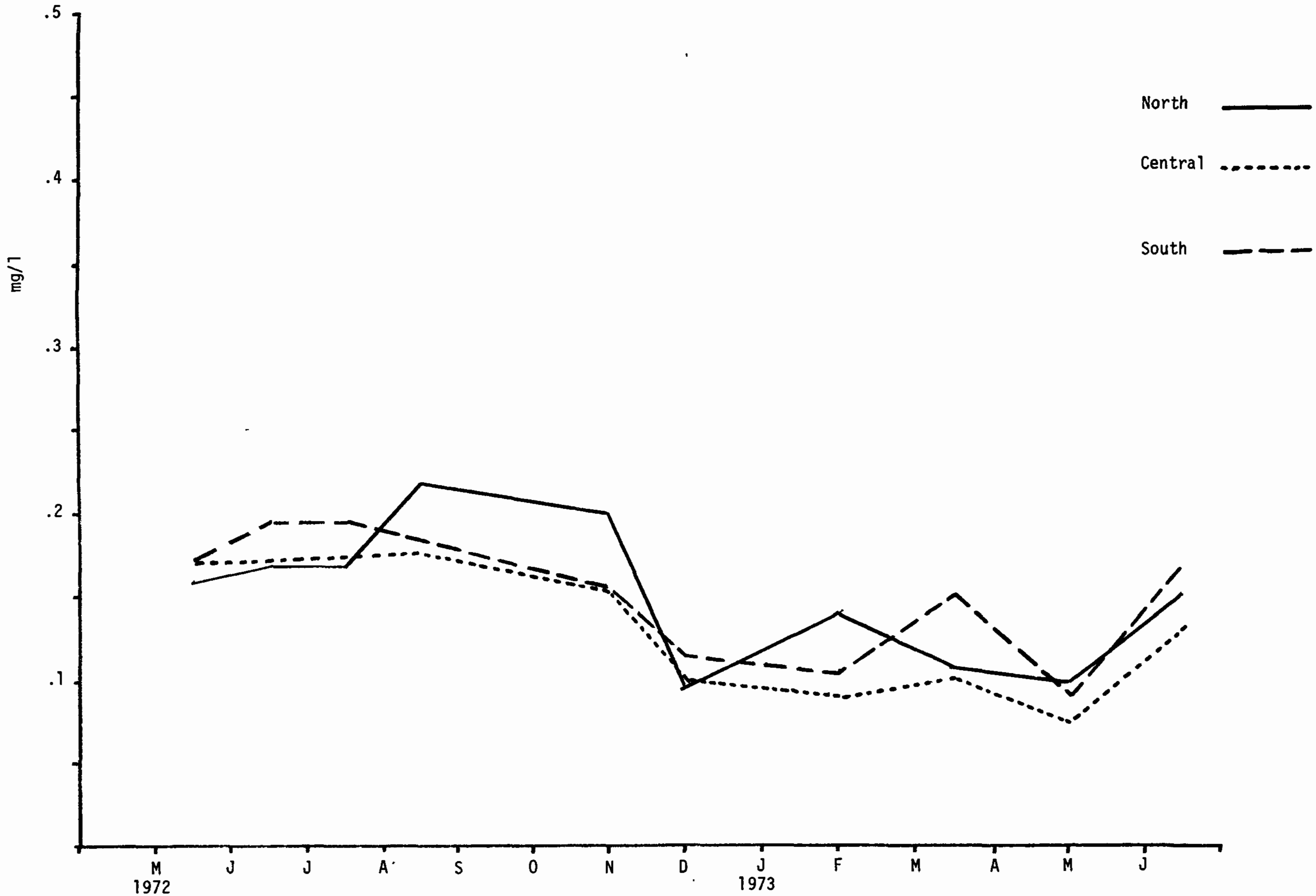


Figure 4.9d North-South Variation of Mean Total Kjeldahl Nitrogen During the Field Year

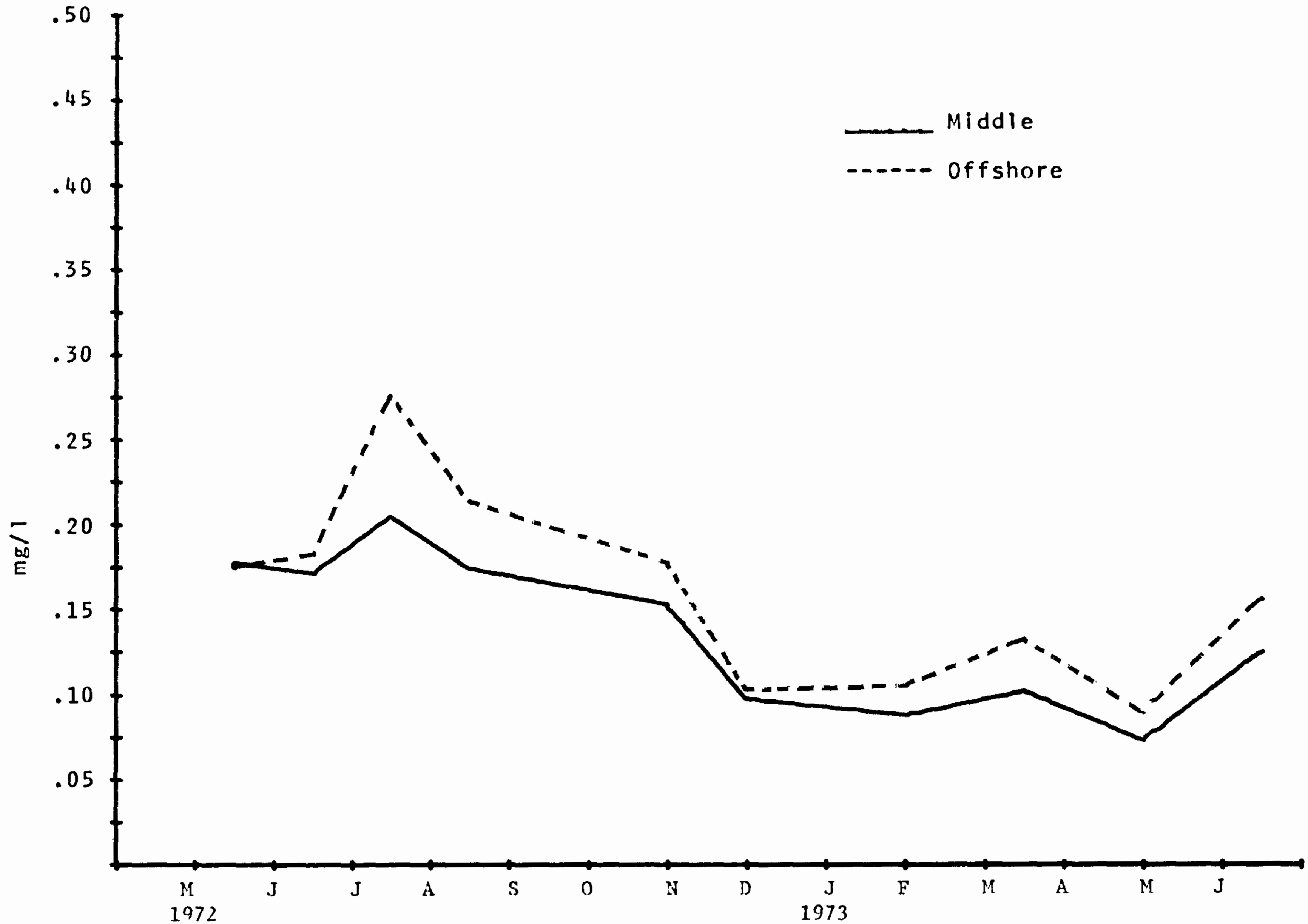


Figure 4.9e Middle Lake-Offshore Variations of mean Total Kjeldahl Nitrogen Concentration

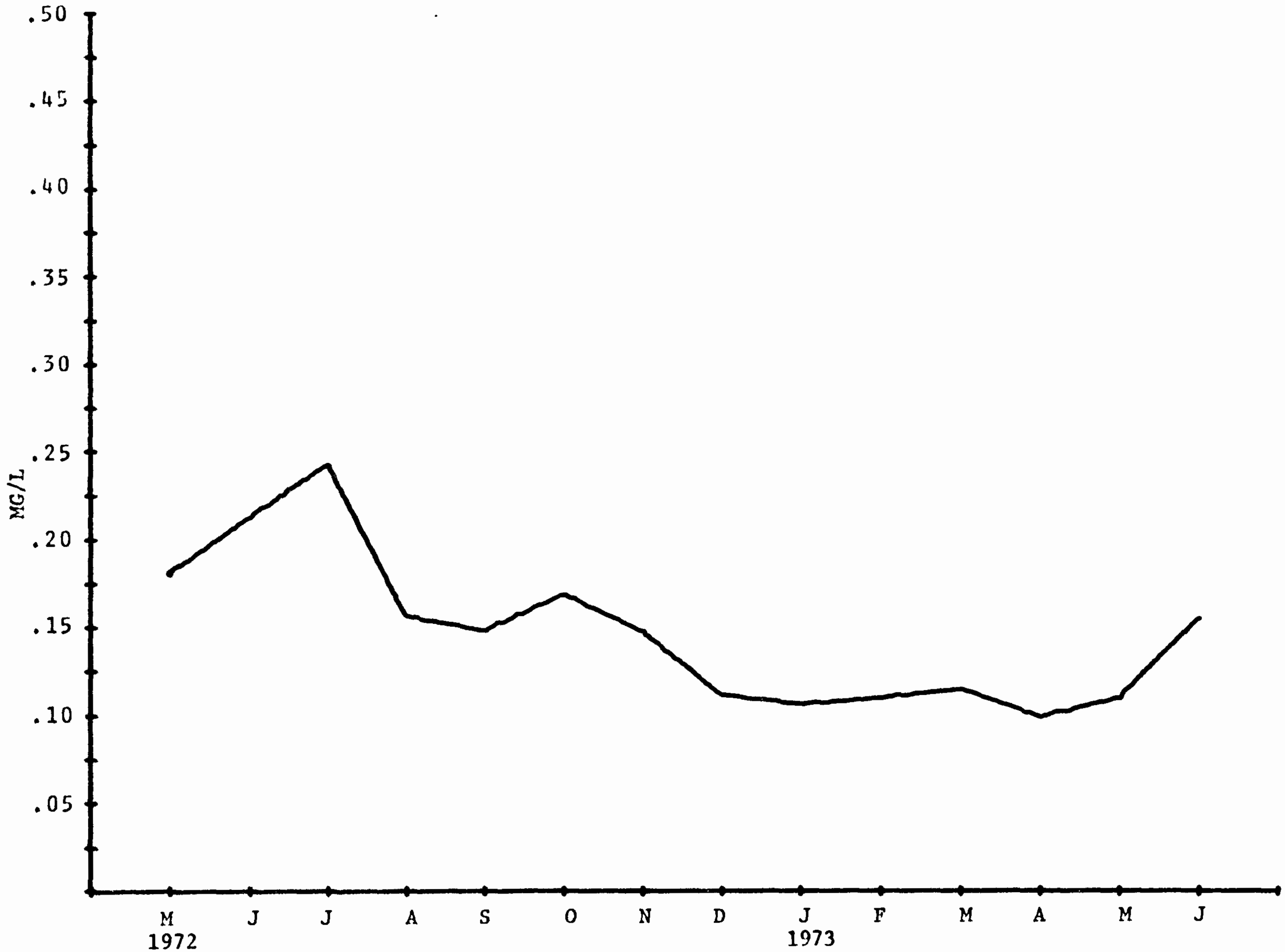


Figure 4. 9f Mean surface variation of Total Kjeldahl Nitrogen concentration during the field year.

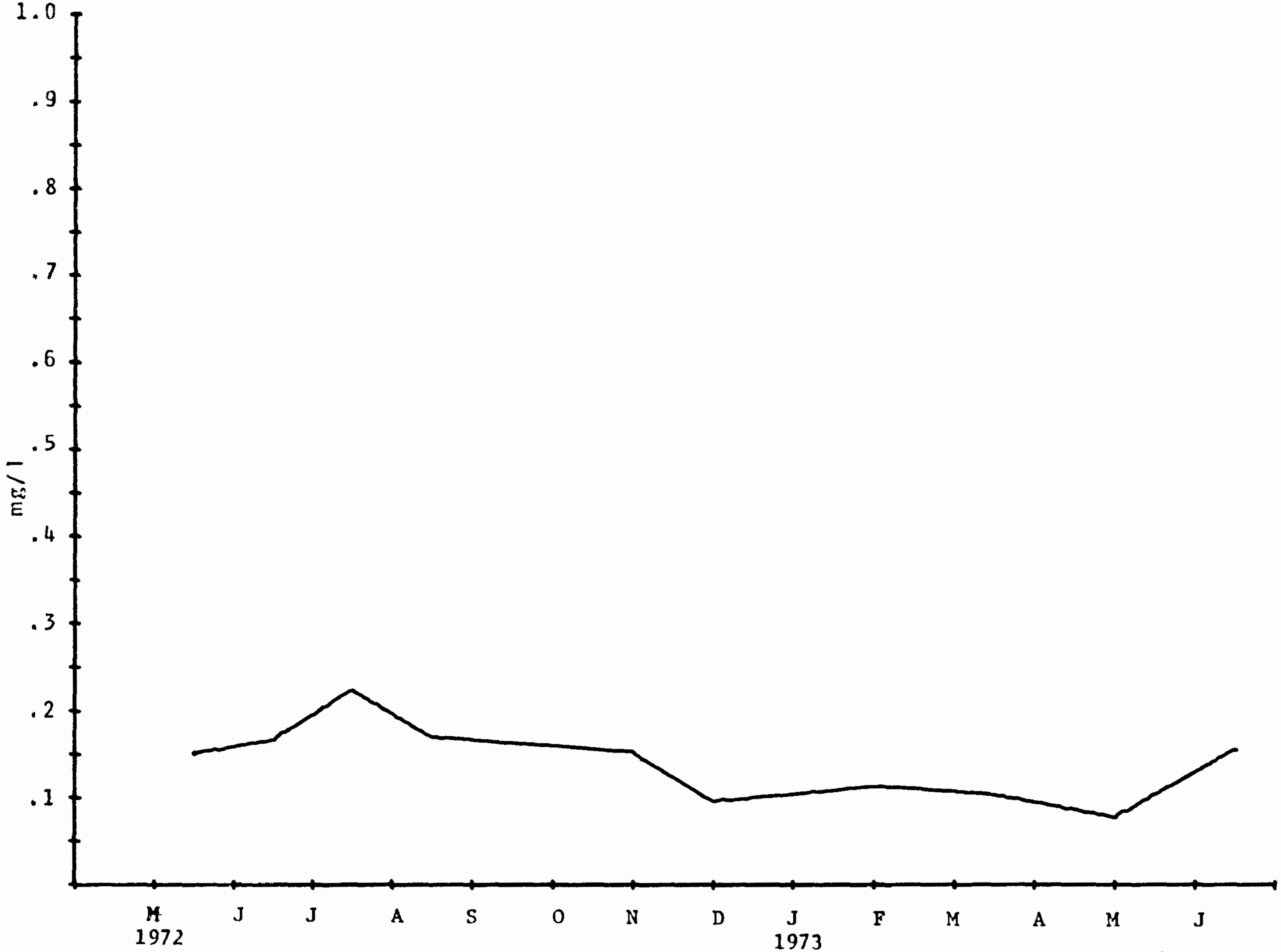


Figure 4.9g Mean Bottom Variation of Total Kjeldahl Nitrogen Concentration During the Field Year

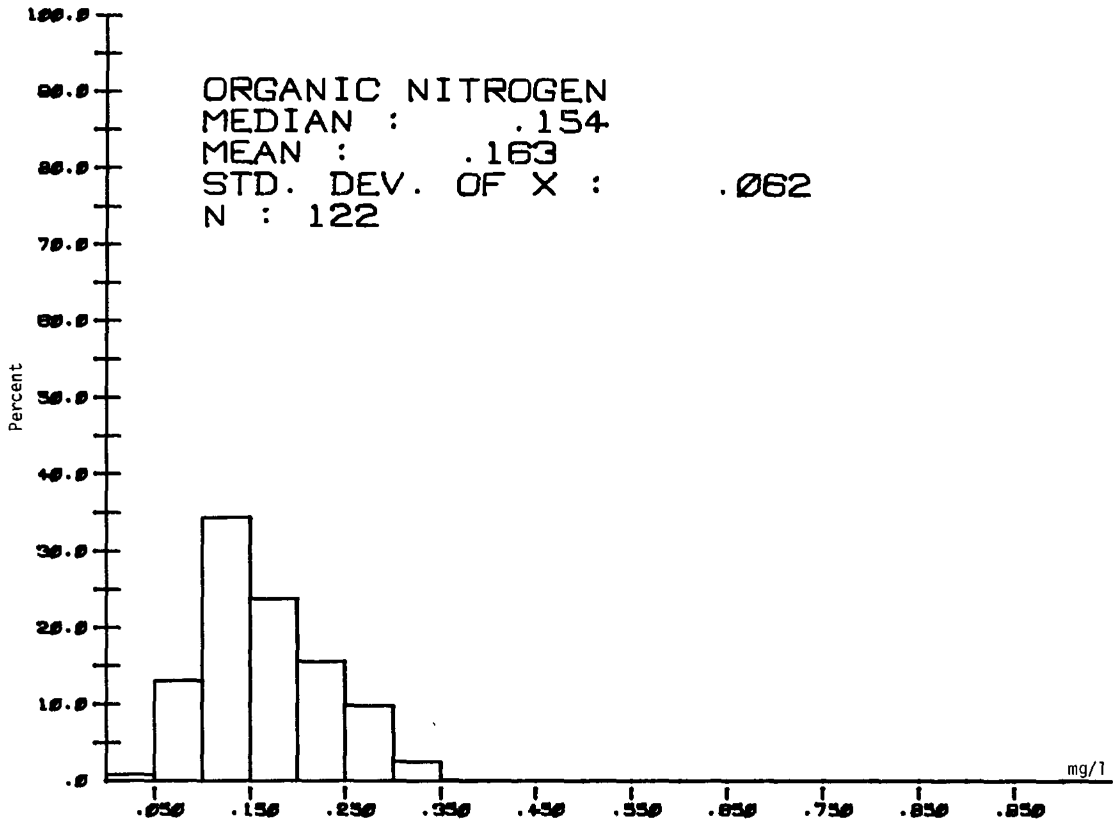


Figure 4.10a Histograms for Organic Nitrogen - Cruise 2

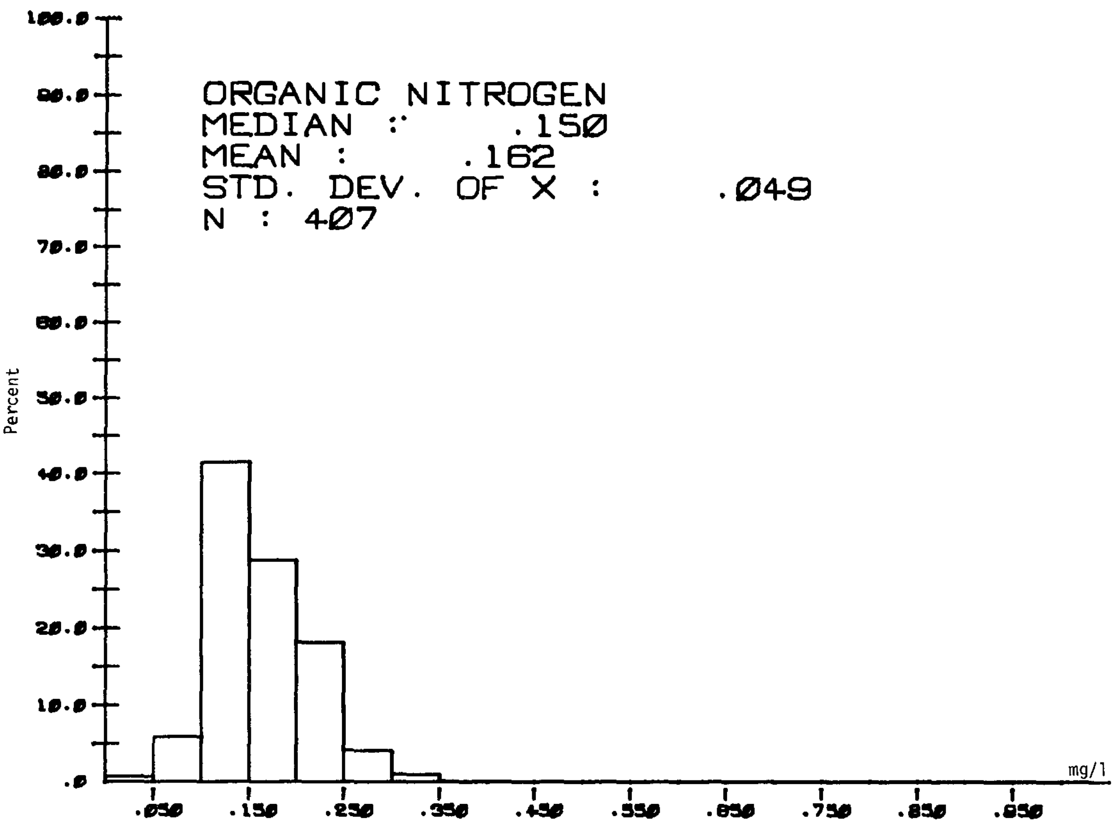


Figure 4.10a Histograms for Organic Nitrogen - Cruise 3

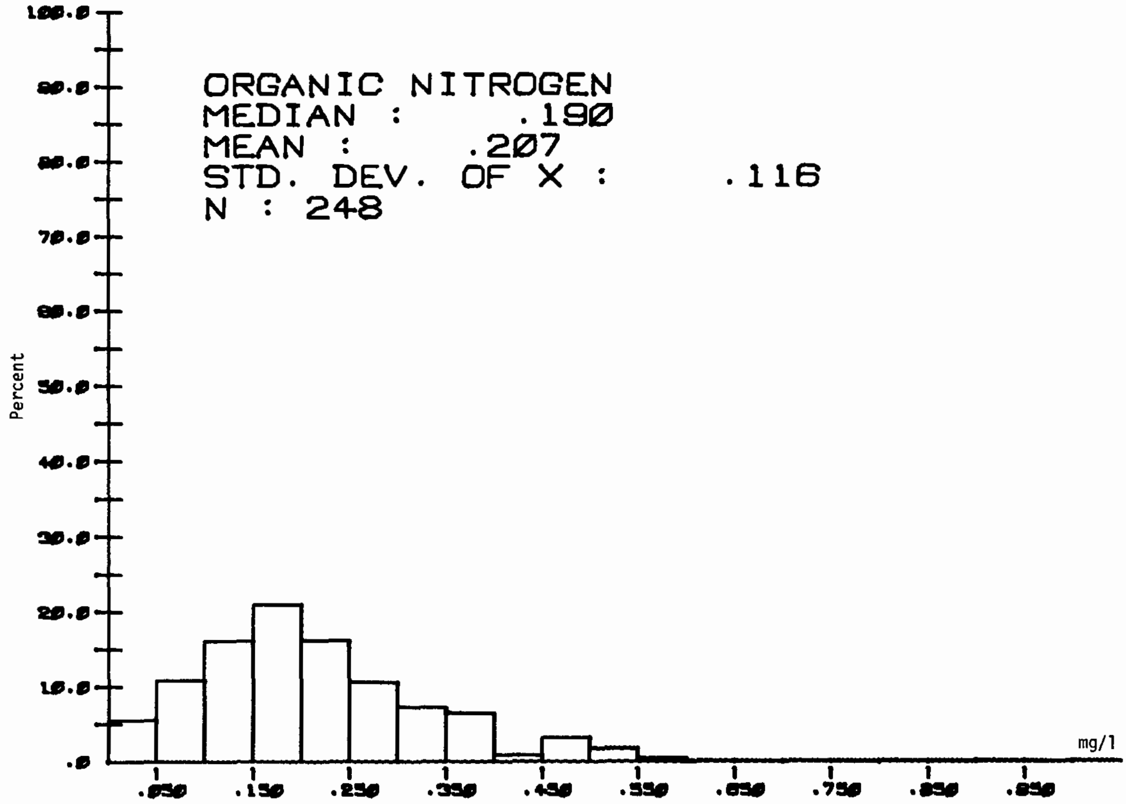


Figure 4.10a Histograms for Organic Nitrogen - Cruise 4

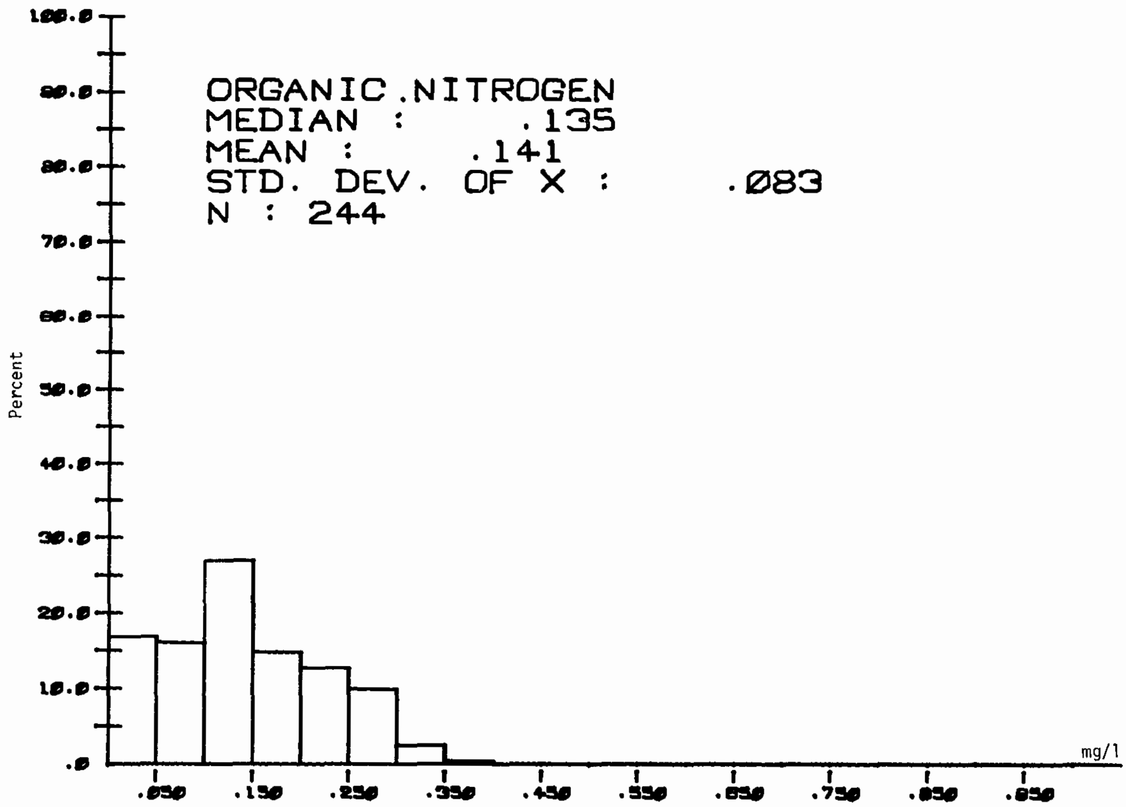


Figure 4-10a Histograms for Organic Nitrogen - Cruise 6

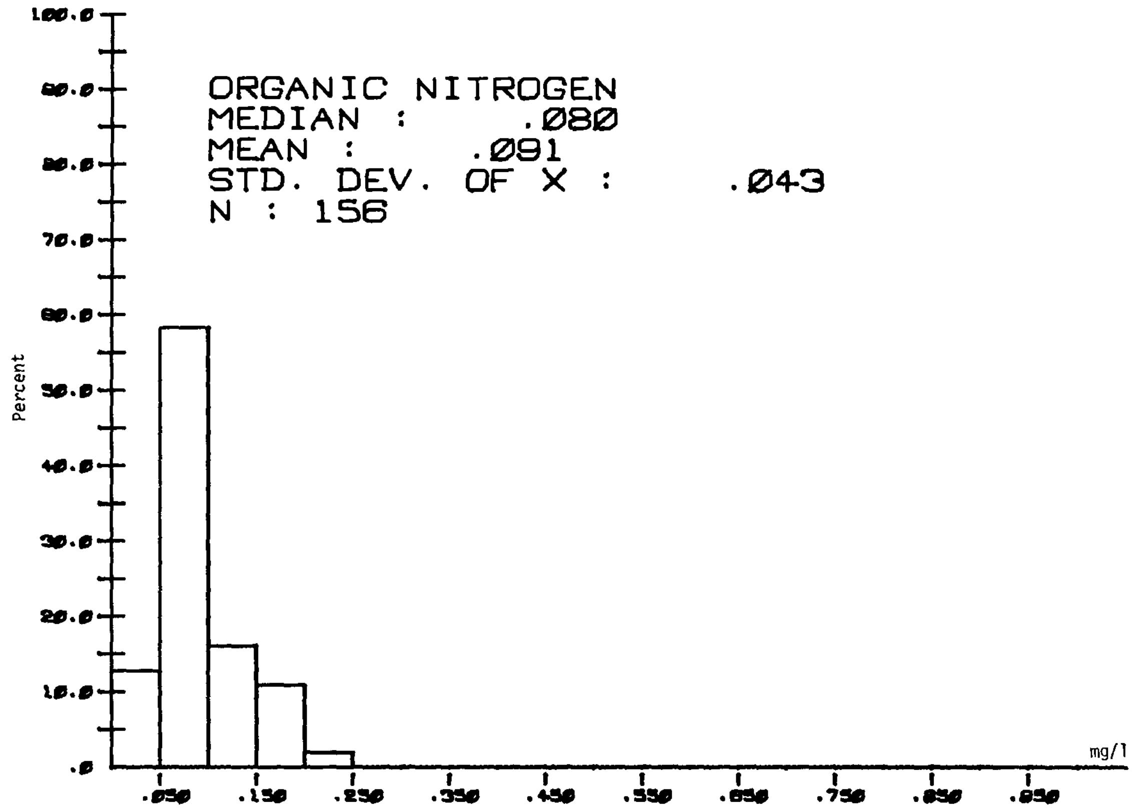


Figure 4.10a Histograms for Organic Nitrogen - Cruise 7

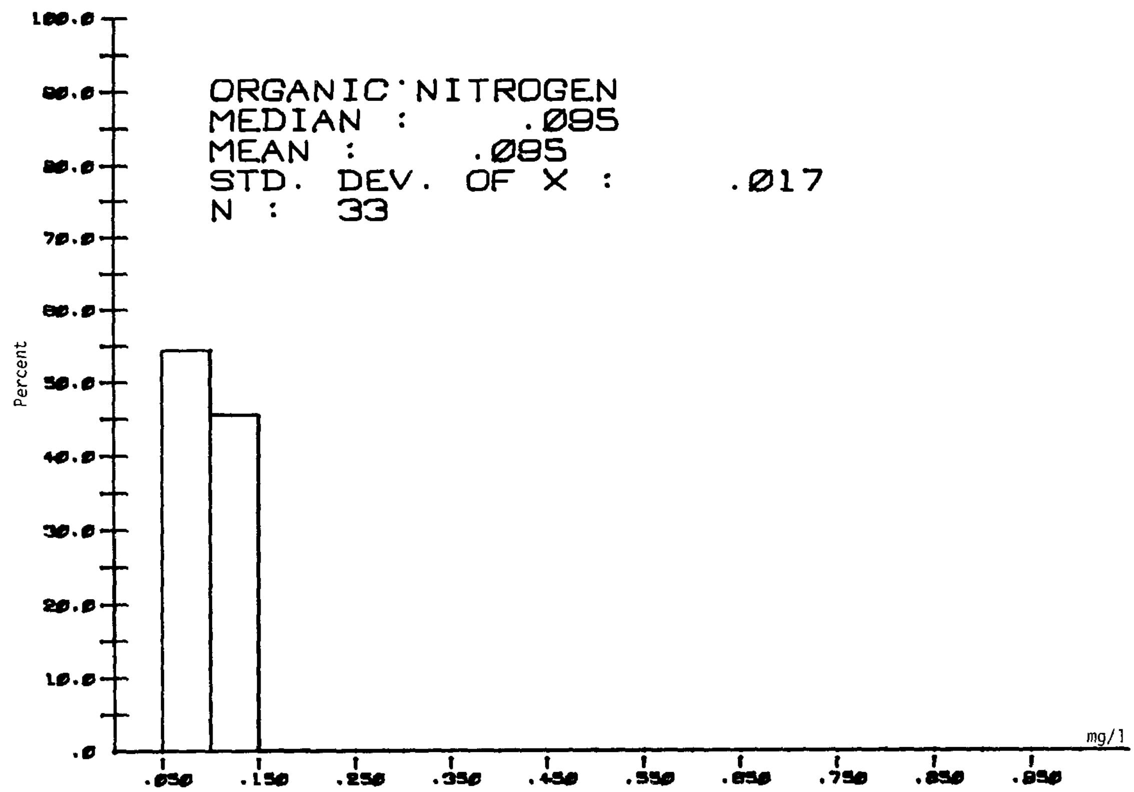


Figure 4.10a Histograms for Organic Nitrogen - Cruise 8

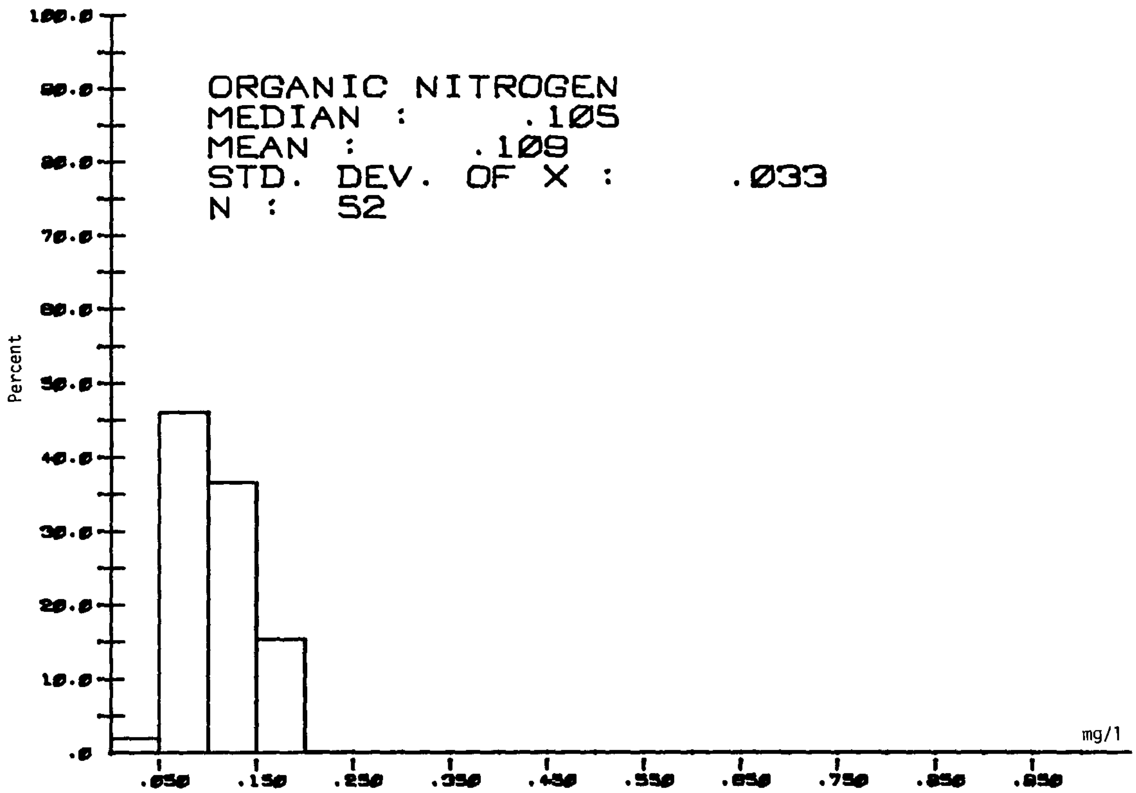


Figure 4.10a Histograms for Organic Nitrogen - Cruise 9

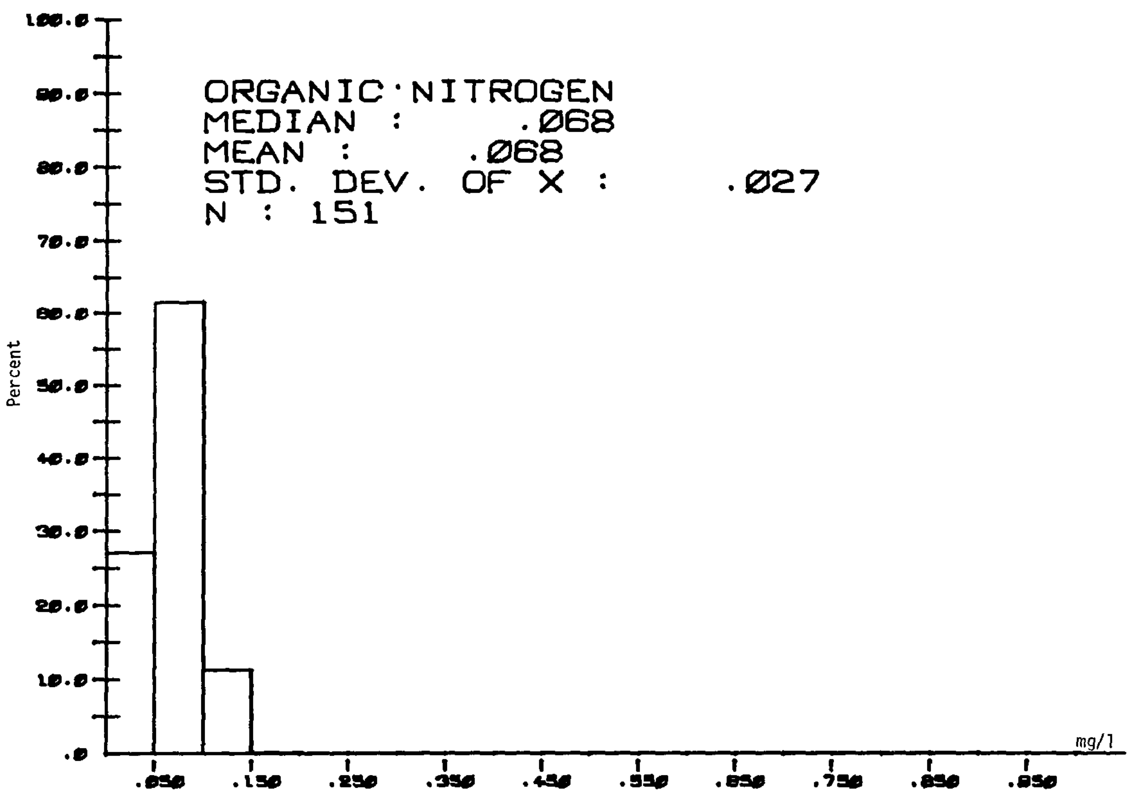


Figure 4.10a Histograms for Organic Nitrogen - Cruise 10

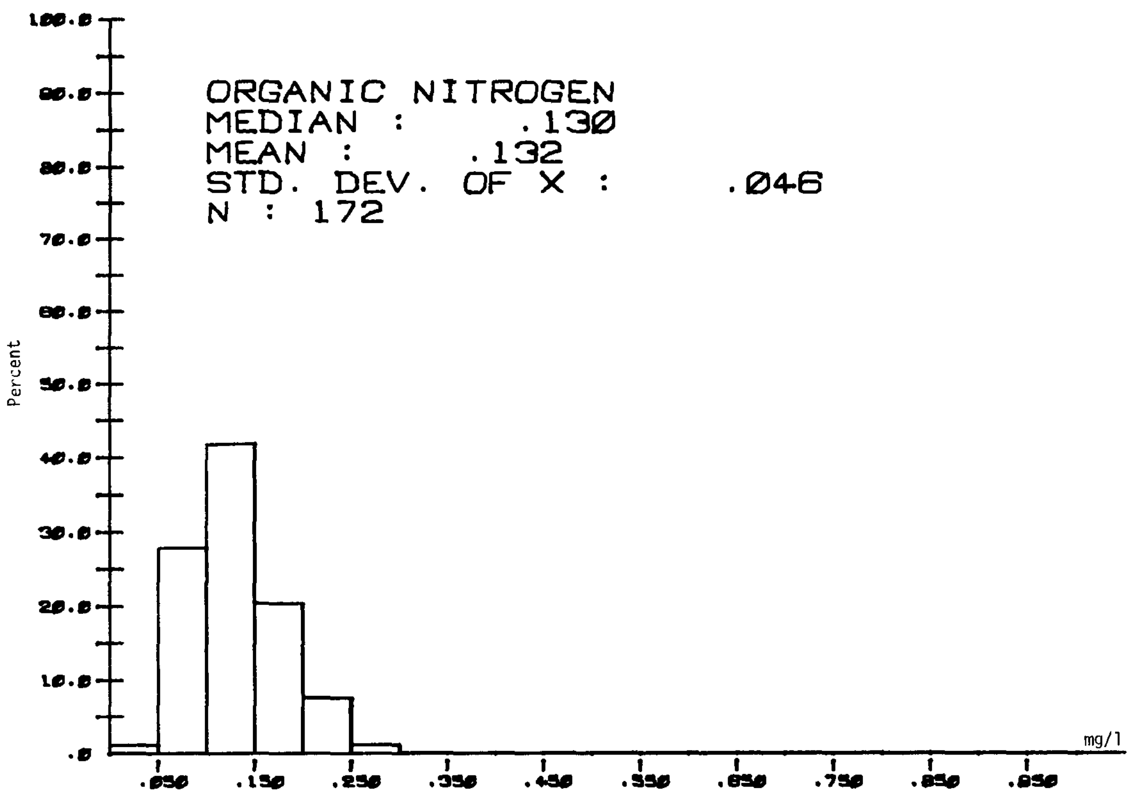


Figure 4.10a Histograms for Organic Nitrogen - Cruise 11

SAMPLING STATION	MG/L						
		MINIMUM	0.05	0.09	0.14	0.18	0.22
		MAXIMUM	0.09	0.14	0.18	0.22	0.26
			%%%%%%%%%	000000000	*********	+++++++++	---------

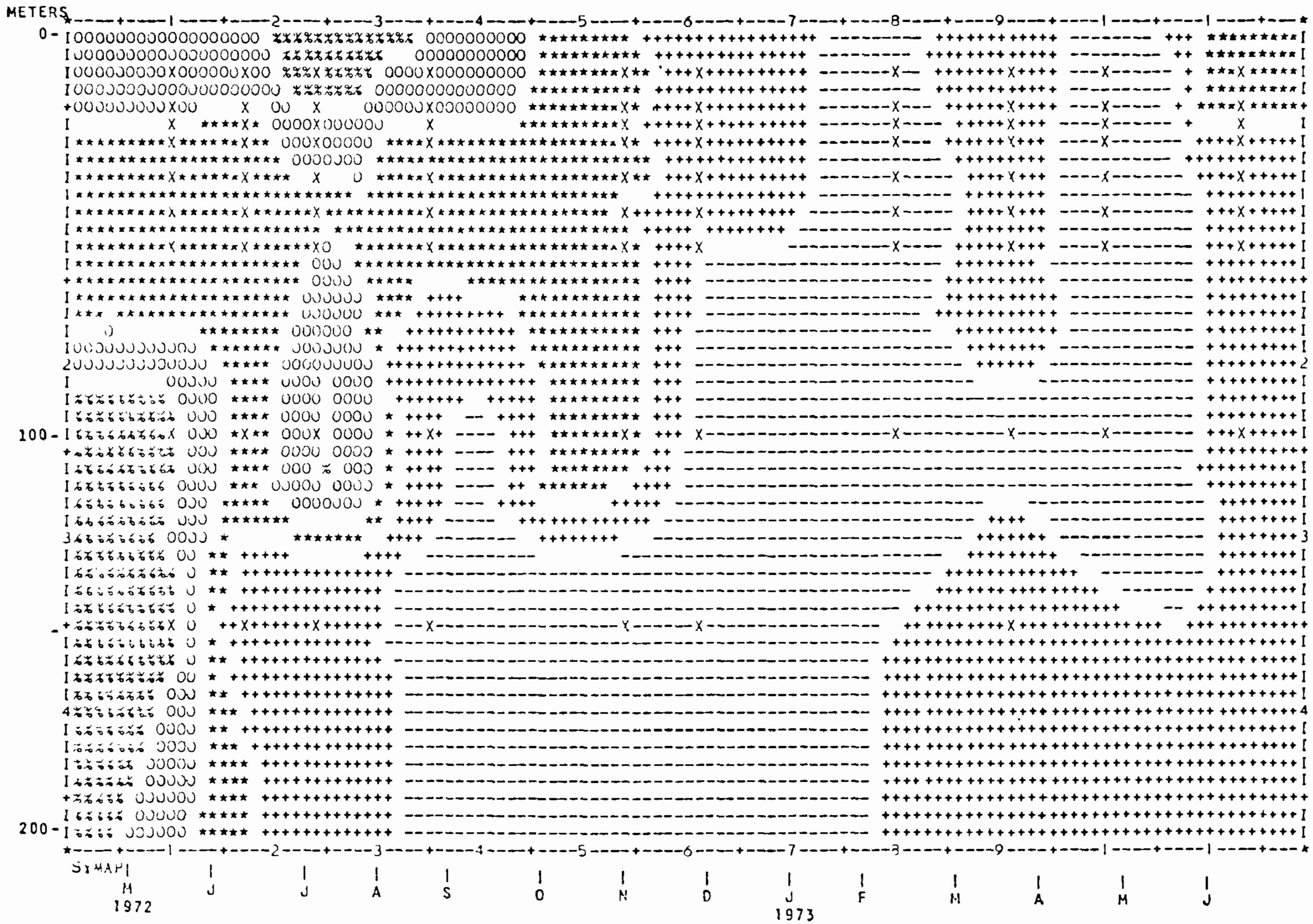


Figure 4.10c Depth Versus Time Contours of Constant Organic Nitrogen

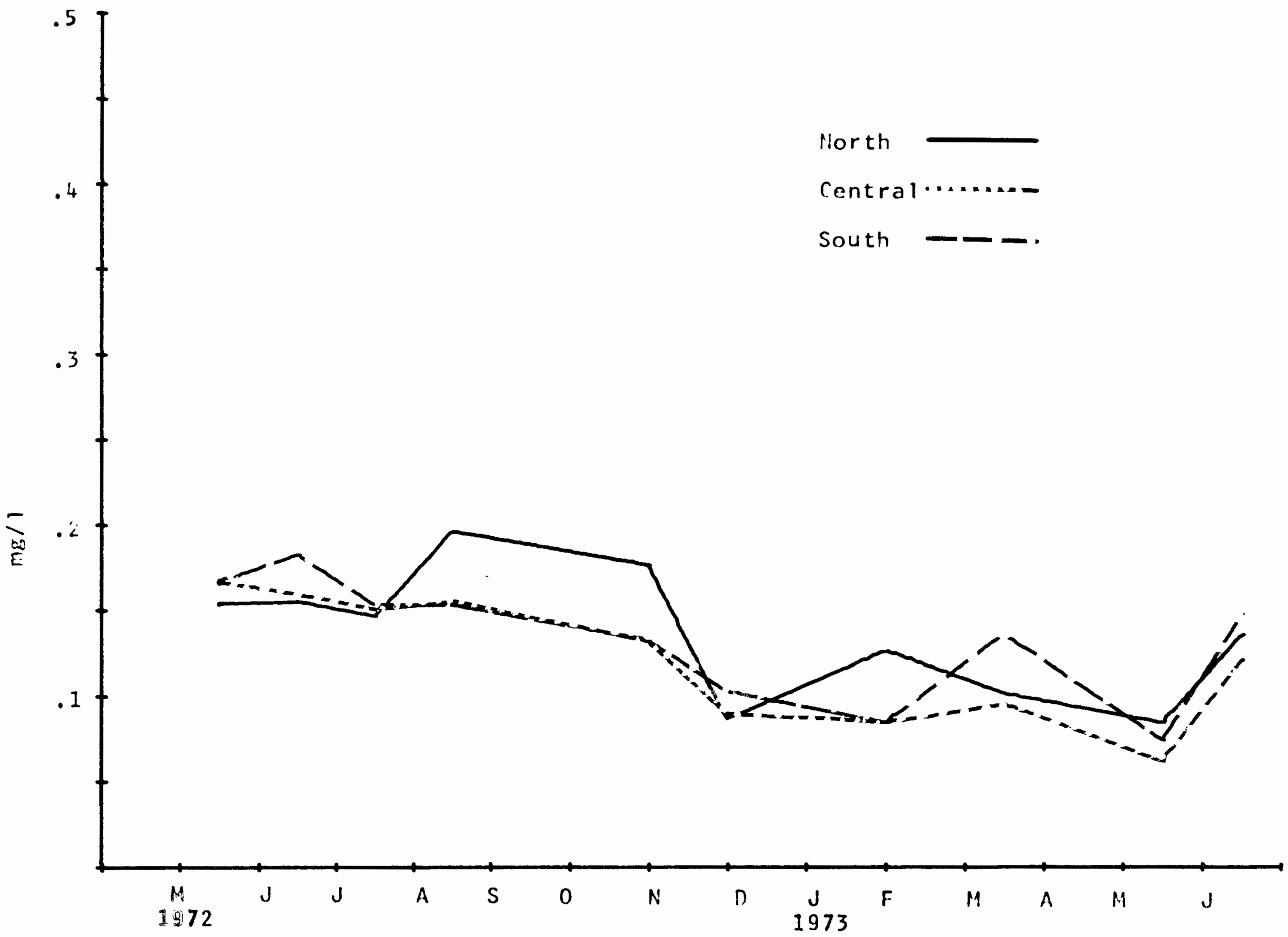


Figure 4.10d North-South Variation of Organic Nitrogen During the Field Year

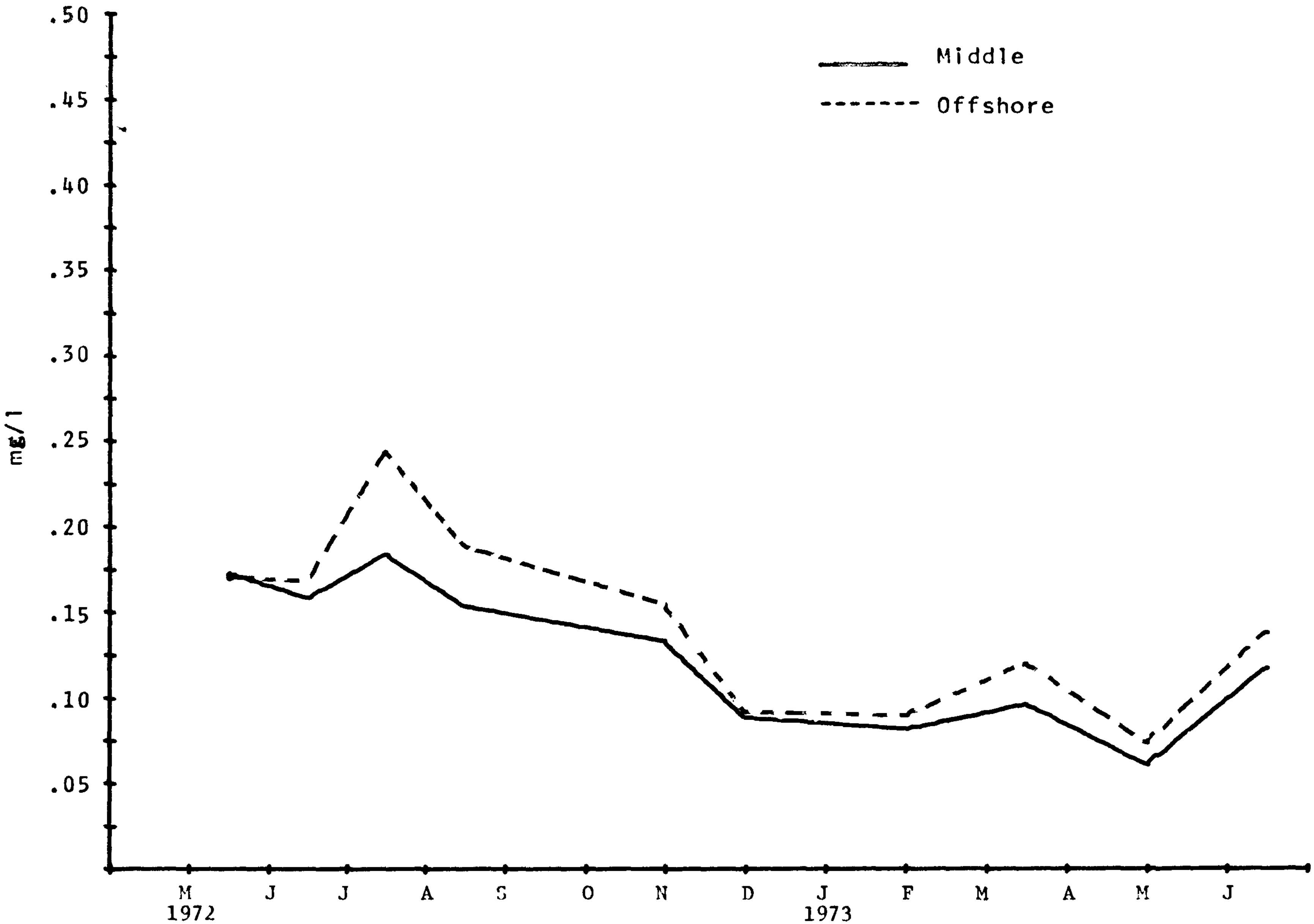


Figure 4.10e Middle Lake-Offshore Variations of Mean Organic Nitrogen Concentration

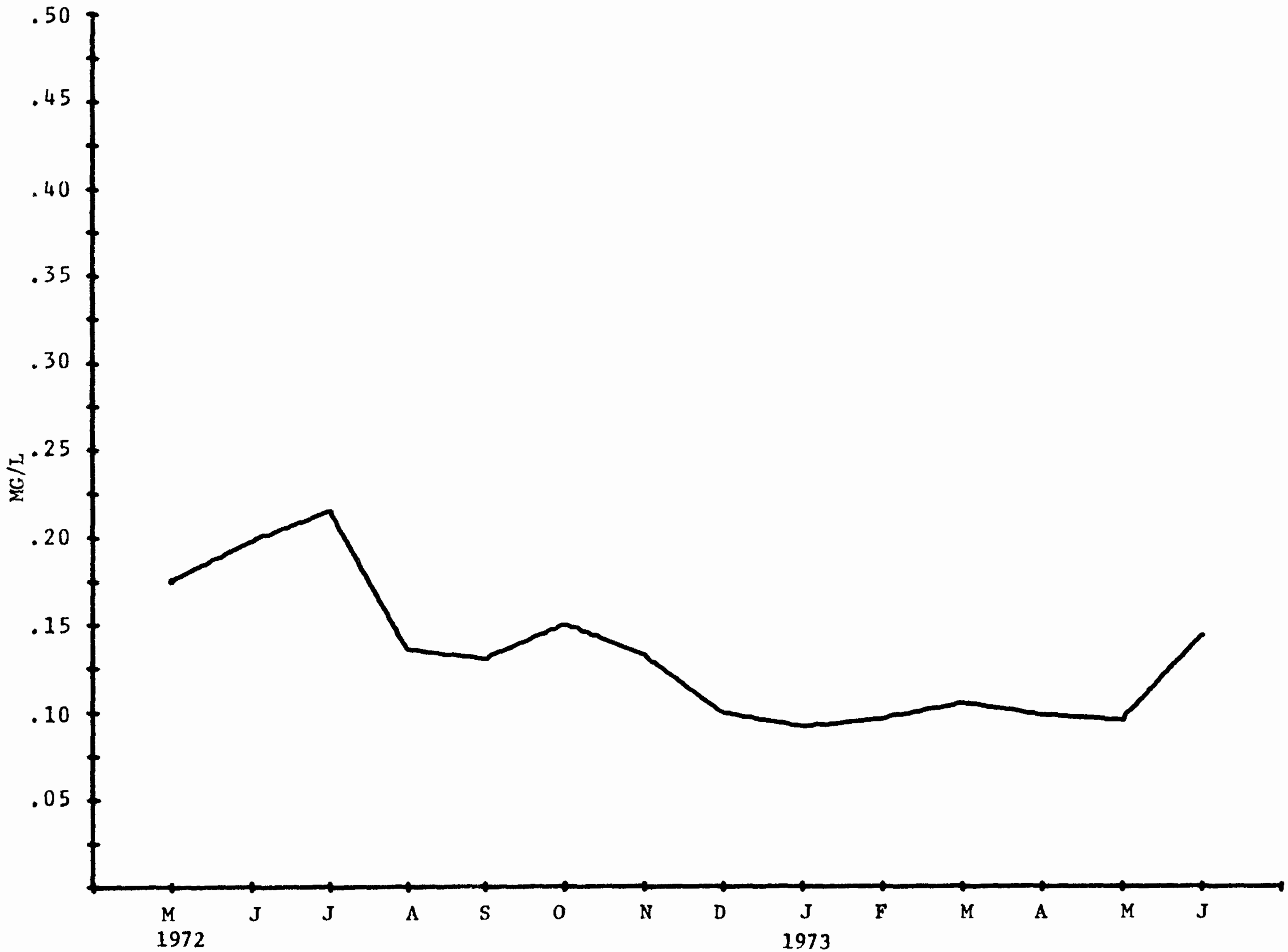


Figure 4.10f Mean surface variation of Organic Nitrogen concentration during the field year.

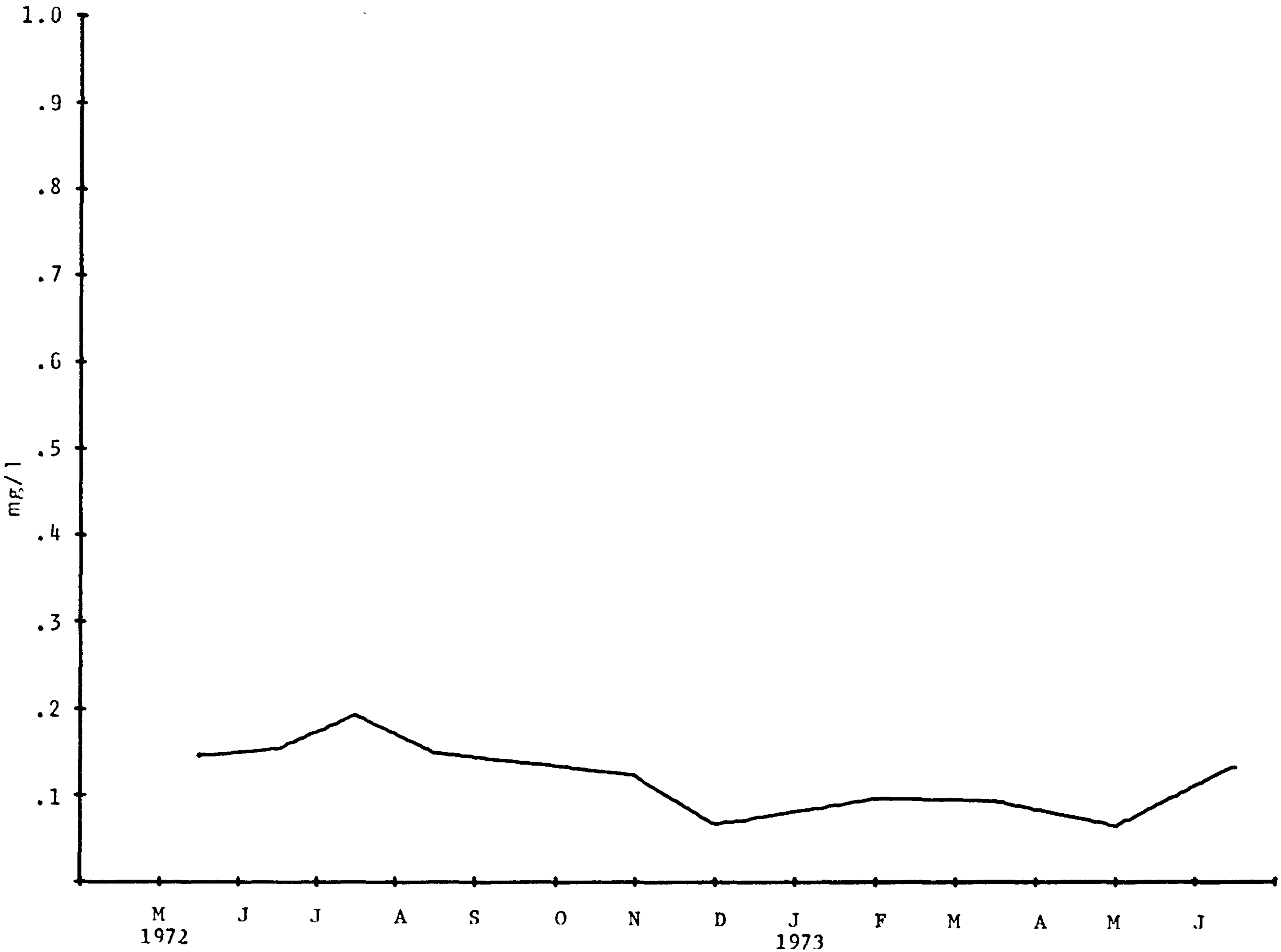


Figure 4.10g Mean Bottom Variation of Organic Nitrogen Concentration During the Field Year

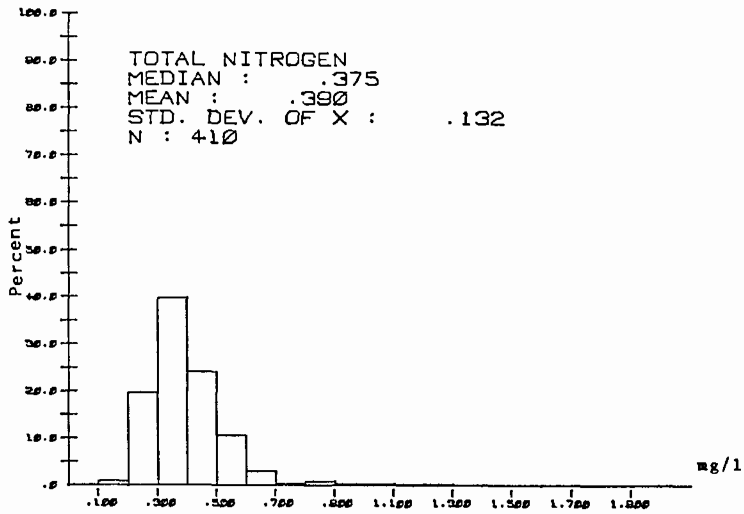


Figure 4.11a Histograms for Total Nitrogen - Cruise 3

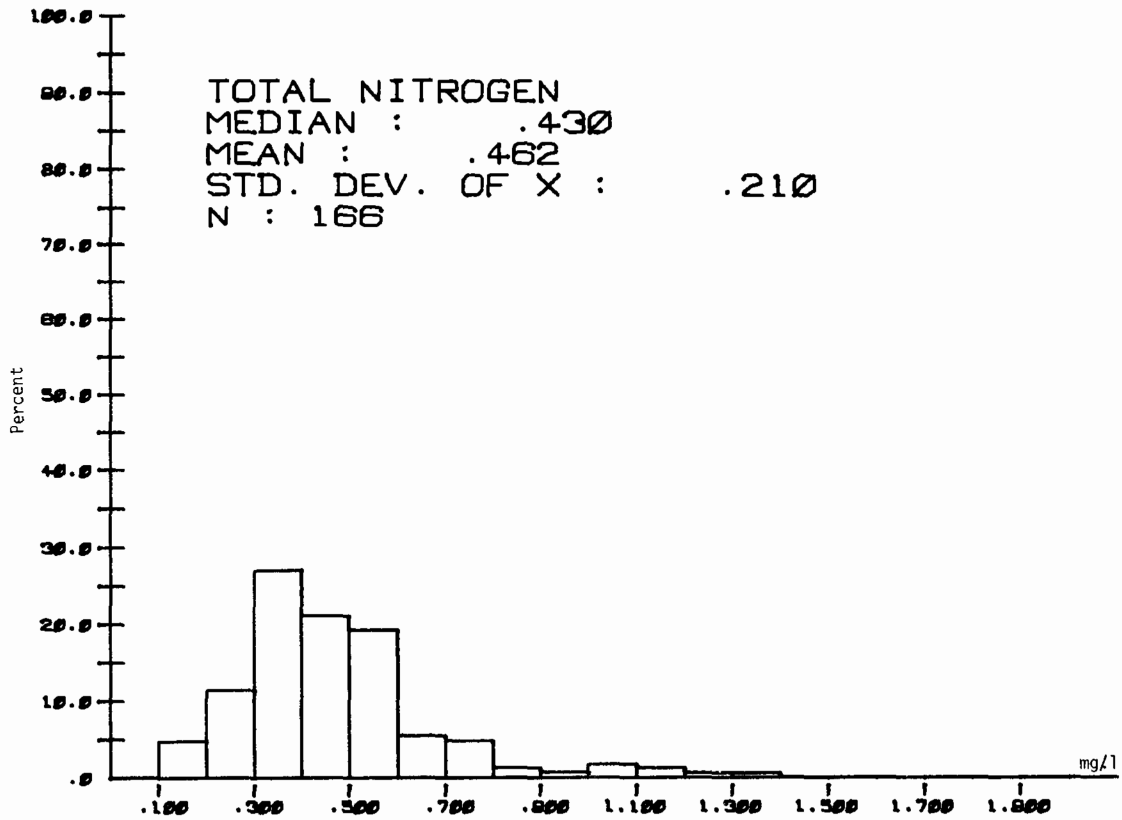


Figure 4.11a Histograms for Total Nitrogen

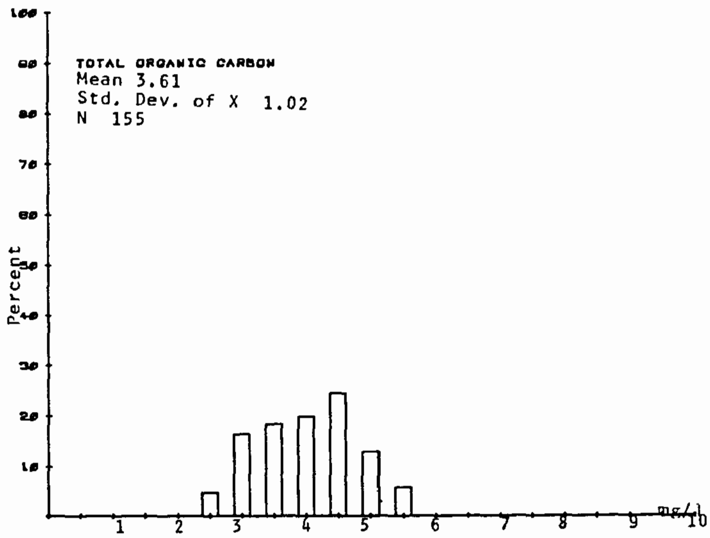


Figure 4.12a Histograms for Total Organic Carbon - Cruise 5

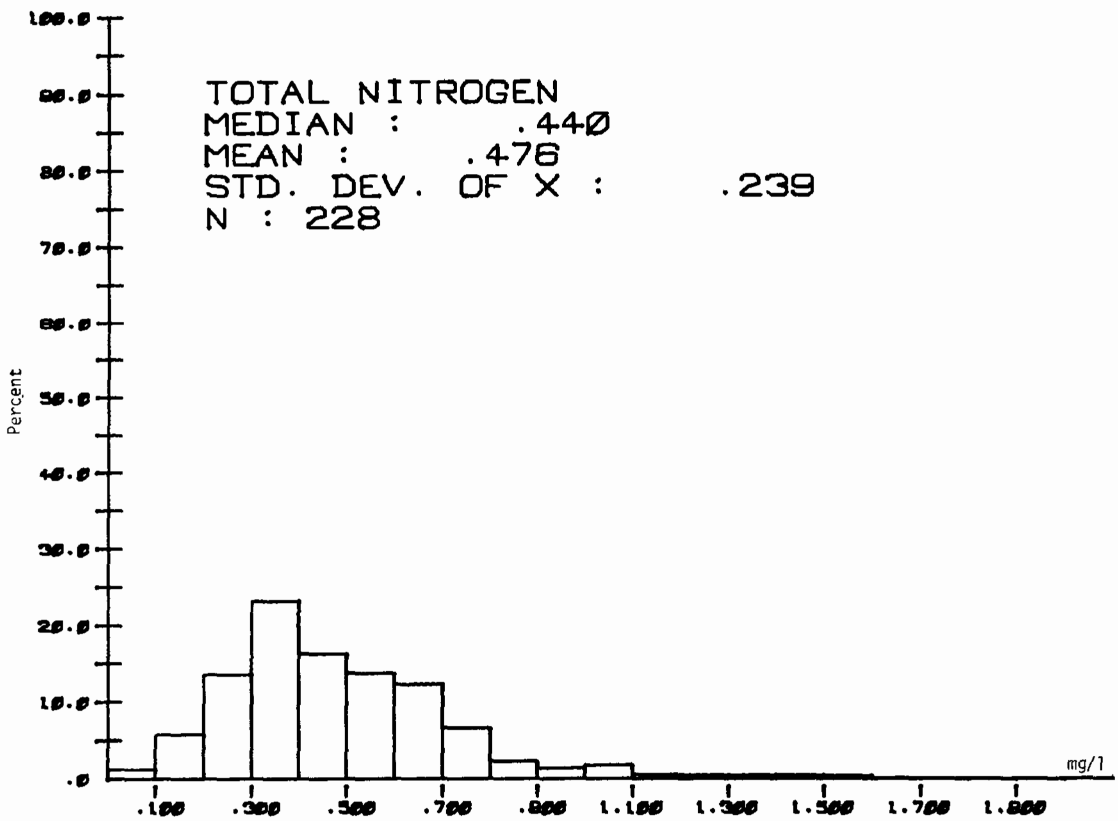


Figure 4.11a Histograms for Total Nitrogen - Cruise 4

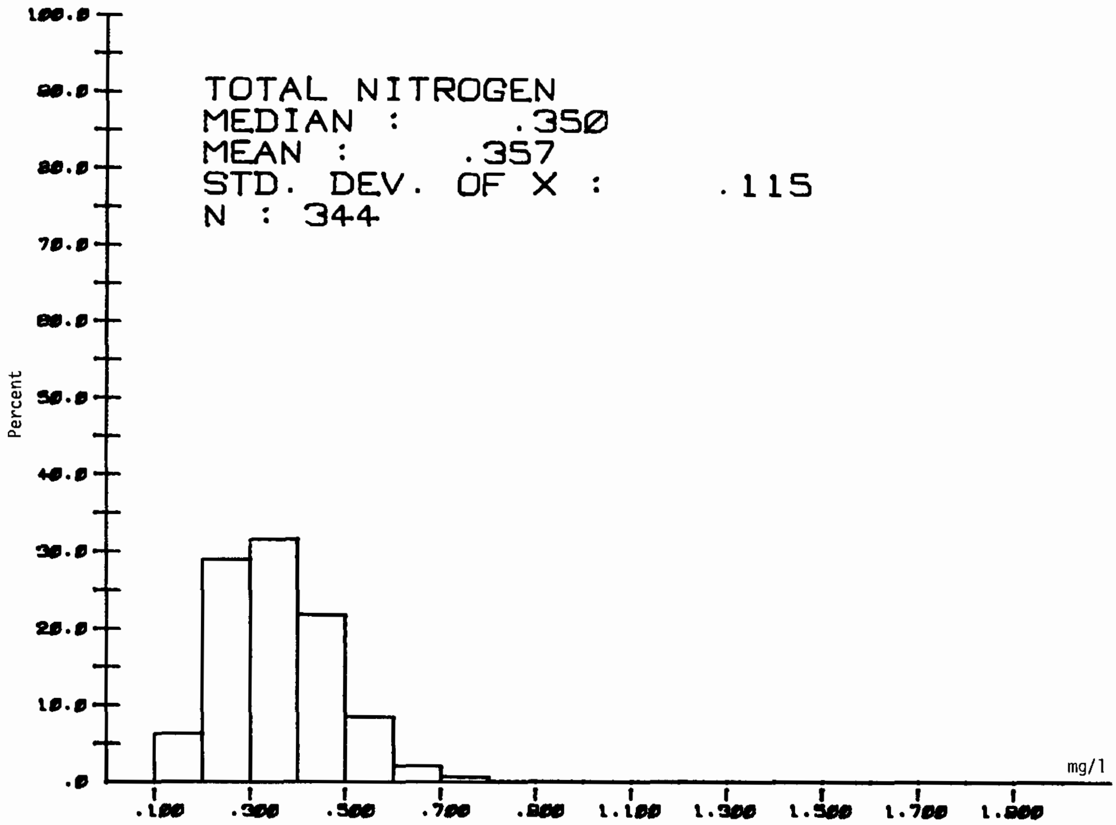


Figure 4.11a Histograms for Total Nitrogen - Cruise 6

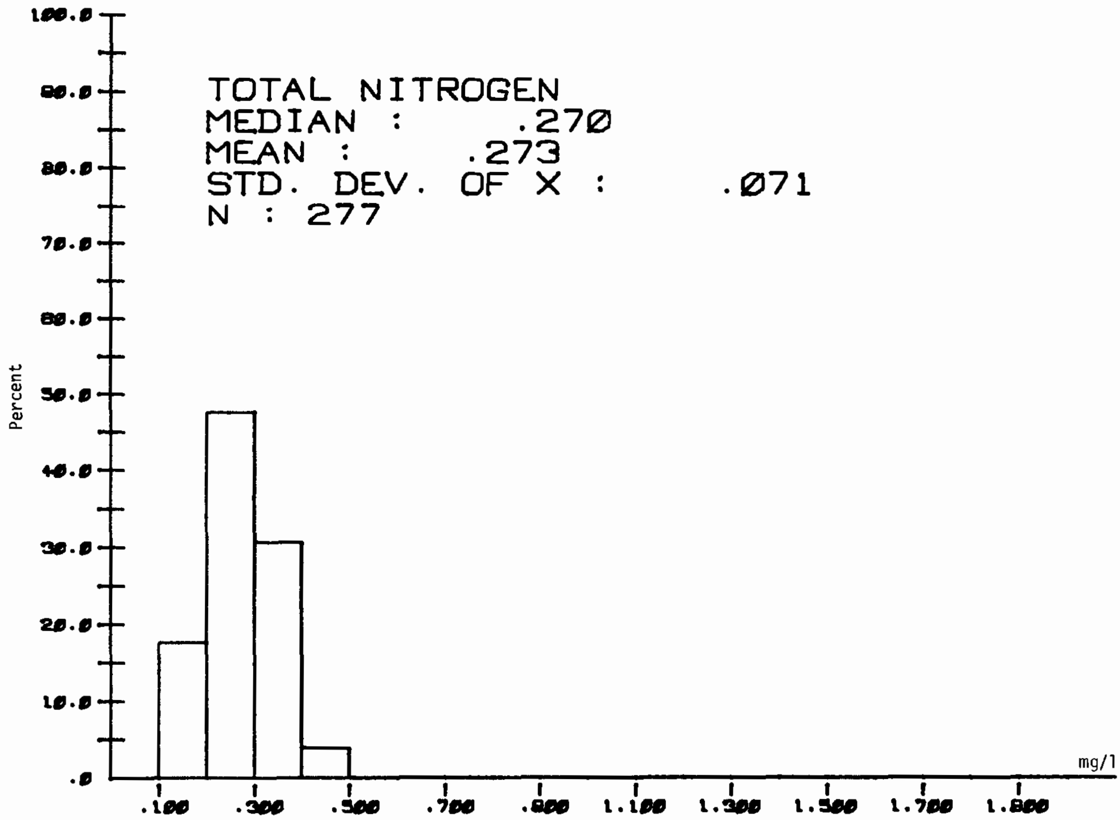


Figure 4.11a Histograms for Total Nitrogen - Cruise 7

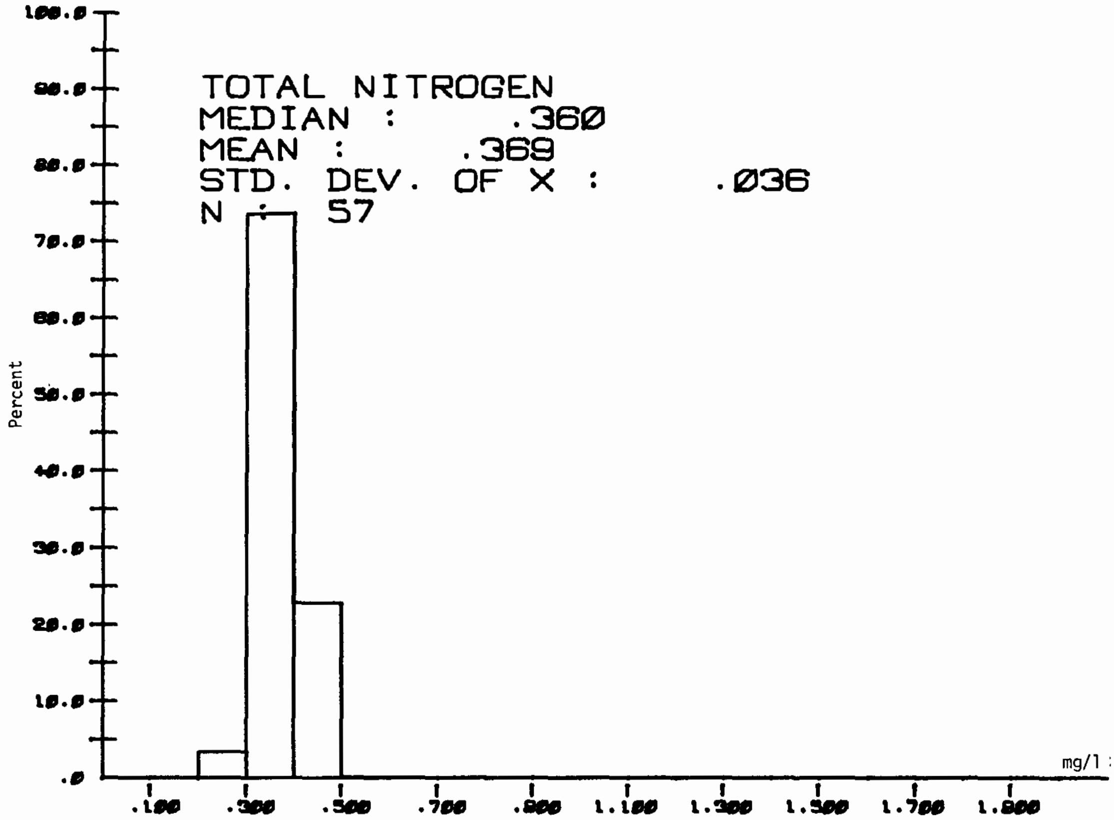


Figure 4.11a Histograms for Total Nitrogen - Cruise 8

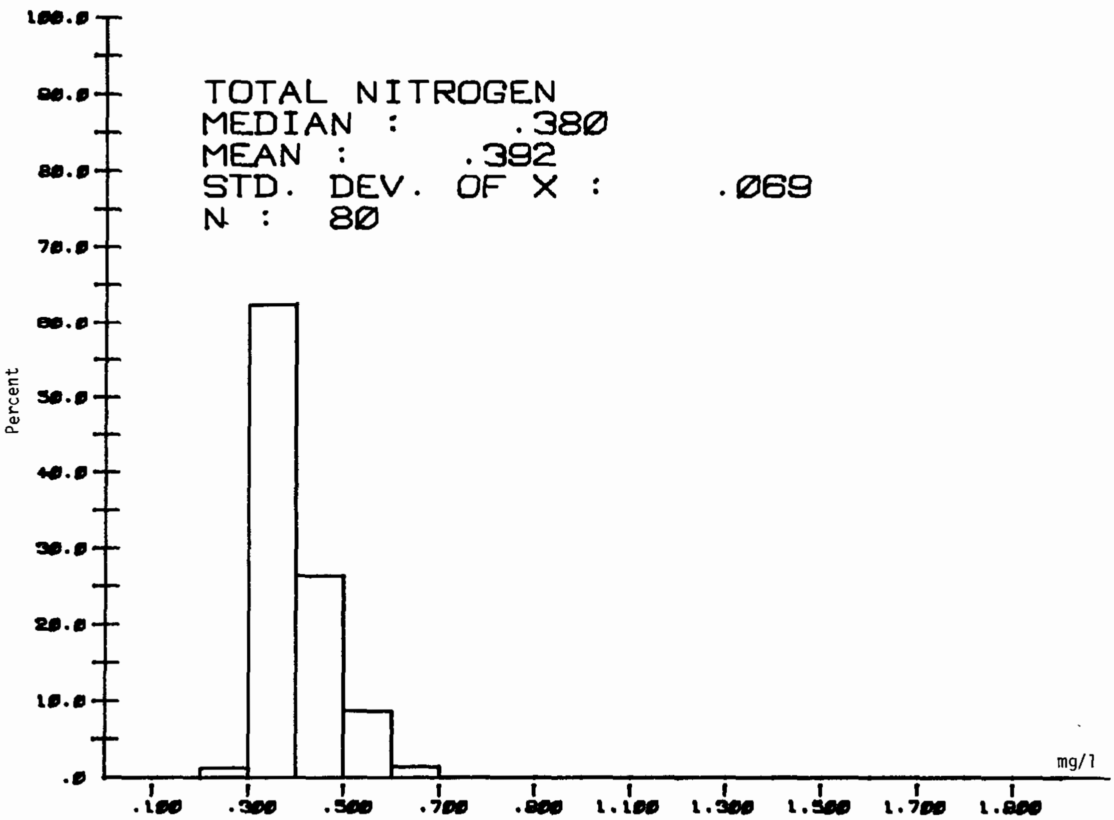


Figure 4.11a Histograms for Total Nitrogen - Cruise 9

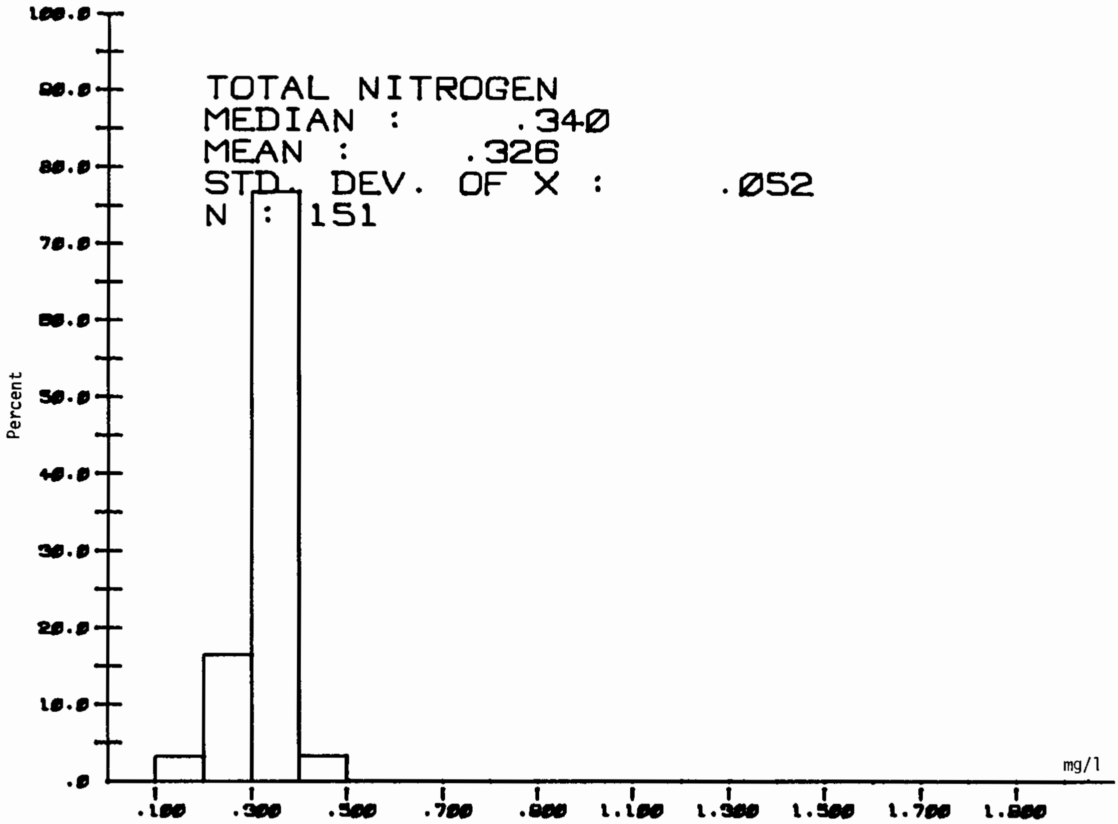


Figure 4.11a Histograms for Total Nitrogen - Cruise 10

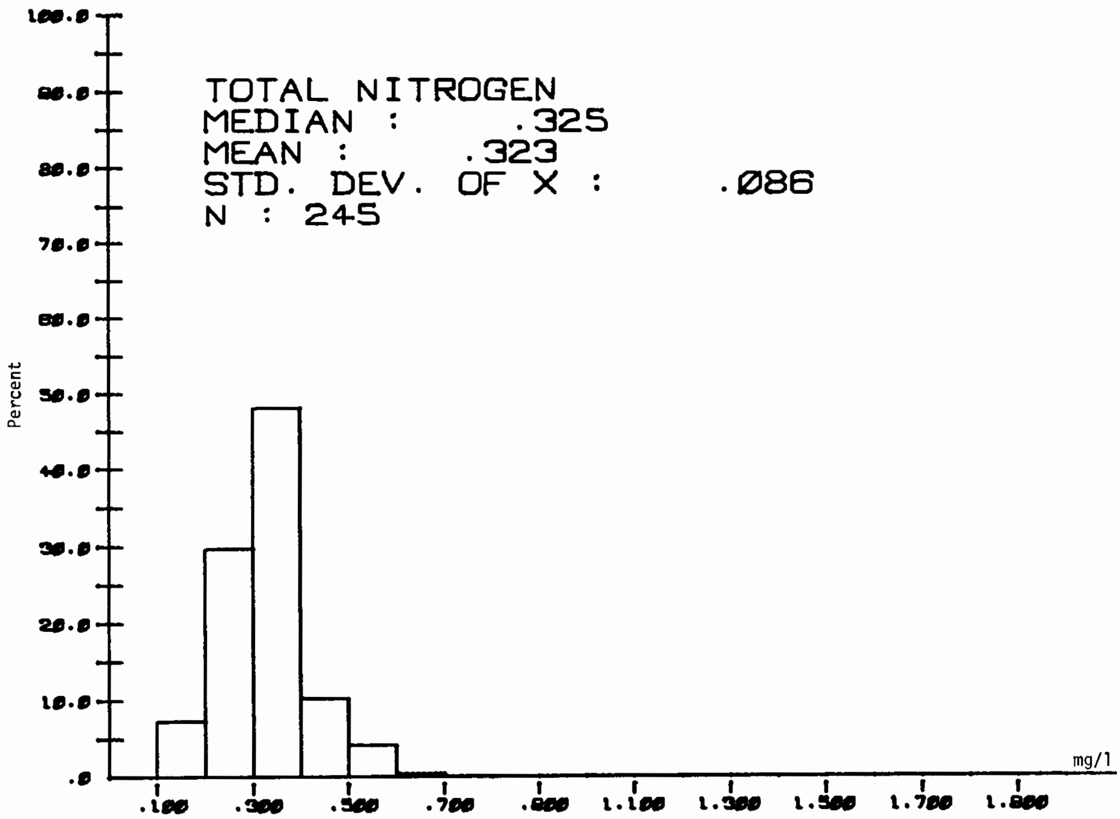


Figure 4.11a Histograms for Total Nitrogen - Cruise 11

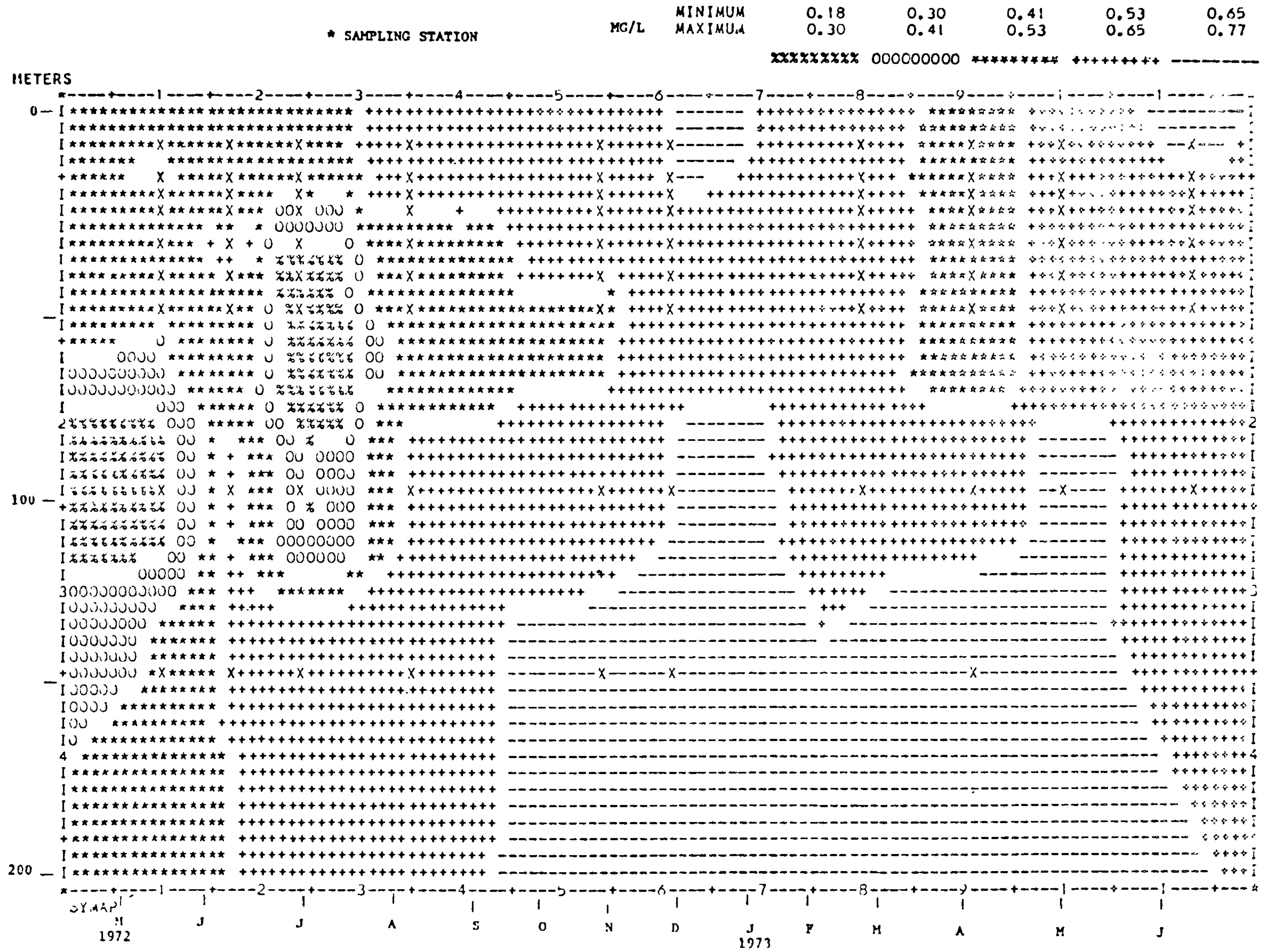


Figure 4.11c Depth Versus Time Contours of Constant Total Nitrogen

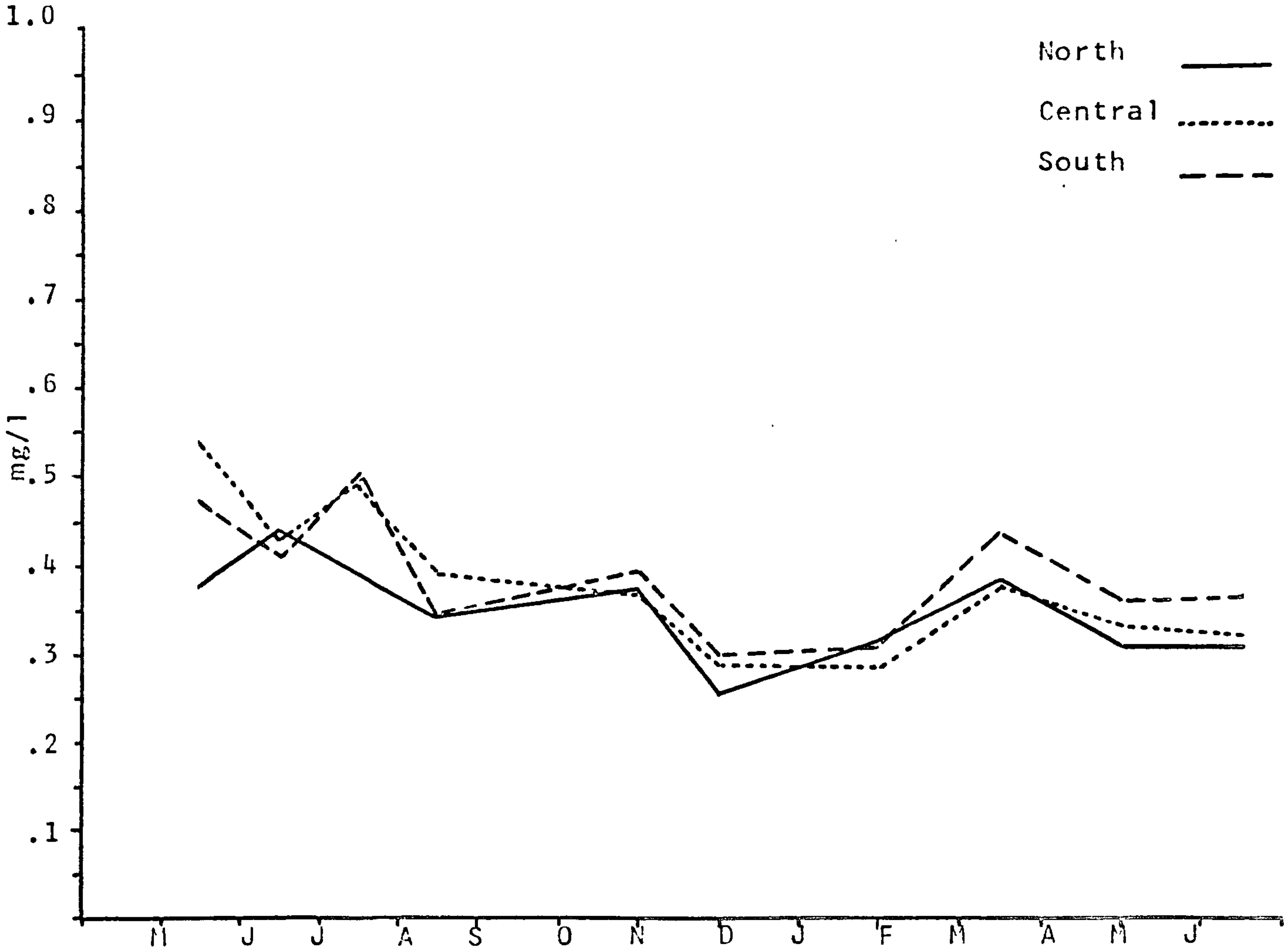


Figure 4.11 d North-south Variation of Mean Total Nitrogen
During the Field Year

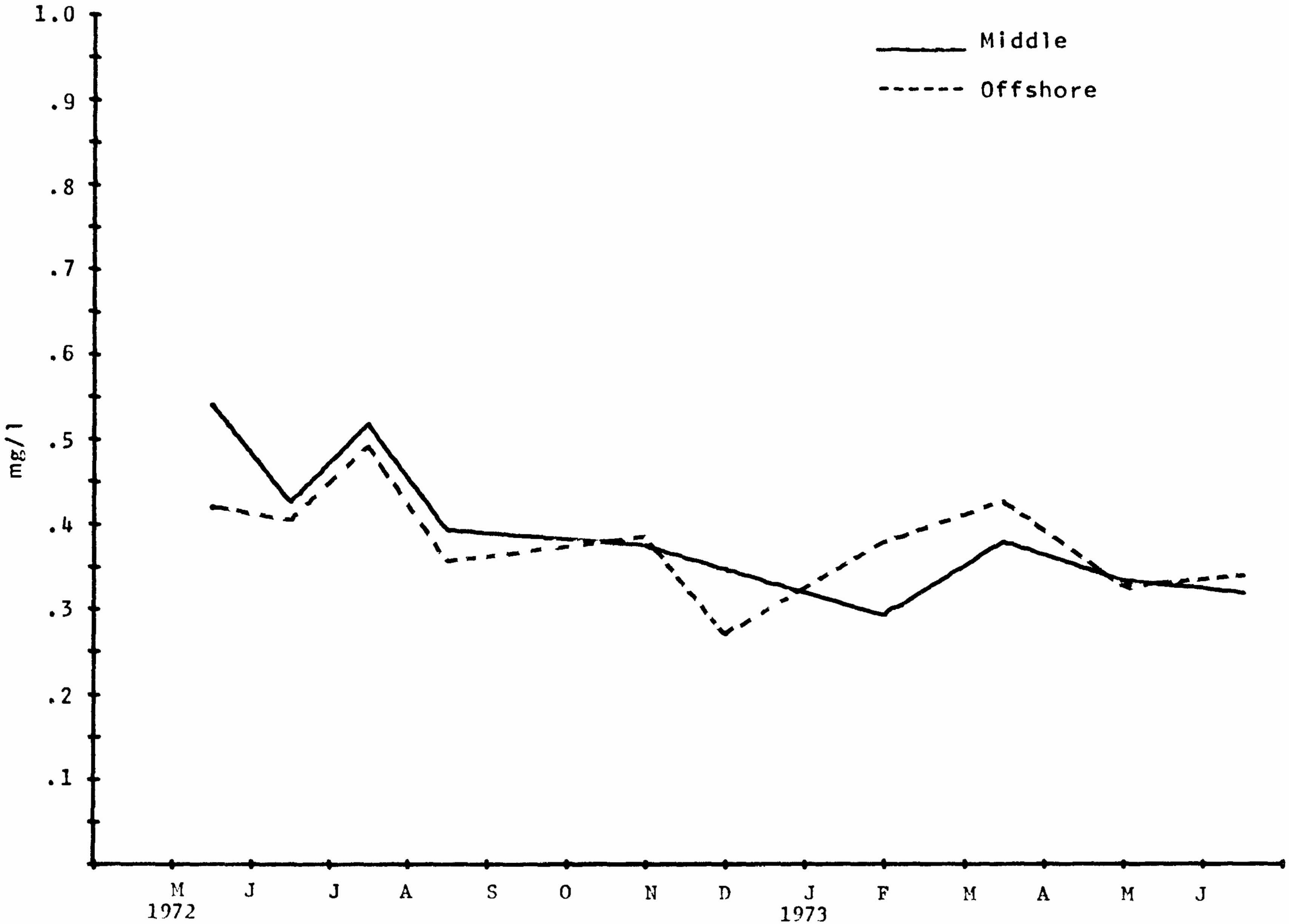


Figure 4.11e Middle Lake-Offshore Variations of Total Nitrogen Concentration

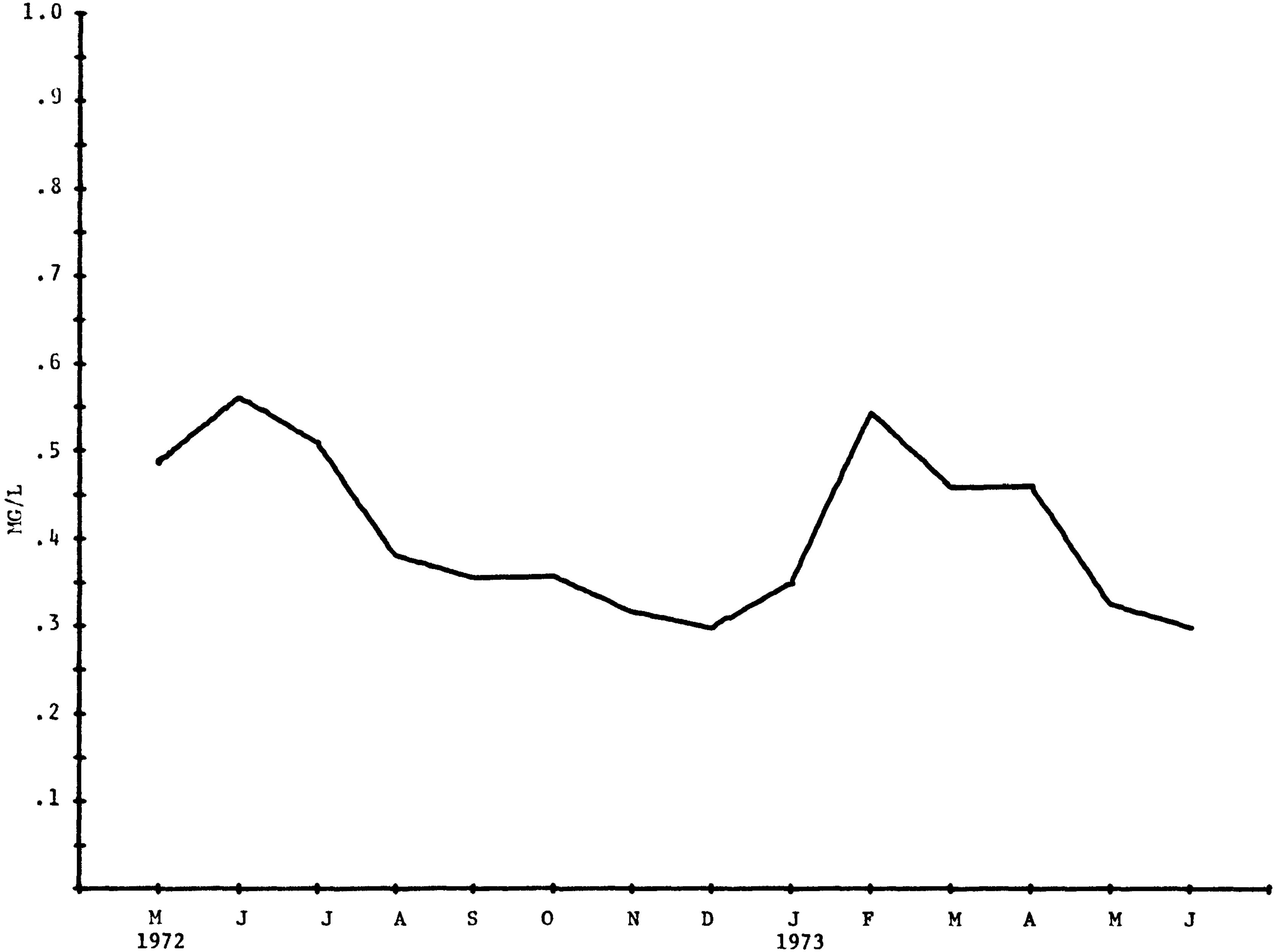


Figure 4.11f Mean surface variation of Total Nitrogen concentration during the field year.

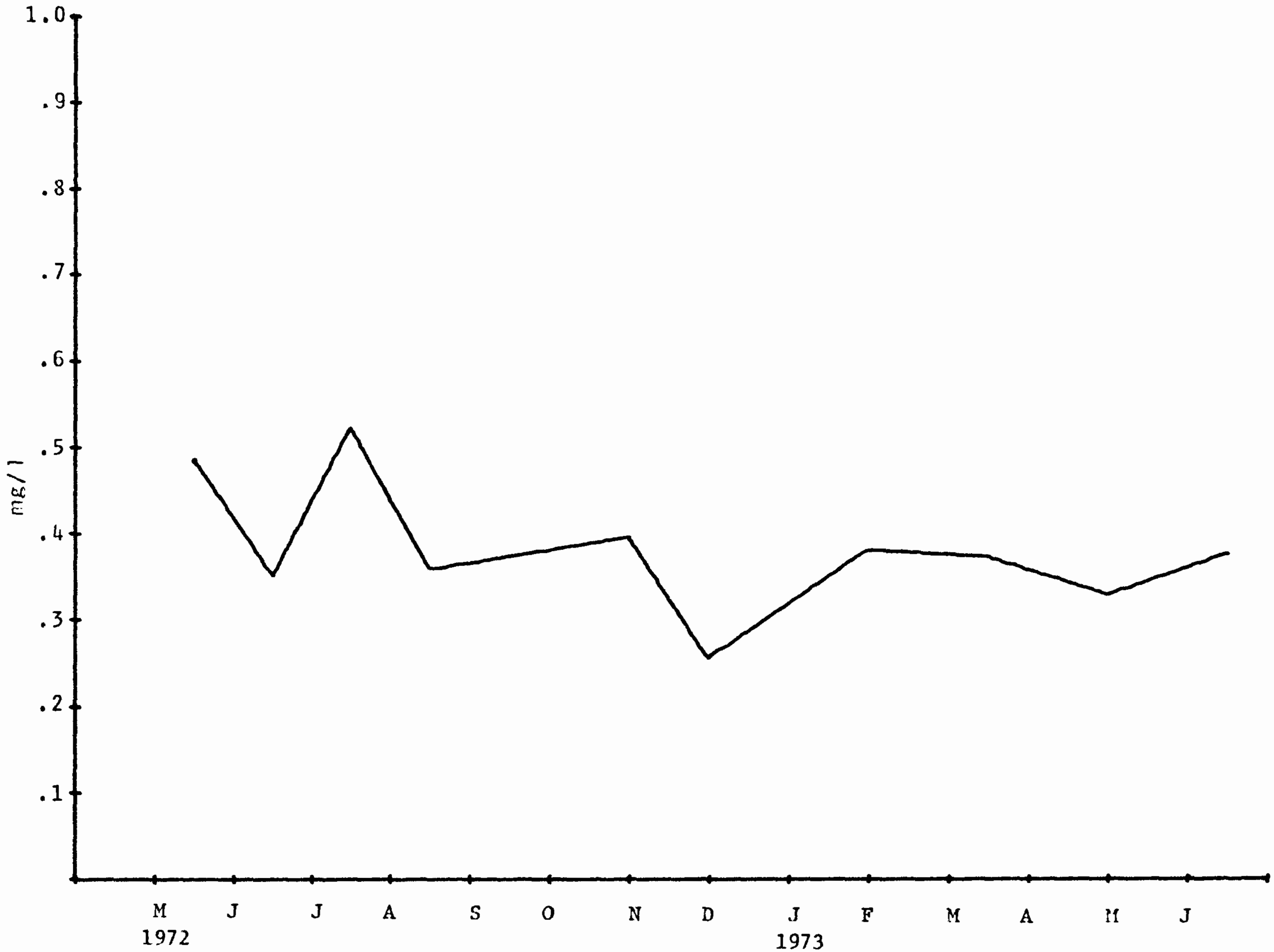


Figure 4.11g Mean Bottom Variation of Total Nitrogen Concentration During the Field Year

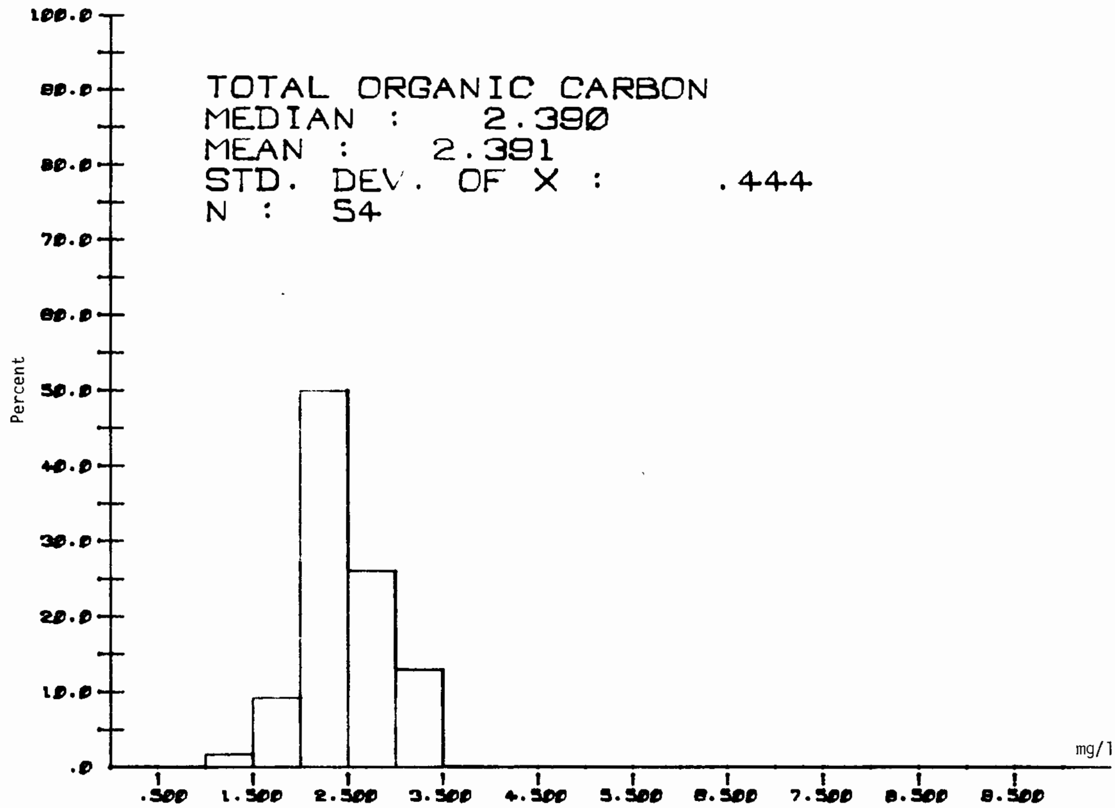


Figure 4.12a Histograms for Total Organic Carbon - Cruise 1

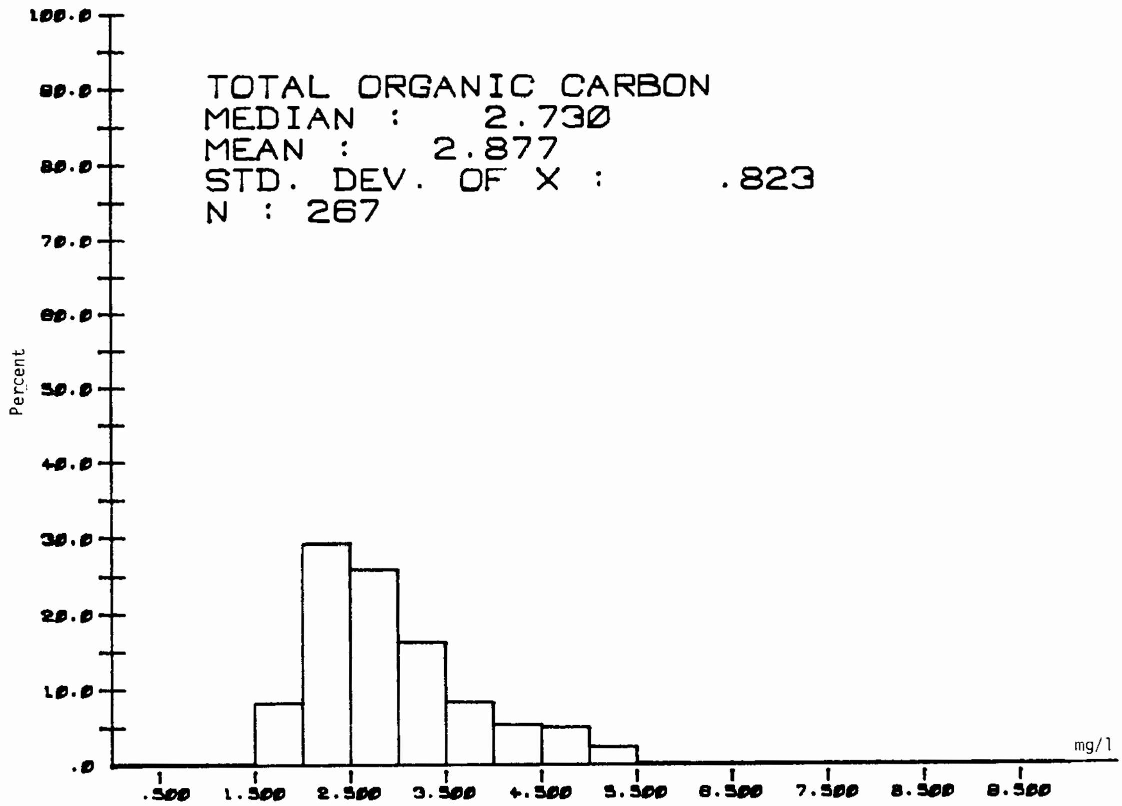


Figure 4.12a Histograms for Total Organic Carbon - Cruise 2

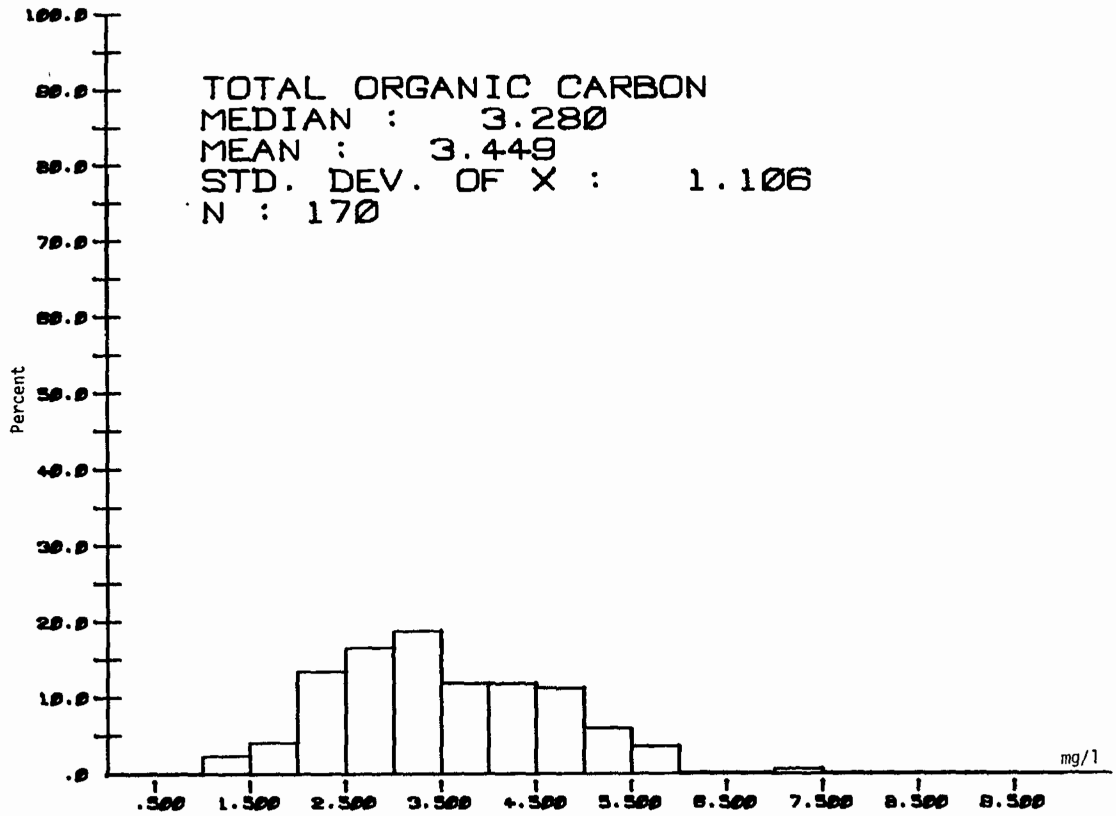


Figure 4.12a Histograms for Total Organic Carbon -
Cruise 3

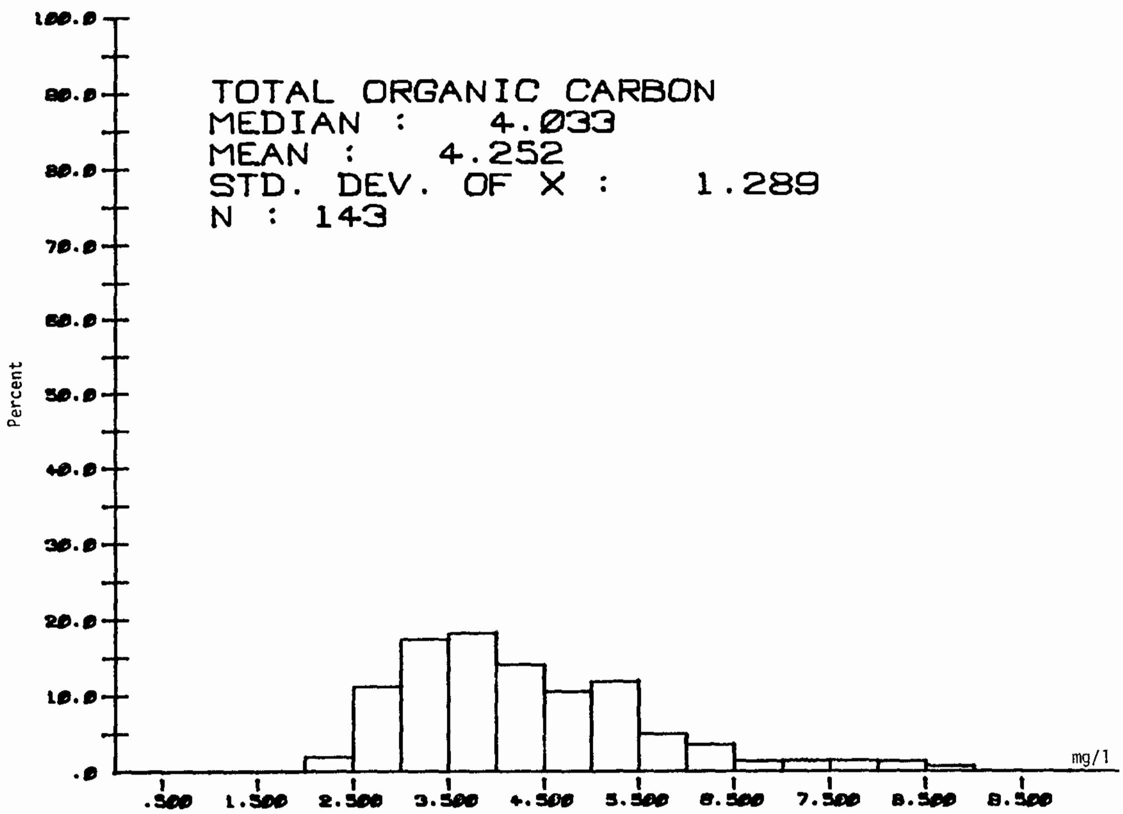


Figure 4.12a Histograms for Total Organic Carbon -
Cruise 4

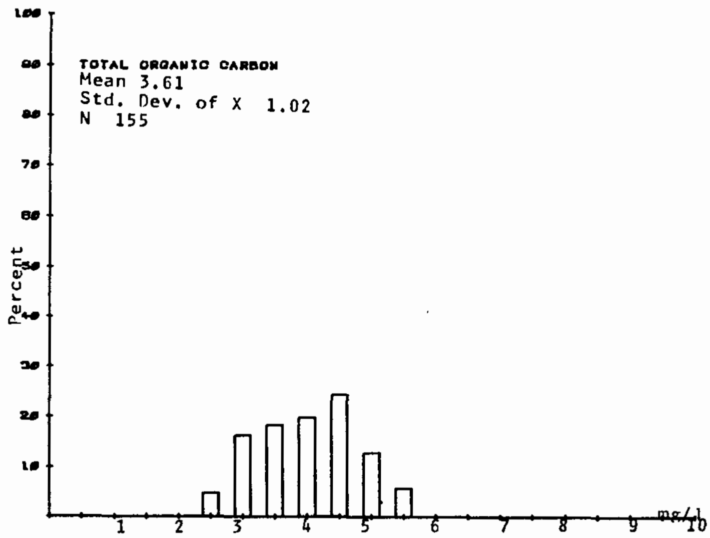


Figure 4.12a Histograms for Total Organic Carbon - Cruise 5

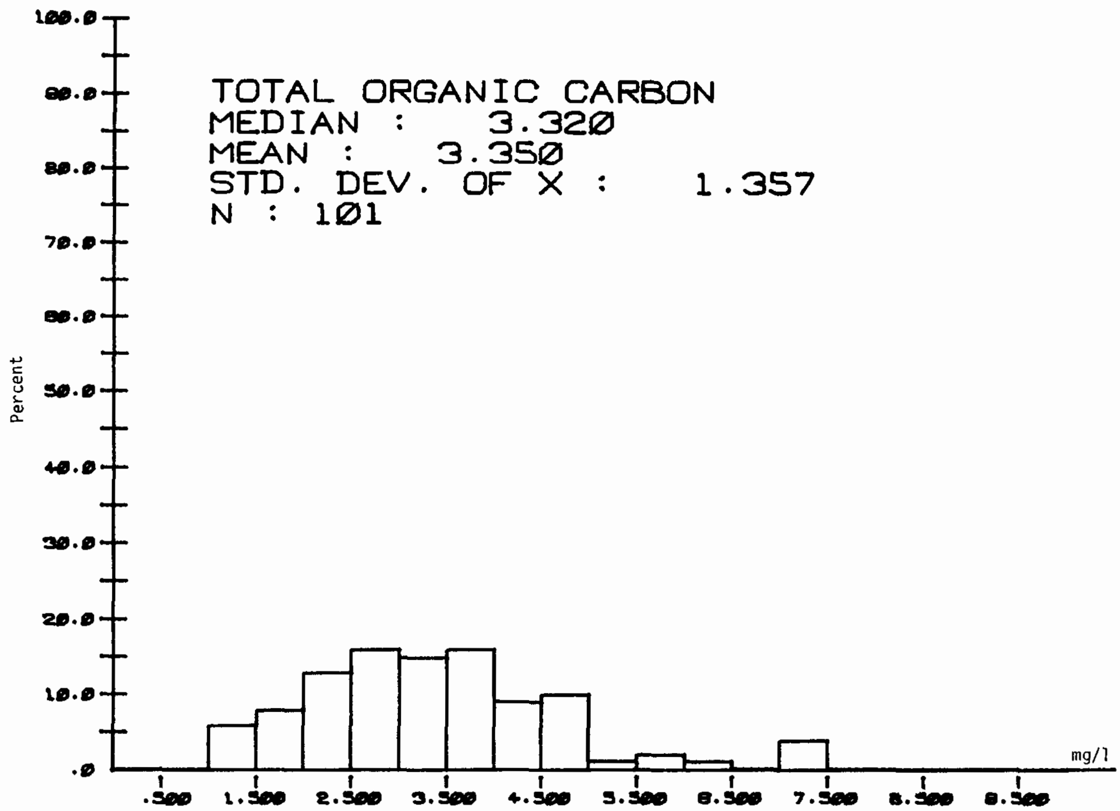


Figure 4.12a Histograms for Total Organic Carbon - Cruise 6

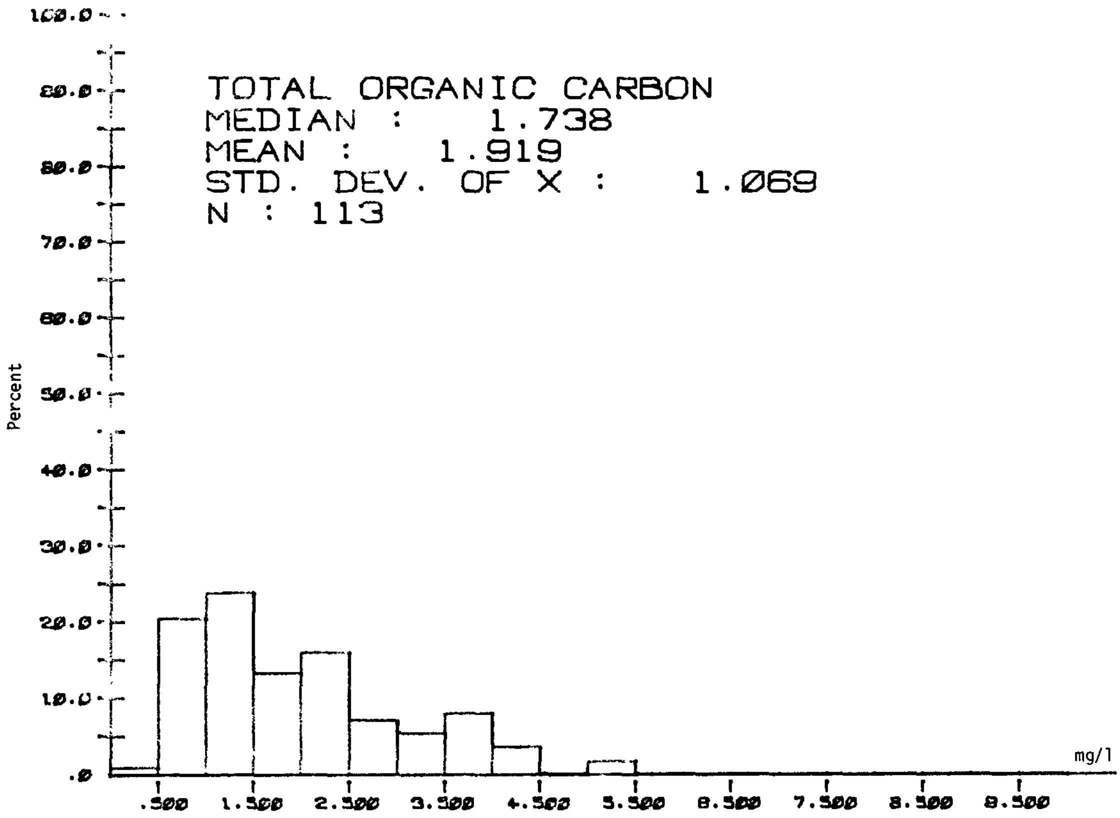


Figure 4.12a Histograms for Total Organic Carbon - Cruise 8

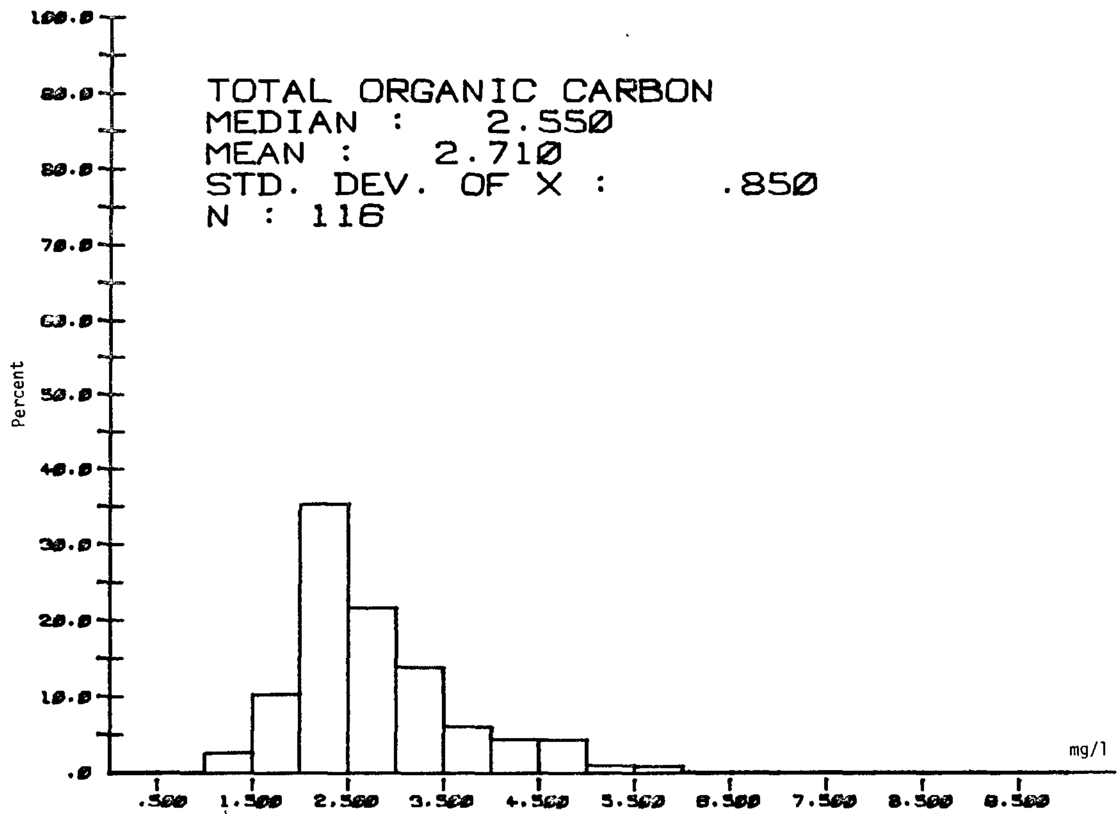


Figure 4.12a Histograms for Total Organic Carbon - Cruise 9

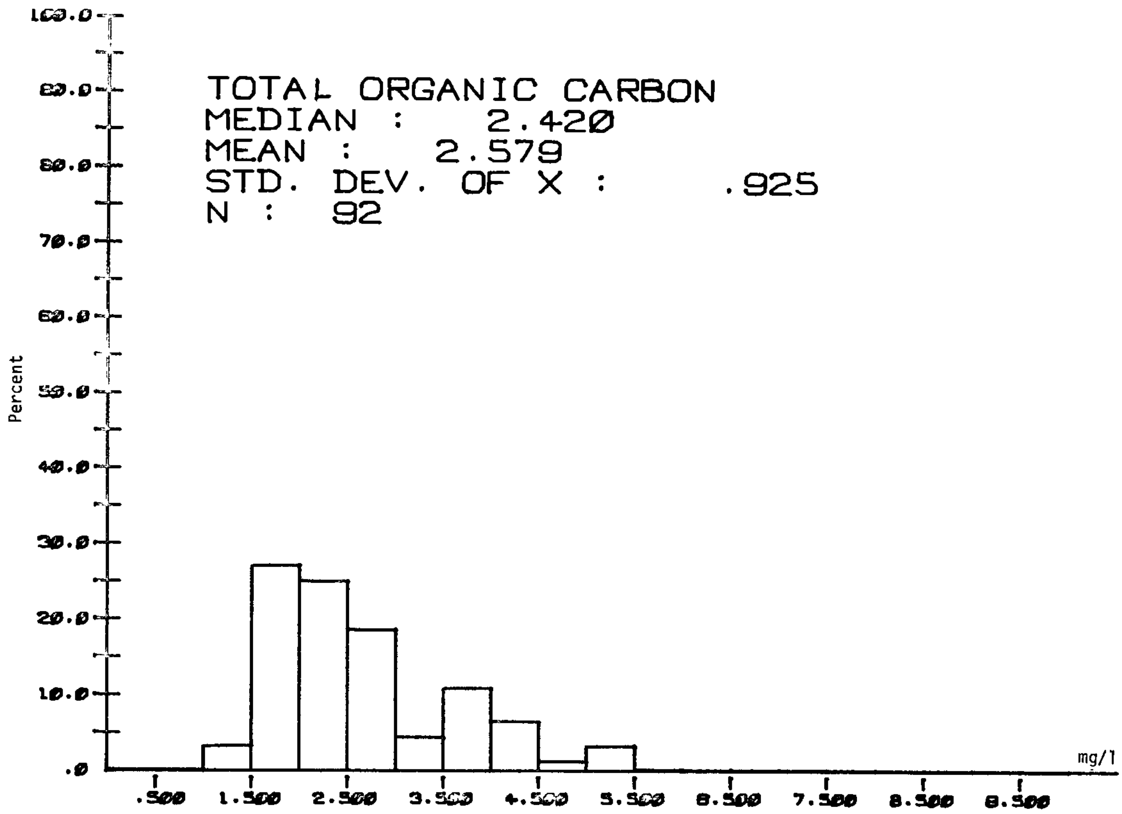


Figure 4.12a Histograms for Total Organic Carbon -
Cruise 10

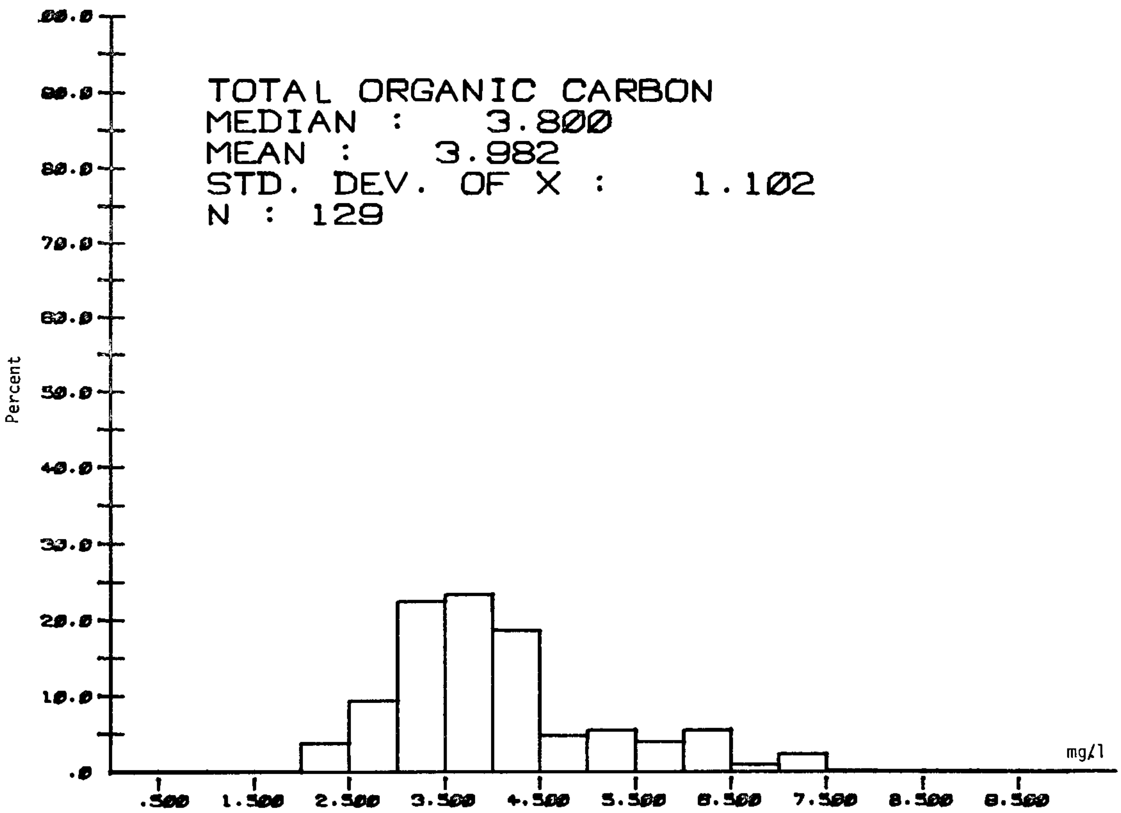


Figure 4.12a Histograms for Total Organic Carbon -
Cruise 11

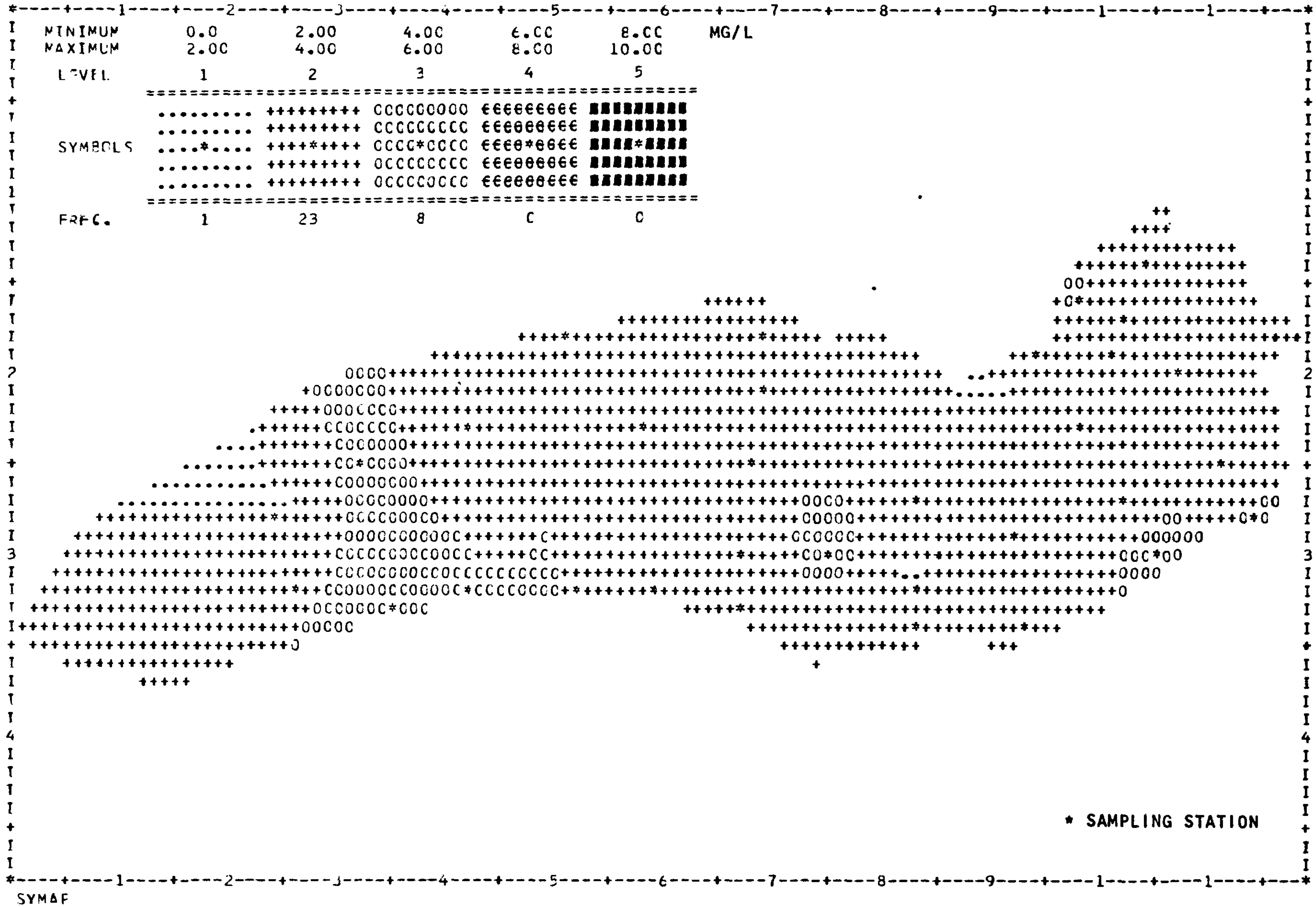


Figure 4.12b Contours of Constant Surface Total Organic Carbon

CRUISE NUMBER 2: MAY 15, 1972 TO MAY 19, 1972

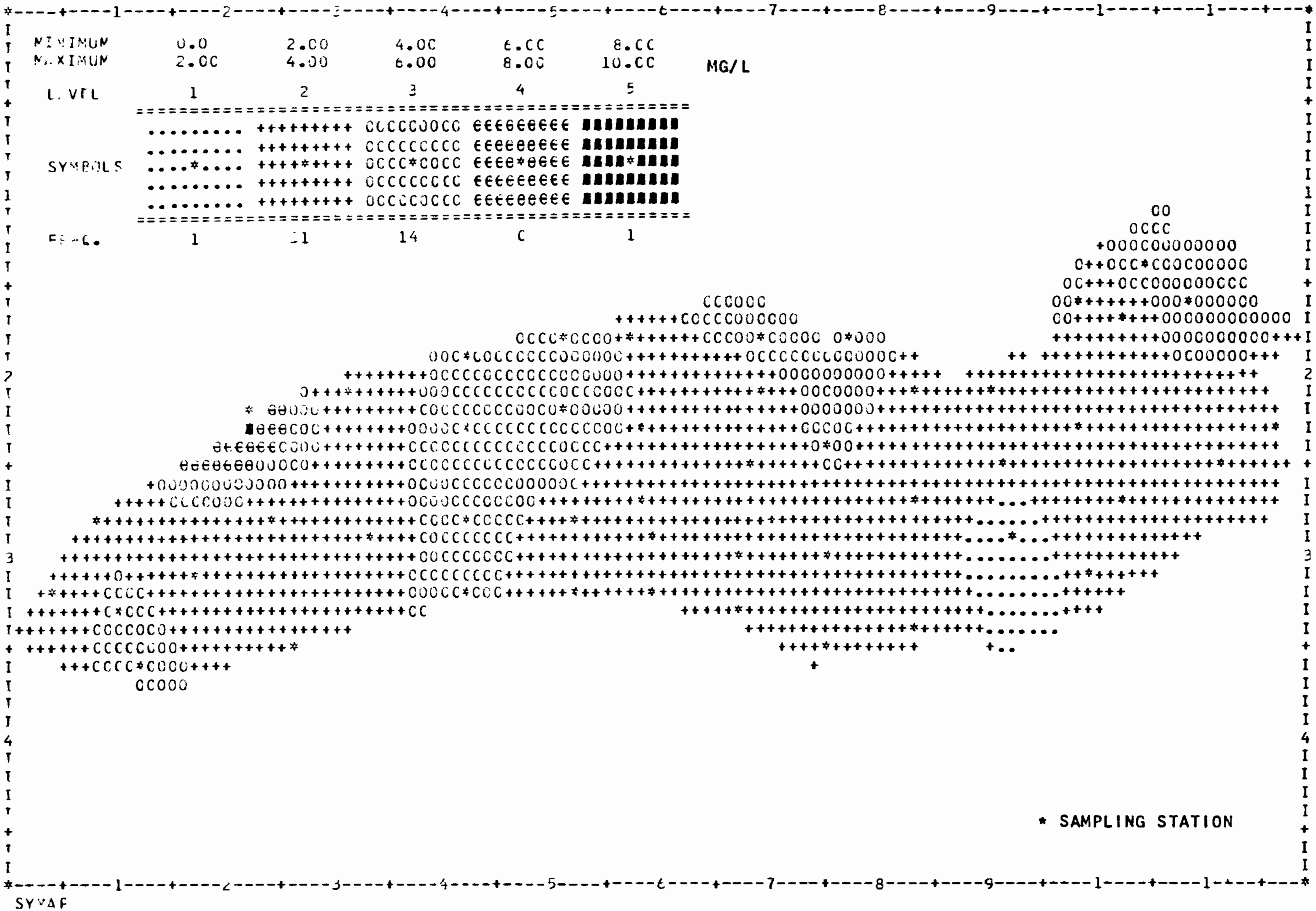


Figure 4.12b Contours of Constant Surface Total Organic Carbon

CRUISE NUMBER 3: JUNE 12, 1972 TO JUNE 16, 1972

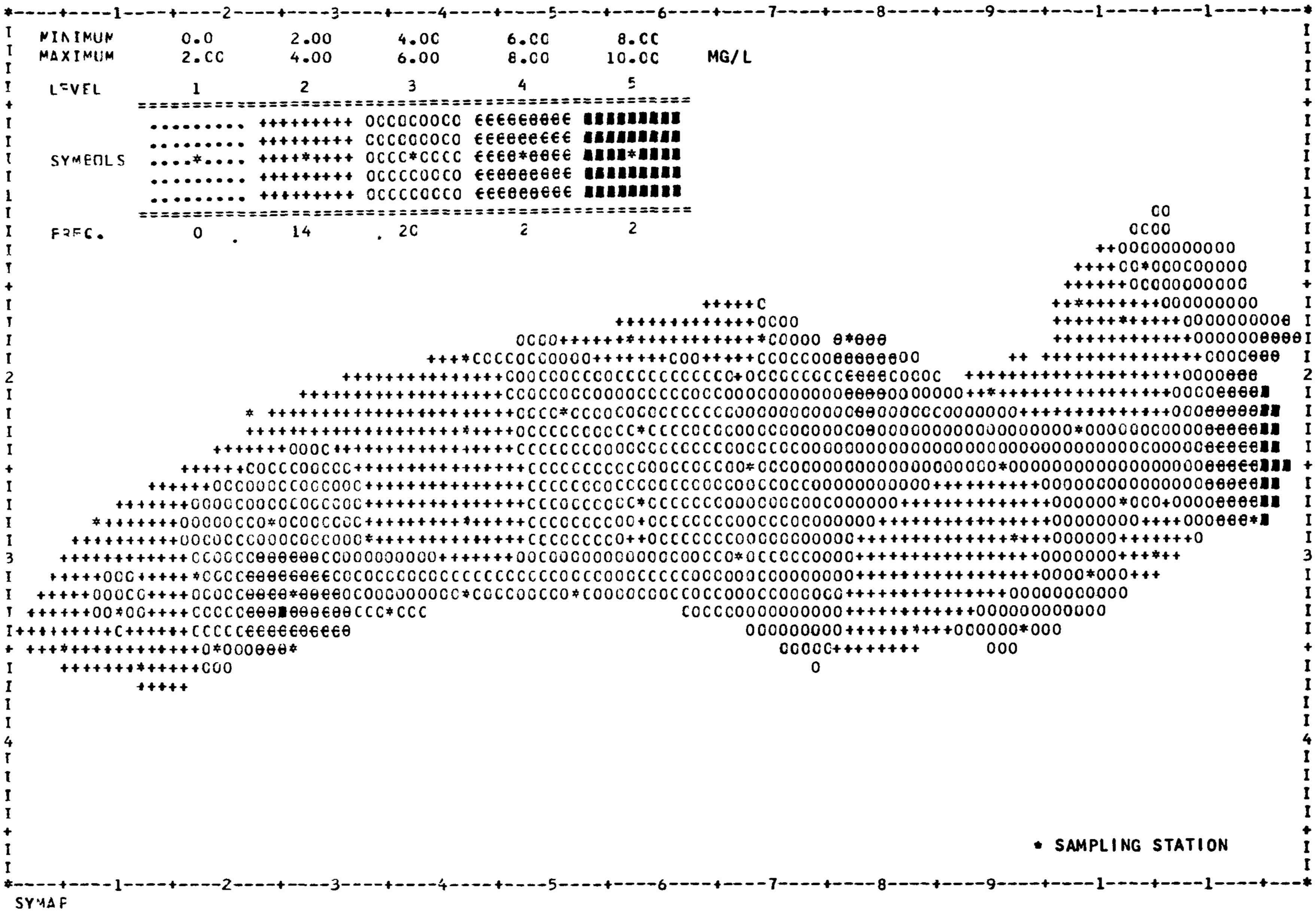


Figure 4.12b Contours of Constant Surface Total Organic Carbon

CRUISE NUMBER 4: JULY 10, 1972 TO JULY 14, 1972

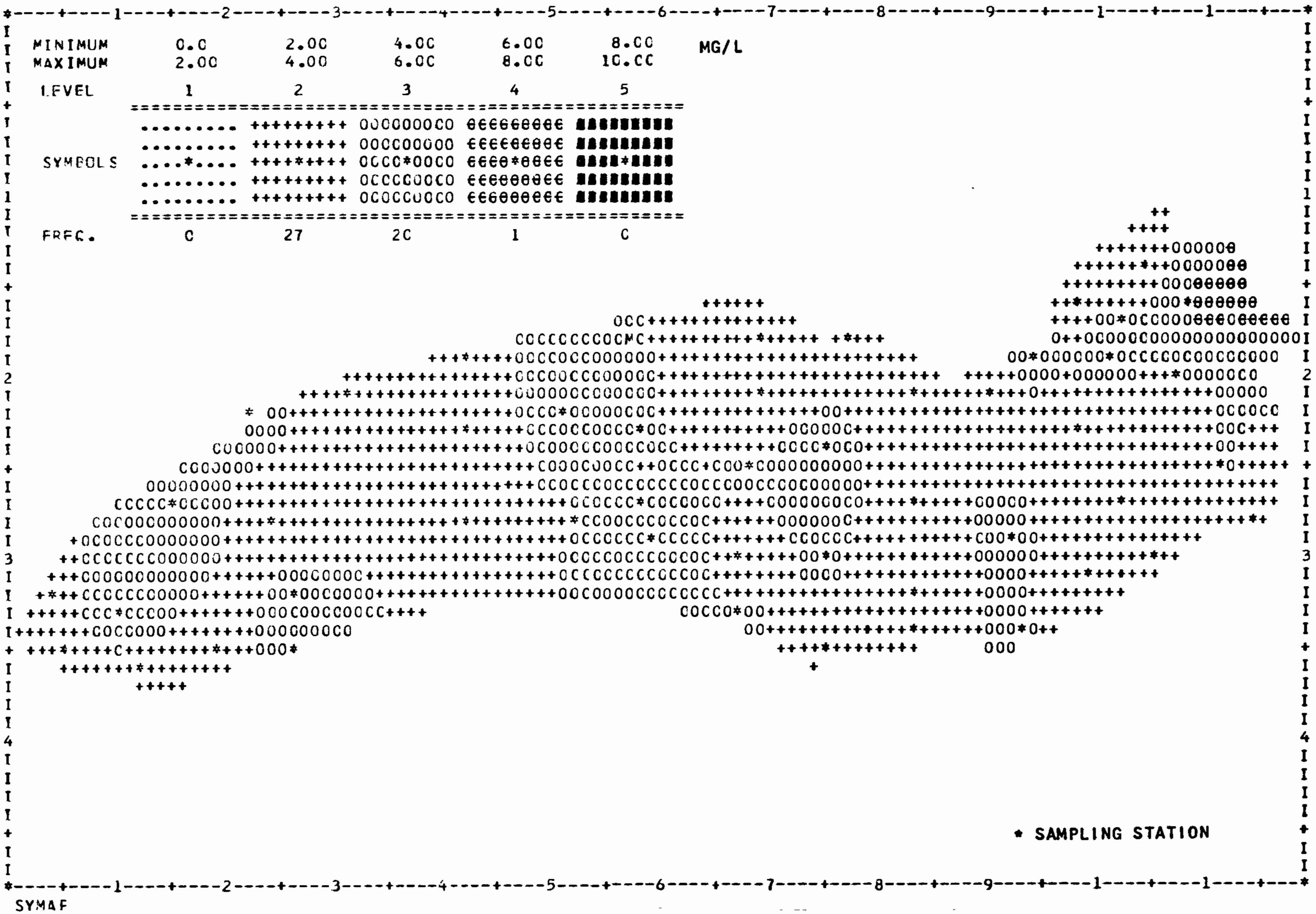


Figure 4.12b Contours of Constant Surface Total Organic Carbon

CRUISE NUMBER 5: AUGUST 21, 1972 TO AUGUST 25, 1972

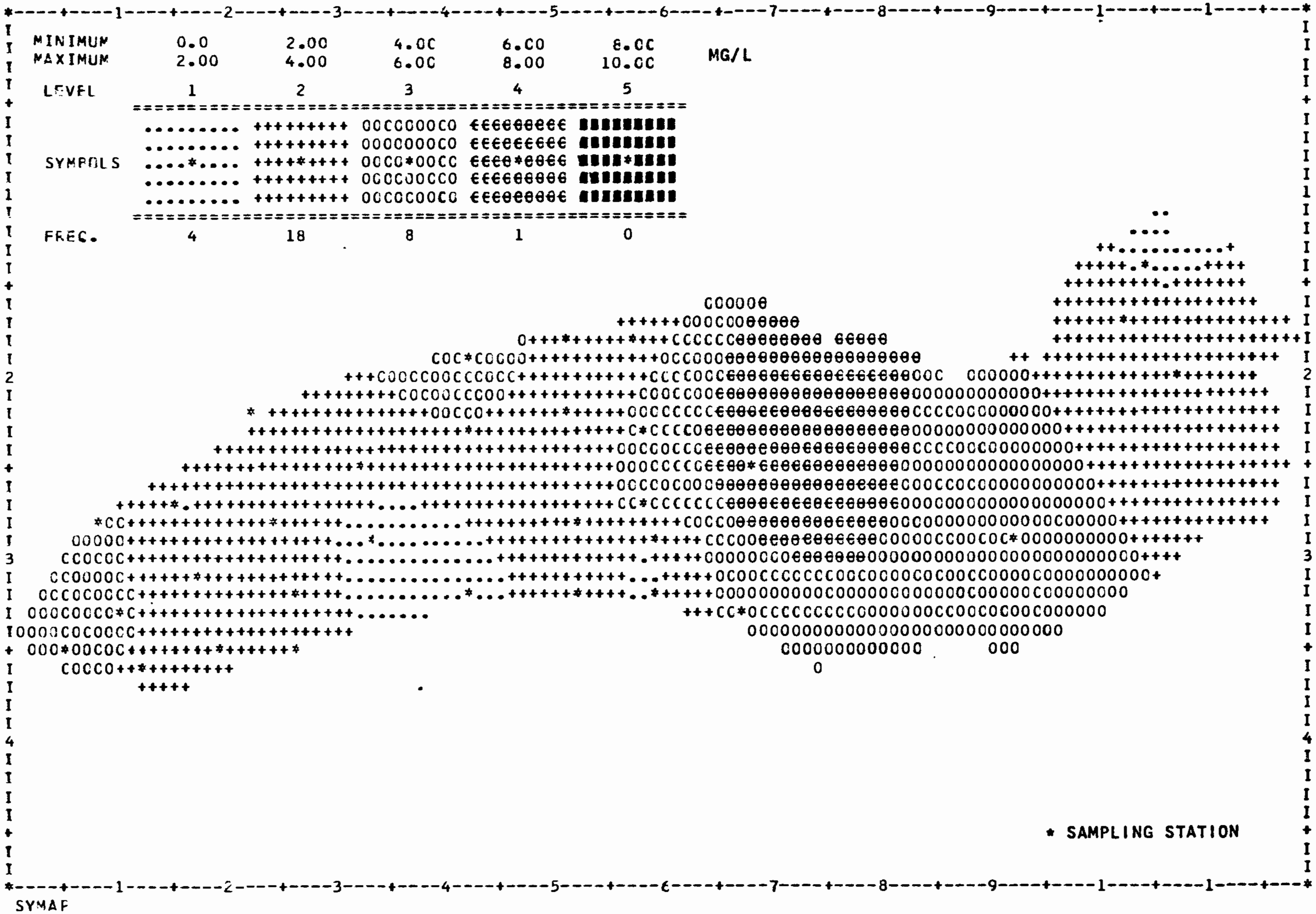


Figure 4.12b Contours of Constant Surface Total Organic Carbon

CRUISE NUMBER 6: OCTOBER 30, 1972 TO NOVEMBER 3, 1972

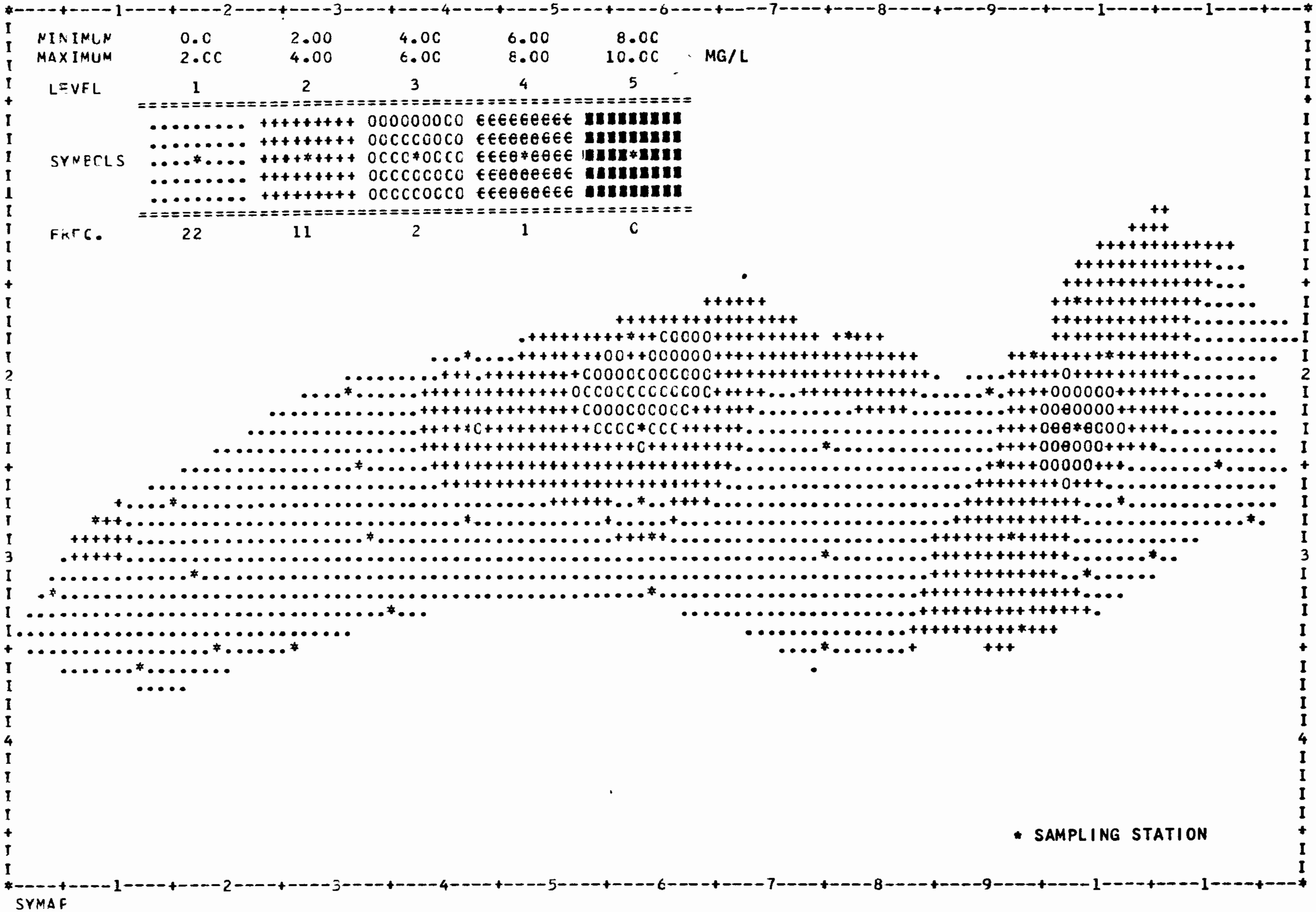


Figure 4.12b Contours of Constant Surface Total Organic Carbon

CRUISE NUMBER 8: FEBRUARY 5, 1973 TO FEBRUARY 9, 1973

MINIMUM	0.0	2.00	4.00	6.00	8.00	
MAXIMUM	2.00	4.00	6.00	8.00	10.00	MG/L
LEVEL	1	2	3	4	5	
SYMBOLS	....	+++++++++	000000000	θθθθθθθθθ	███████	
FREQ.	22	11	2	1	0	

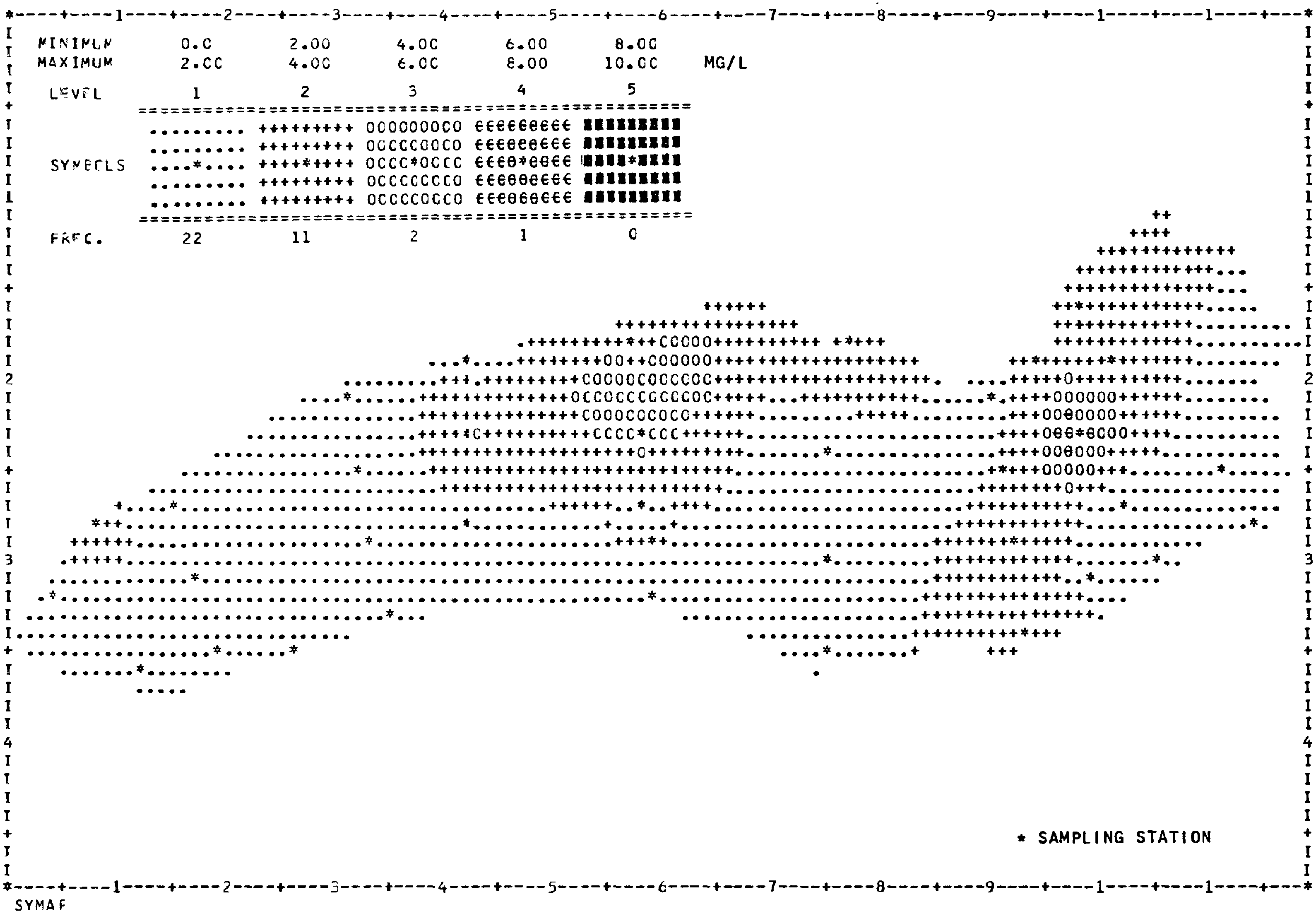


Figure 4.12b Contours of Constant Surface Total Organic Carbon

CRUISE NUMBER 8: FEBRUARY 5, 1973 TO FEBRUARY 9, 1973

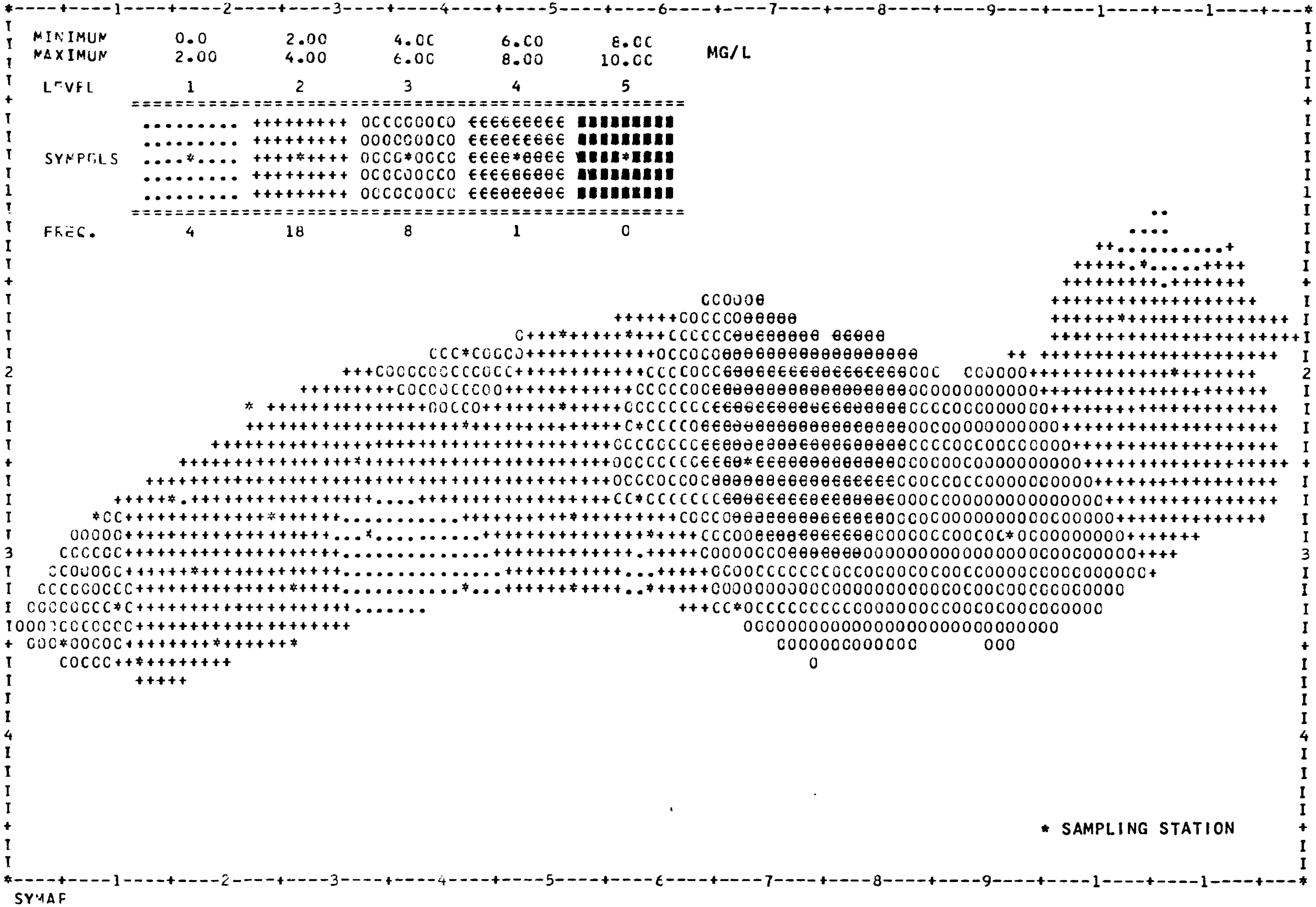
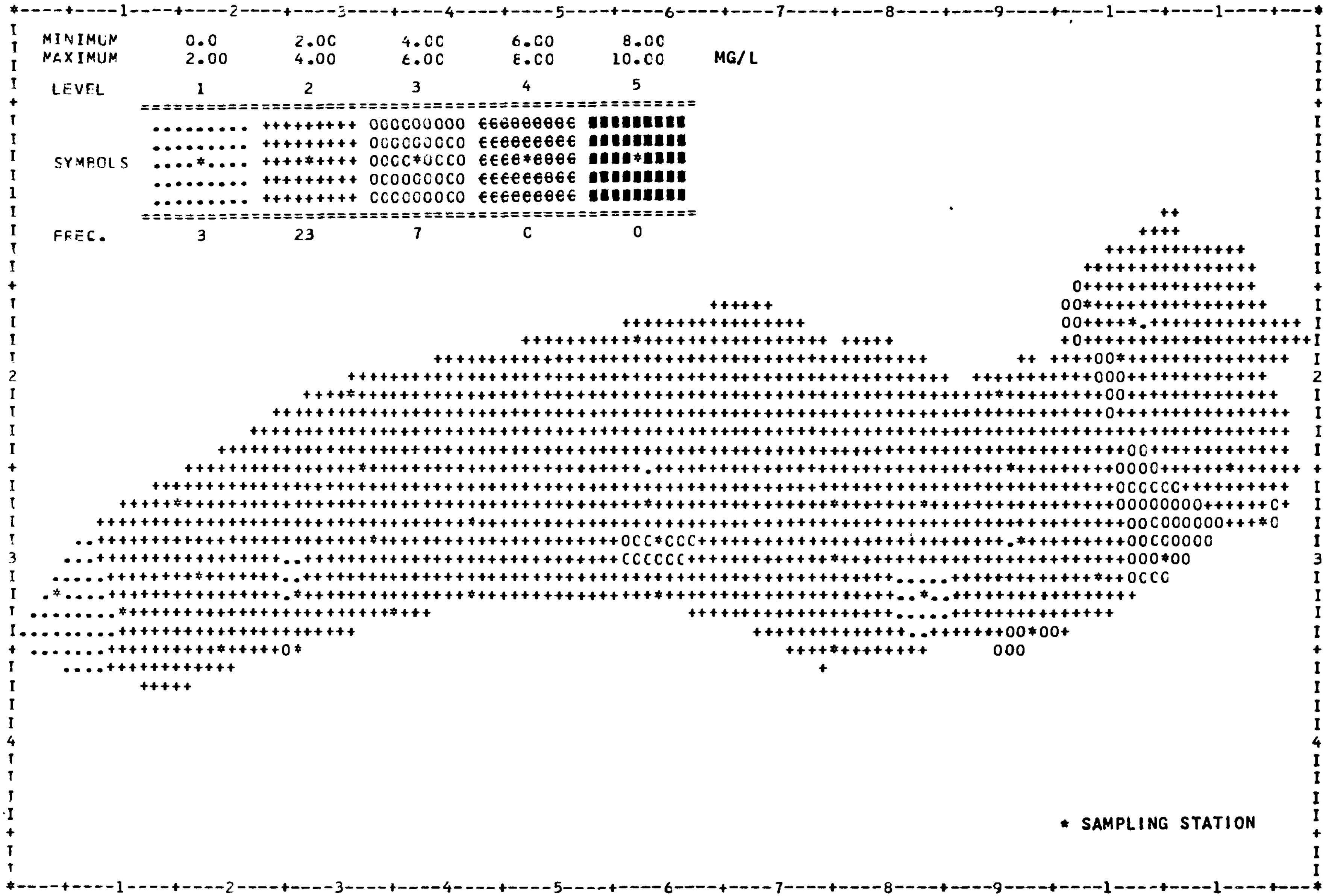


Figure 4.12b Contours of Constant Surface Total Organic Carbon

CRUISE NUMBER 6: OCTOBER 30, 1972 TO NOVEMBER 3, 1972



SYMAP

Figure 4.12b Contours of Constant Surface Total Organic Carbon

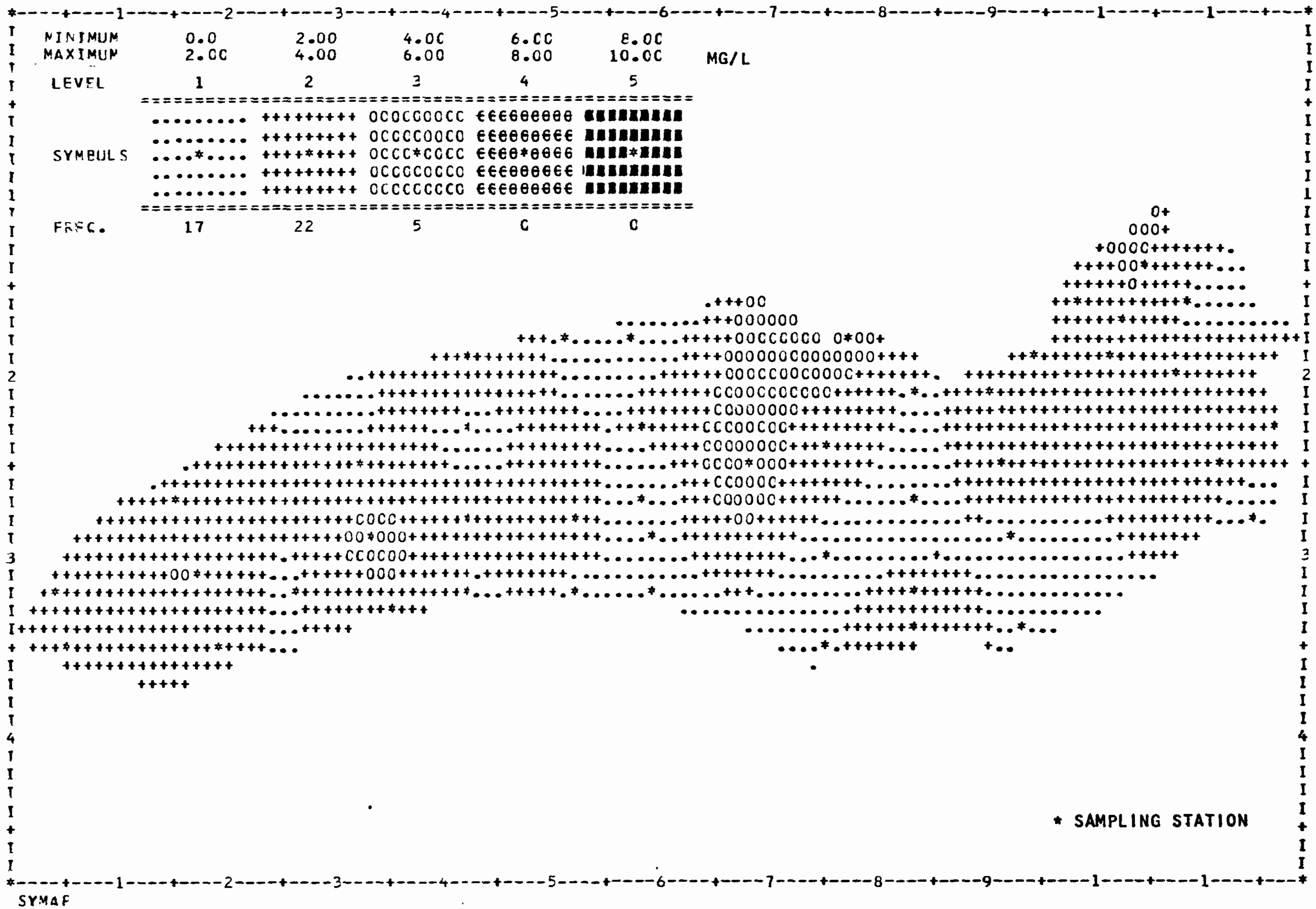
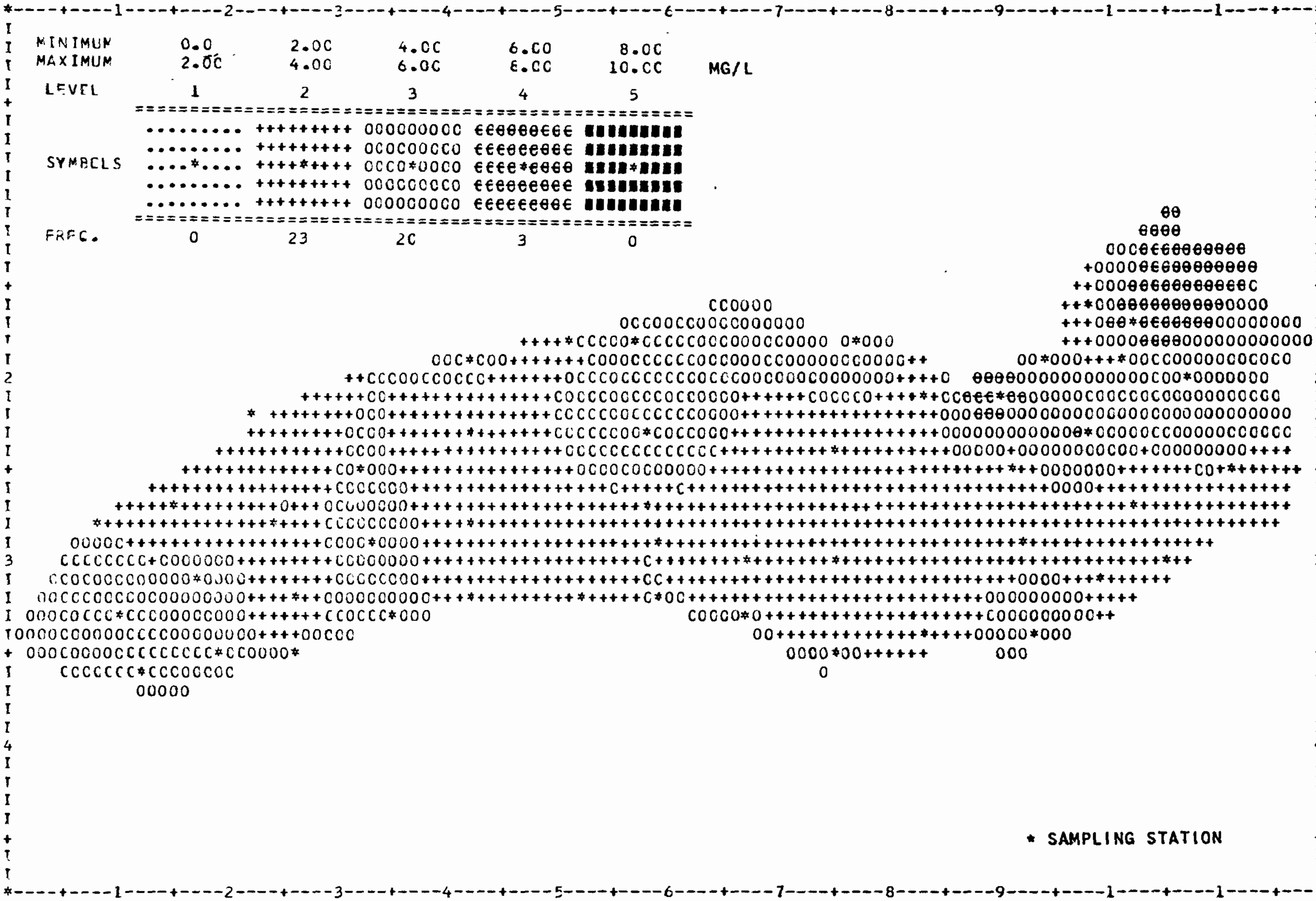


Figure 4.12b Contours of Constant Surface Total Organic Carbon

CRUISE NUMBER 10: APRIL 24, 1973 TO APRIL 3C, 1973



SYMAP

Figure 4.12b Contours of Constant Surface Total Organic Carbon

CRUISE NUMBER 11: JUNE 11, 1973 TO JUNE 15, 1973

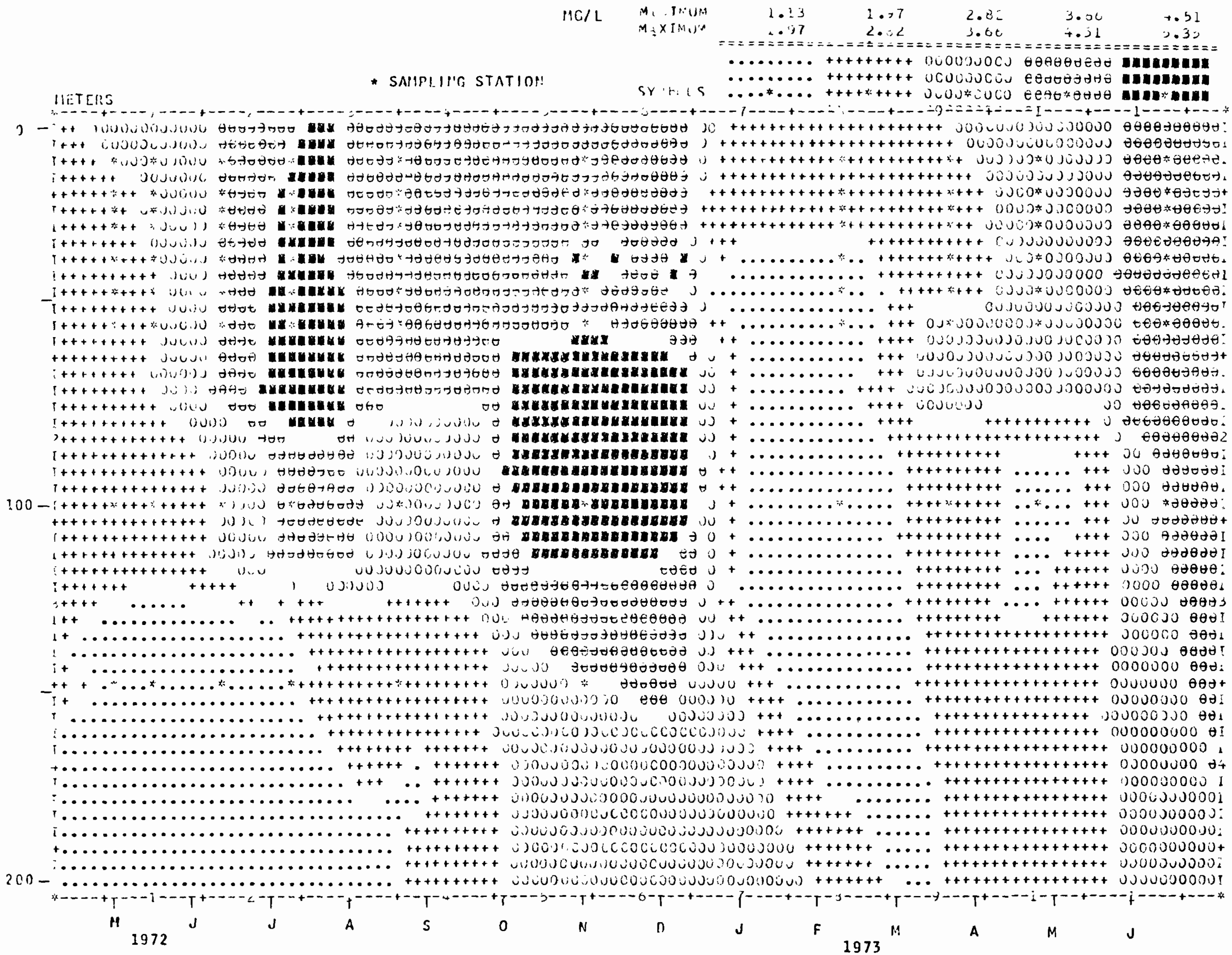


Figure 4.12c Depth Versus Time Contours of Constant Total Organic Carbon

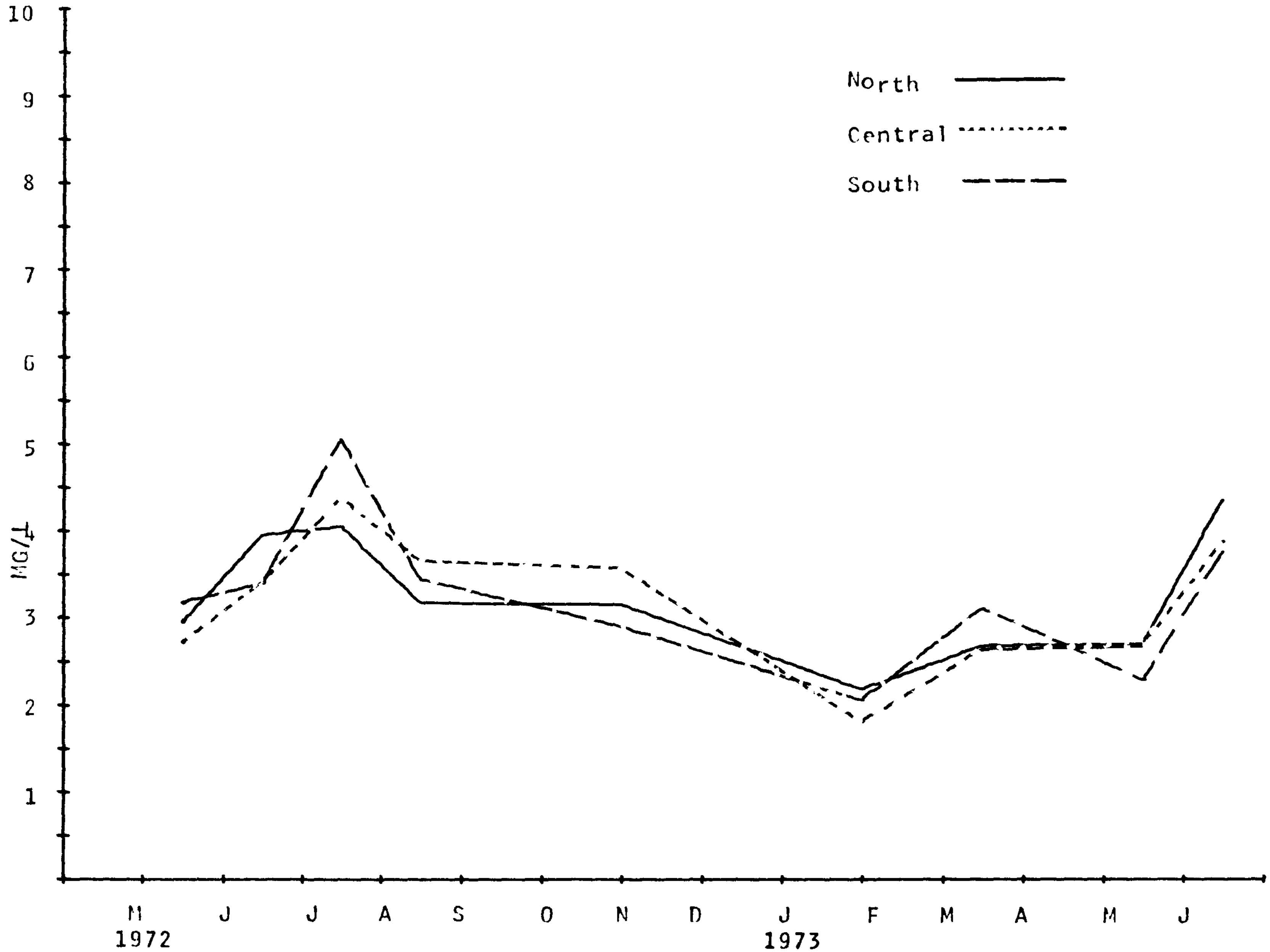


Figure 4.12d North-south variation of total organic carbon

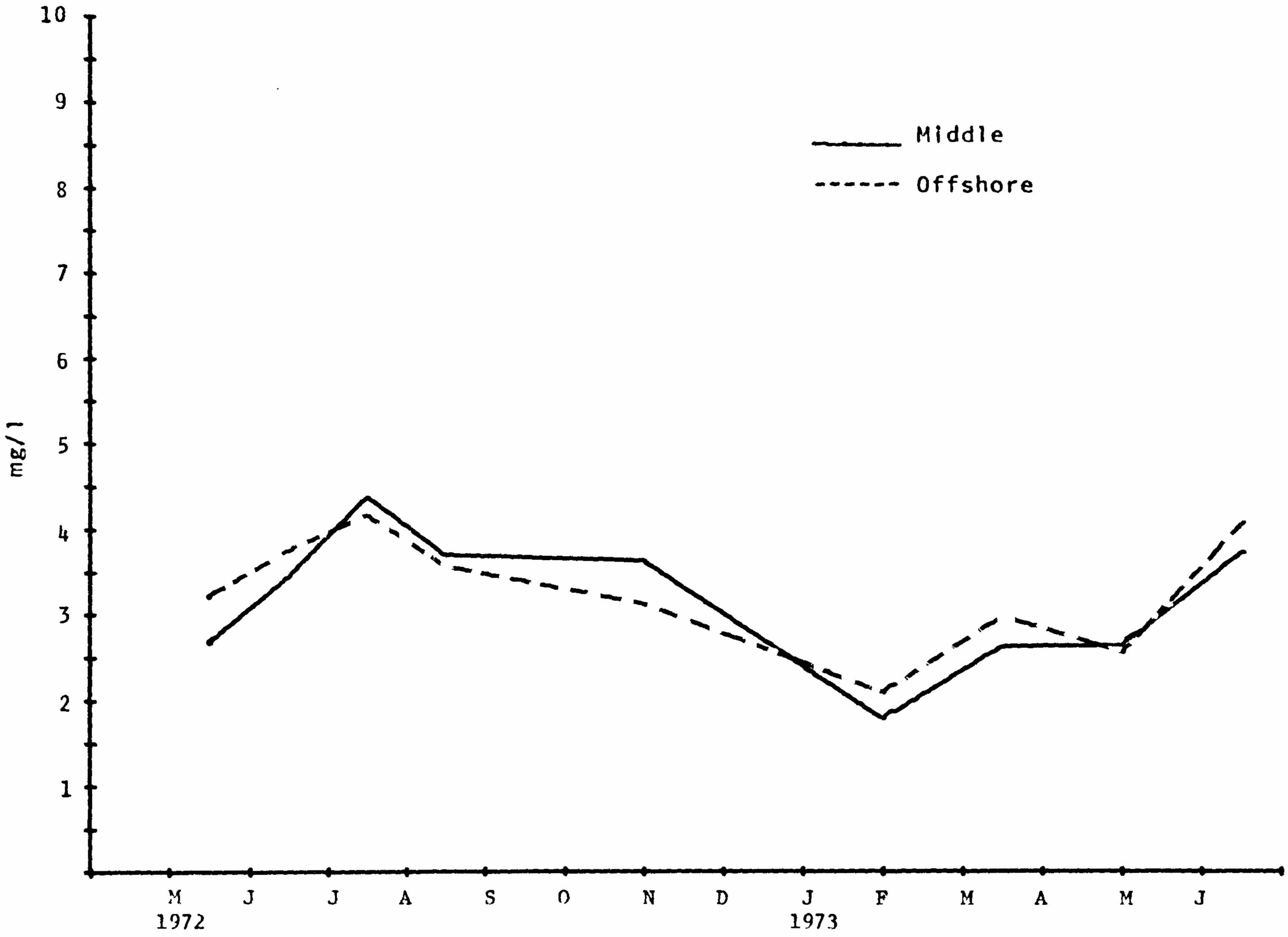


Figure 4.12e Middle Lake-Offshore Variations of Mean Total Organic Carbon Concentration

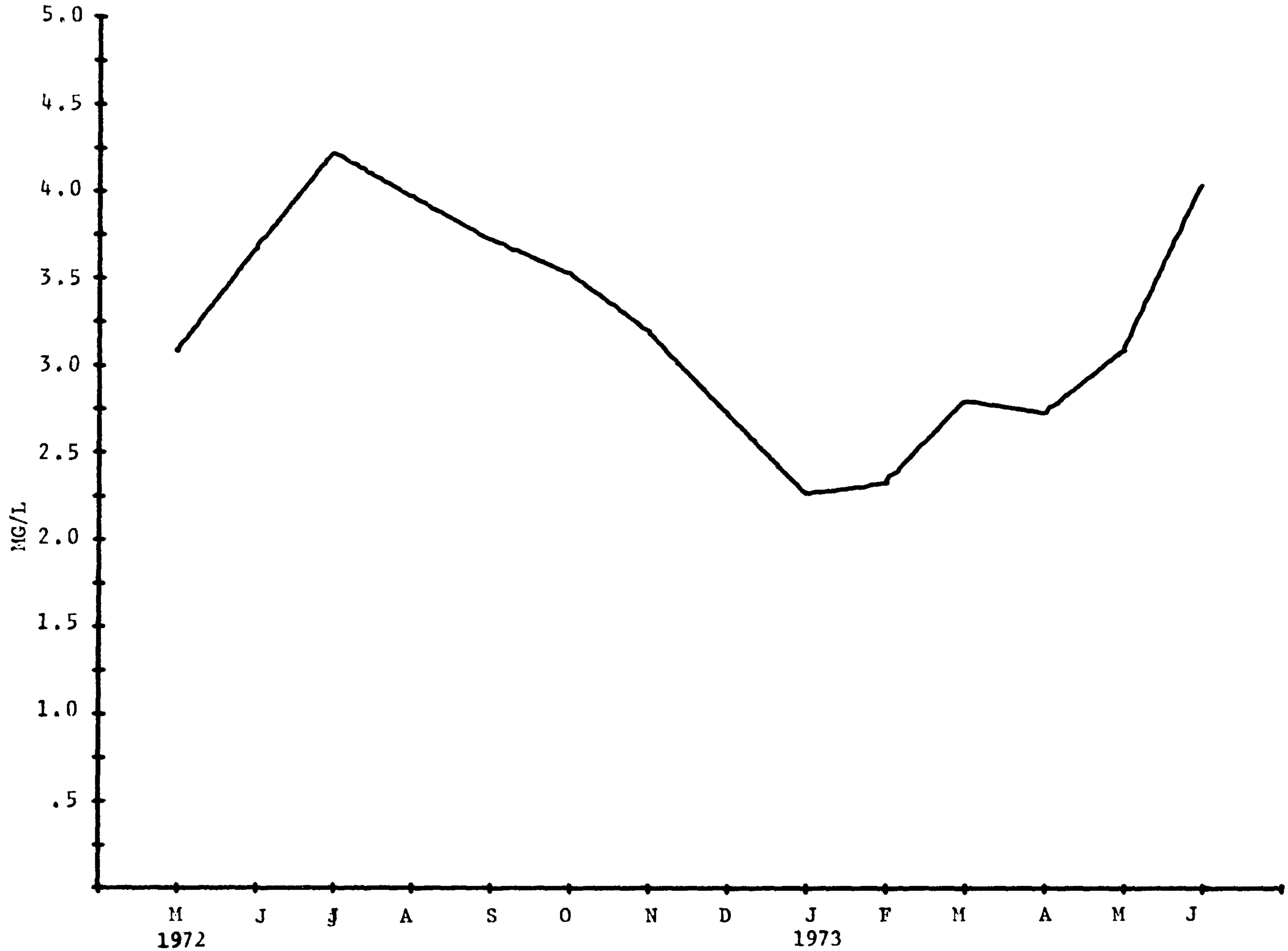


Figure 4.12f Mean surface variation of Total Organic Carbon concentration during the field year.

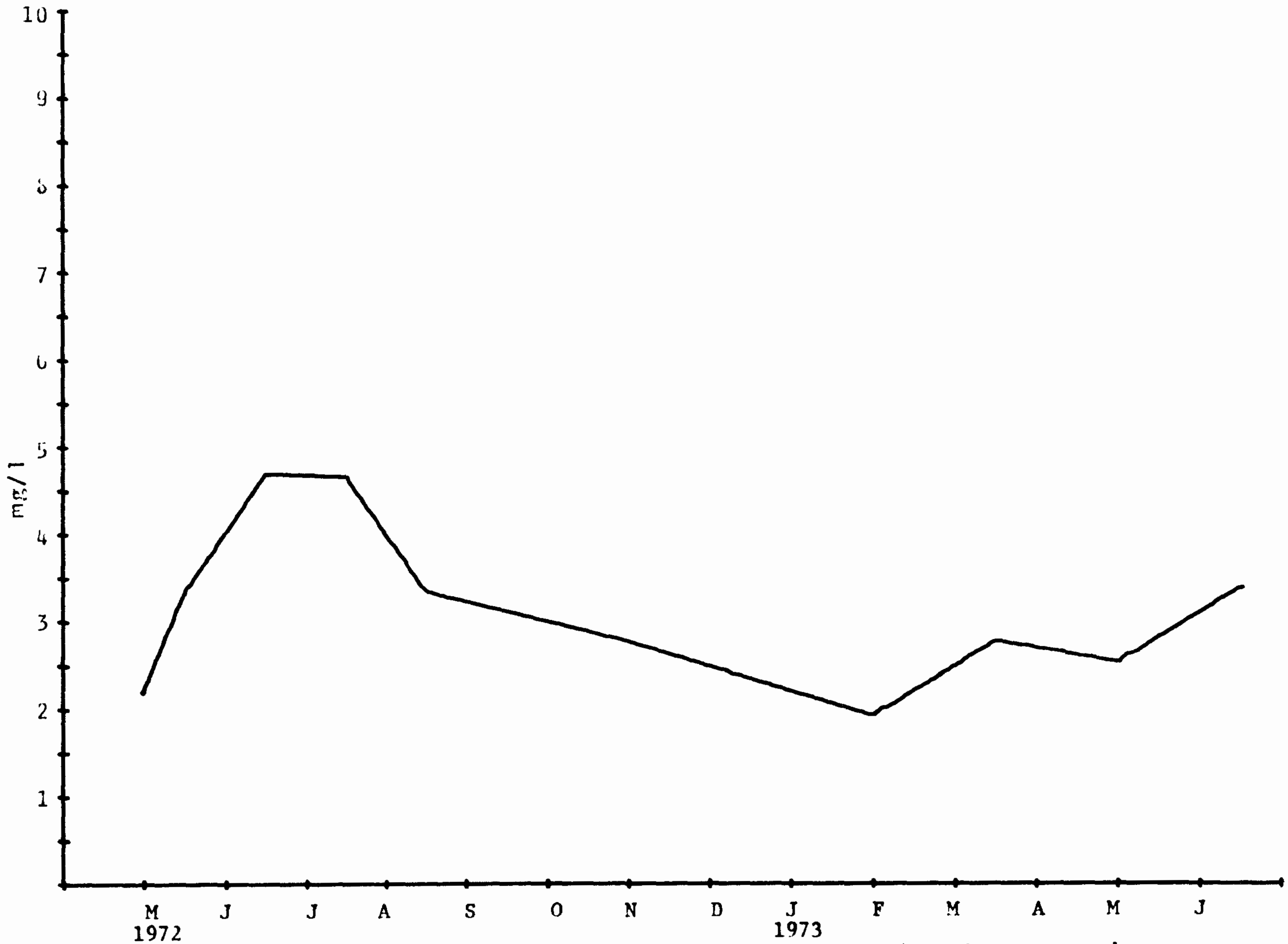


Figure 4.12g Mean Bottom Variation of Total Organic Carbon Concentration During the Field Year

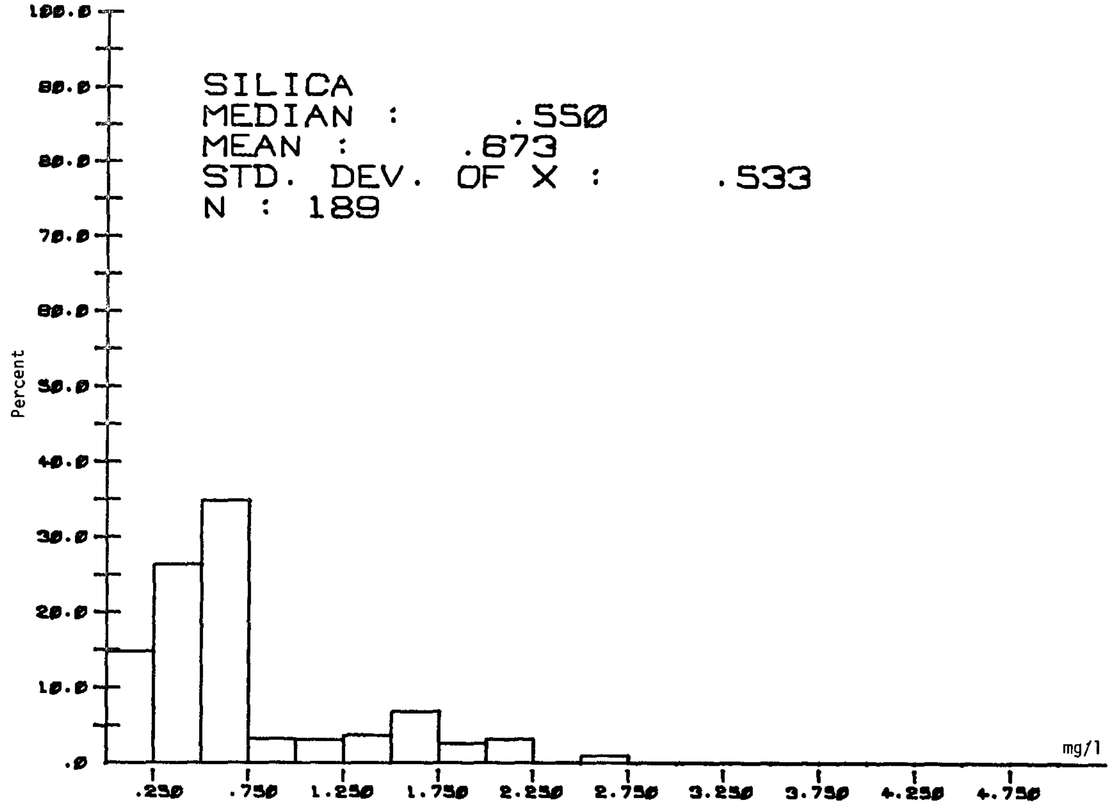


Figure 4.13a Histograms for Silica - Cruise 1

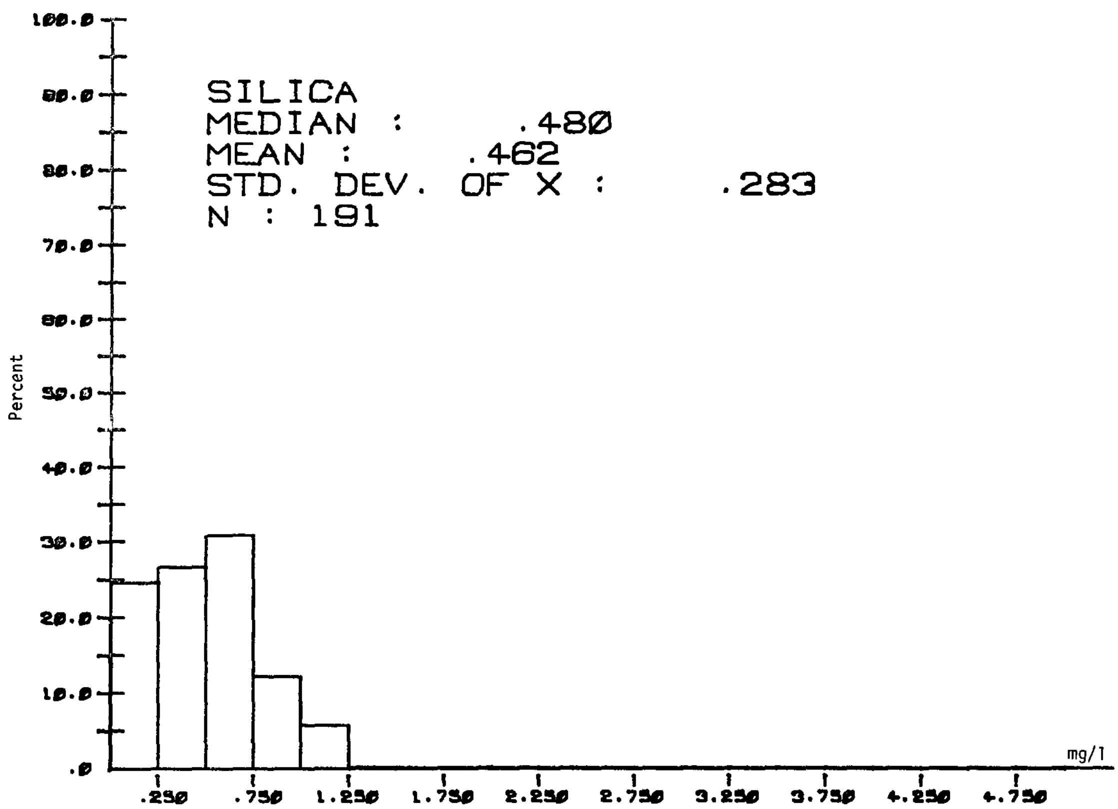


Figure 4.13a Histograms for Silica - Cruise 2

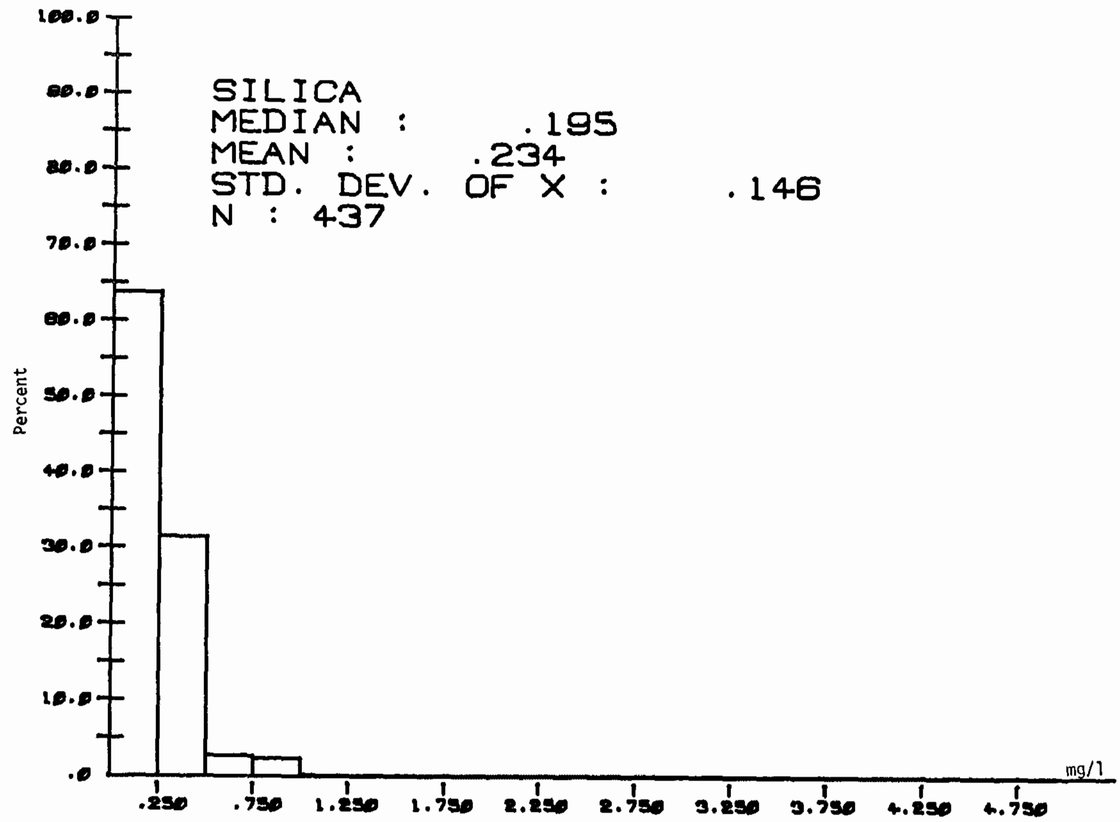


Figure 4.13a Histograms for Silica - Cruise 3

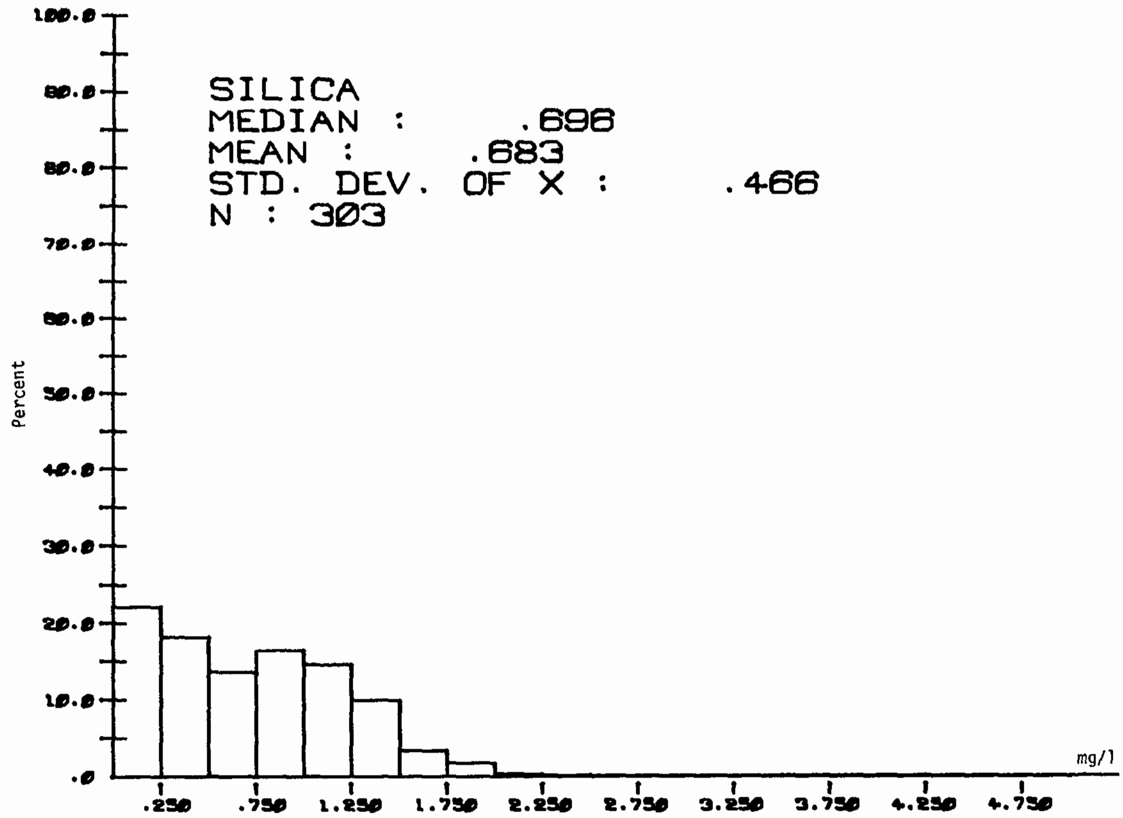


Figure 4.13a Histograms for Silica - Cruise 4

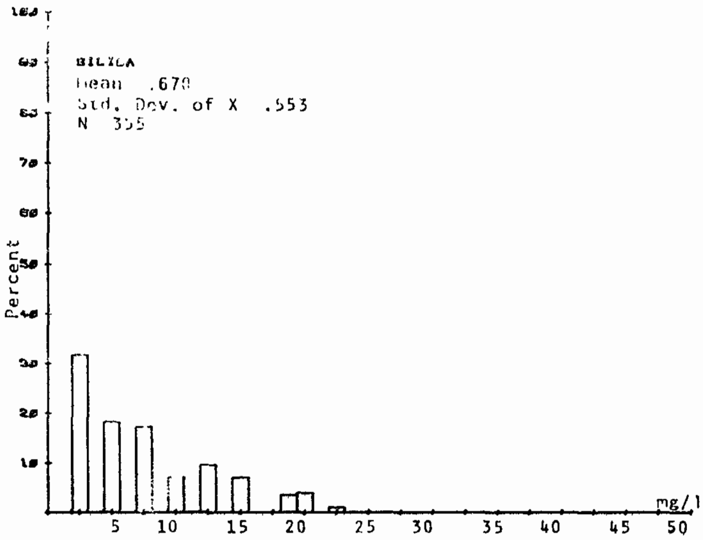


Figure 4.13a Histograms for Silica -
Cruise 5

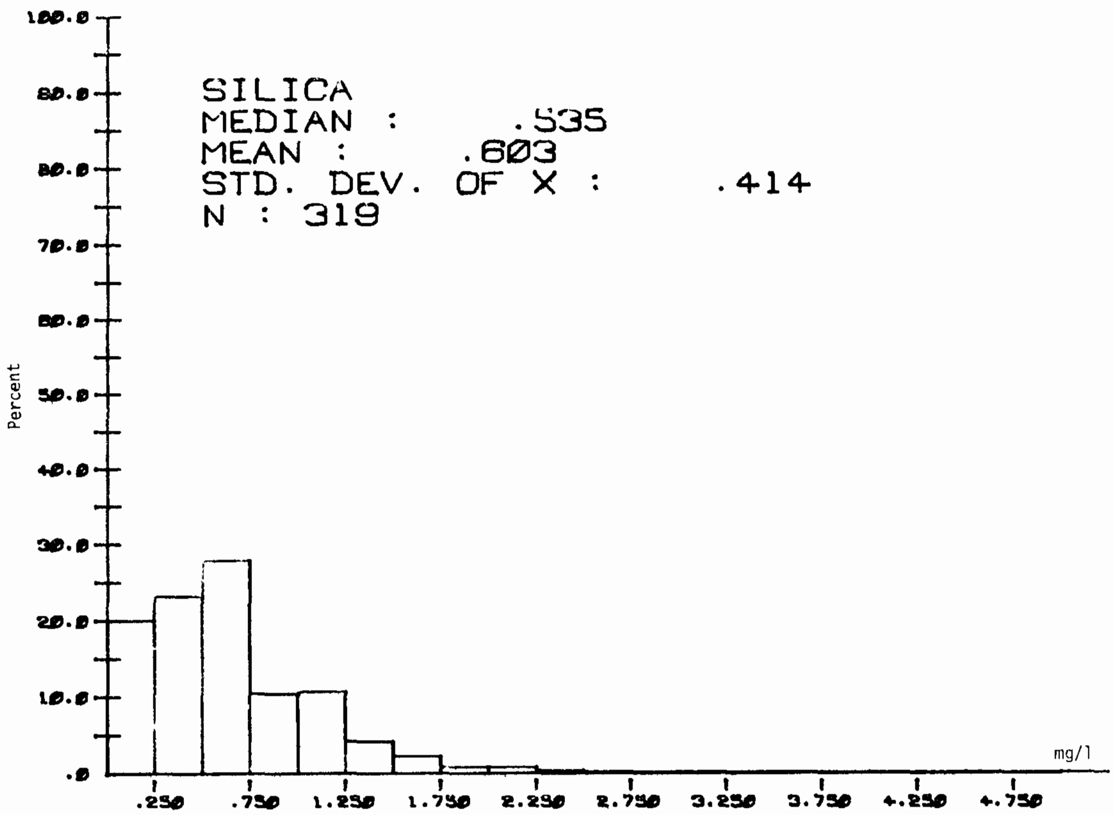


Figure 4.13a Histograms for Silica - Cruise 6

Figure 4.13a Histograms for Silica - Cruise 7

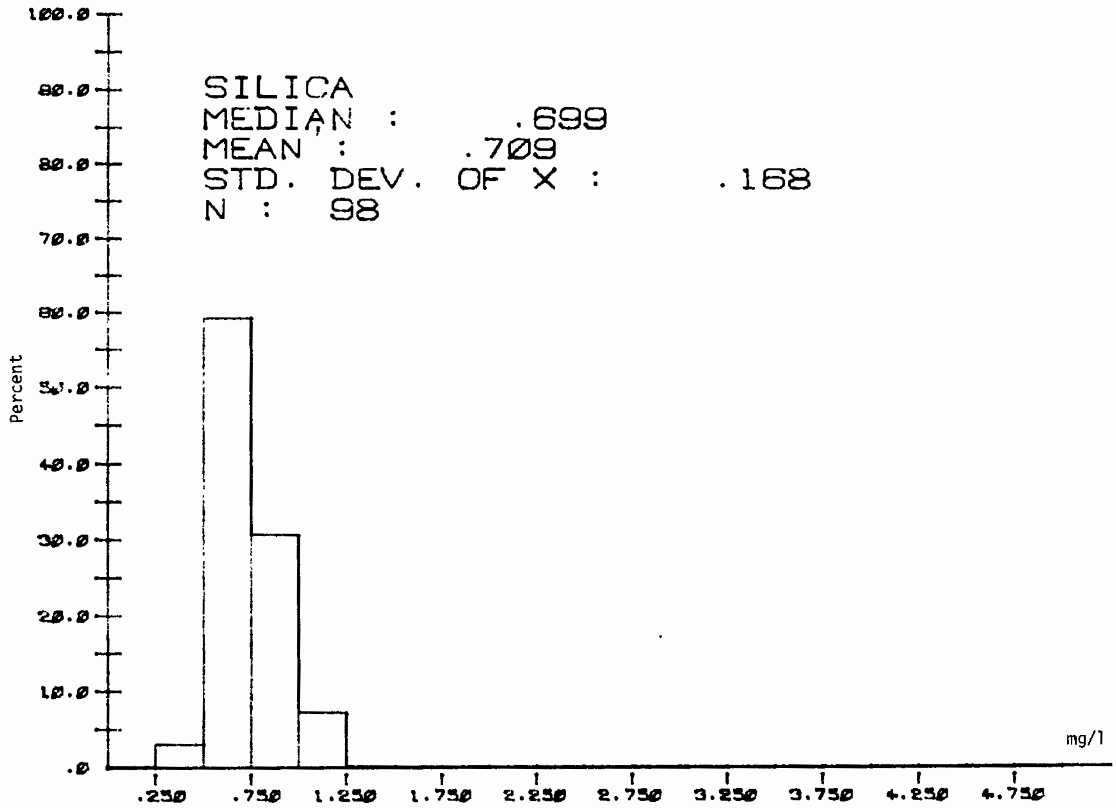


Figure 4.13a Histograms for Silica - Cruise 8

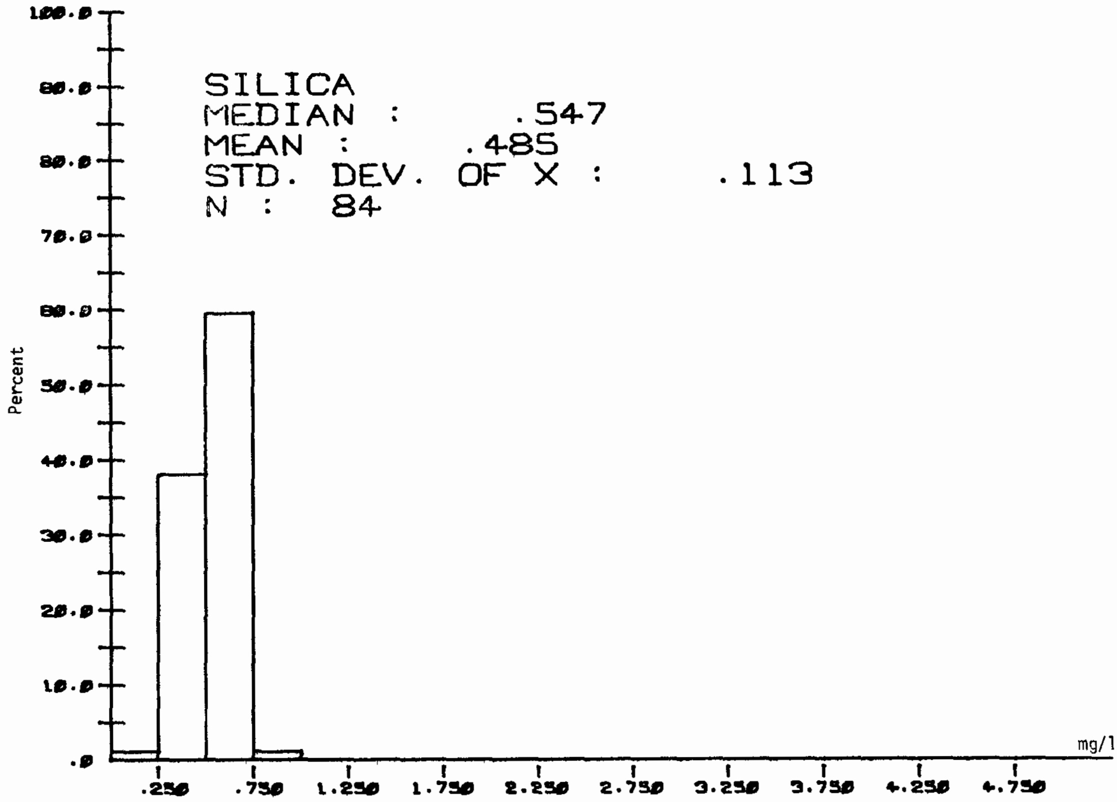


Figure 4.13a Histograms for Silica - Cruise 9

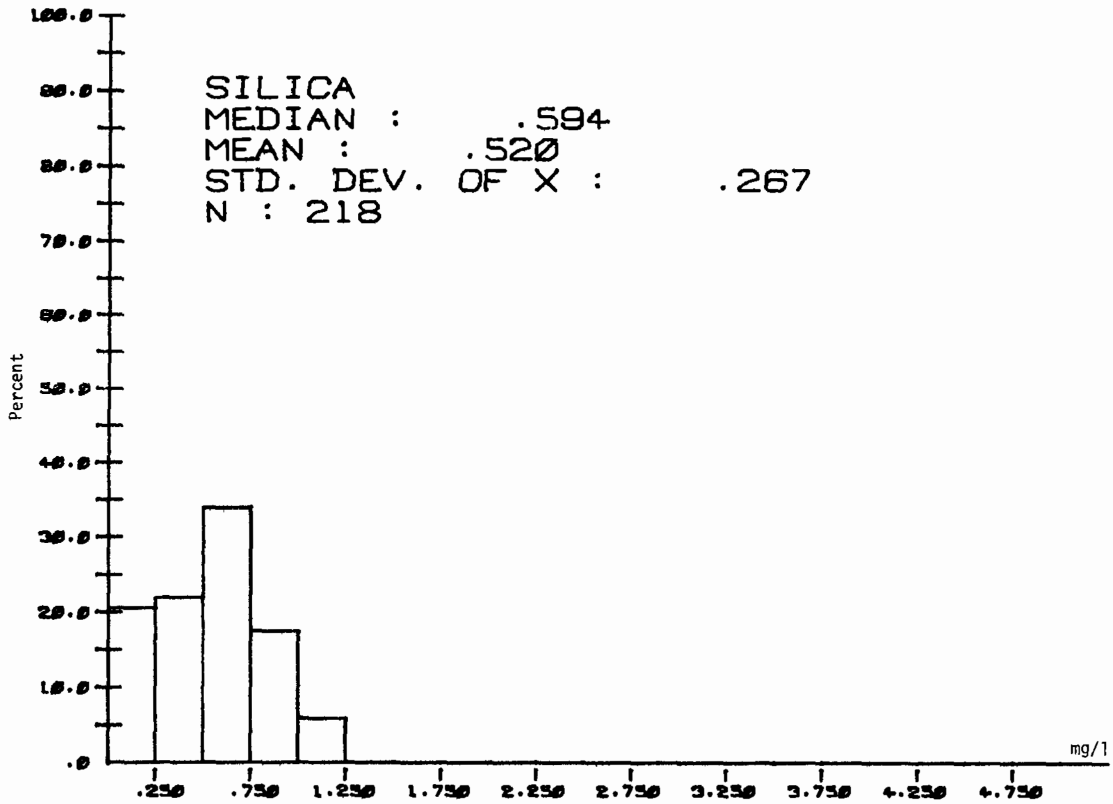


Figure 4.13a Histograms for Silica - Cruise 10

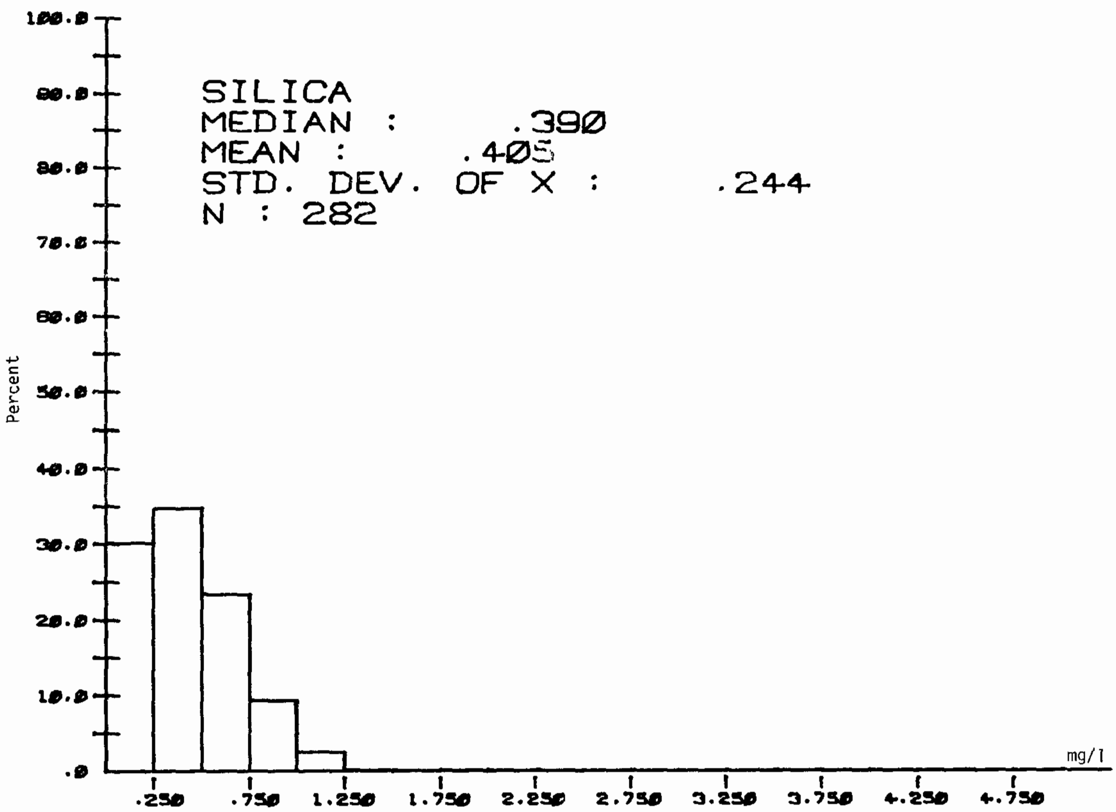


Figure 4.13a Histograms for Silica - Cruise 11

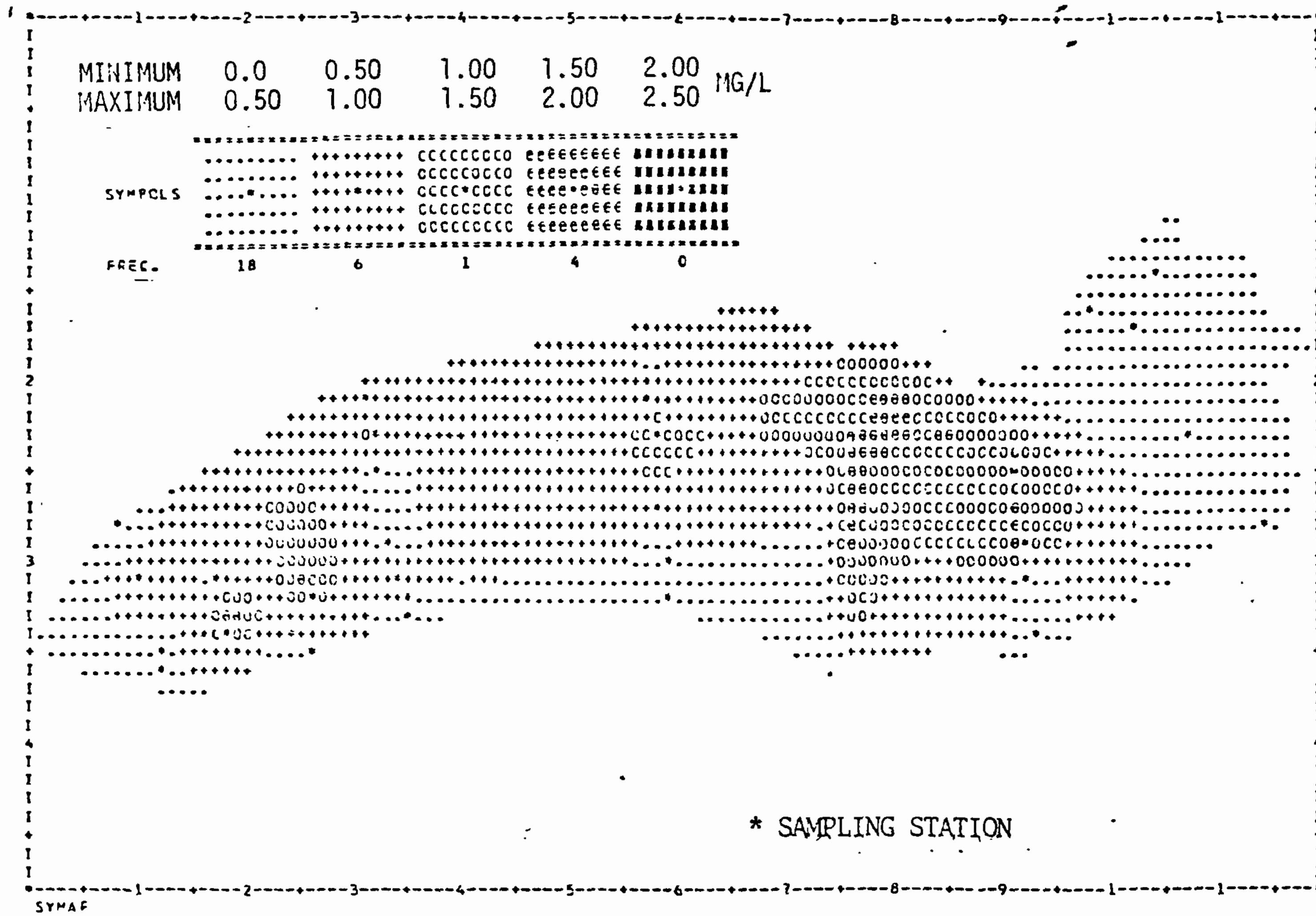
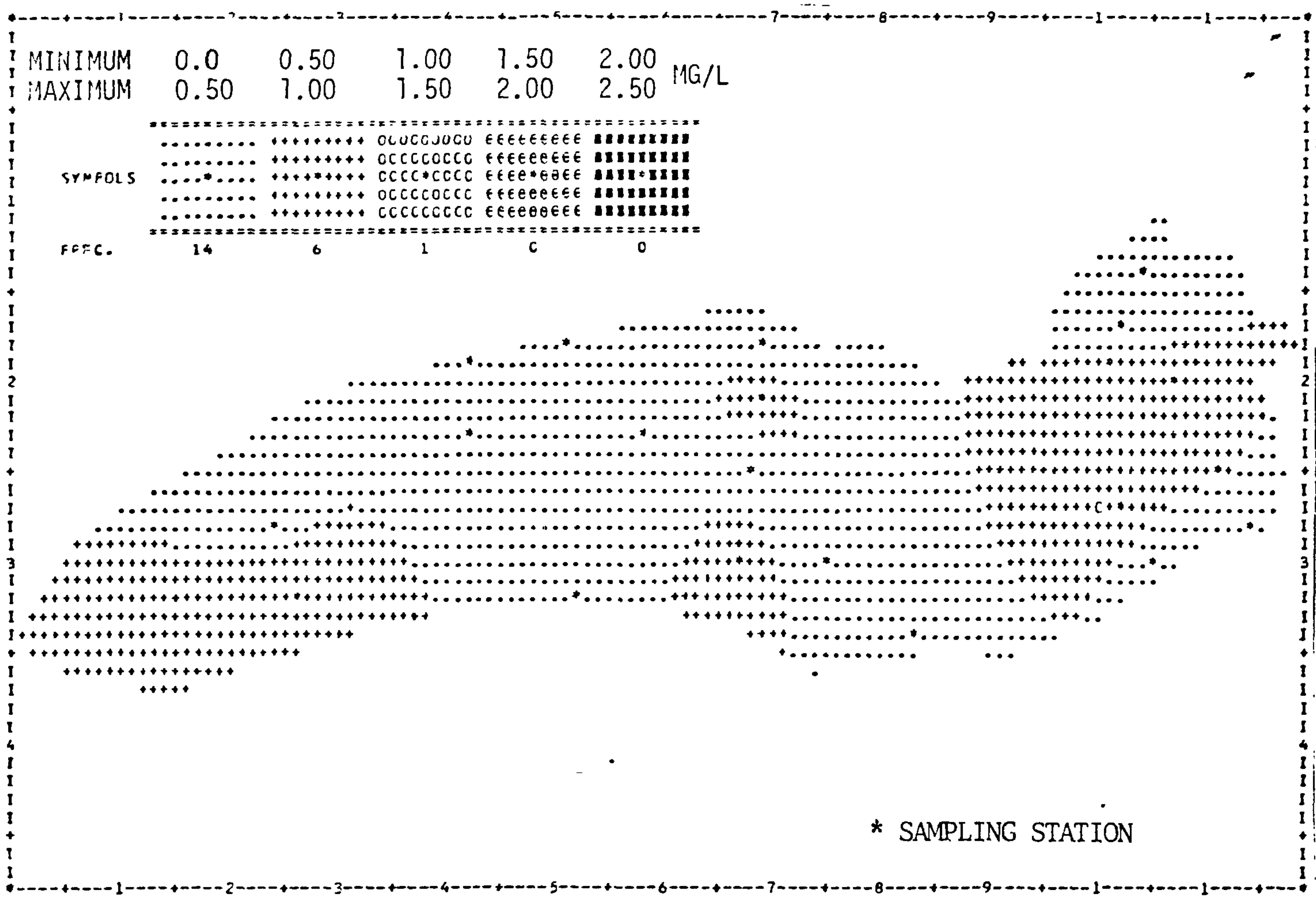


Figure 4.13b Contours of Constant Silica Concentration
Cruise Number 1: May 1, 1972 to May 5, 1972



SYMAP

Figure 4.13b Contours of Constant Silica Concentration
Cruise Number 2: May 15, 1972 to May 19, 1972

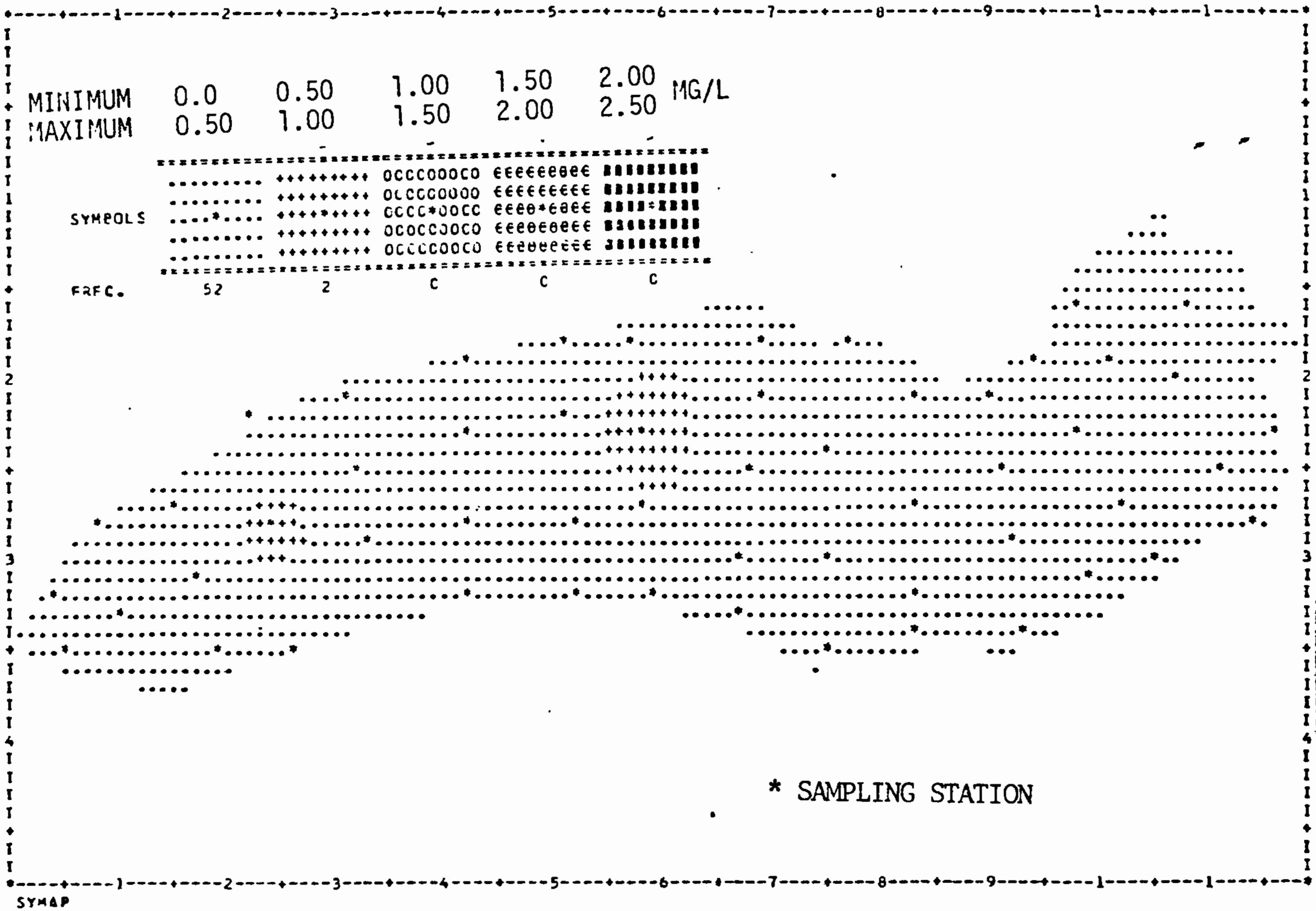


Figure 4.13b Contours of Constant Silica Concentration
Cruise Number 3: June 12, 1972 to June 16, 1972

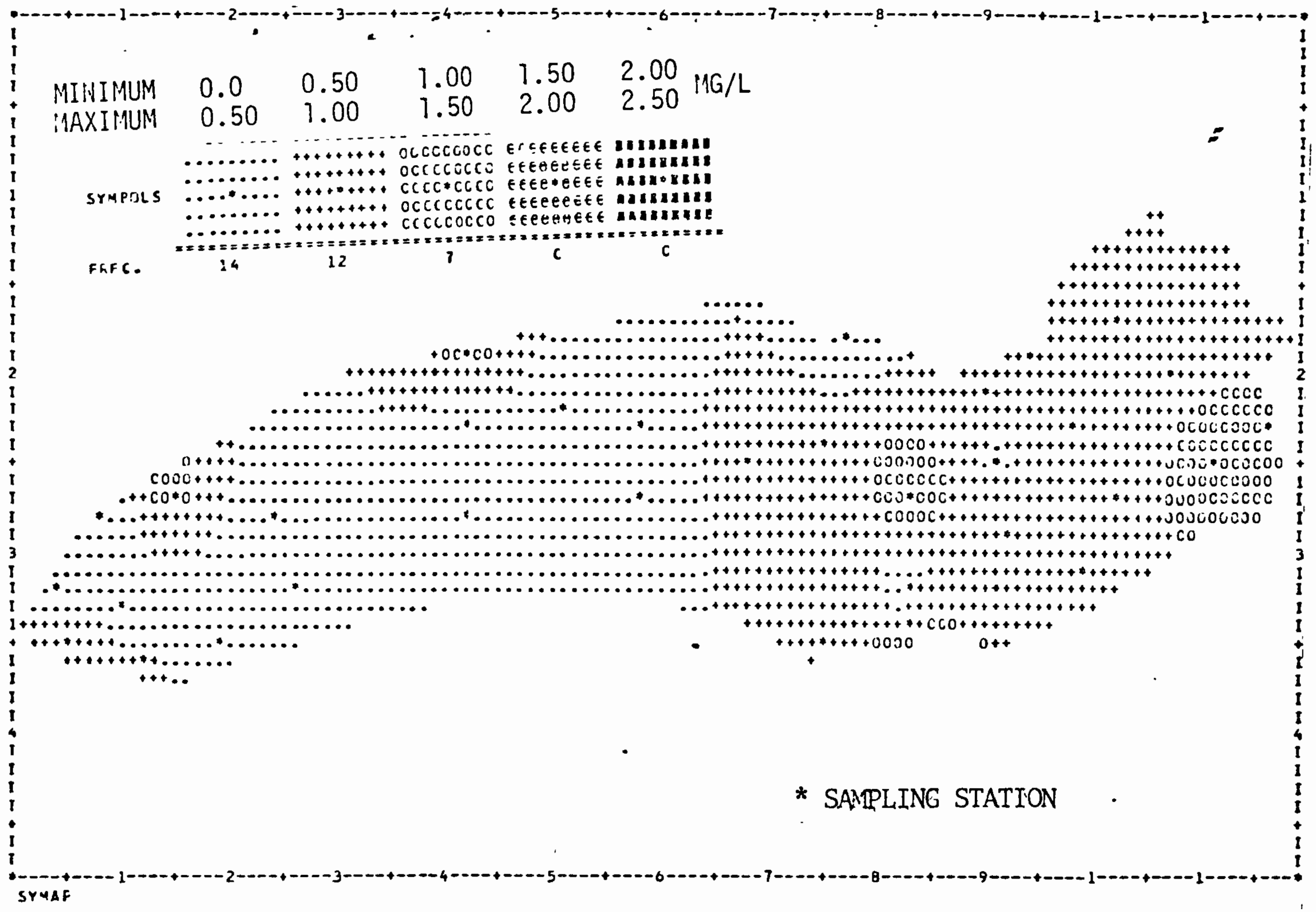


Figure 4.13b Contours of Constant Silica Concentration
Cruise Number 4: July 10, 1972 to July 14, 1972

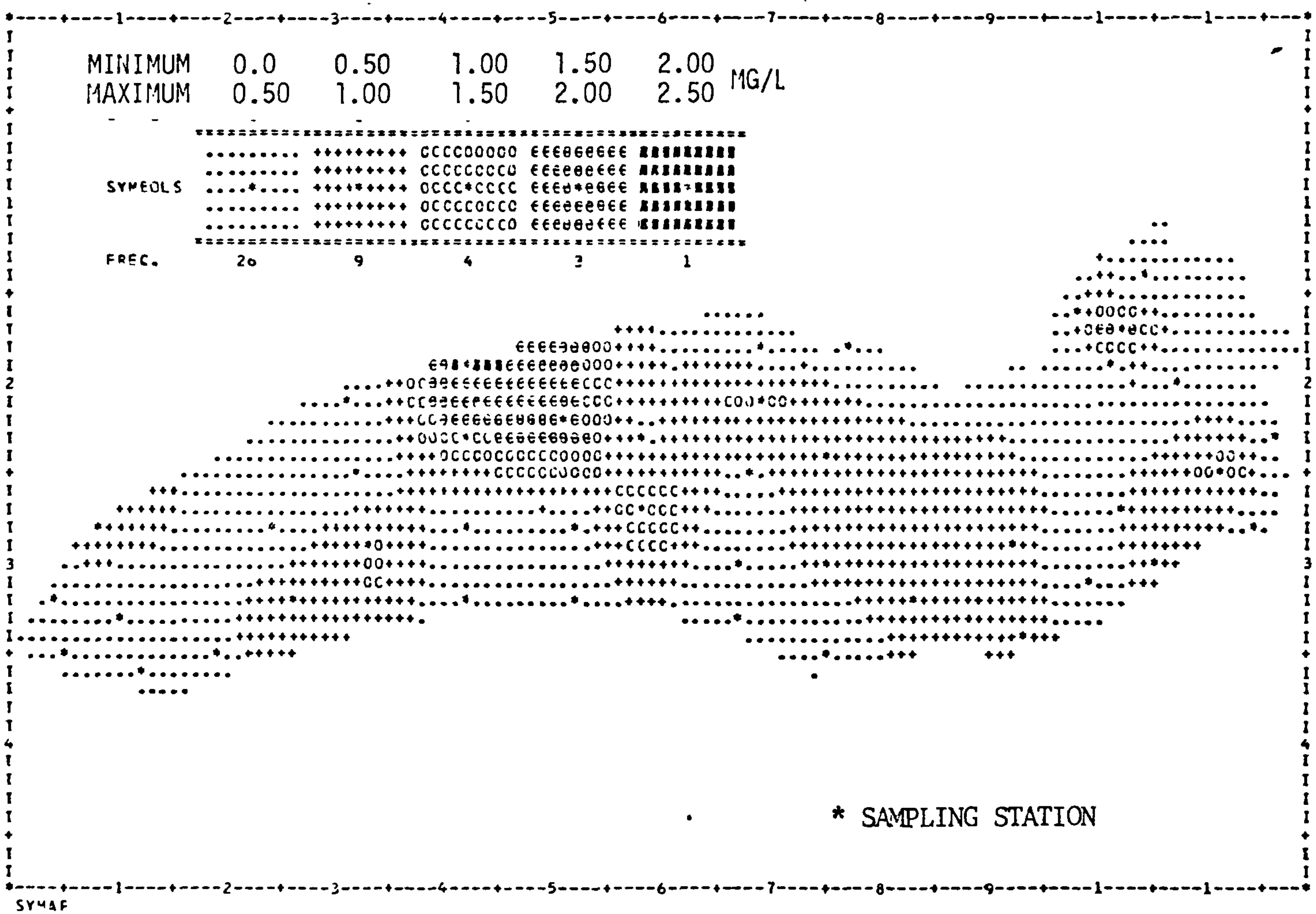


Figure 4.13b Contours of Constant Silica Concentration
Cruise Number 5: August 21, 1972 to August 25, 1972

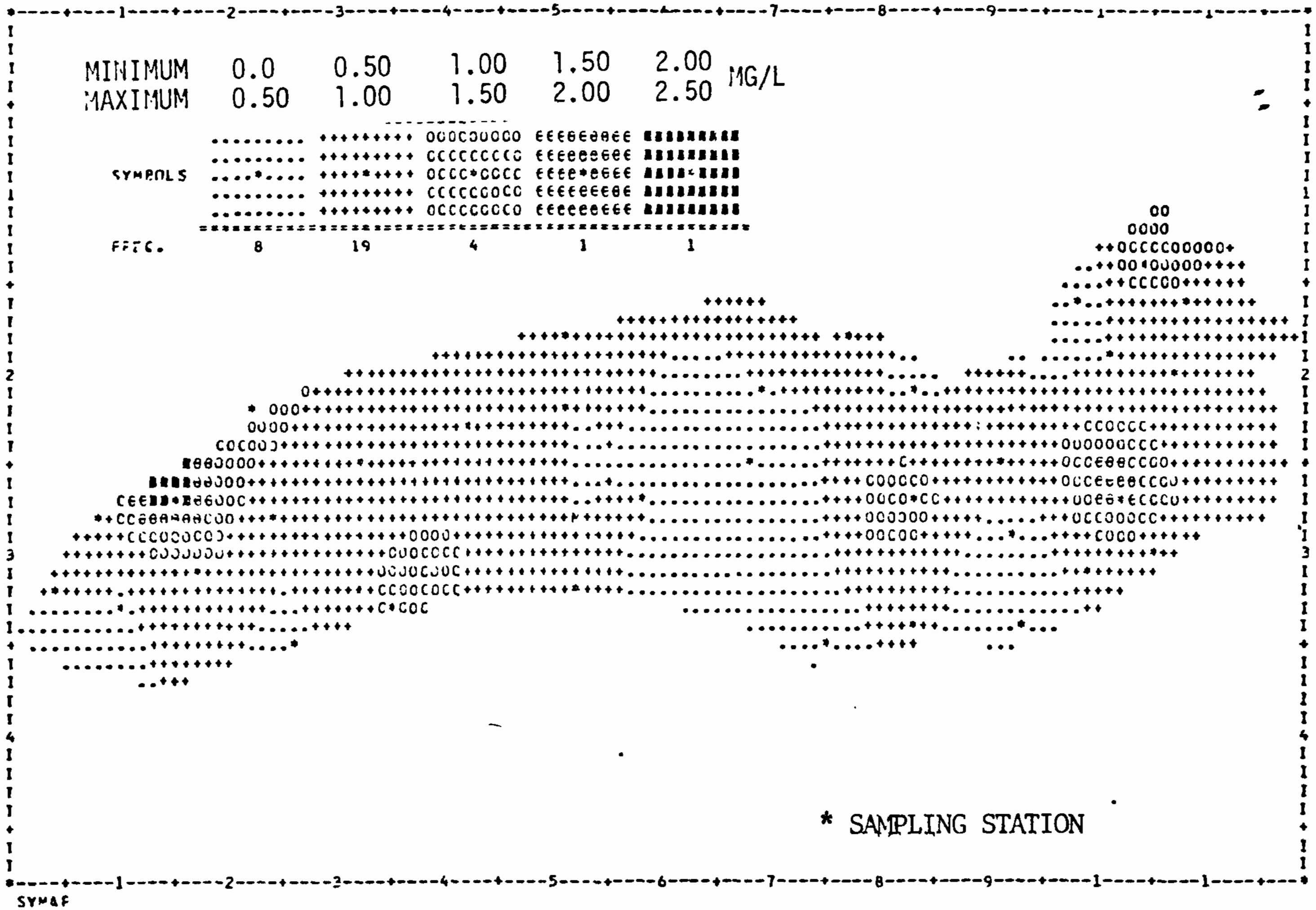


Figure 4.13b Contours of Constant Silica Concentration
Cruise Number 6: October 30, 1972 to November 3, 1972

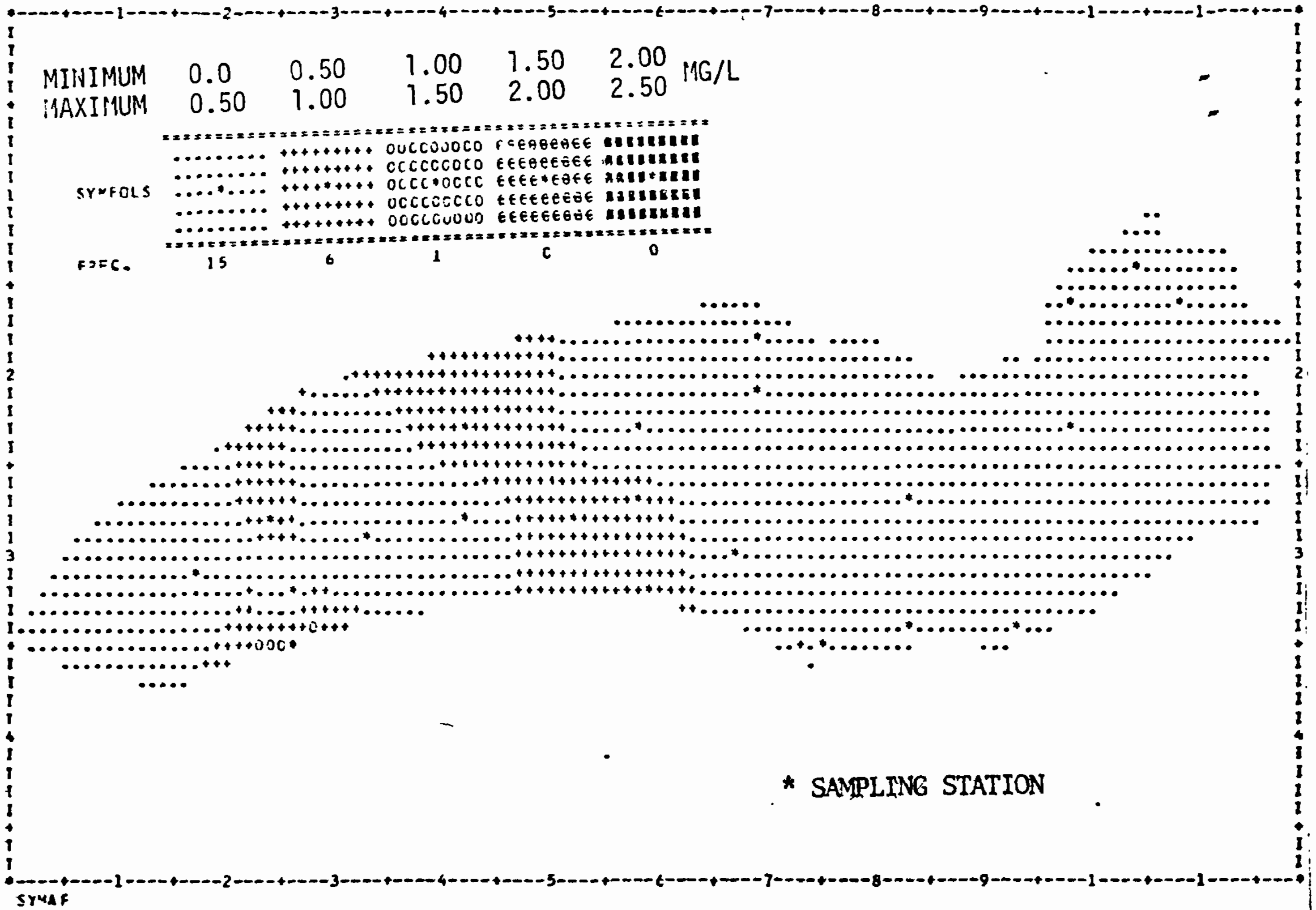


Figure 4.13b Contours of Constant Silica Concentration

Cruise Number 7: November 27, 1972 to December 2, 1972

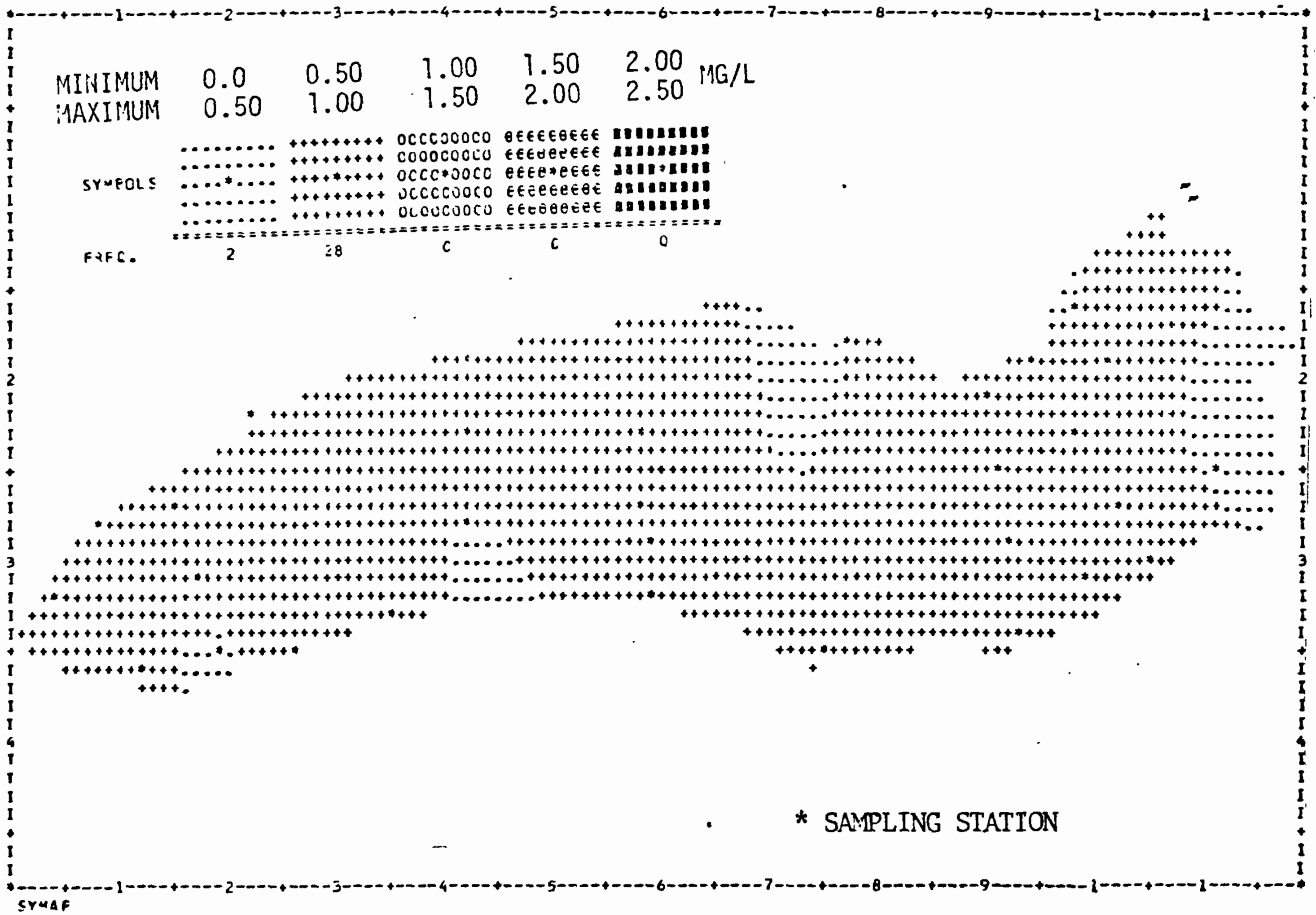


Figure 4.13b Contours of Constant Silica Concentration
Cruise Number 8: February 5, 1973 to Febraury 9, 1973

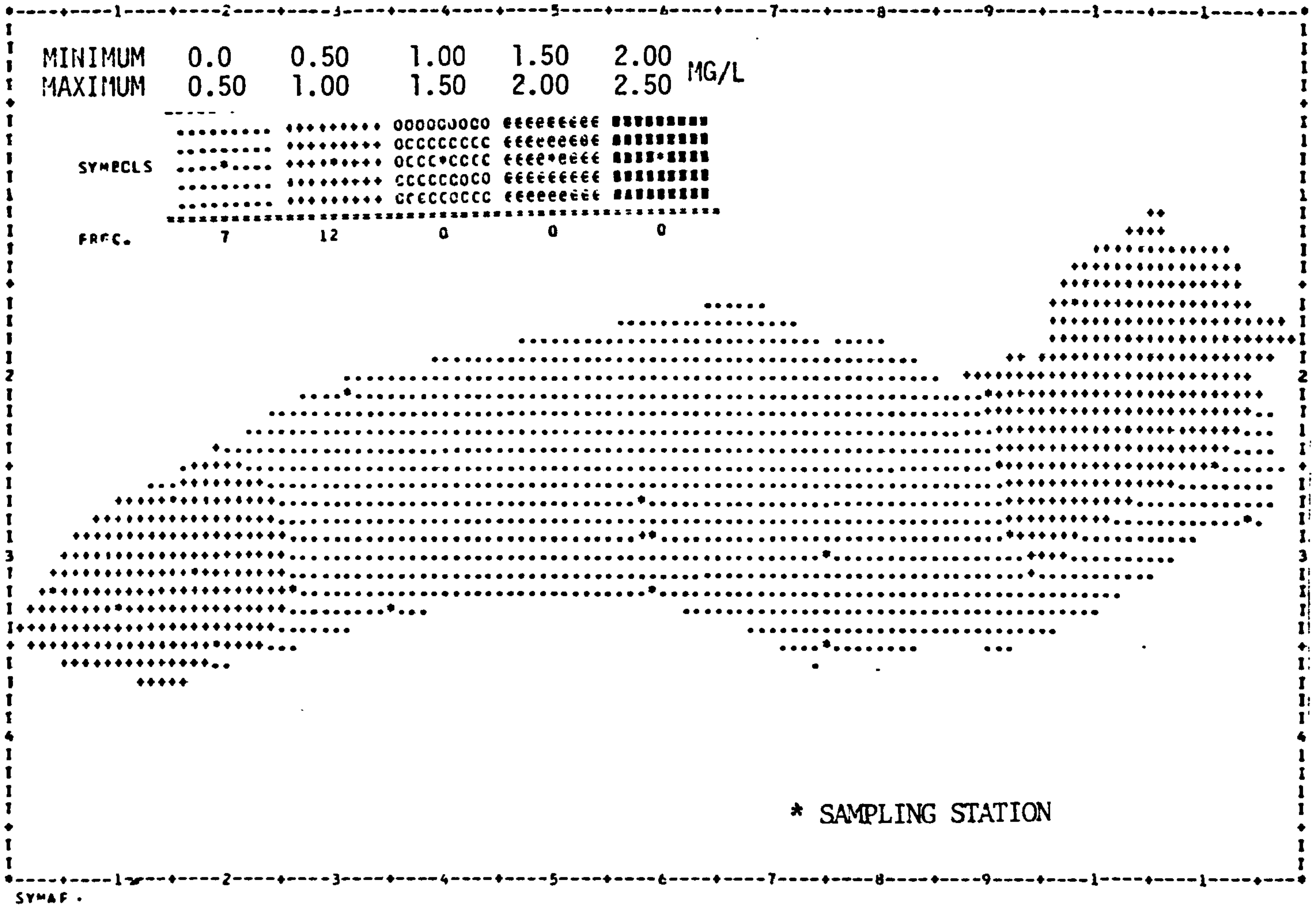


Figure 4.13b Contours of Constant Silica Concentration
Cruise Number 9: March 18, 1973 to March 23, 1973

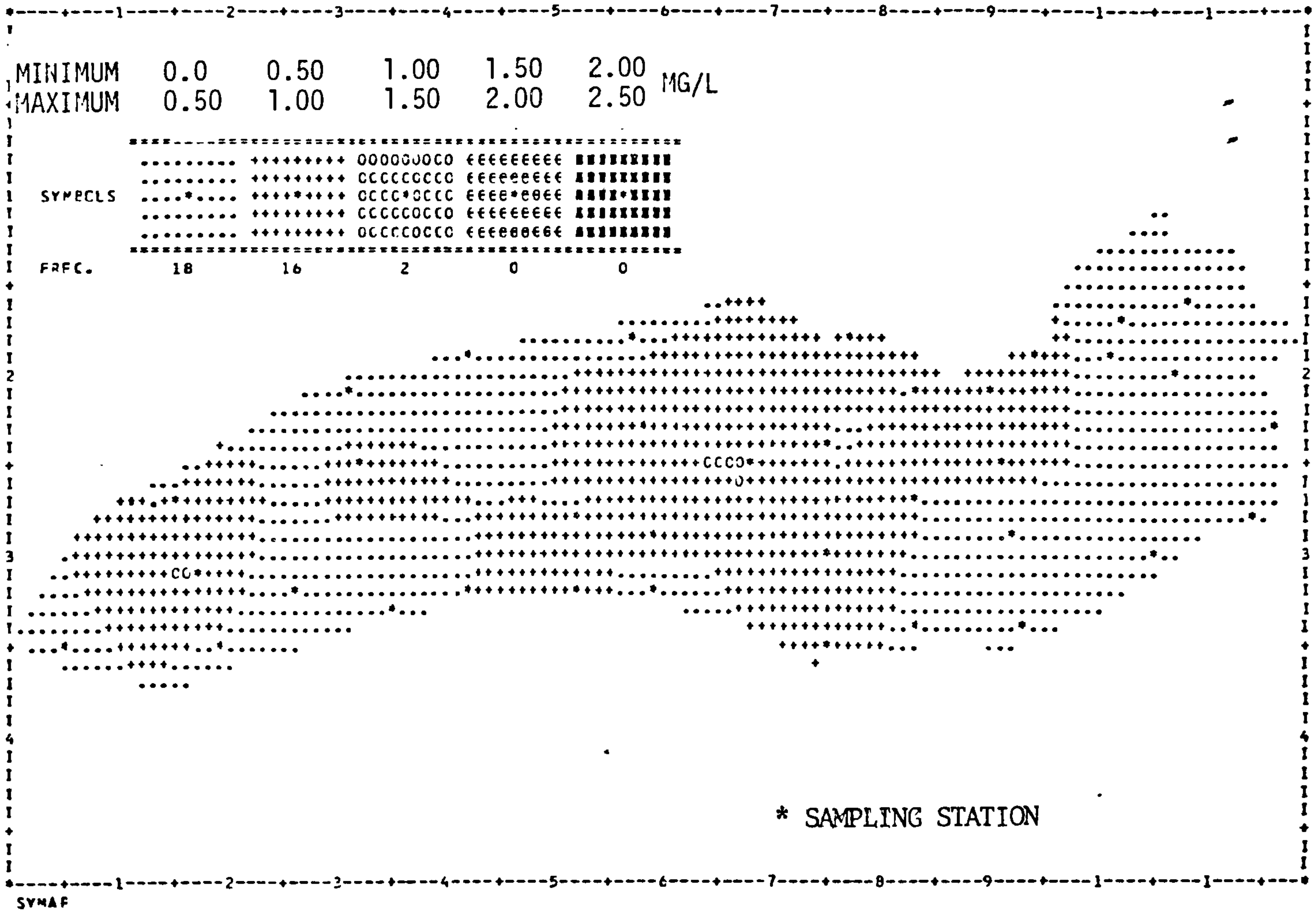


Figure 4.13b Contours of Constant Silica Concentration
Cruise Number 10: April 24, 1973 to April 30, 1973

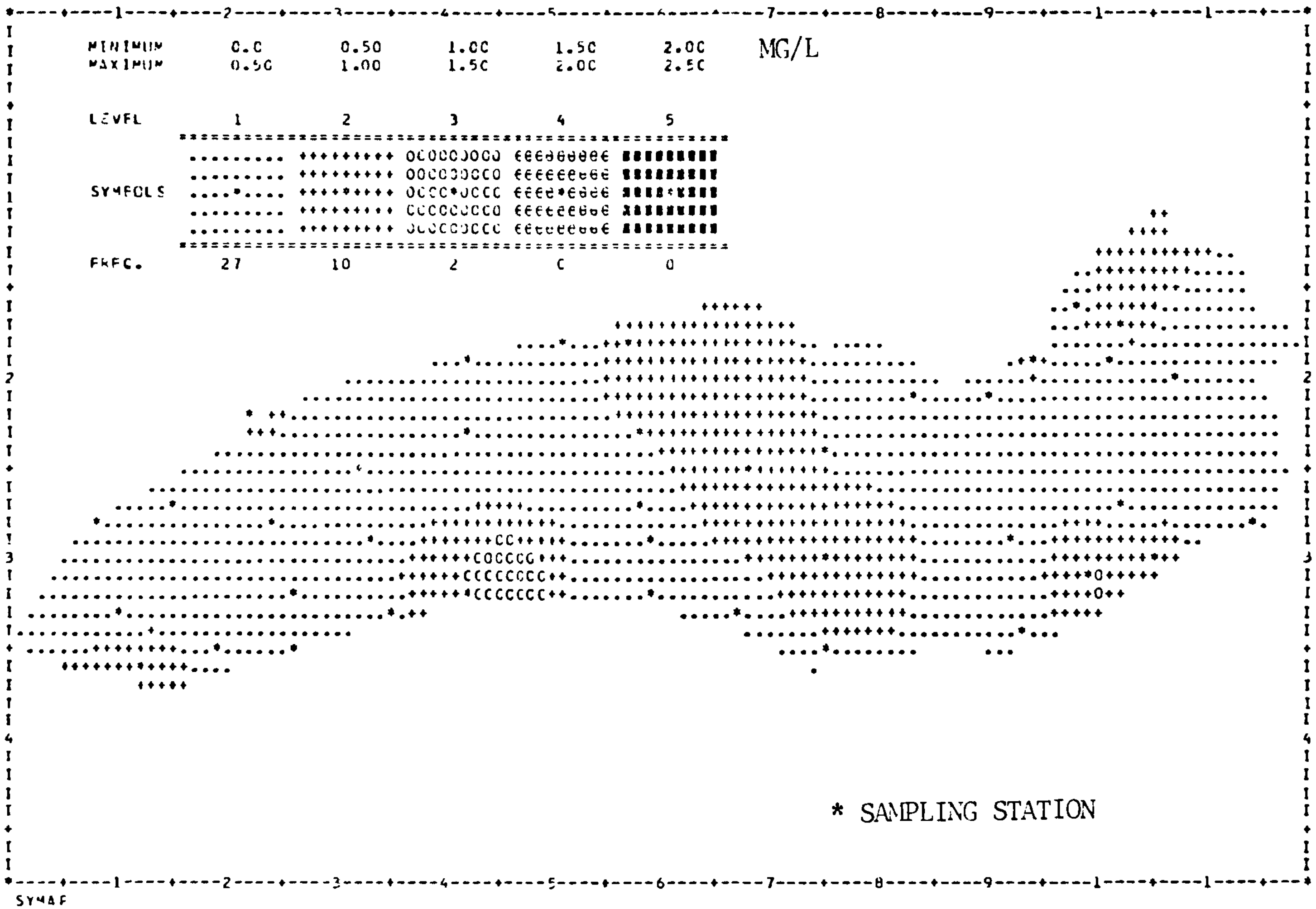


Figure 4.13b Contours of Constant Silica Concentration

CRUISE NUMBER 11: JUNE 11, 1973 TO JUNE 15, 1973

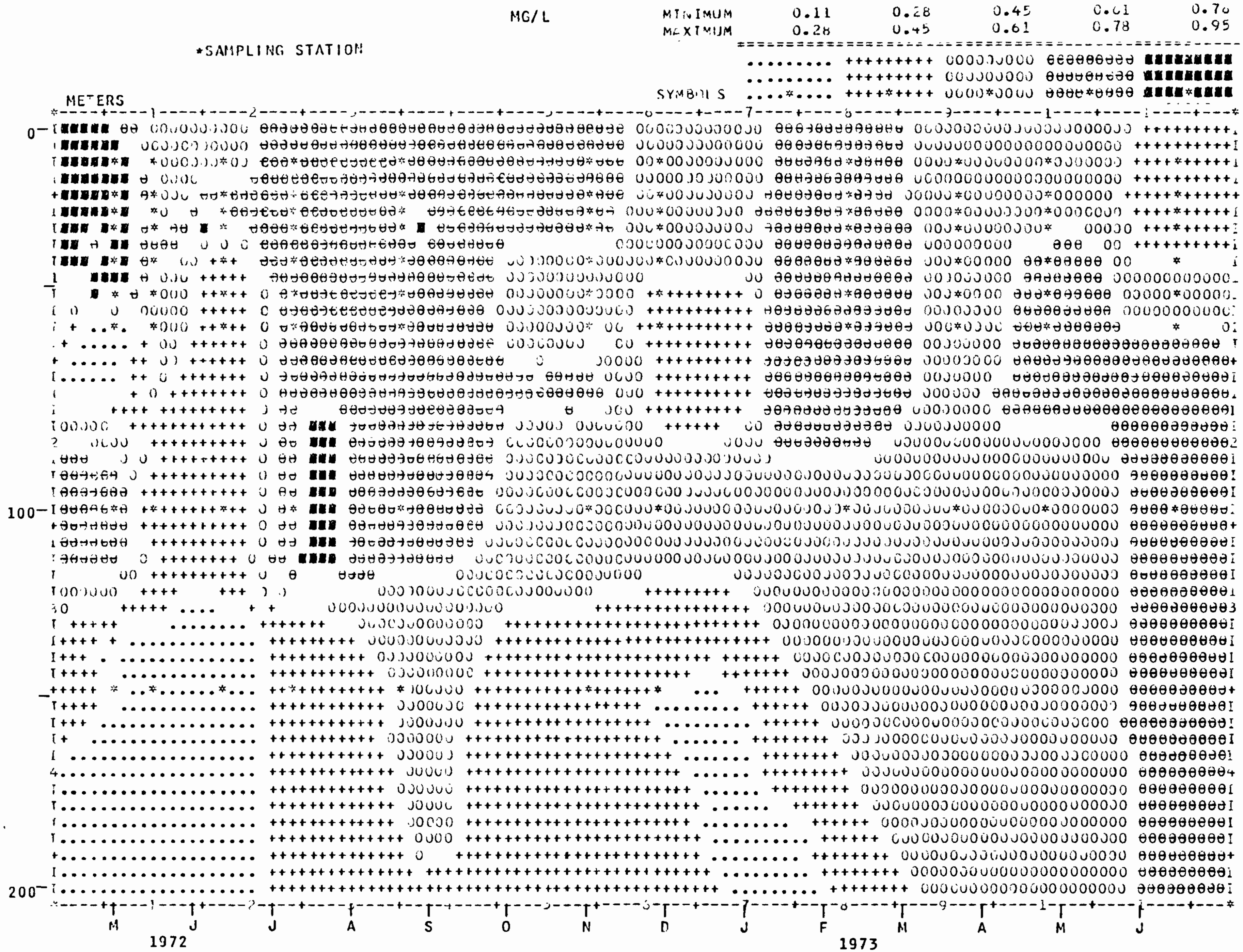


Figure 4.13c Depth Versus Time Contours of Constant Silica

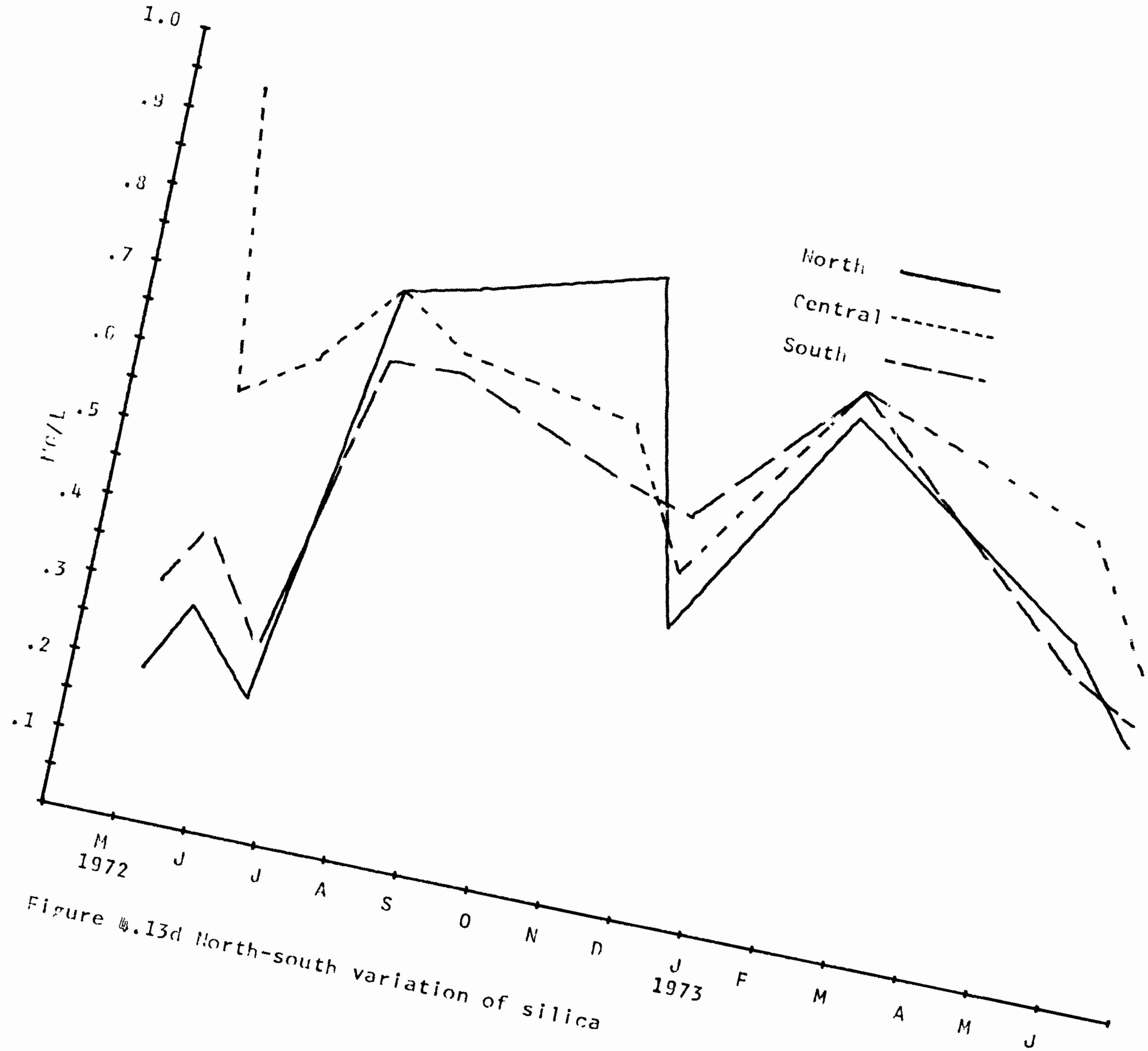


Figure 4.13d North-south variation of silica

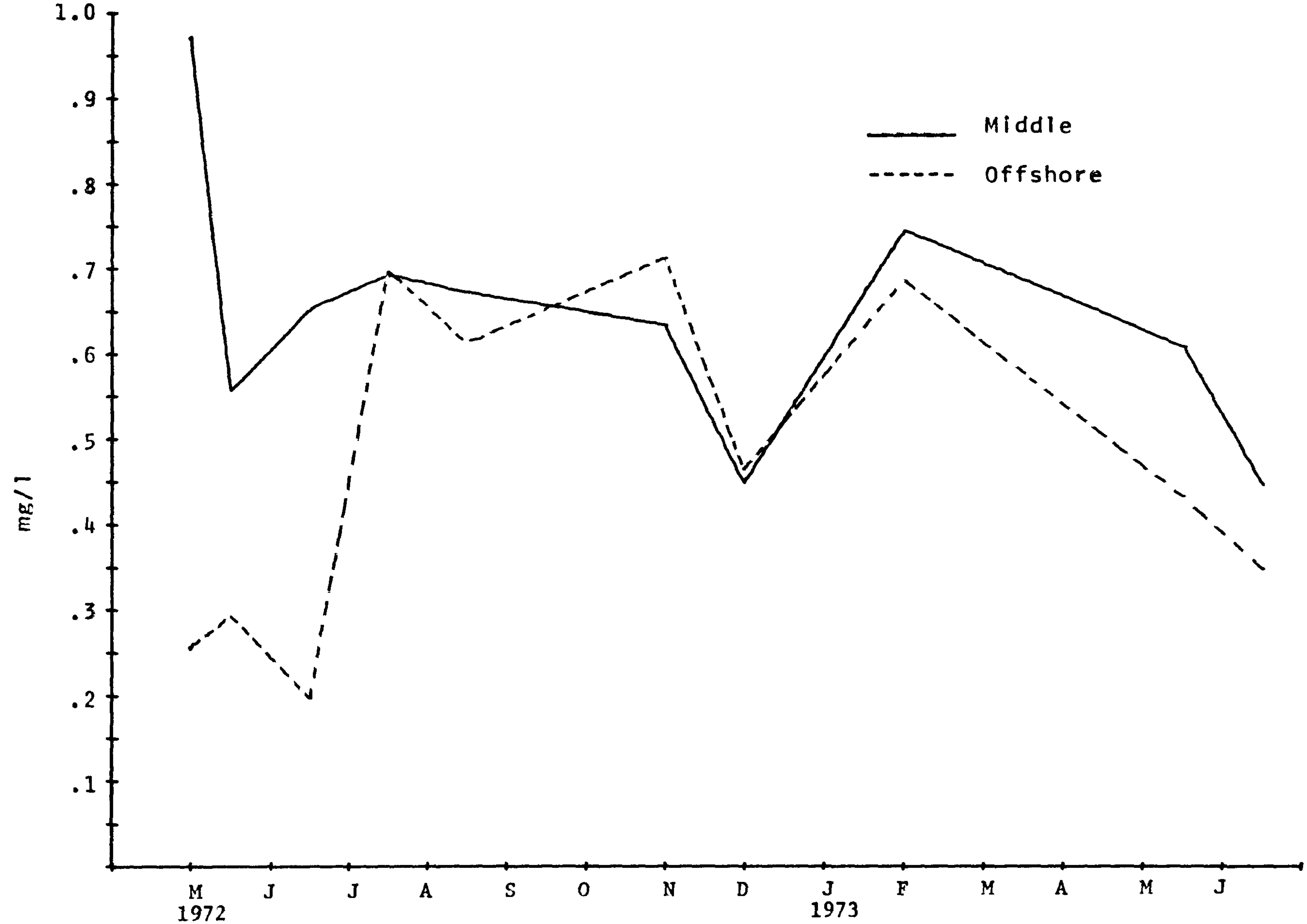


Figure 4.13e Middle Lake-Offshore Variations of Mean Silica Concentration

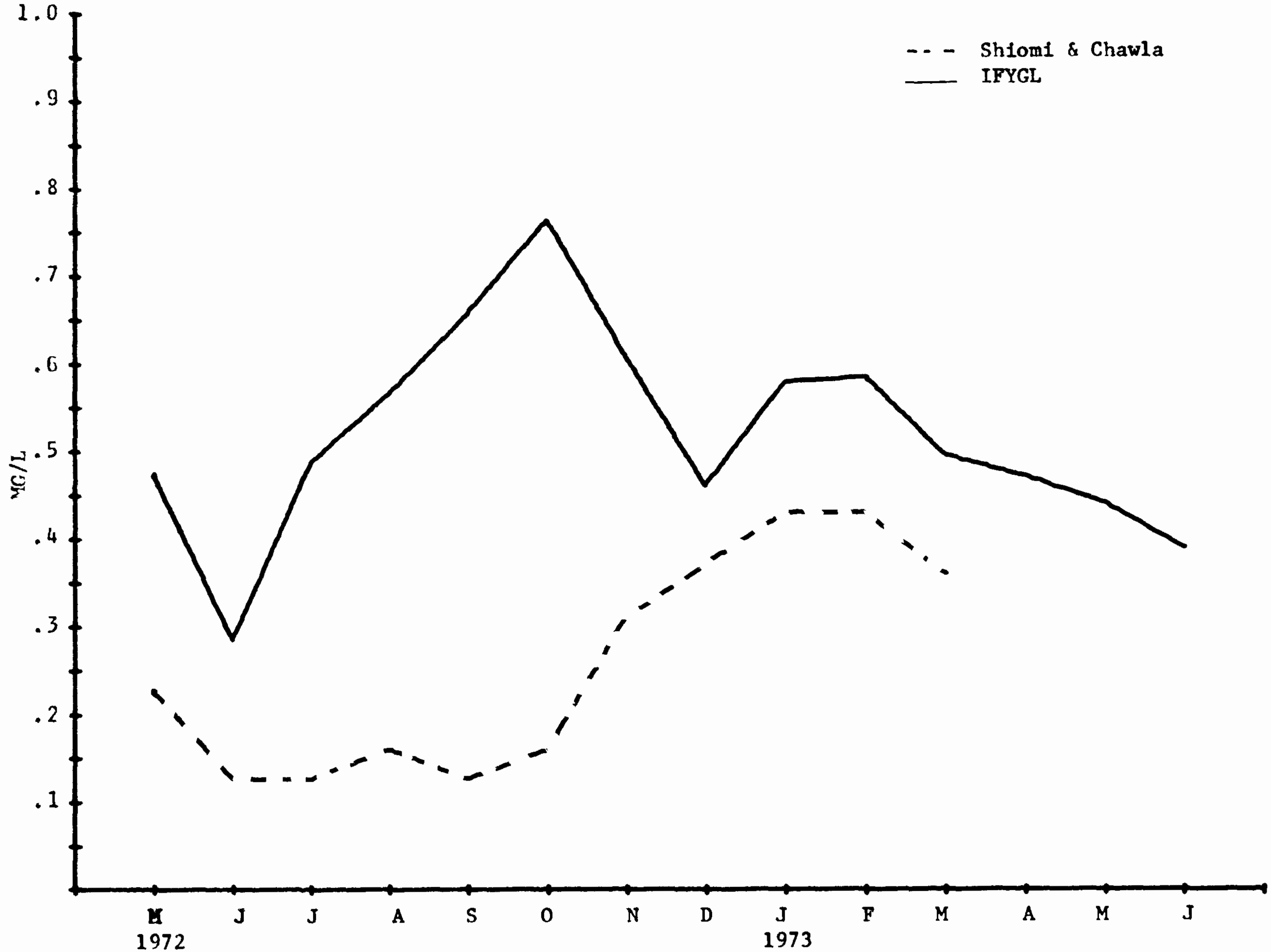


Figure 4.13f Mean surface variation of Silica concentration during the field year.

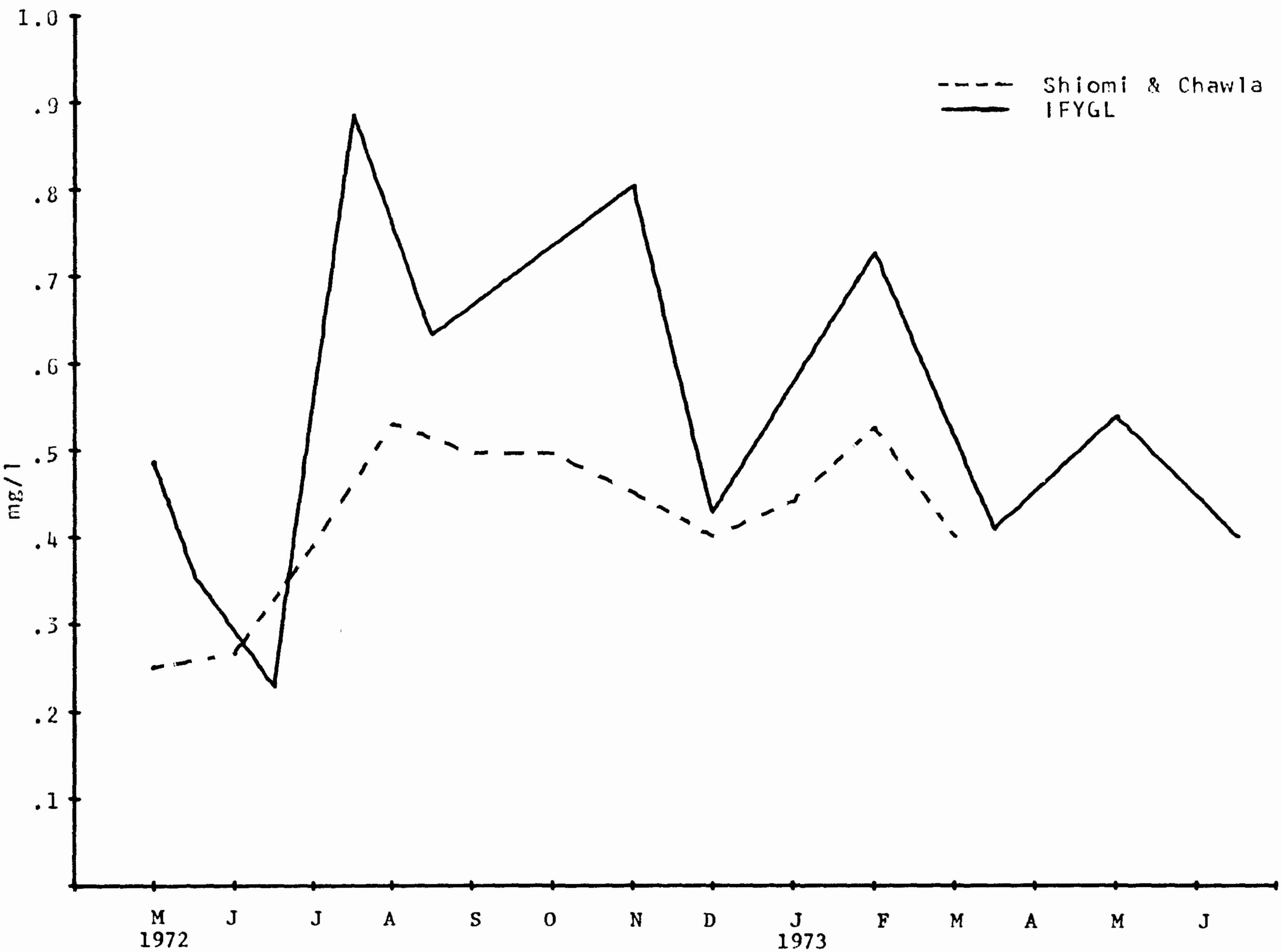


Figure 4.13g Mean Bottom Variation of Silica Concentration During the Field Year

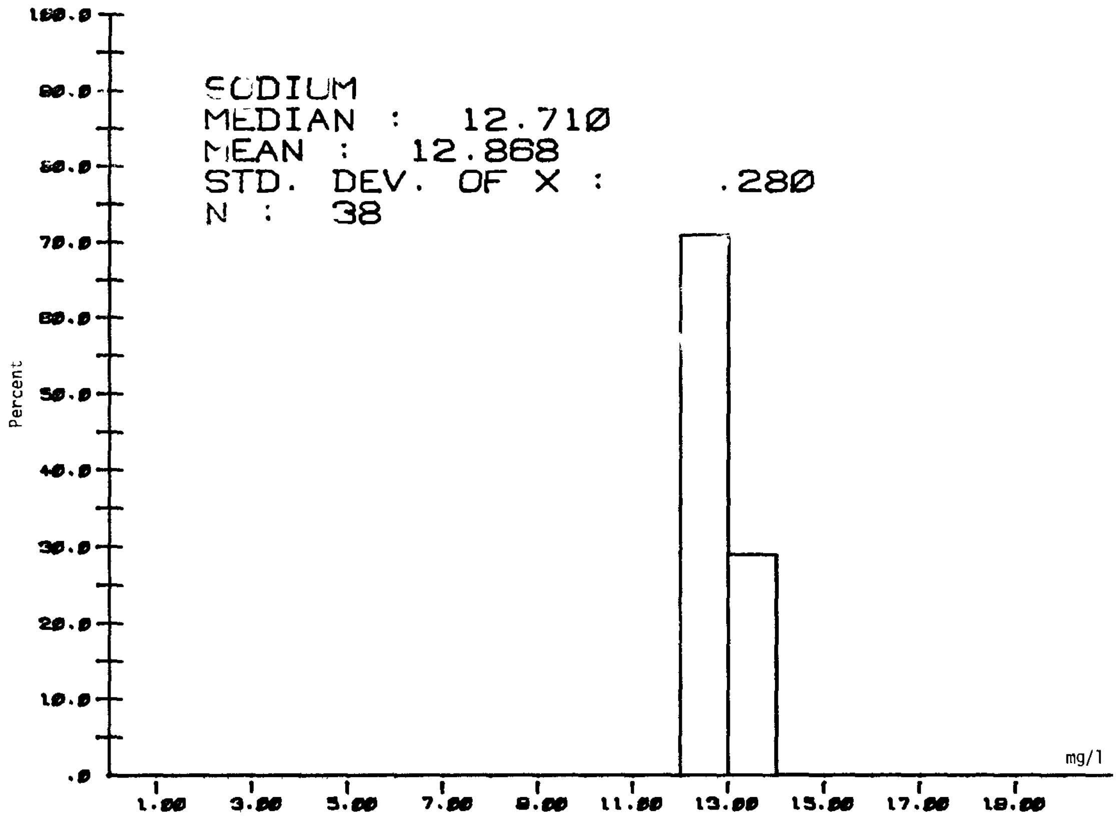


Figure 4.14a Histograms for Sodium - Cruise 1

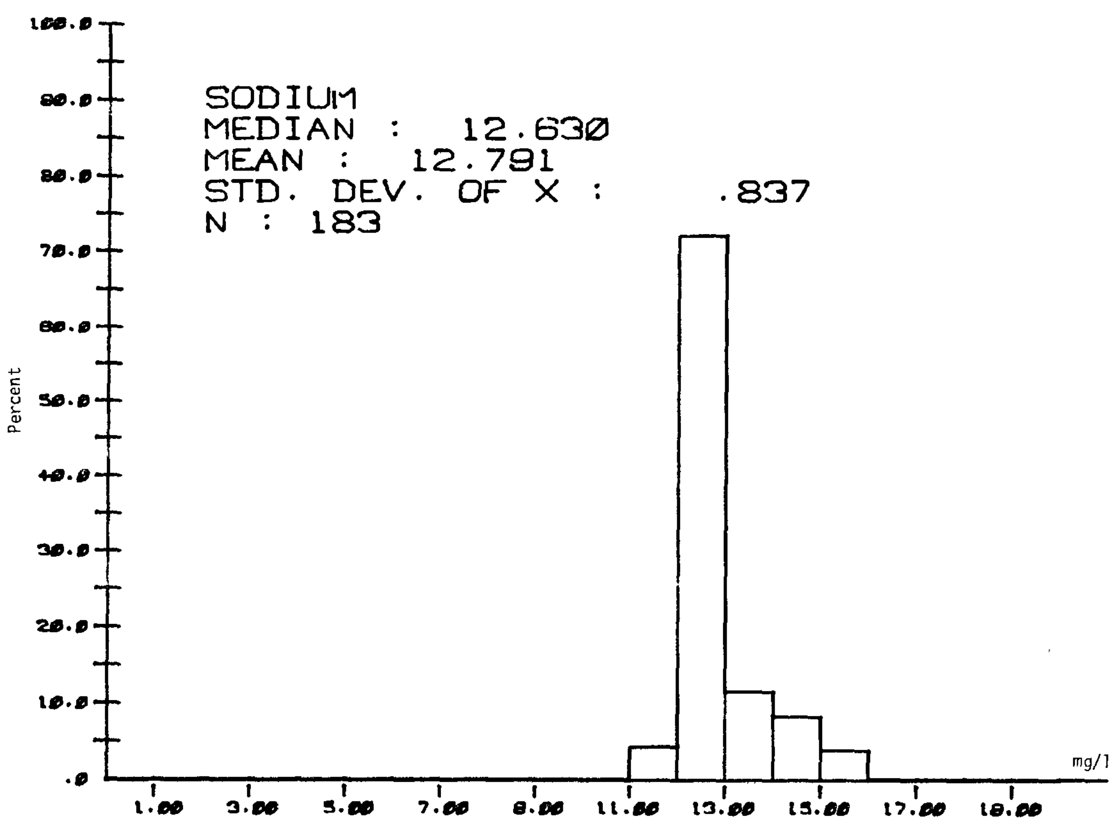


Figure 4.14a Histograms for Sodium - Cruise 2

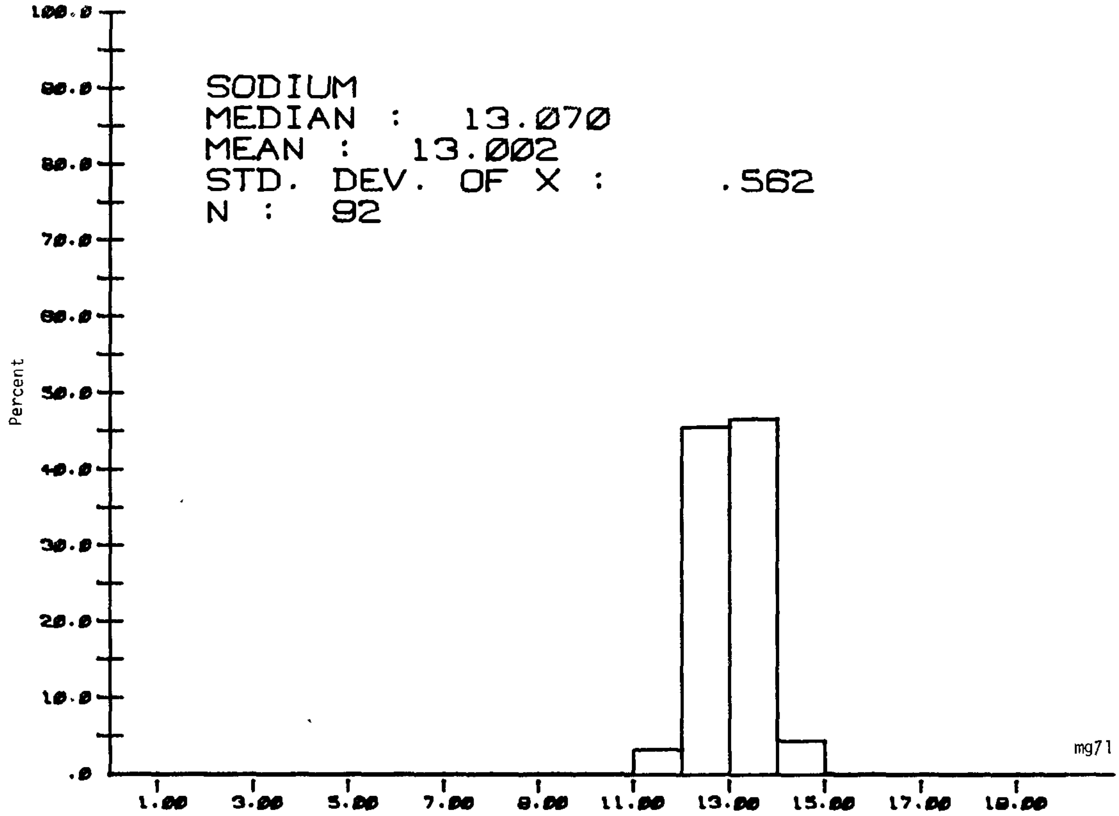


Figure 4.14a Histograms for Sodium - Cruise 3

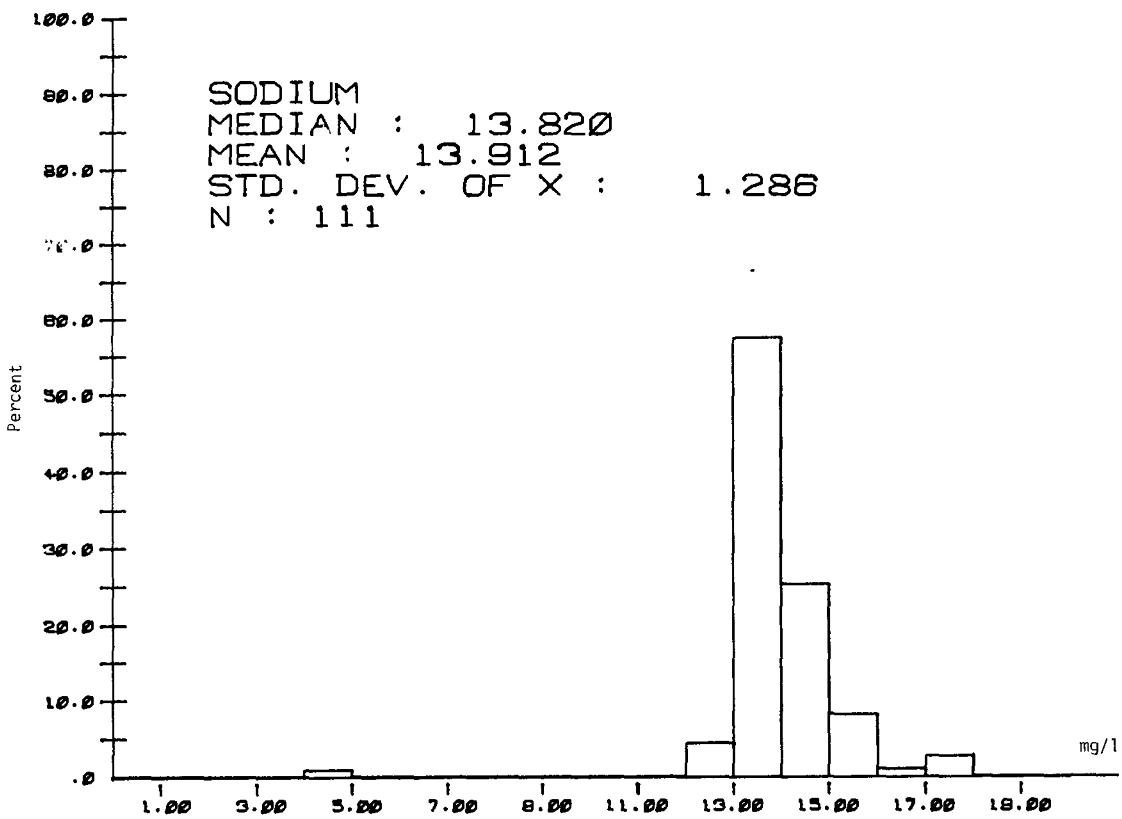


Figure 4.14a Histograms for Sodium - Cruise 4

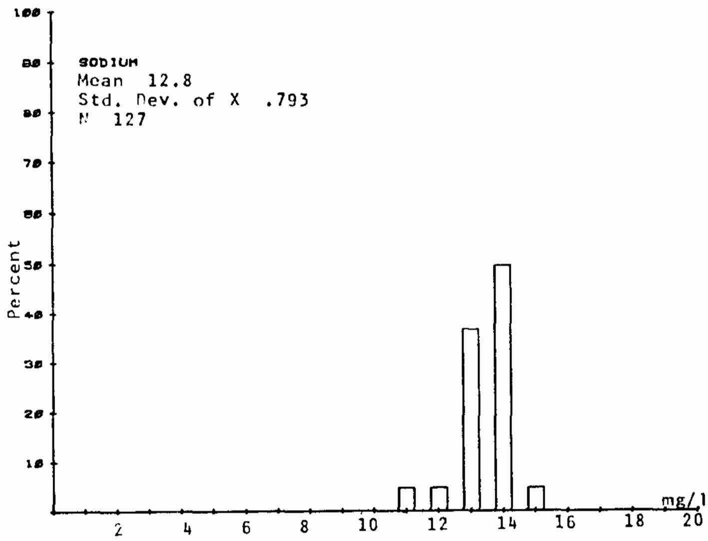
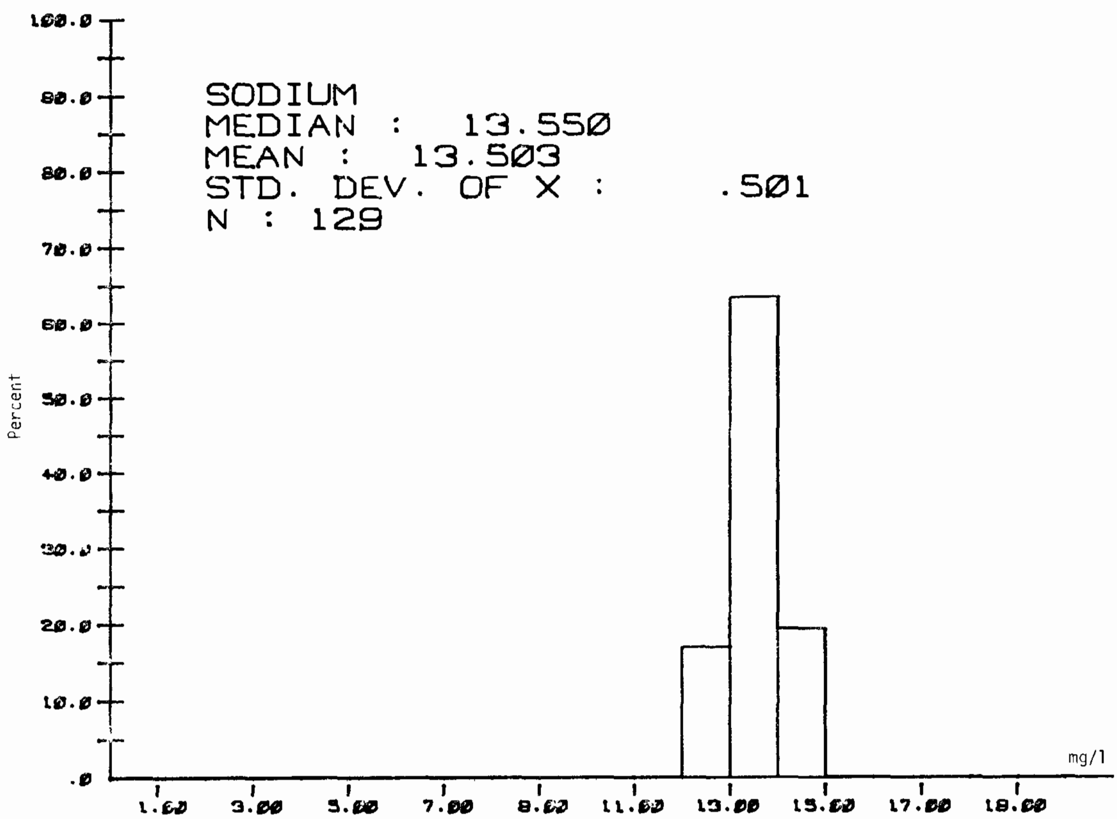


Figure 4.14a Histograms for Sodium - Cruise 5



4 14a Histograms for Sodium - Cruise 6

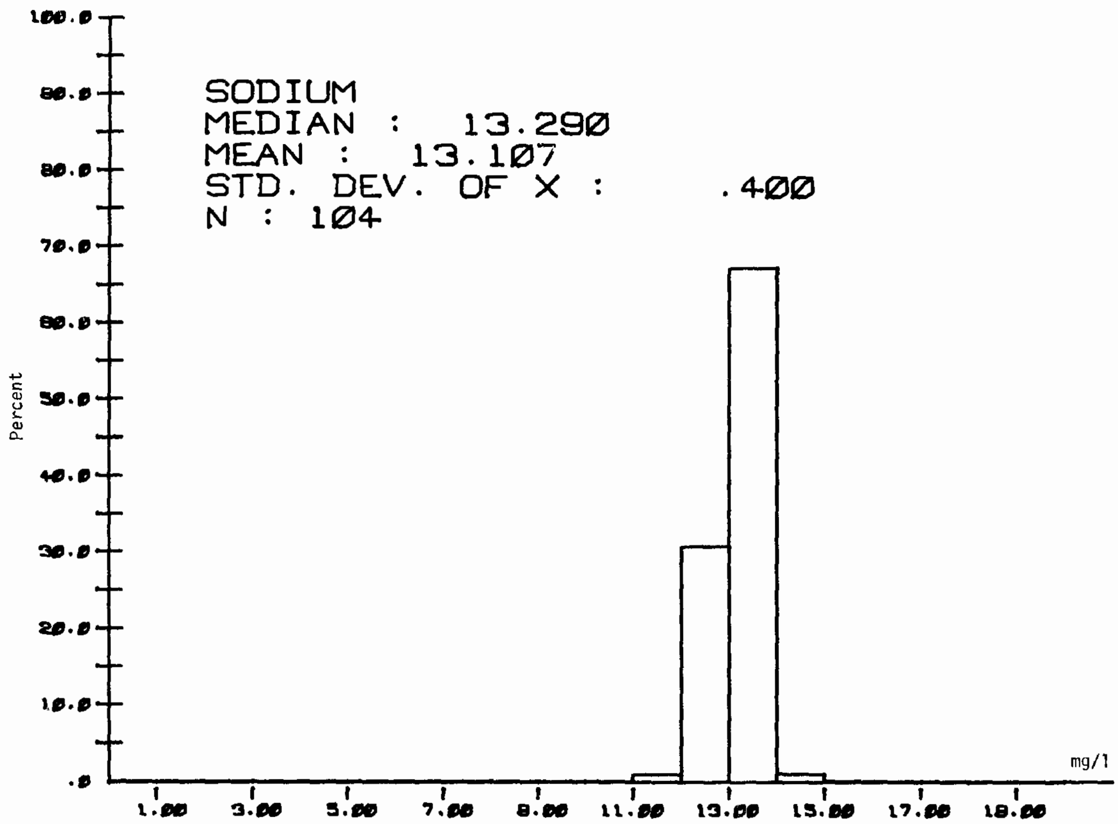


Figure 4.14a Histograms for Sodium - Cruise 7

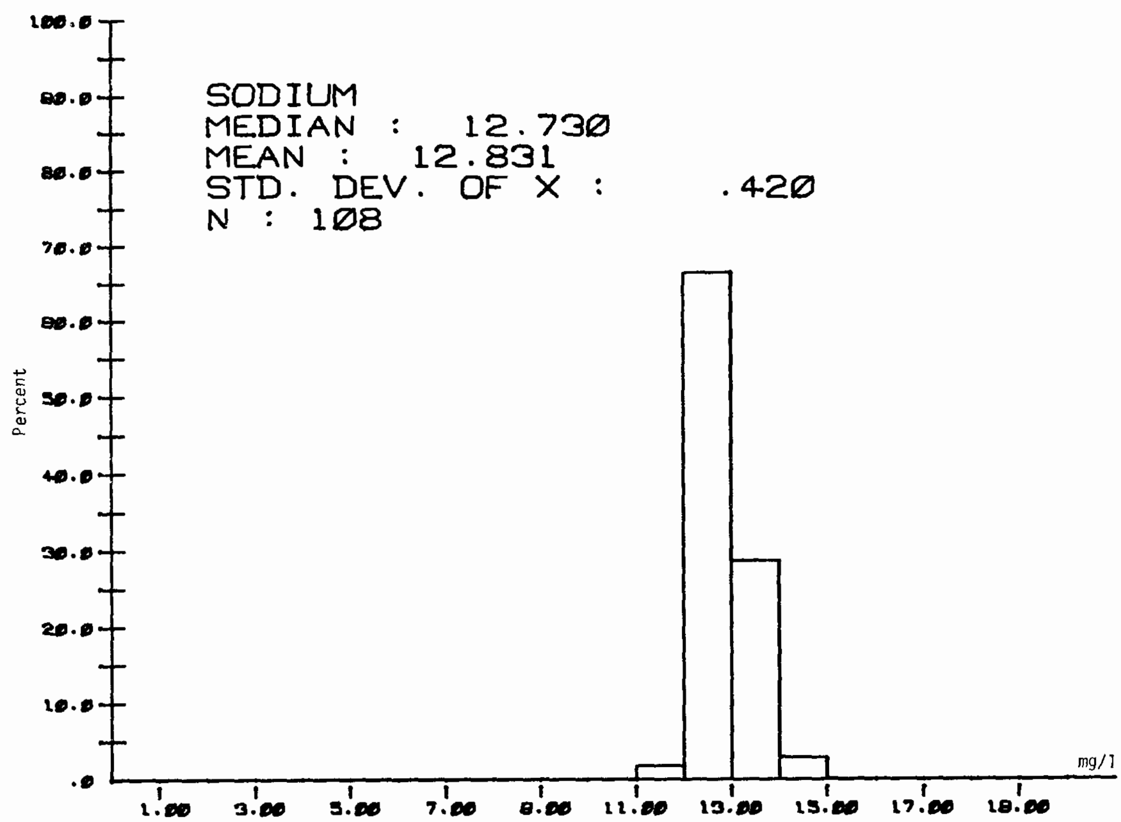


Figure 4.14a Histograms for Sodium - Cruise 8

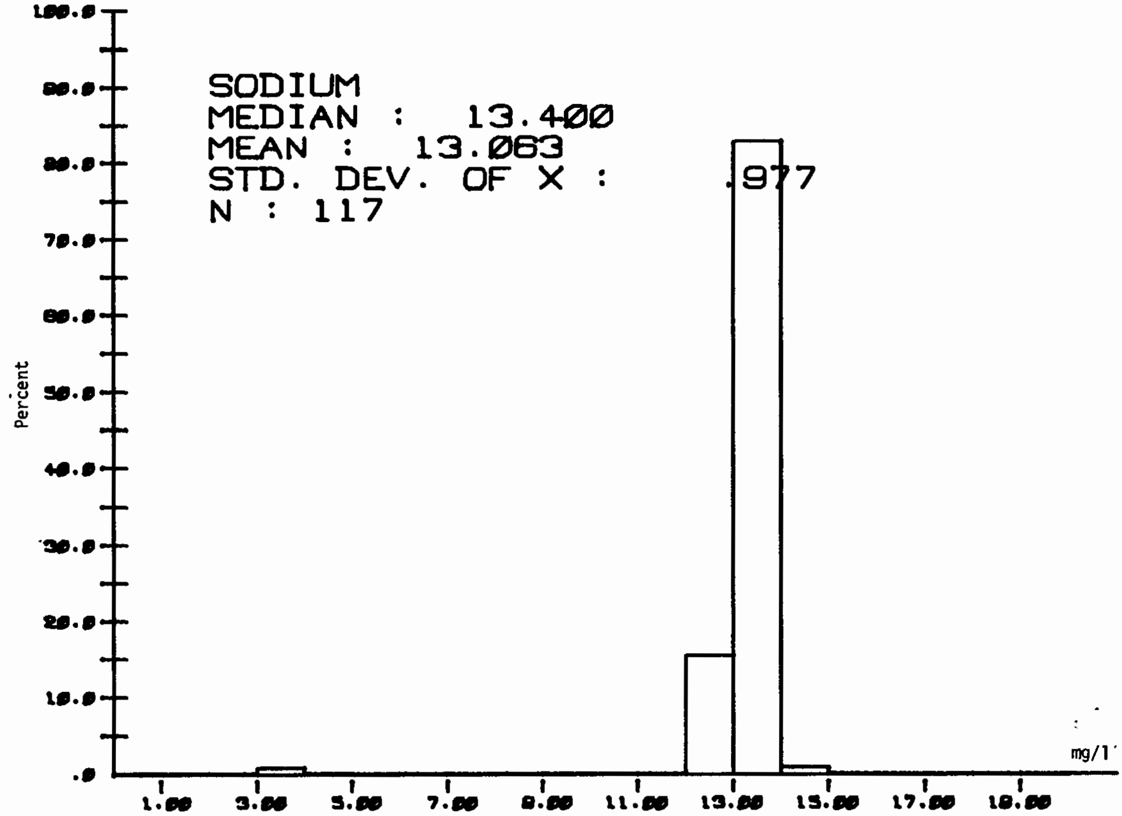


Figure 4.14a Histograms for Sodium - Cruise 9

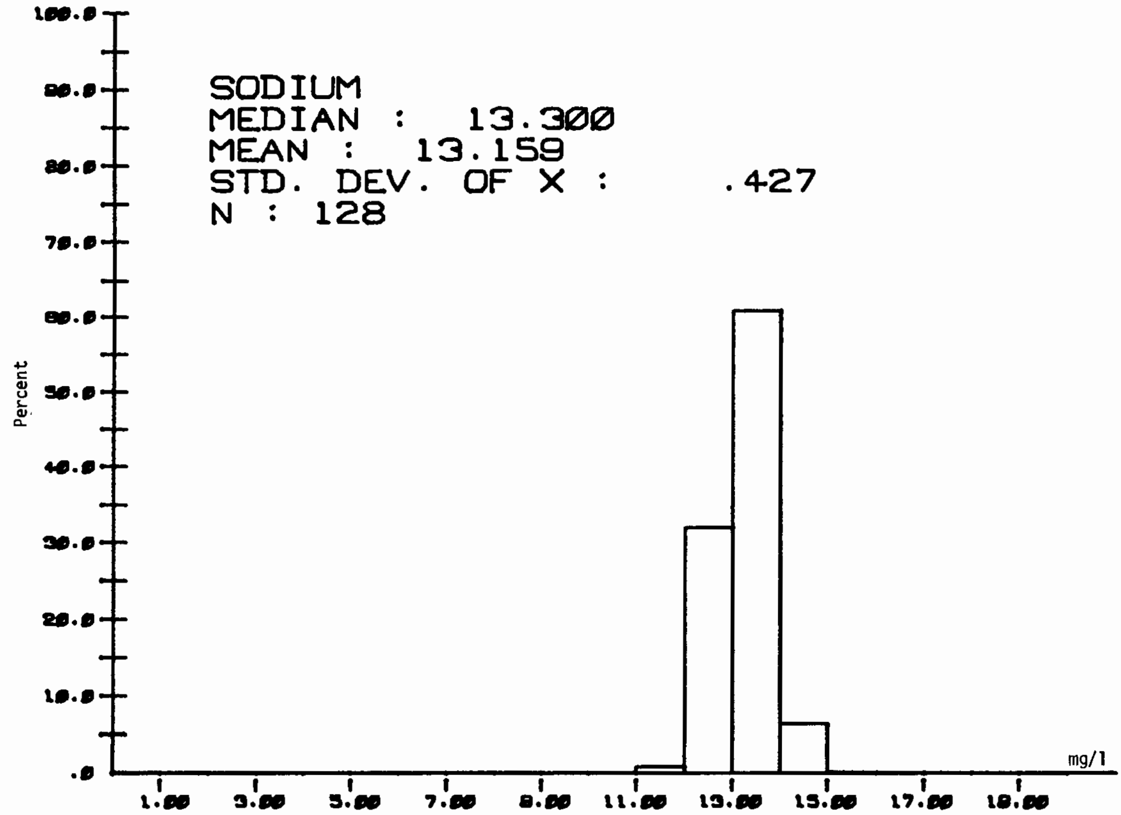


Figure 4.14a Histograms for Sodium - Cruise 11

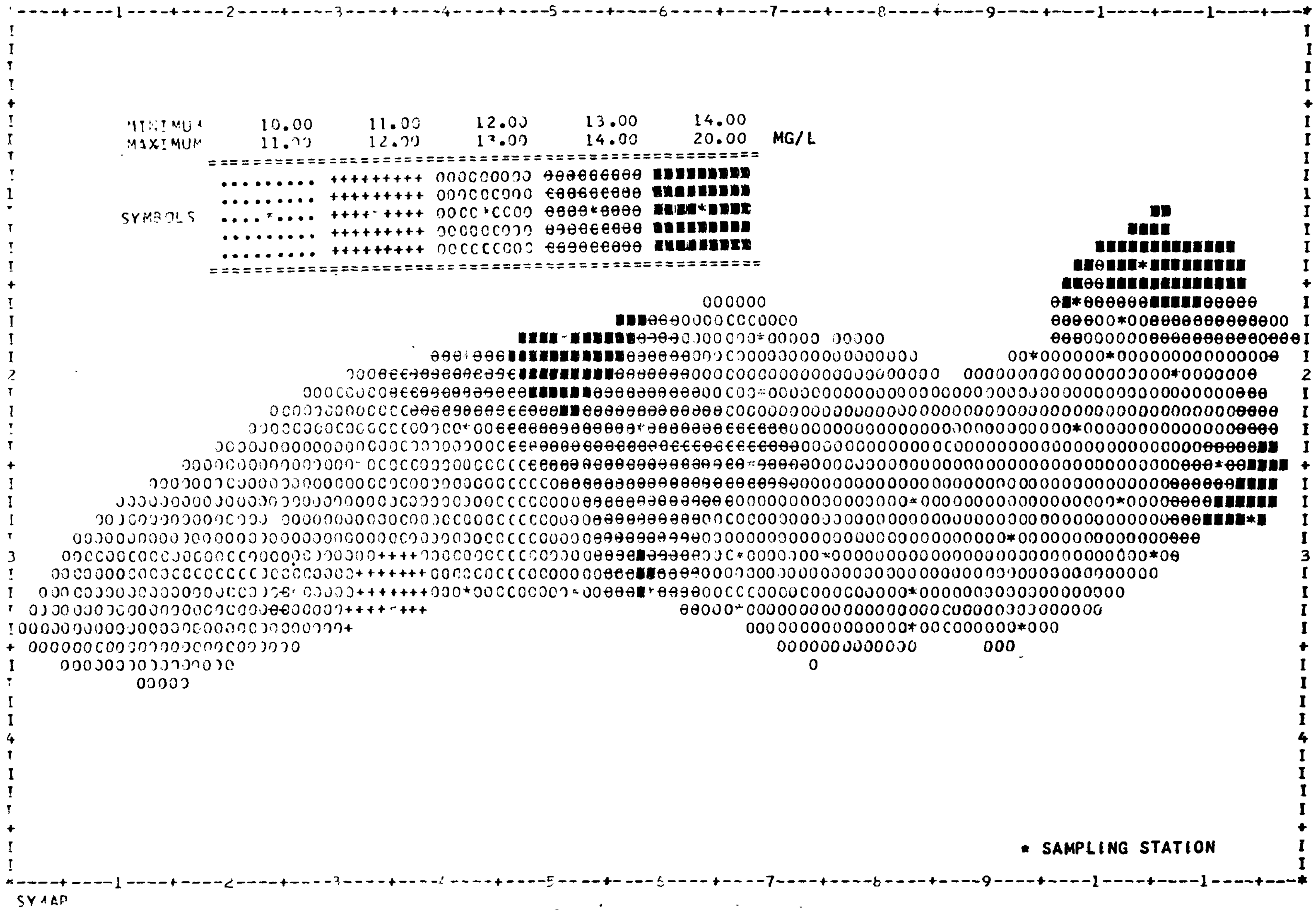


Figure 4.14b Contours for Constant Surface Sodium

CRUISE NUMBER 2: MAY 15, 1972 TO MAY 19, 1972

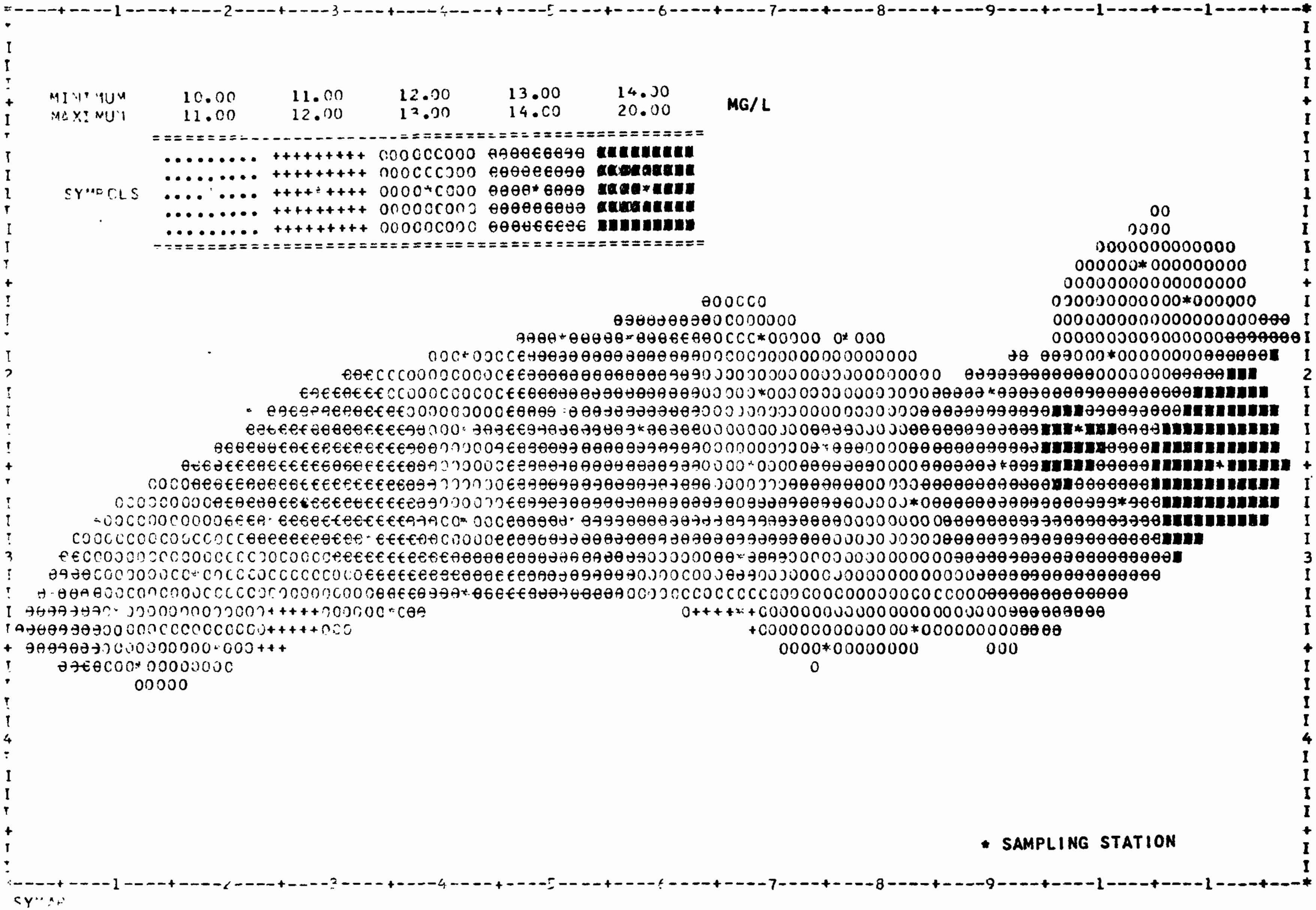


Figure 4.14b Contours for Constant Surface Sodium

CRUISE NUMBER 3: JUNE 12, 1972 TO JUNE 16, 1972

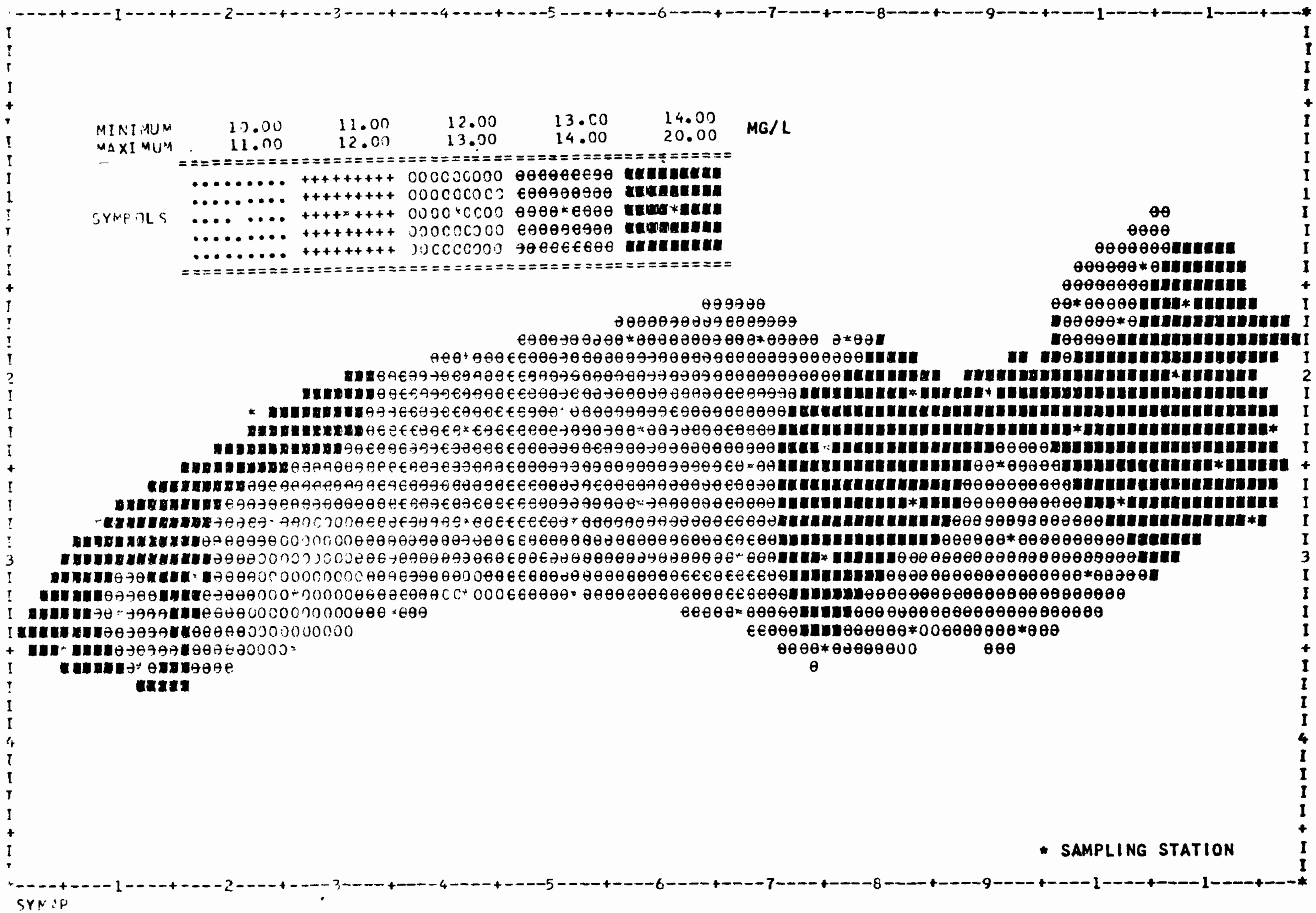


Figure 4.14b Contours for Constant Surface Sodium

CRUISE NUMBER 4: JULY 11, 1972 TO JULY 14, 1972

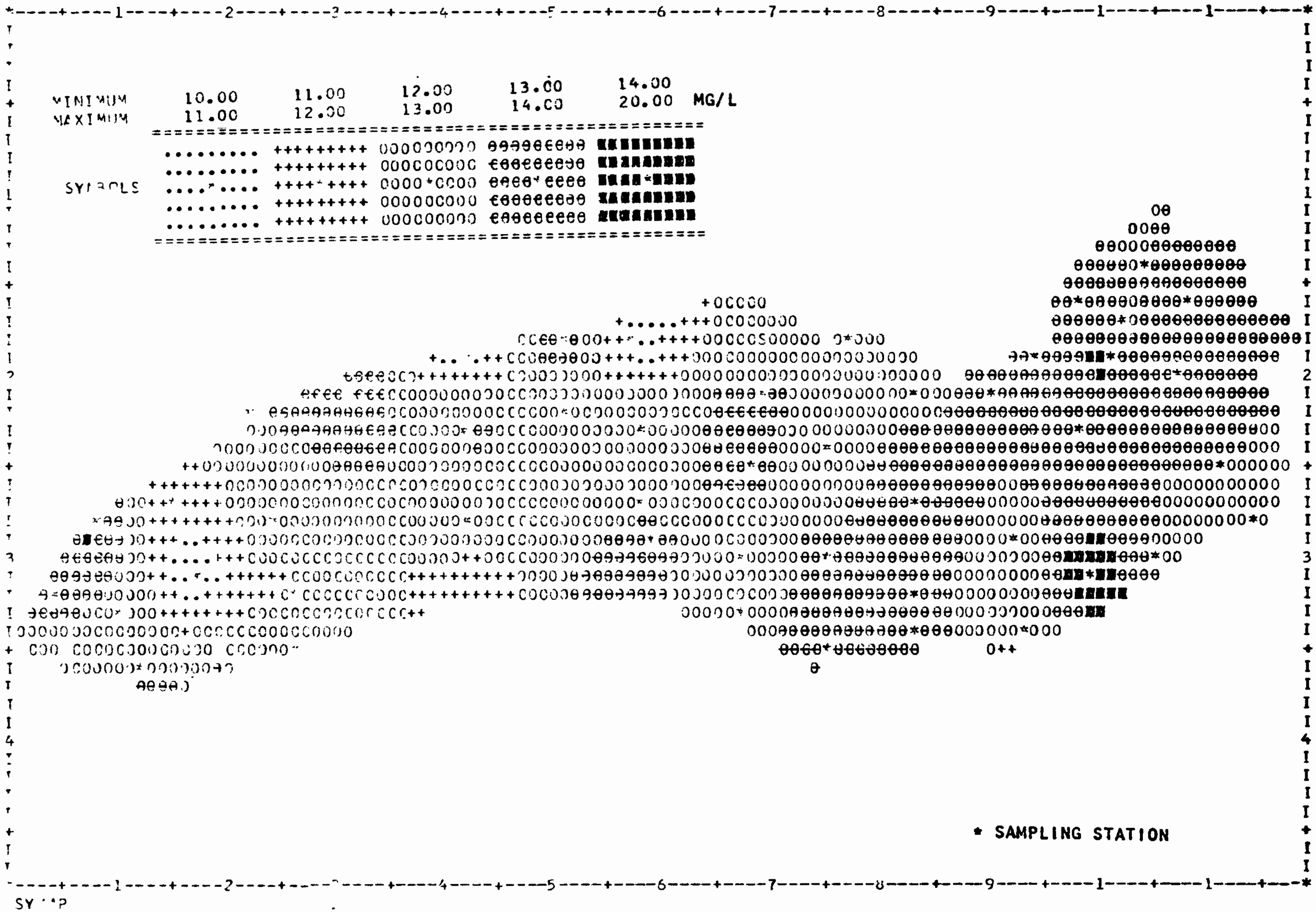


Figure 4.14b Contours for Constant Surface Sodium

CRUISE NUMBER 5: AUGUST 21, 1972 TO AUGUST 25, 1972

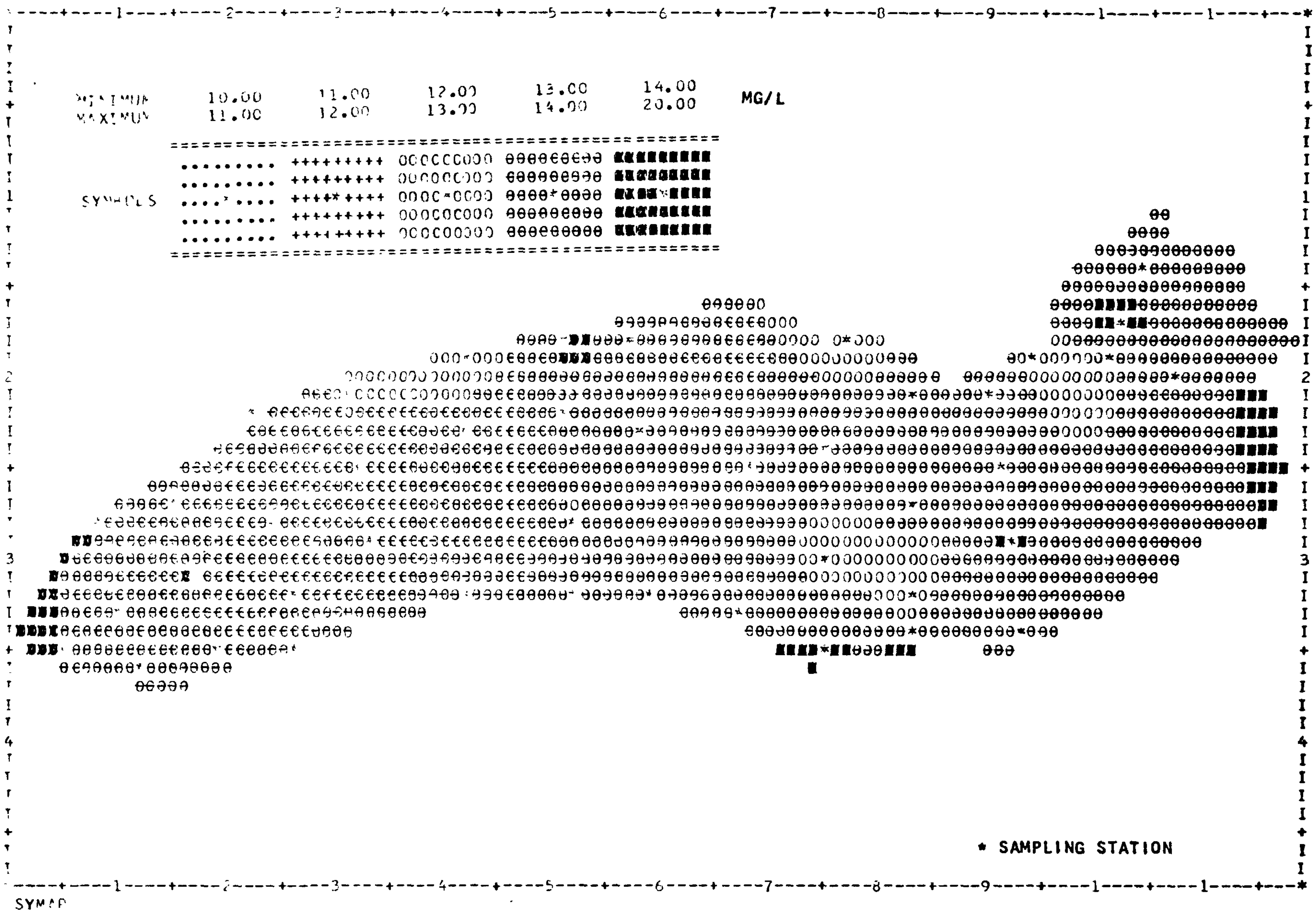


Figure 4.14b Contours for Constant Surface Sodium

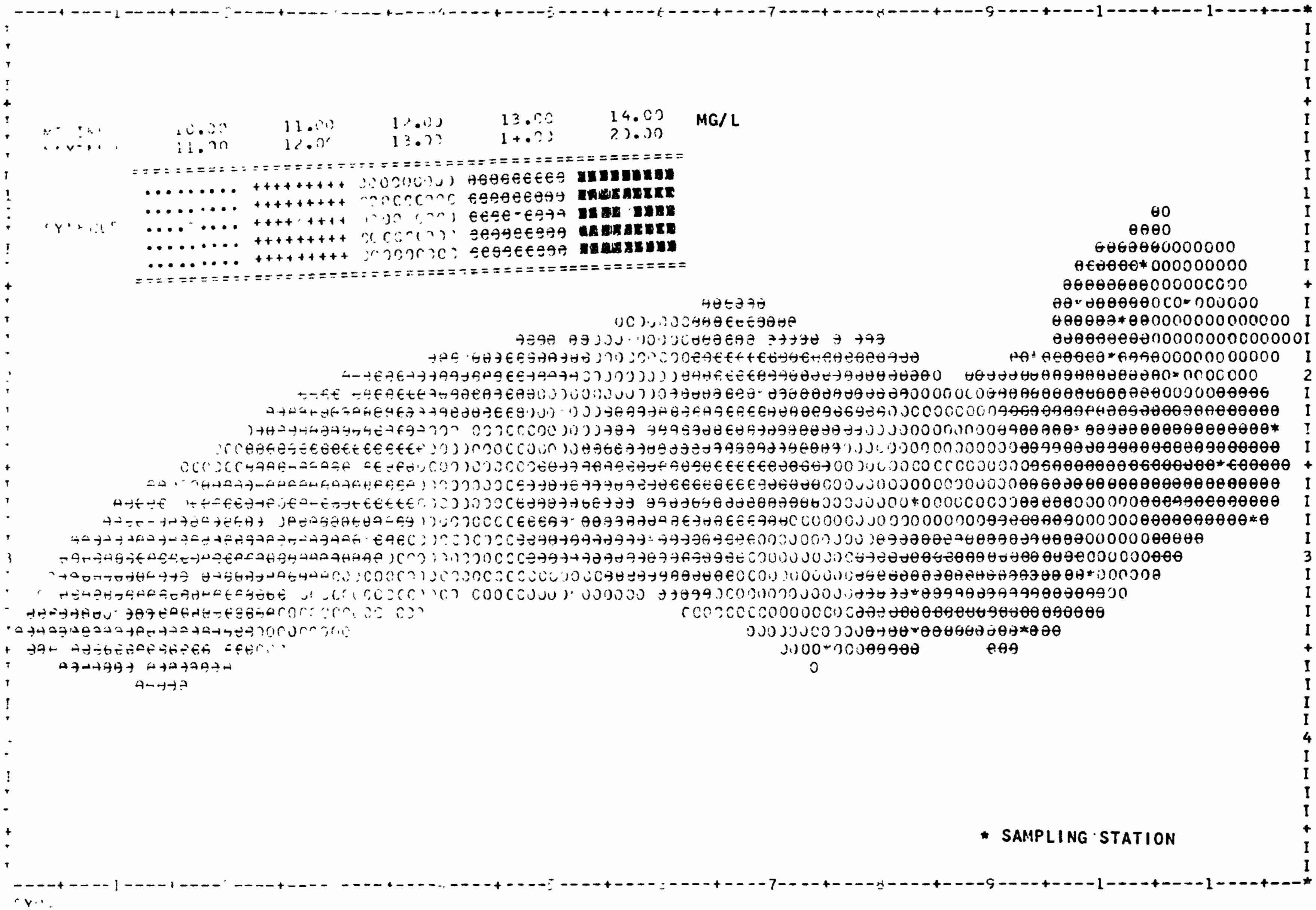


Figure 4.14b Contours for Constant Surface Sodium

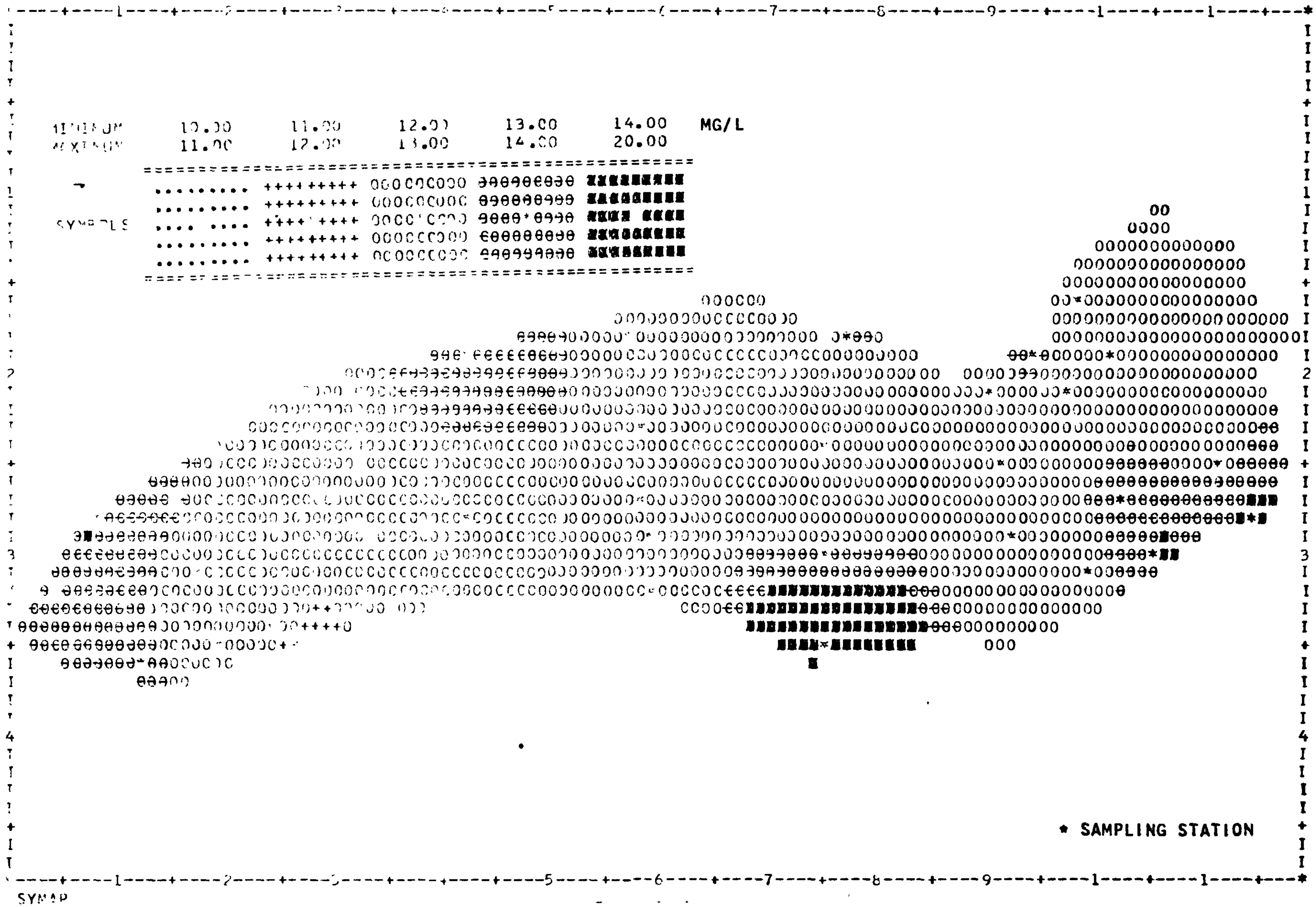


Figure 4.14b Contours for Constant Surface Sodium

CRUISE NUMBER 8: FEBRUARY 5, 1973 TO FEBRUARY 9, 1973

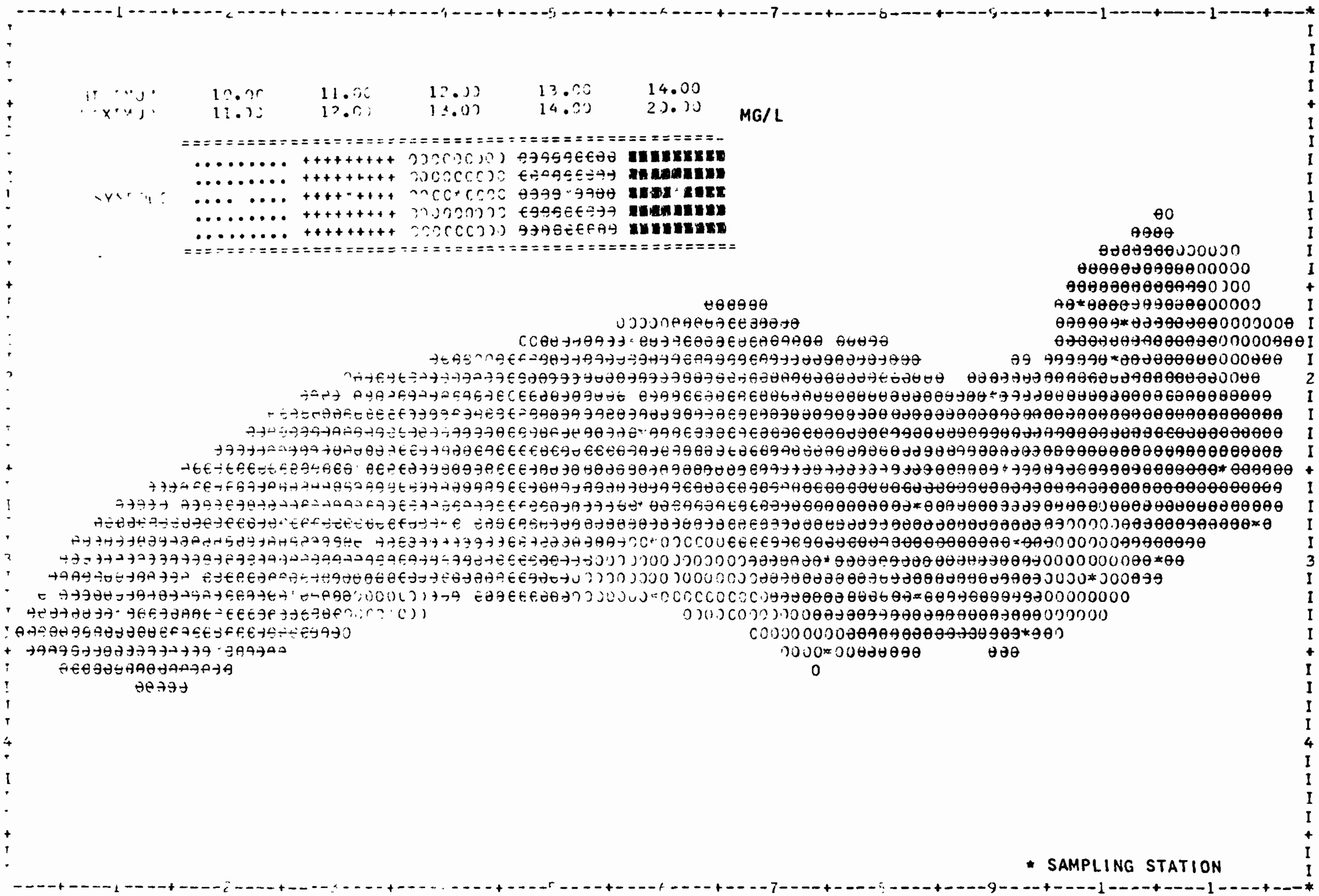


Figure 4.14b Contours for Constant Surface Sodium

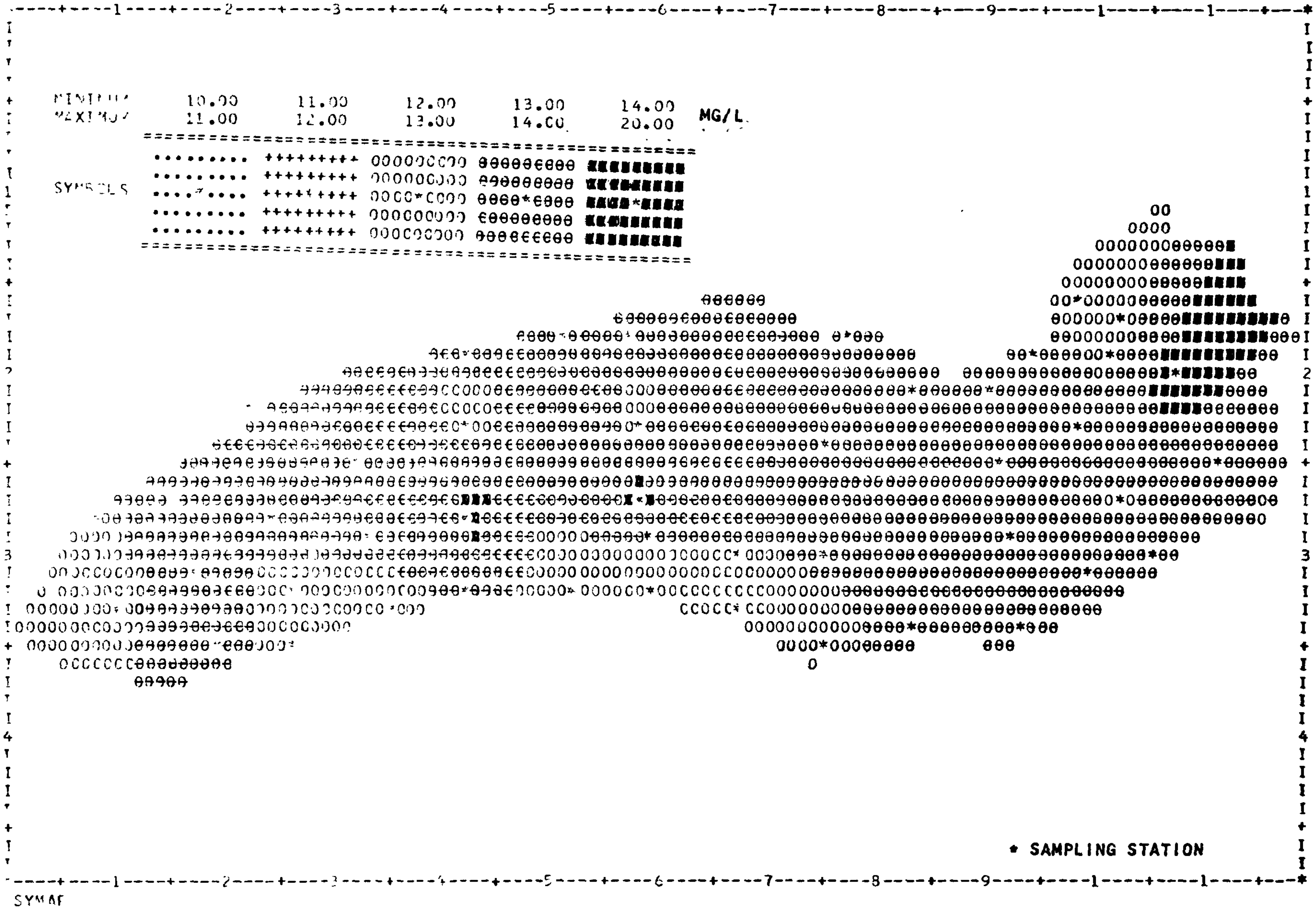


Figure 4.14b Contours for Constant Surface Sodium

CRUISE NUMBER 11: JUNE 11, 1973 TO JUNE 15, 1973

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5
FREQ.	4	3	9	49	25
MINIMUM	9.40	10.52	11.64	12.76	13.88
MAXIMUM	10.52	11.64	12.76	13.88	15.00

* SAMPLING STATION

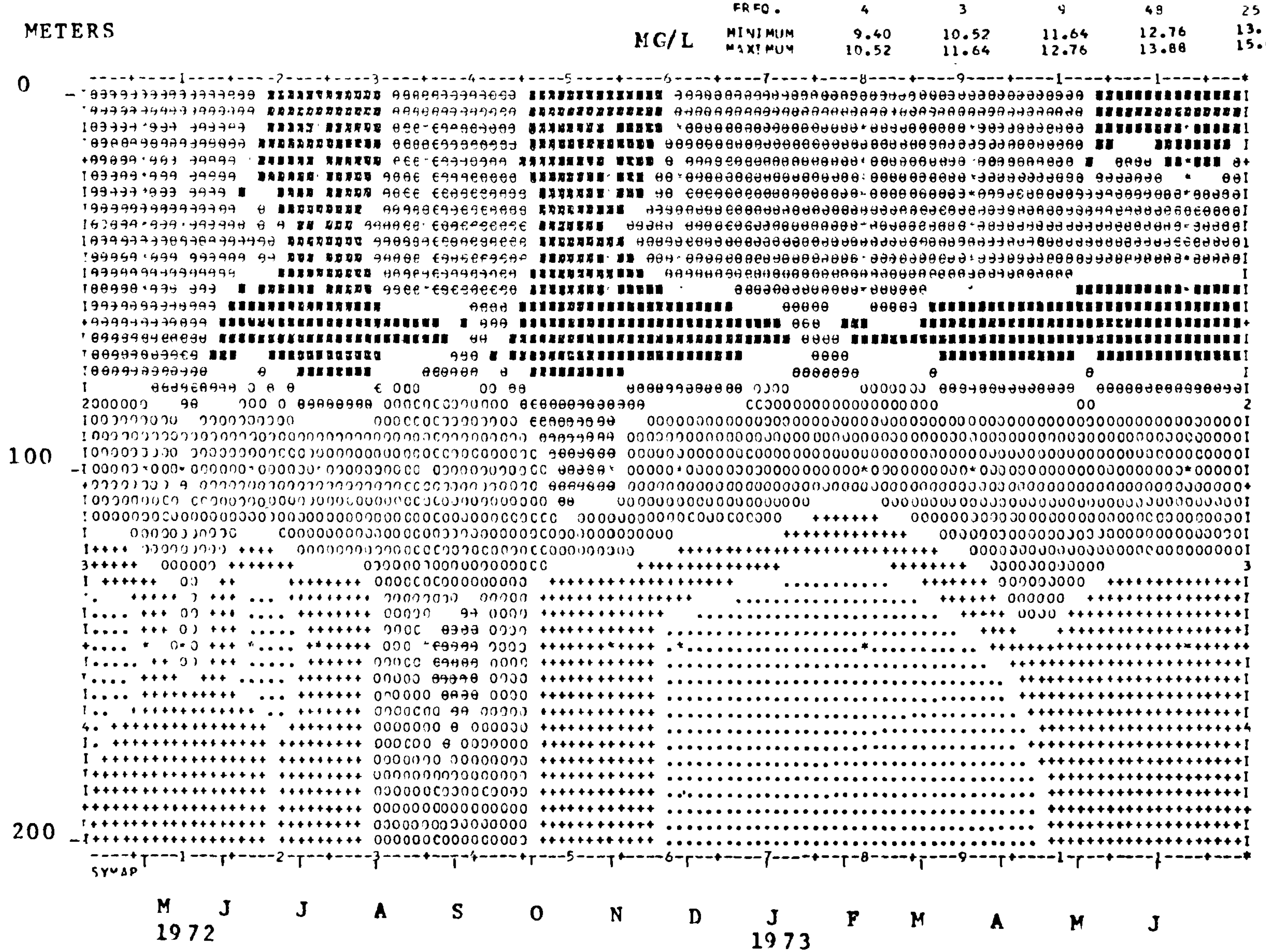


Figure 4.14c Depth Versus Time Contours of Constant Sodium

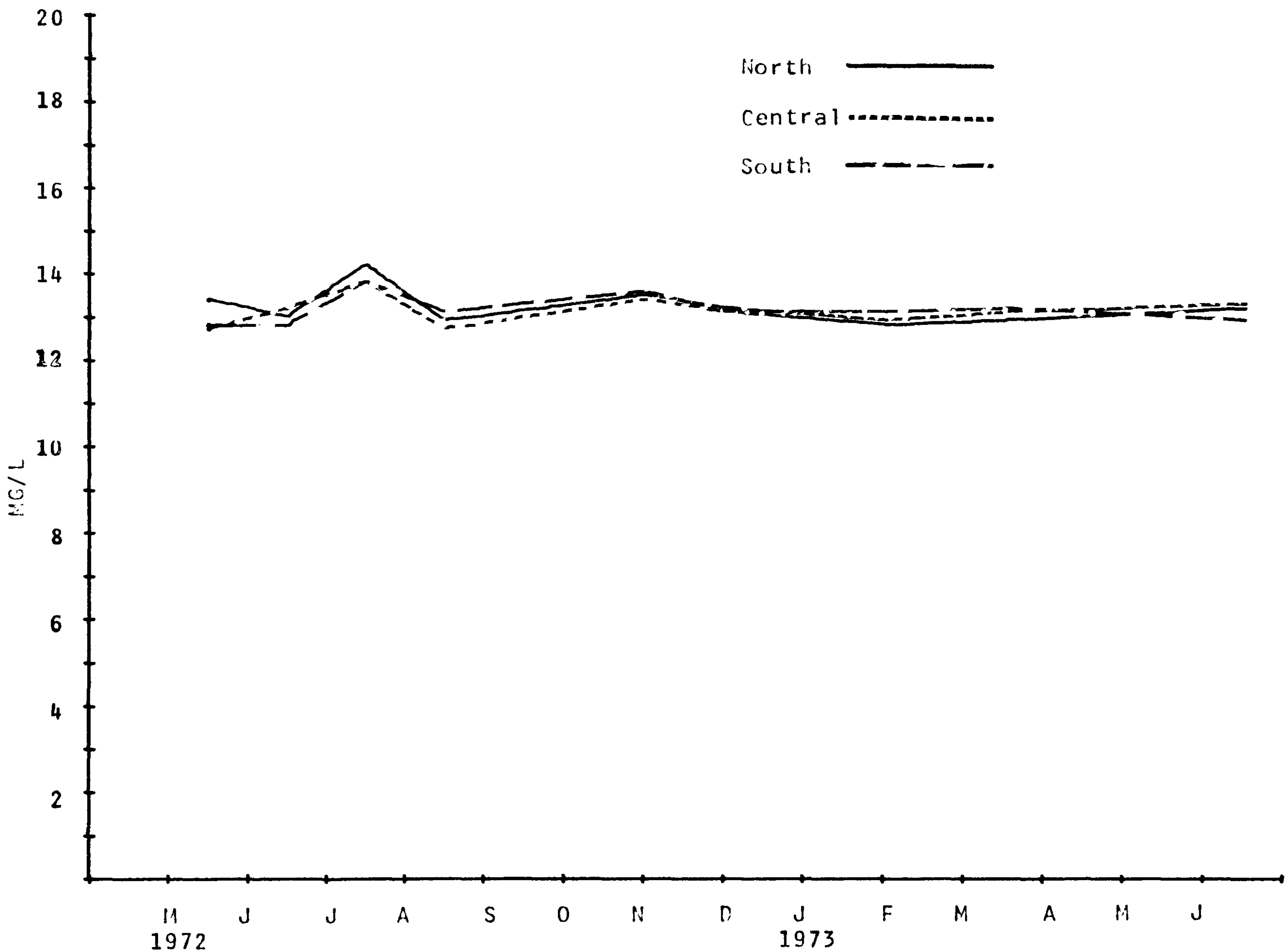


Figure 4.14d North-south variation of sodium

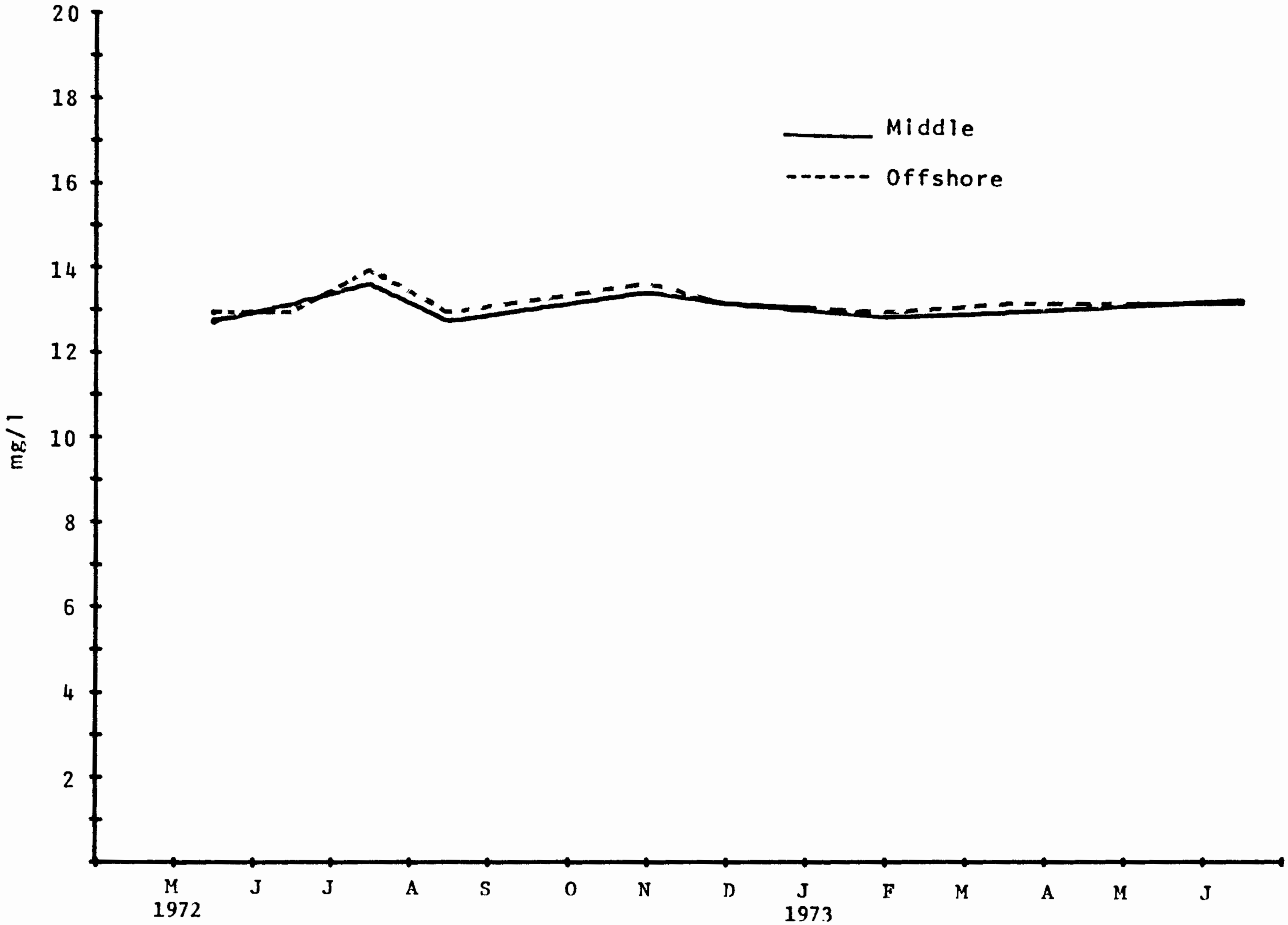


Figure 4.14e Middle Lake-Offshore Variations of Mean Sodium Concentration

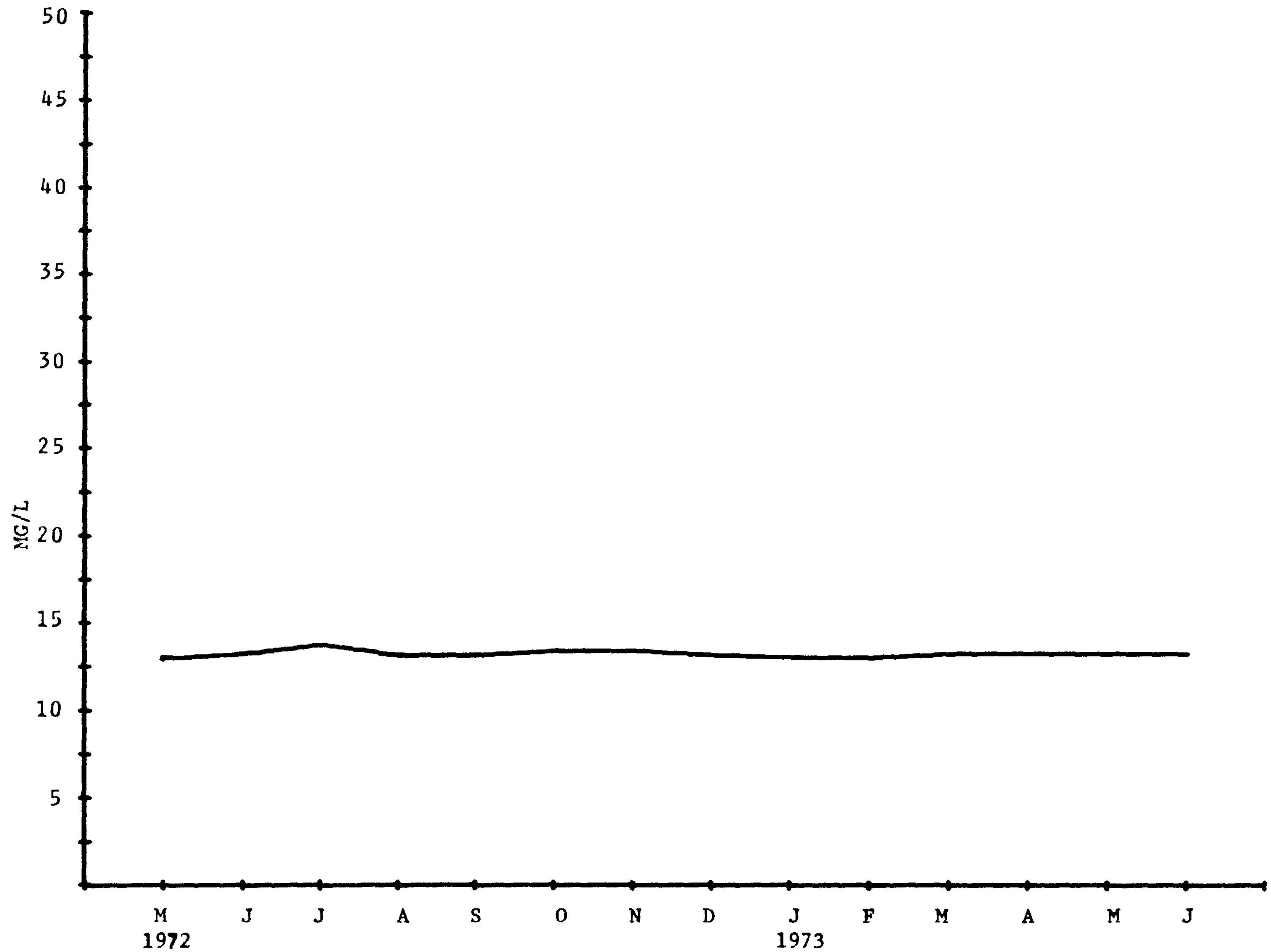


Figure 4.14f Mean surface variation of Sodium concentration during the field year.

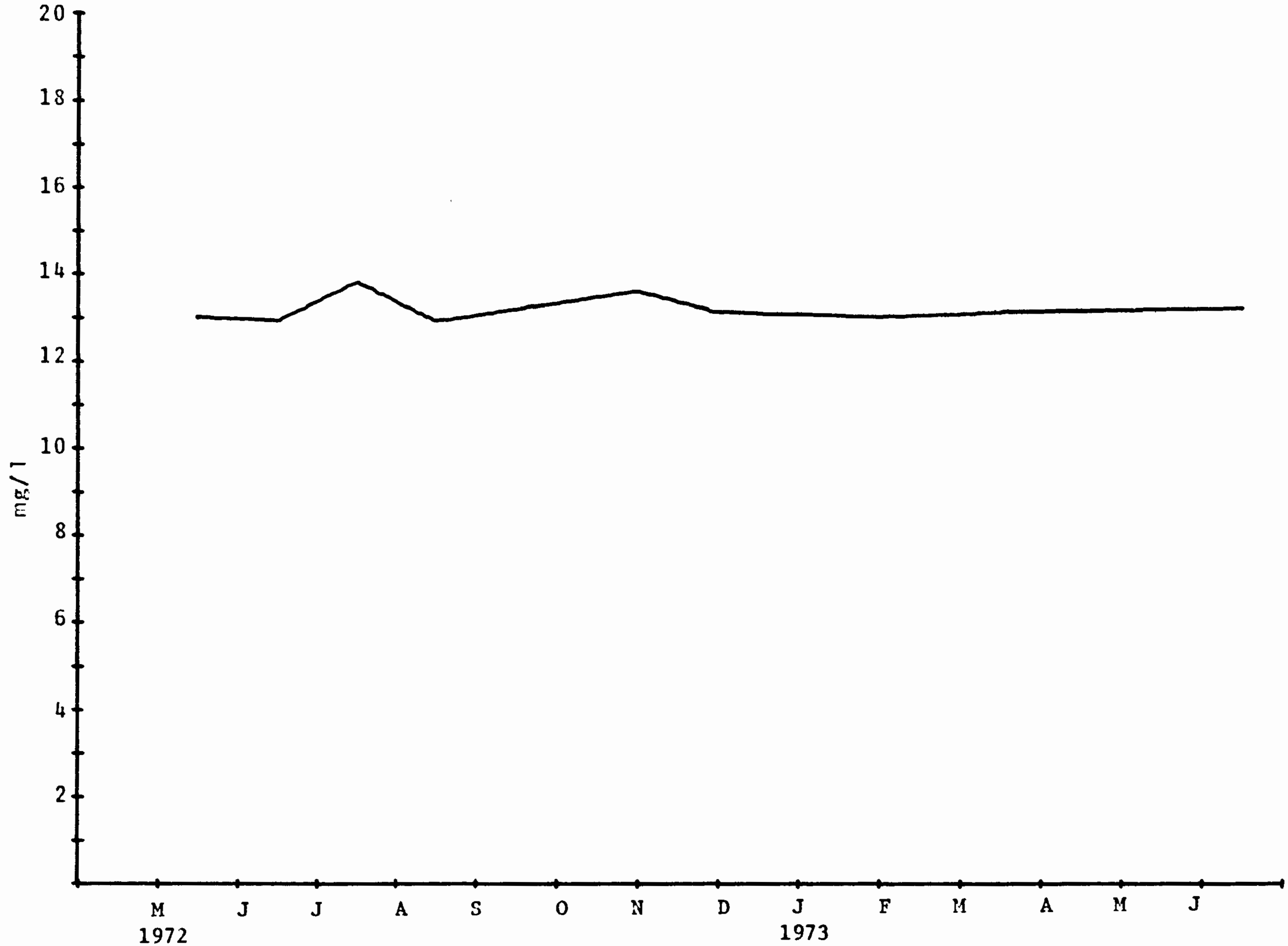


Figure 4.14g Mean Bottom Variation of Sodium Concentration During the Field Year

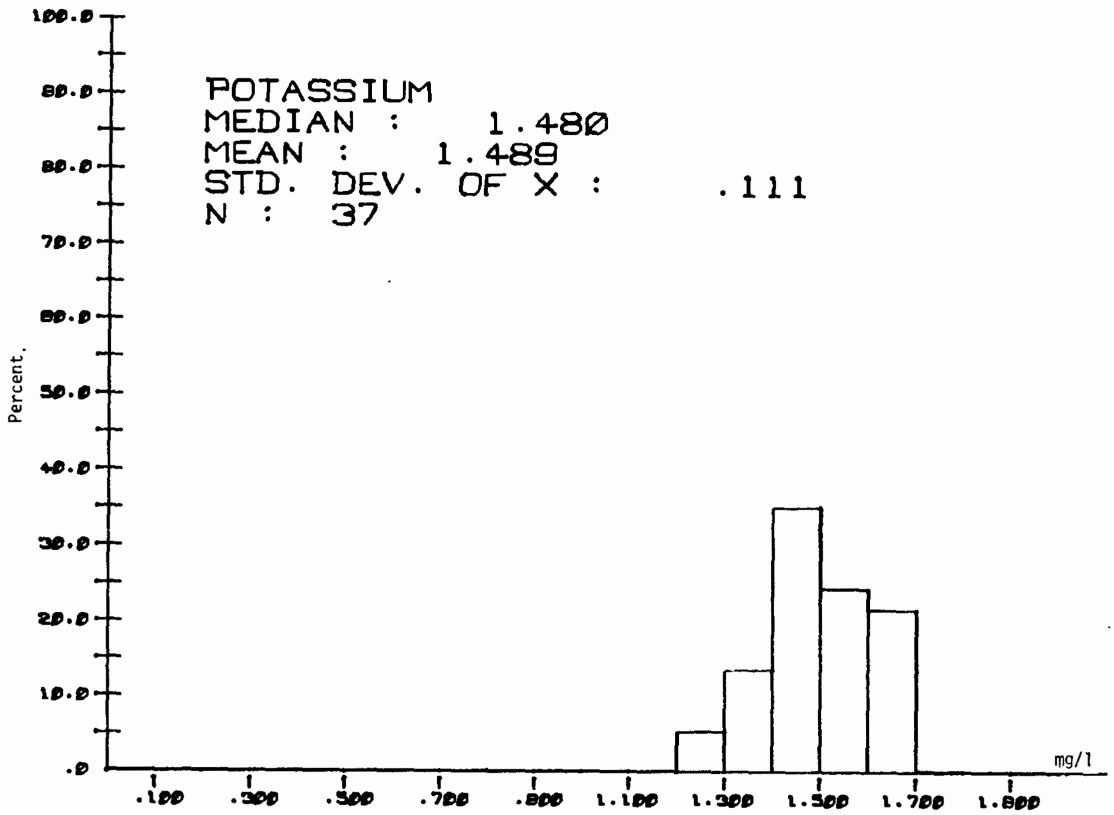


Figure 4.15a Histograms for Potassium - Cruise 1

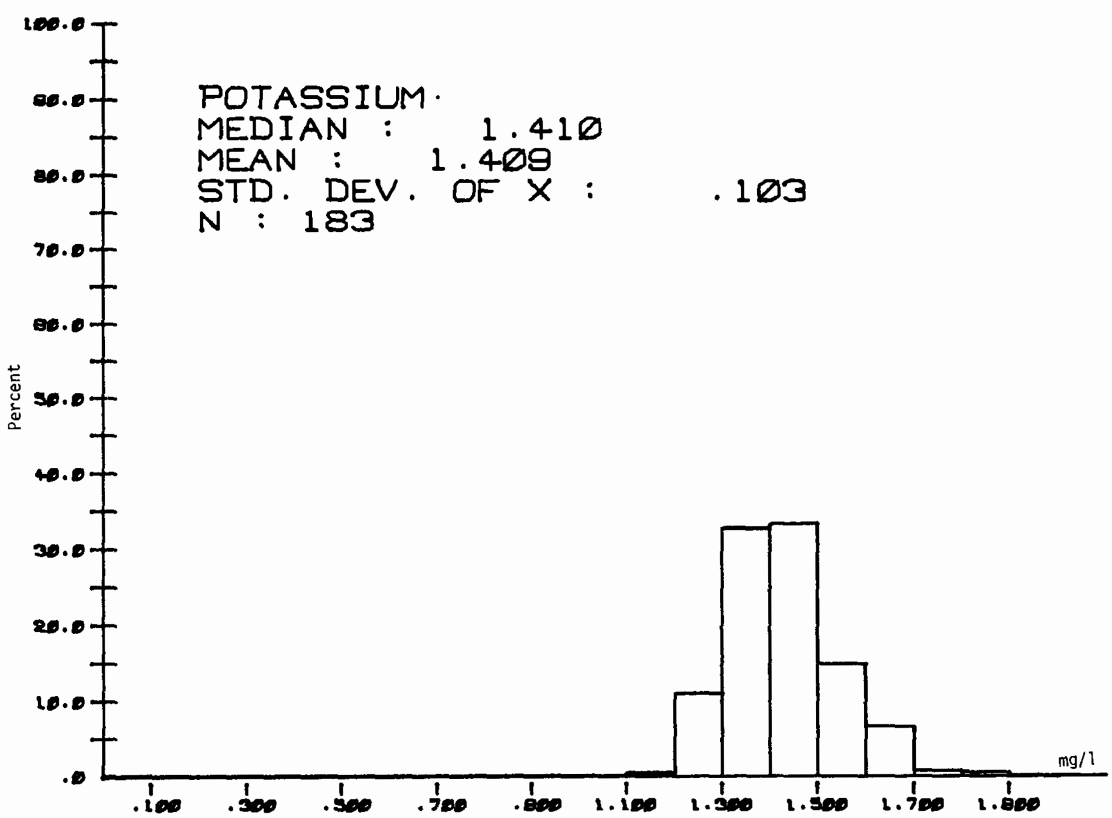


Figure 4.15a Histograms for Potassium - Cruise 2

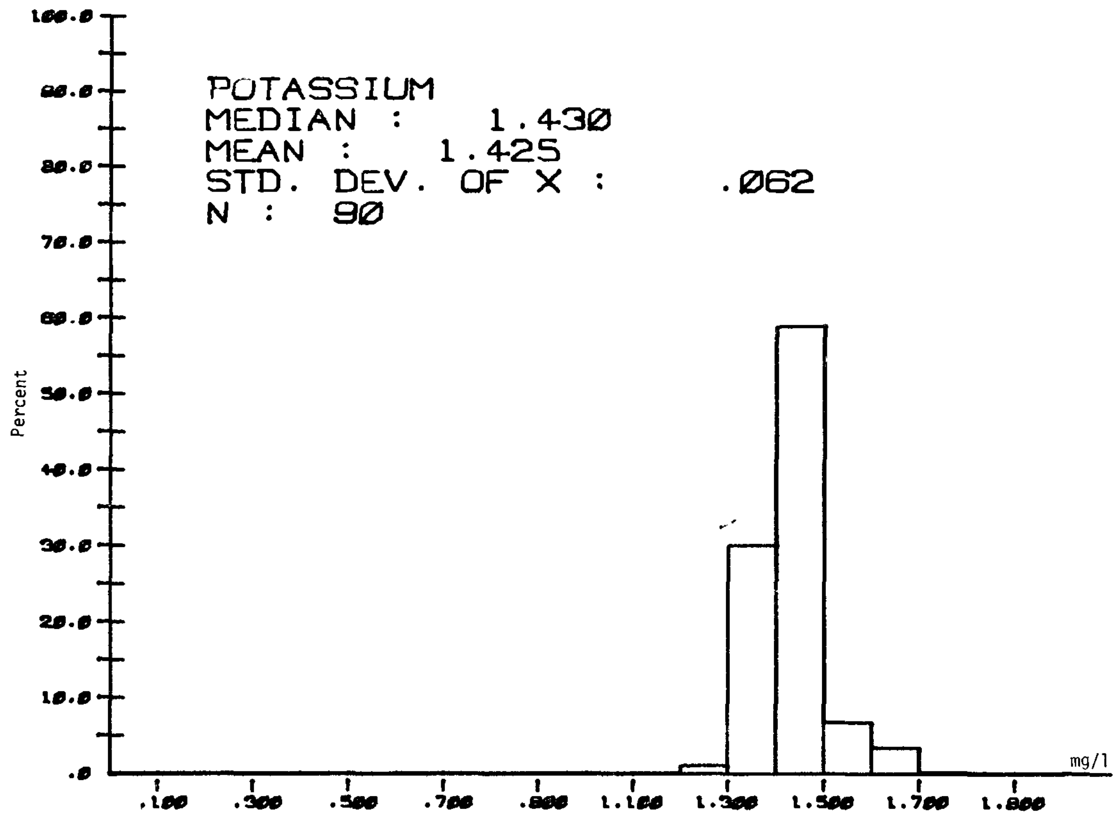


Figure 4.15a Histograms for Potassium - Cruise 3

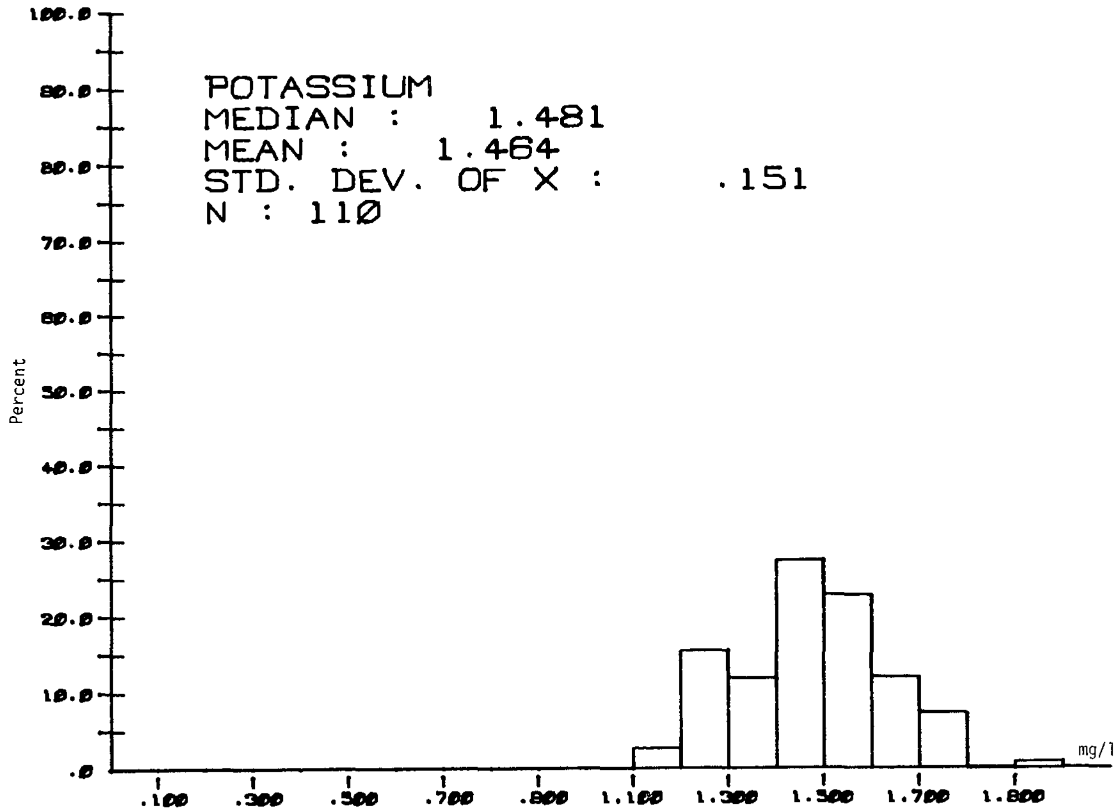


Figure 4.15a Histograms for Potassium - Cruise 4

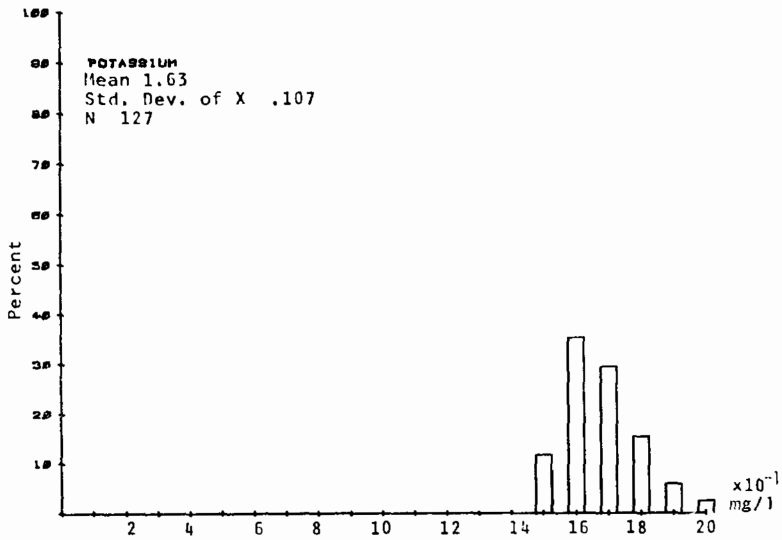


Figure 4.15a Histograms for Potassium - Cruise 5

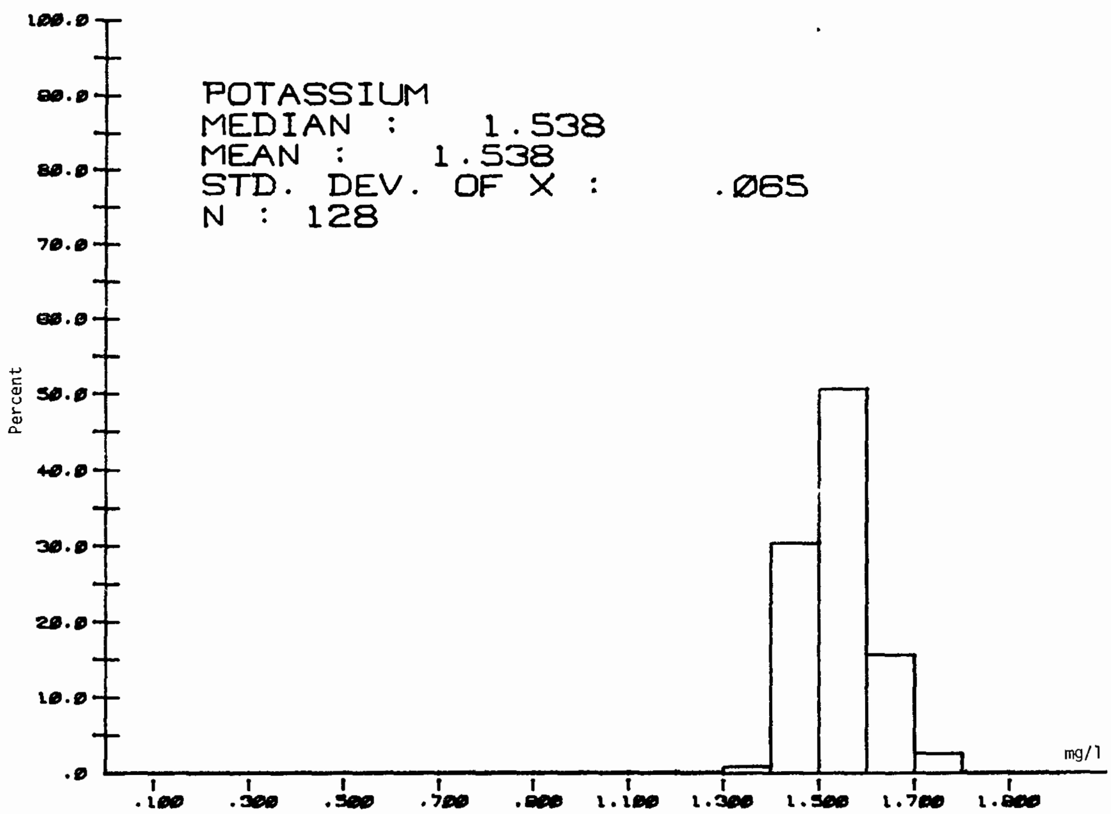


Figure 4.15a Histograms for Potassium - Cruise 6

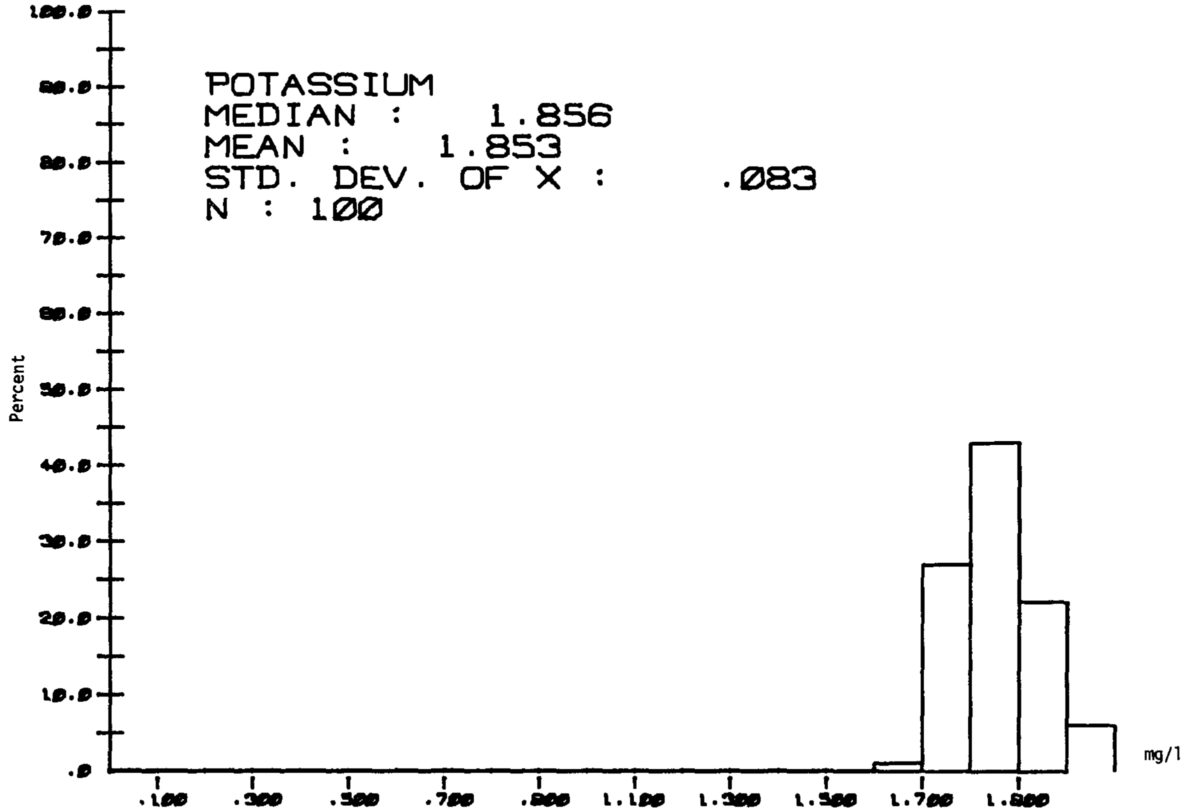


Figure 4.15a Histograms for Potassium - Cruise 7

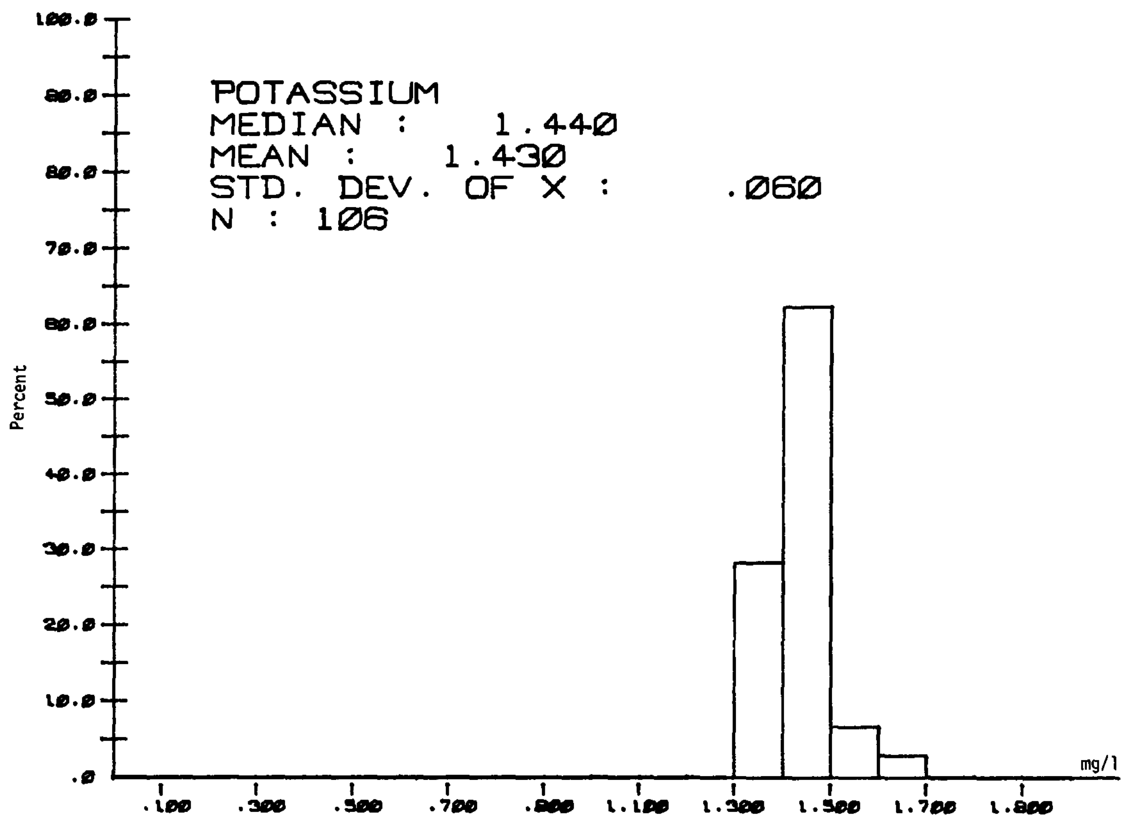


Figure 4.15a Histograms for Potassium - Cruise 8

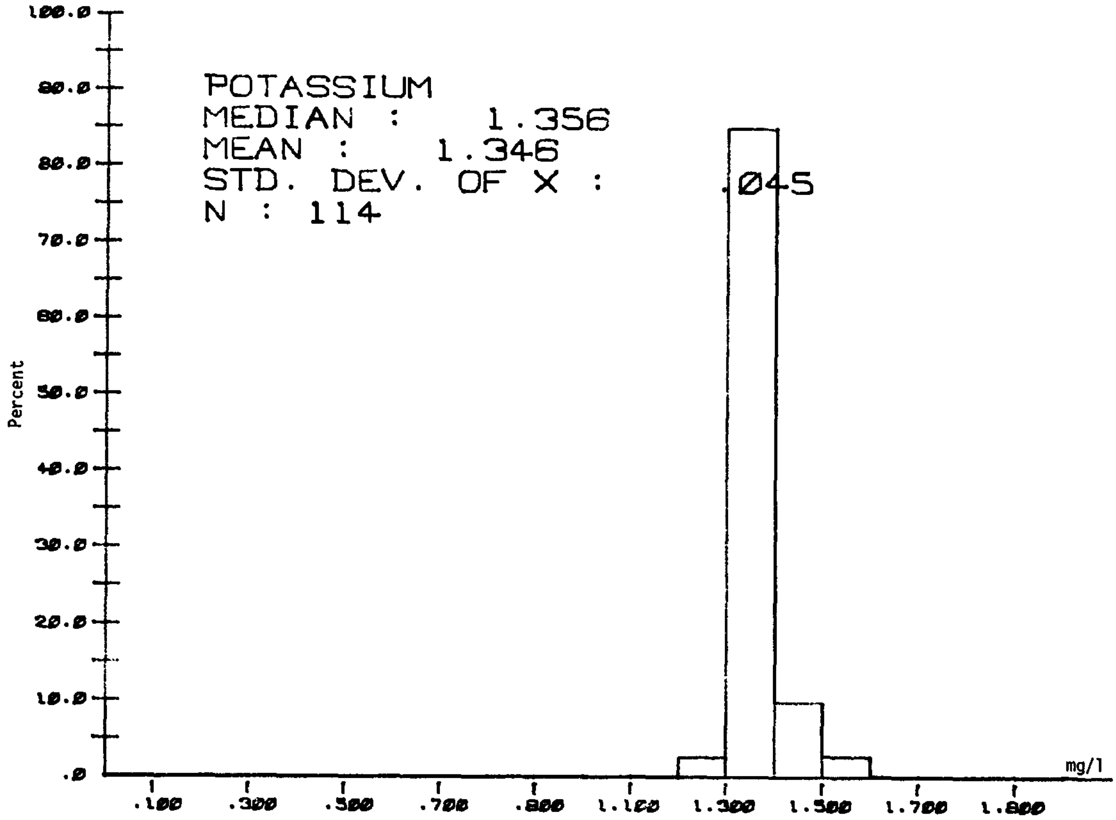


Figure 4.15a Histograms for Potassium - Cruise 9

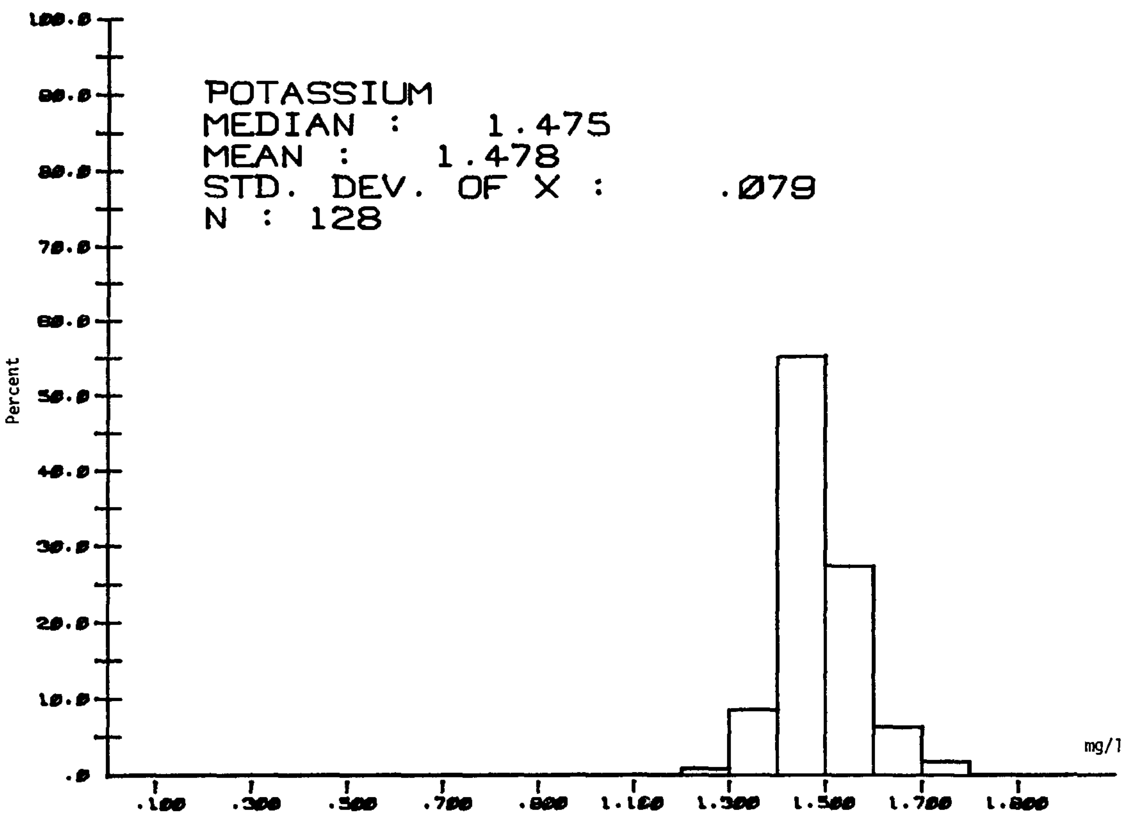


Figure 4.15a Histograms for Potassium - Cruise 11

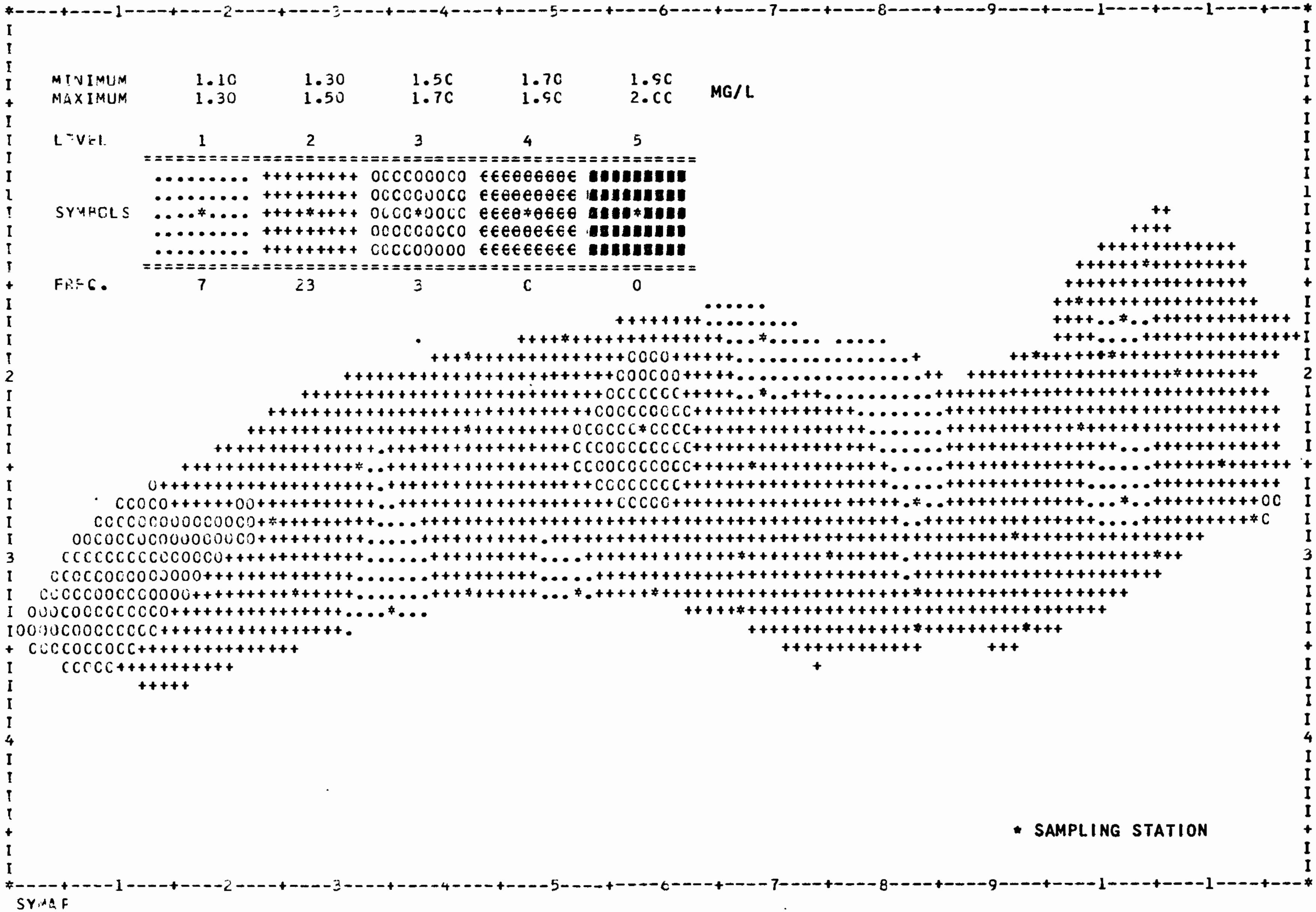


Figure 4.15b Contours of Constant Surface Potassium

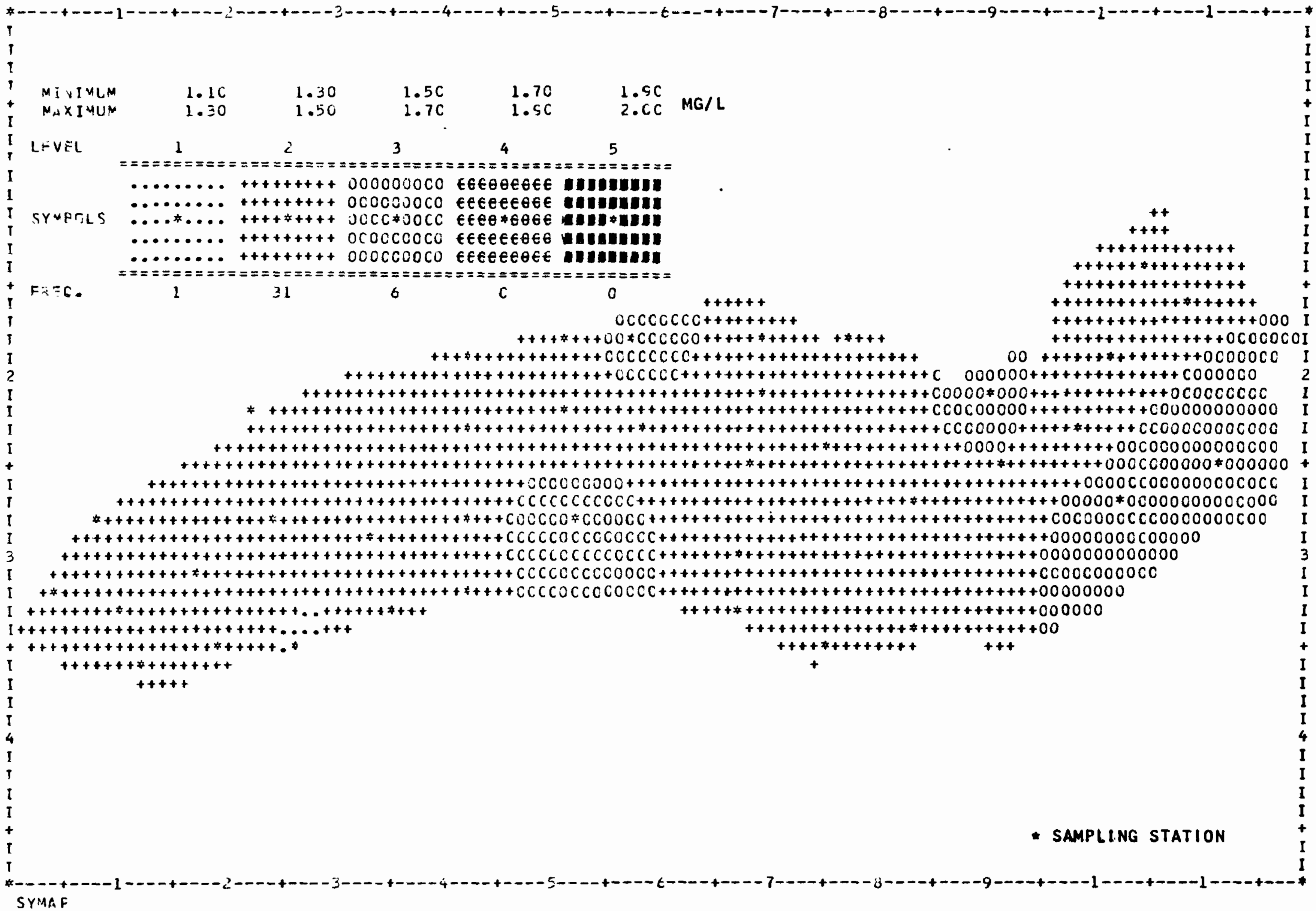


Figure 4.15b Contours of Constant Surface Potassium

CRUISE NUMBER 3: JUNE 12, 1972 TO JUNE 16, 1972

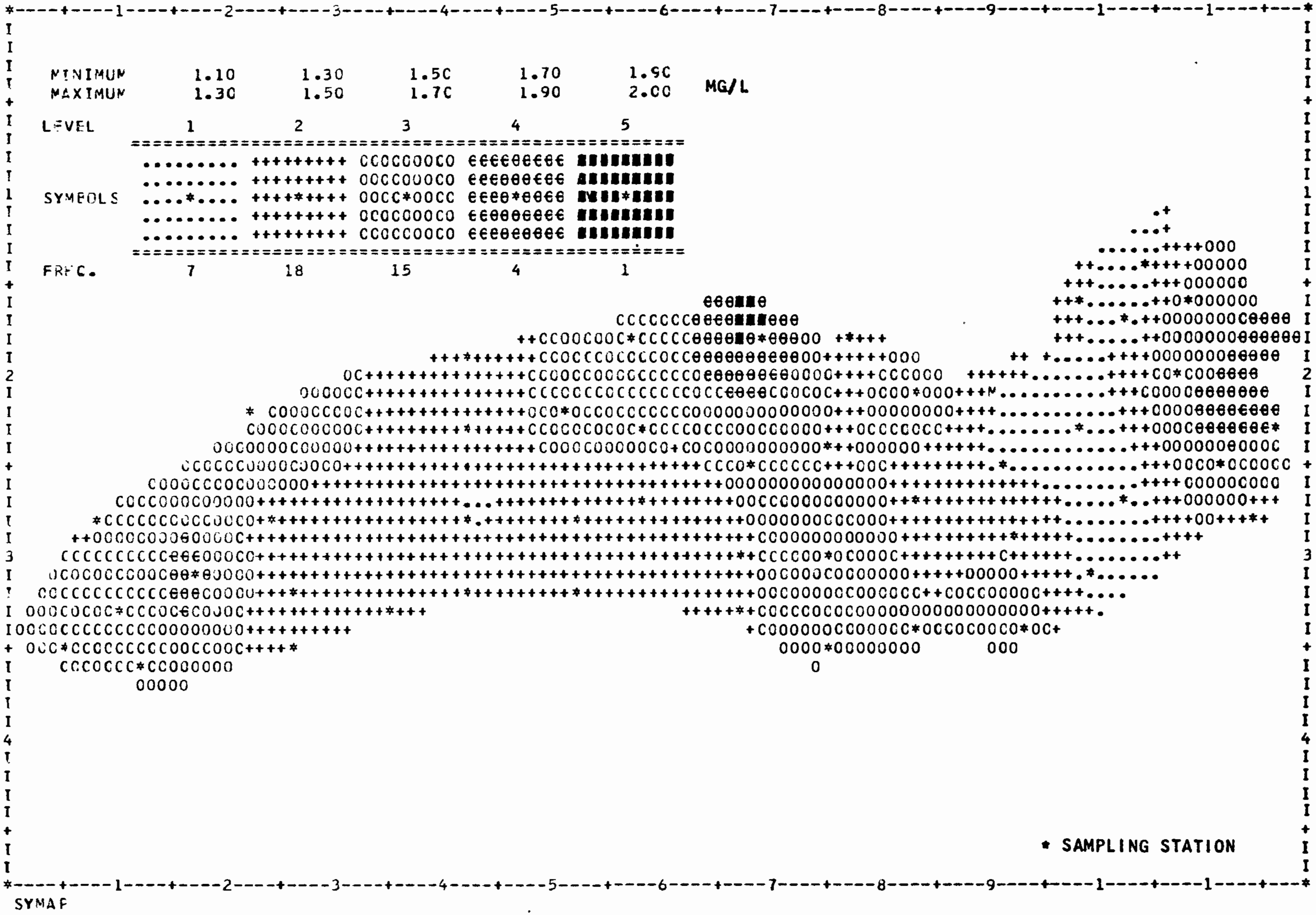
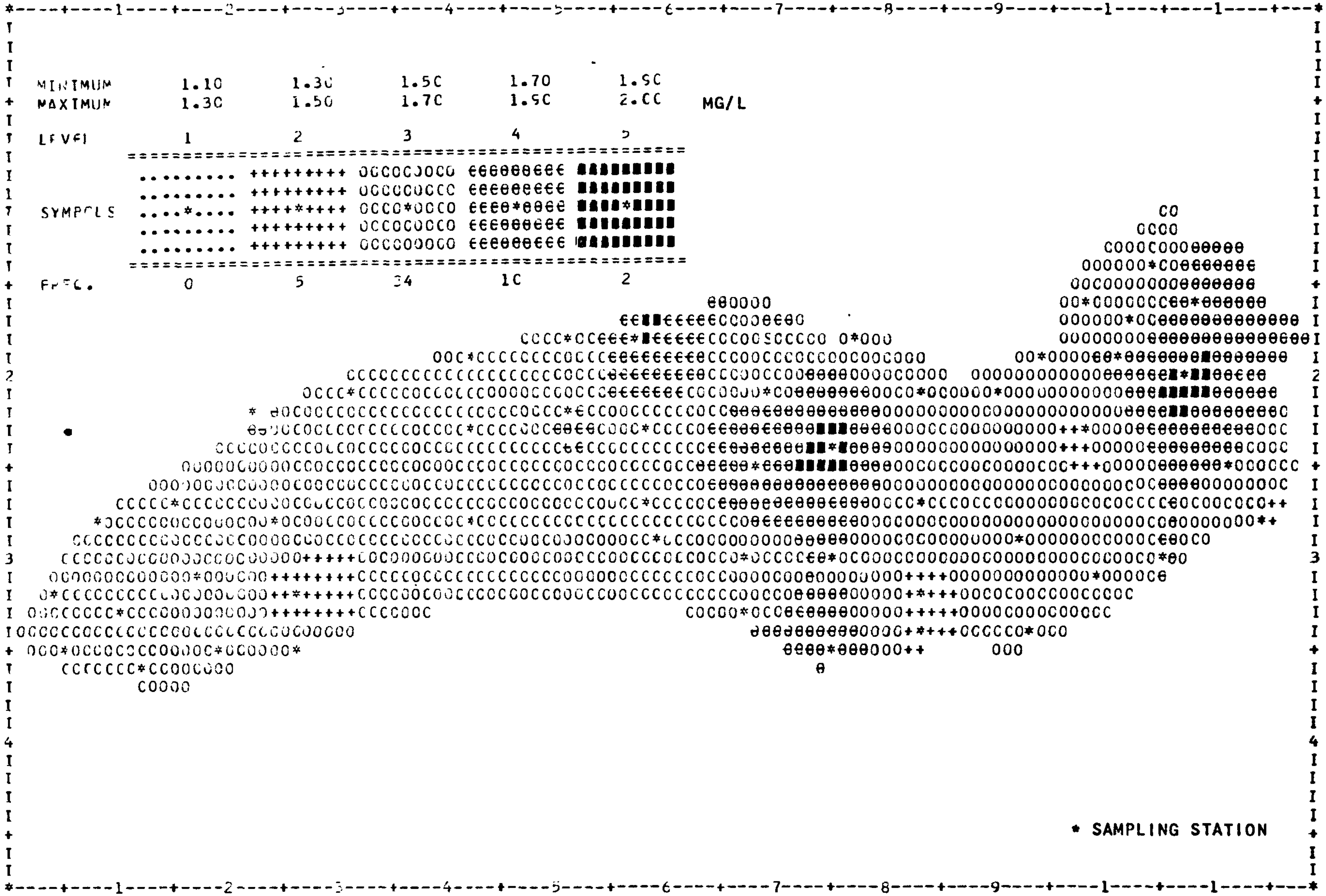


Figure 4.15b Contours of Constant Surface Potassium

CRUISE NUMBER 4: JULY 10, 1972 TO JULY 14, 1972



SYMAP

Figure 4.15b Contours of Constant Surface Potassium

CRUISE NUMBER 5: AUGUST 21, 1972 TO AUGUST 25, 1972

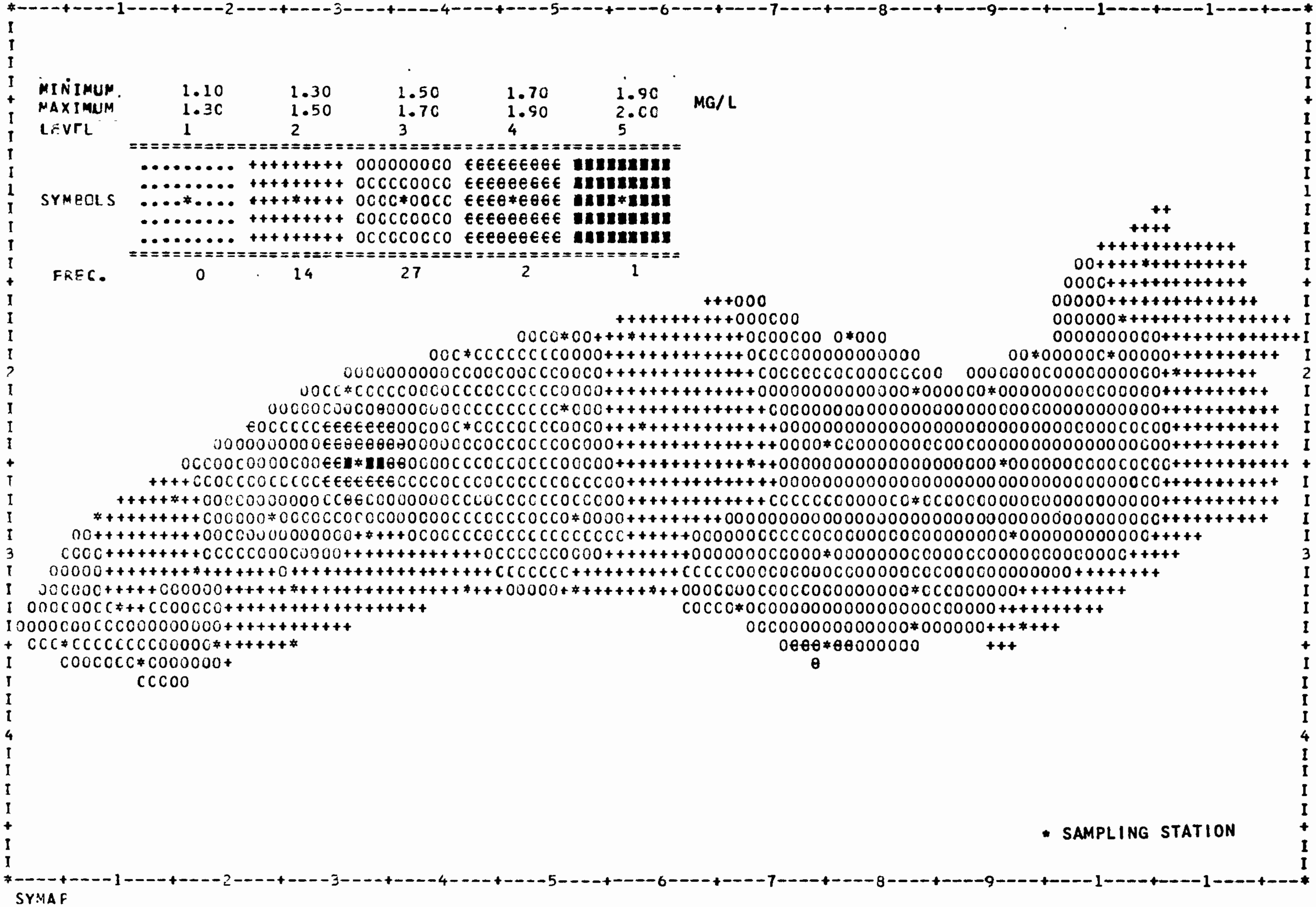


Figure 4.15b Contours of Constant Surface Potassium

CRUISE NUMBER 6: OCTOBER 30, 1972 TO NOVEMBER 3, 1972

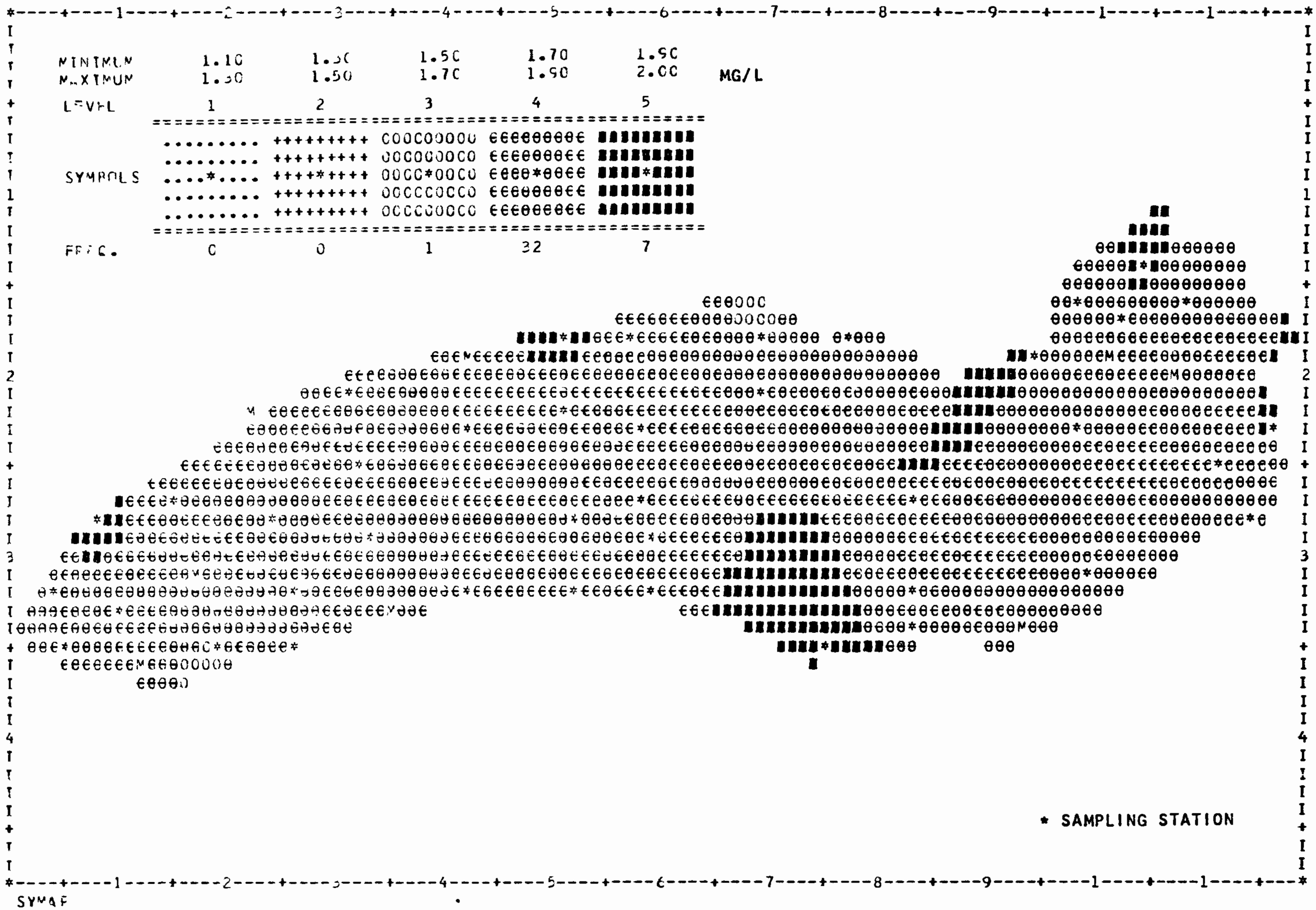
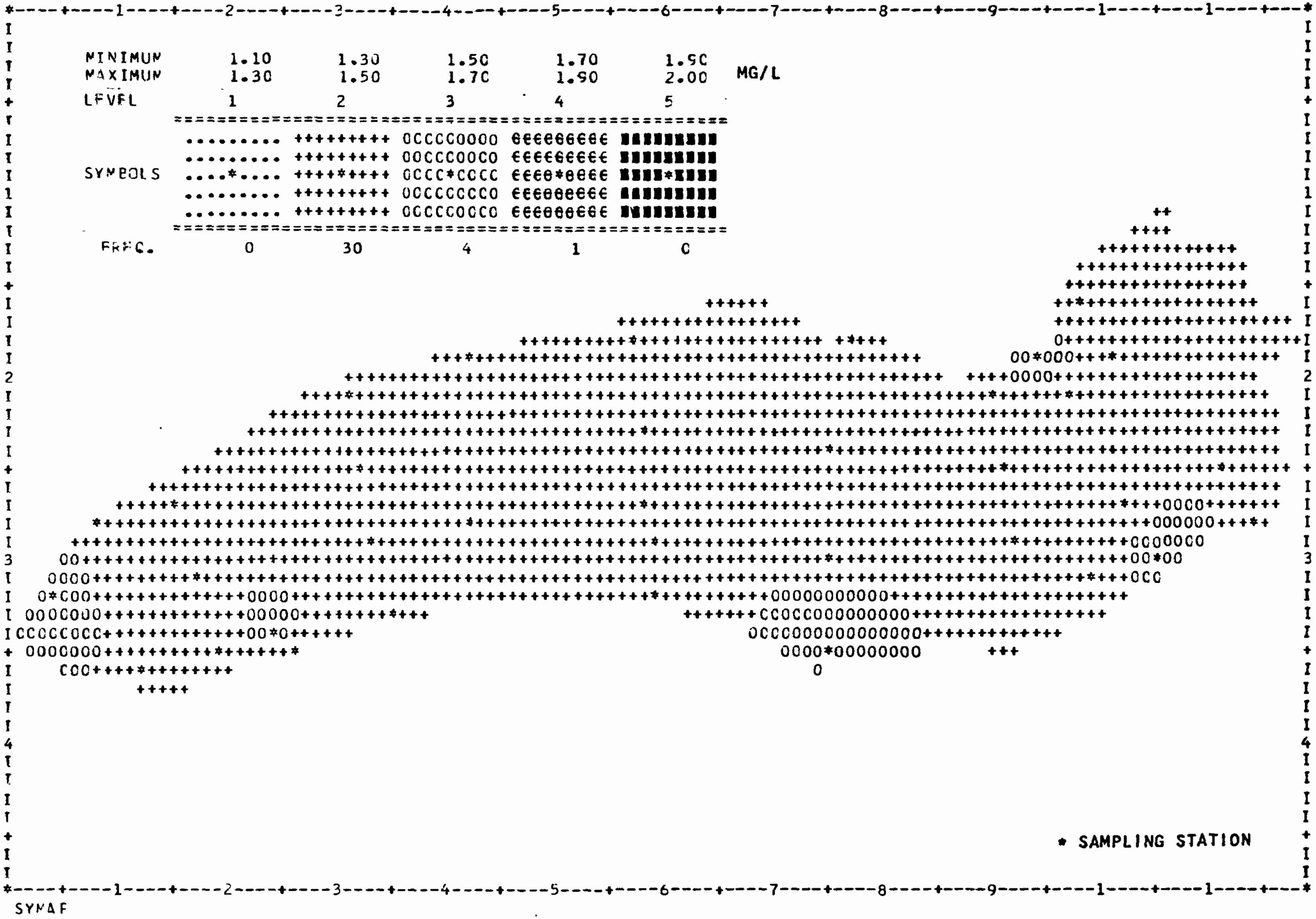


Figure 4.15b Contours of Constant Surface Potassium

CRUISE NUMBER 7: NOVEMBER 27, 1972 TO DECEMBER 2, 1972



C.C MINLTES FOR MAP

Figure 4.15b Contours of Constant Surface Potassium

CRUISE NUMBER 8: FEBRUARY 5, 1973 TO FEBRUARY 9, 1973

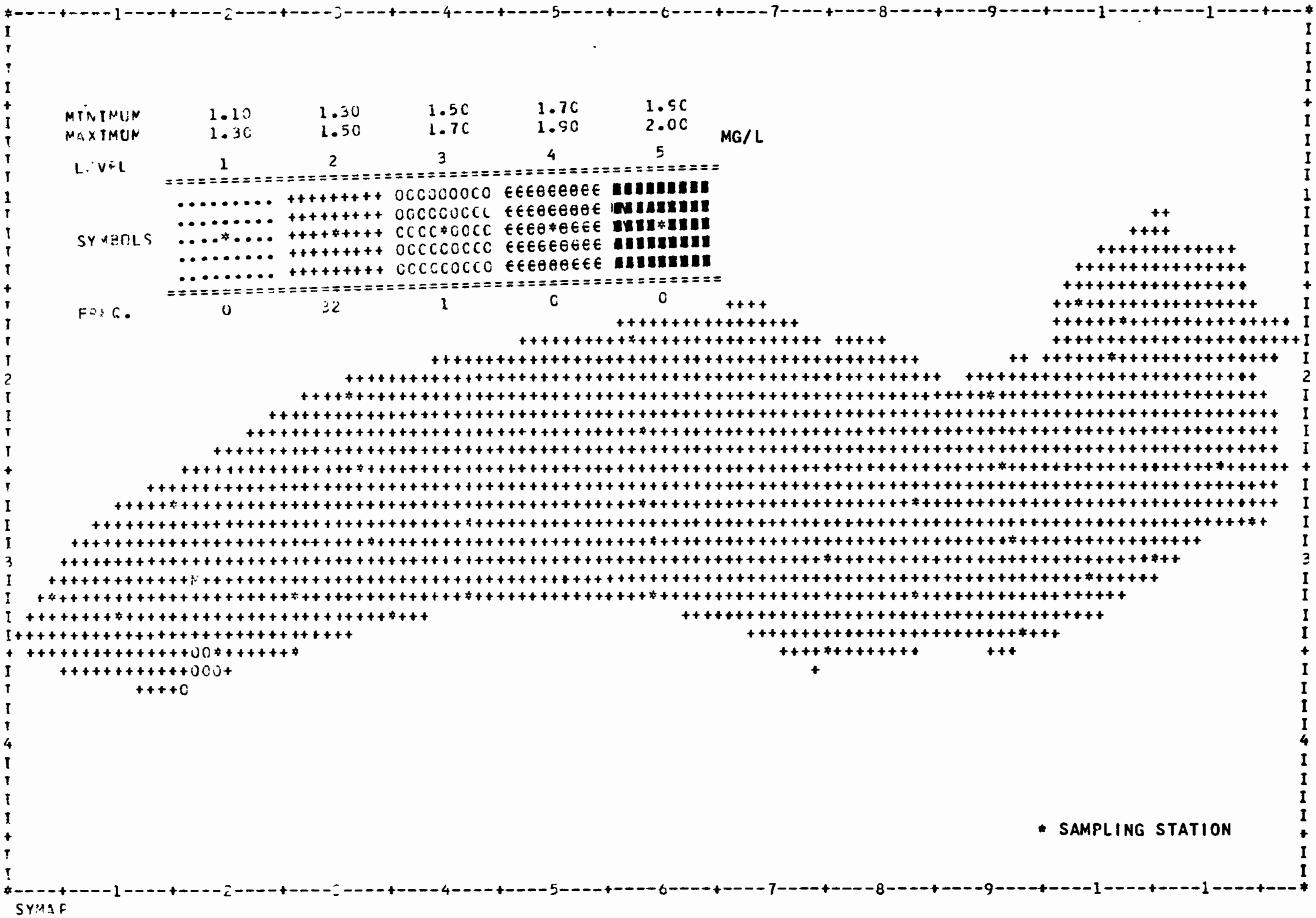


Figure 4.15b Contours of Constant Surface Potassium

CRUISE NUMBER 9: MARCH 19, 1973 TO MARCH 23, 1973

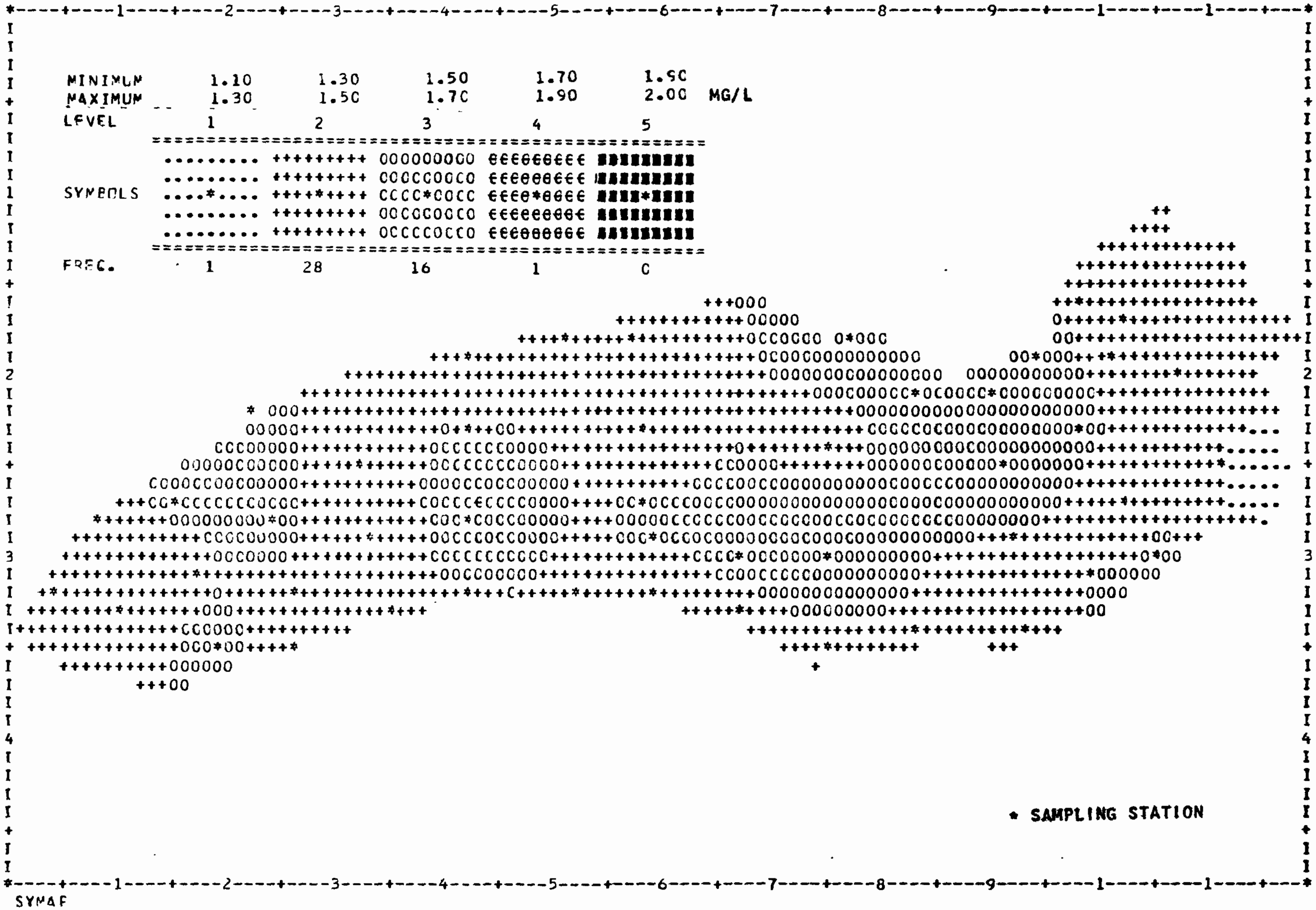


Figure 4.15b Contours of Constant Surface Potassium

Versus Time Contours of Constant Potassium

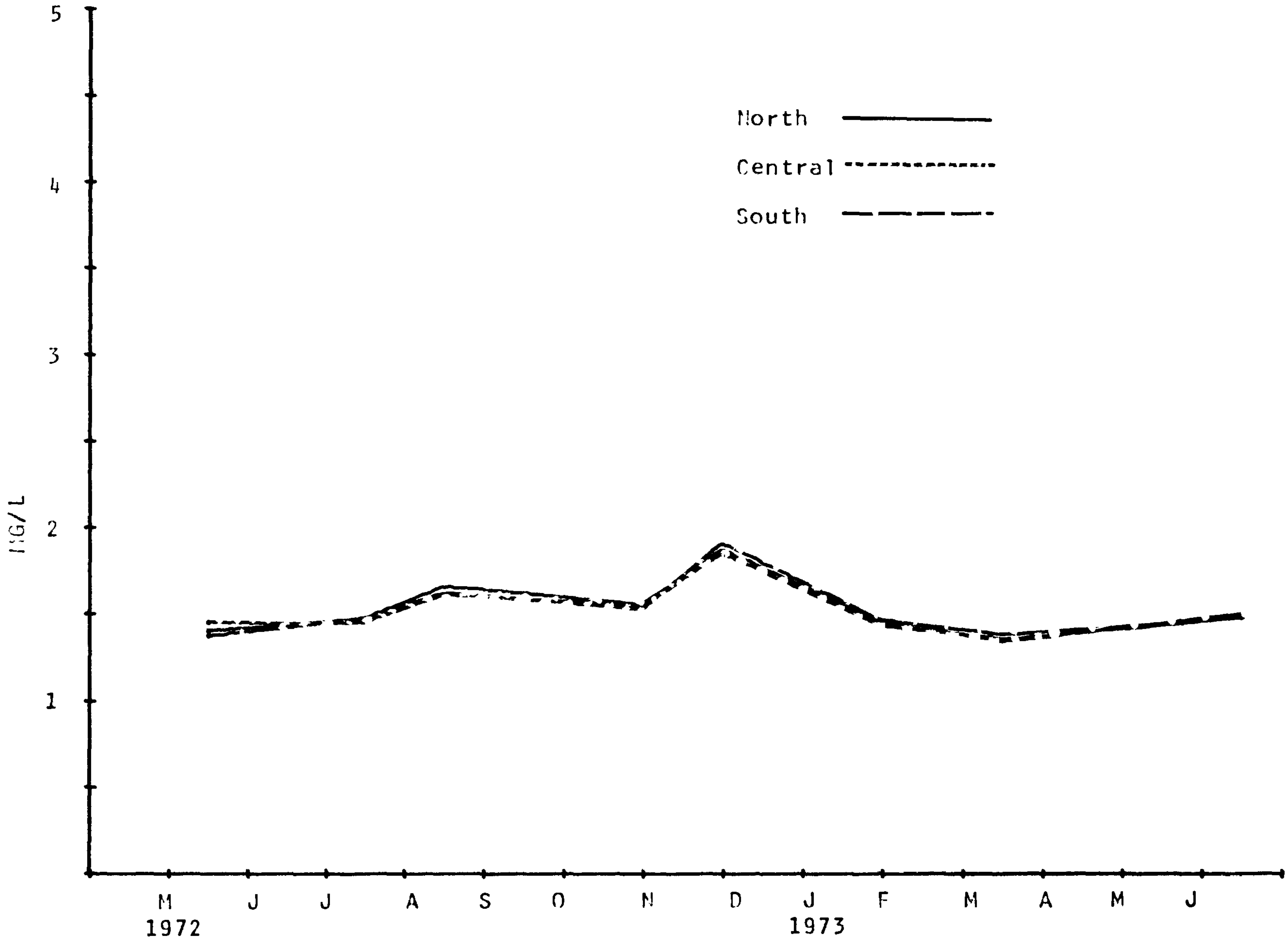


Figure 4.15d North-south variation of potassium

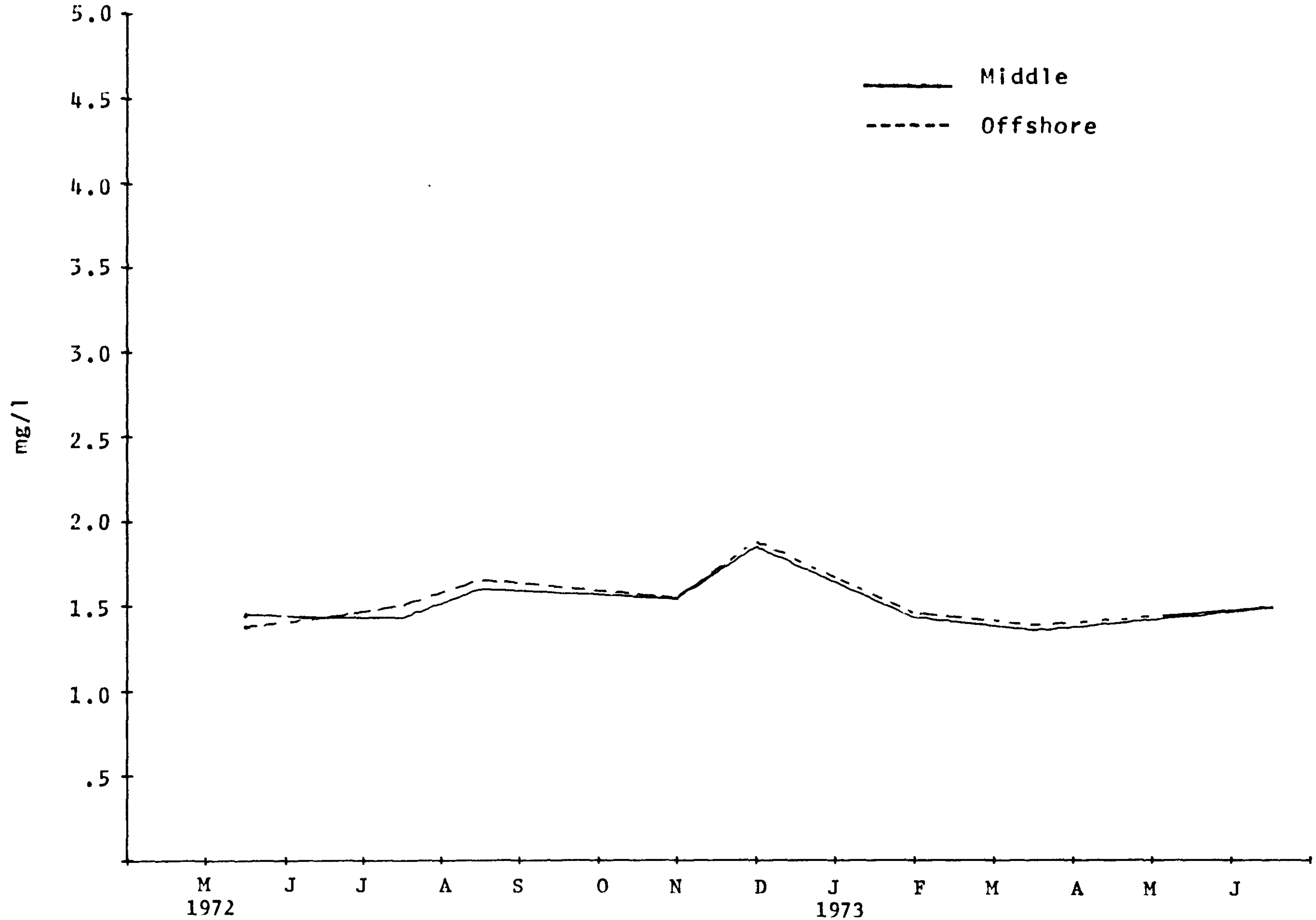


Figure 4.15e Middle Lake-Offshore Variations of Mean Potassium Concentration

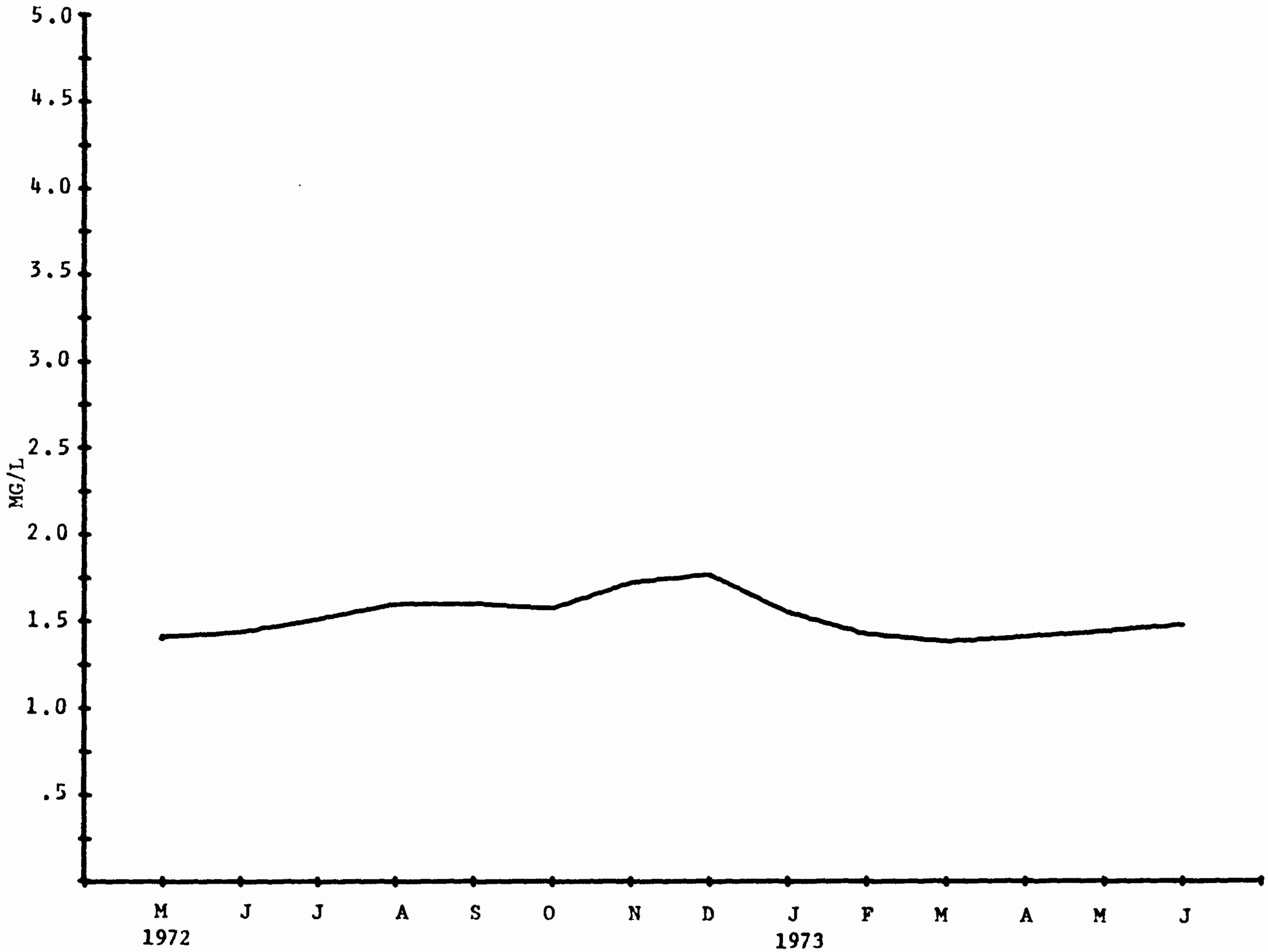


Figure 4.15f Mean surface variation of Potassium concentration during the field year.

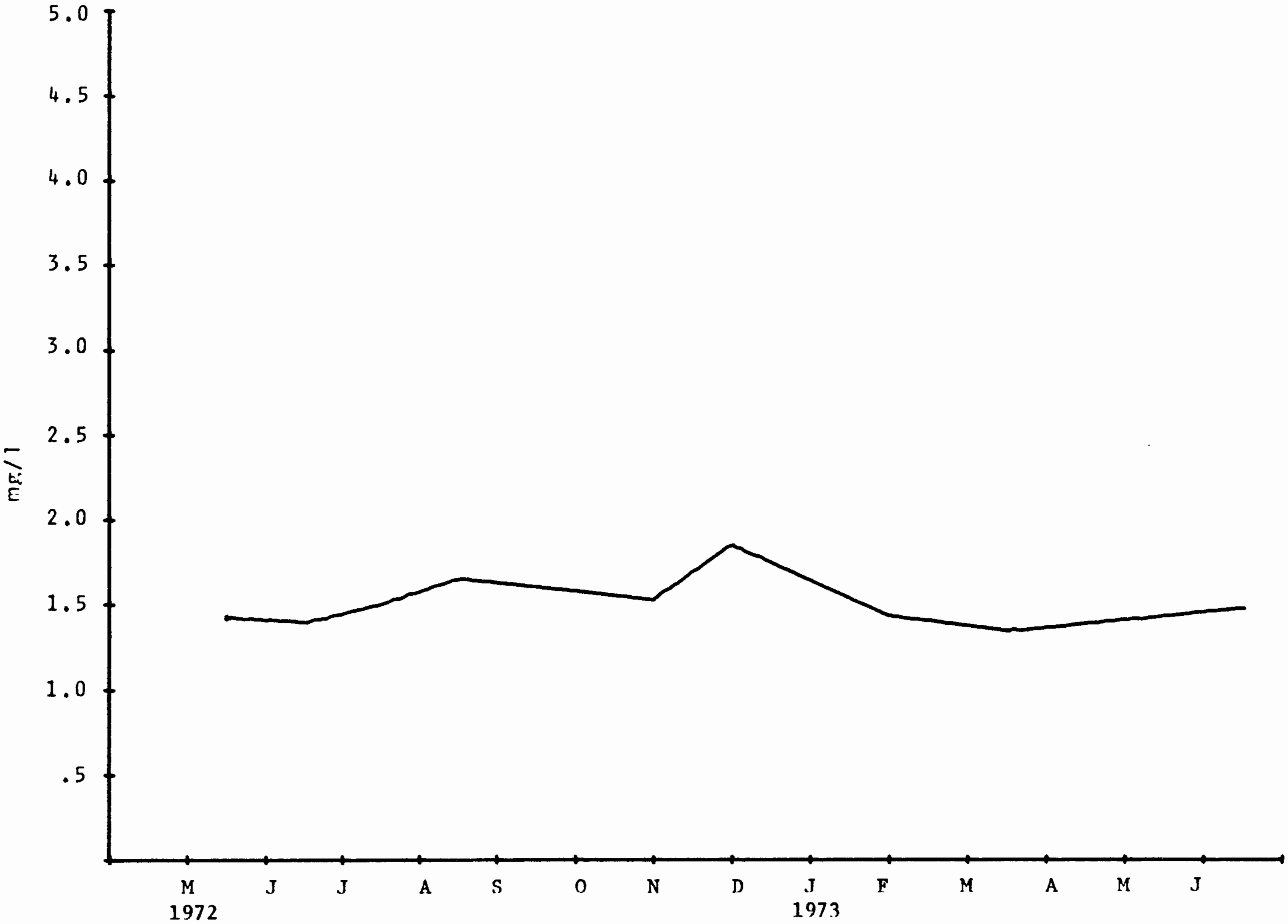


Figure 4.15g Mean Bottom Variation of Potassium Concentration During the Field Year

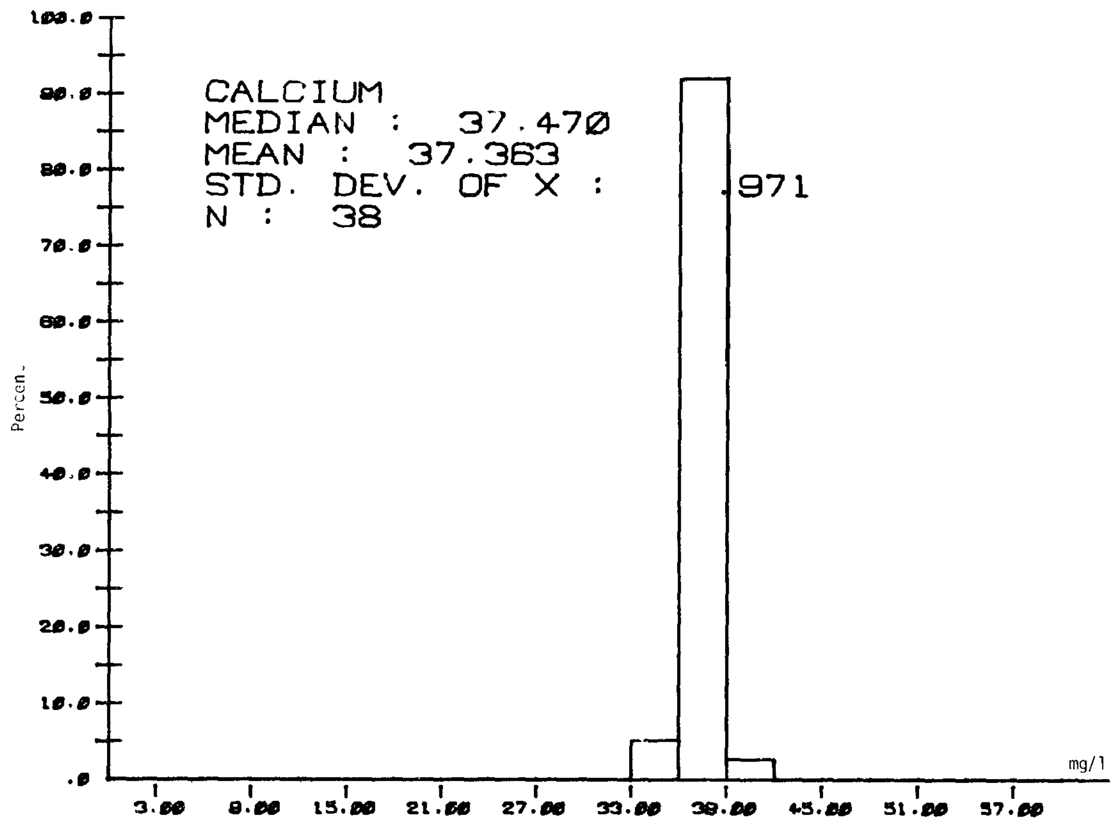


Figure 4.16a Histograms for Calcium - Cruise 1

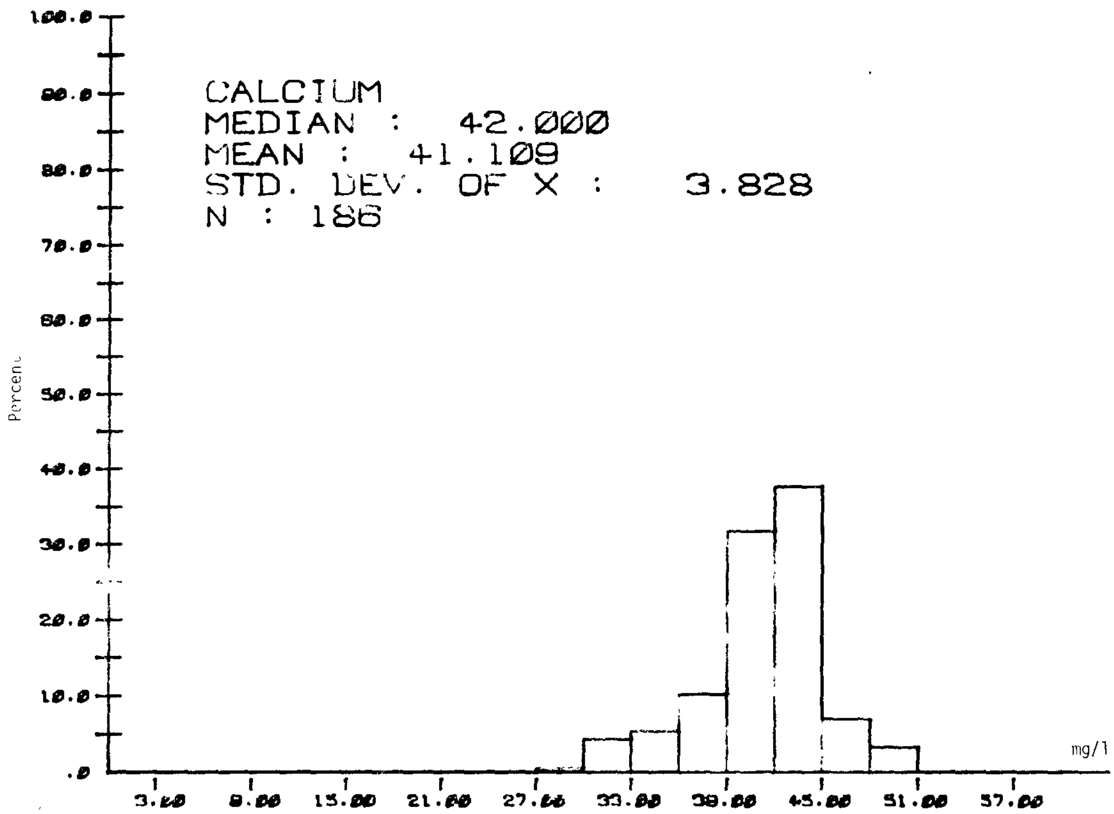


Figure 4.16a Histograms for Calcium - Cruise 2

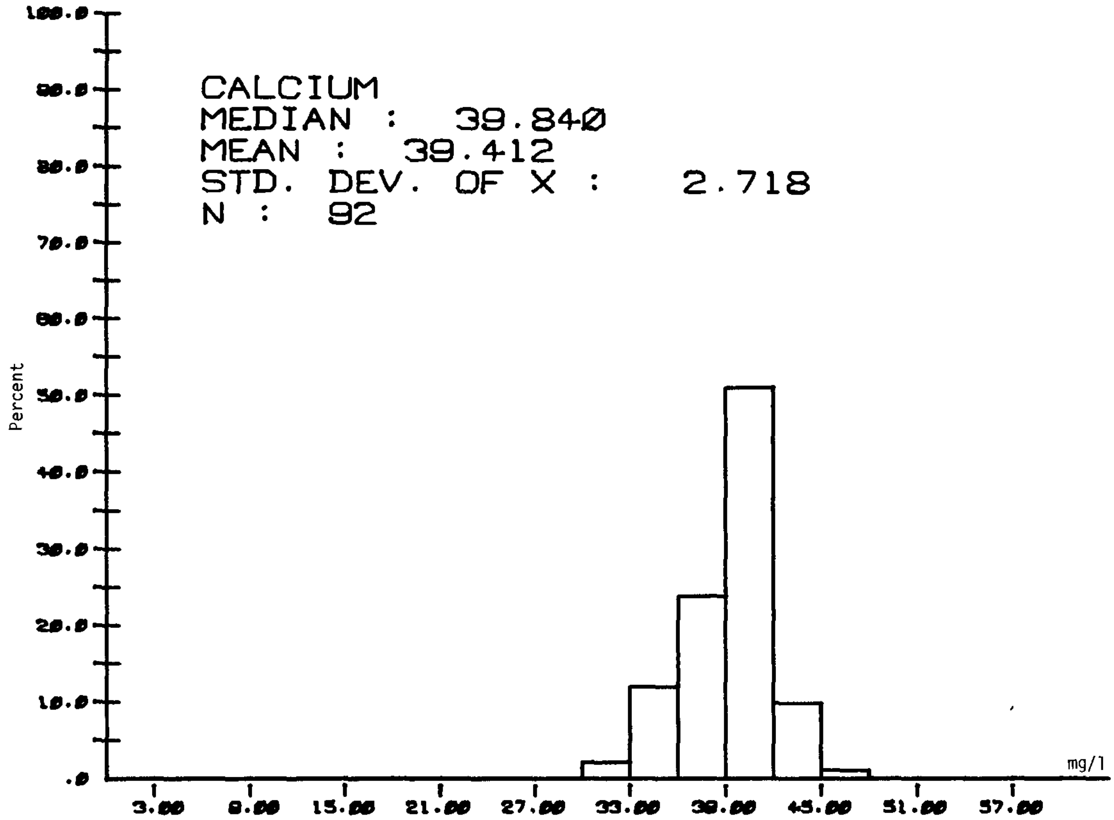


Figure 4.16a Histograms for Calcium - Cruise 3

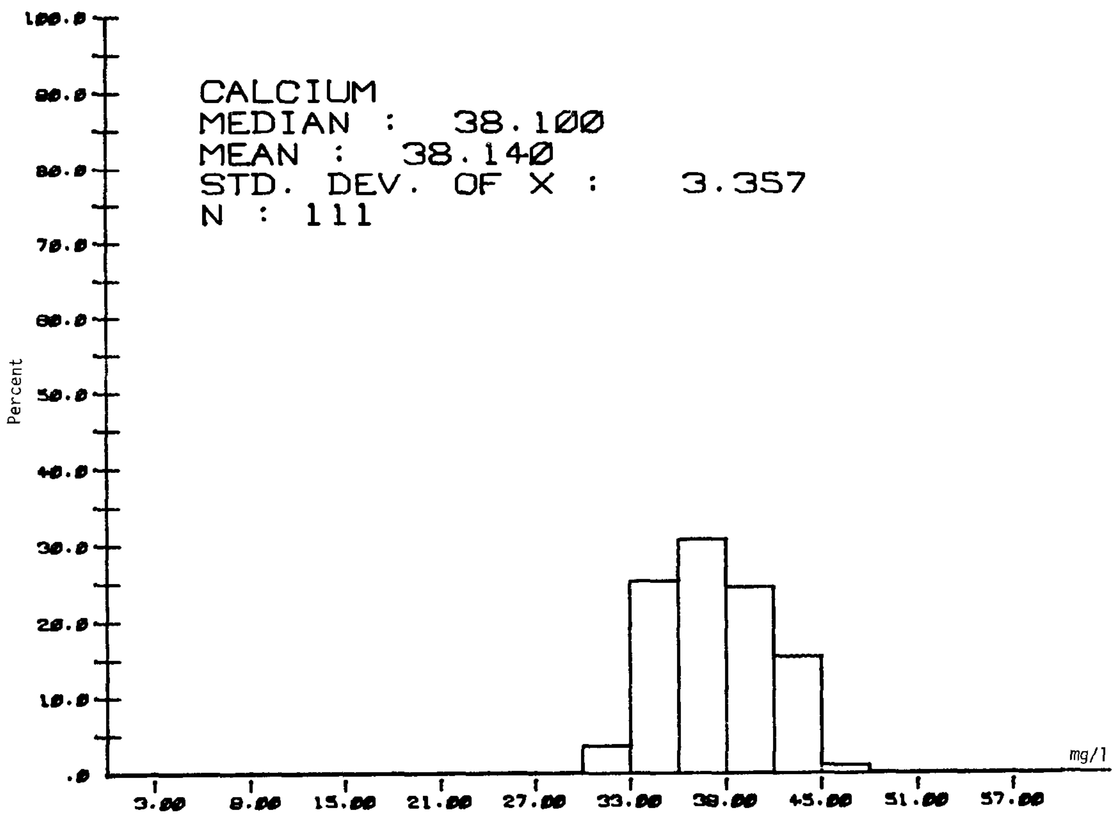


Figure 4.16a Histograms for Calcium - Cruise 4

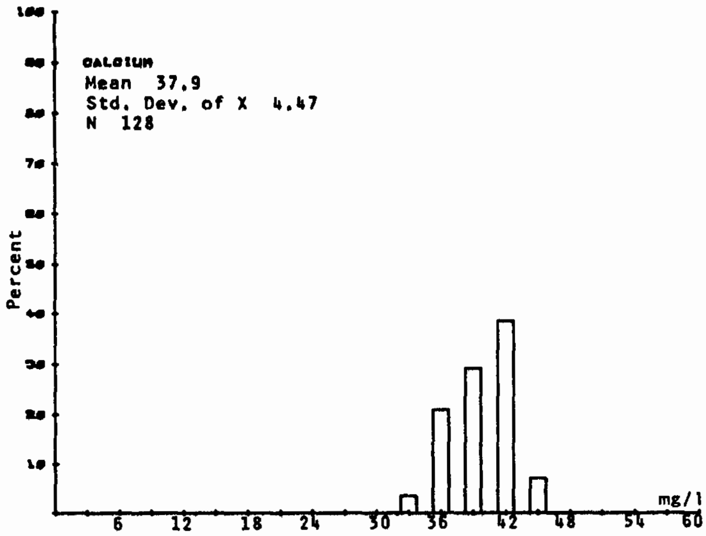


Figure 4.16a Histograms for Calcium - Cruise 5

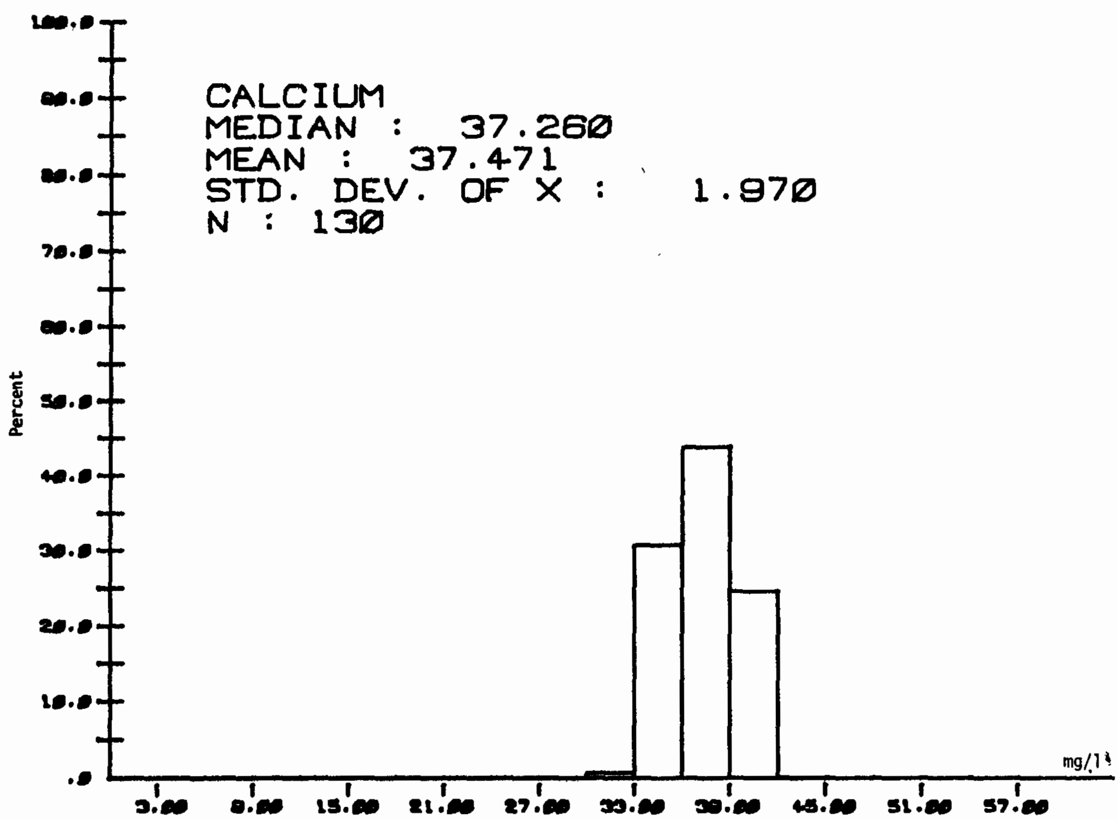


Figure 4.16a Histograms for Calcium - Cruise 6

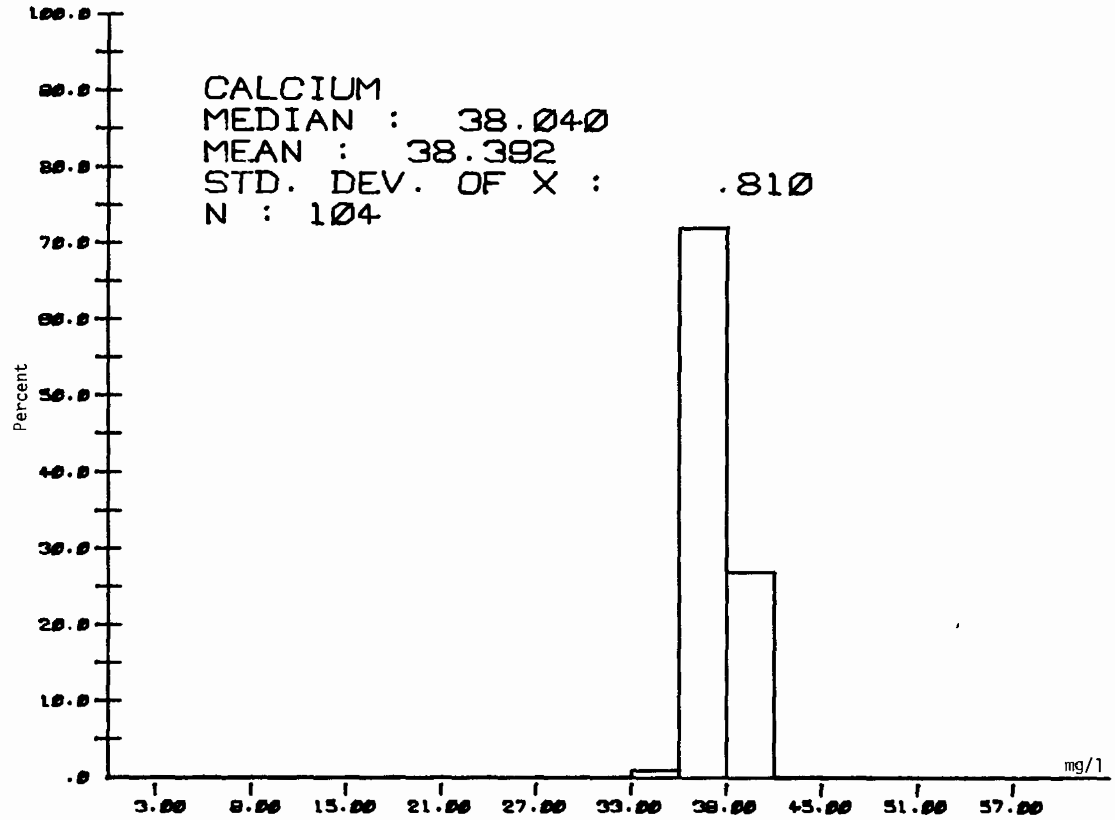


Figure 4.16a Histograms for Calcium - Cruise 7

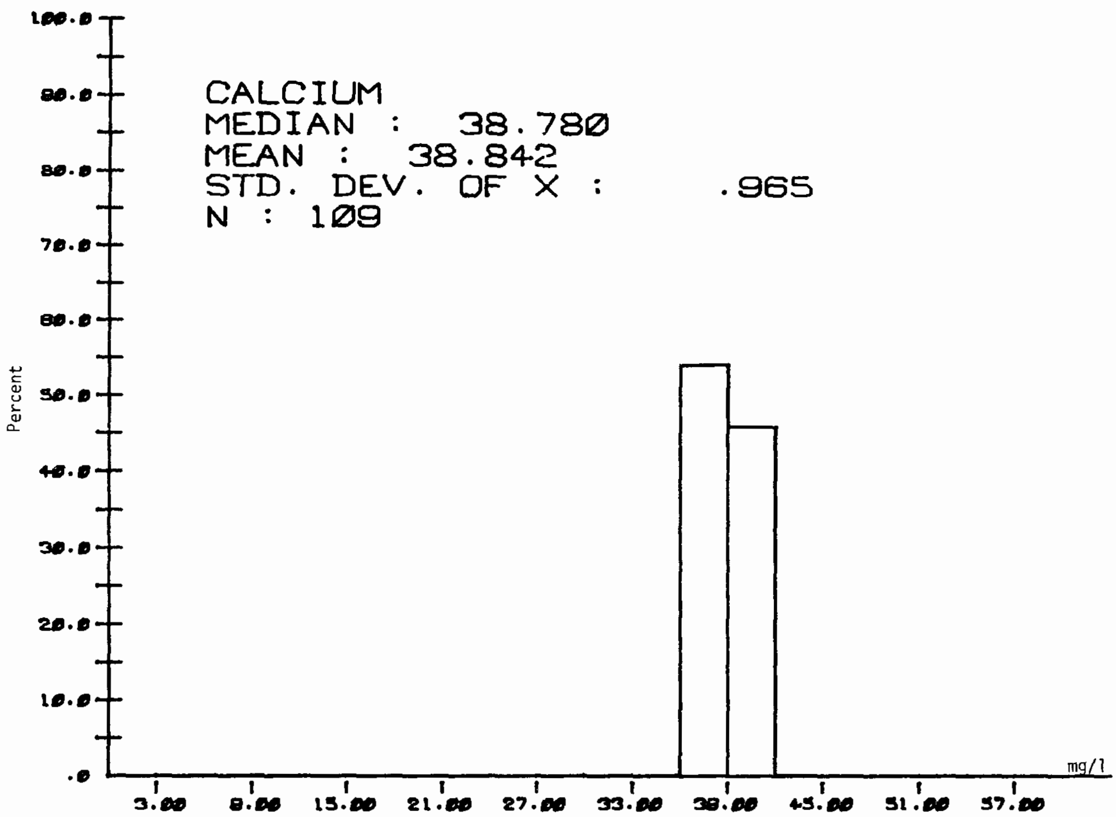


Figure 4.16a Histograms for Calcium - Cruise 8

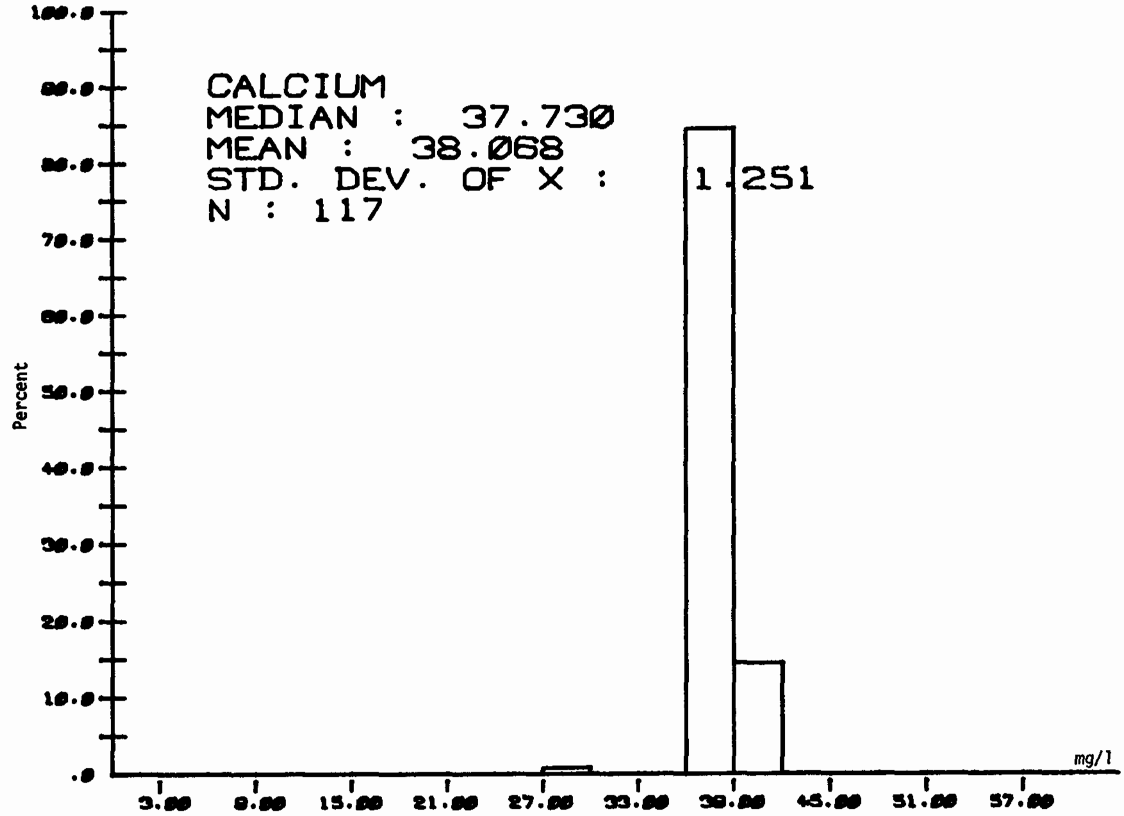


Figure 4.16a Histograms for Calcium - Cruise 9

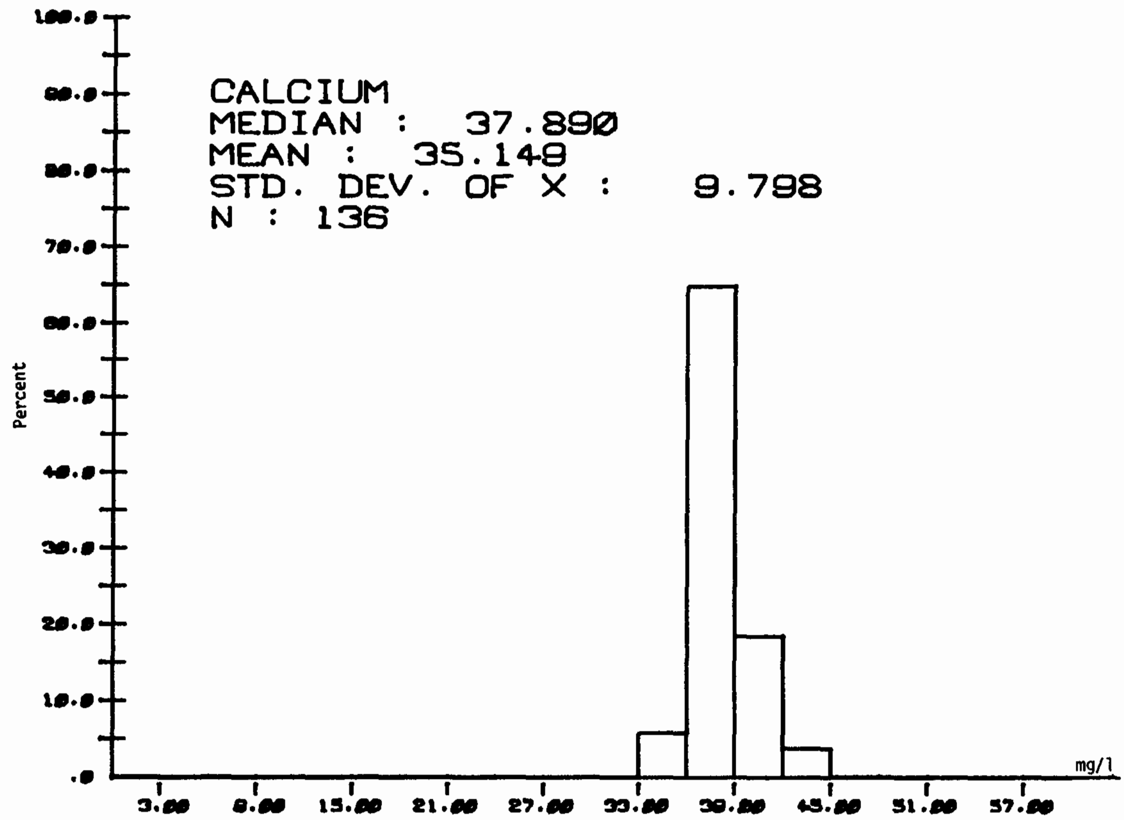


Figure 4.16a Histograms for Calcium - Cruise 11

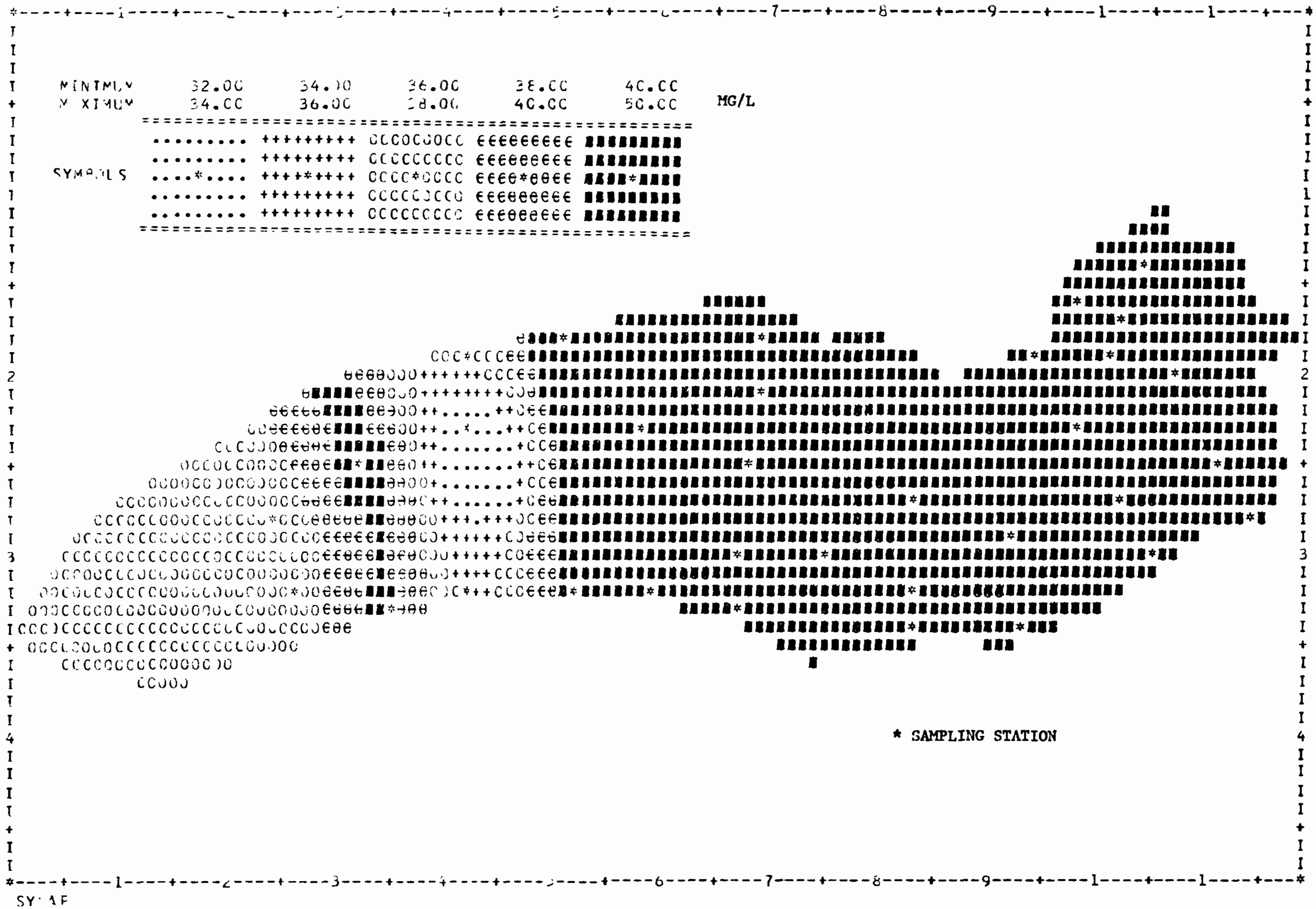


Figure 4.16b Contours of Constant Surface Calcium

CRUISE NUMBER 3: MAY 15, 1972 TO MAY 19, 1972

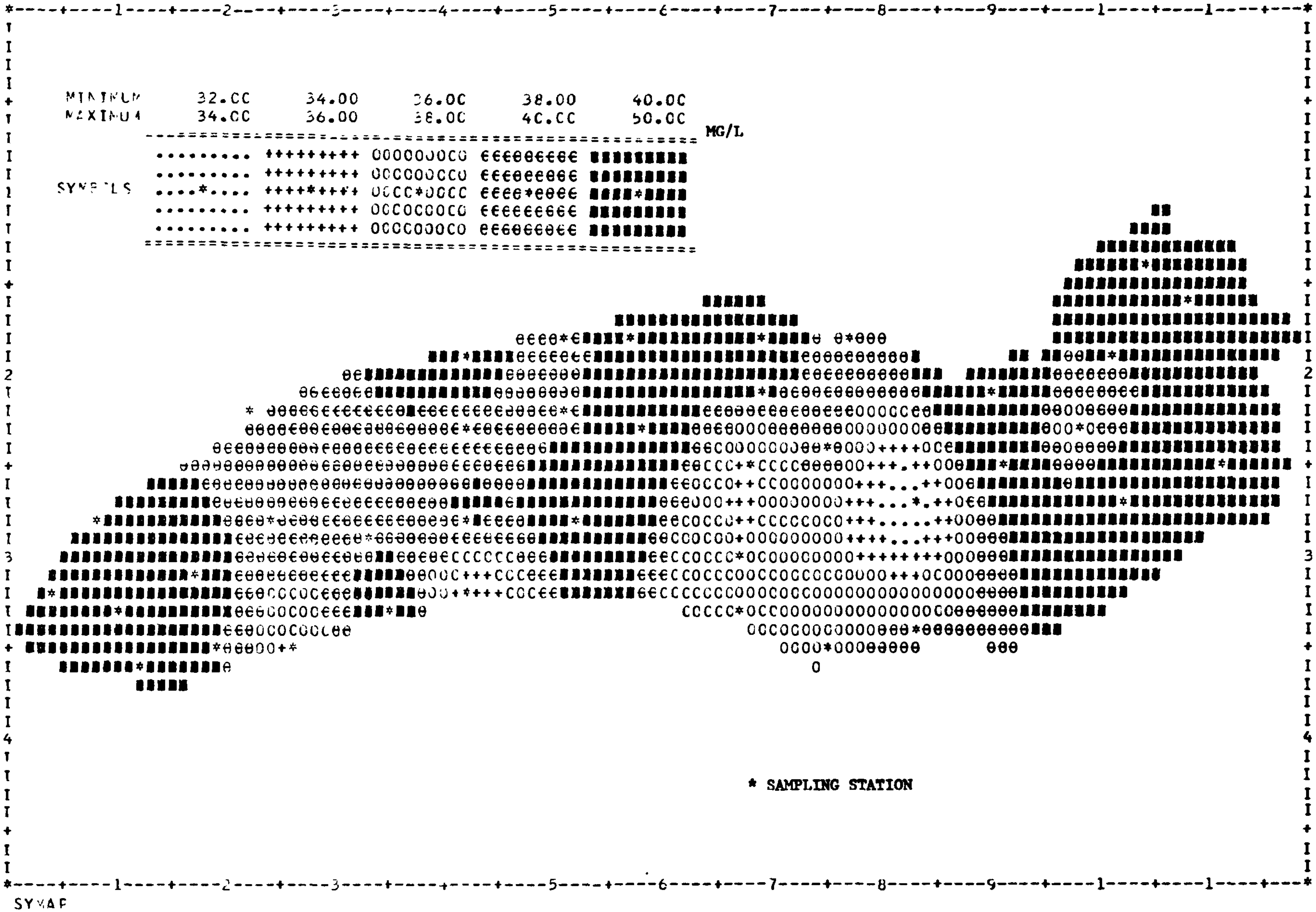


Figure 4.16b Contours of Constant Surface Calcium

CRUISE NUMBER 3: JUNE 12, 1972 TO JUNE 16, 1972

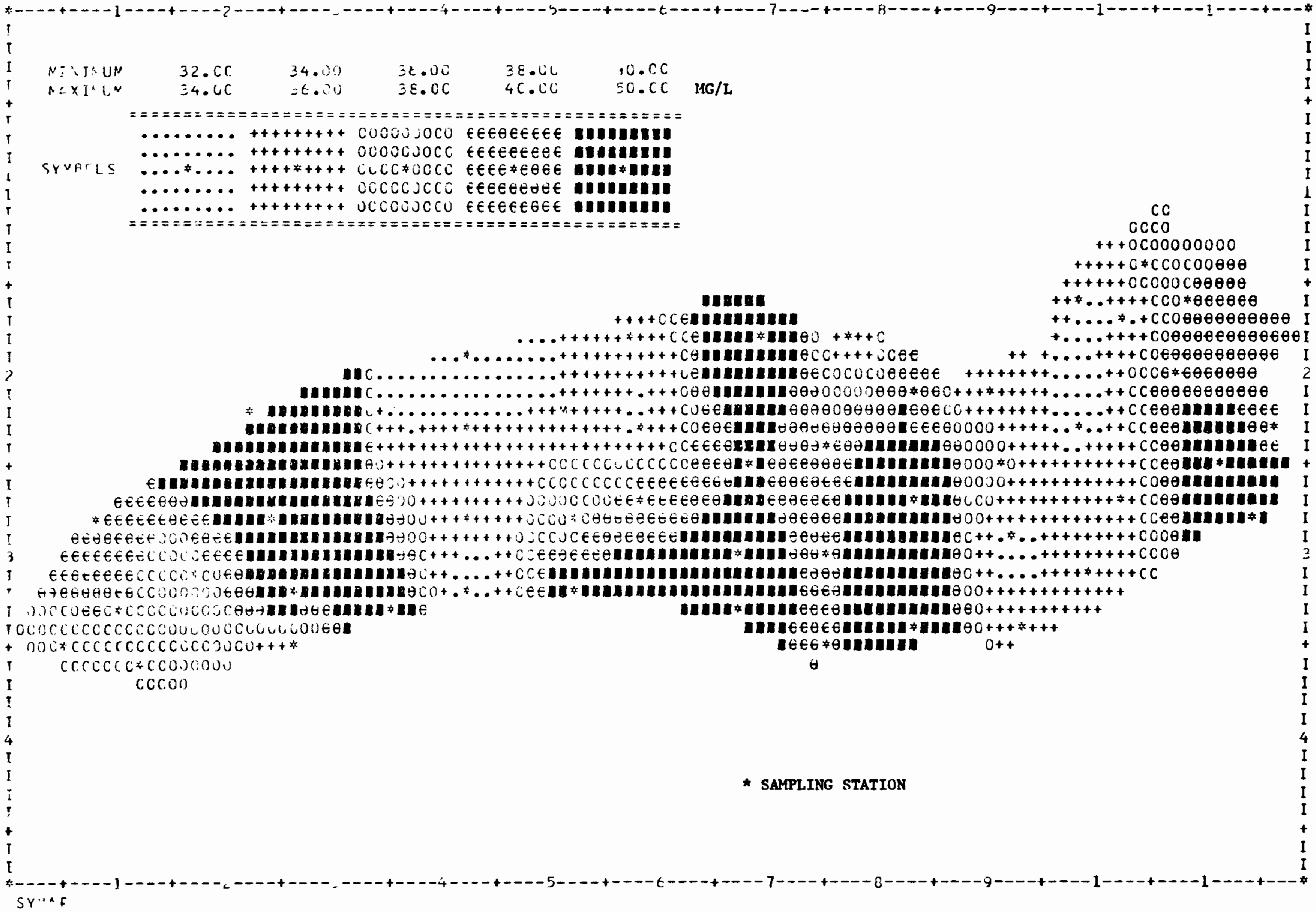


Figure 4.16b Contours of Constant Surface Calcium

JULY 10, 1972 TO JULY 14, 1972

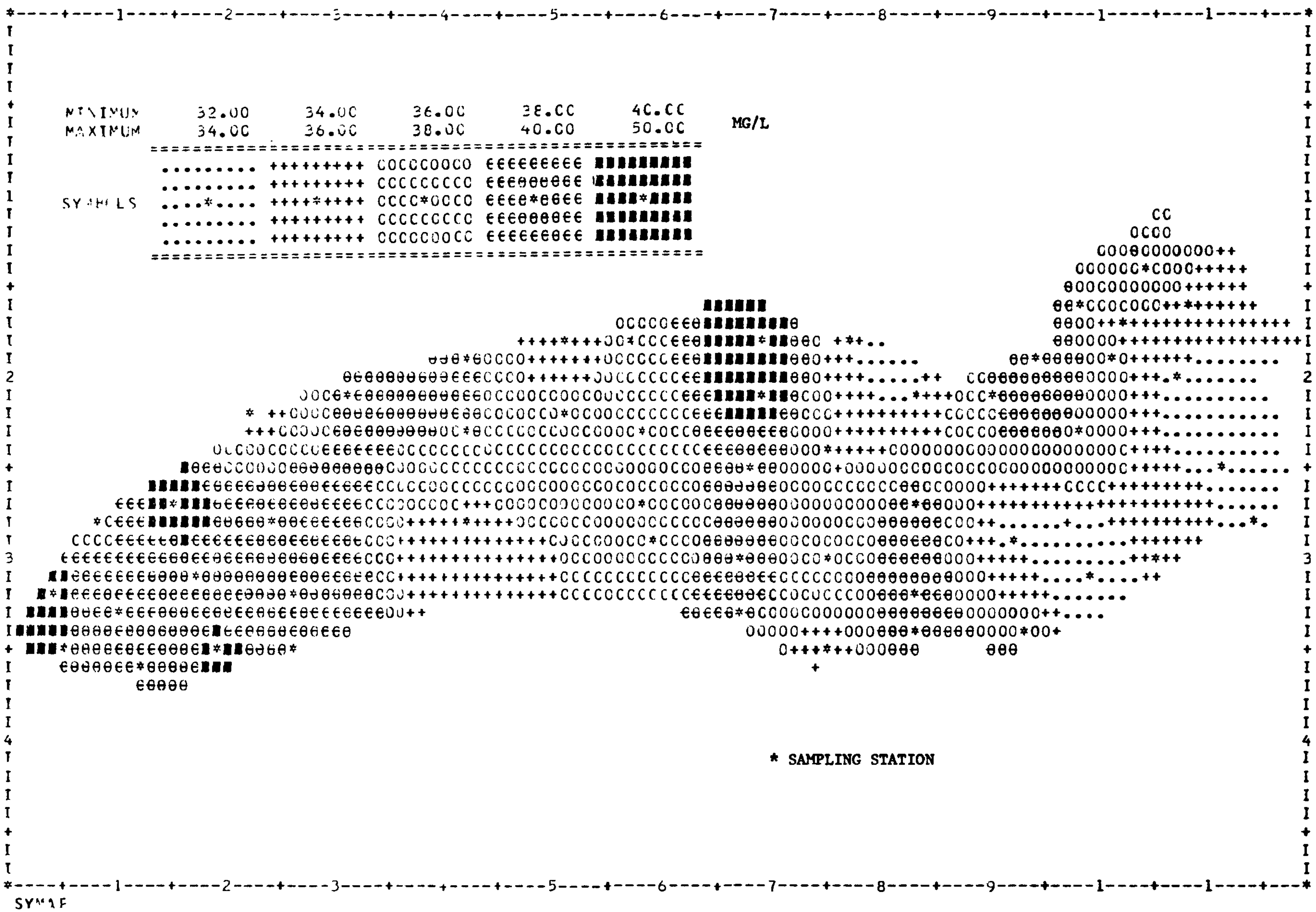


Figure 4.16b Contours of Constant Surface Calcium

CRUISE NUMBER 5: AUGUST 21, 1972 TO AUGUST 25, 1972

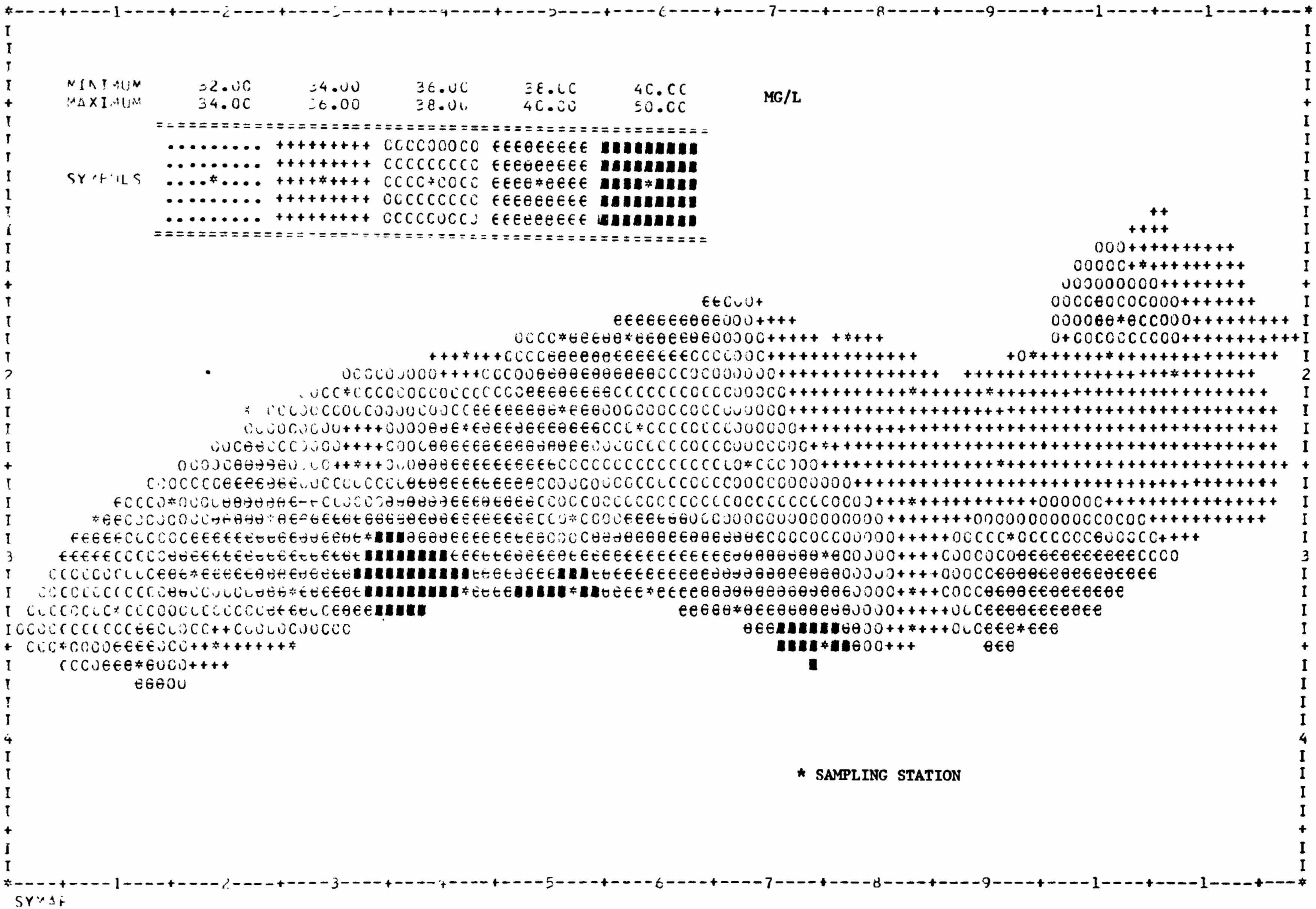


Figure 4.16b Contours of Constant Surface Calcium

CRUISE NUMBER 6: OCTOBER 30, 1972 TO NOV WEEK 3, 1972

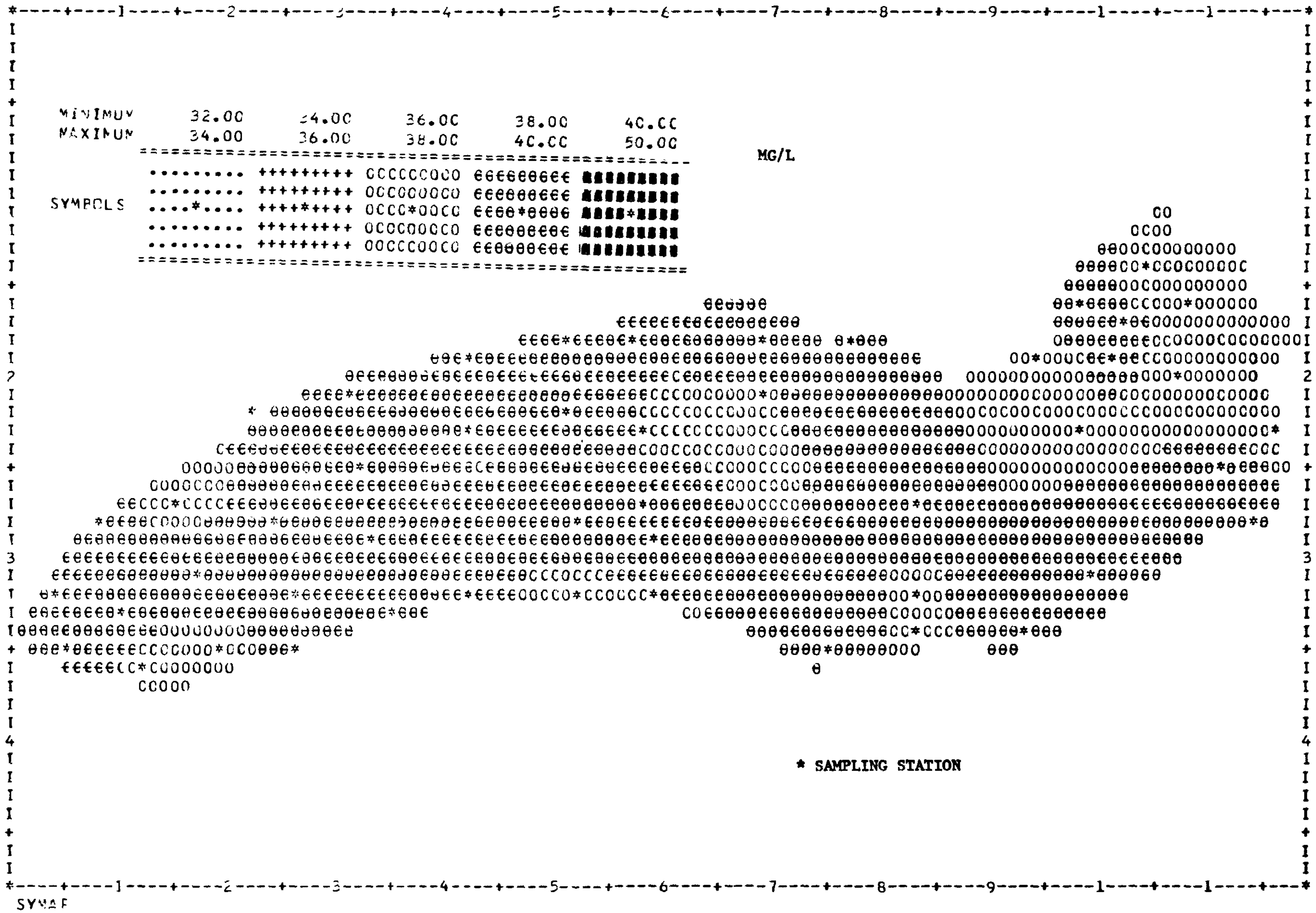


Figure 4.16b Contours of Constant Surface Calcium

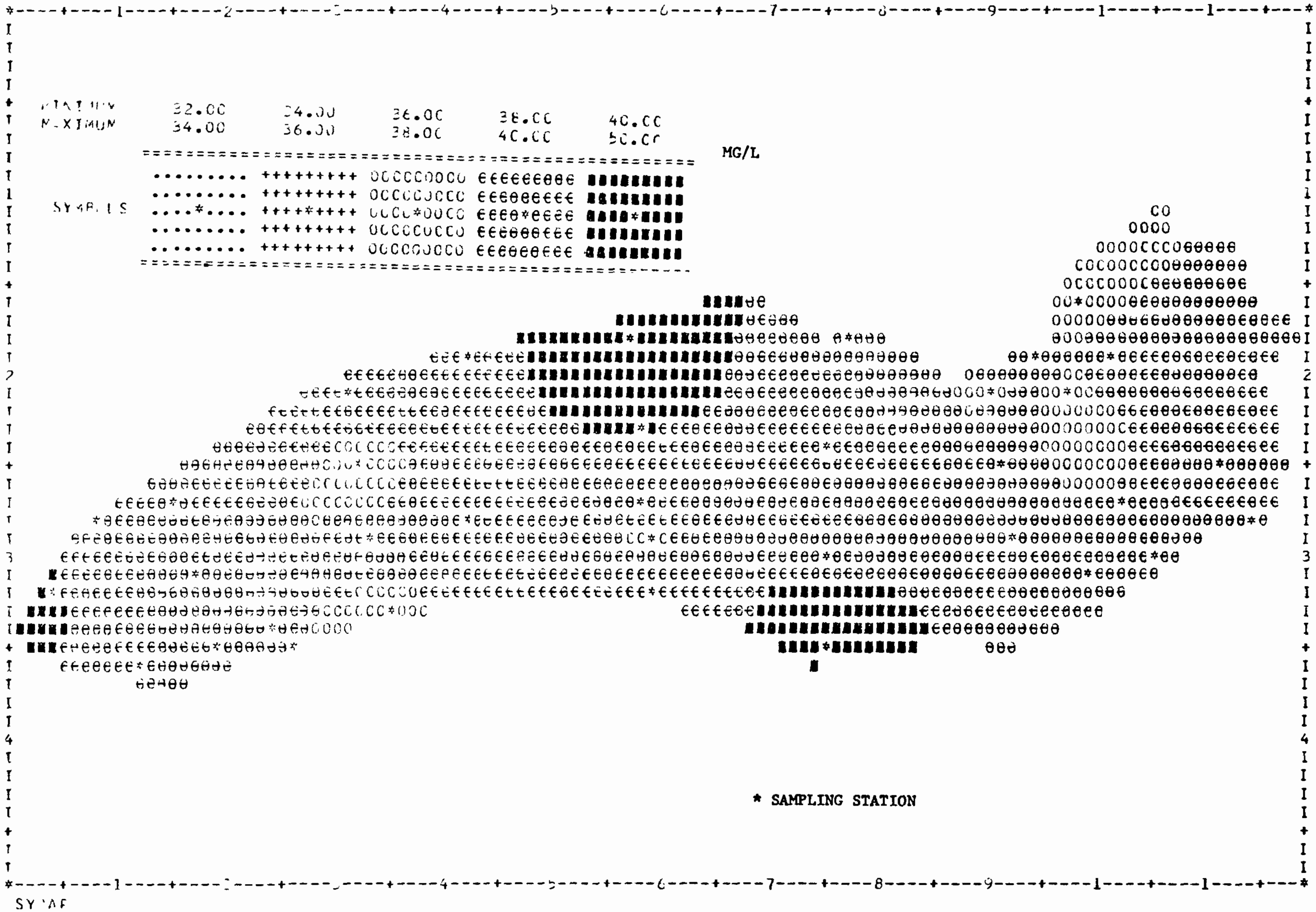


Figure 4.16b Contours of Constant Surface Calcium

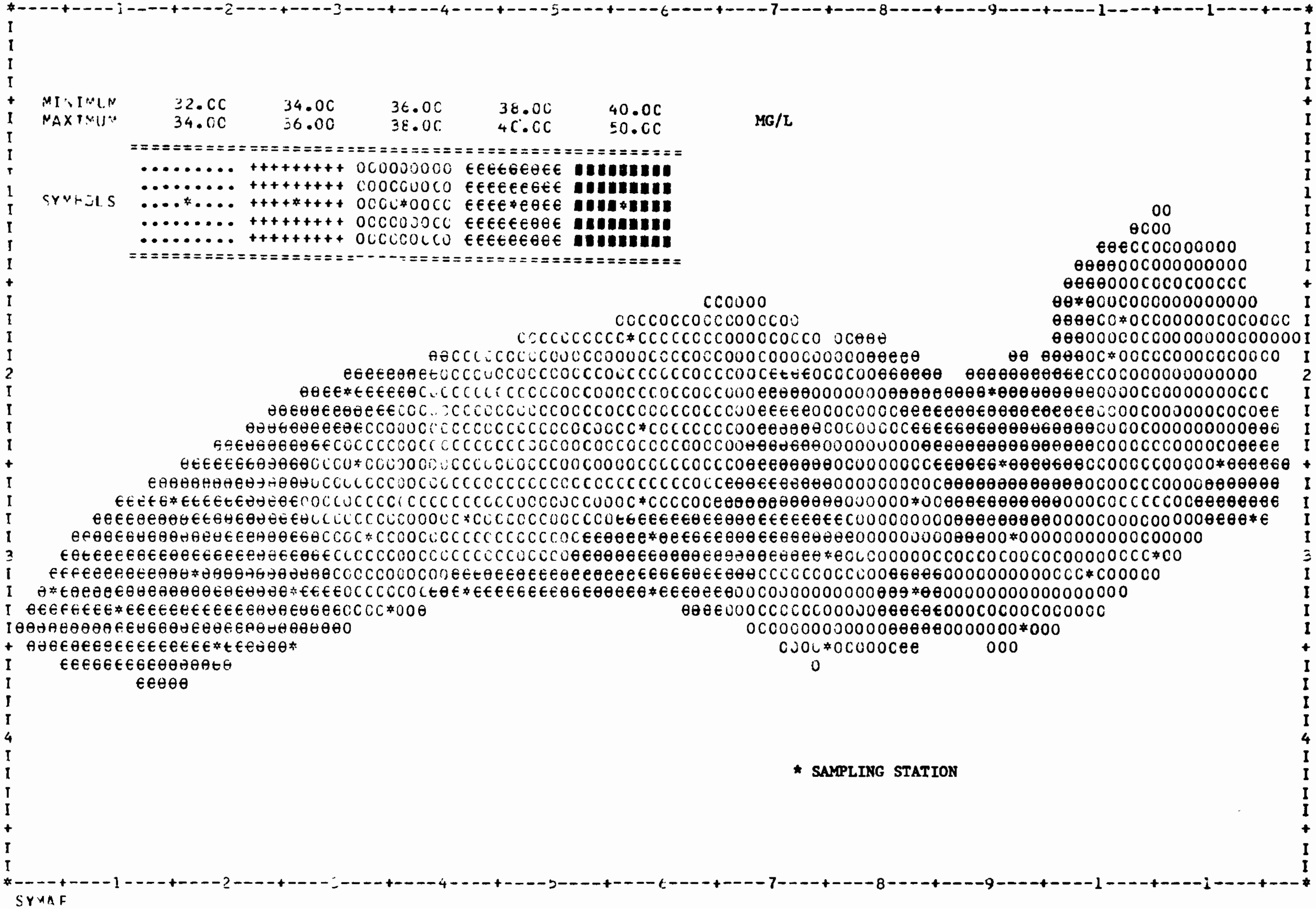


Figure 4.16b Contours of Constant Surface Calcium

CRUISE NUMBER 9: MARCH 18, 1973 TO MARCH 23, 1973

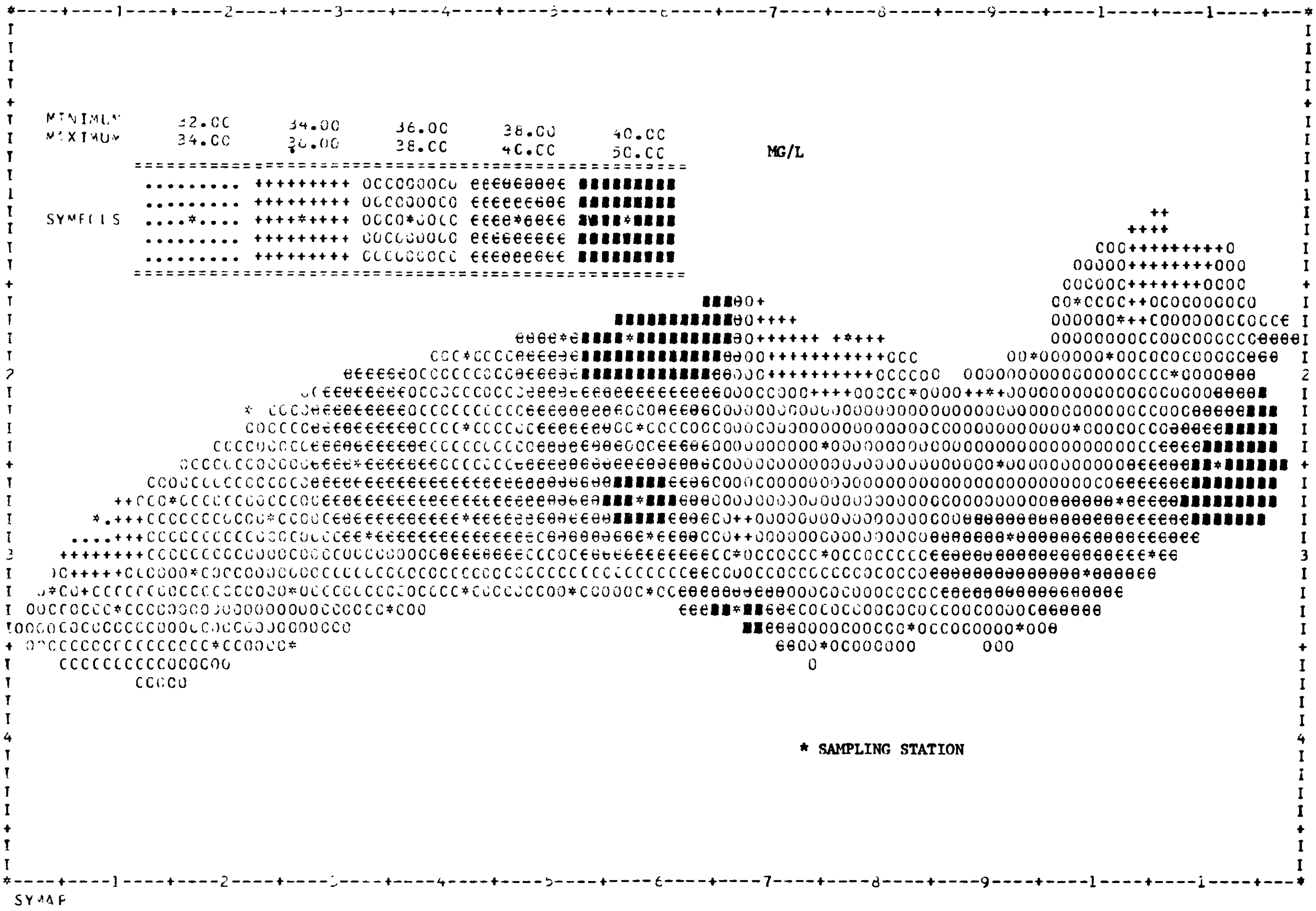


Figure 4.16b Contours of Constant Surface Calcium

CRUISE NUMBER 11: JUNE 11, 1973 TO JUNE 15, 1973

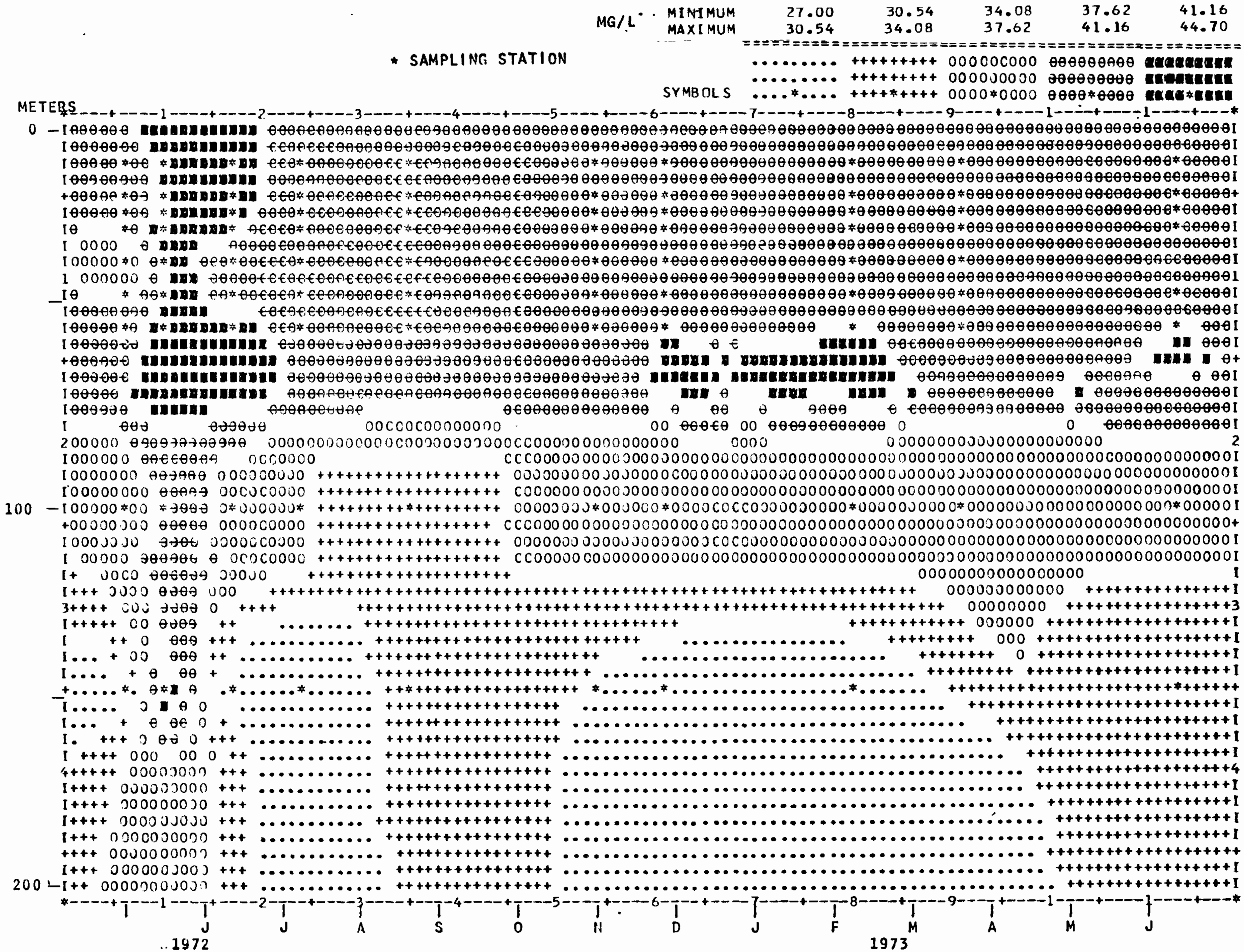


Figure 4.16c Depth Versus Time Contours of Constant Calcium

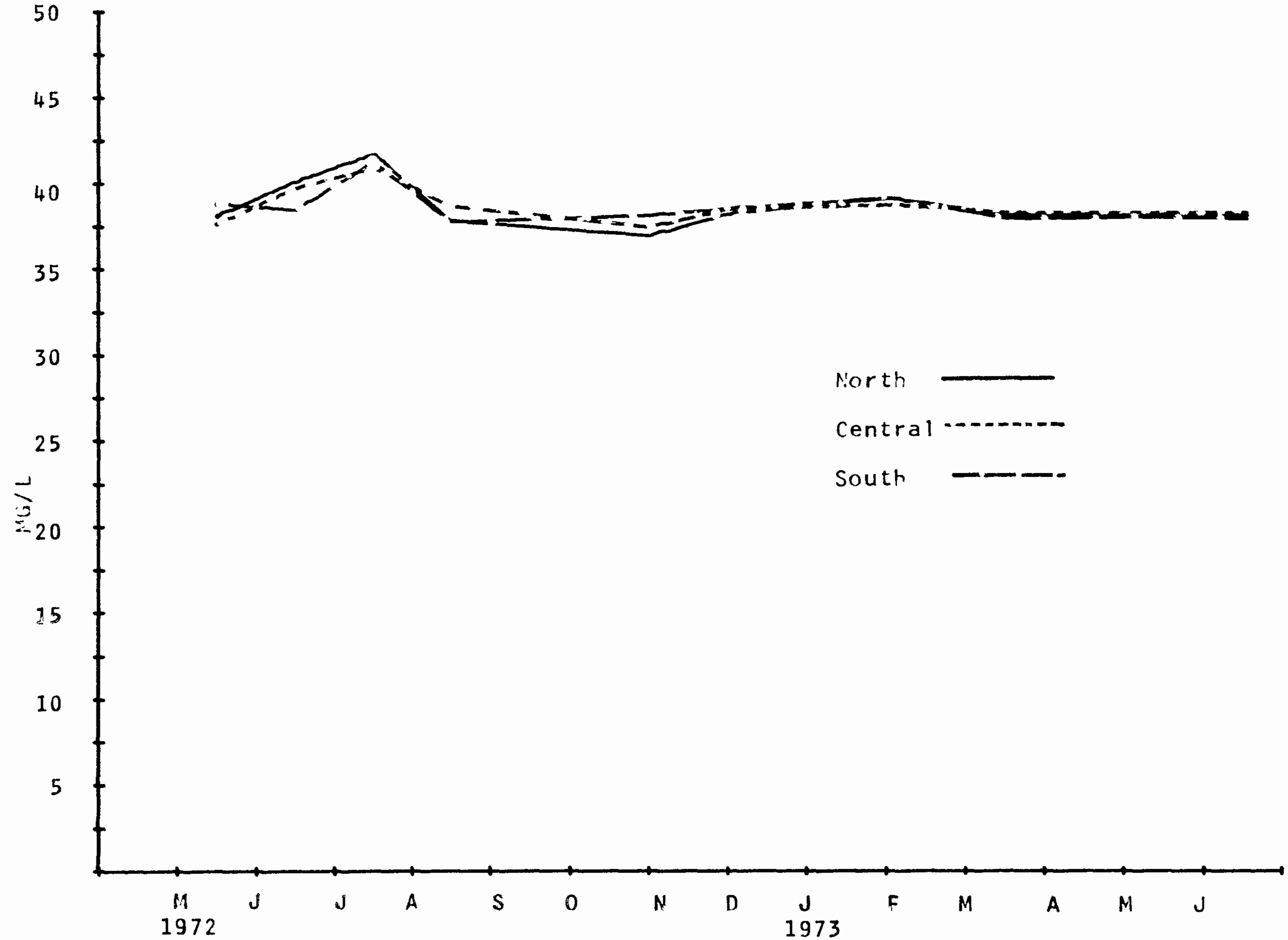


Figure 4.16d North-south variation of calcium

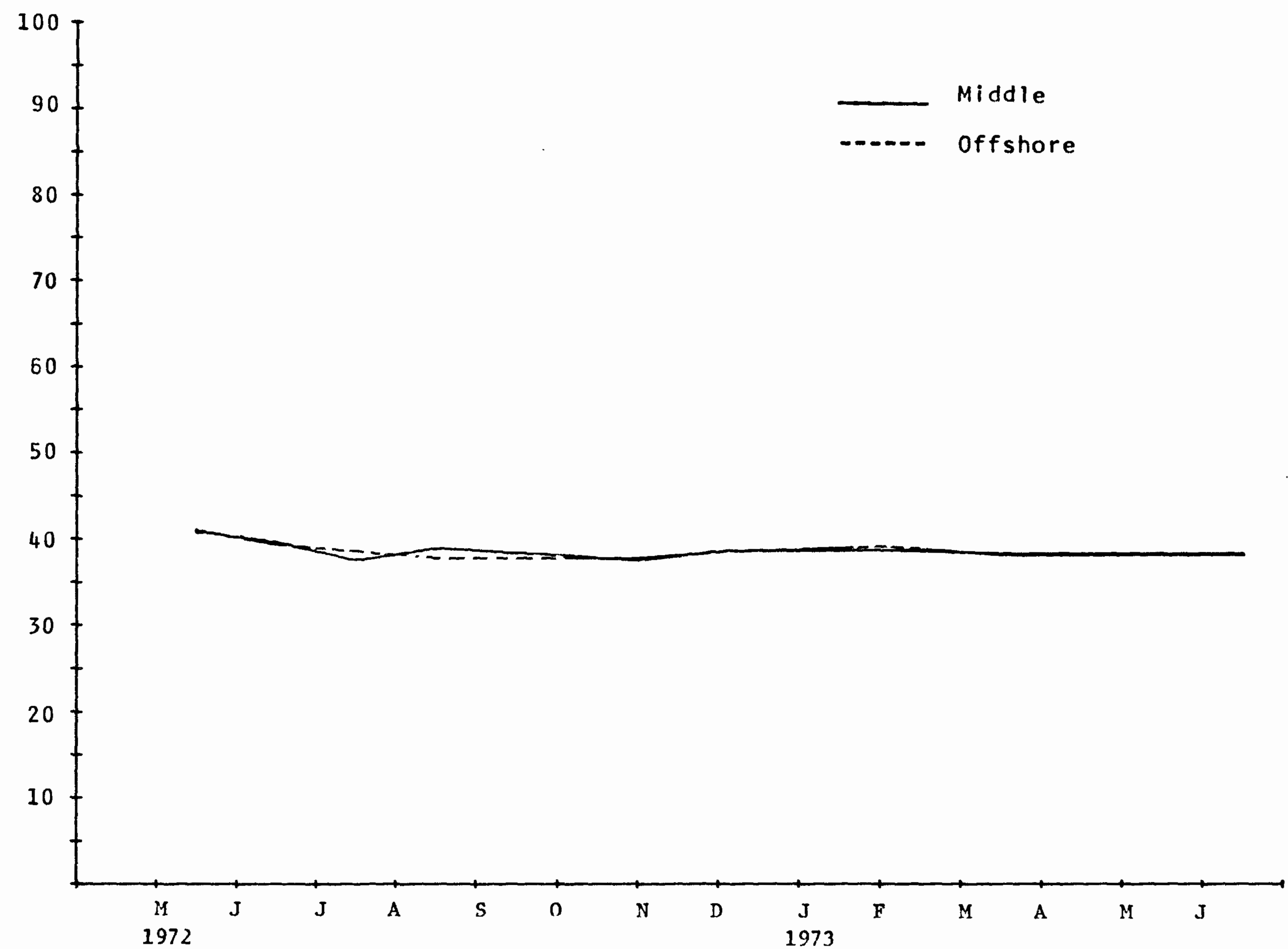


Figure 4.16e Middle Lake-Offshore Variations of Mean Calcium Concentration

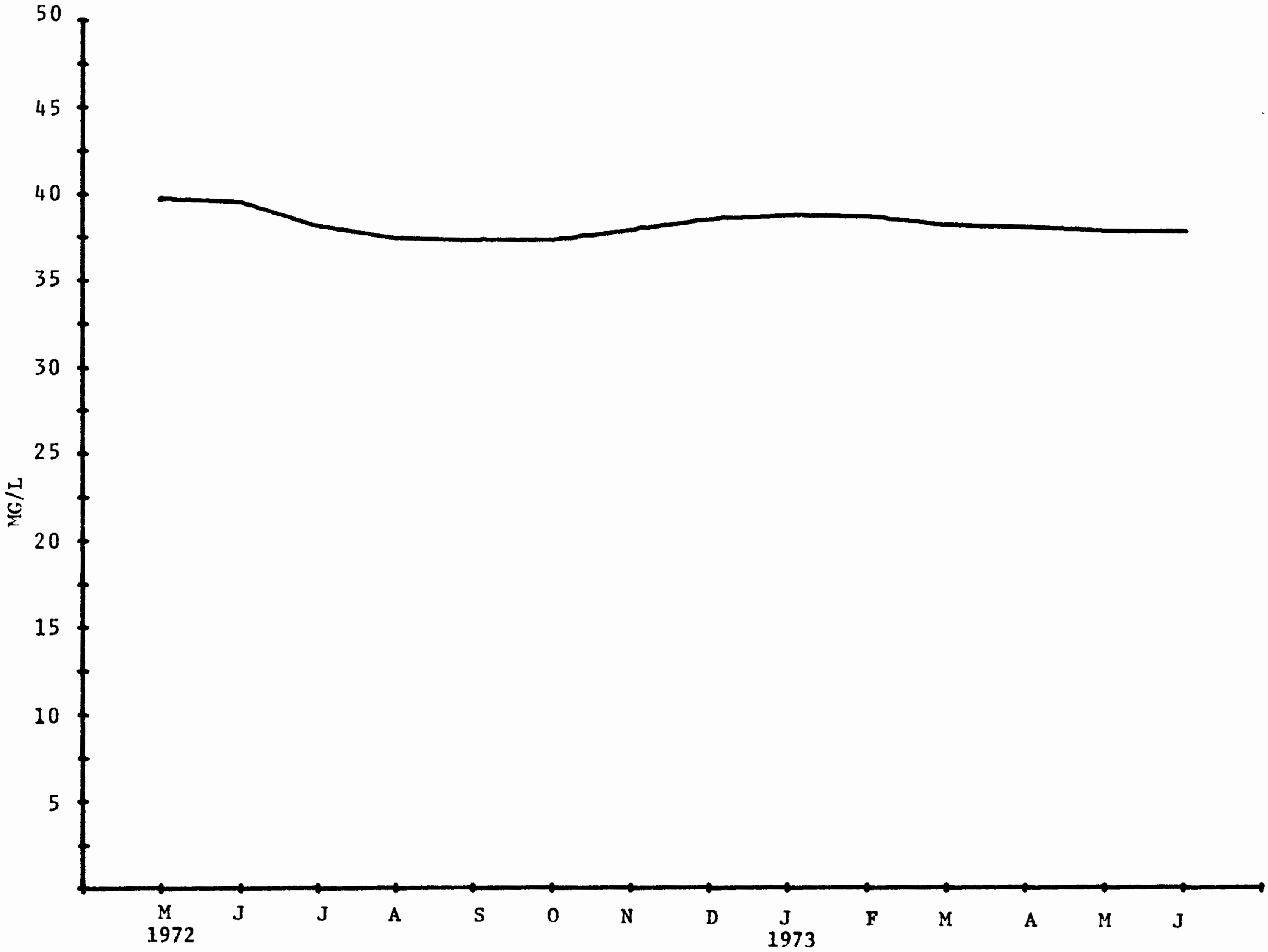


Figure 4.16f Mean surface variation of Calcium concentration during the field year.

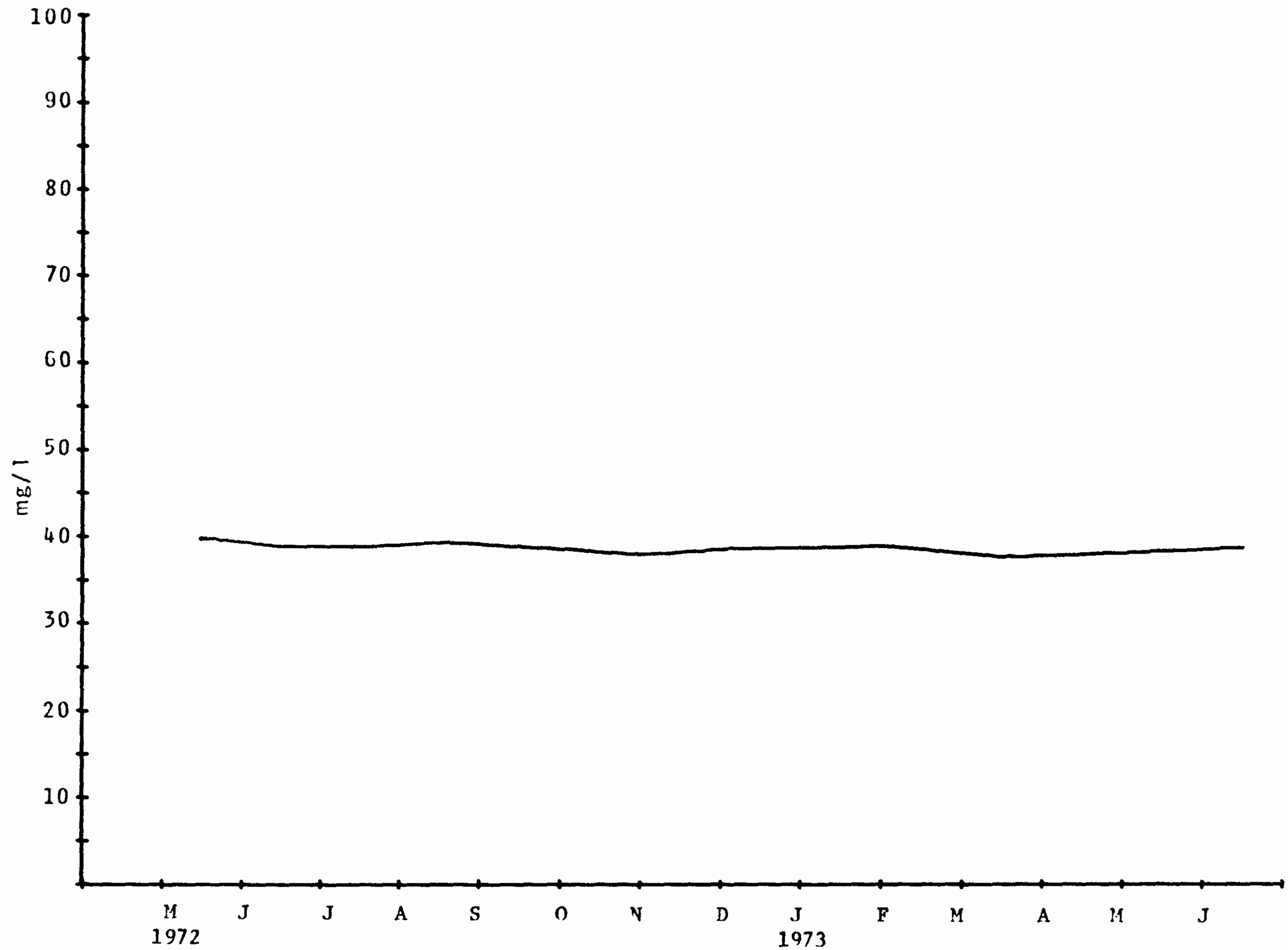


Figure 4.16g Mean Bottom Variation of Calcium Concentration During the Field Year

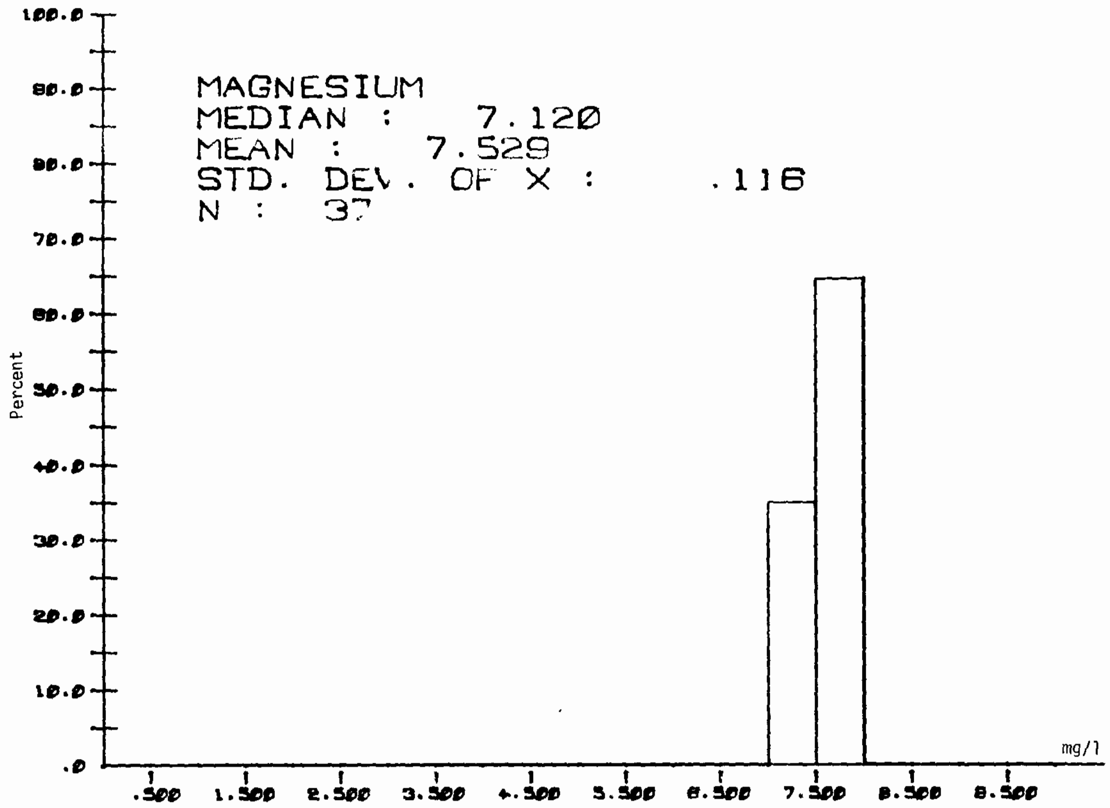


Figure 4.17a Histograms for Magnesium - Cruise 1

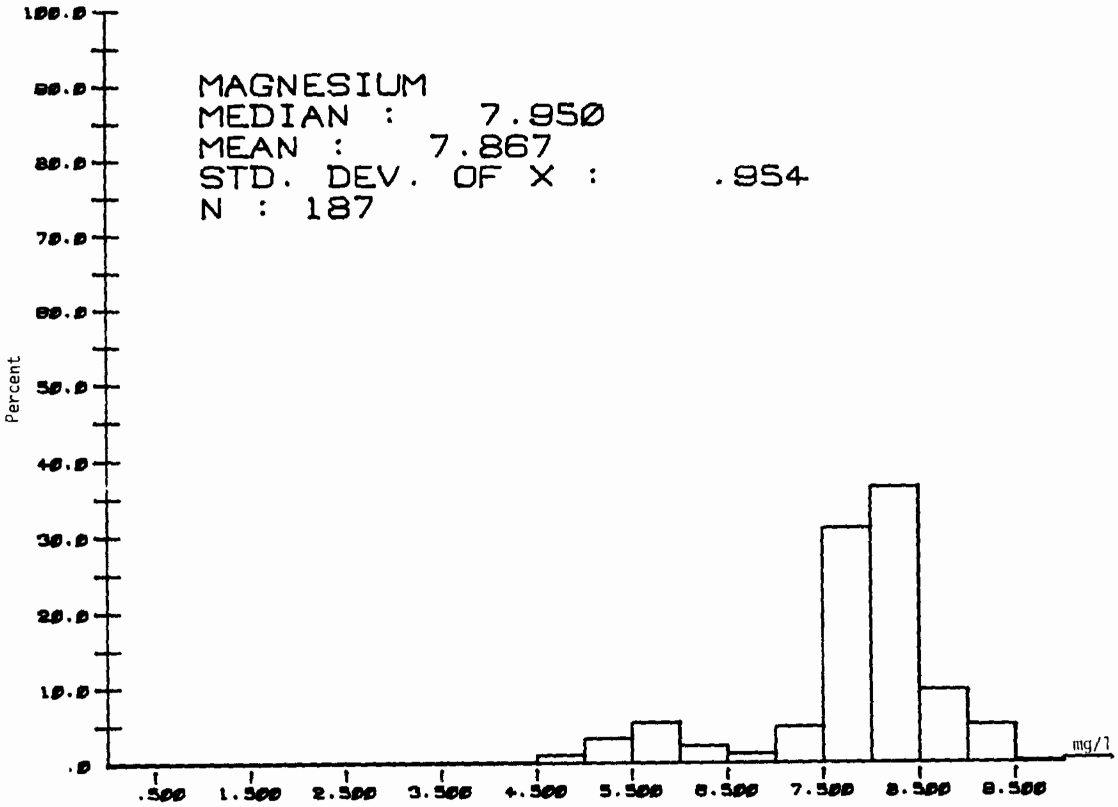


Figure 4 17a Histograms for Magnesium - Cruise 2

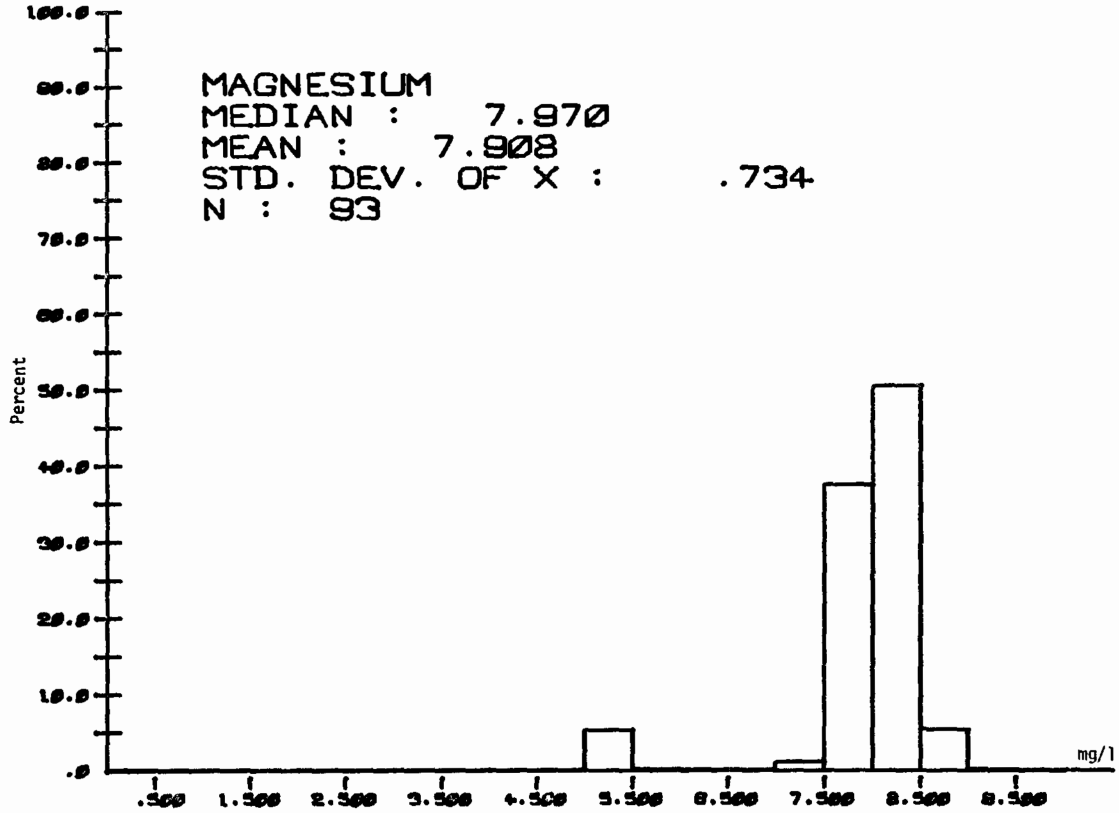


Figure 4.17a Histograms for Magnesium - Cruise 3

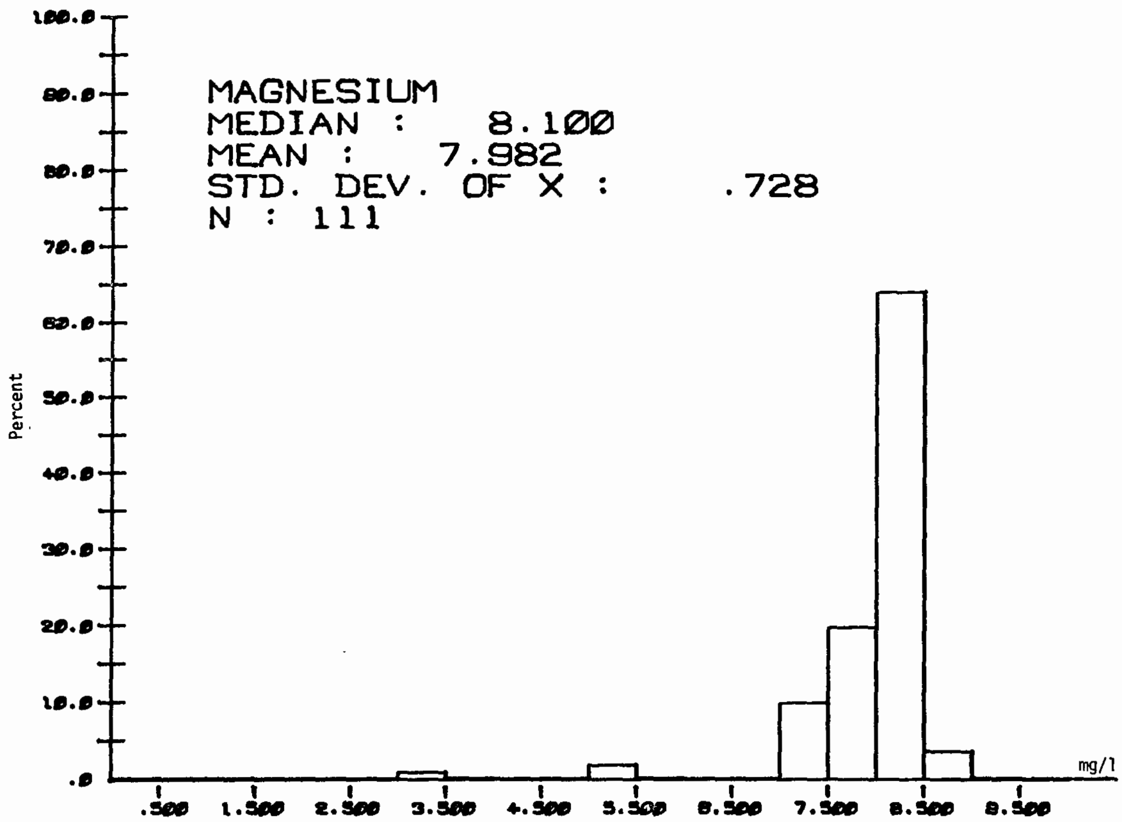


Figure 4.17a Histograms for Magnesium - Cruise 4

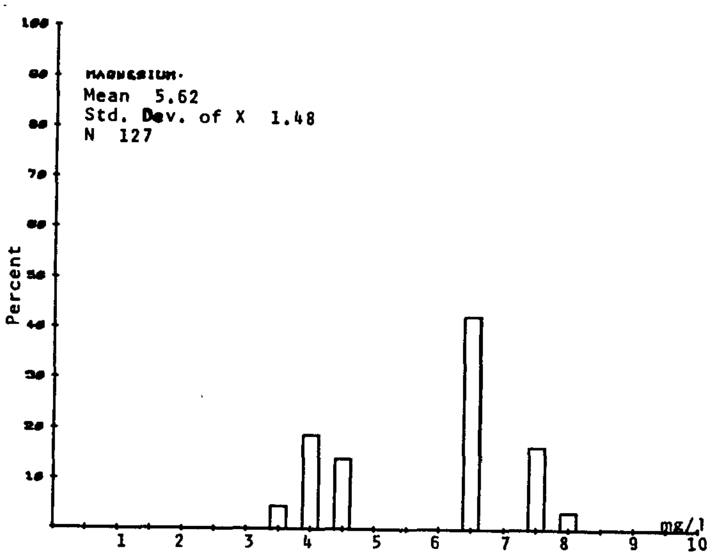


Figure 4.17a Histograms for Magnesium - Cruise 5

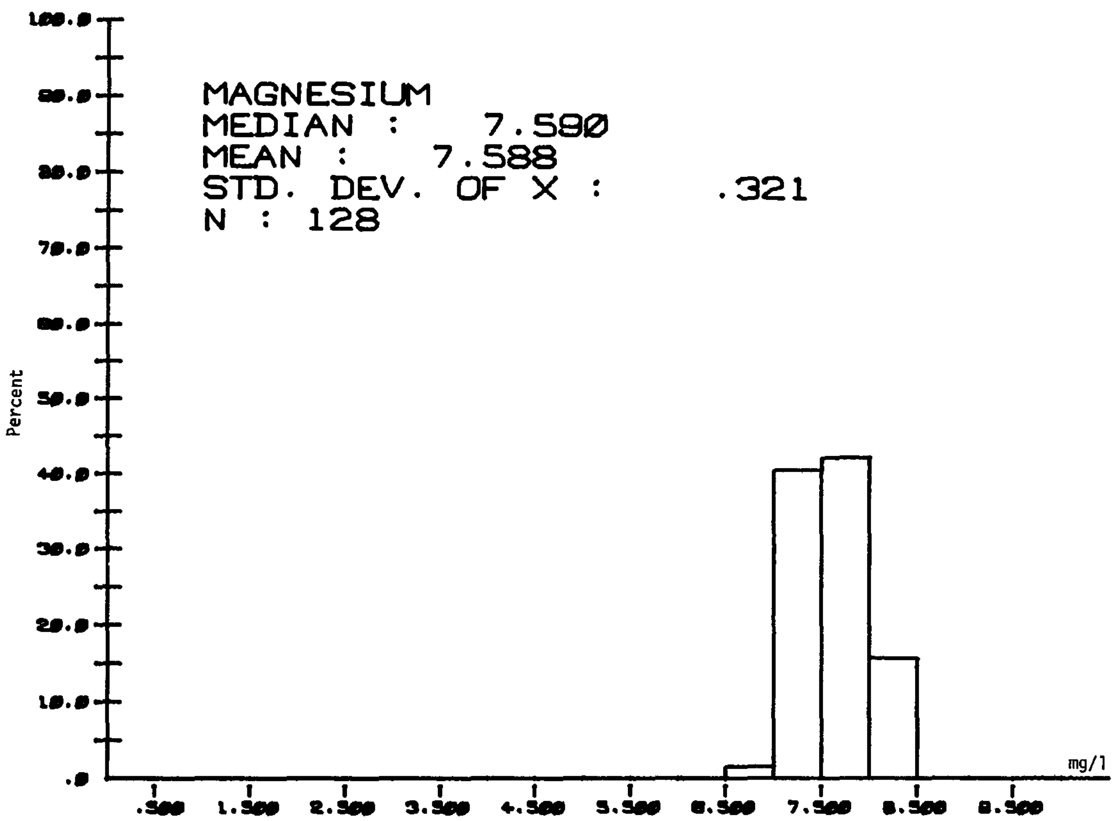


Figure 4.17a Histograms for Magnesium - Cruise 6

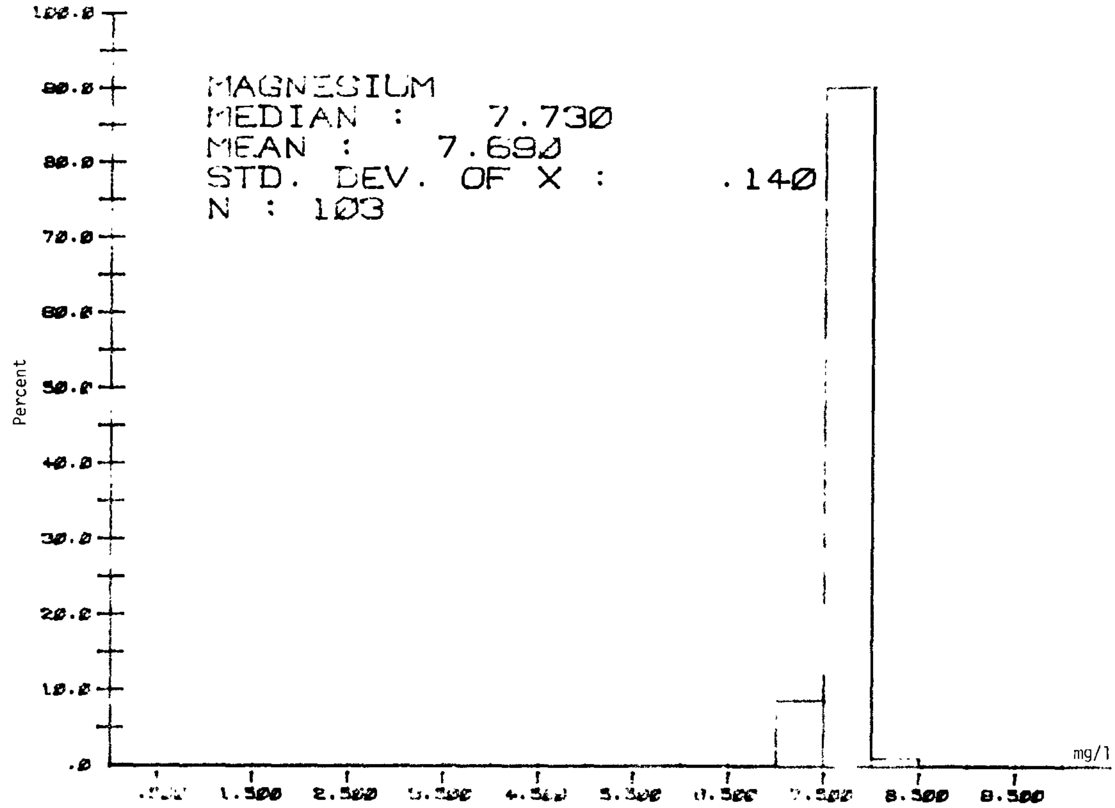


Figure 4.17a Histograms for Magnesium - Cruise 7

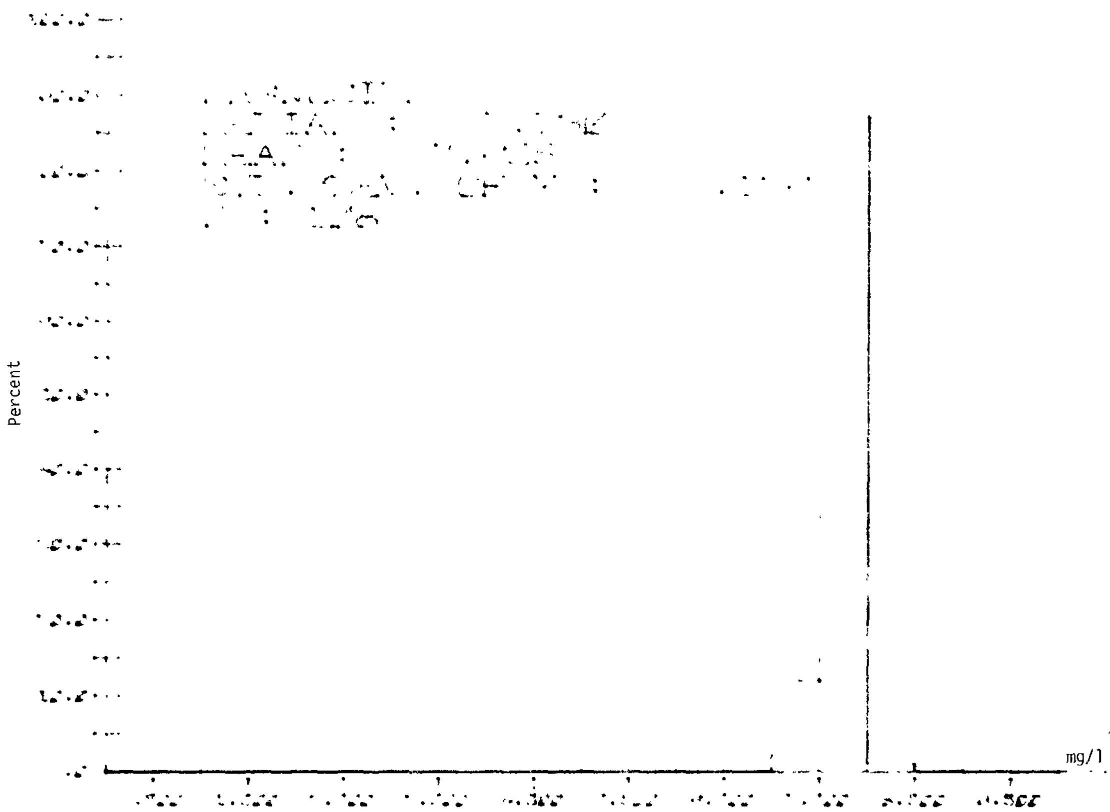


Figure 4.17a Histograms for Magnesium - Cruise 8

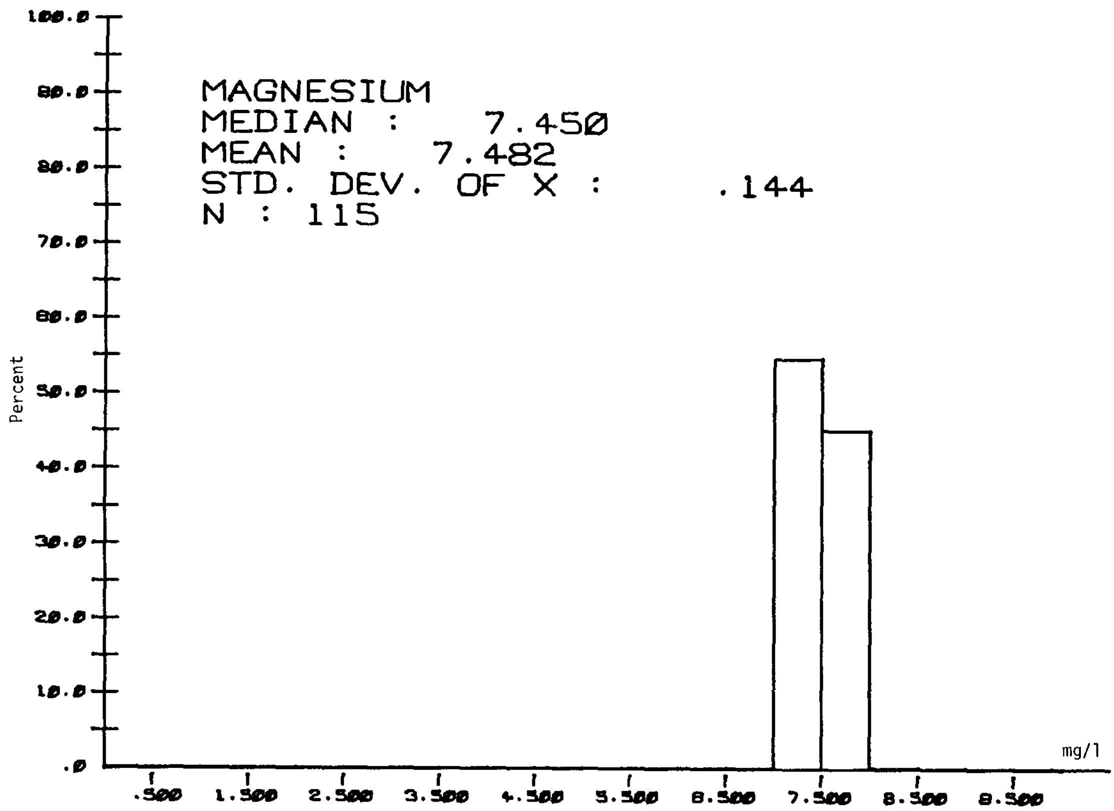


Figure 4.17a Histograms for Magnesium - Cruise 9

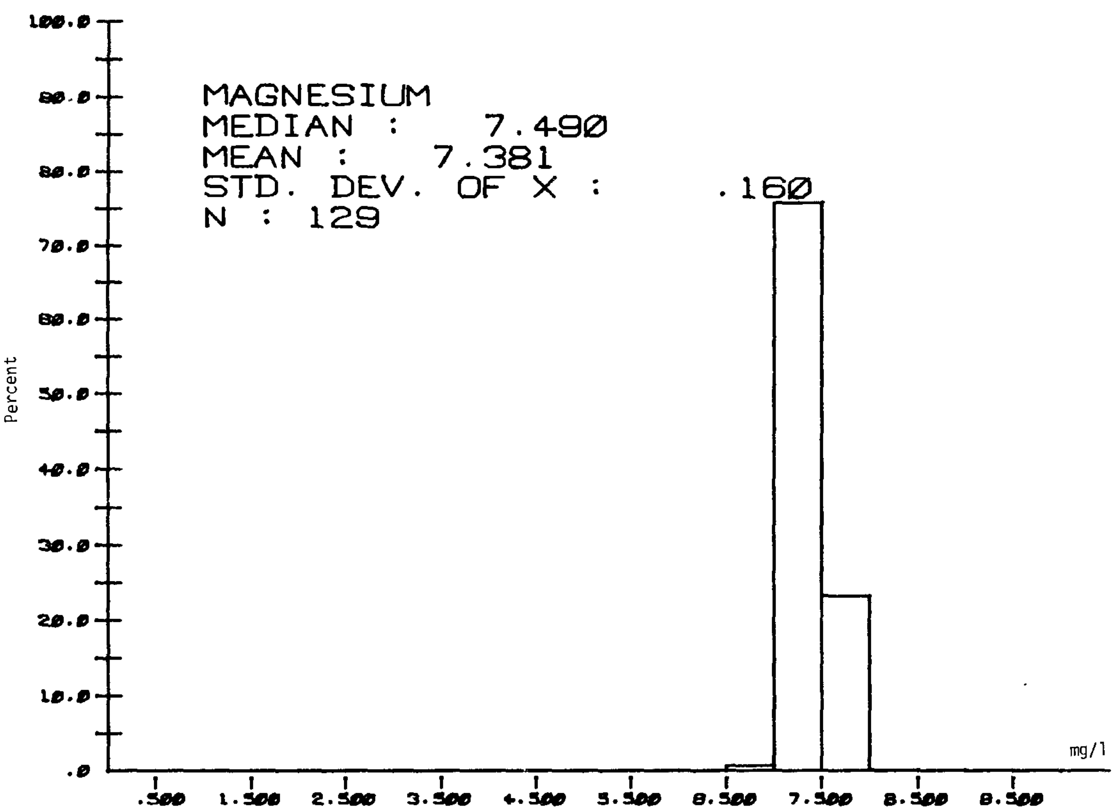


Figure 4.17a Histograms for Magnesium - Cruise 11

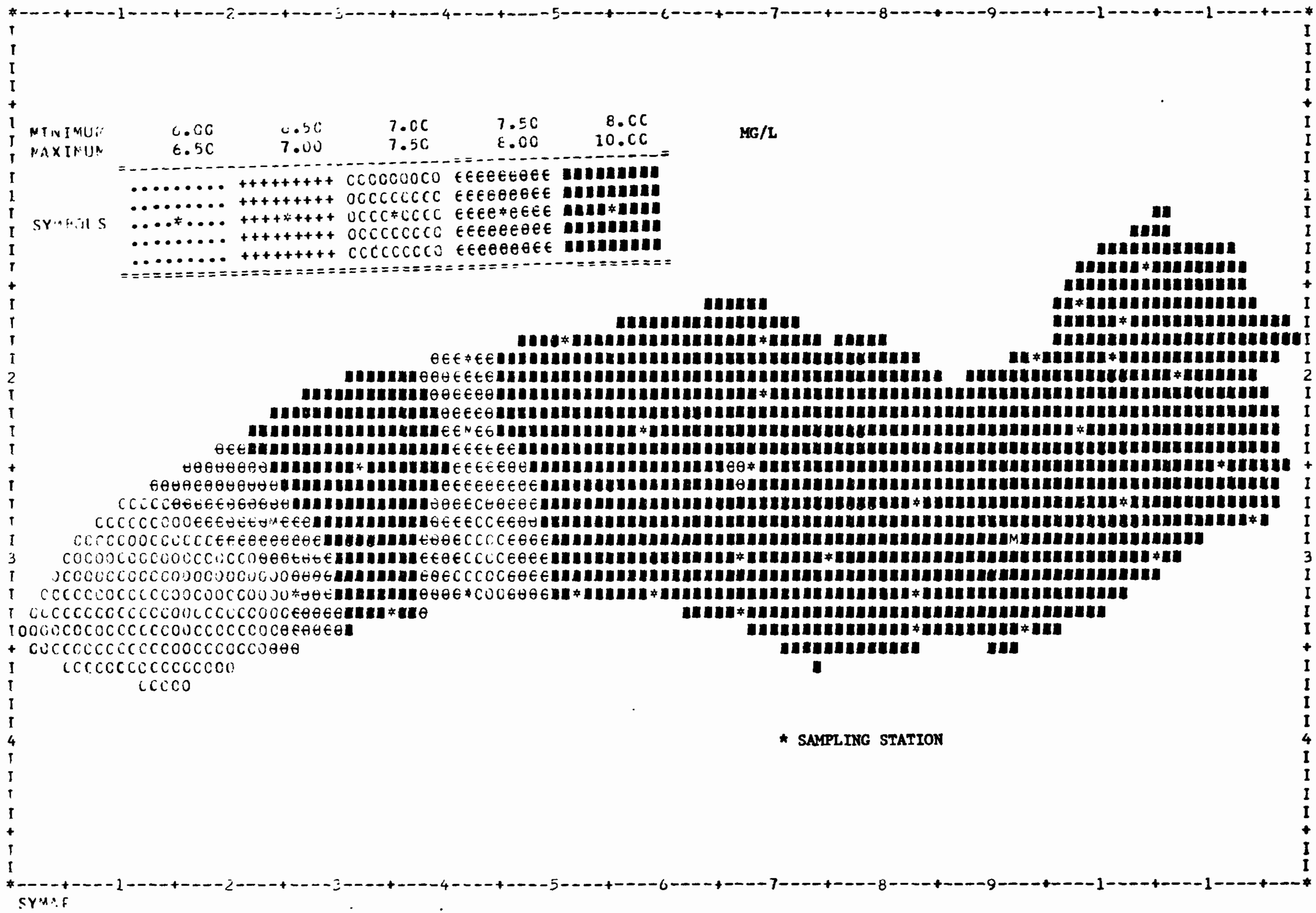


Figure 4.17b Contours of Constant Surface Magnesium

CRUISE NUMBER 2: MAY 15, 1972 TO MAY 19, 1972

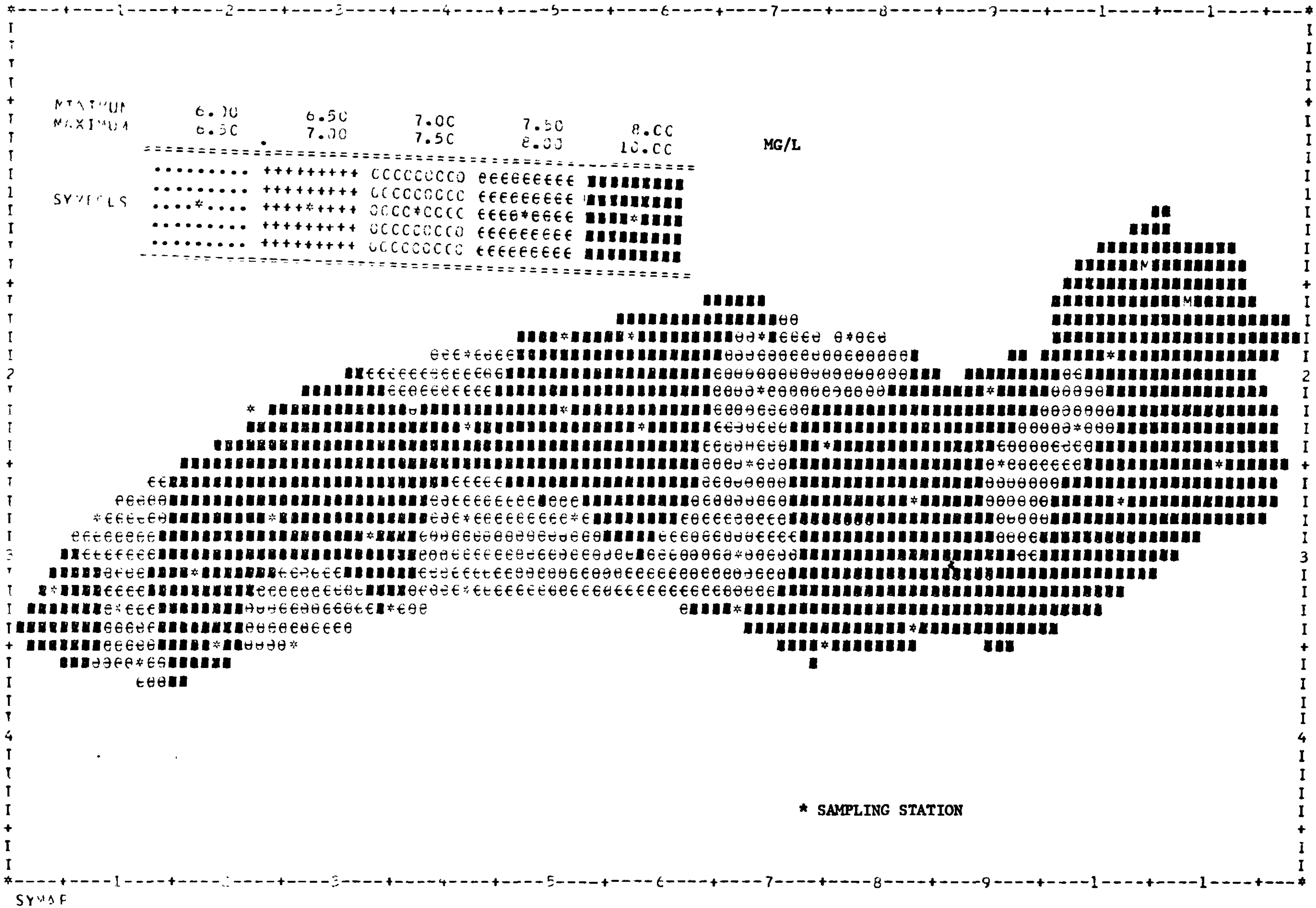


Figure 4.17b Contours of Constant Surface Magnesium

CRUISE NUMBER 3: JUN 12, 1972 TO JUNE 16, 1972

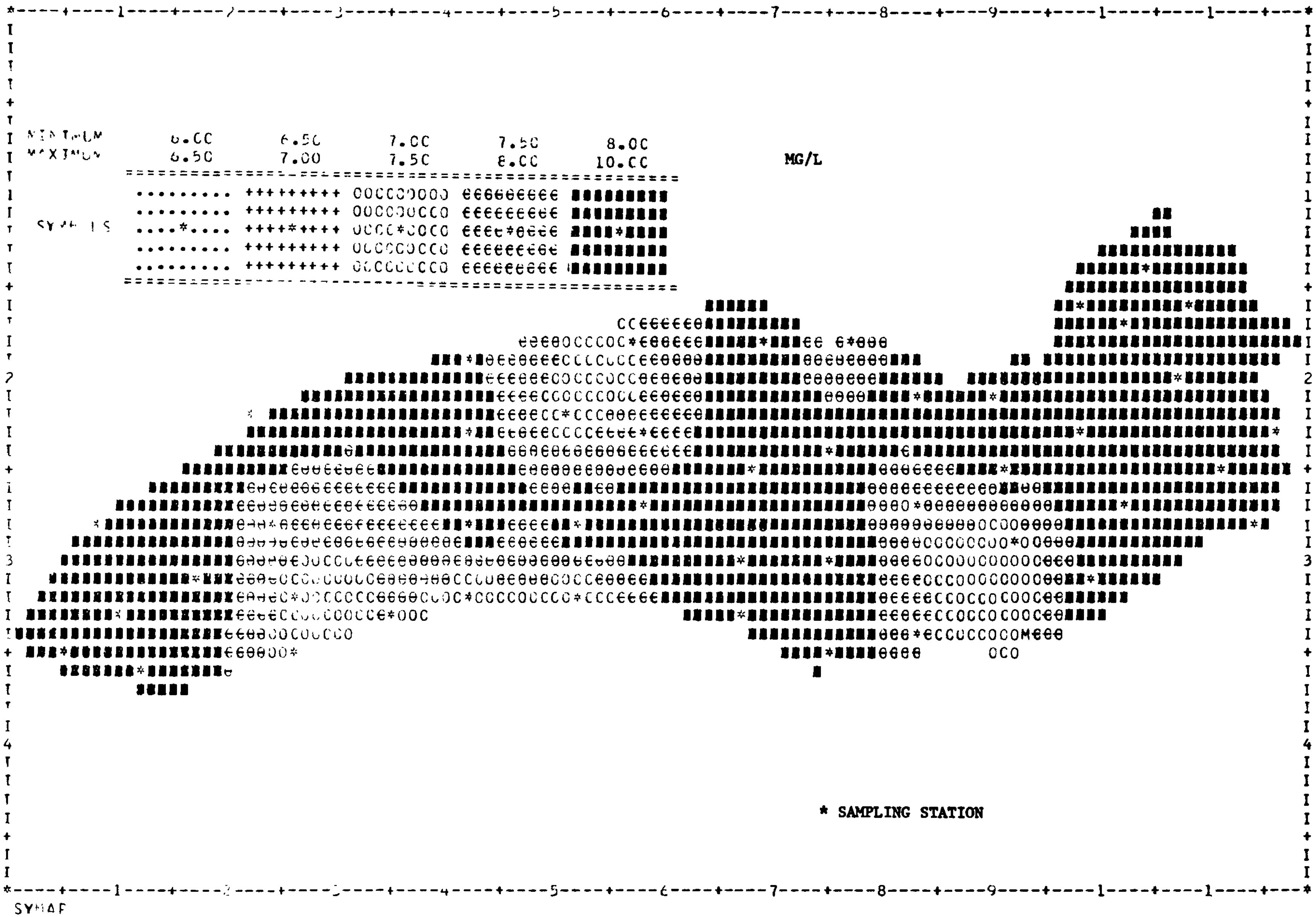


Figure 4.17b Contours of Constant Surface Magnesium

CRUISE NUMBER 4: JULY 10, 1972 TO JULY 14, 1972

Figure 4.17b Contours of Constant Surface Magnesium

[illegible] AUGUST 21, 1972 T[illegible] UGUST 22, 1972

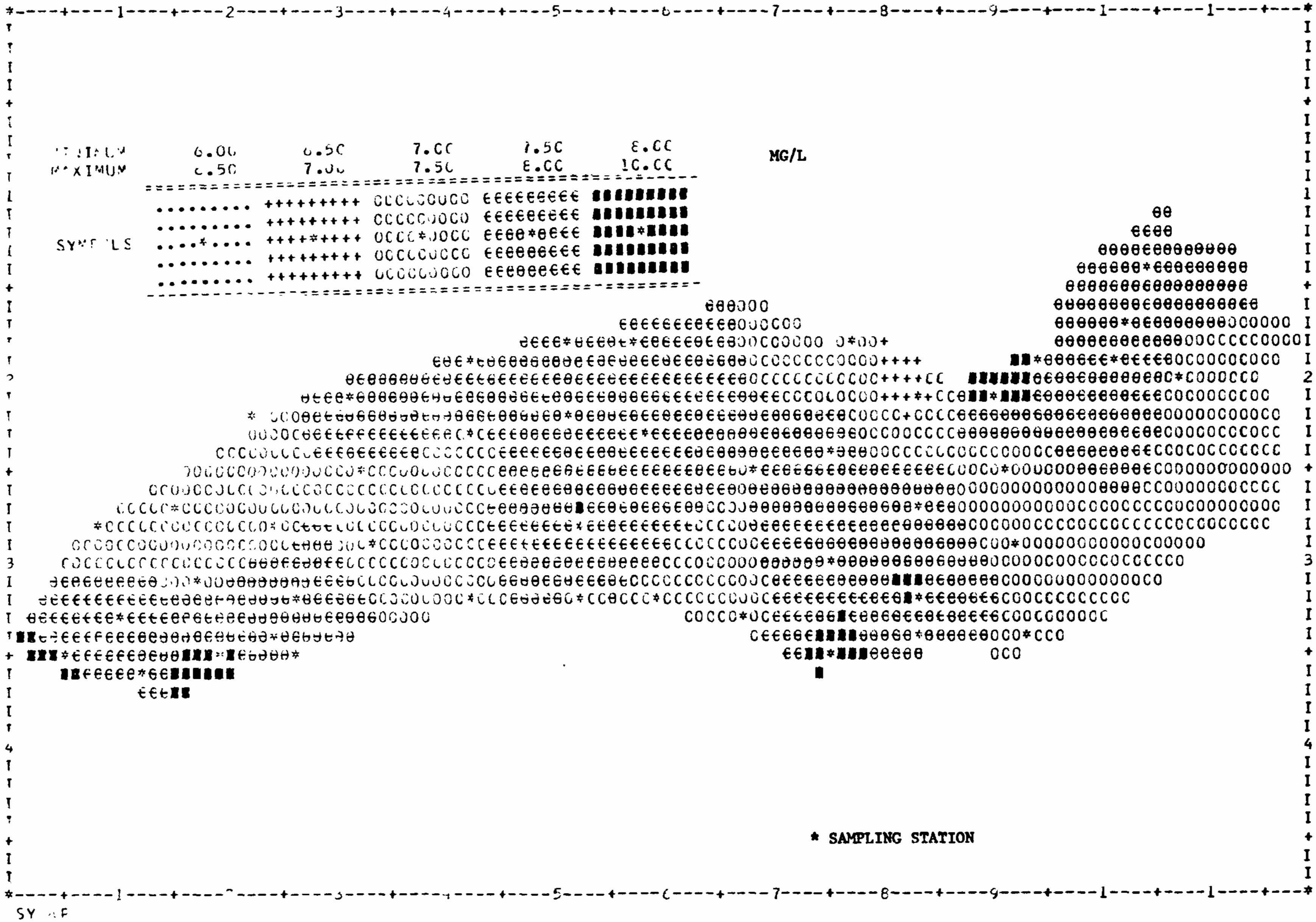


Figure 4.17b Contours of Constant Surface Magnesium

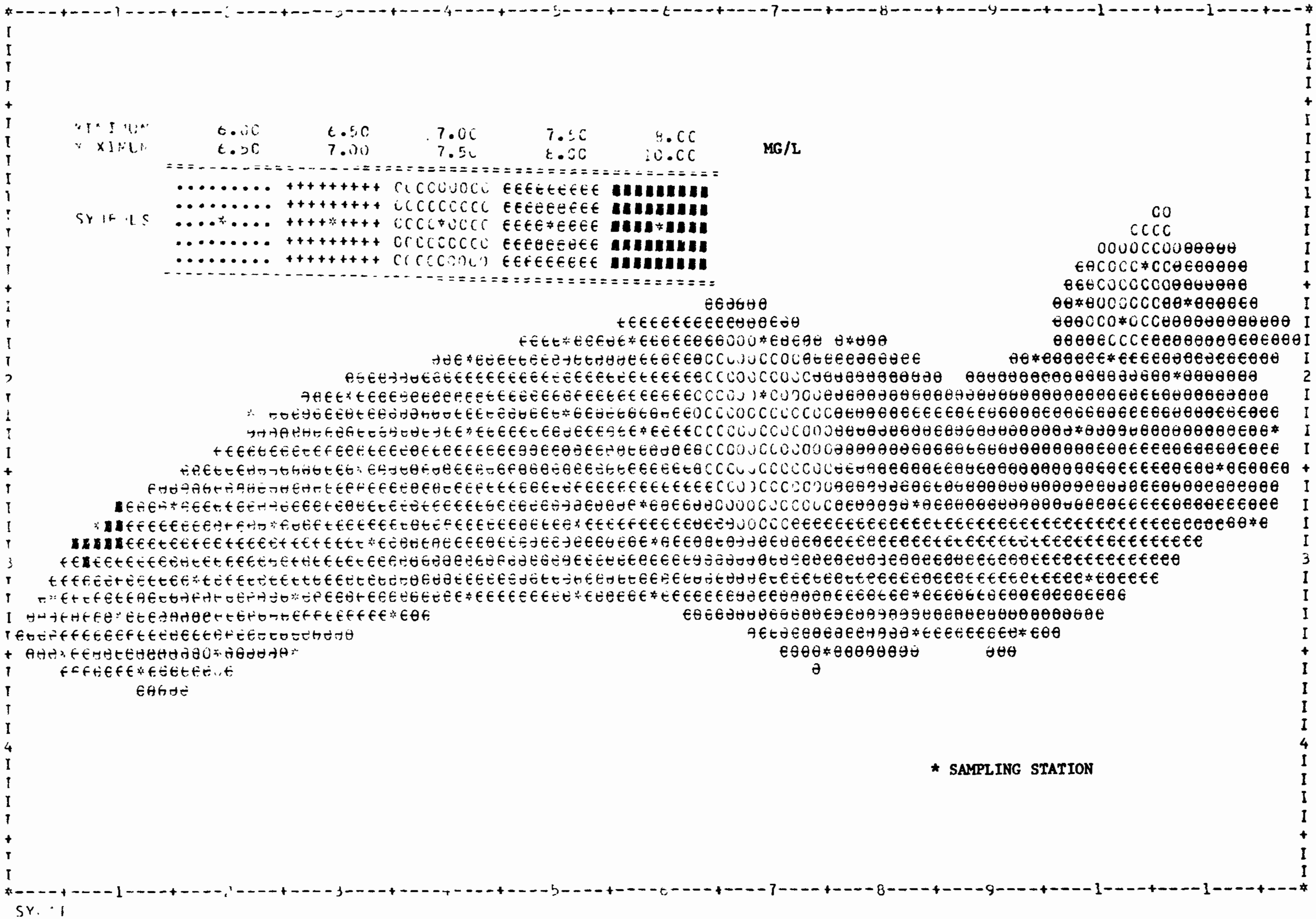


Figure 4.17b Contours of Constant Surface Magnesium

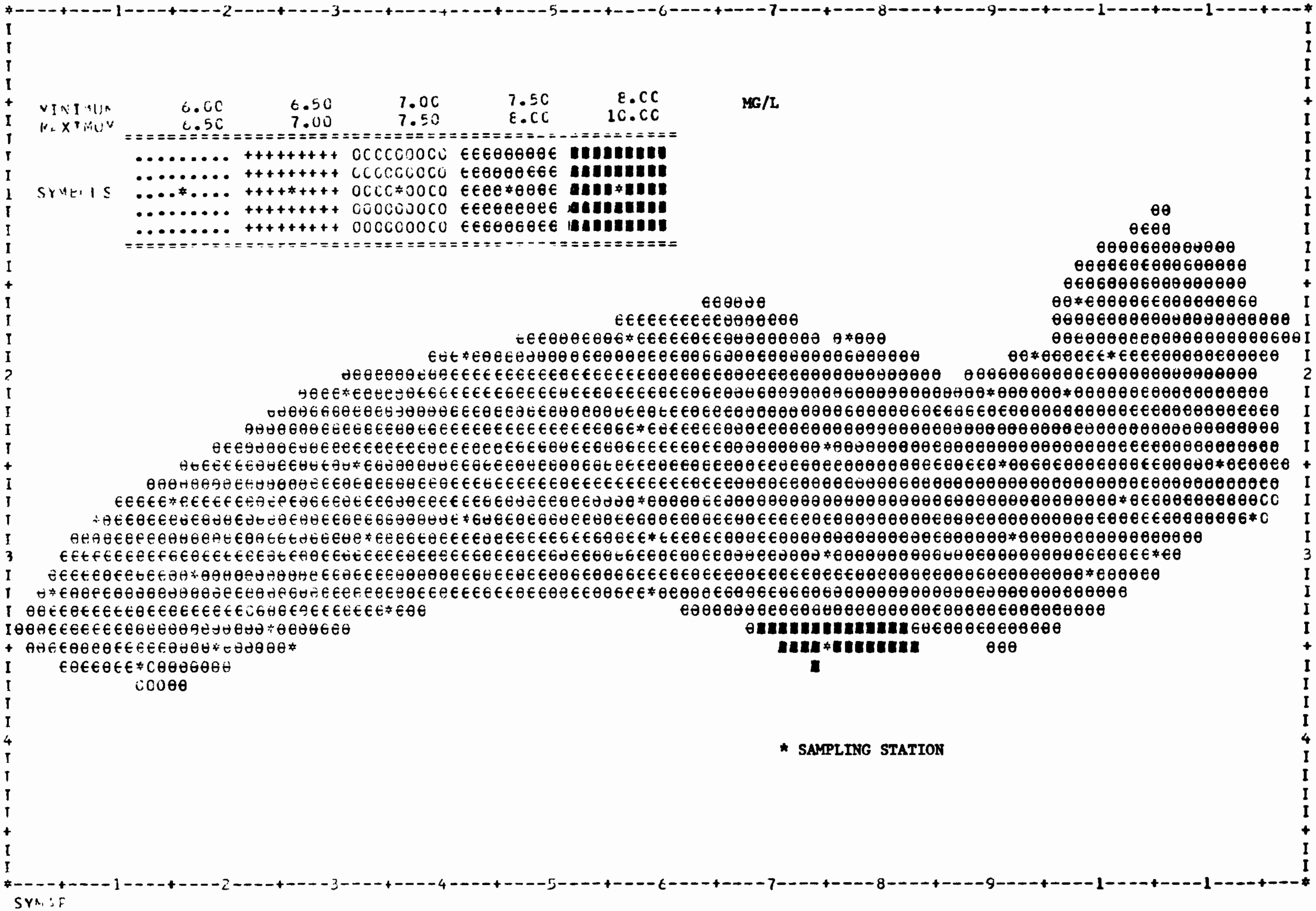


Figure 4.17b Contours of Constant Surface Magnesium

CRUISE NUMBER 8: FEBRUARY 5, 1973 TO FEBRUARY 9, 1973

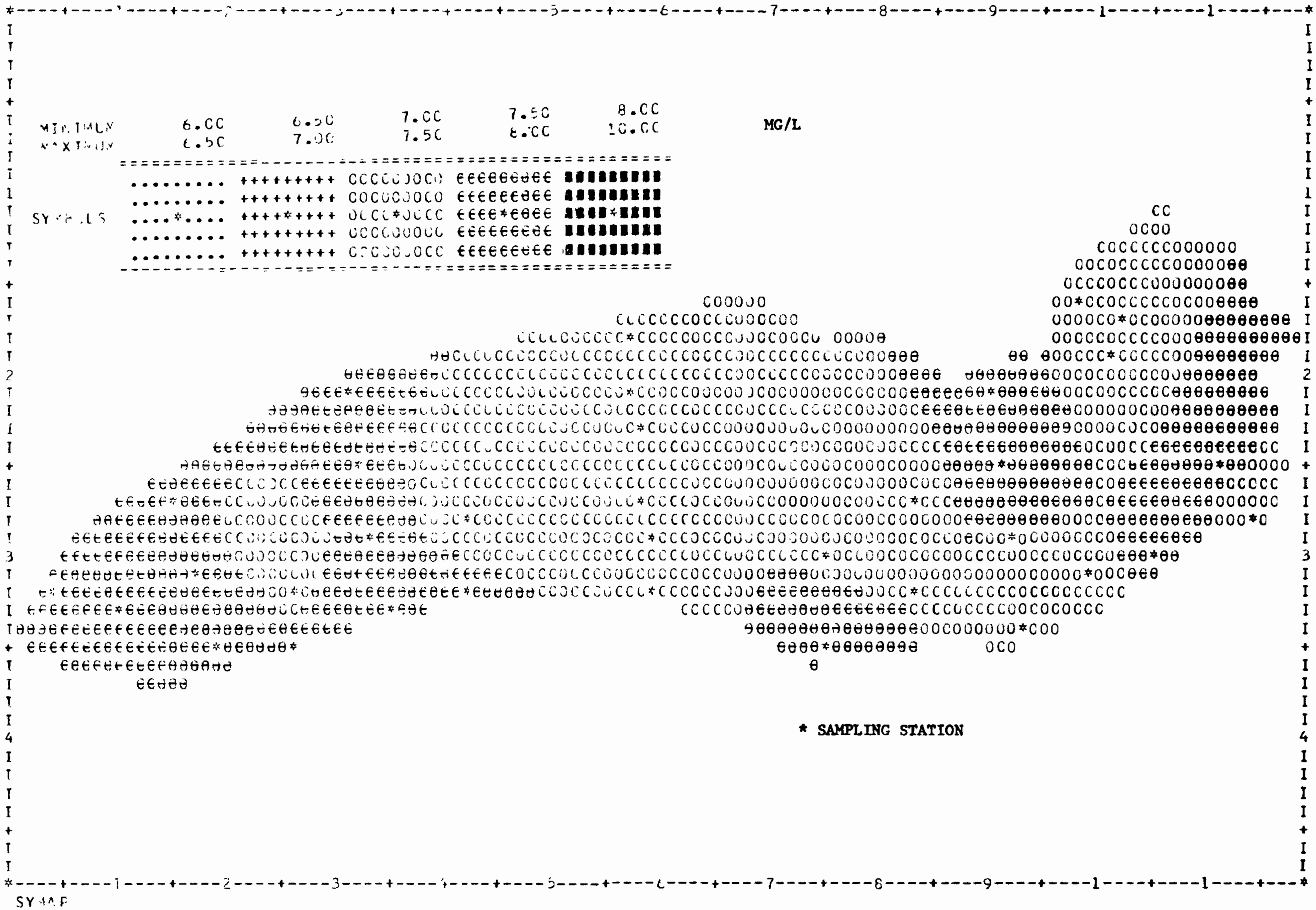


Figure 4.17b Contours of Constant Surface Magnesium

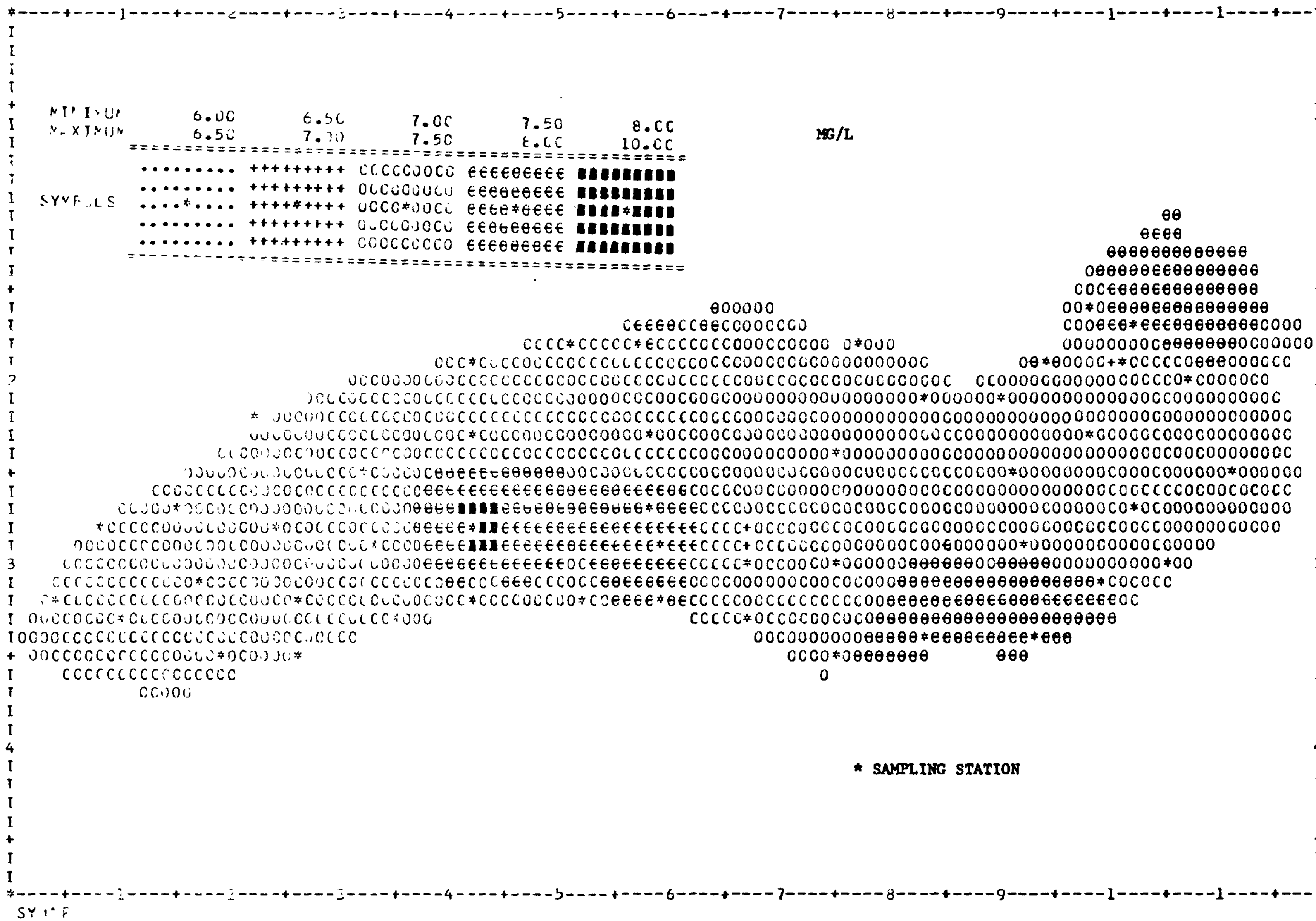


Figure 4.17b Contours of Constant Surface Magnesium

CRUIS NUMB 11: JUN 11, 1973 TO JUN 15, 1973

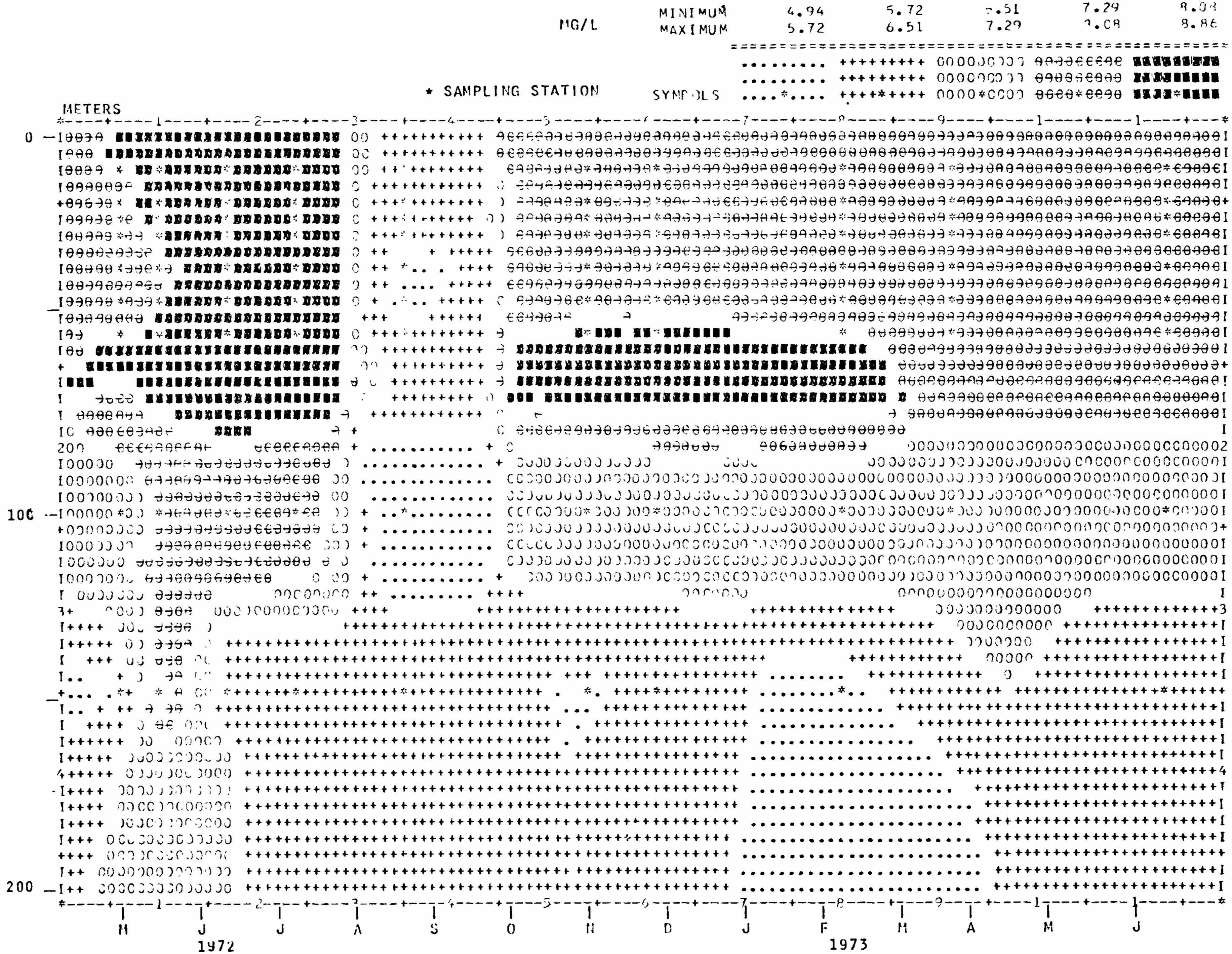


Figure 4.17c Depth Versus Time Contours of Constant Magnesium

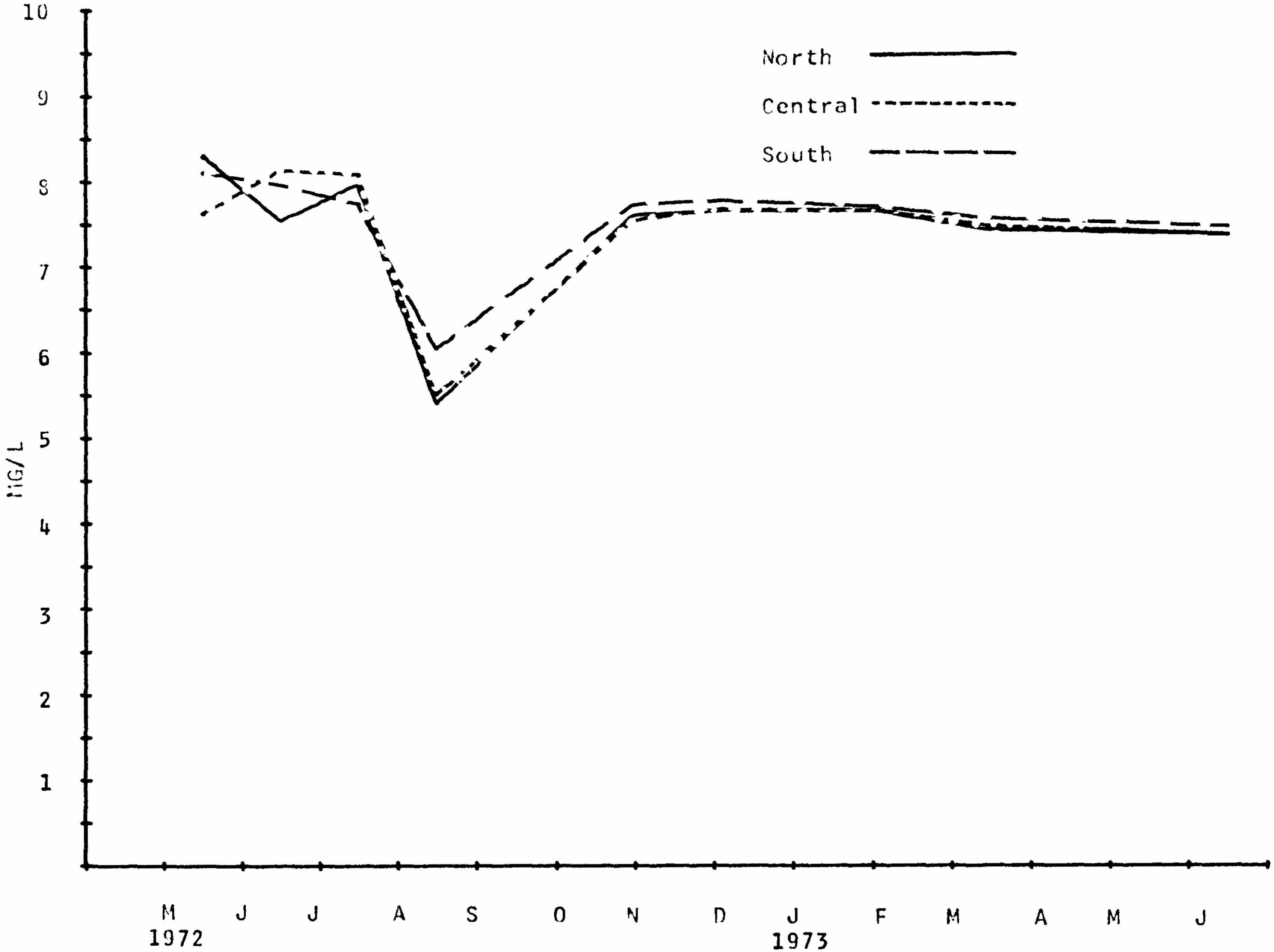


Figure 4.17d North-south variation of magnesium

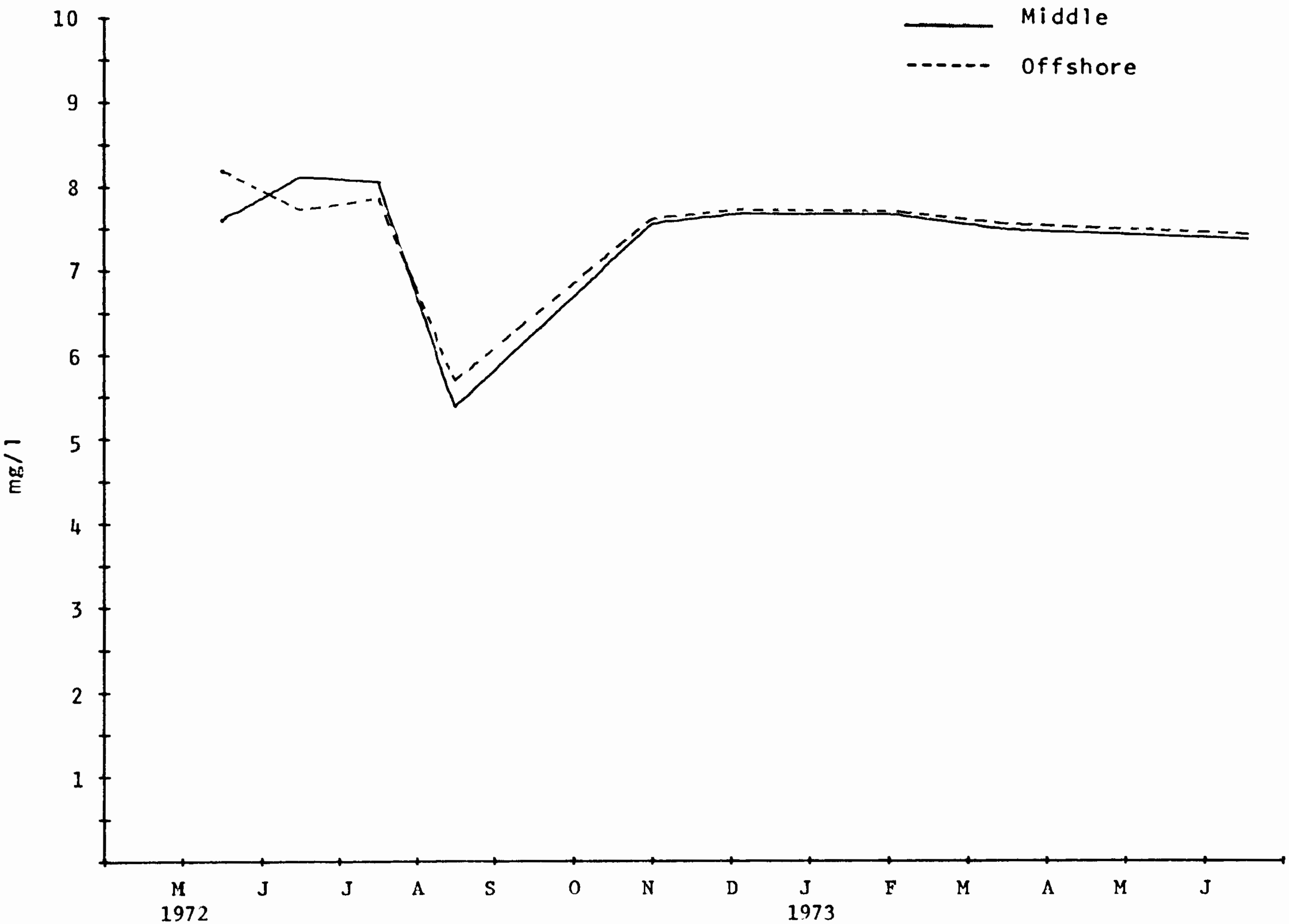


Figure 4.17e Middle Lake-Offshore Variations of Mean Magnesium Concentration

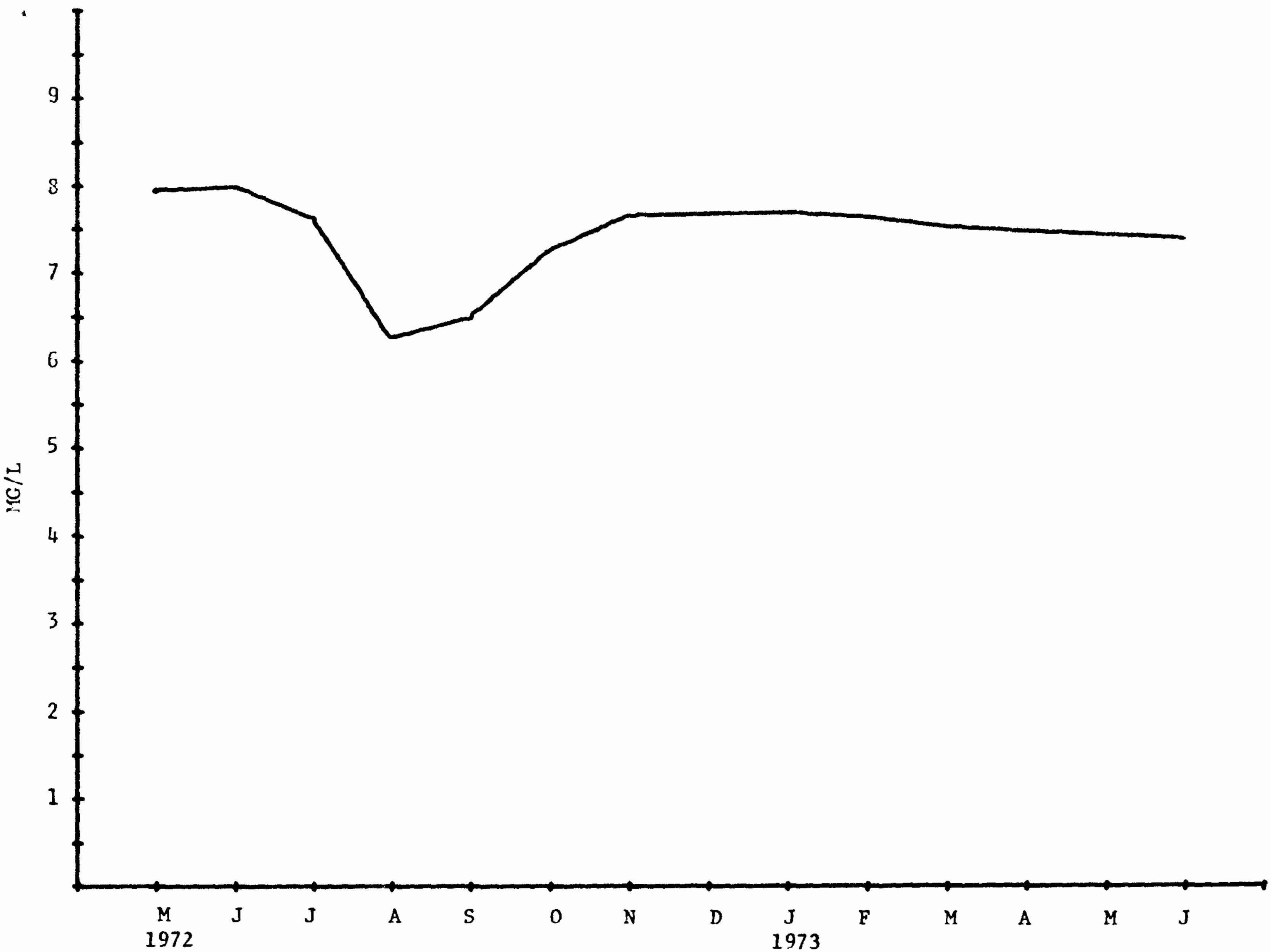


Figure 4.17f Mean surface variation of Magnesium concentration during the field year.

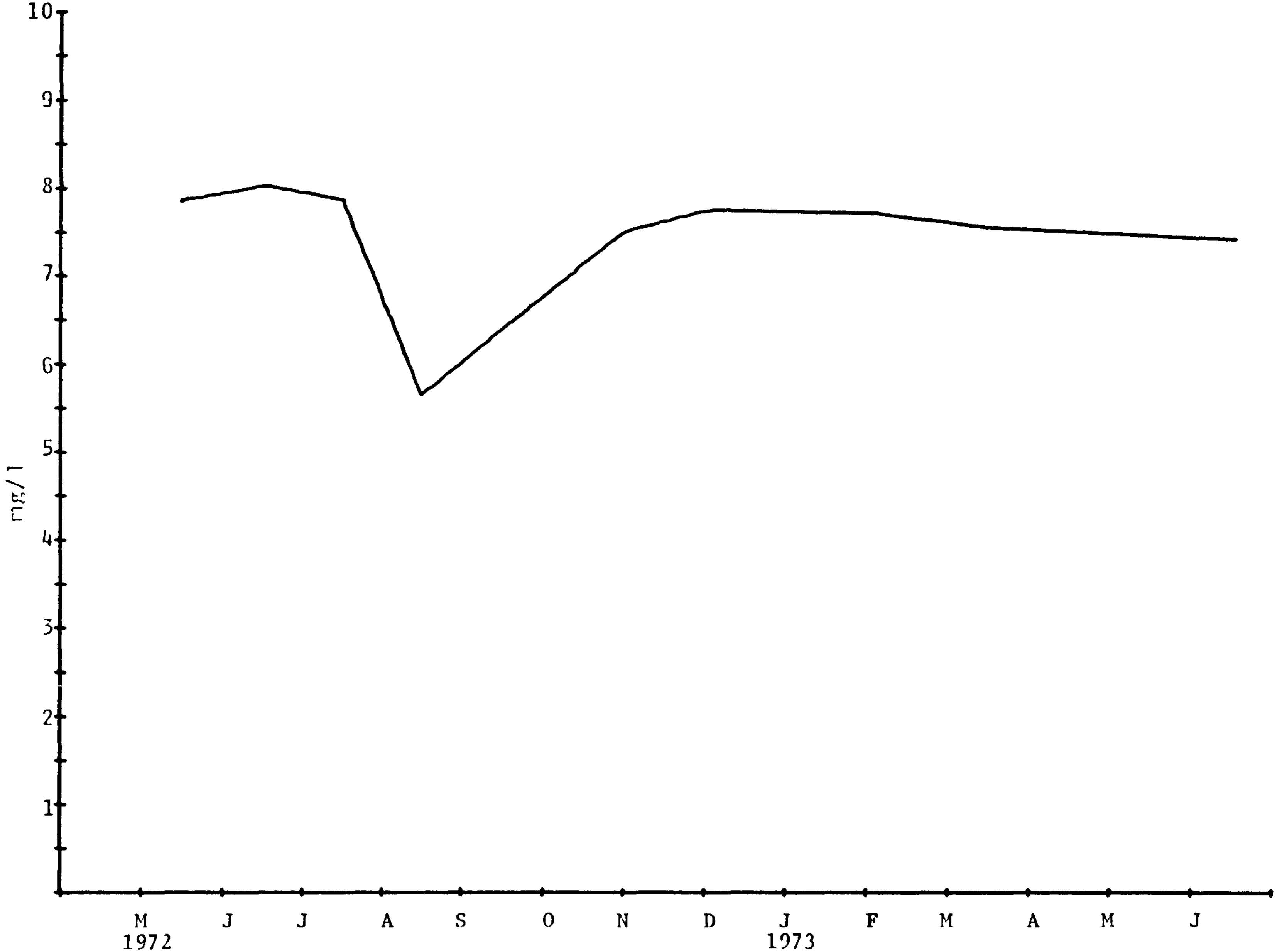


Figure 4.17g Mean Bottom Variation of Magnesium Concentration During the Field Year

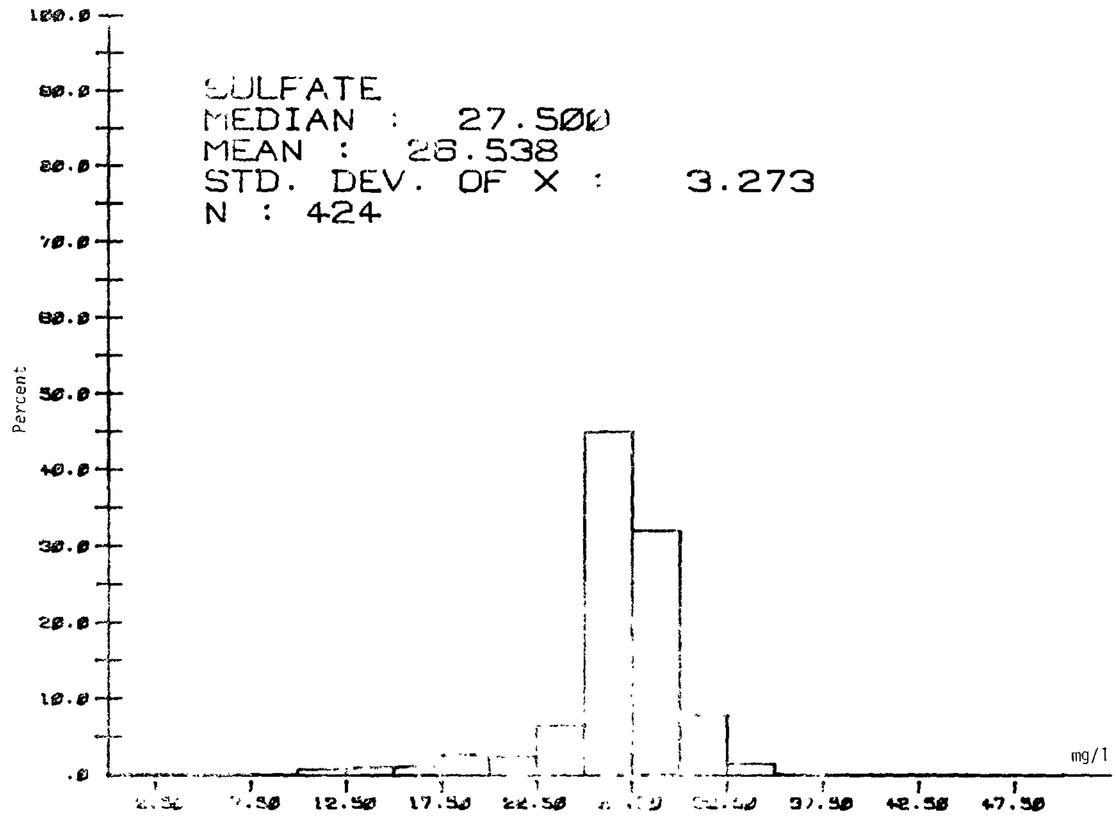


Figure 4.18a Histograms for Sulfate - Cruise 6

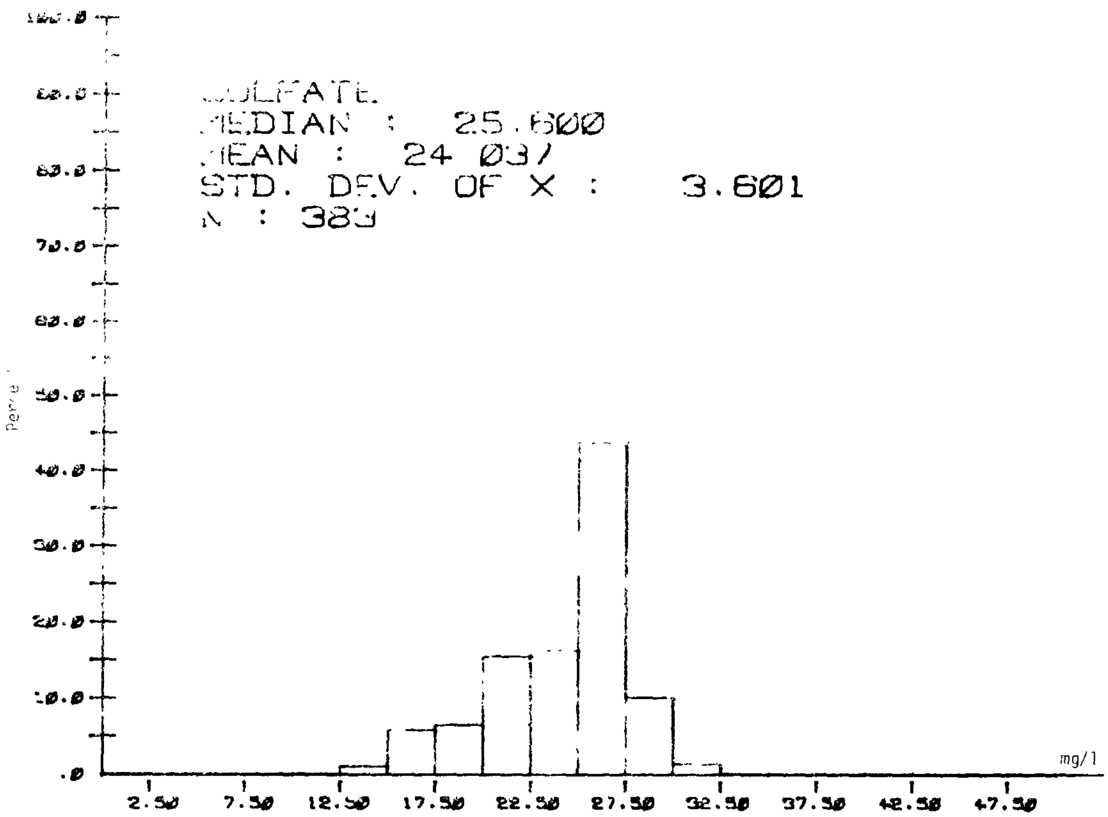


Figure 4.18a Histograms for Sulfate - Cruise 7

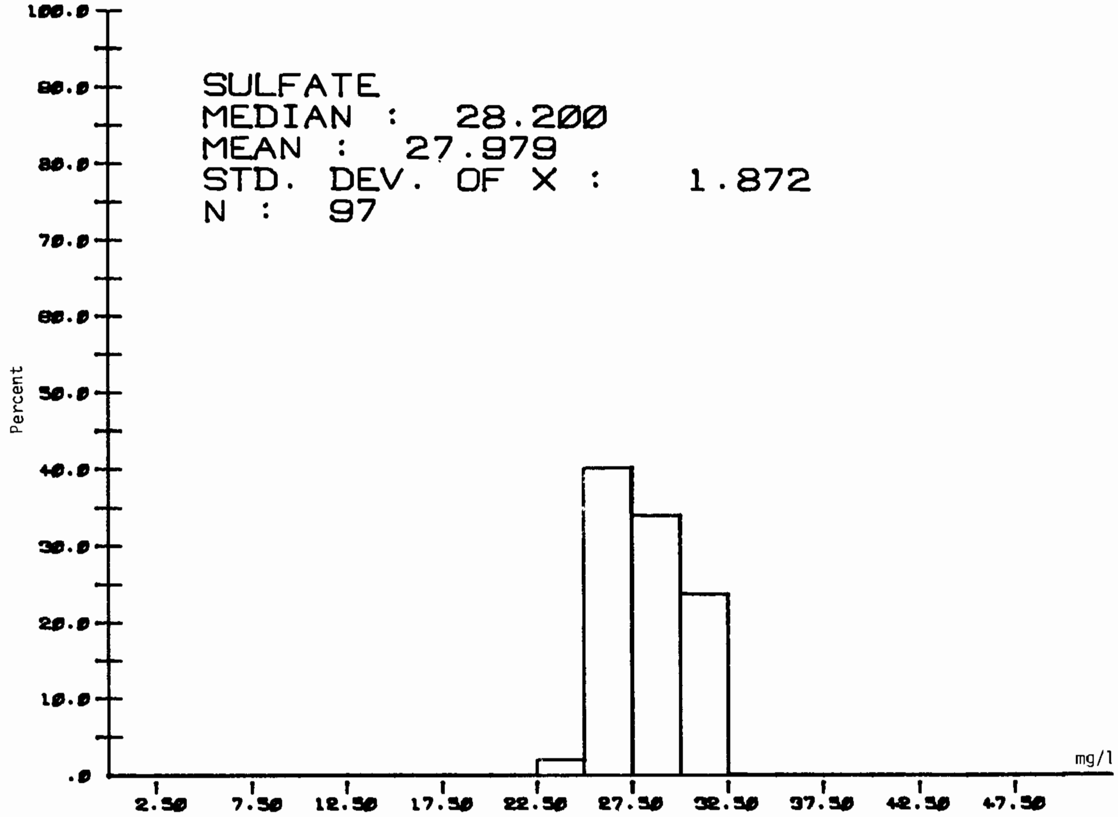


Figure 4.18a Histograms for Sulfate - Cruise 8

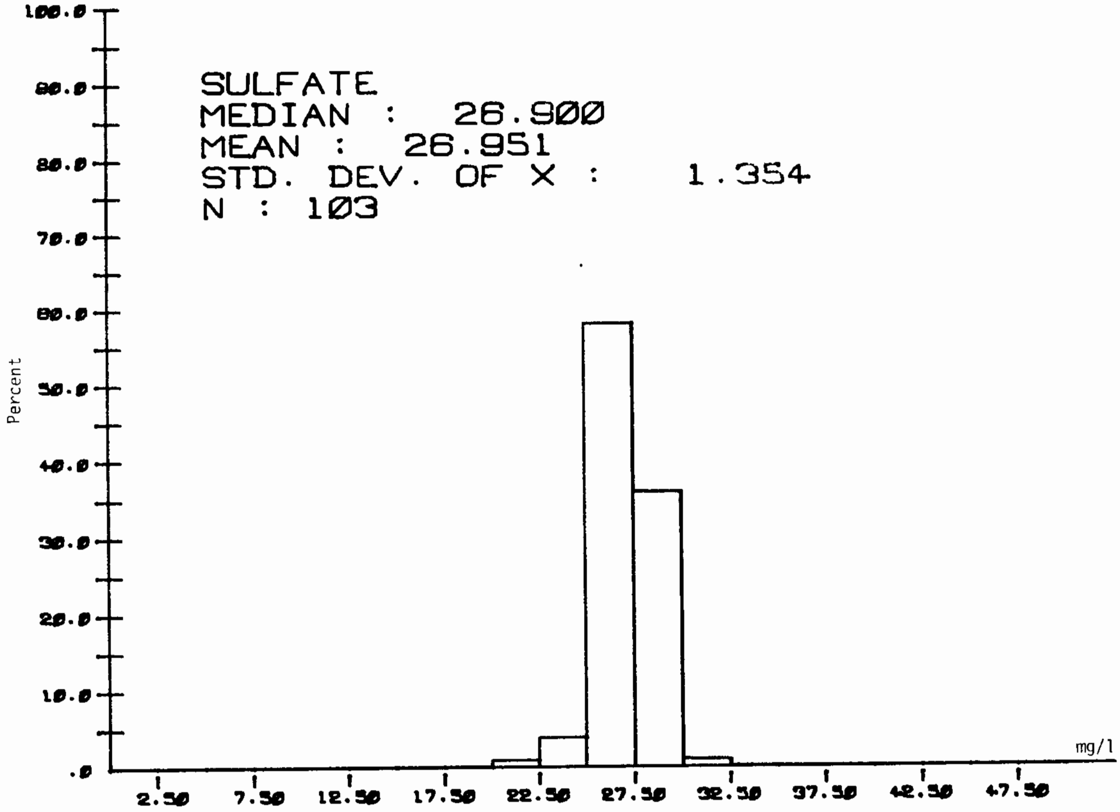


Figure 4.18a Histograms for Sulfate - Cruise 9

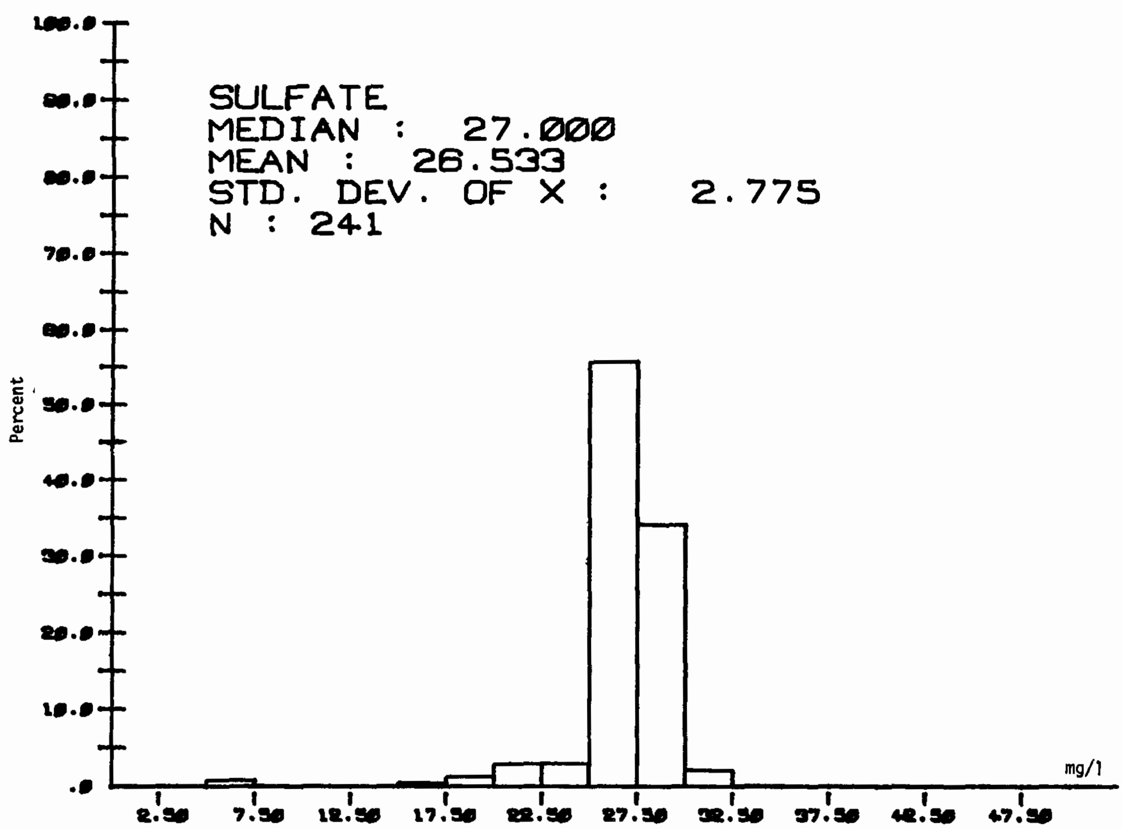


Figure 4.18a Histograms for Sulfate - Cruise 10

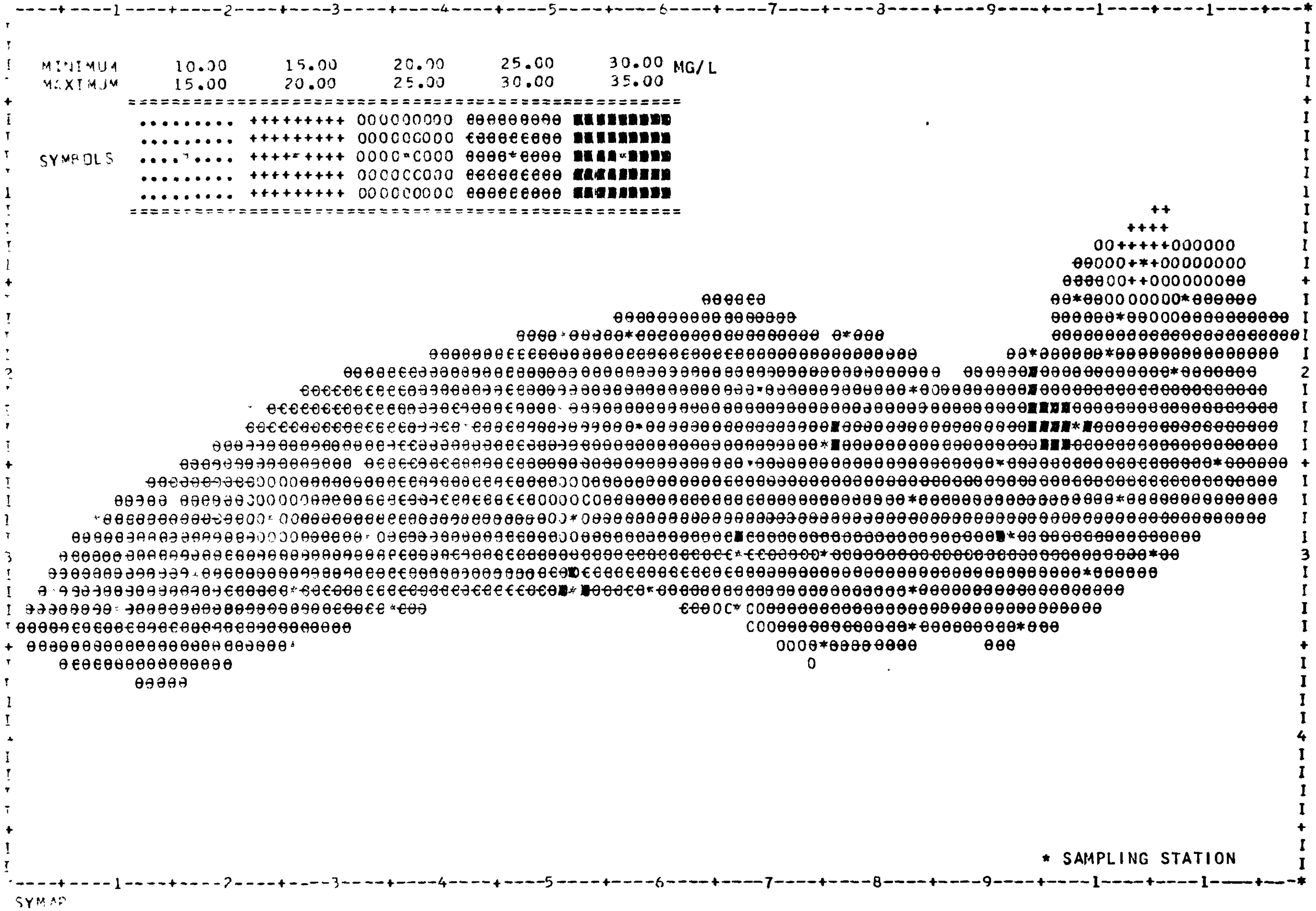


Figure 4.18b Contours of Constant Surface Sulfate

CRUISE NUMBER 4: OCTOBER 30, 1972 TO NOVEMBER 3, 1972

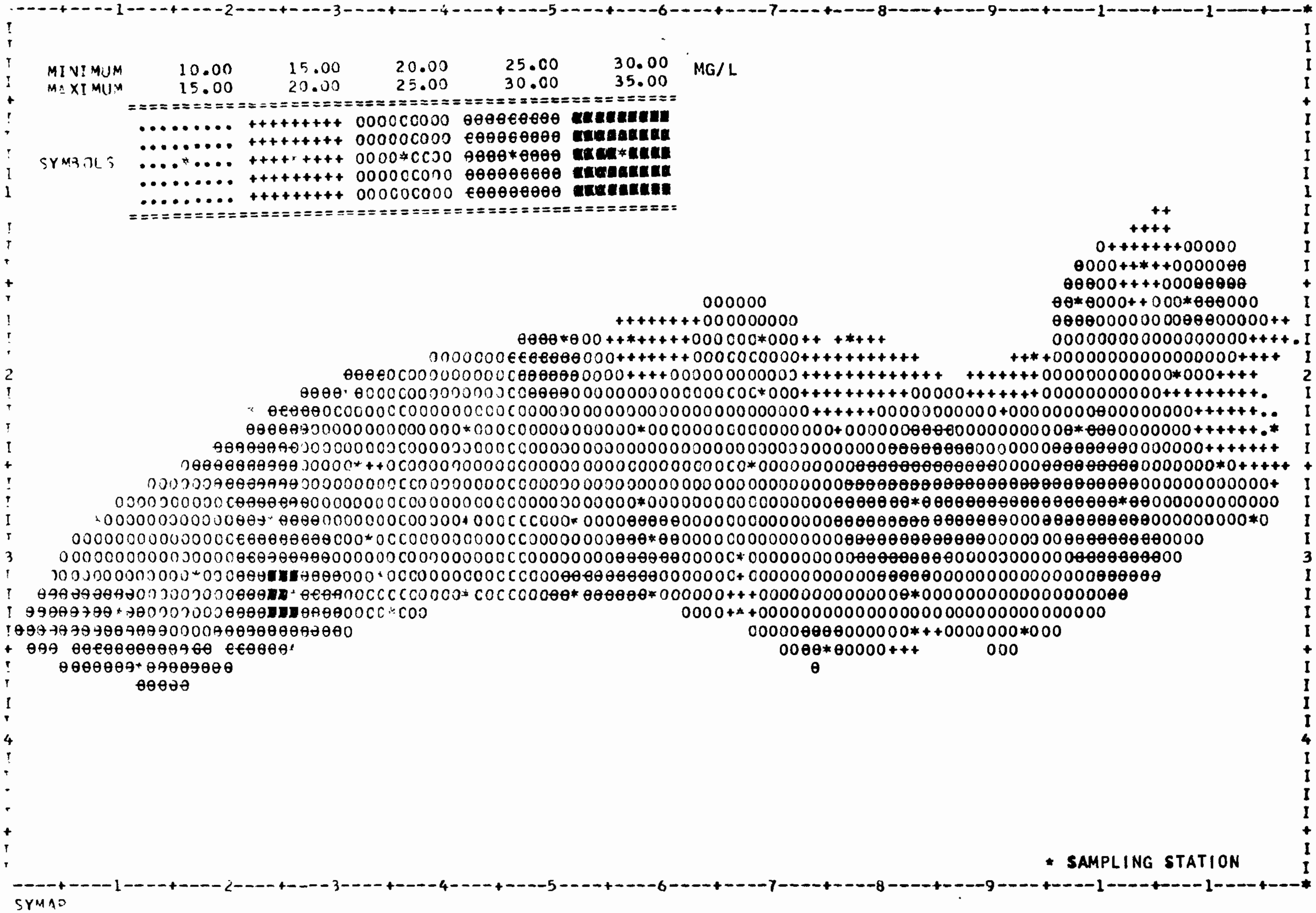


Figure 4.18b Contours of Constant Surface Sulfate

CRUISE NUMBER 7: NOVEMBER 27, 1972 TO DECEMBER 2, 1972

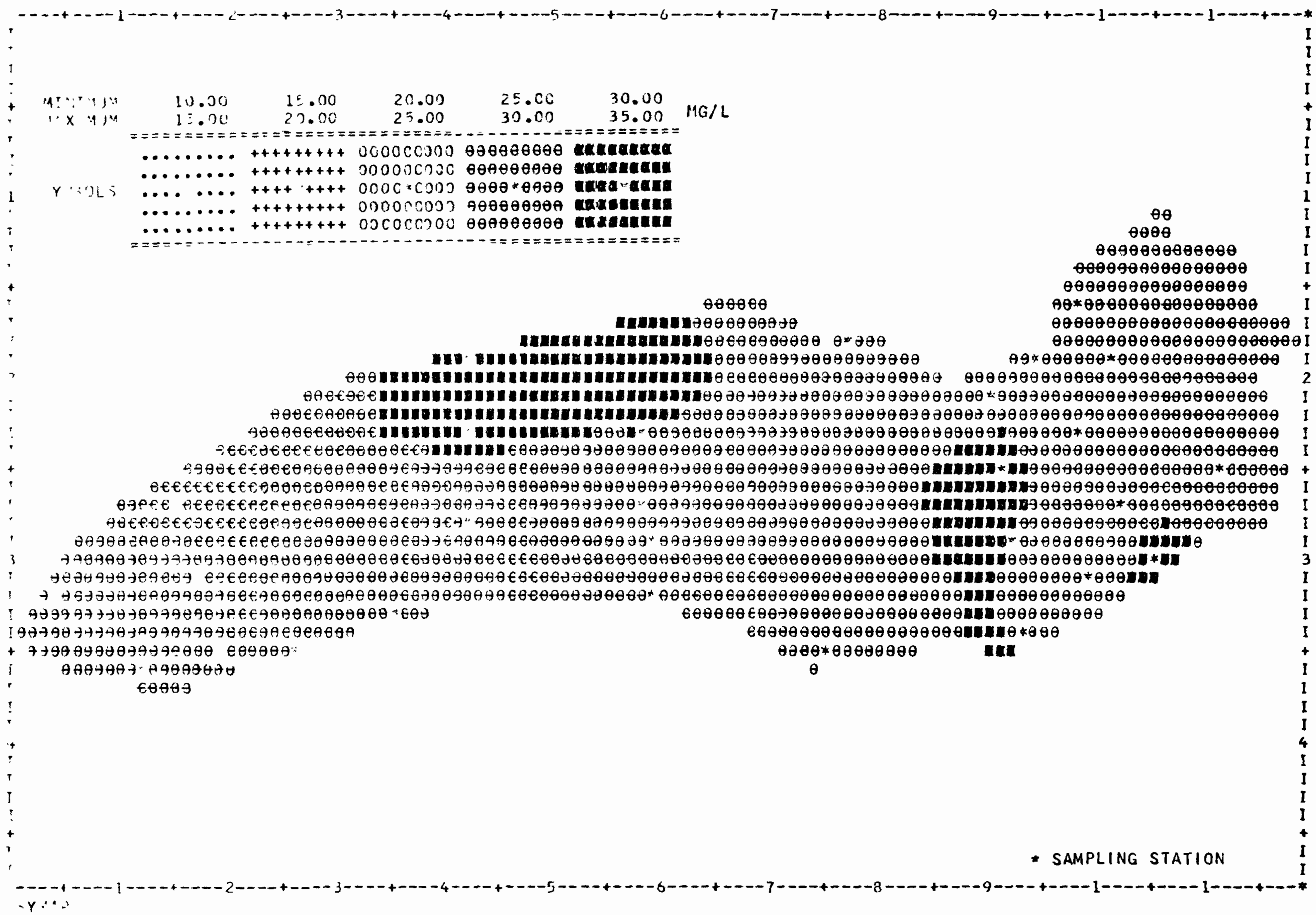


Figure 4.18b Contours of Constant Surface Sulfate

CRUISE NUMBER : FEBRUARY 5, 1973 TO FEBRUARY 5, 1973

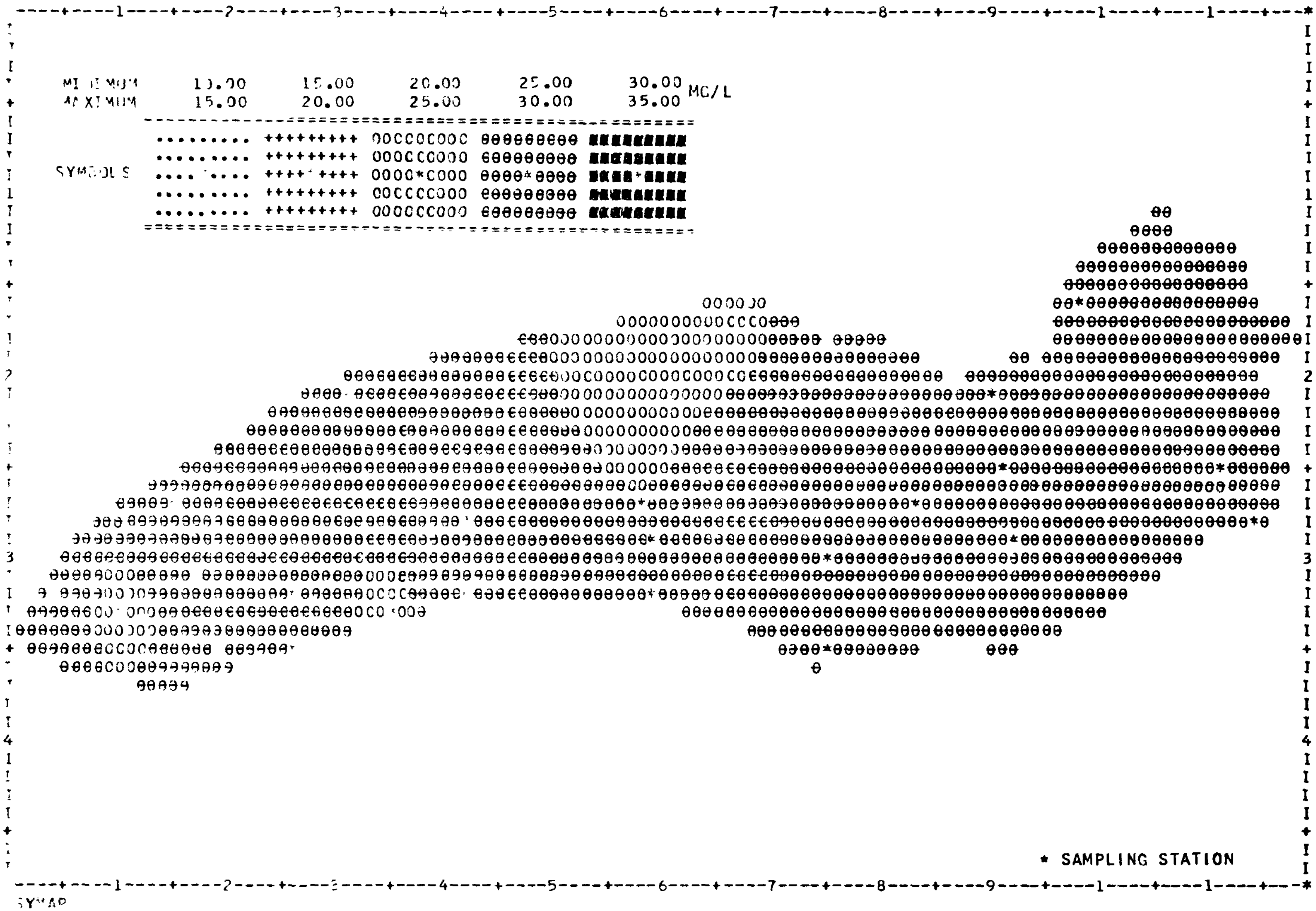


Figure 4.18b Contours of Constant Surface Sulfate

CRUISE NUMBER 9: MARCH 16, 1973 TO MARCH 23, 1973

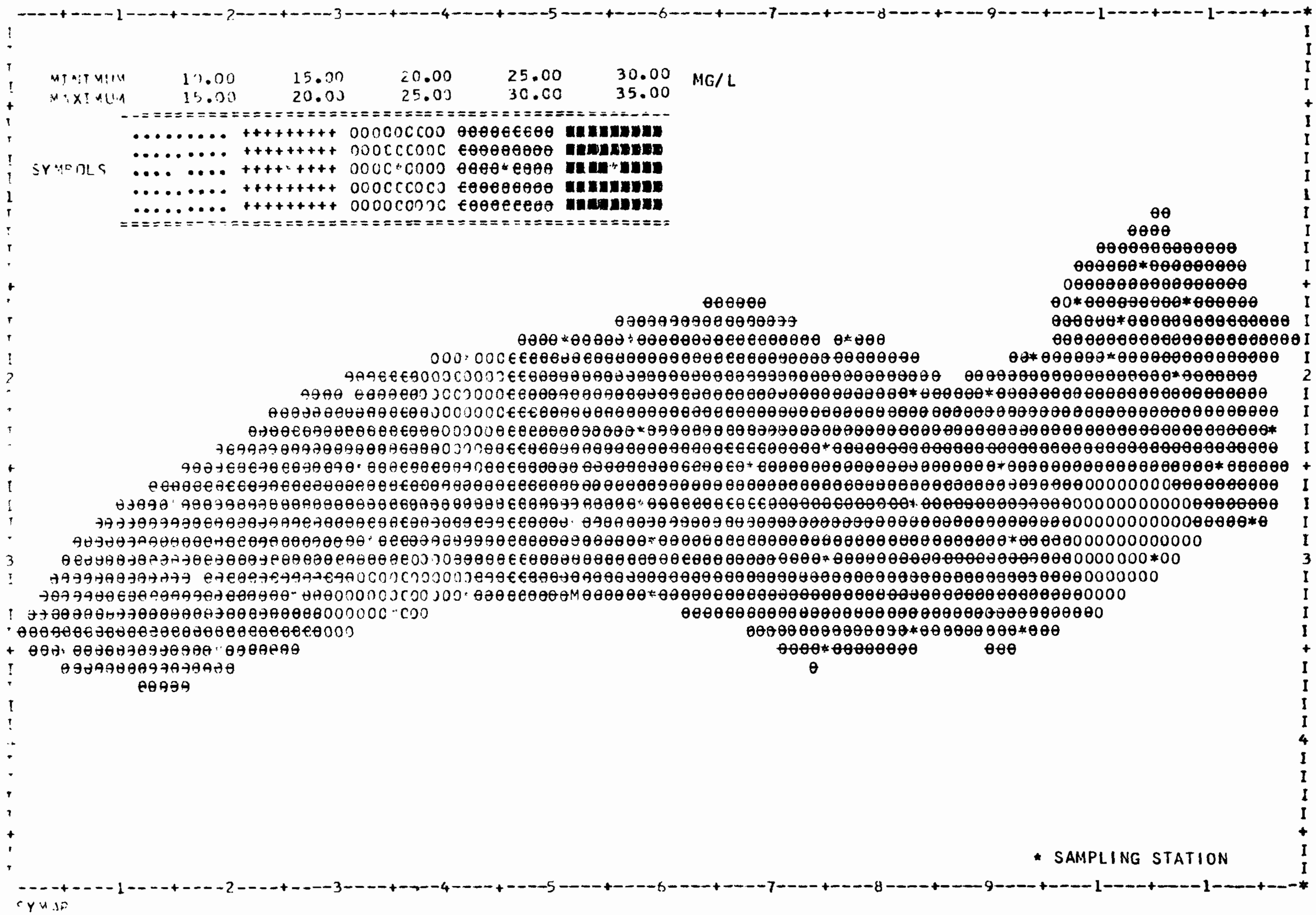


Figure 4.18b Contours of Constant Surface Sulfate

CRUISE NUMBER 10: APRIL 24, 1973 TO APRIL 30, 1973

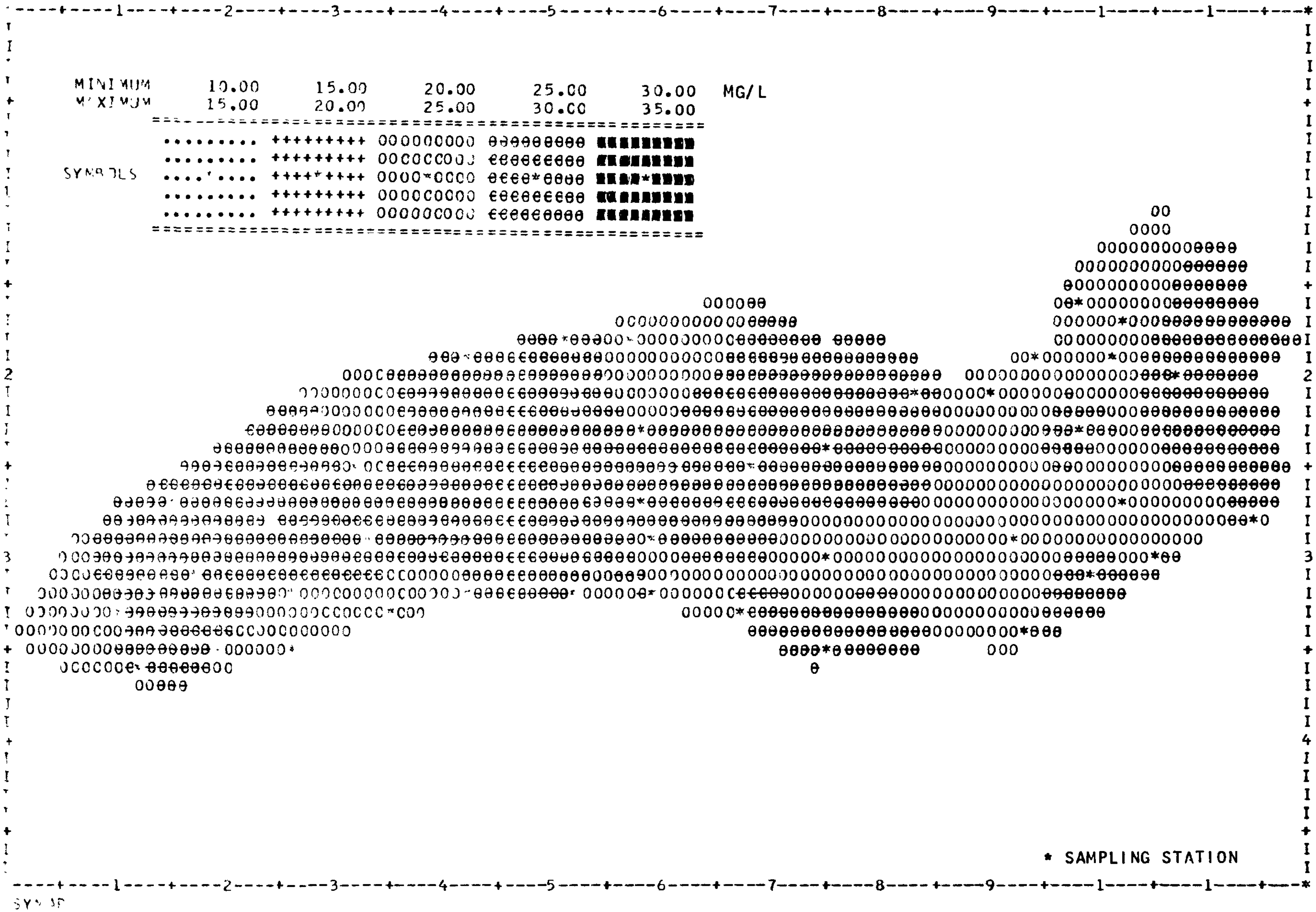


Figure 4.18b Contours of Constant Surface Sulfate

CRUISE NUMBER 11: JUNE 11, 1973 TO JUNE 15, 1973

MG/L						
	MINIMUM	11.60	15.42	19.24	23.06	26.88
	MAXIMUM	15.42	19.24	23.06	26.88	30.70
		....	+++++++++	000000000	θθθθθθθθθ	■■■■■■■■■
*SAMPLING STATION		....	+++++++++	000000000	θθθθθθθθθ	■■■■■■■■■

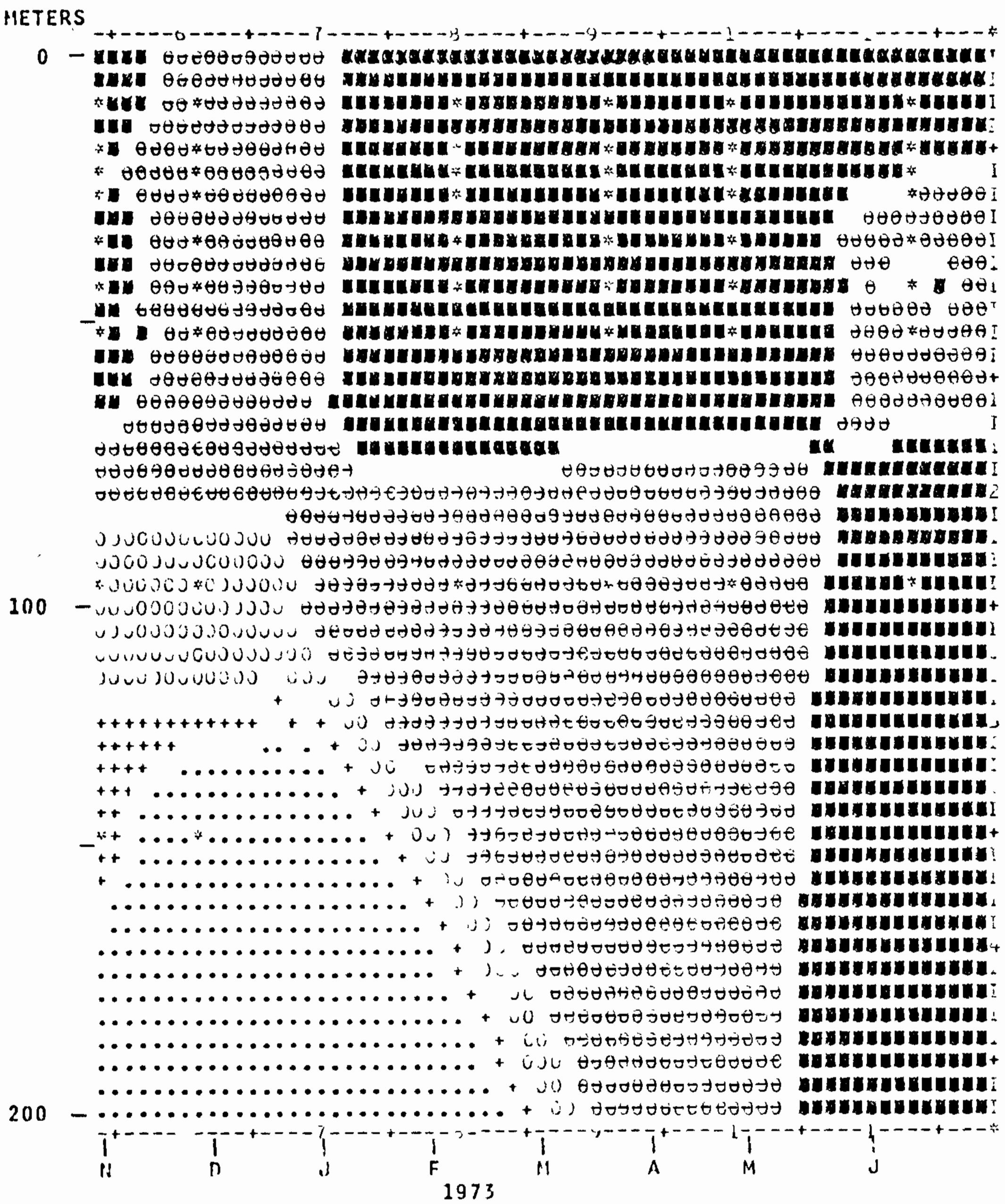


Figure 4.18c Depth Versus Time Contours of Constant Sulfate

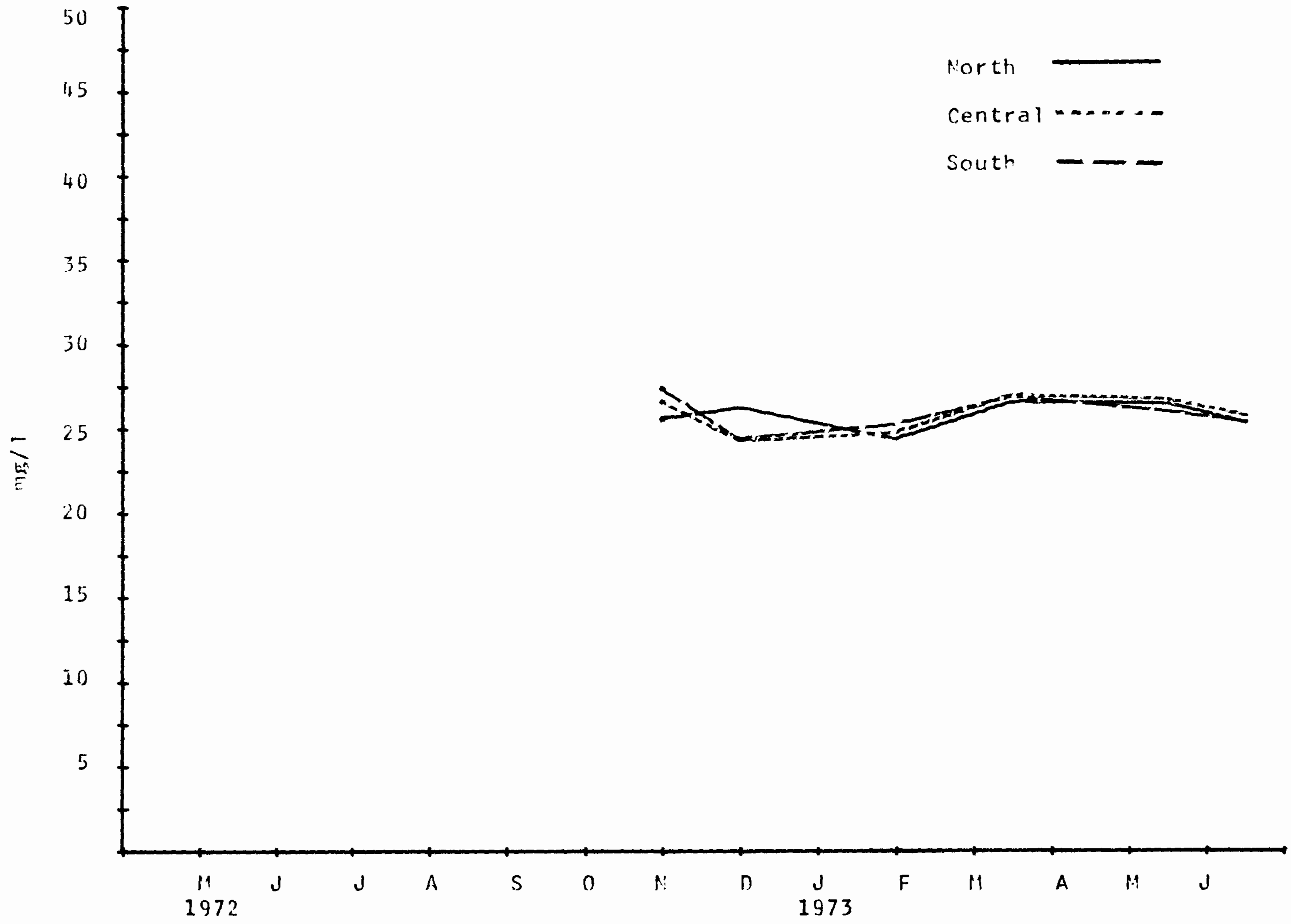


Figure 4.18d. North-south variations of sulfate during the field year

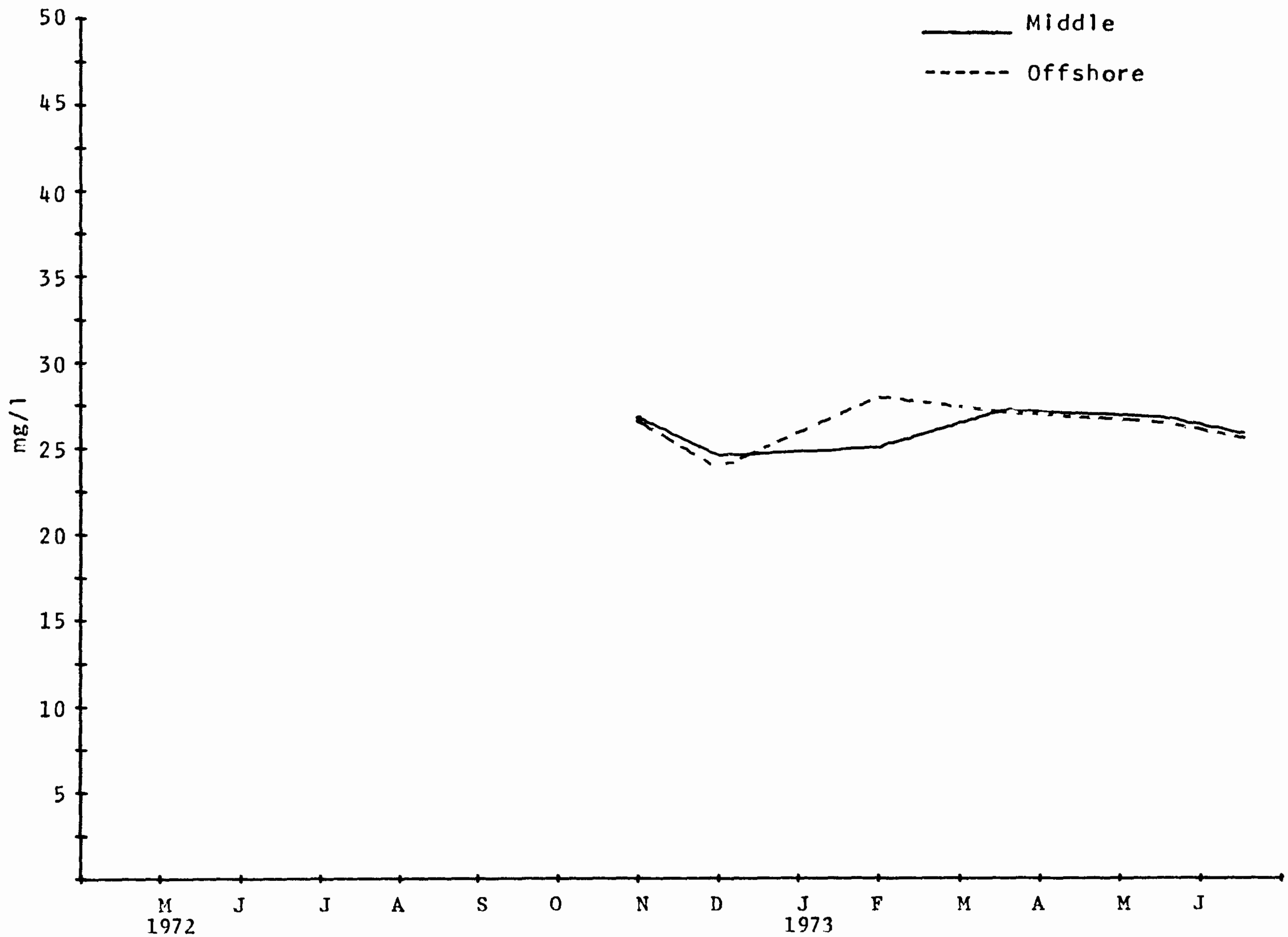


Figure 4.18e Middle Lake-Offshore Variations of Mean Sulfate Concentration

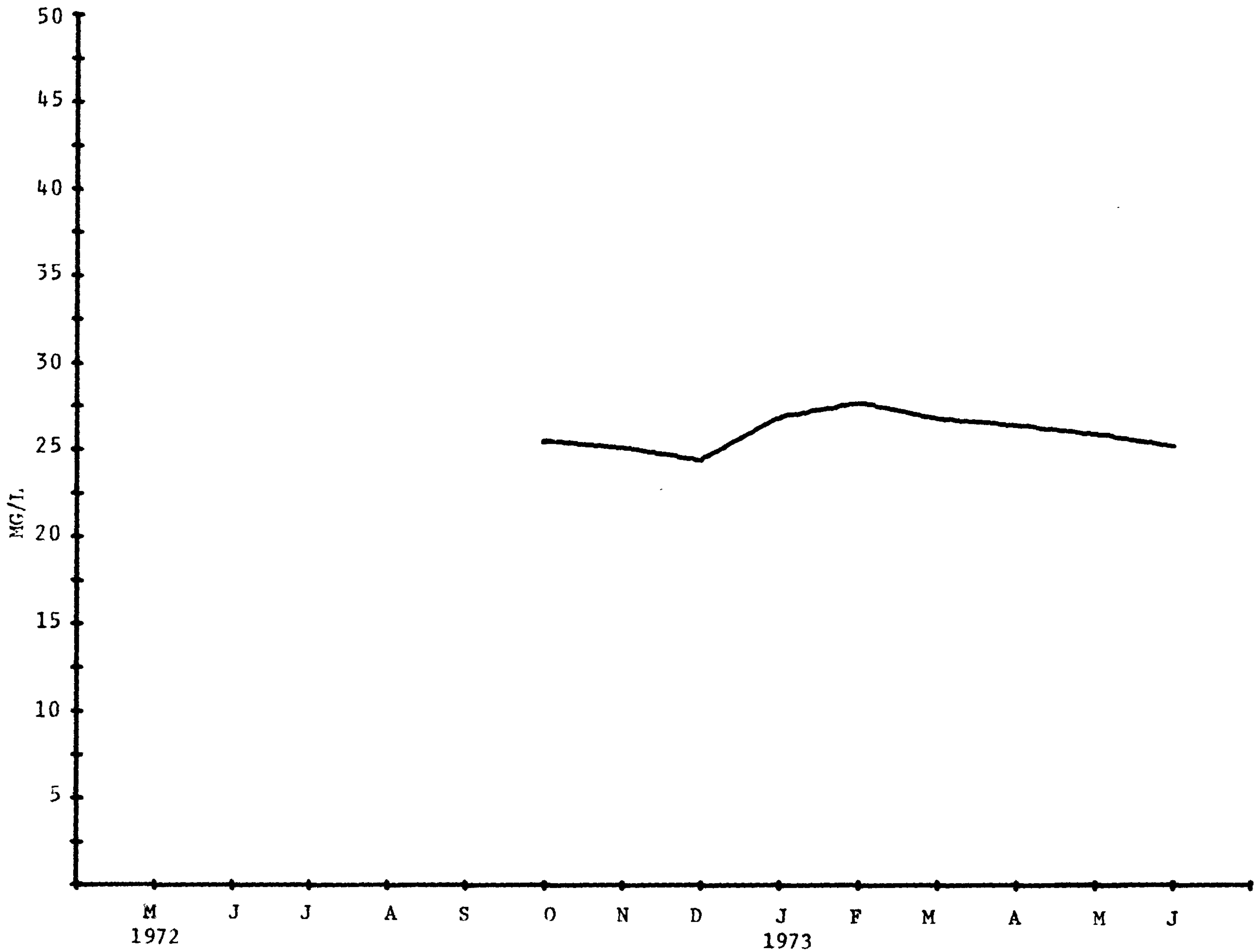


Figure 4.18f Mean surface variation of Sulfate concentration during the field year.

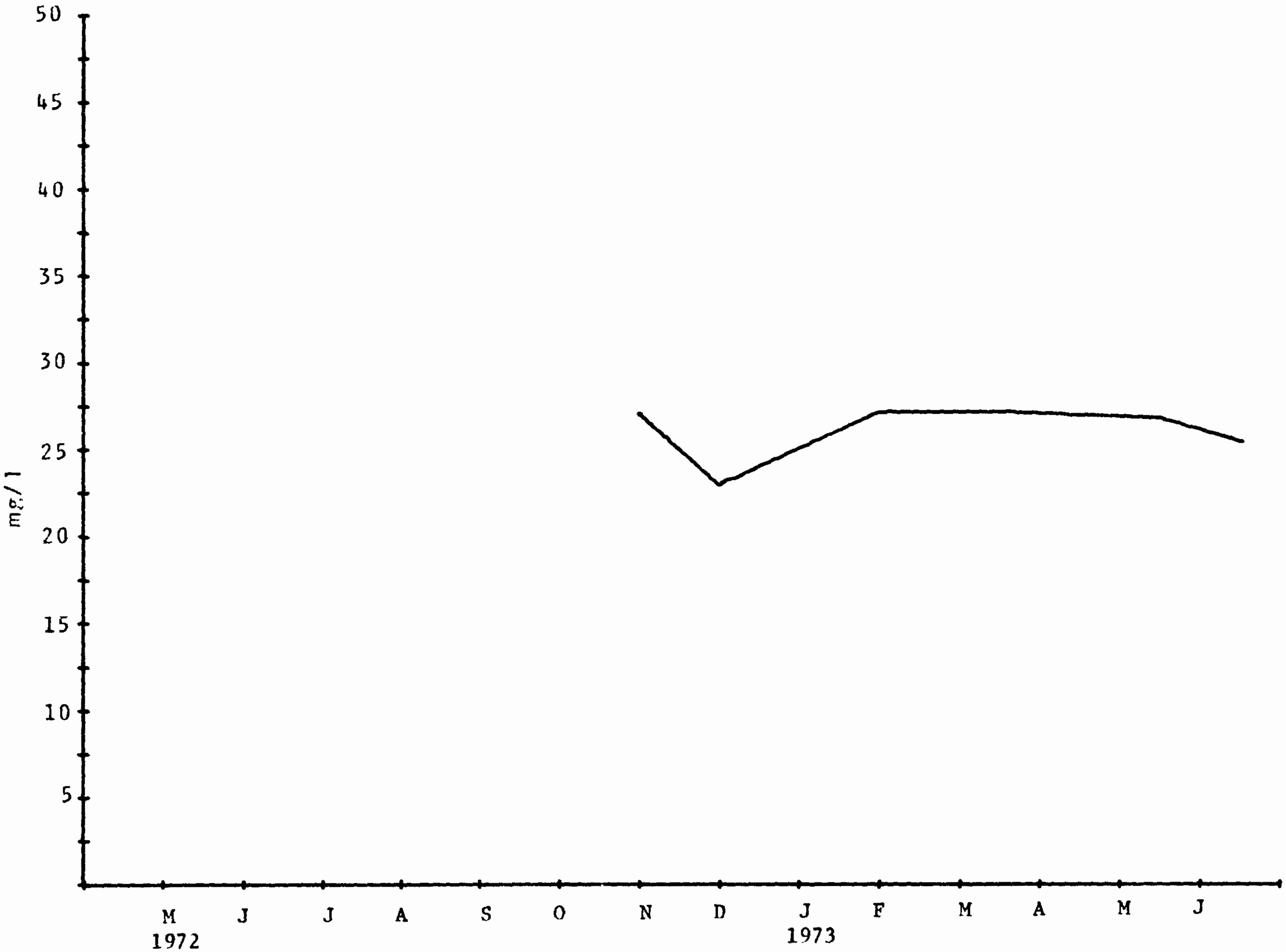


Figure 4.18g Mean Bottom Variation of Sulfate Concentration During the Field Year

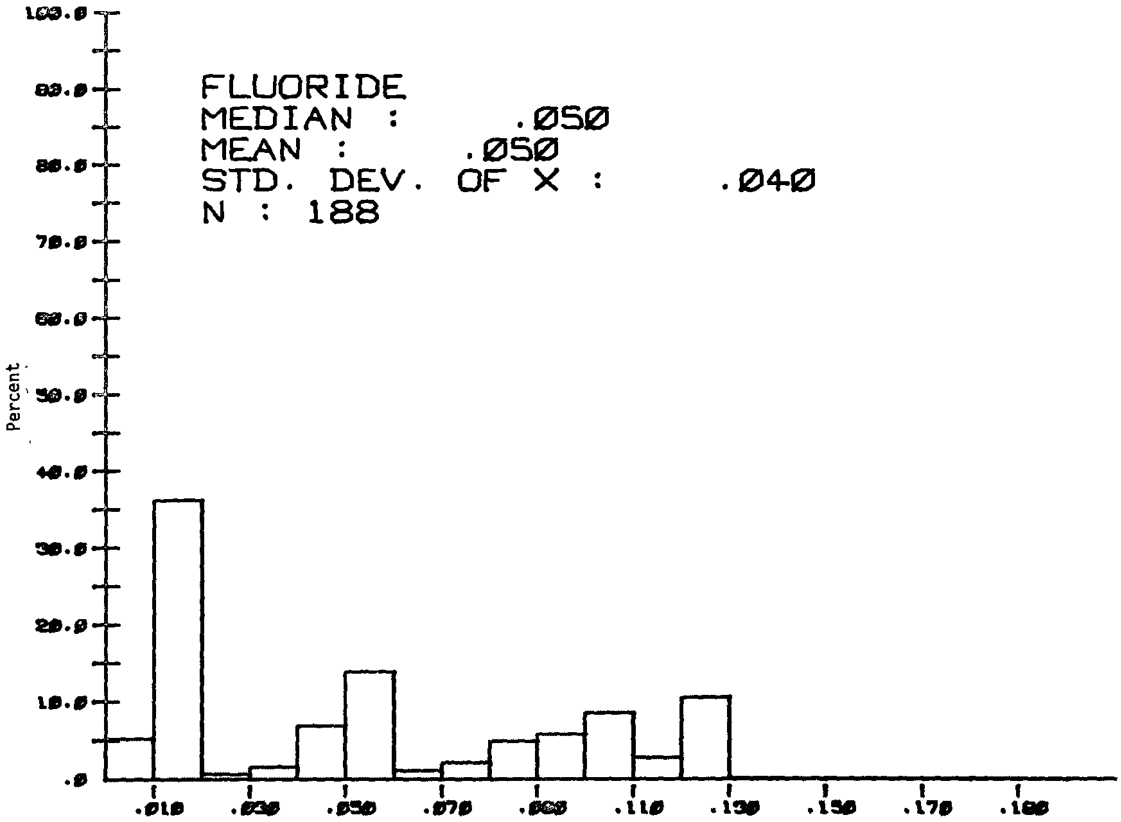


Figure 4.19a Histograms for Fluoride - Cruise 1

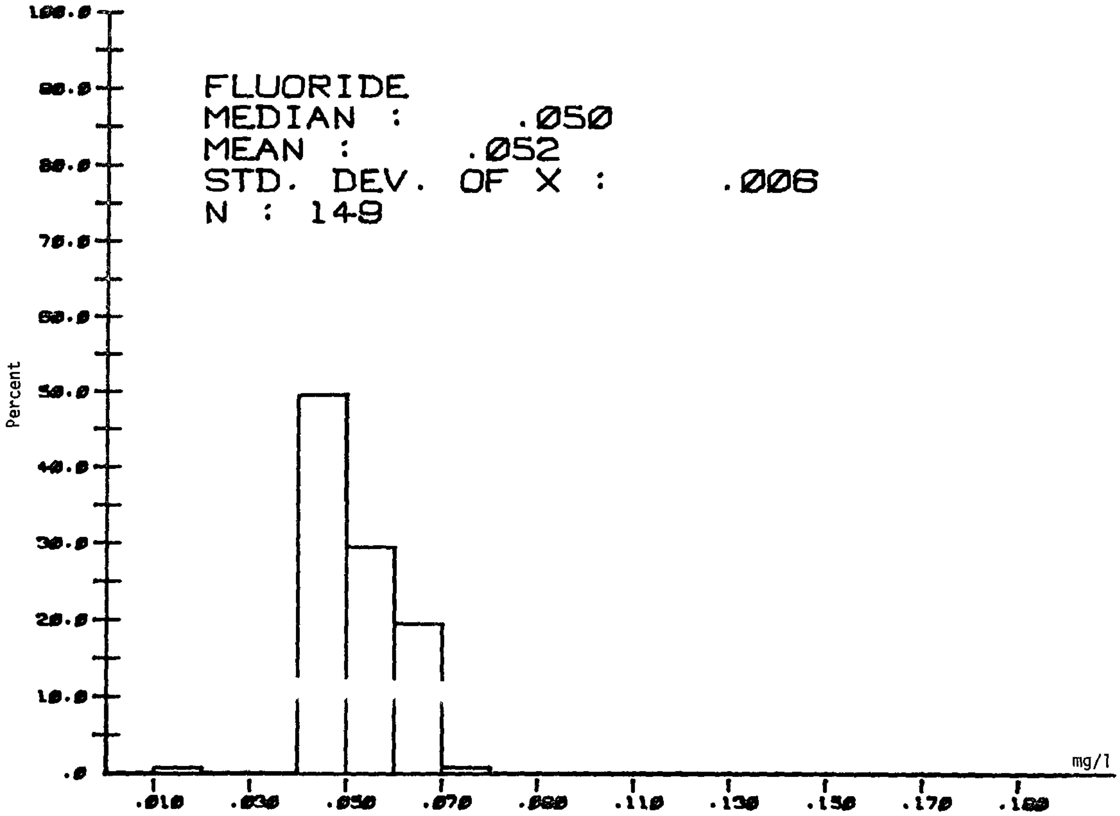


Figure 4.19a Histograms for Fluoride - Cruise 2

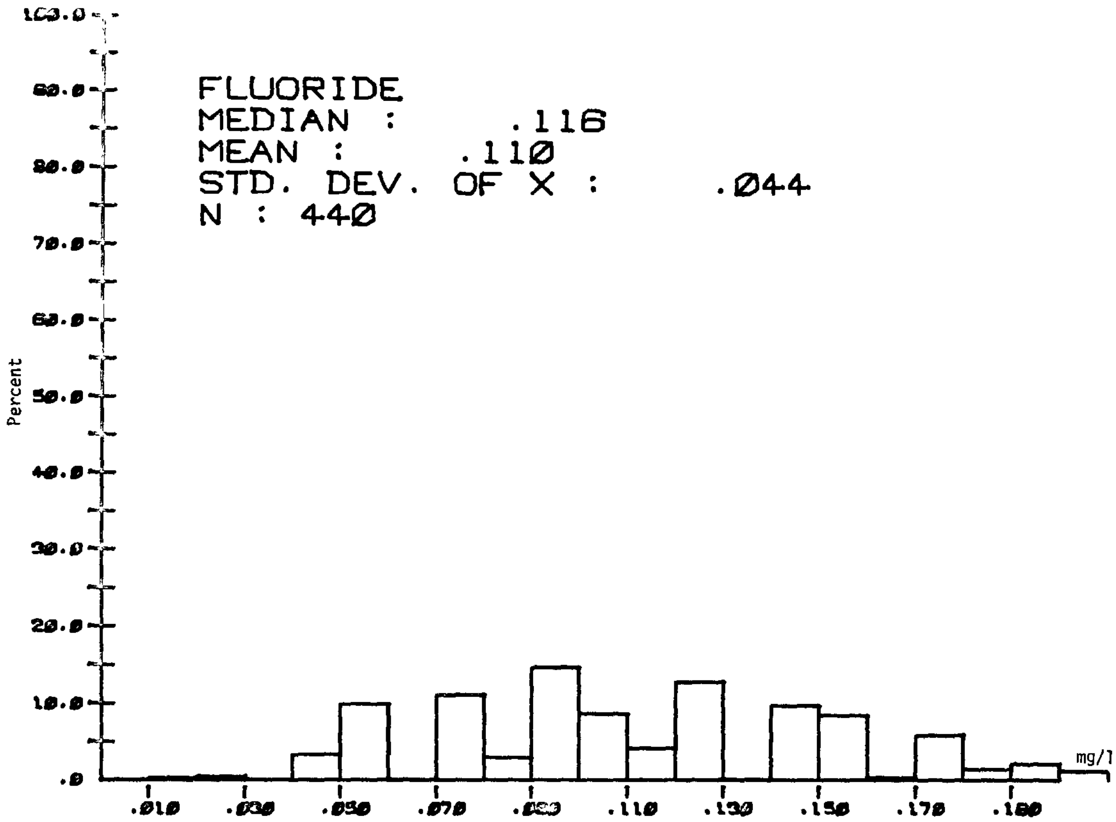


Figure 4.19a Histograms for Fluoride - Cruise 3

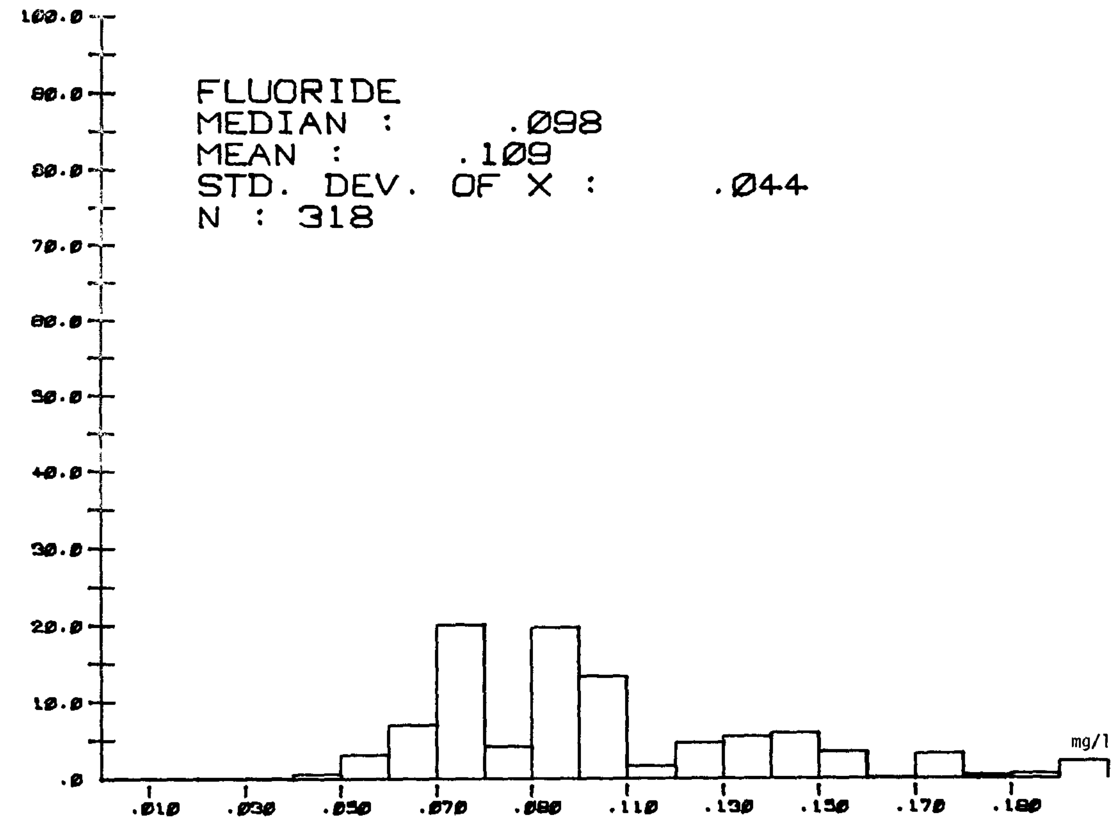


Figure 4.19a Histograms for Fluoride - Cruise 4

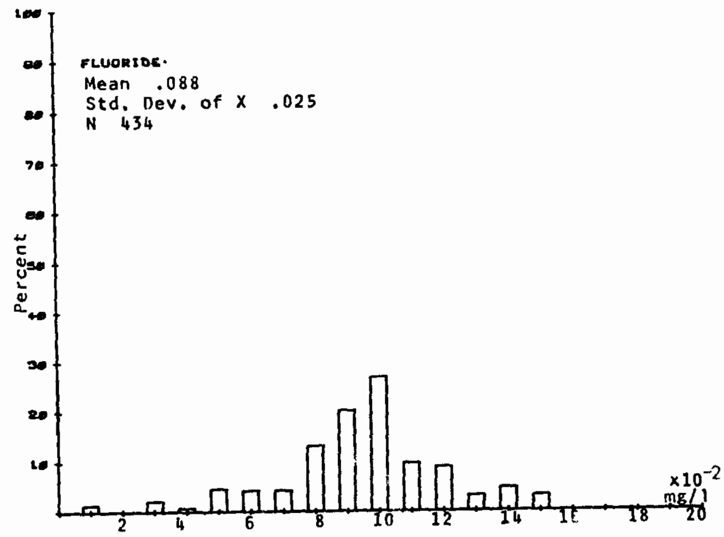


Figure 4.19a Histograms for Fluoride - Cruise 5

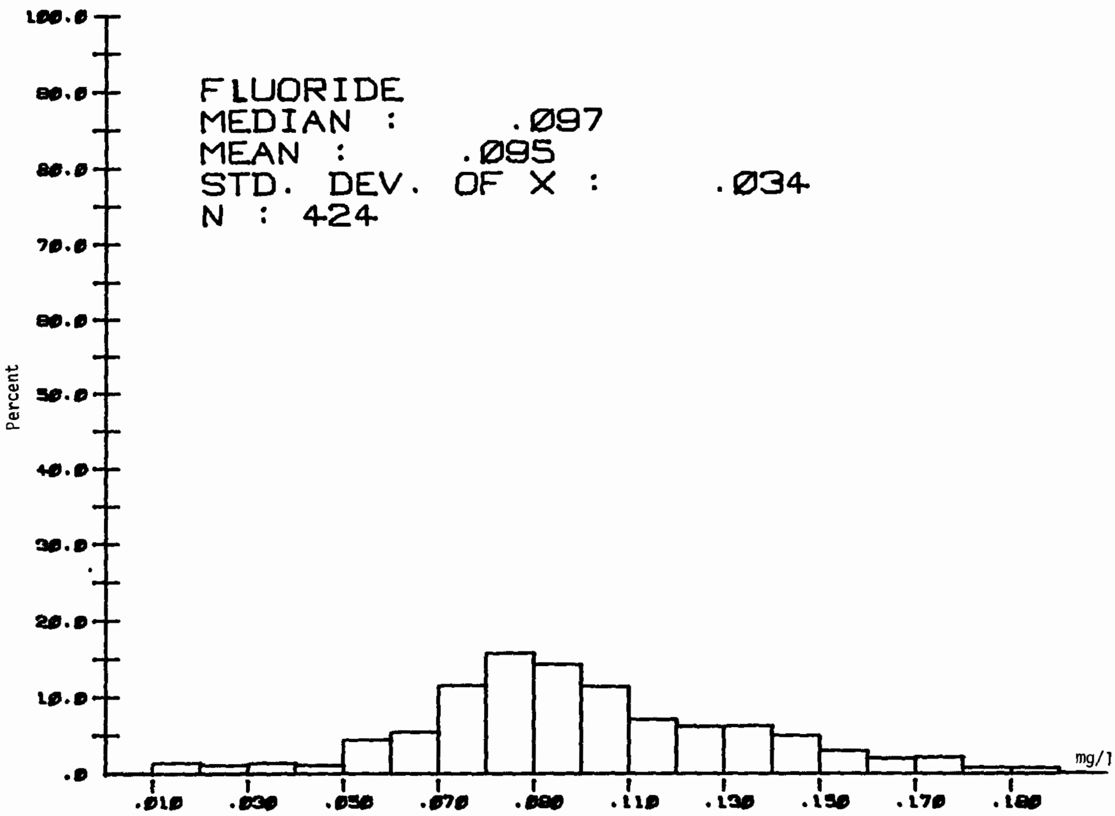


Figure 4.19a Histograms for Fluoride - Cruise 6

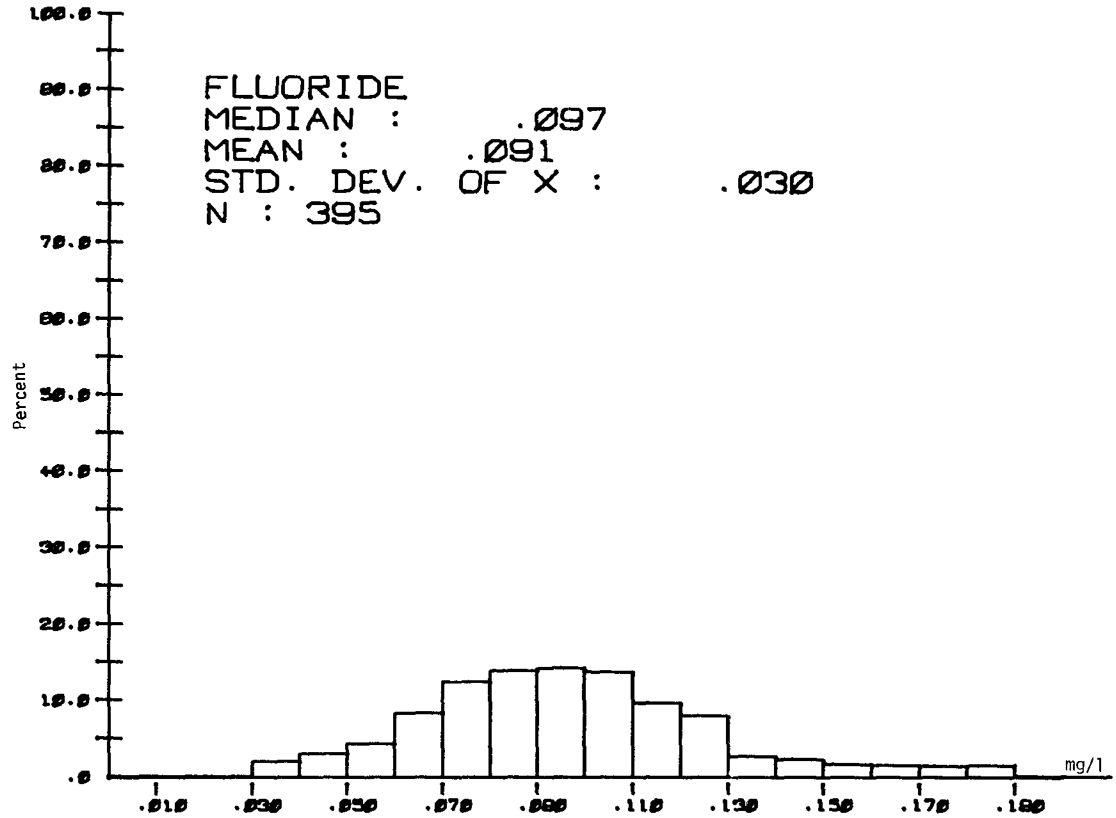


Figure 4.19a Histograms for Fluoride - Cruise 7

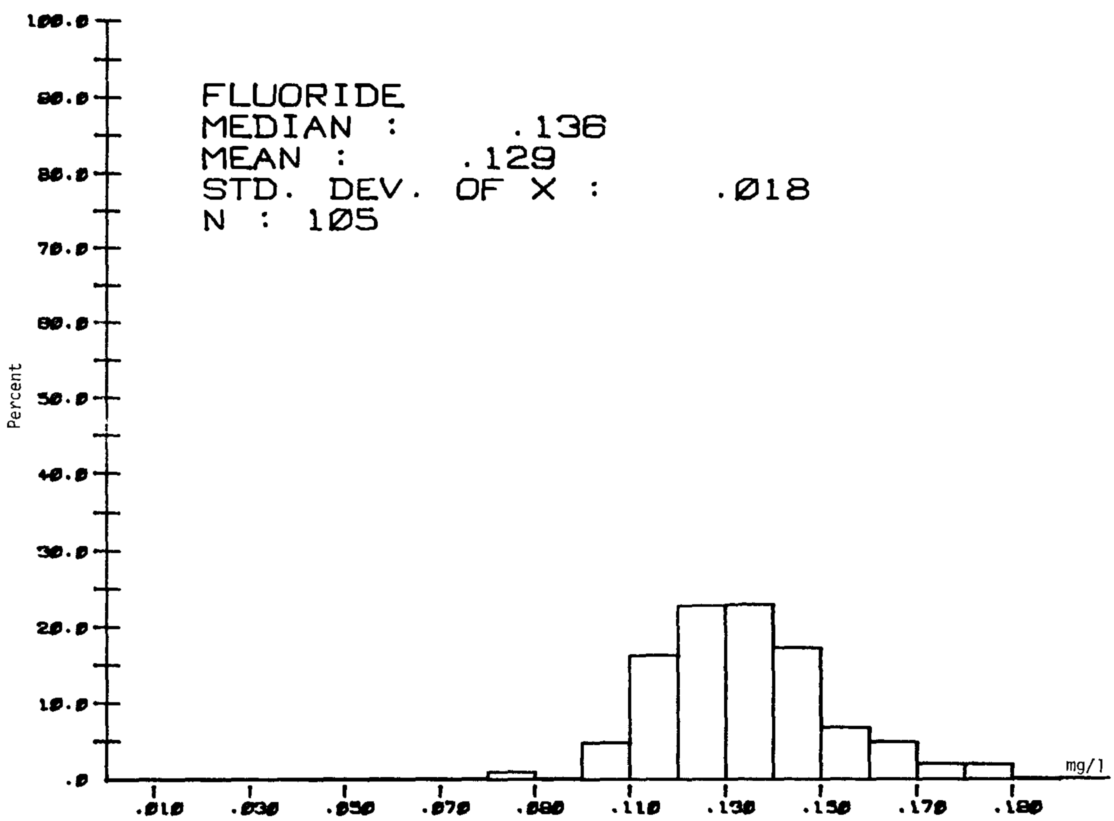


Figure 4.19a Histograms for Fluoride - Cruise 9

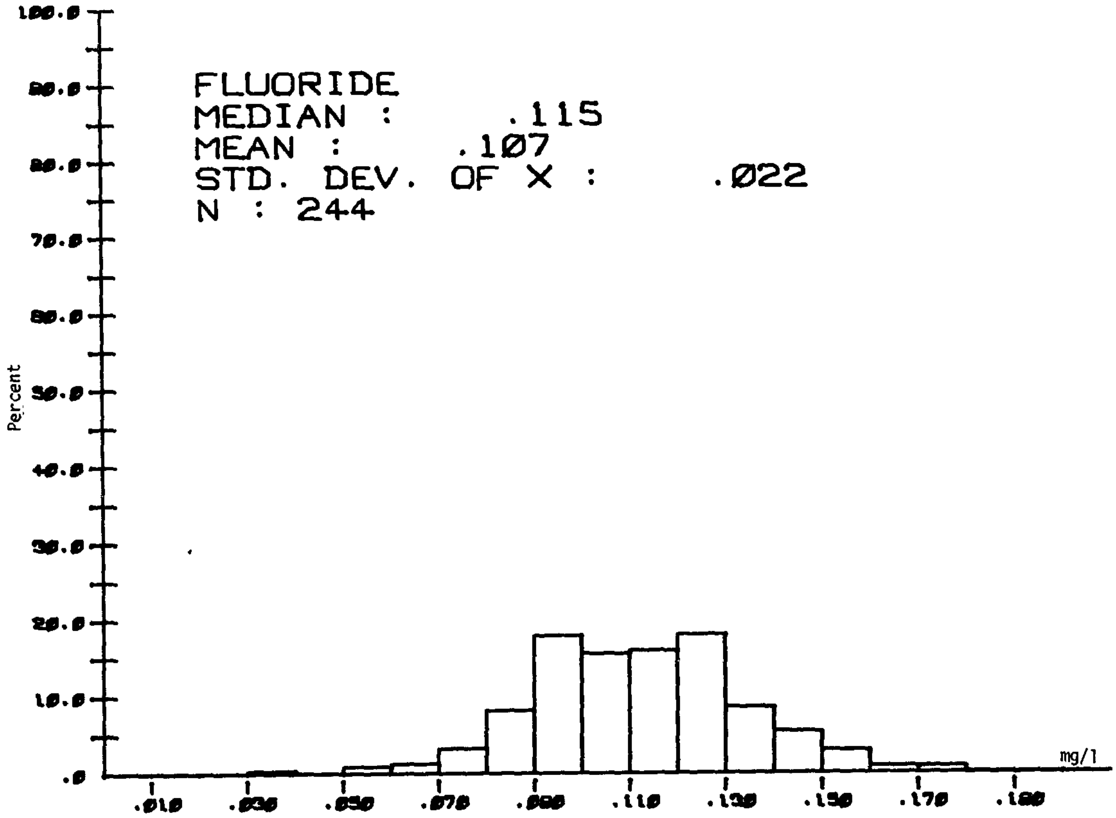


Figure 4.19a Histograms for Fluoride - Cruise 10

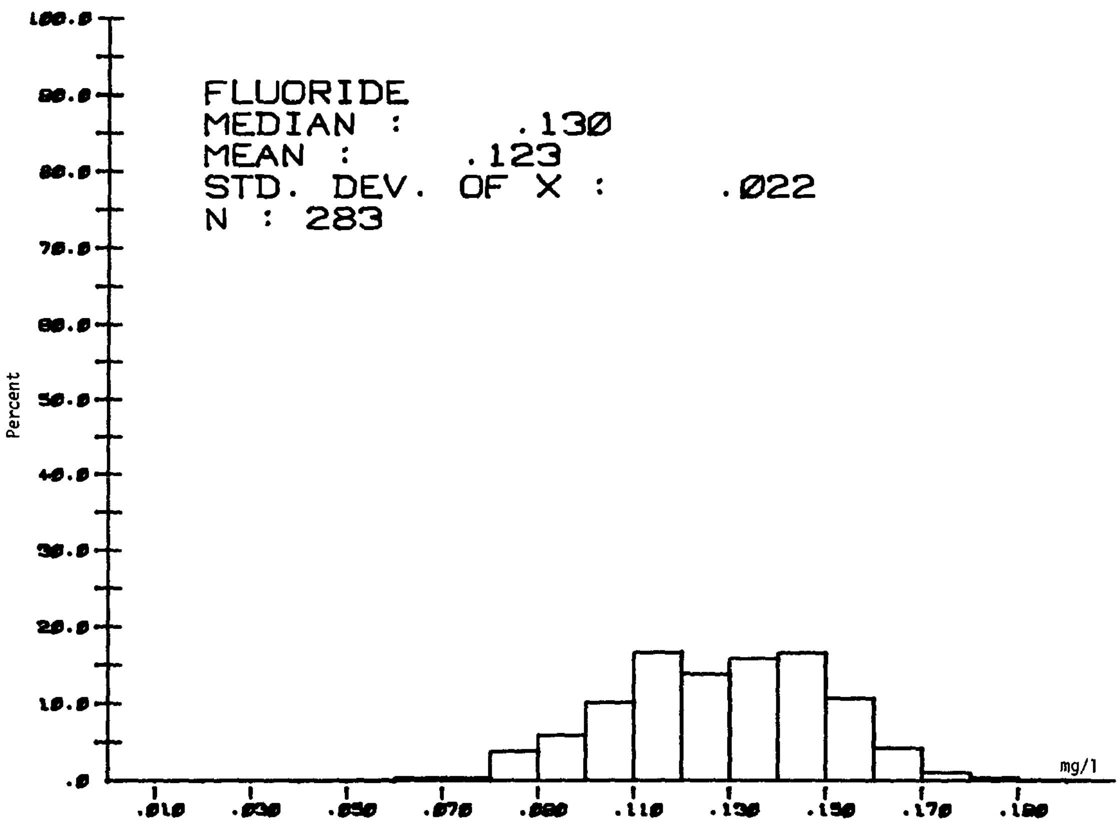


Figure 4.19a Histograms for Fluoride - Cruise 11

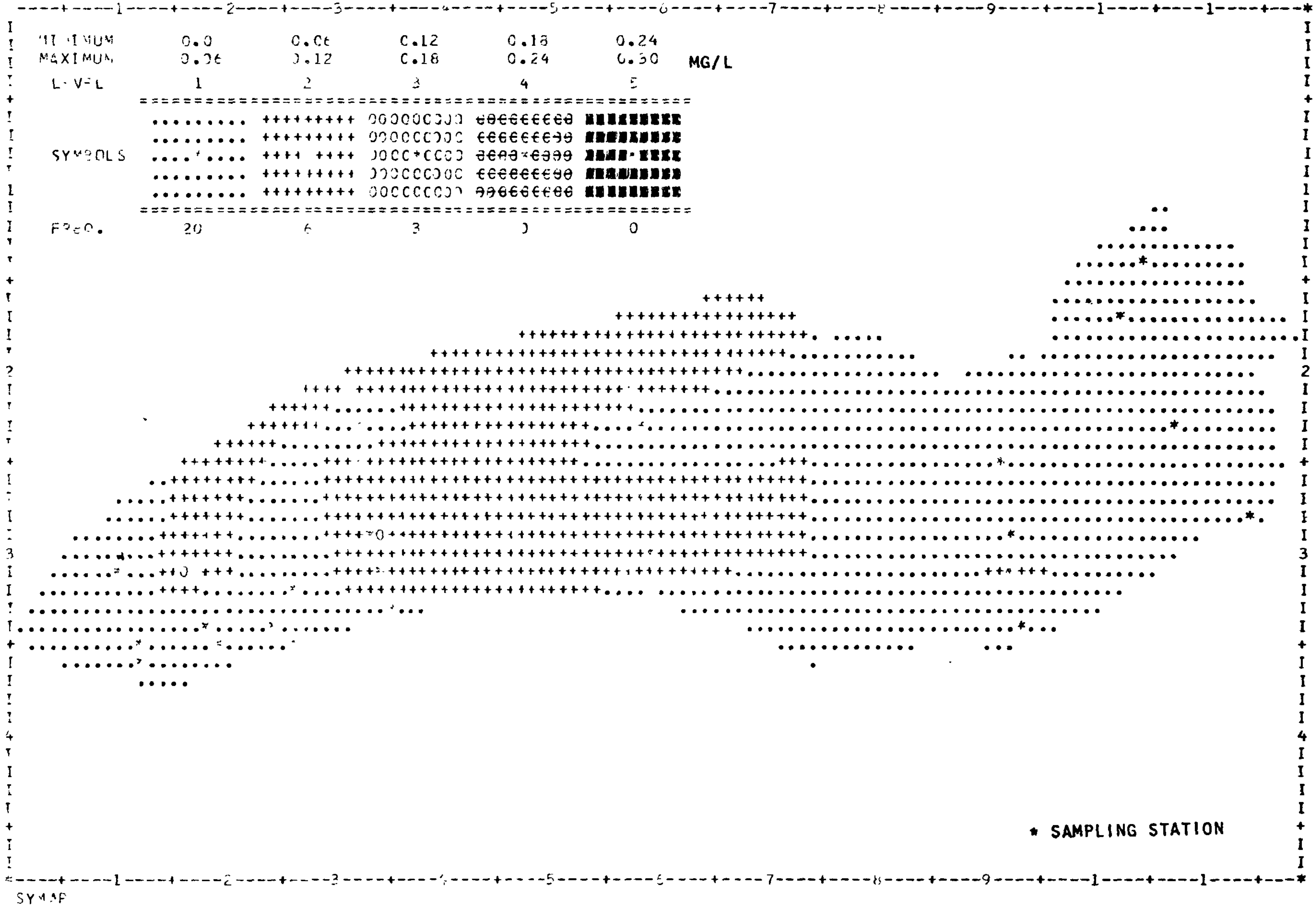


Figure 4.19b Contours of Constant Surface Fluoride

CRUISE NUMBER 1: MAY 1, 1972 TO MAY 5, 1972

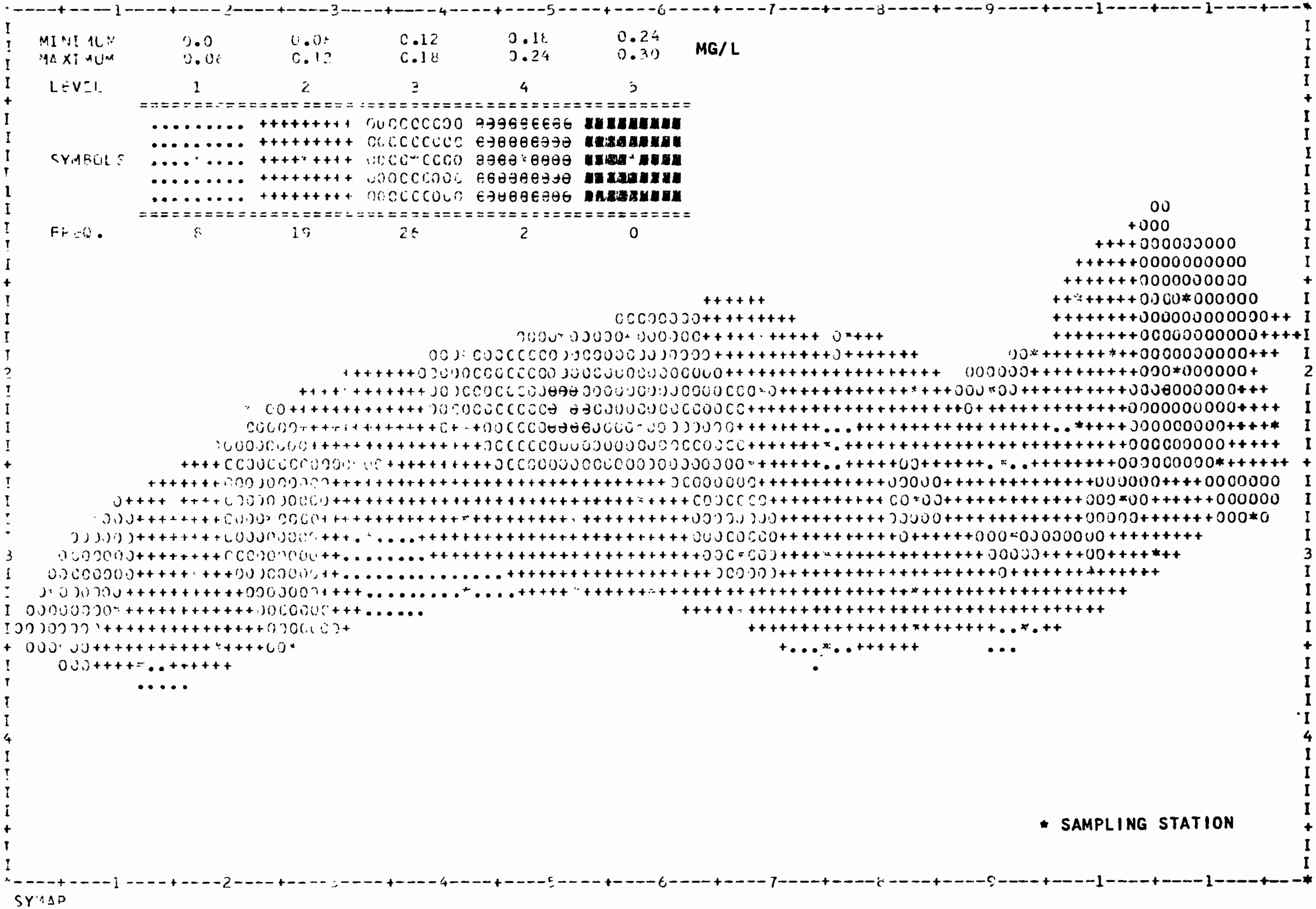


Figure 4.19b Contours of Constant Surface Fluoride

CRUISE NUMBER 2: JUNE 12, 1972 TO JUNE 16, 1972

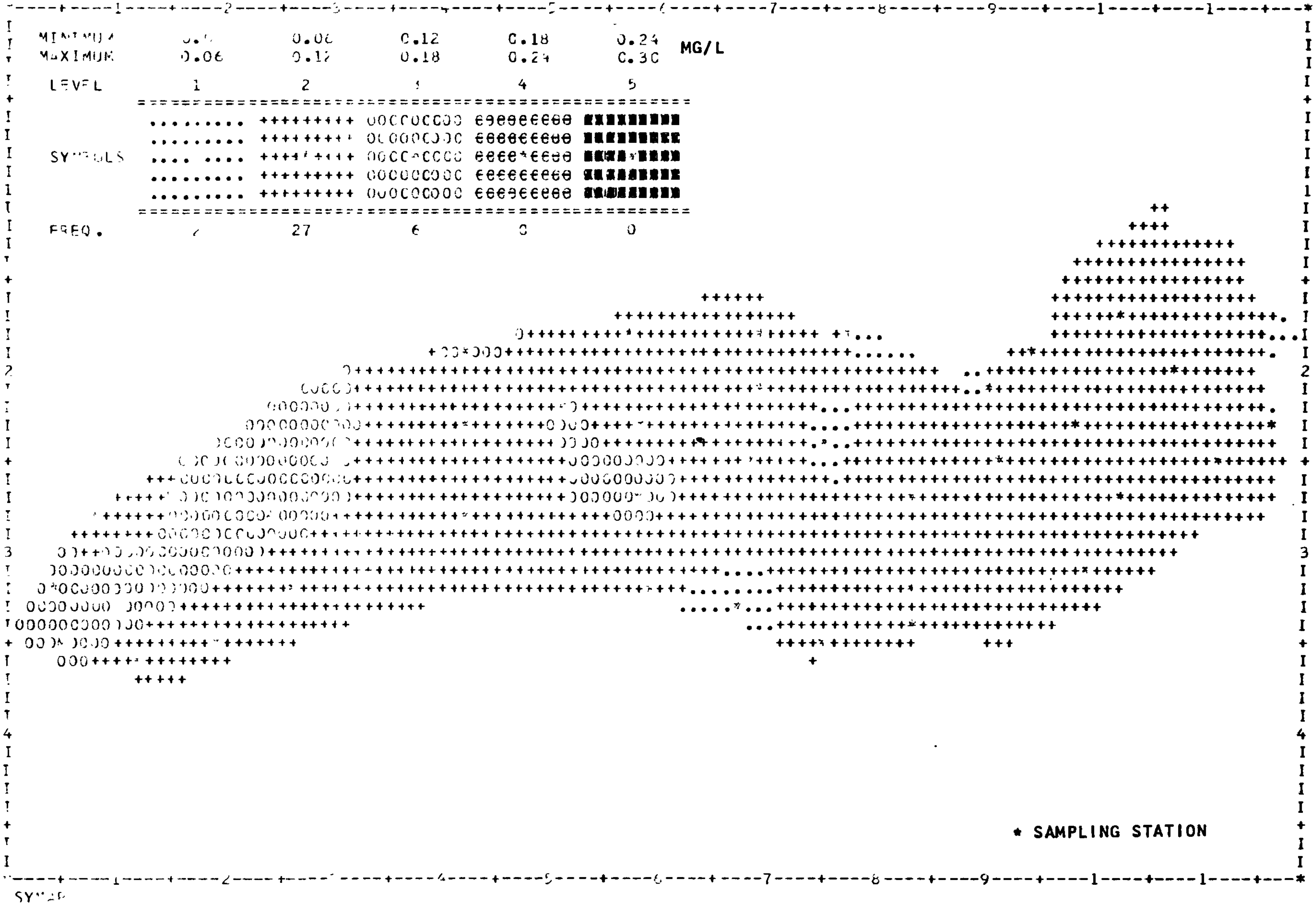
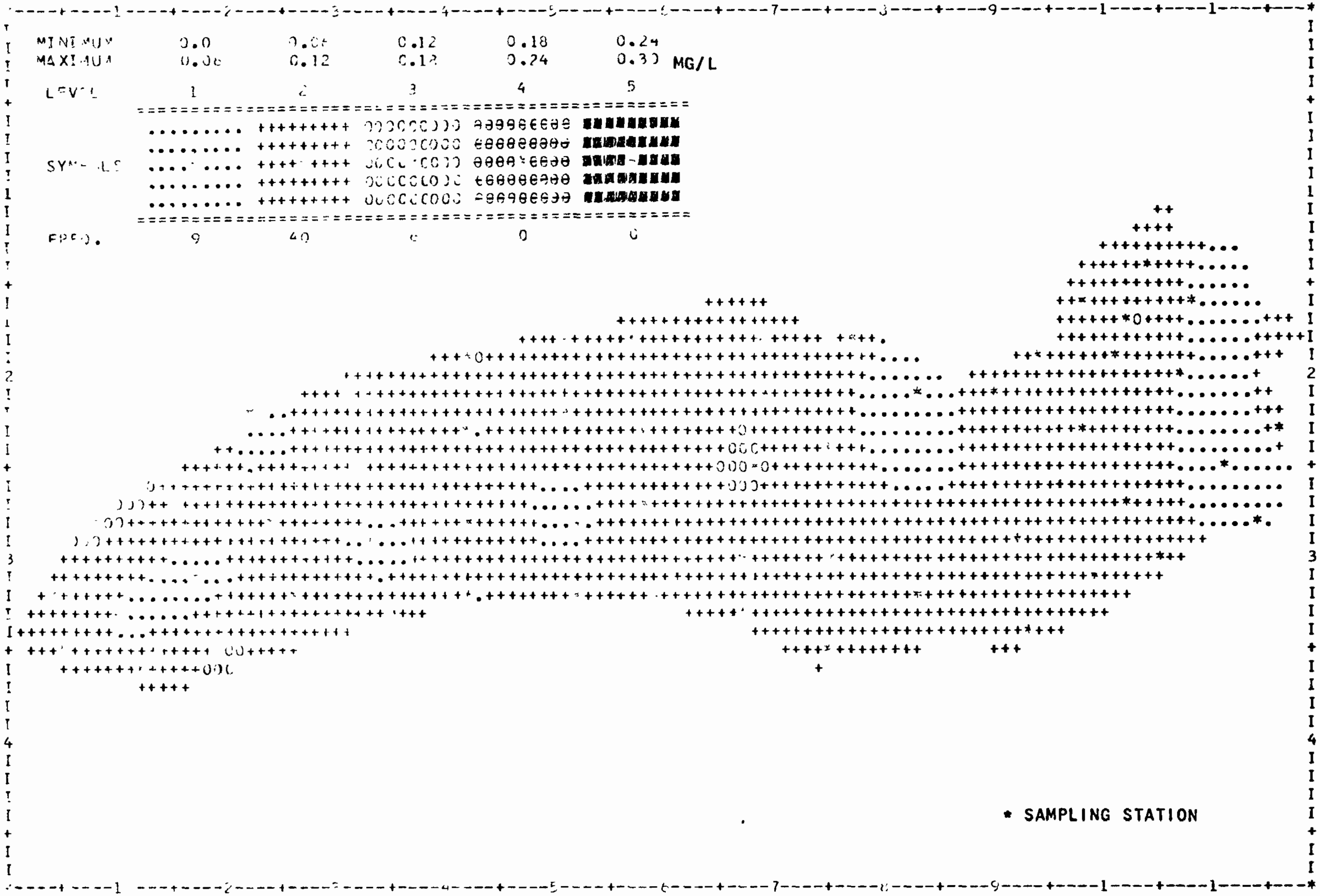


Figure 4.19b Contours of Constant Surface Fluoride

CRUISE NUMBER 4: JULY 10, 1972 TO JULY 14, 1972

MINIMUM	0.0	0.06	0.12	0.18	0.24
MAXIMUM	0.06	0.12	0.18	0.24	0.30 MG/L
LEVEL	1	2	3	4	5
SYMBOLS	....	+++++++++	OOOOOOOOO	ØØØØØØØØØ	■■■■■■■■■
FREQ.	9	40	6	0	0

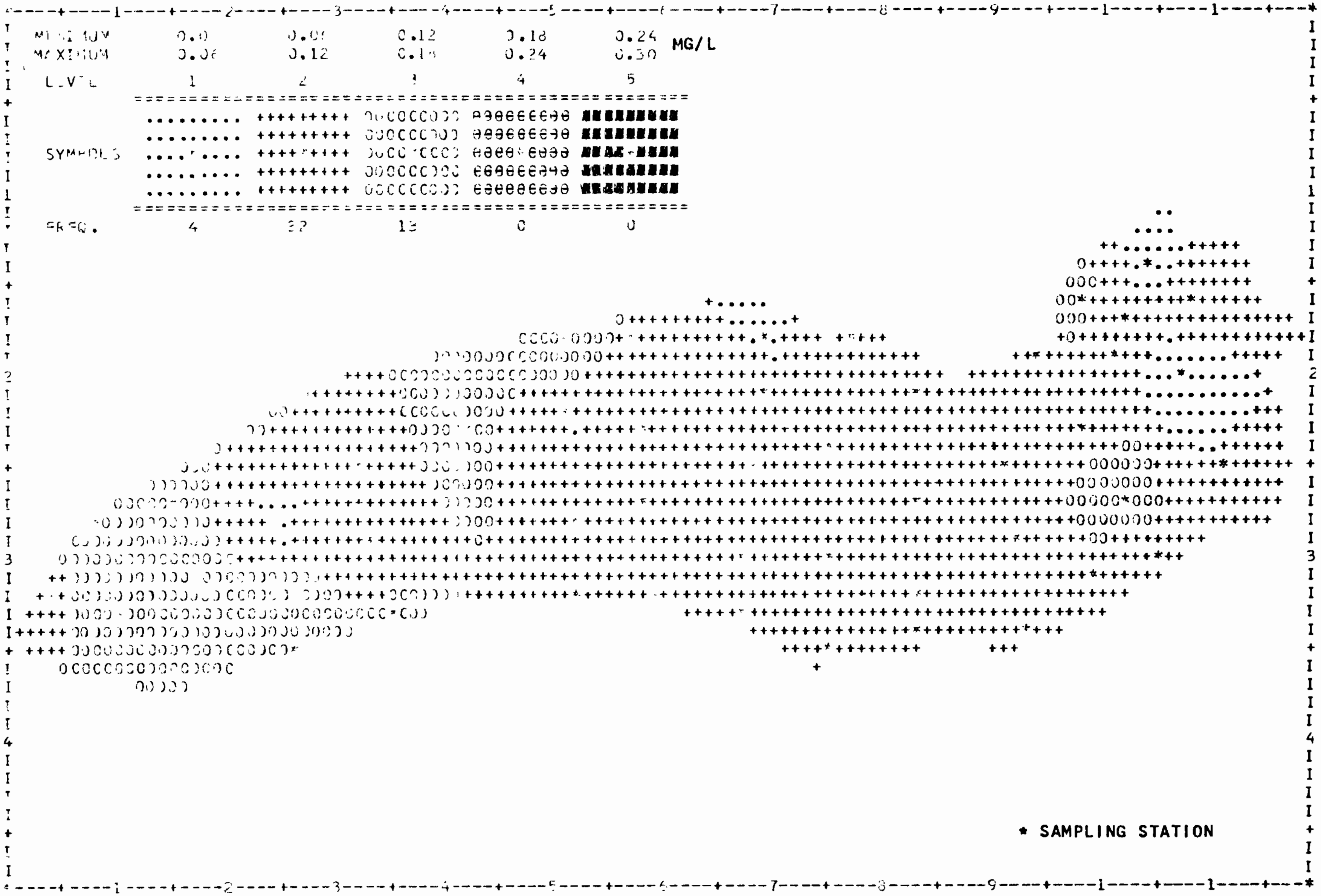


SYMAP

0.0 MINUTES FOR MAP

Figure 4.19b Contours of Constant Surface Fluoride

CRUISE NUMBER 5: AUGUST 21, 1972 TO AUGUST 25, 1972



SYMAP

Figure 4.19b Contours of Constant Surface Fluoride

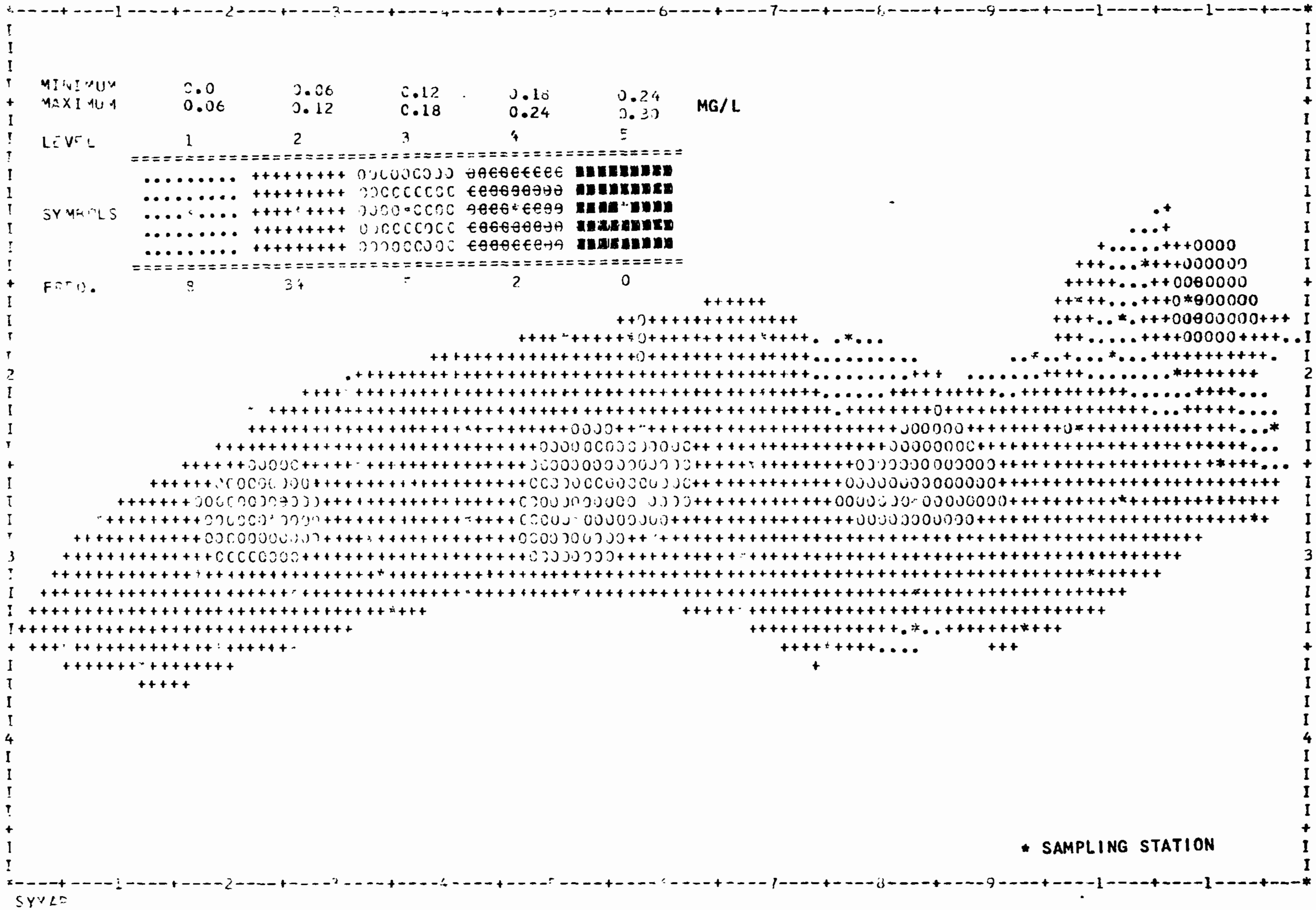


Figure 4.19b Contours of Constant Surface Fluoride

CRUISE NUMBER 7: NOVEMBER 27, 1972 TO DECEMBER 2, 1972

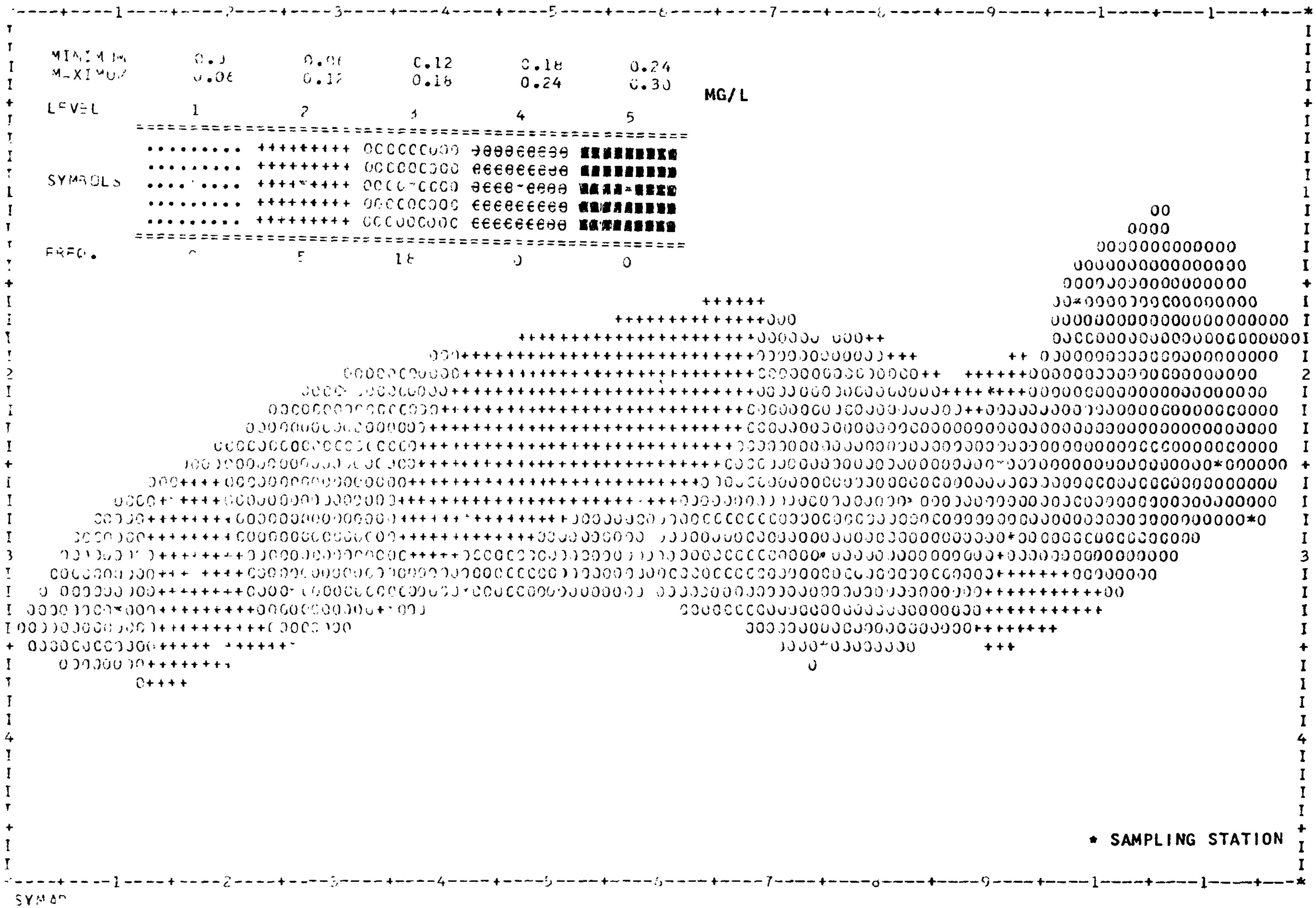


Figure 4.19b Contours of Constant Surface Fluoride

16, 1973 TO MARCH 23, 1973

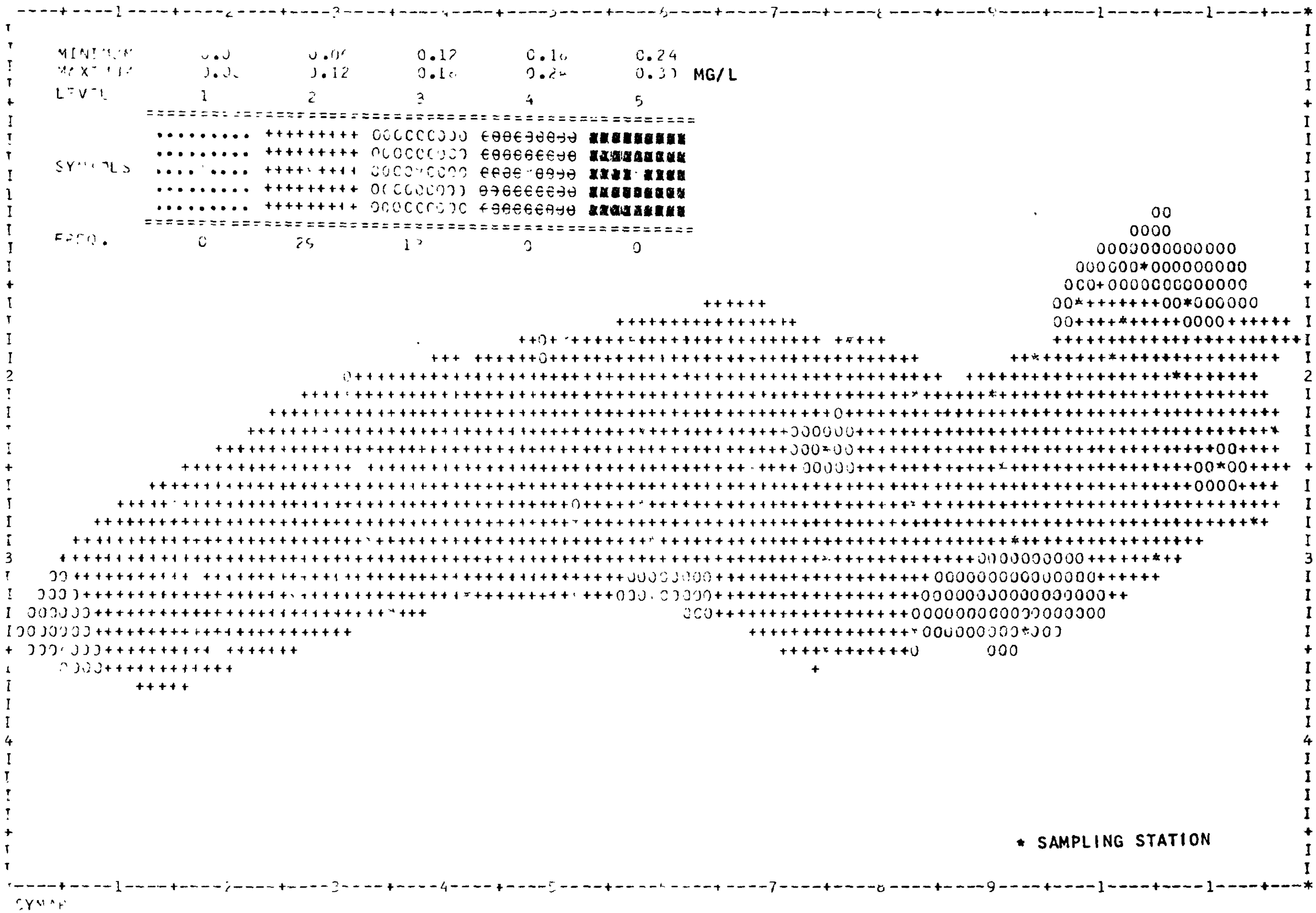


Figure 4.19b Contours of Constant Surface Fluoride

CRUISE NUMBER 10: APRIL 24, 1972 TO APRIL 30, 1972

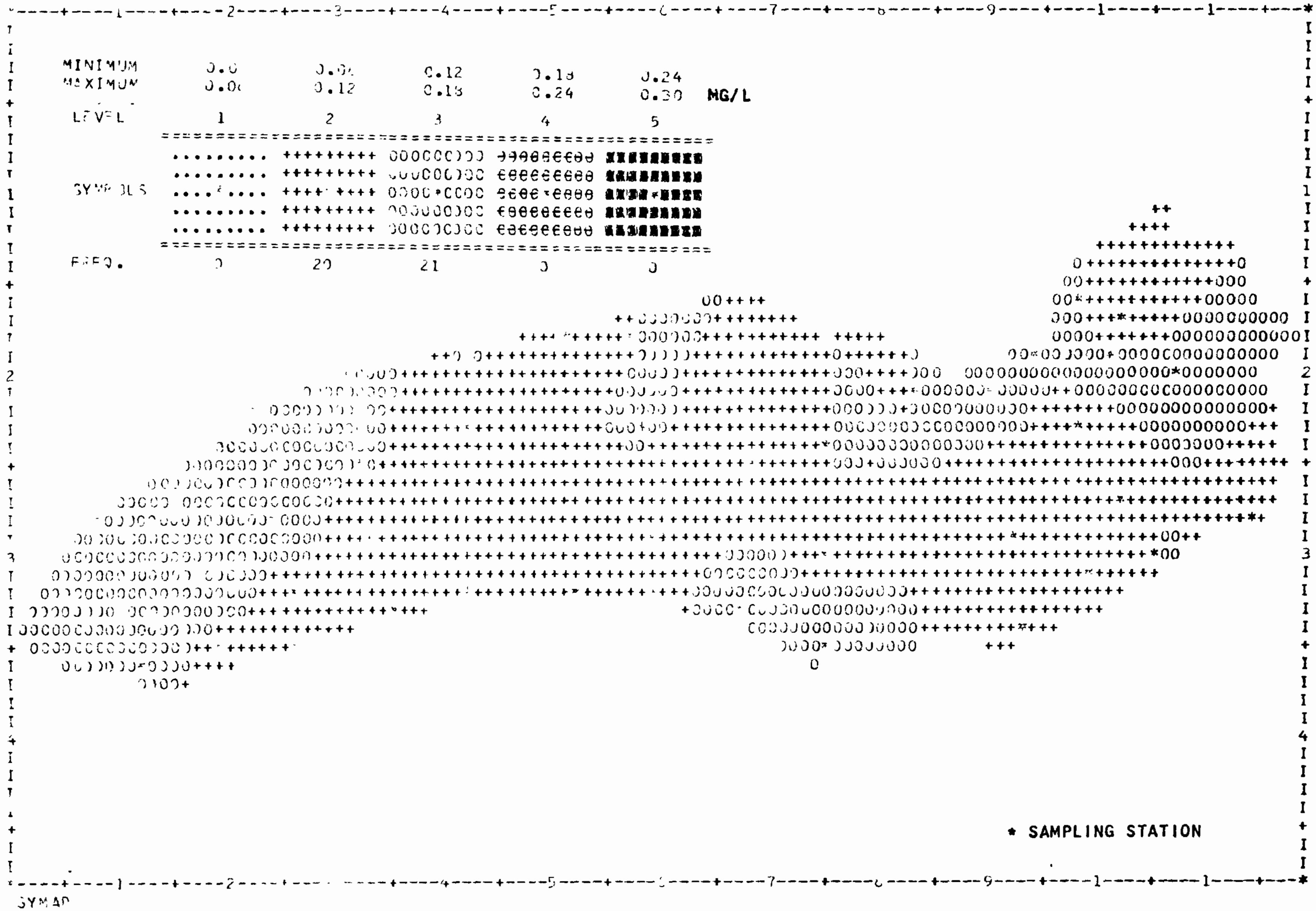


Figure 4.19b Contours of Constant Surface Fluoride

CRUISE NUMBER 11: JUNE 11, 1973 TO JUNE 15, 1973

Figure 4.19c Depth Versus Time Contours of Constant Fluoride

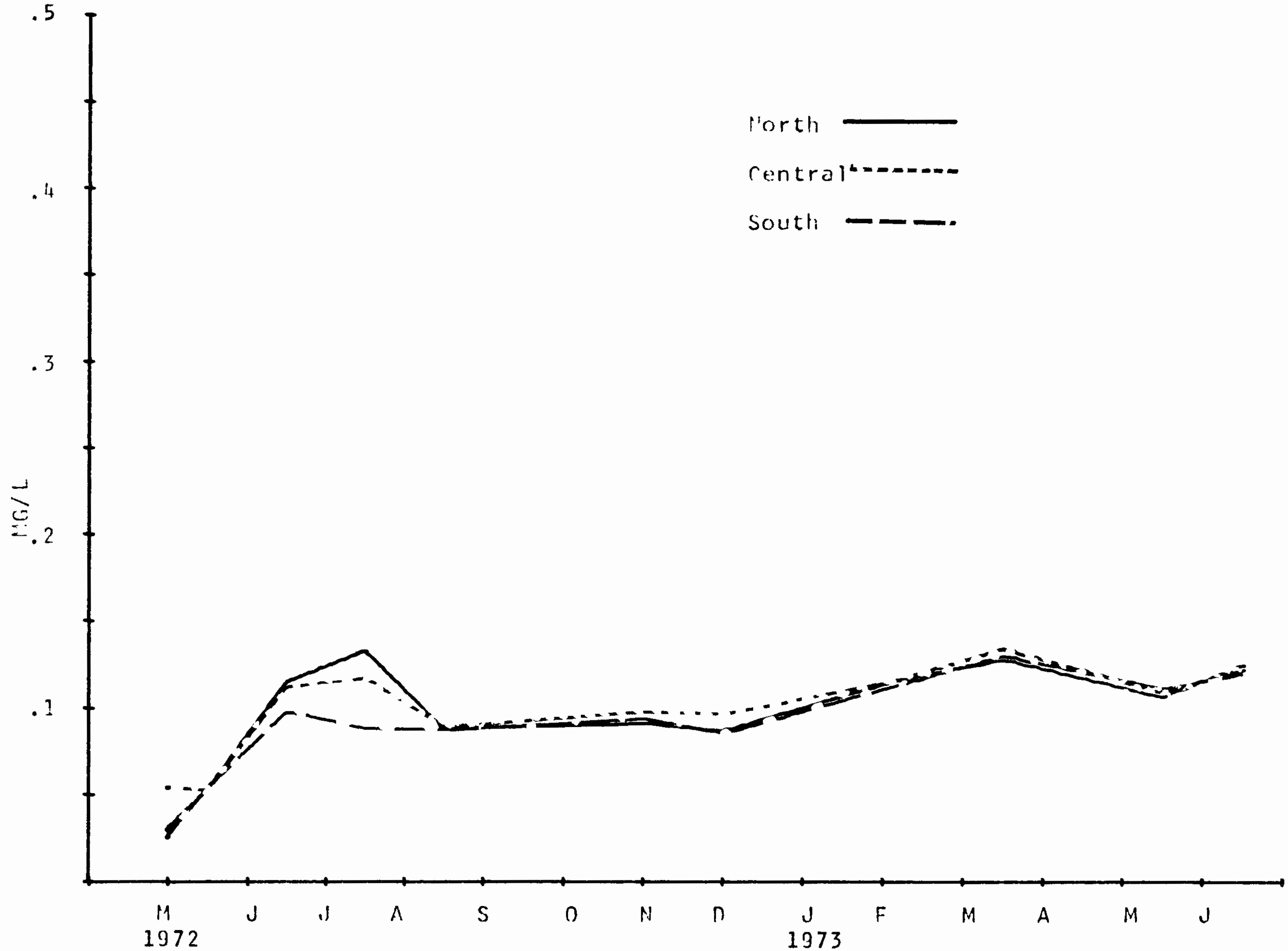


Figure 4.19d North-south variation of fluoride

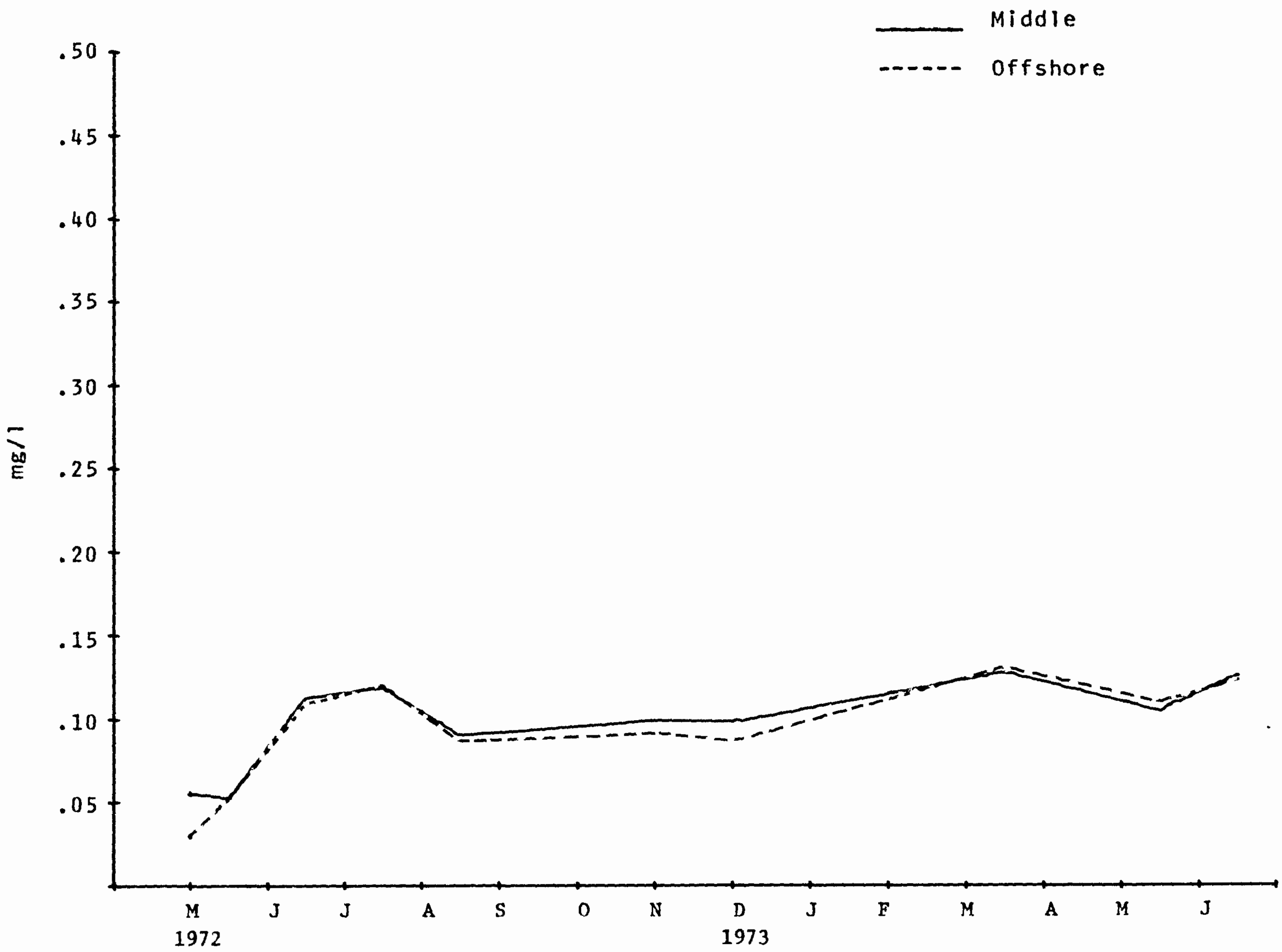


Figure 4.19e Middle Lake-Offshore Variations of Mean Fluoride Concentration

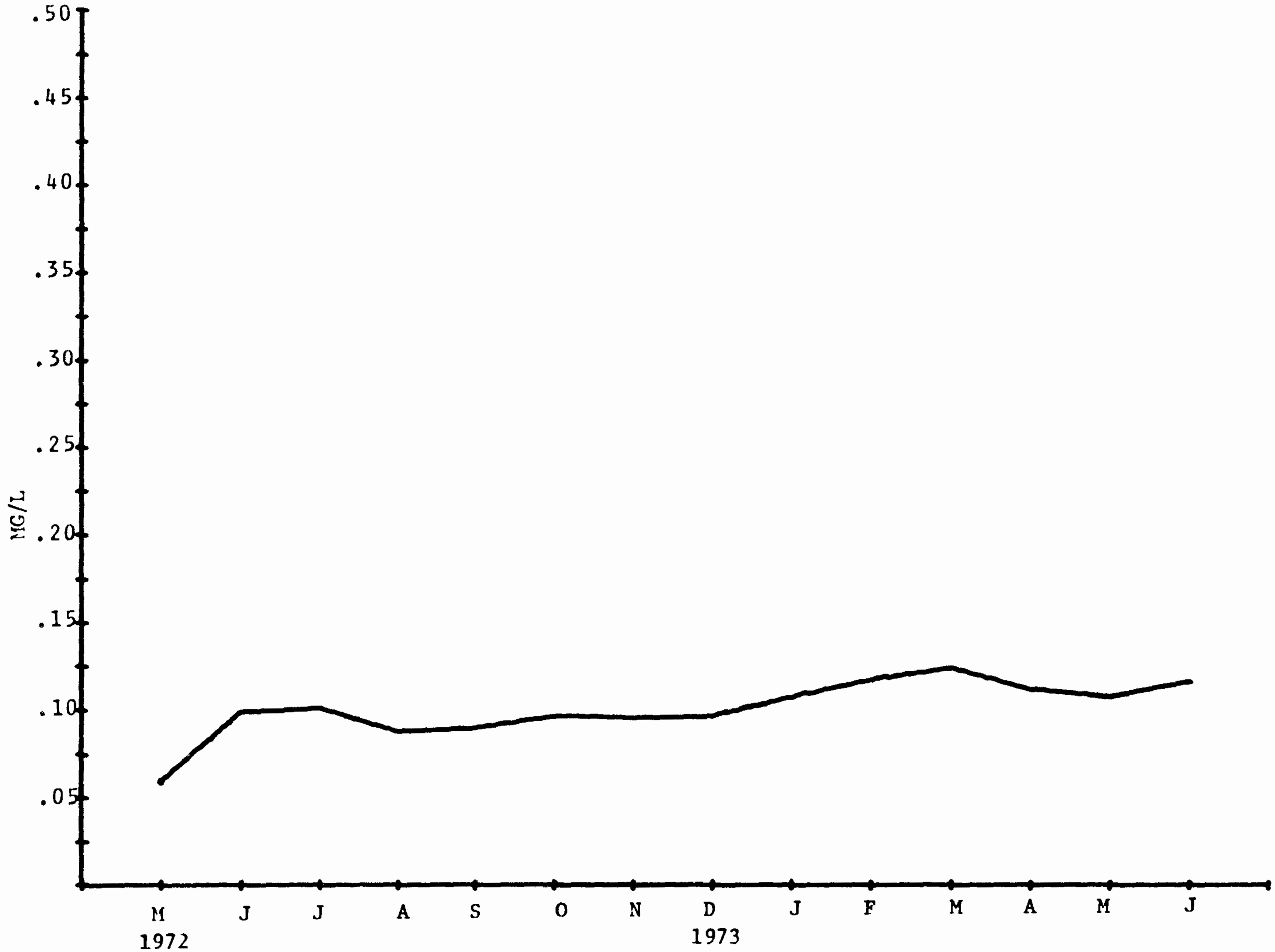


Figure 4.19f Meansurface variation of Fluoride concentration during the field year.

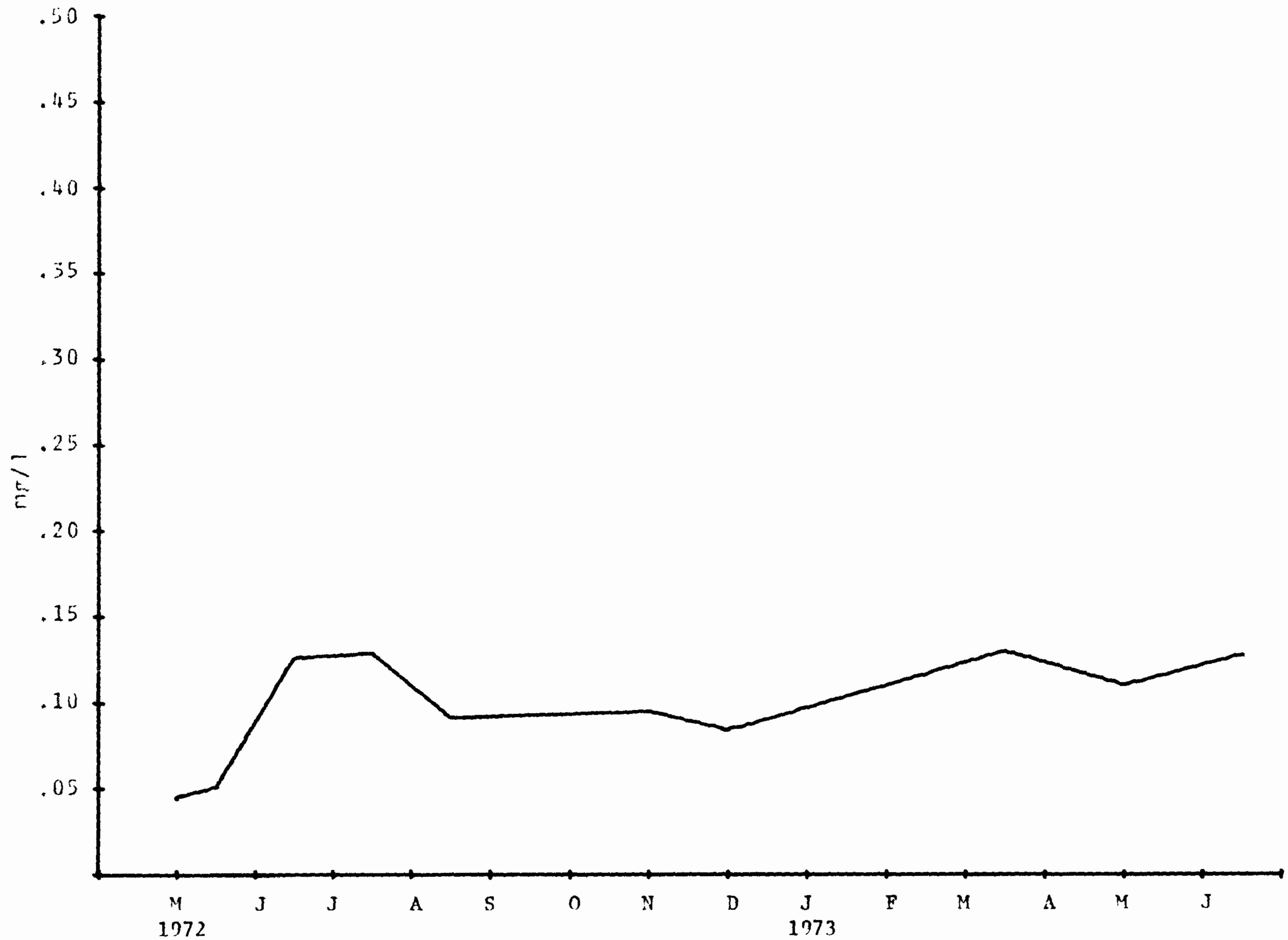


Figure 4.19g Mean Bottom Variation of Fluoride Concentration During the Field Year

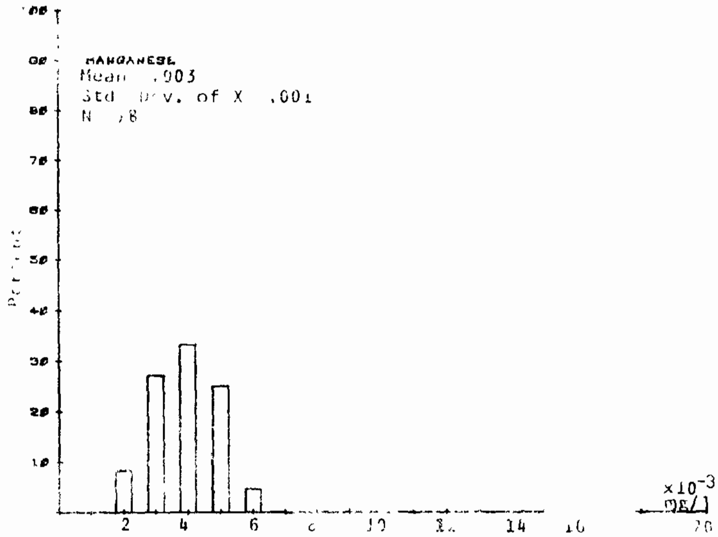


Figure 4.20a Histograms for Manganese - Cruise

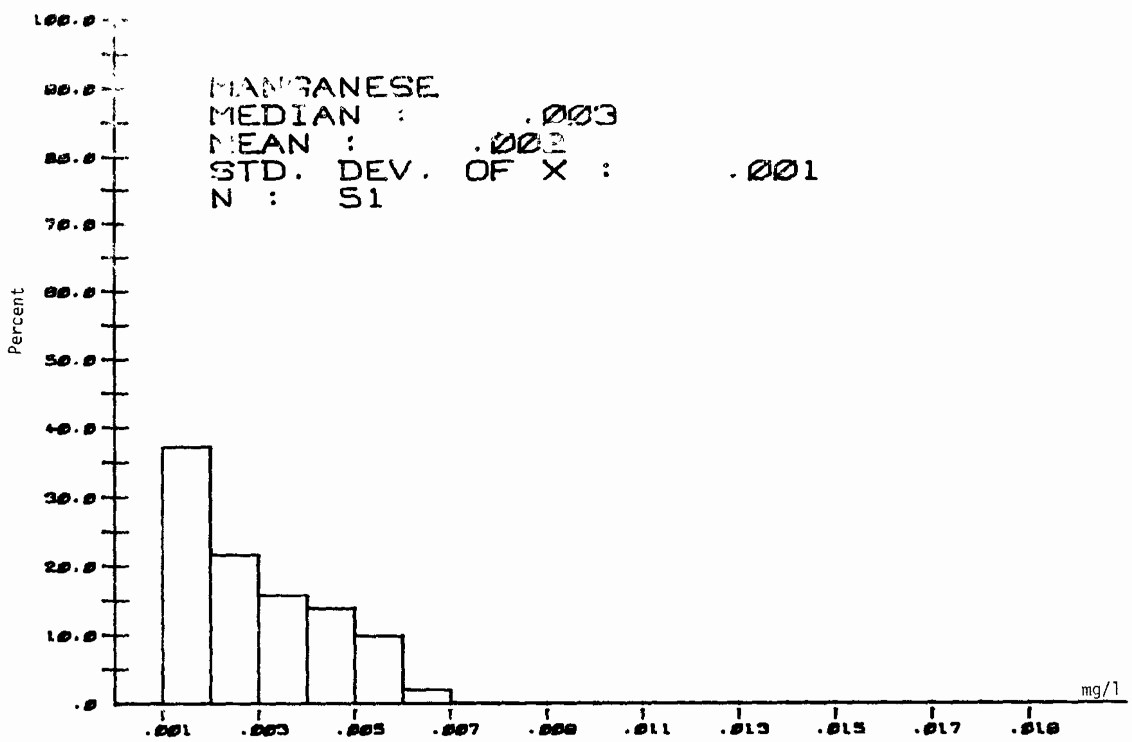


Figure 4.20a Histograms for Manganese - Cruise 3

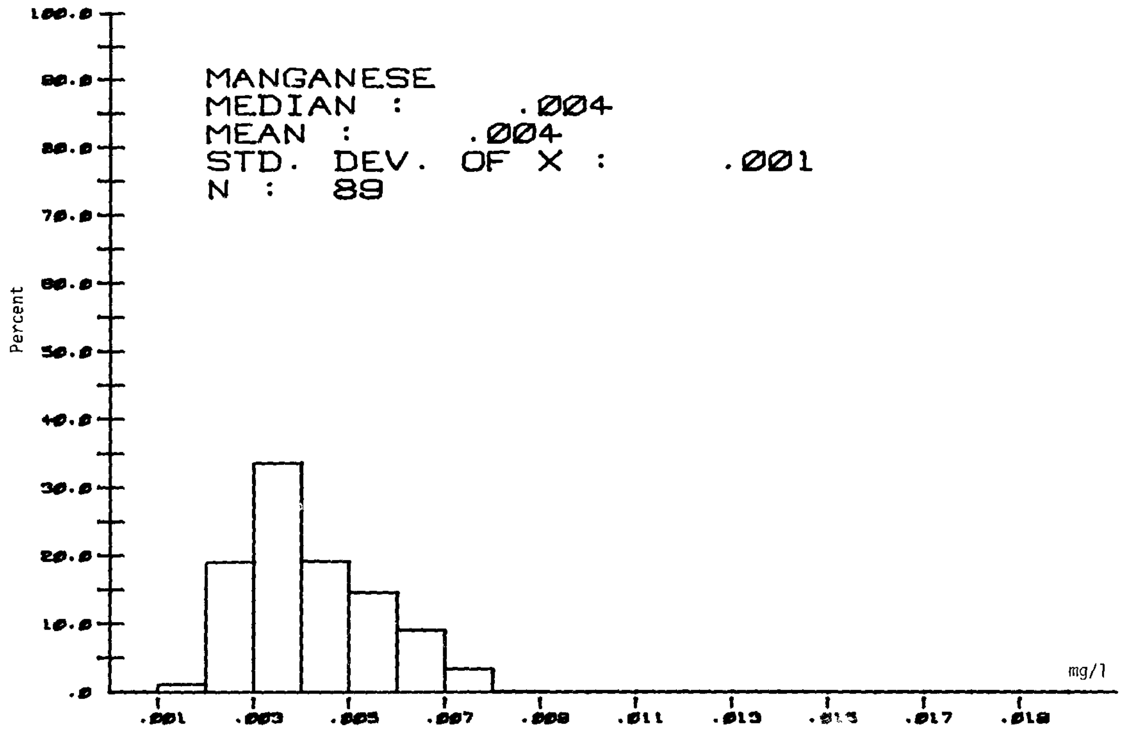


Figure 4.20a Histograms for Manganese - Cruise 7

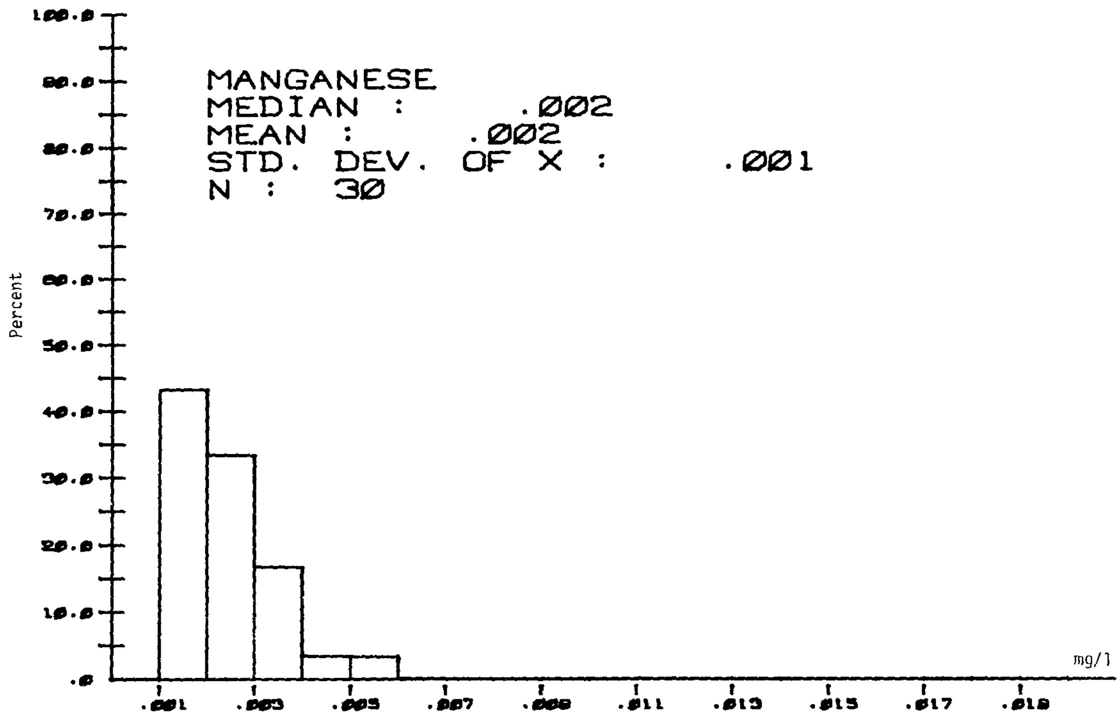


Figure 4.20a Histograms for Manganese - Cruise 8

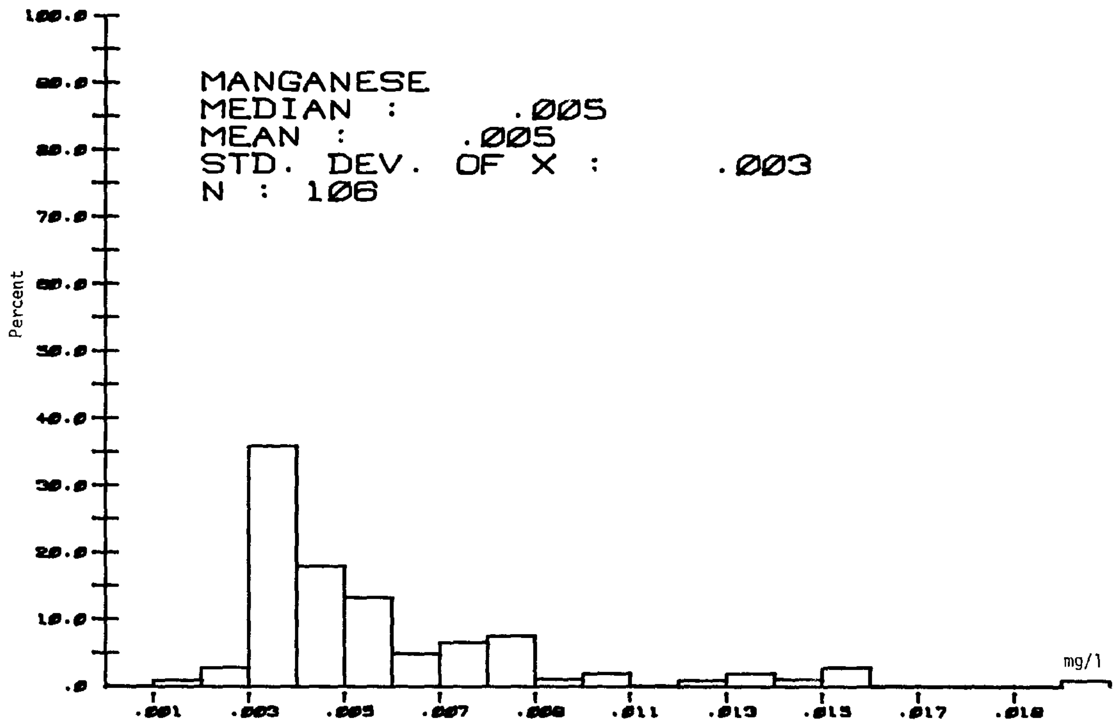


Figure 4.20a Histograms for Manganese - Cruise 9

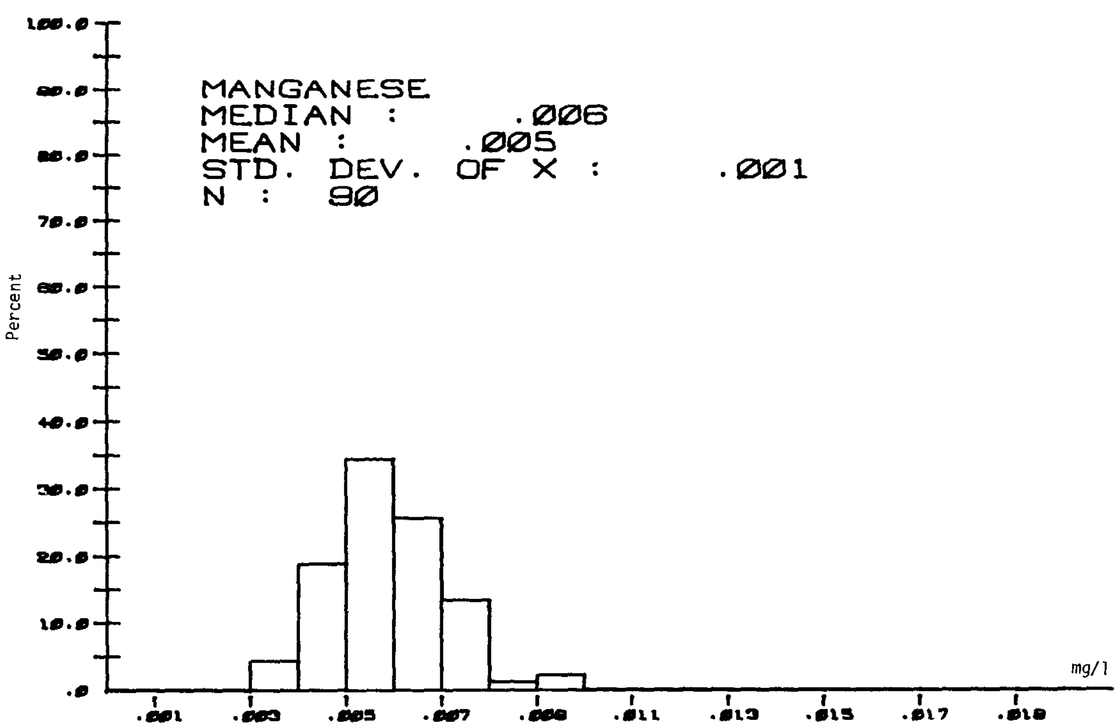


Figure 4.20a Histograms for Manganese - Cruise 10

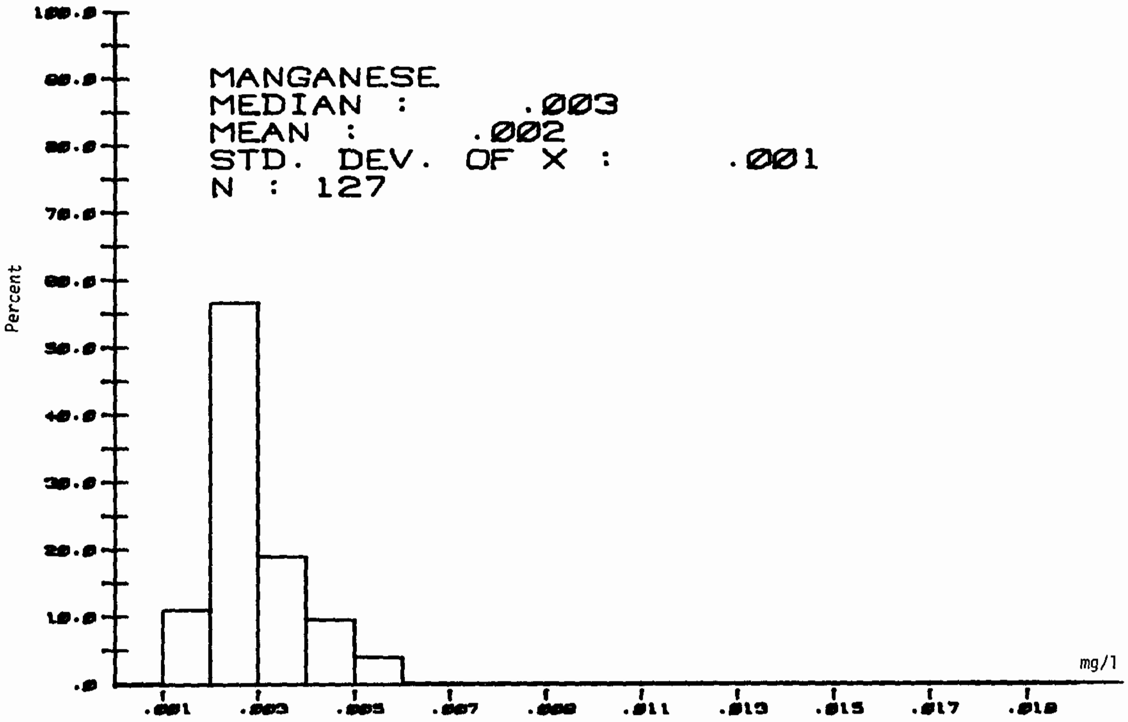


Figure 4.20a Histograms for Manganese -
Cruise 11

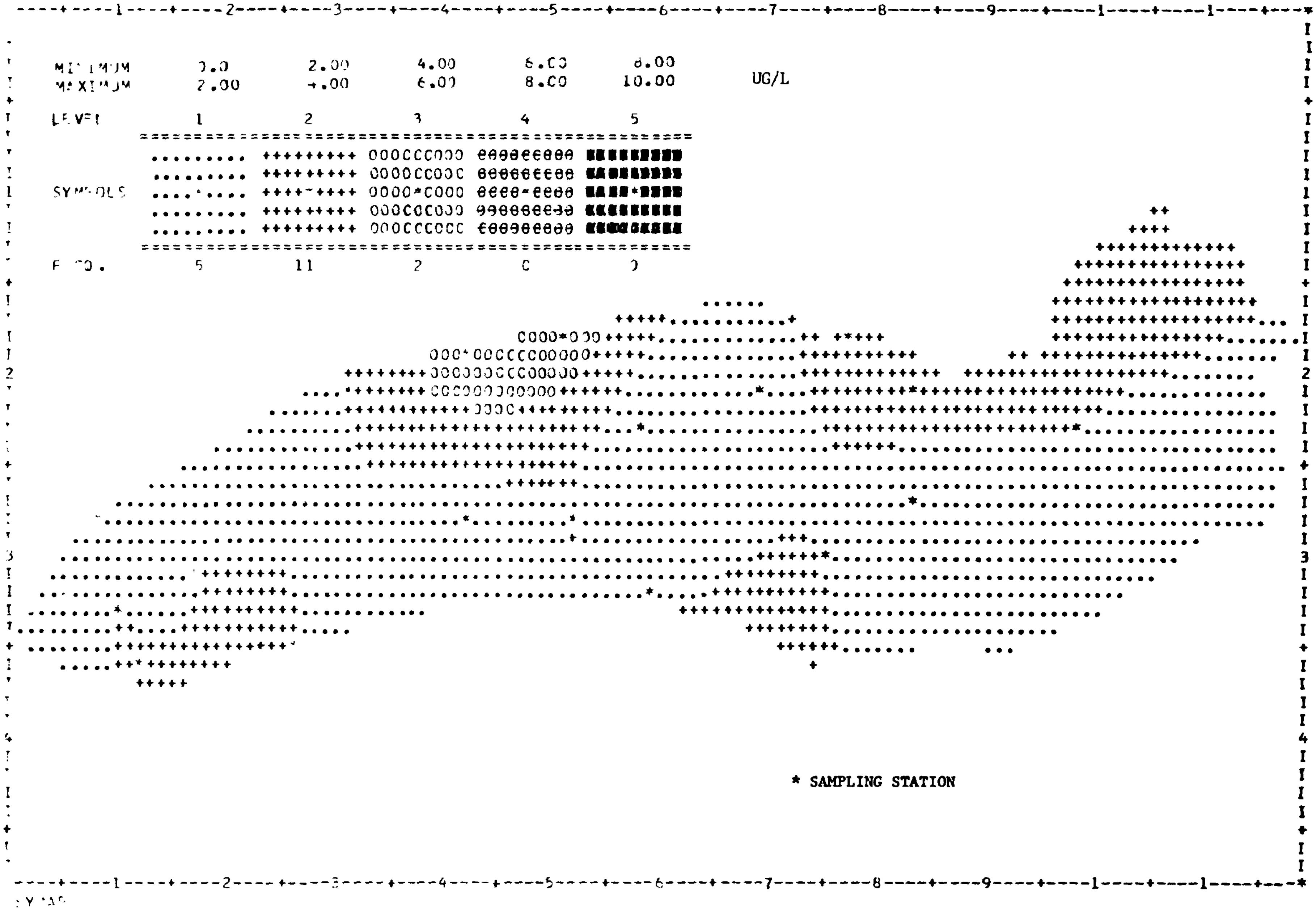


Figure 4.20b Contours of Constant Surface Manganese

CRUISE NUMBER 2: JUNE 12, 1972 TO JUNE 16, 1972

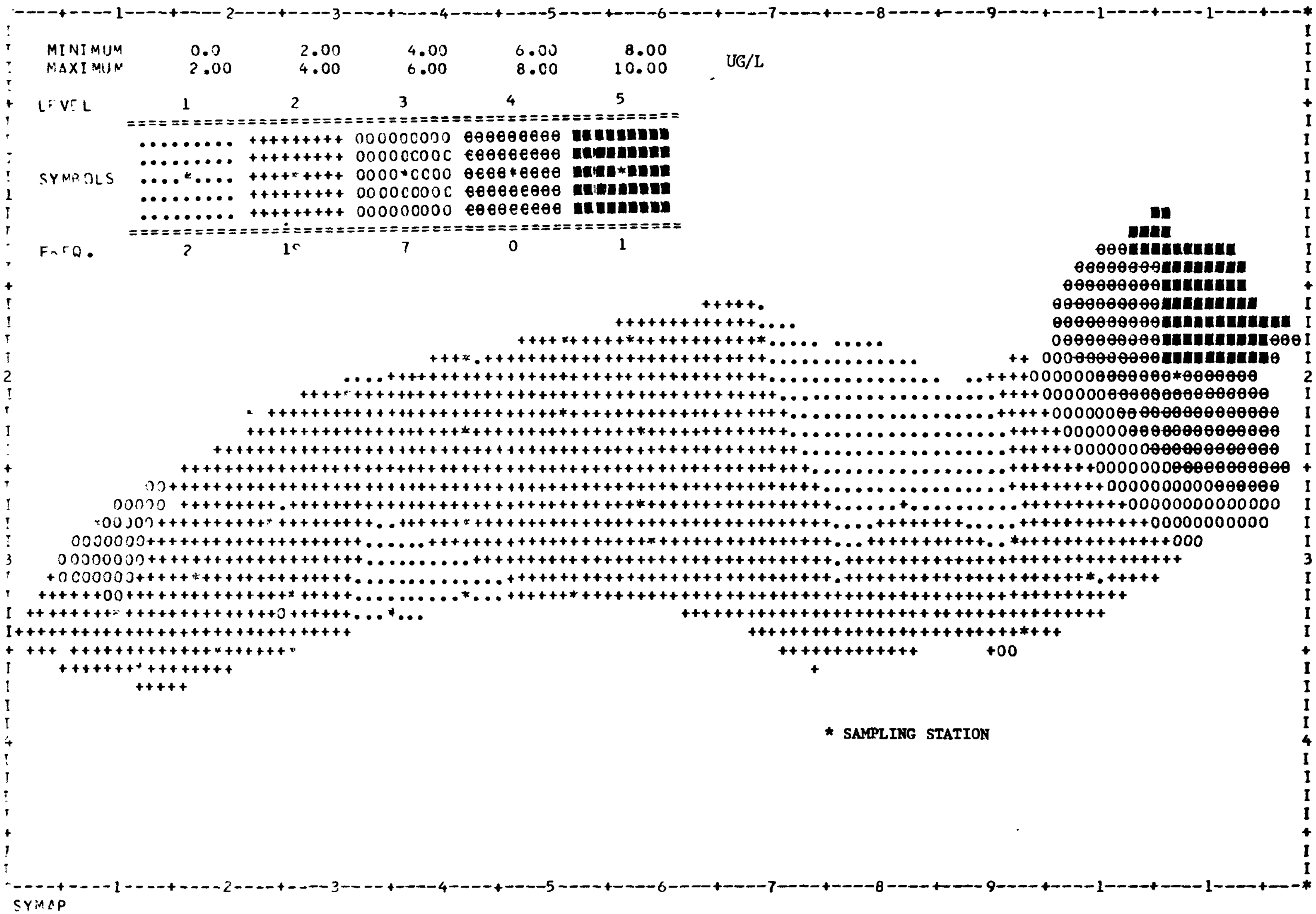


Figure 4.20b Contours of Constant Surface Manganese

CRUISE NUMBER 5: AUGUST 21, 1972 TO AUGUST 25, 1972

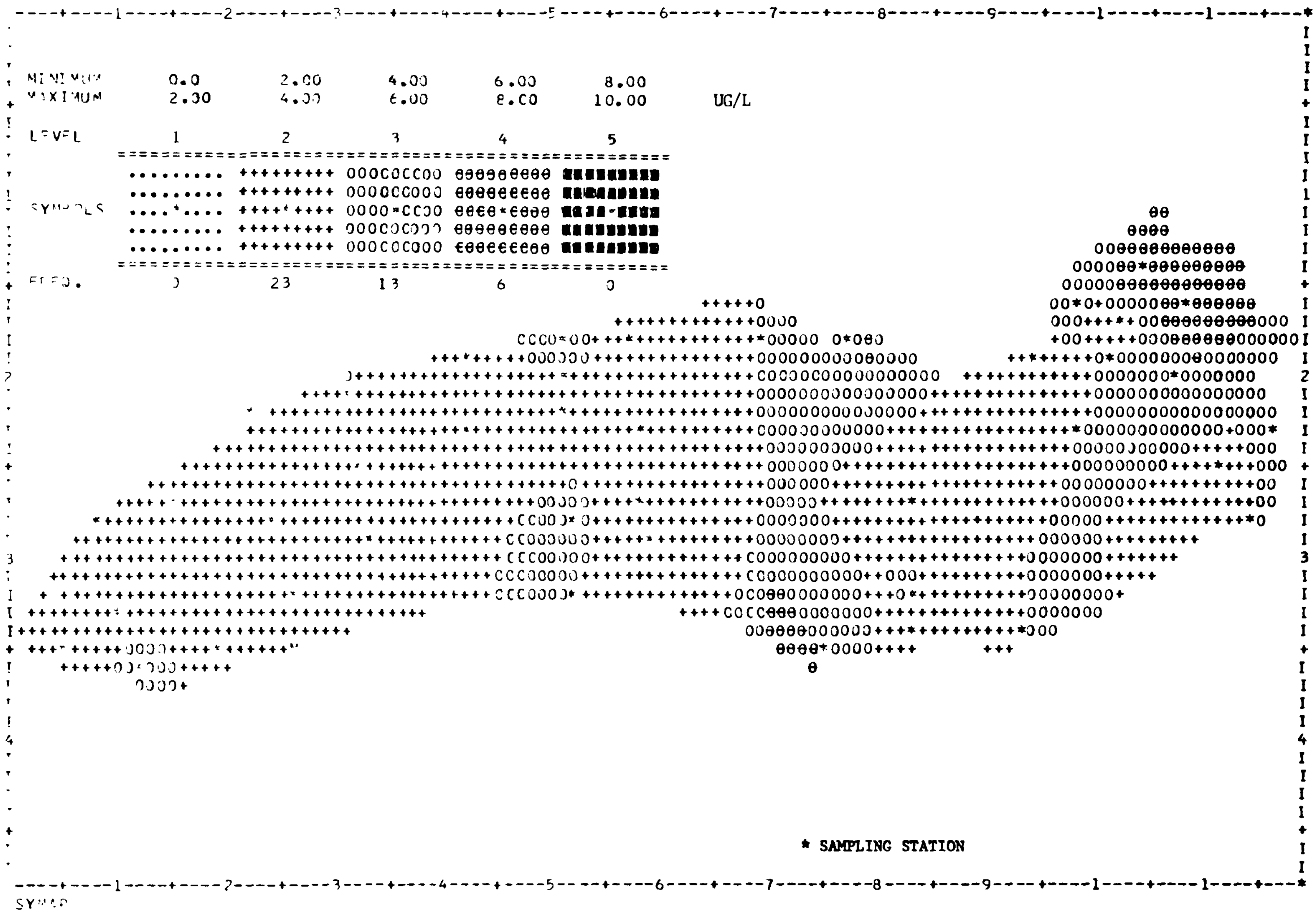


Figure 4.20b Contours of Constant Surface Manganese

CRUISE NUMBER 7: NOVEMBER 27, 1972 TO DECEMBER 2, 1972

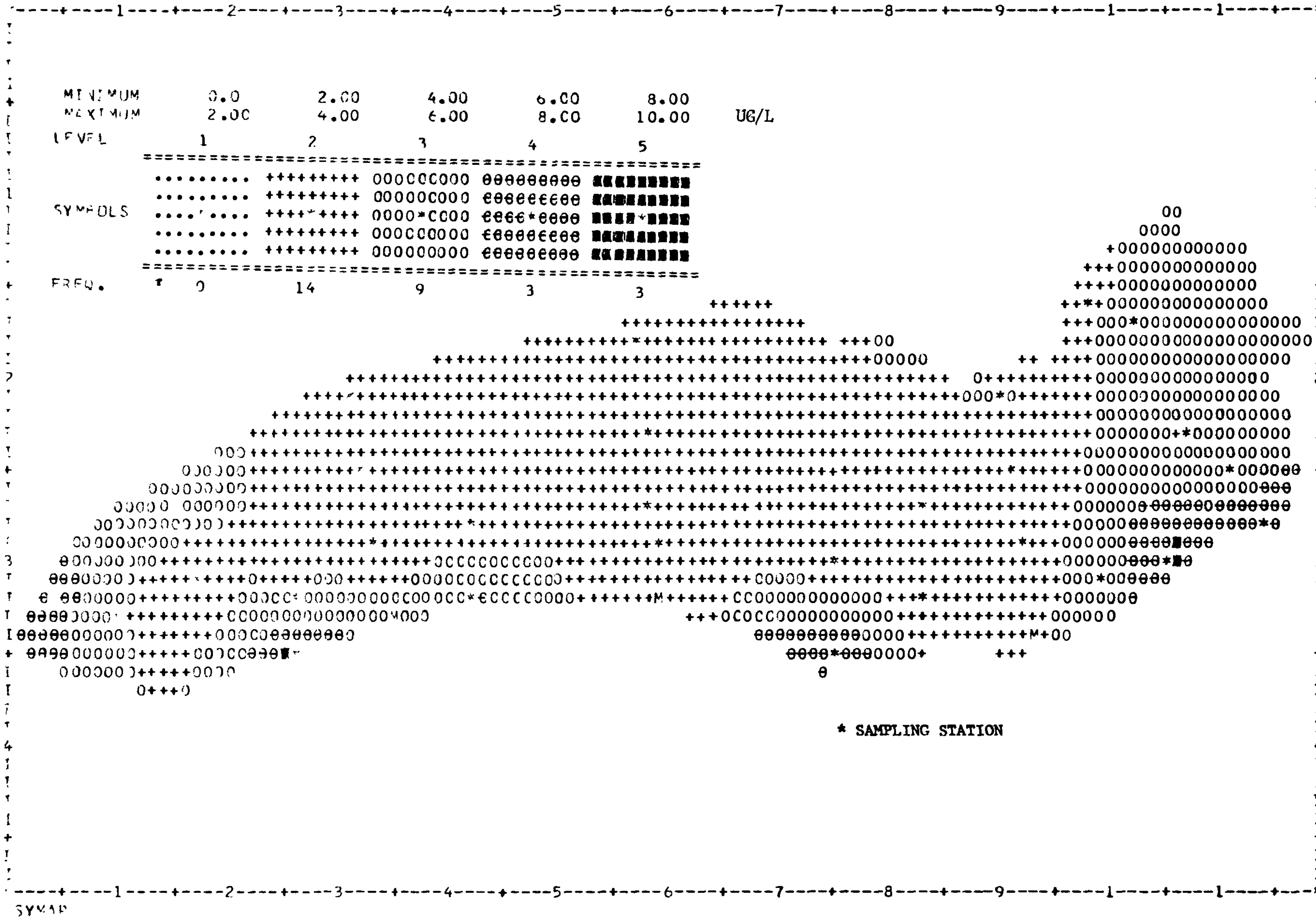


Figure 4.20b Contours of Constant Surface Manganese

CRUISE NUMBER 9: MARCH 16, 1973 TO MARCH 23, 1973

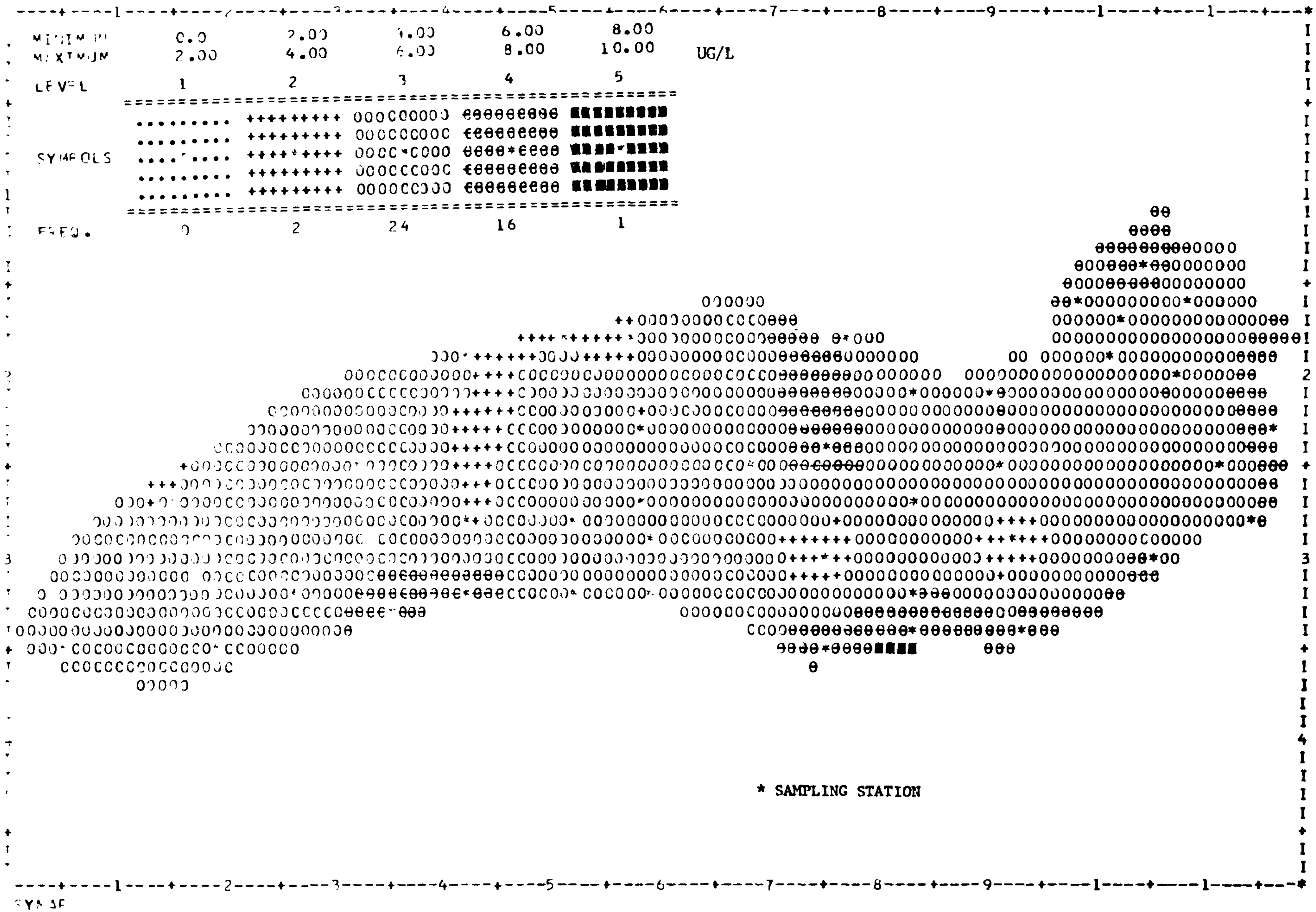


Figure 4.20b Contours of Constant Surface Manganese

CRUISE NUMBER 10: APRIL 24, 1973 TO APRIL 30, 1973

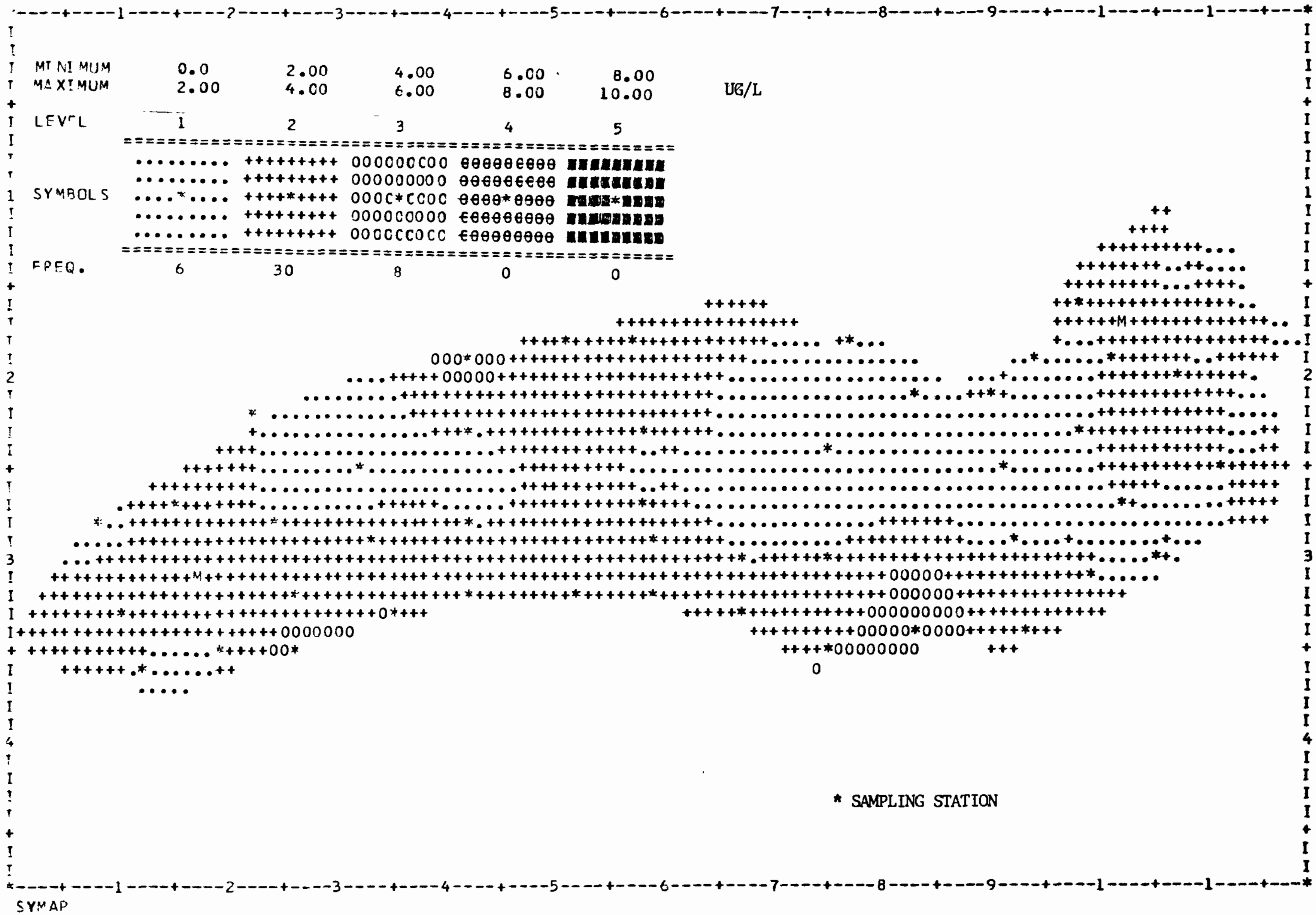


Figure 4.20b Contours of Constant Surface Manganese

CRUISE NUMBER 11: JUNE 11, 1973 TO JUNE 15, 1973

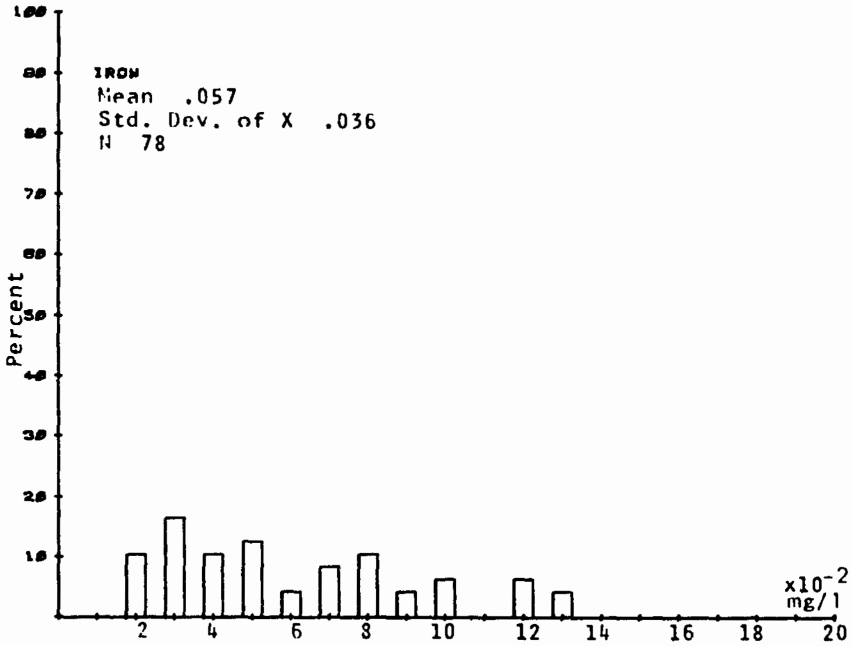


Figure 4.21a Histograms for Iron - Cruise 5

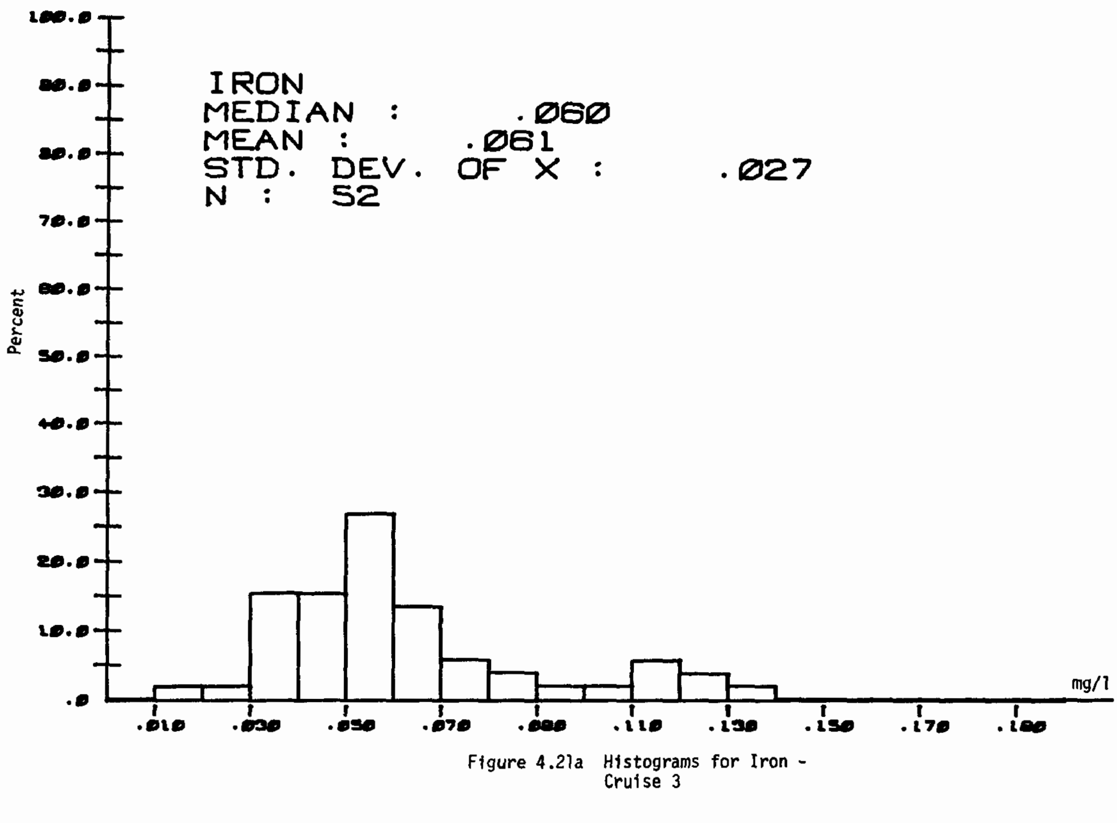


Figure 4.21a Histograms for Iron - Cruise 3

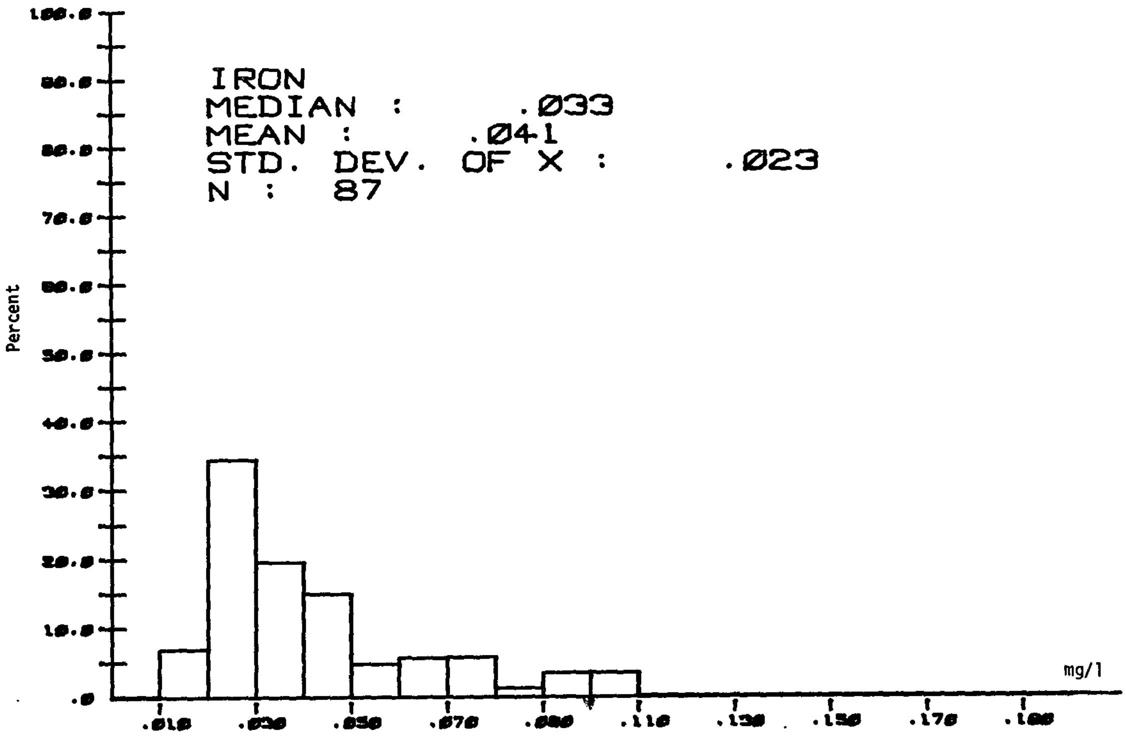


Figure 4.21a Histograms for Iron -
Cruise 7

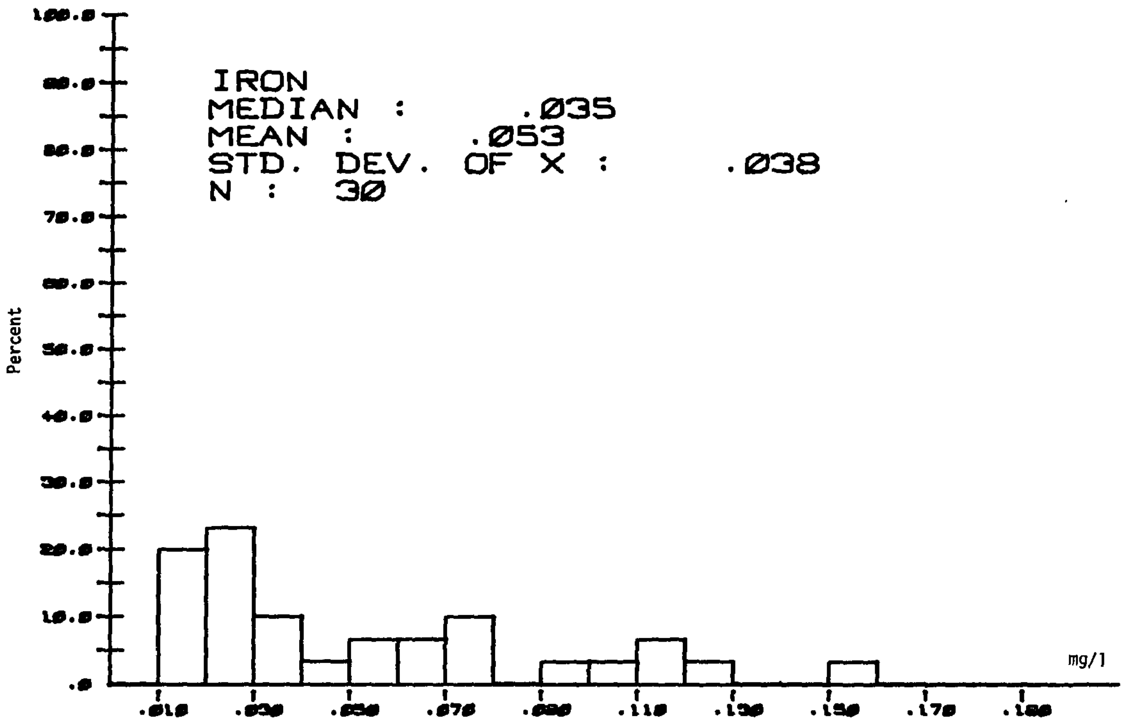


Figure 4.21a Histograms for Iron -
Cruise 8

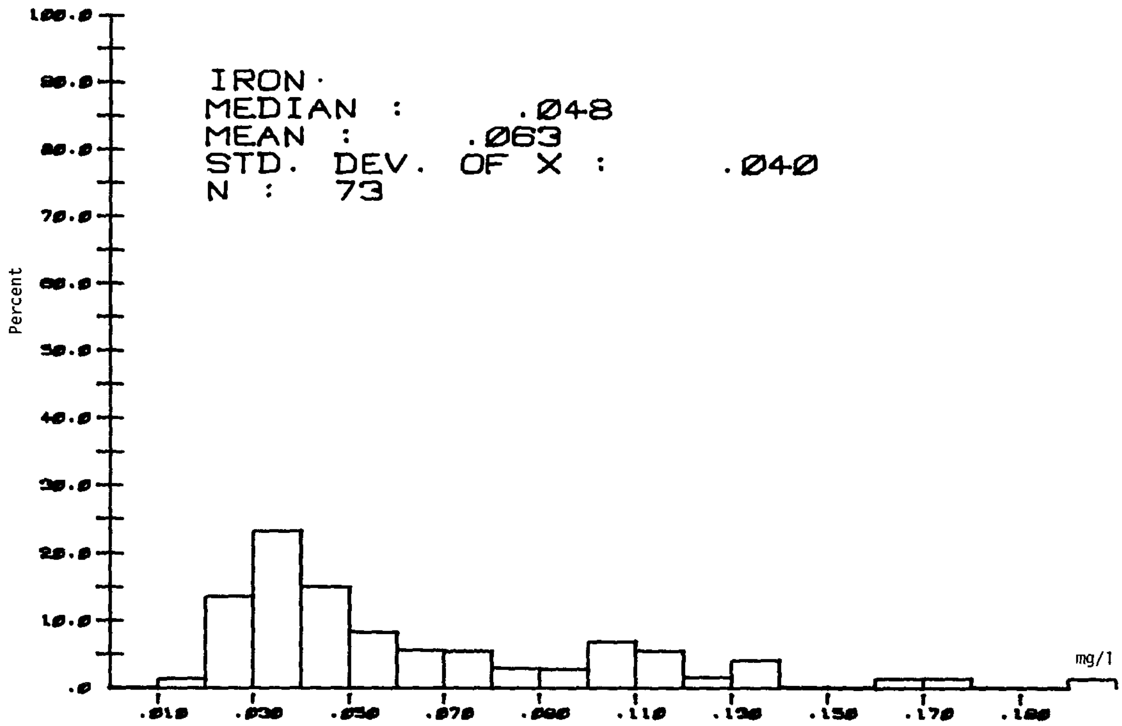


Figure 4.21a Histograms for Iron - Cruise 9

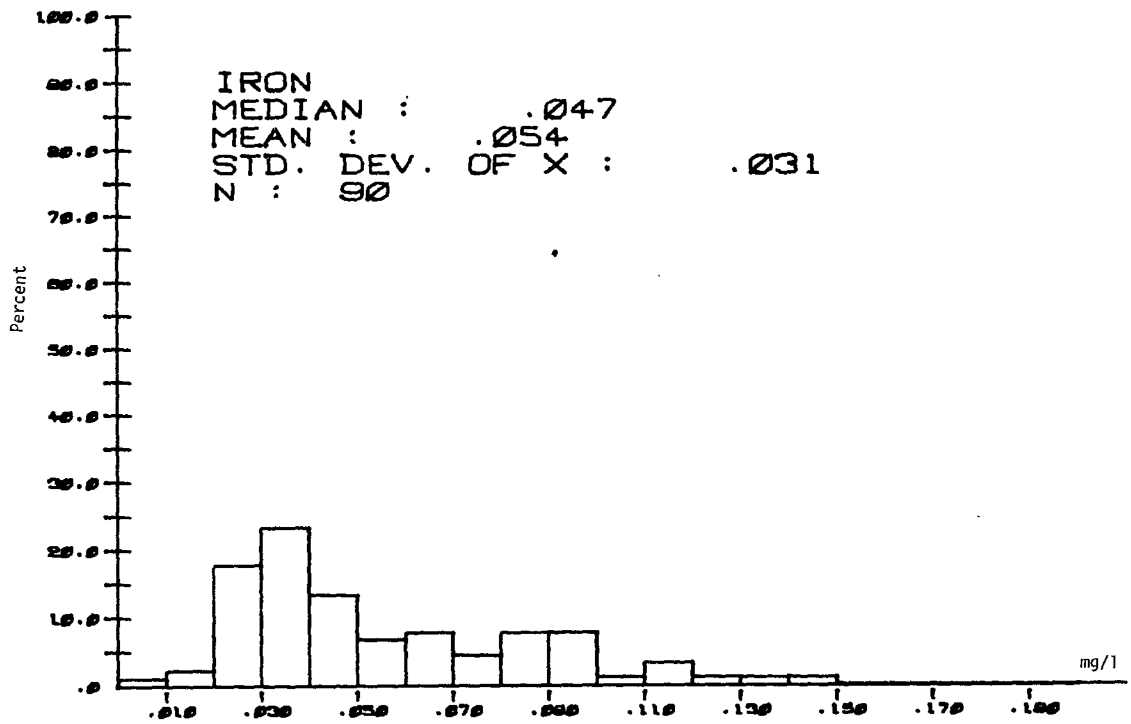


Figure 4.21a Histograms for Iron - Cruise 10

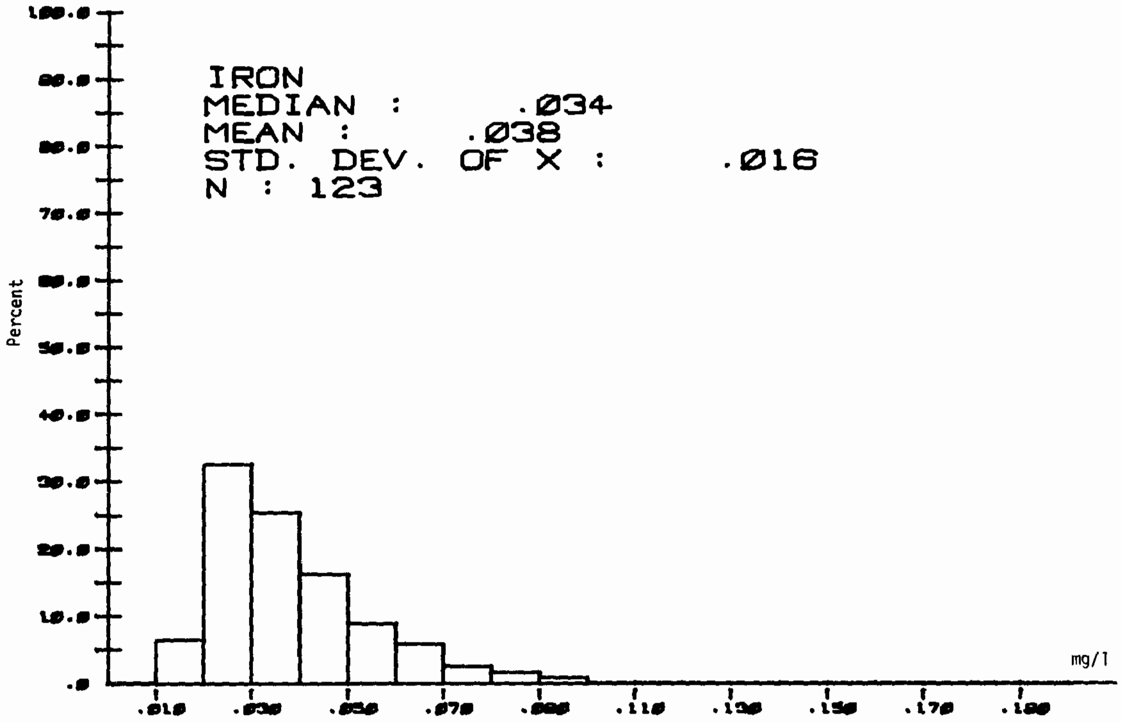


Figure 4.21a Histograms for Iron -
Cruise 11

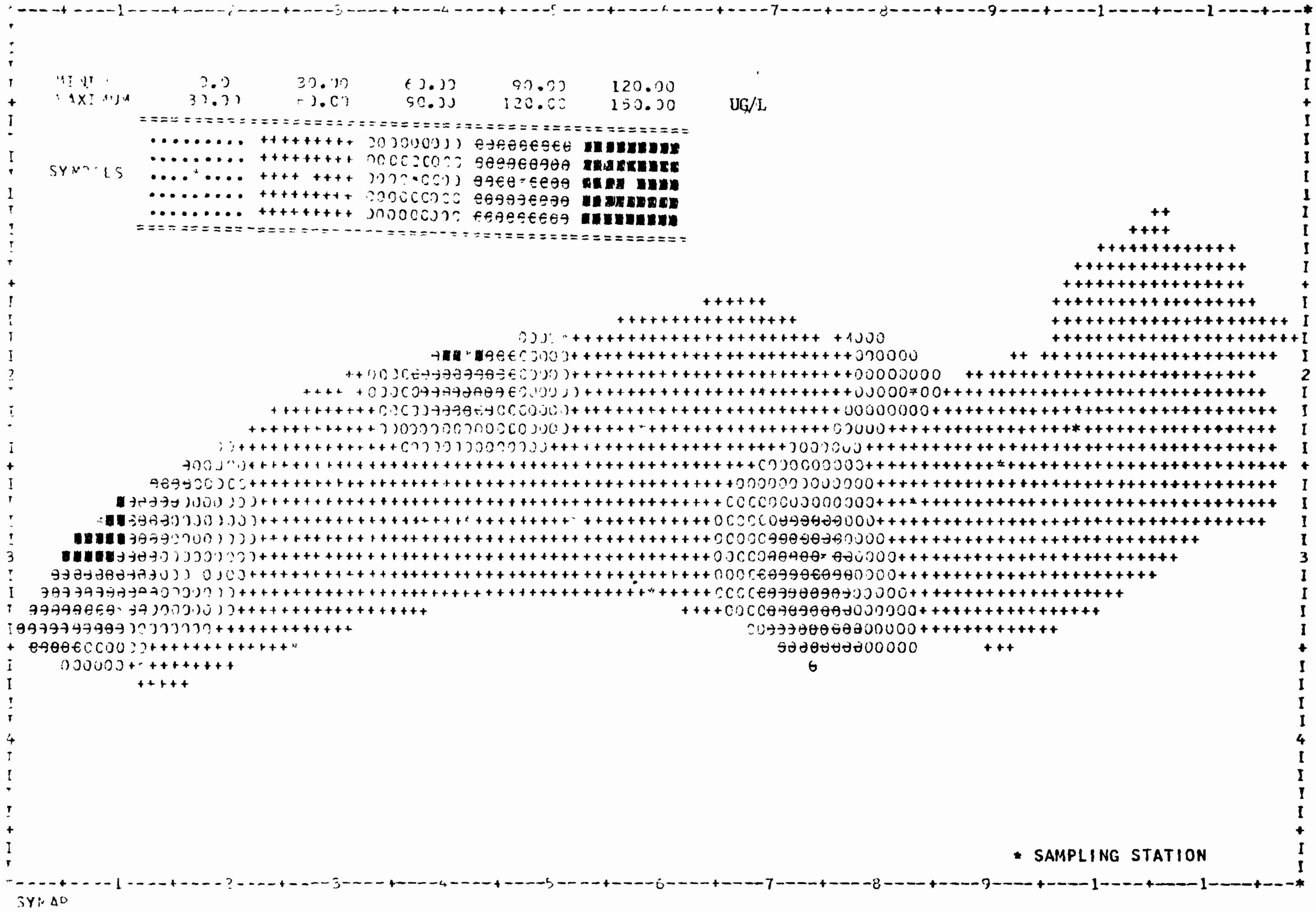


Figure 4.21b Contours of Constant Surface Iron

CRUISE NUMBER 3: JUNE 12, 1972 - JUNE 16, 1972

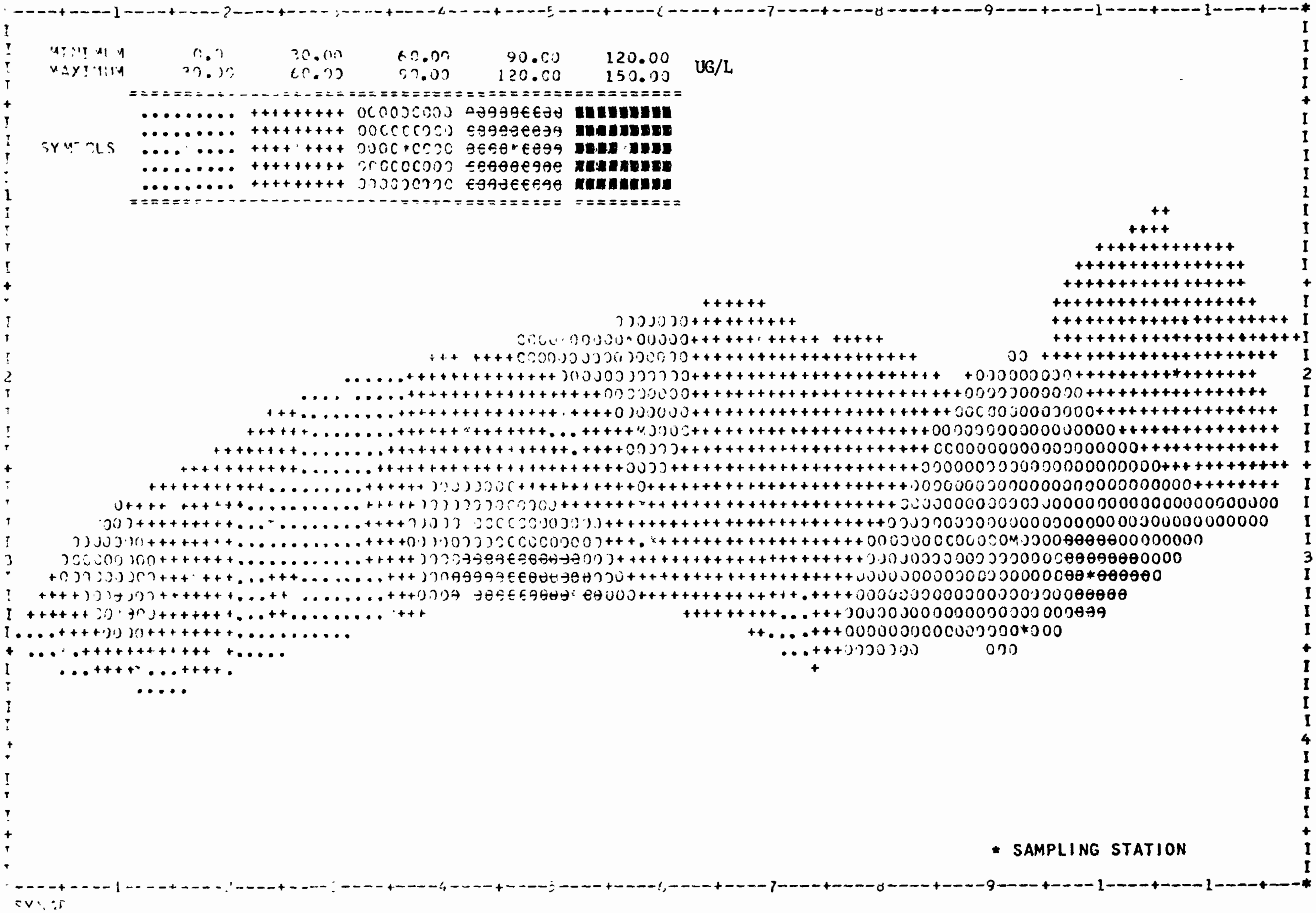
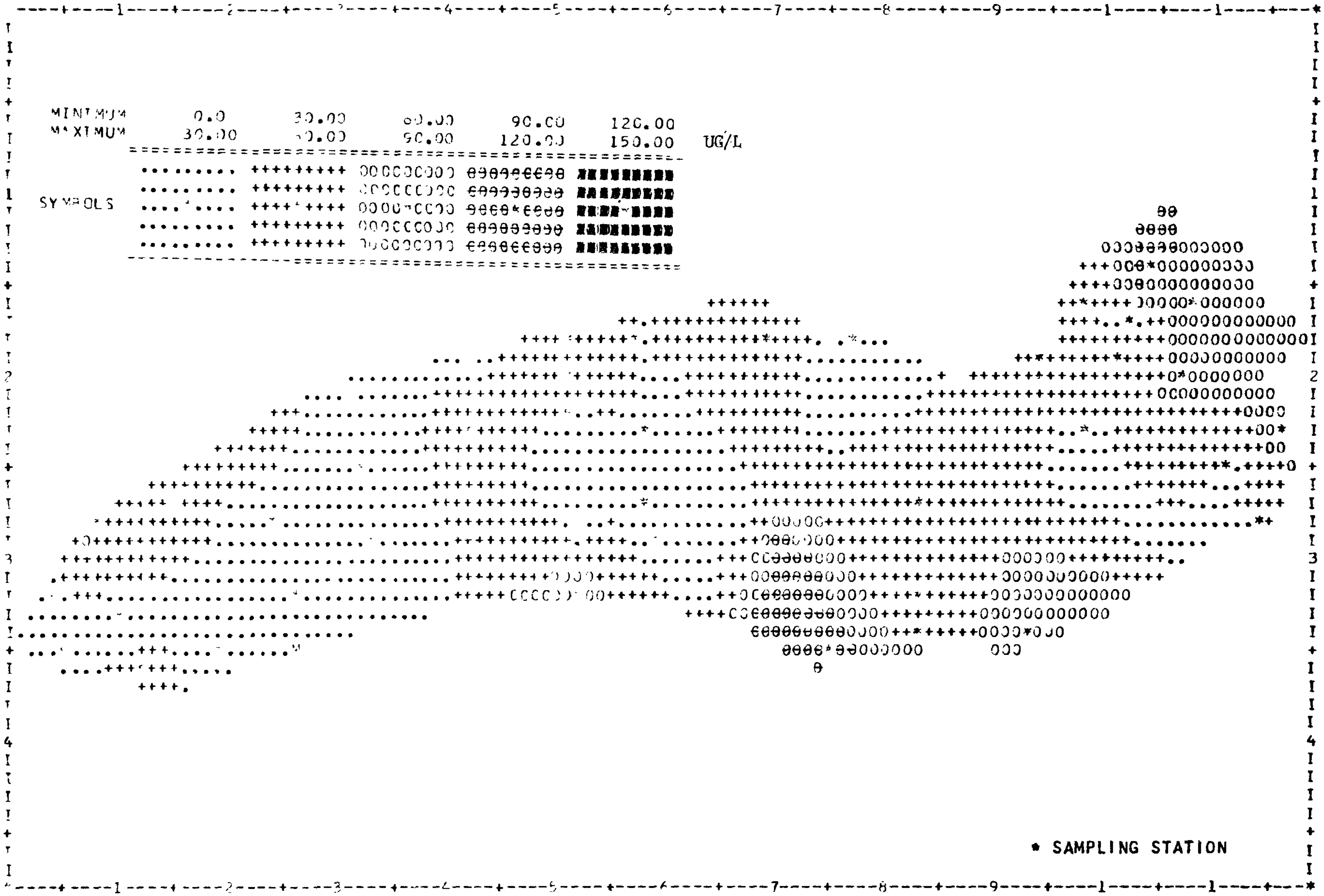


Figure 4.21b Contours of Constant Surface Iron

[illegible] AUGUST 21, 1972 TO AUGUST 25, 1972



SYMAP

Figure 4.21b Contours of Constant Surface Iron

CRUISE NUMBER 7: NOVEMBER 27, 1972 TO DECEMBER 2, 1972

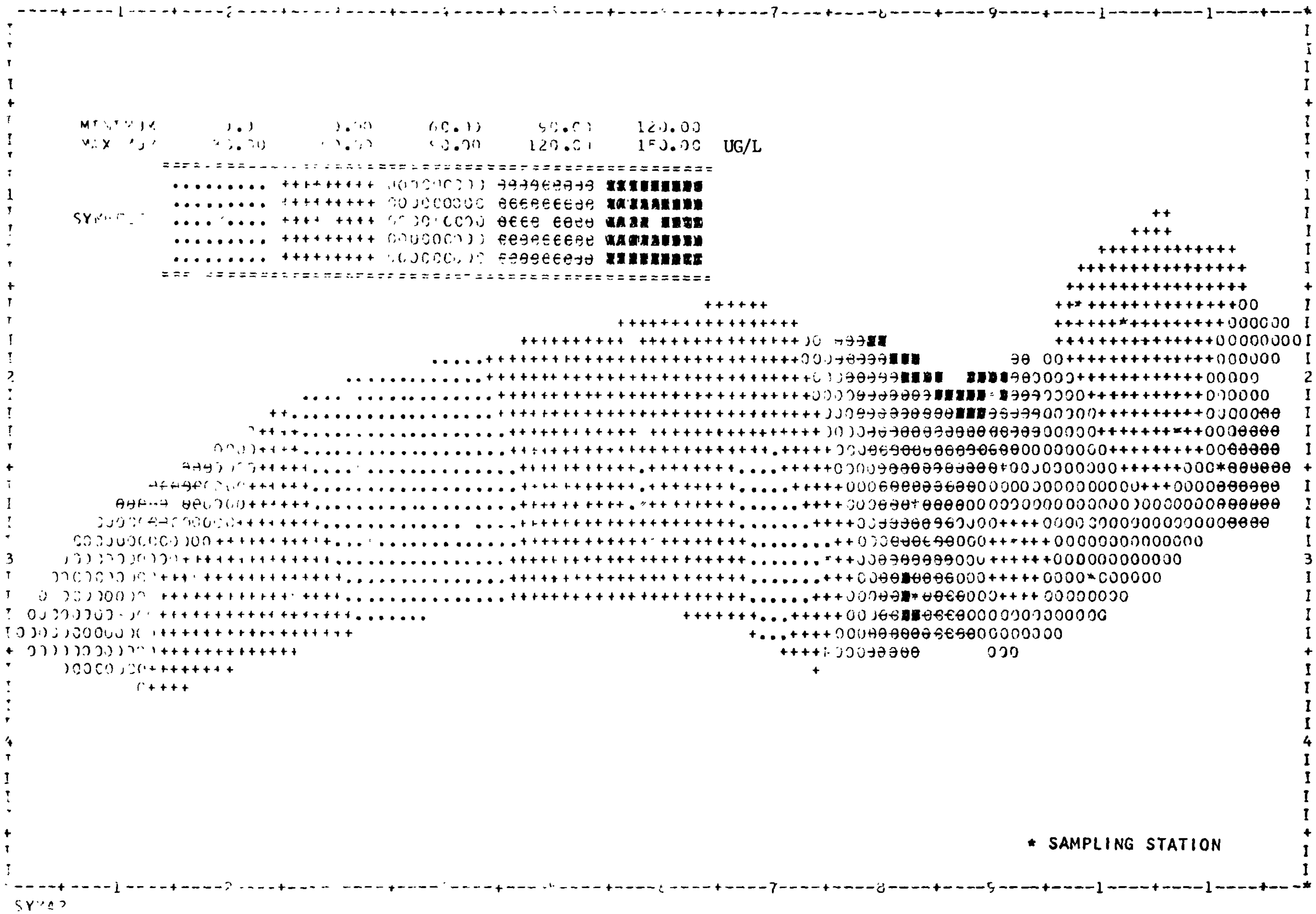


Figure 4.21b Contours of Constant Surface Iron

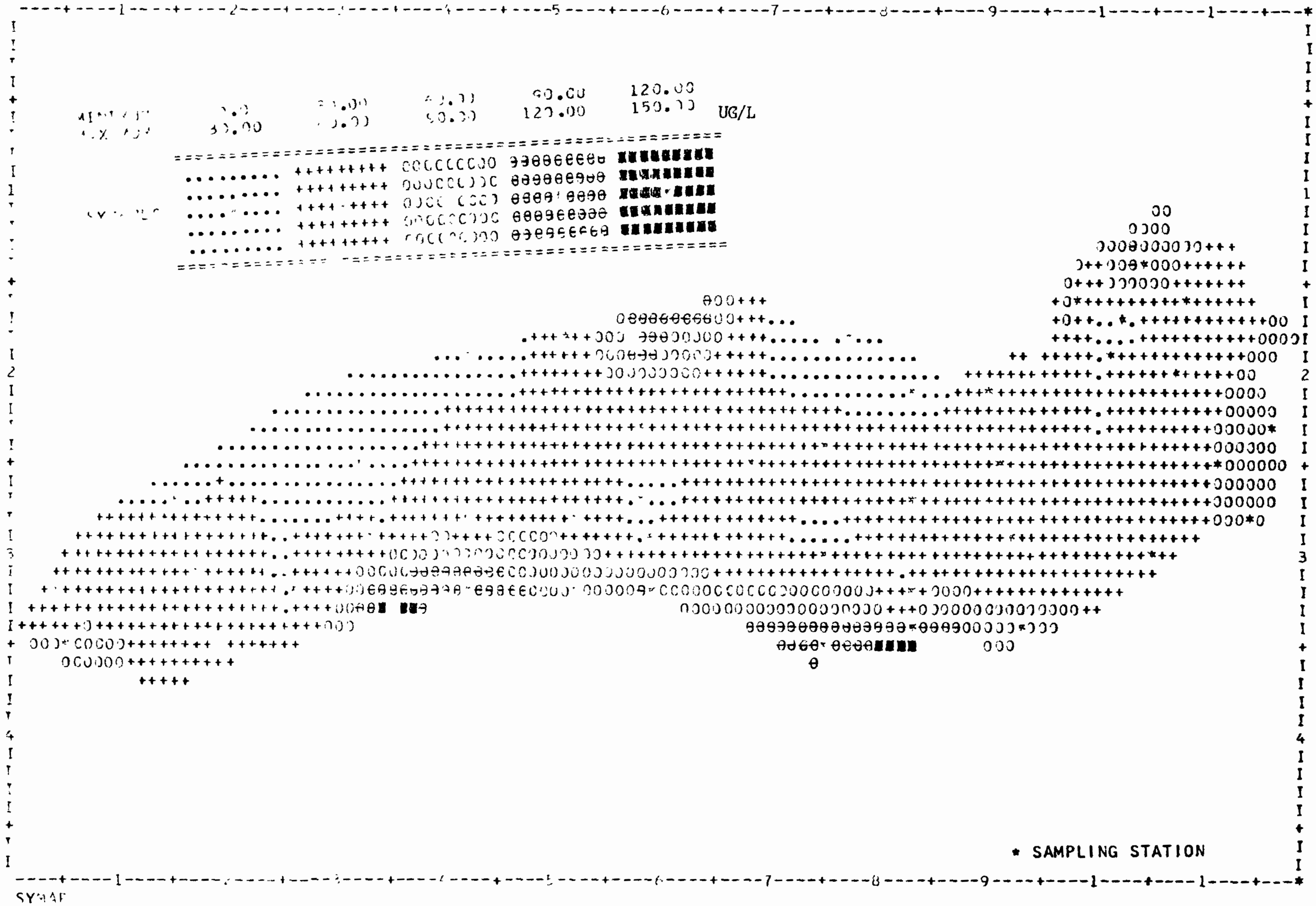


Figure 4.21b Contours of Constant Surface Iron

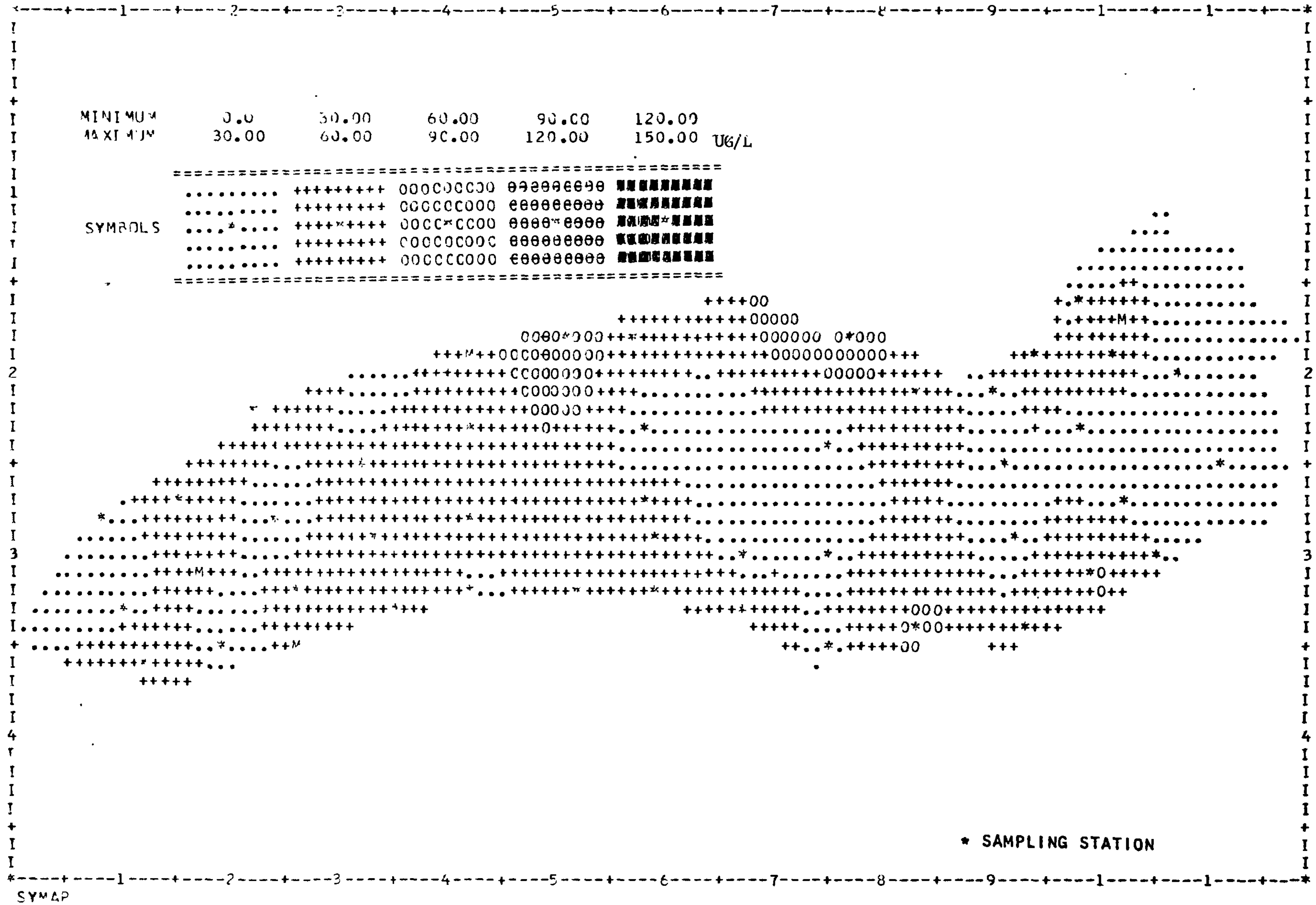


Figure 4.21b Contours of Constant Surface Iron

CRUISE NUMBER 11: JUNE 11, 1973 TO JUNE 15, 1973

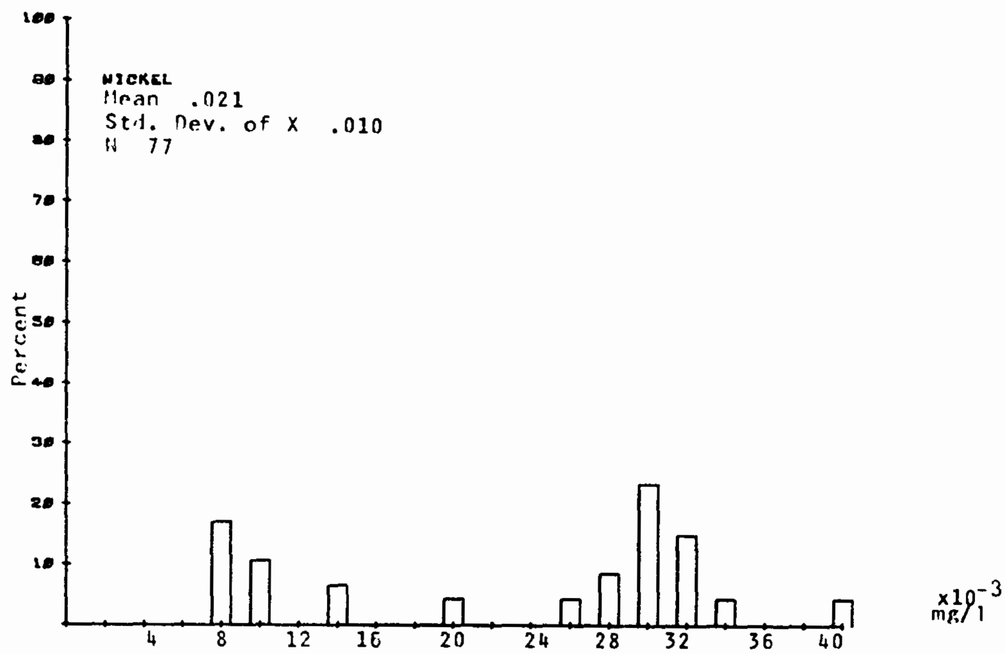


Figure 4.22a Histograms for Nickel -
Cruise 5

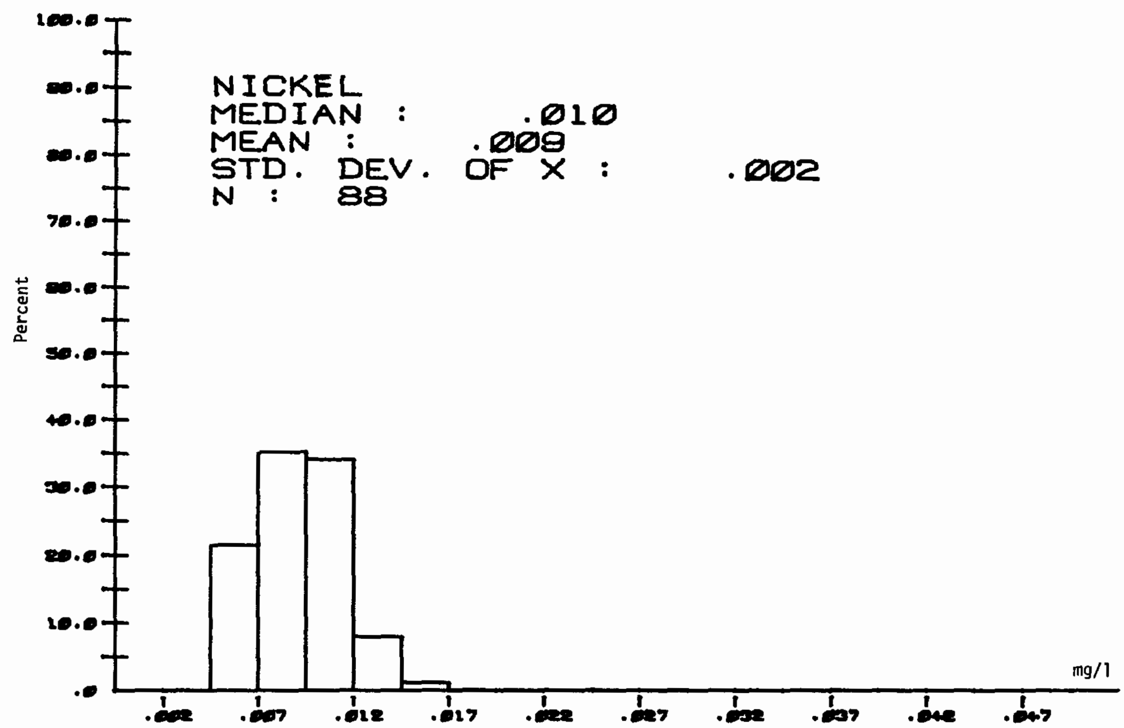


Figure 4.22a Histograms for Nickel -
Cruise 7

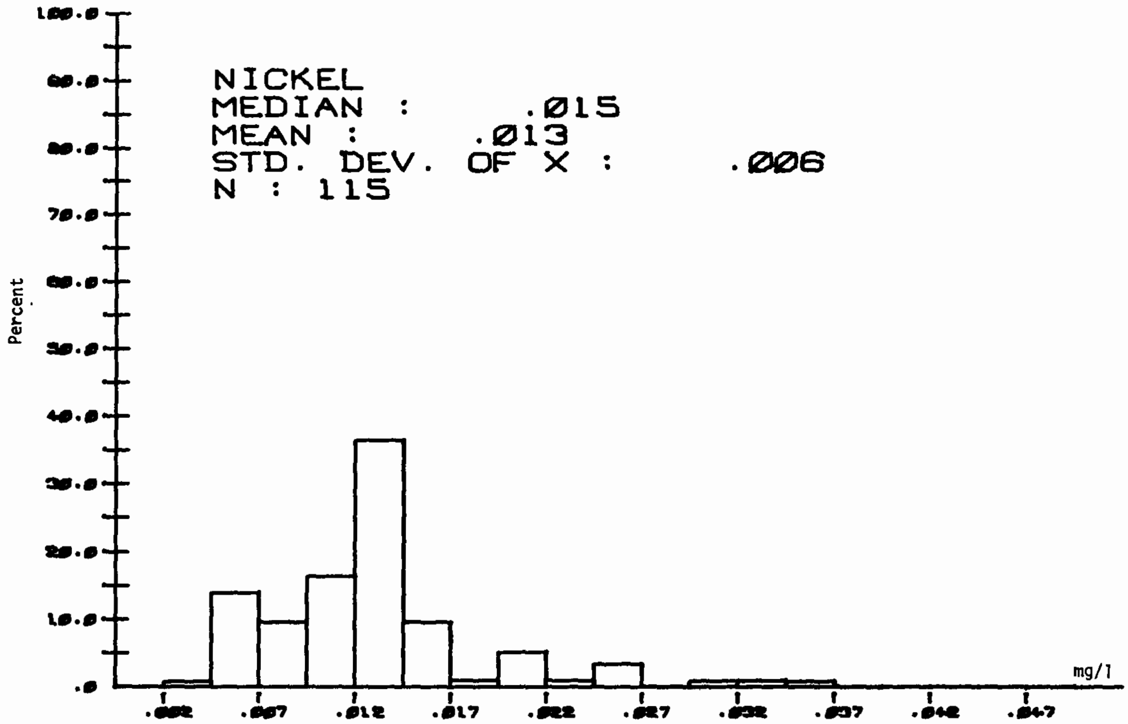


Figure 4.22a Histograms for Nickel -
Cruise 8

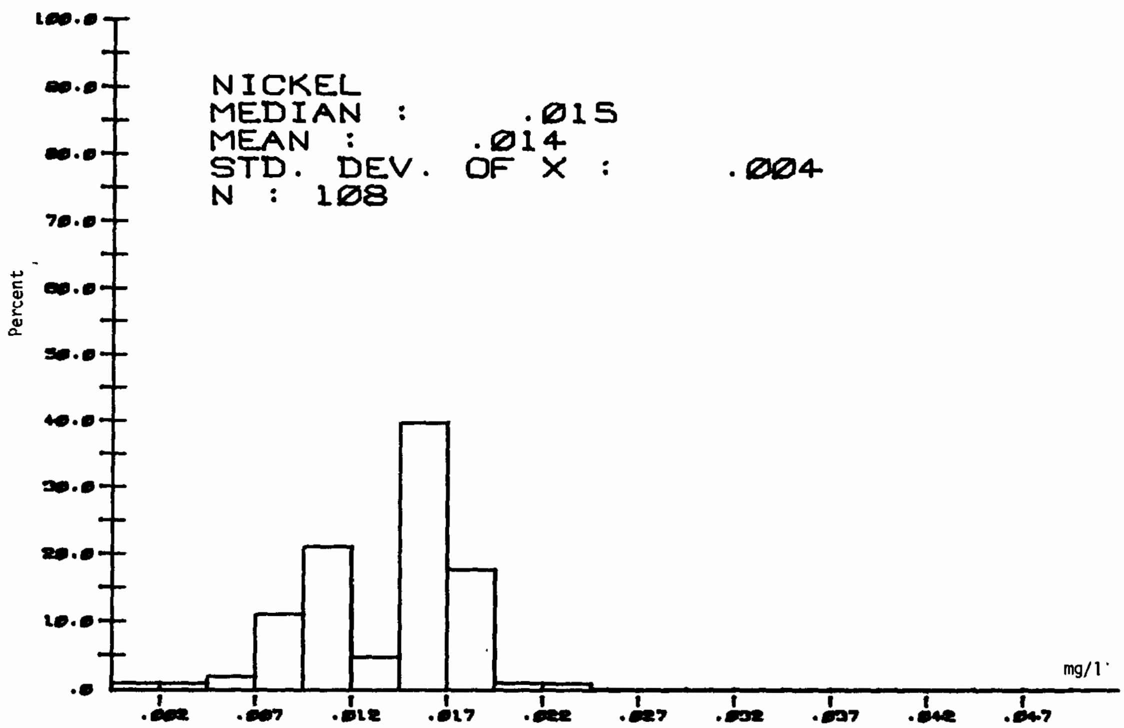


Figure 4.22a Histograms for Nickel -
Cruise 9

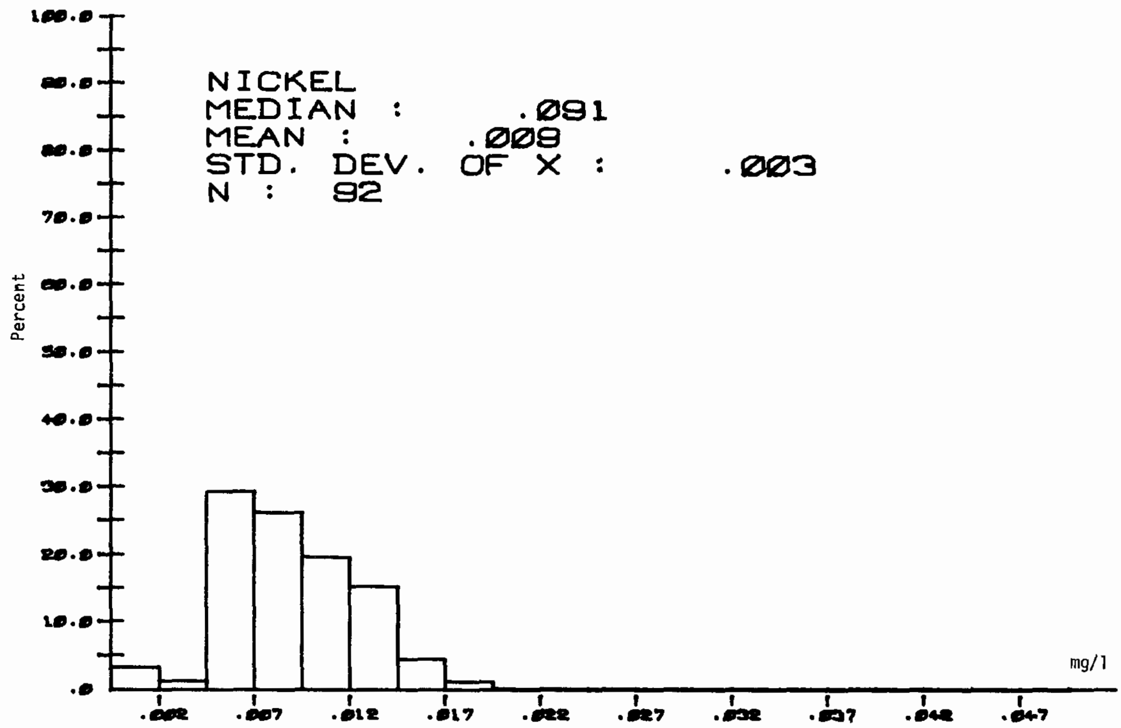


Figure 4.22a Histograms for Nickel - Cruise 10

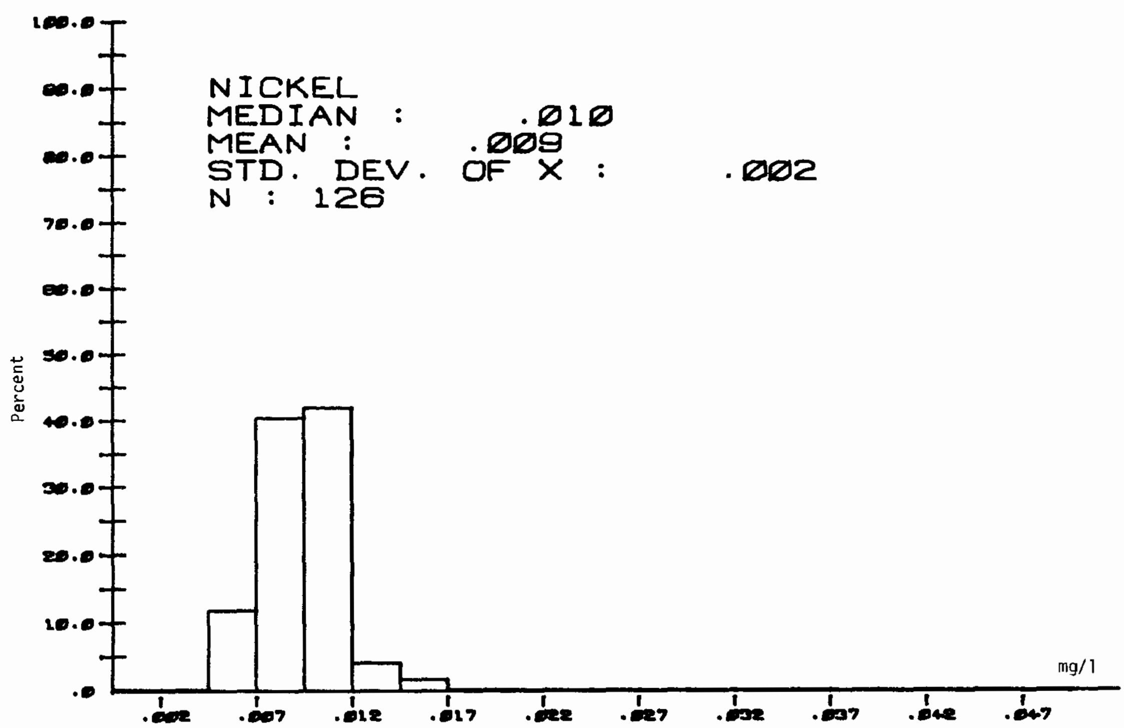


Figure 4.22a Histograms for Nickel - Cruise 11

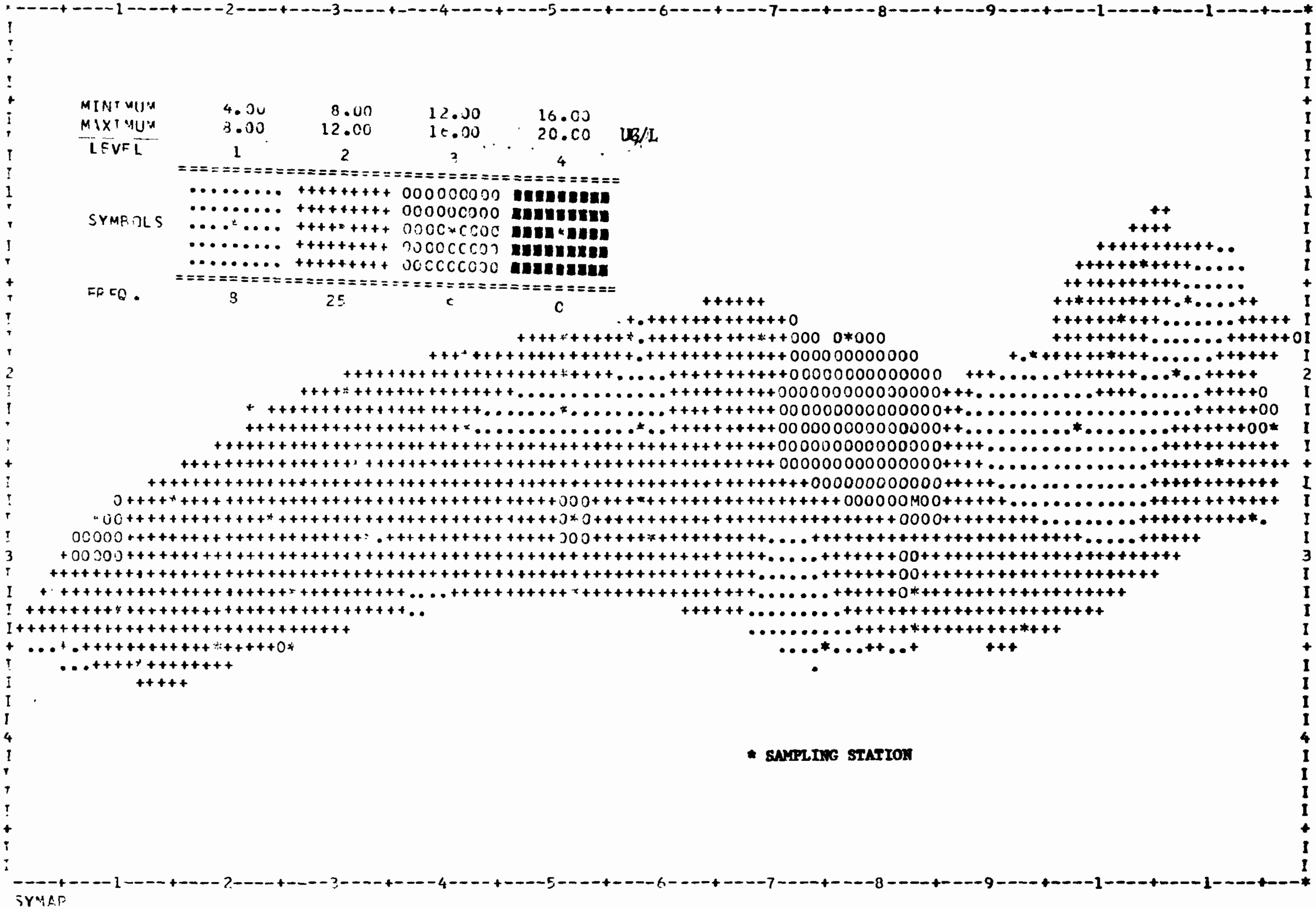


Figure 4.22b Contours of Constant Surface Nickel

CRUISE NUMBER 7: NOVEMBER 27, 1972 TO DECEMBER 2, 1972

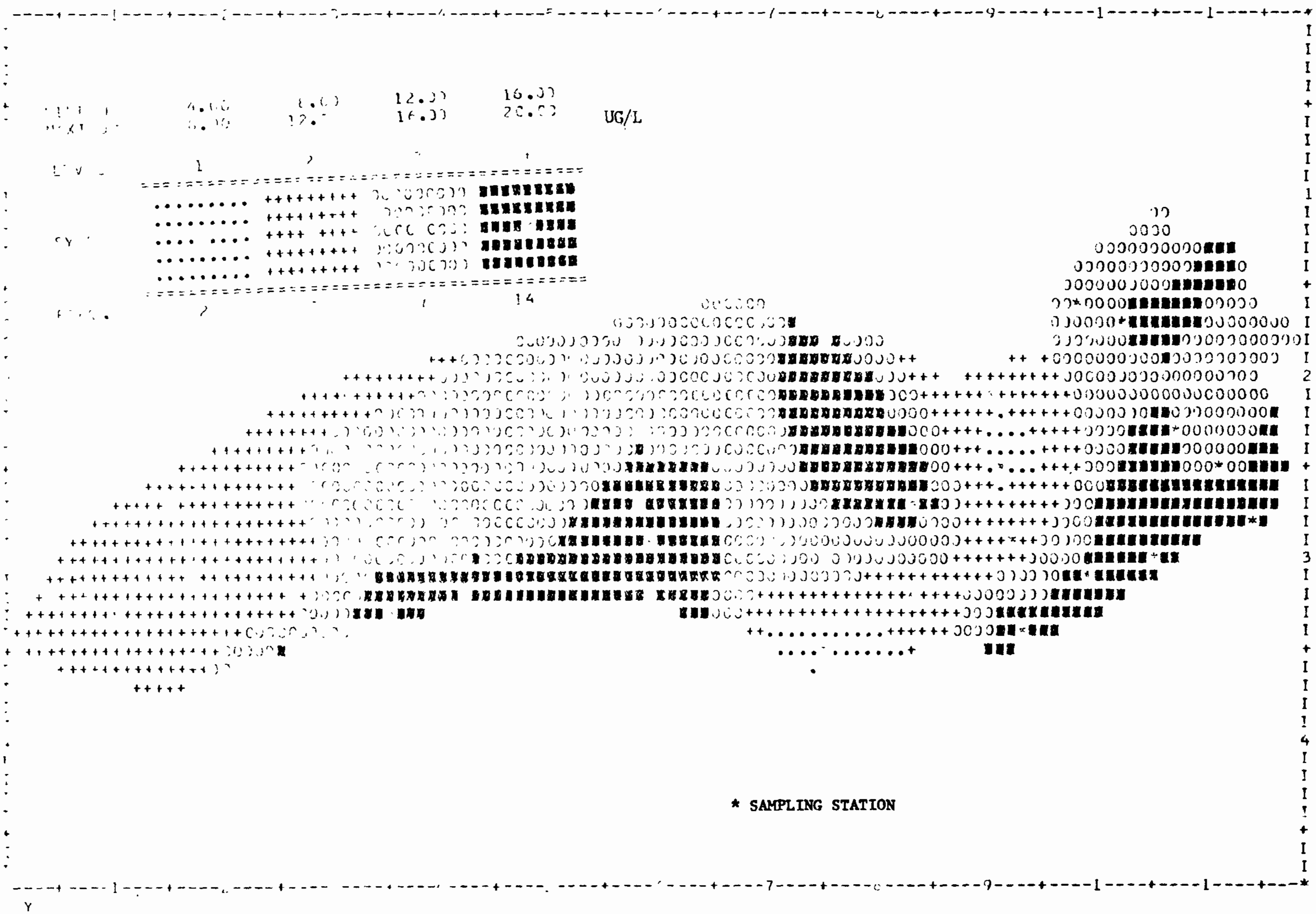


Figure 4.22b Contours of Constant Surface Nickel

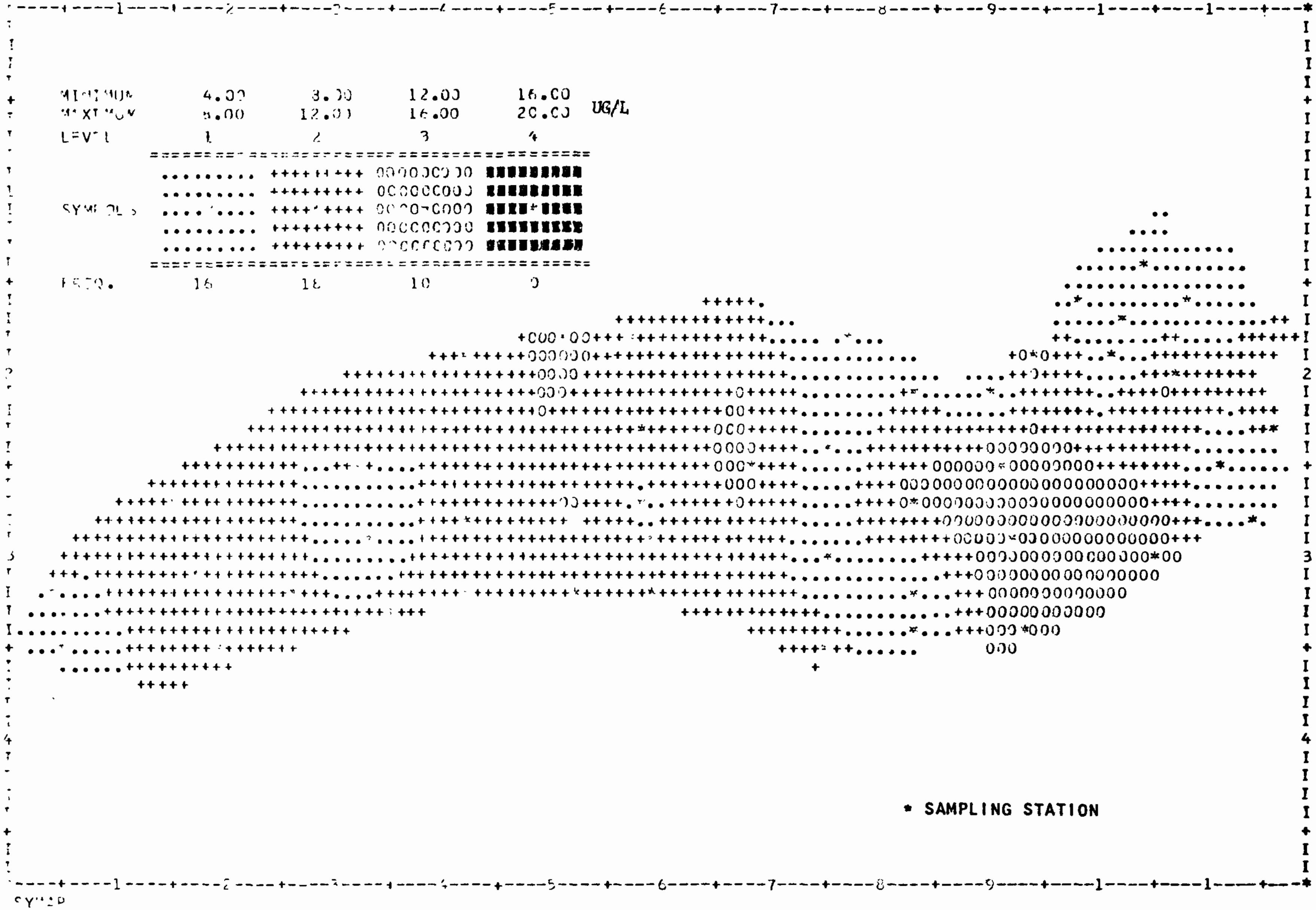


Figure 4.22b Contours of Constant Surface Nickel

CRUISE NUMBER 10: APRIL 24, 1973 TO APRIL 30, 1973

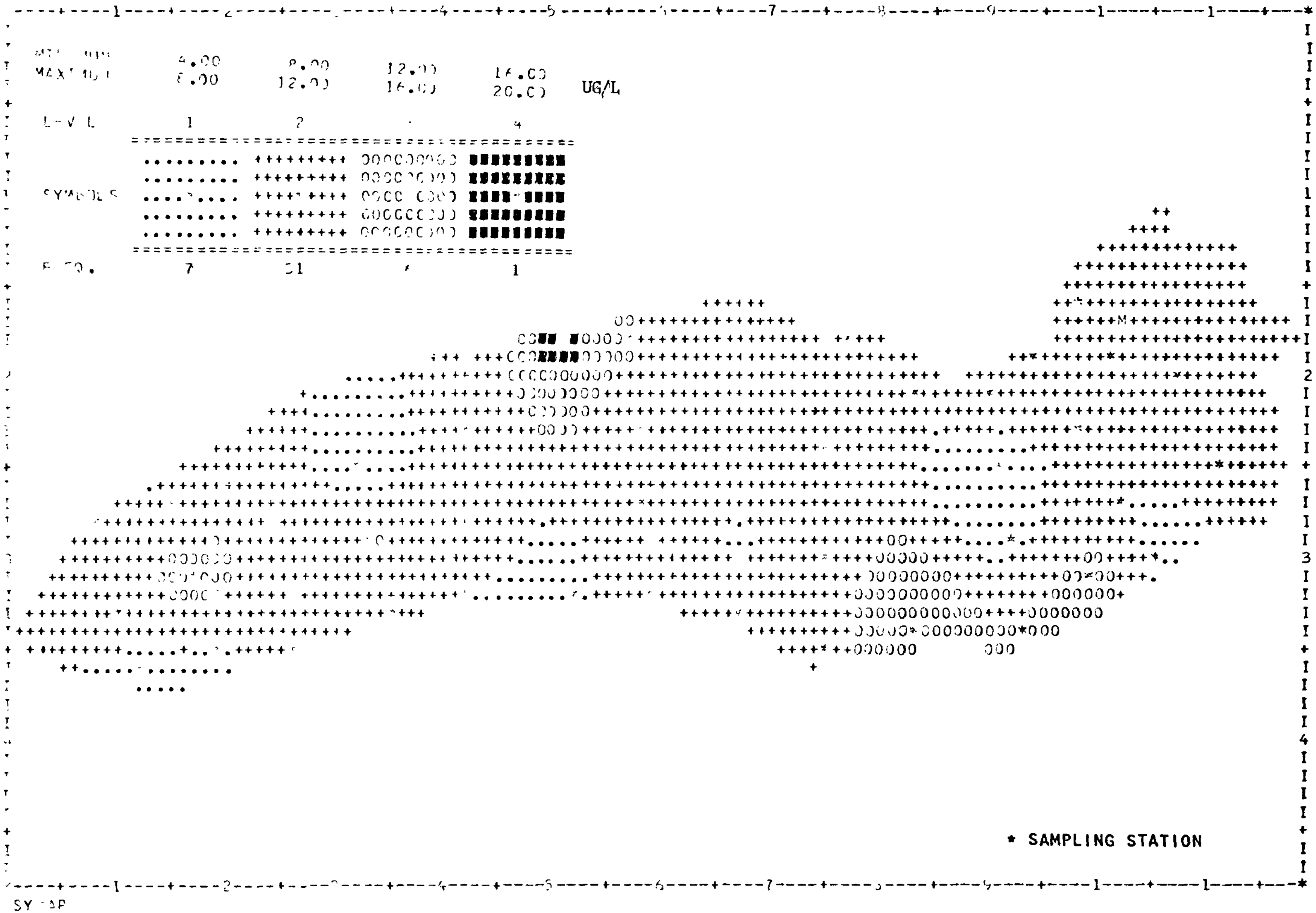


Figure 4.22b Contours of Constant Surface Nickel

CRUISE NUMBER 11: JUNE 11, 1973 TO JUNE 15, 1973

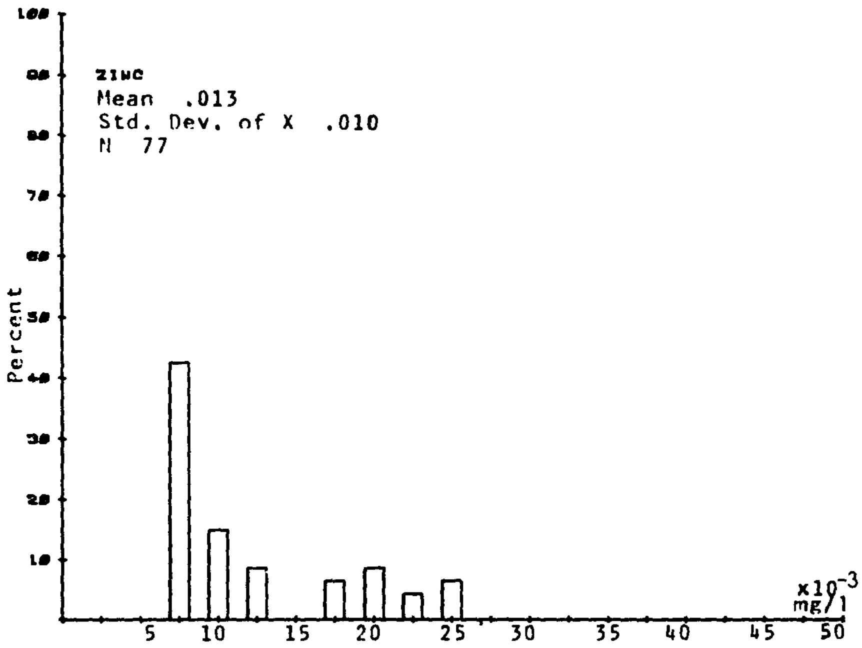


Figure 4.23a Histograms for Zinc -
Cruise 5

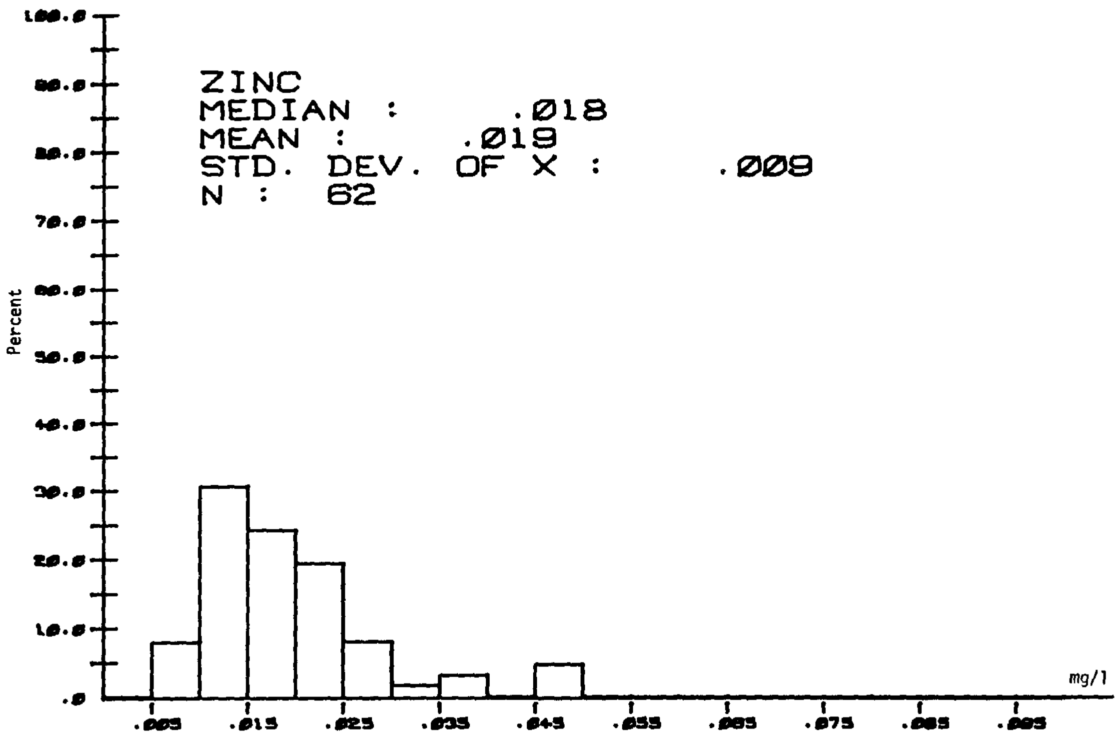


Figure 4.23a Histograms for Zinc -
Cruise 3

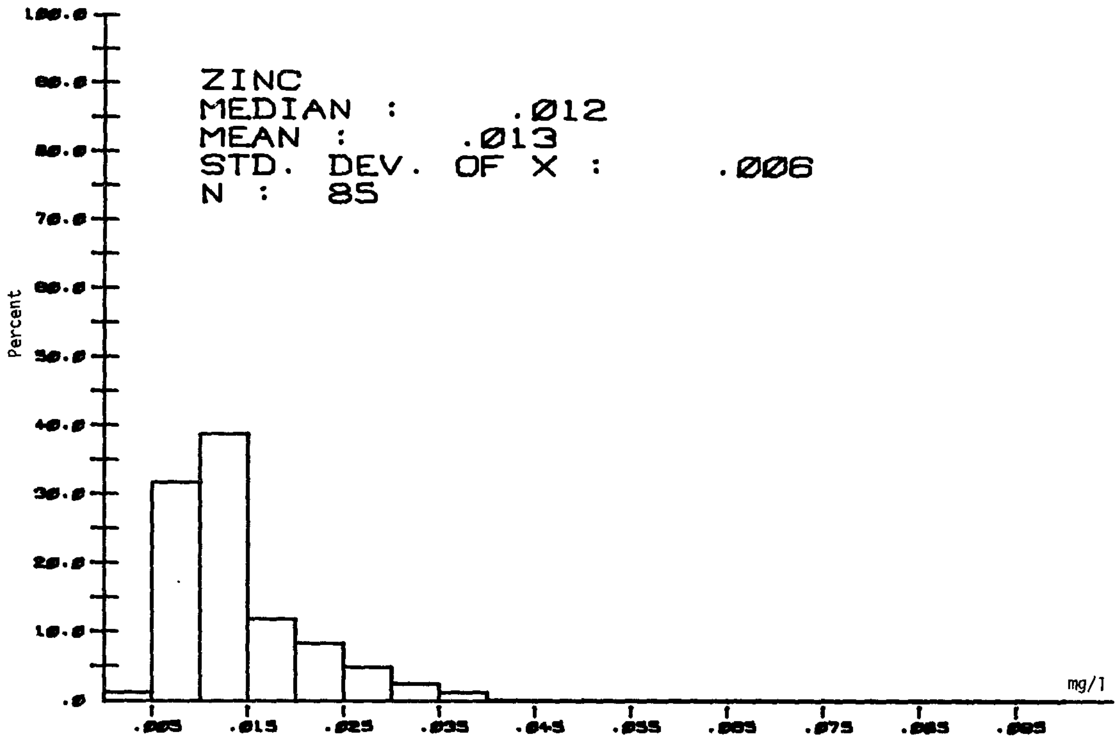


Figure 4.23a Histograms for Zinc -
Cruise 7

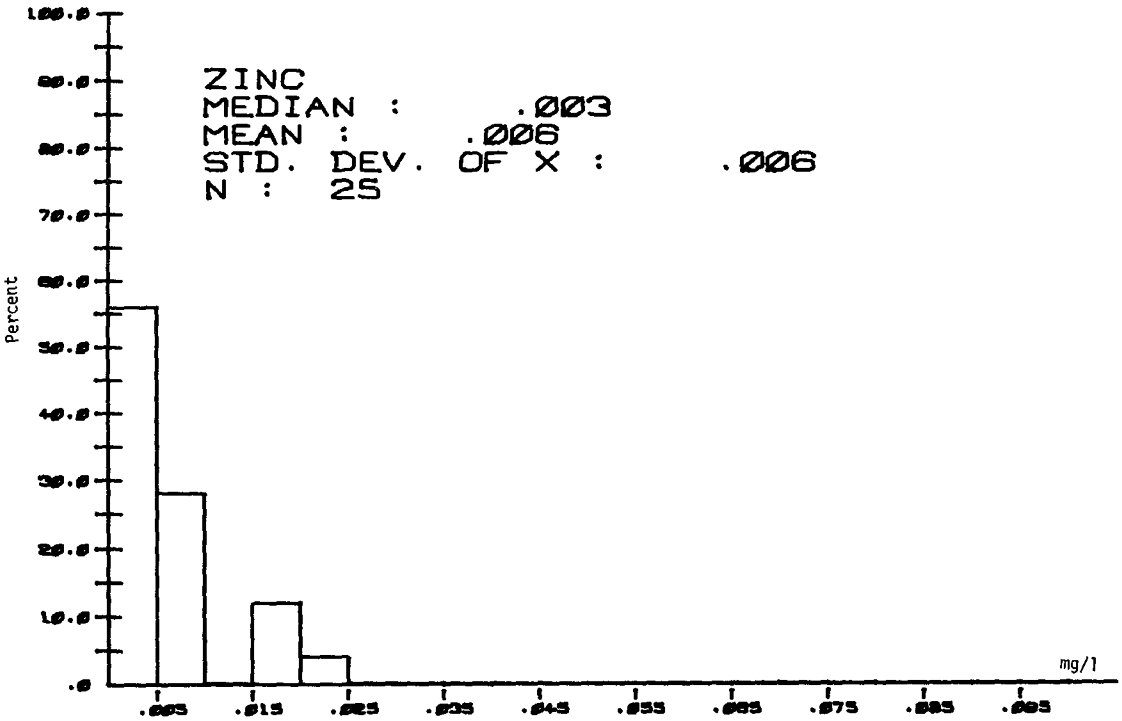


Figure 4.23a Histograms for Zinc -
Cruise 8

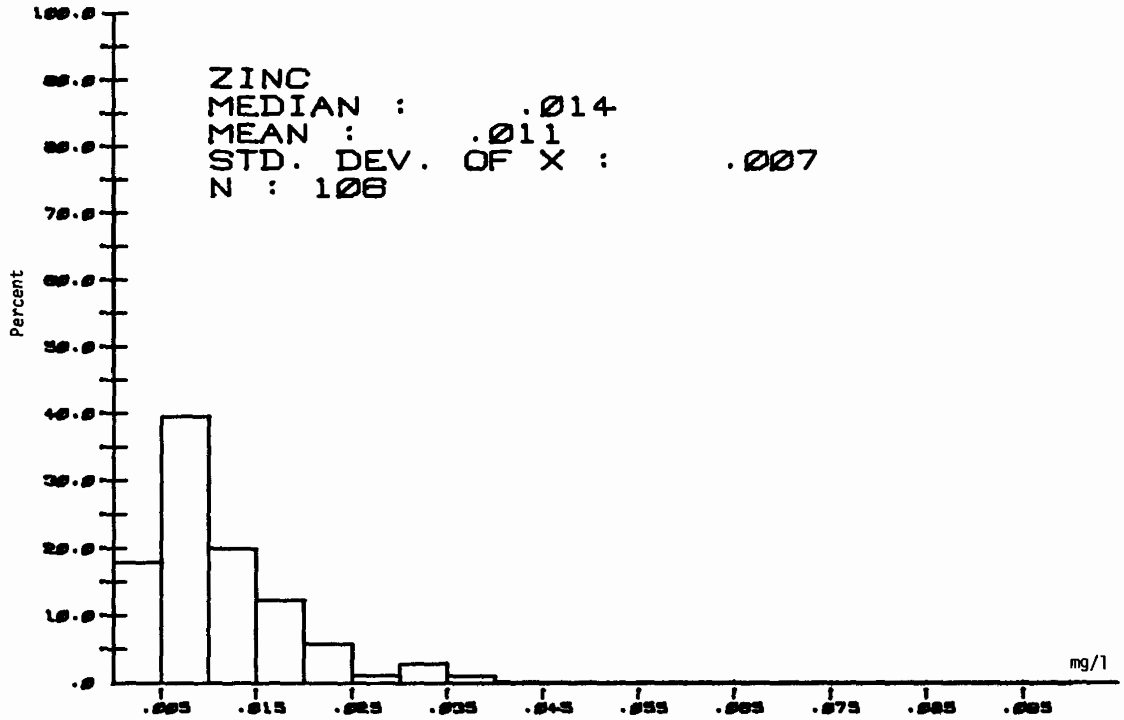


Figure 4.23a Histograms for Zinc - Cruise 9

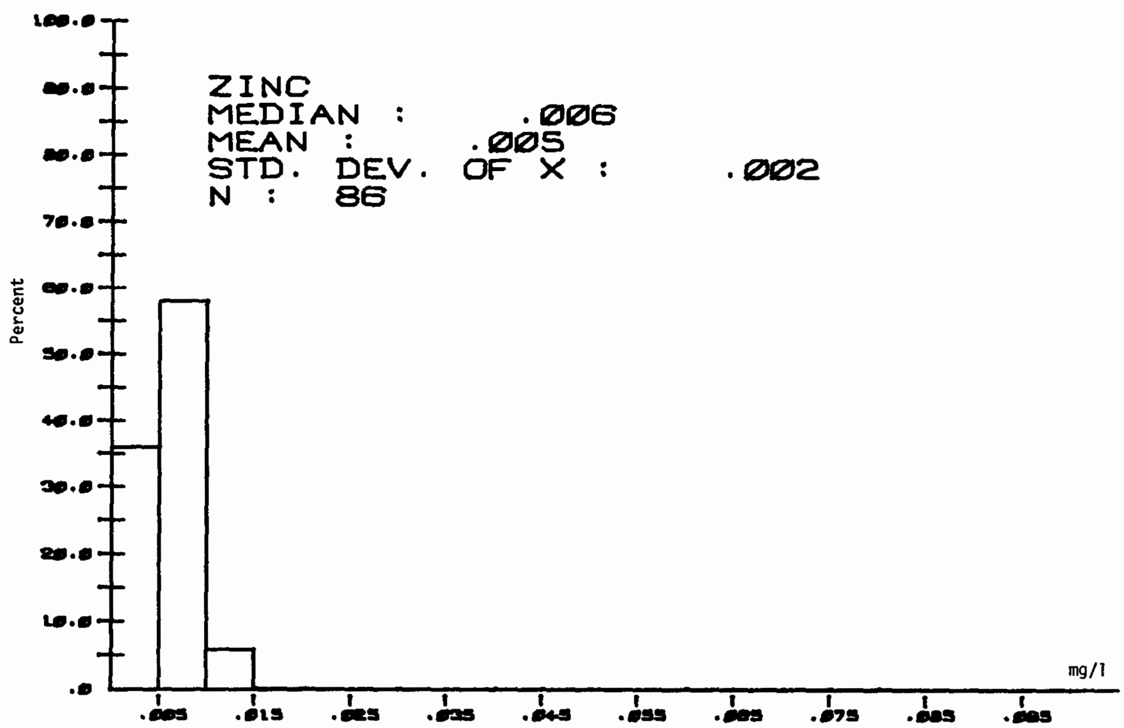


Figure 4.23a Histograms for Zinc - Cruise 10

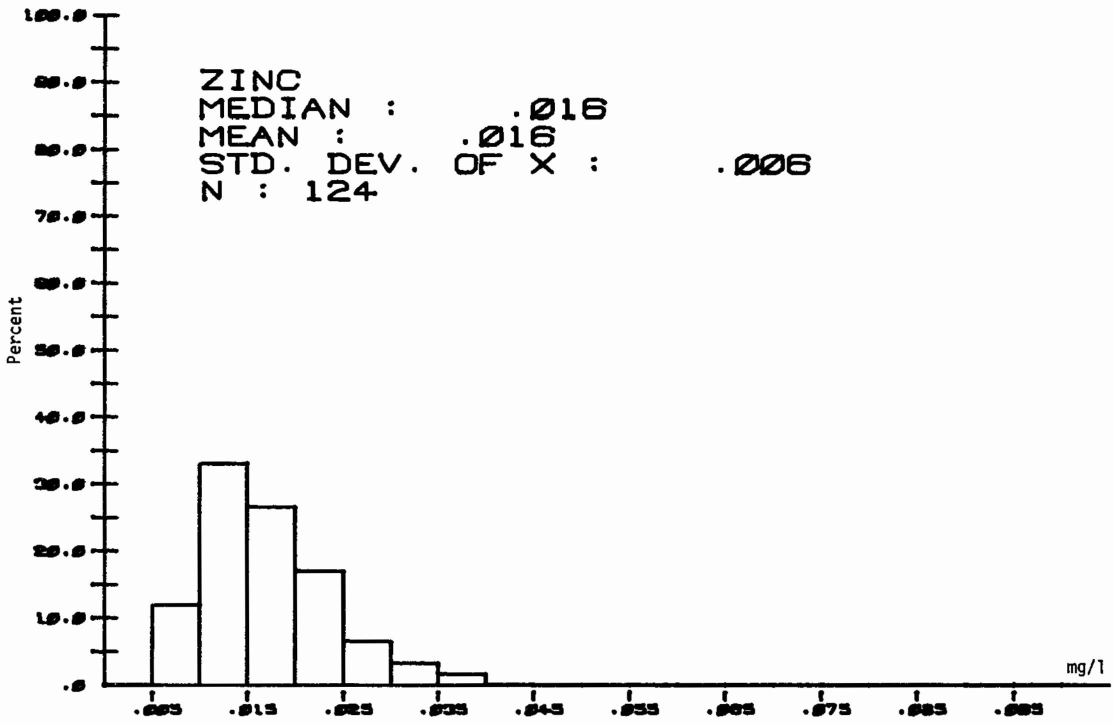


Figure 4.23a Histograms for Zinc - Cruise 11

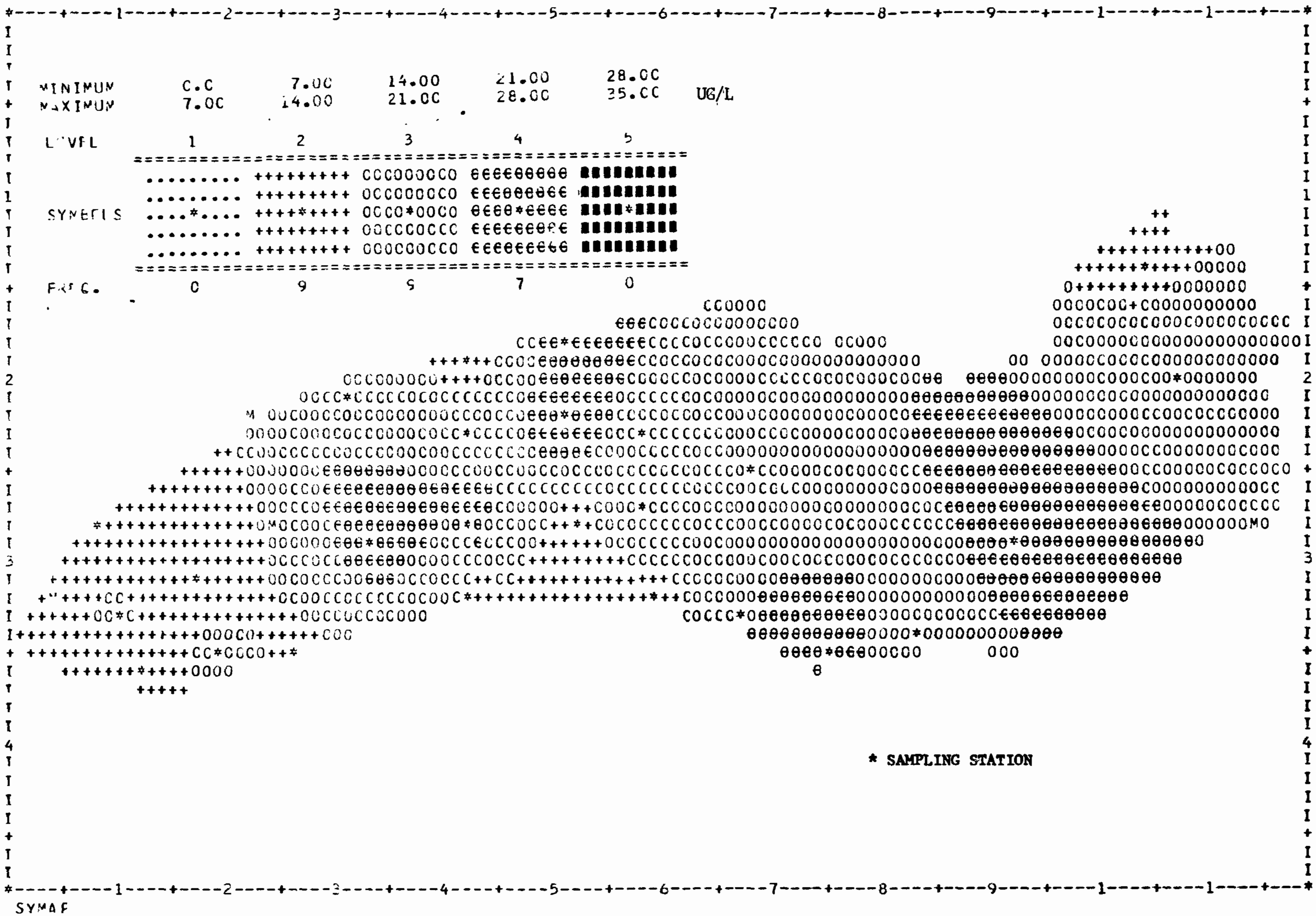


Figure 4.23b Contours of Constant Surface Zinc

CRUISE NUMBER 3: JUNE 12, 1972 TO JUNE 16, 1972

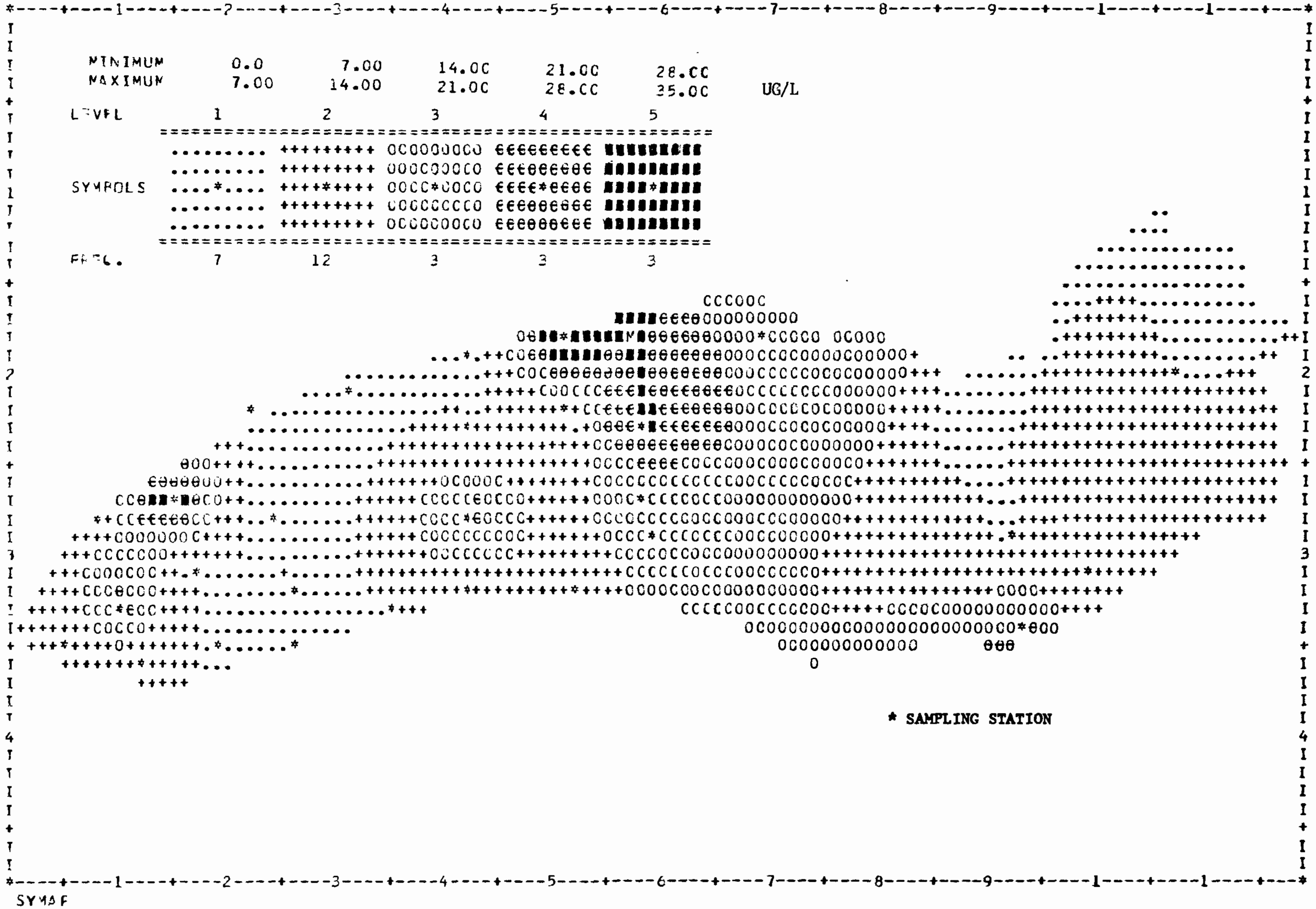


Figure 4.23b Contours of Constant Surface Zinc

CRUISE NUMBER 5: AUGUST 21, 1972 TO AUGUST 25, 1972

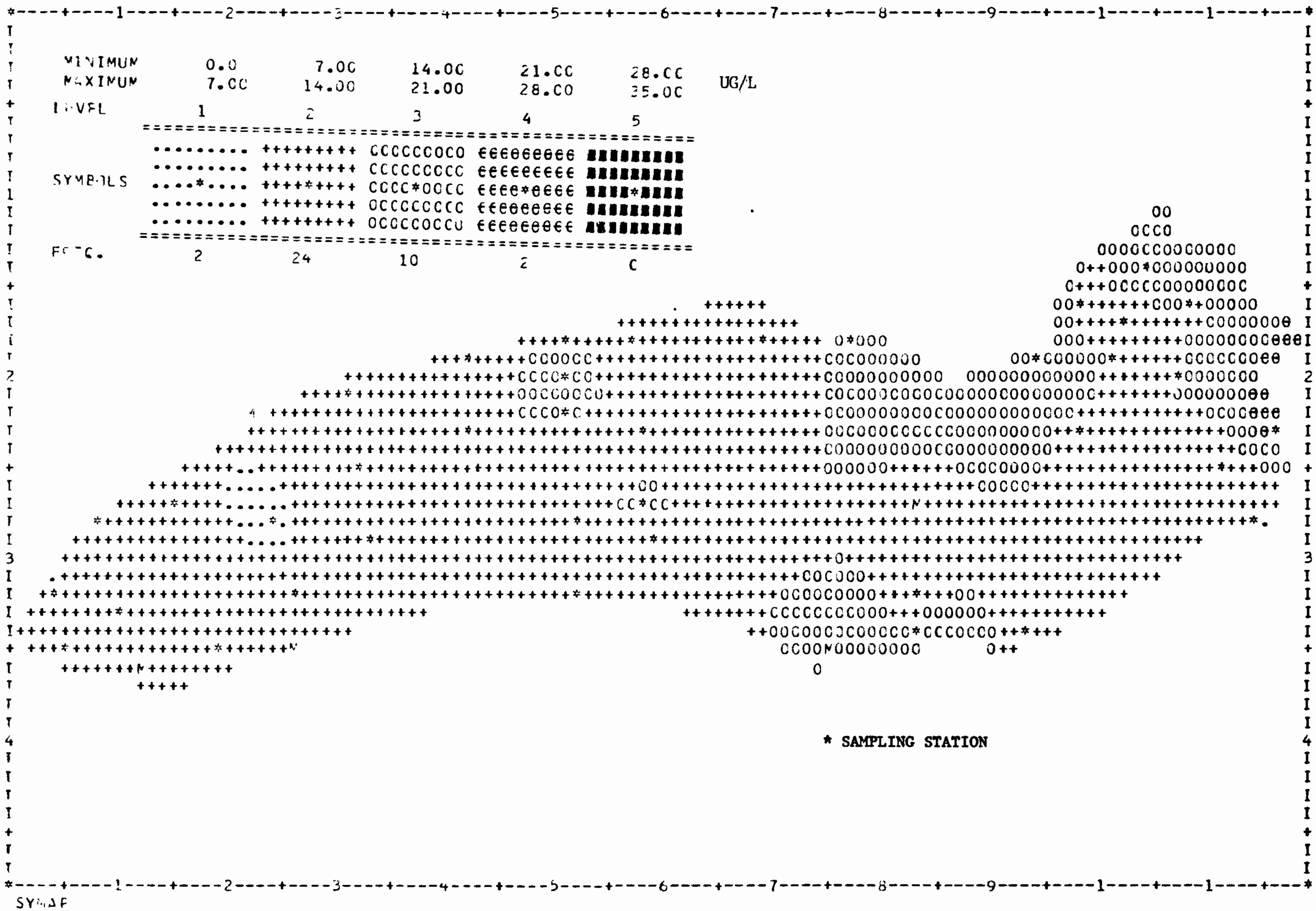


Figure 4.23b Contours of Constant Surface Zinc

CRUISE NUMBER 7: NOVEMBER 27, 1972 TO DECEMBER 2, 1972

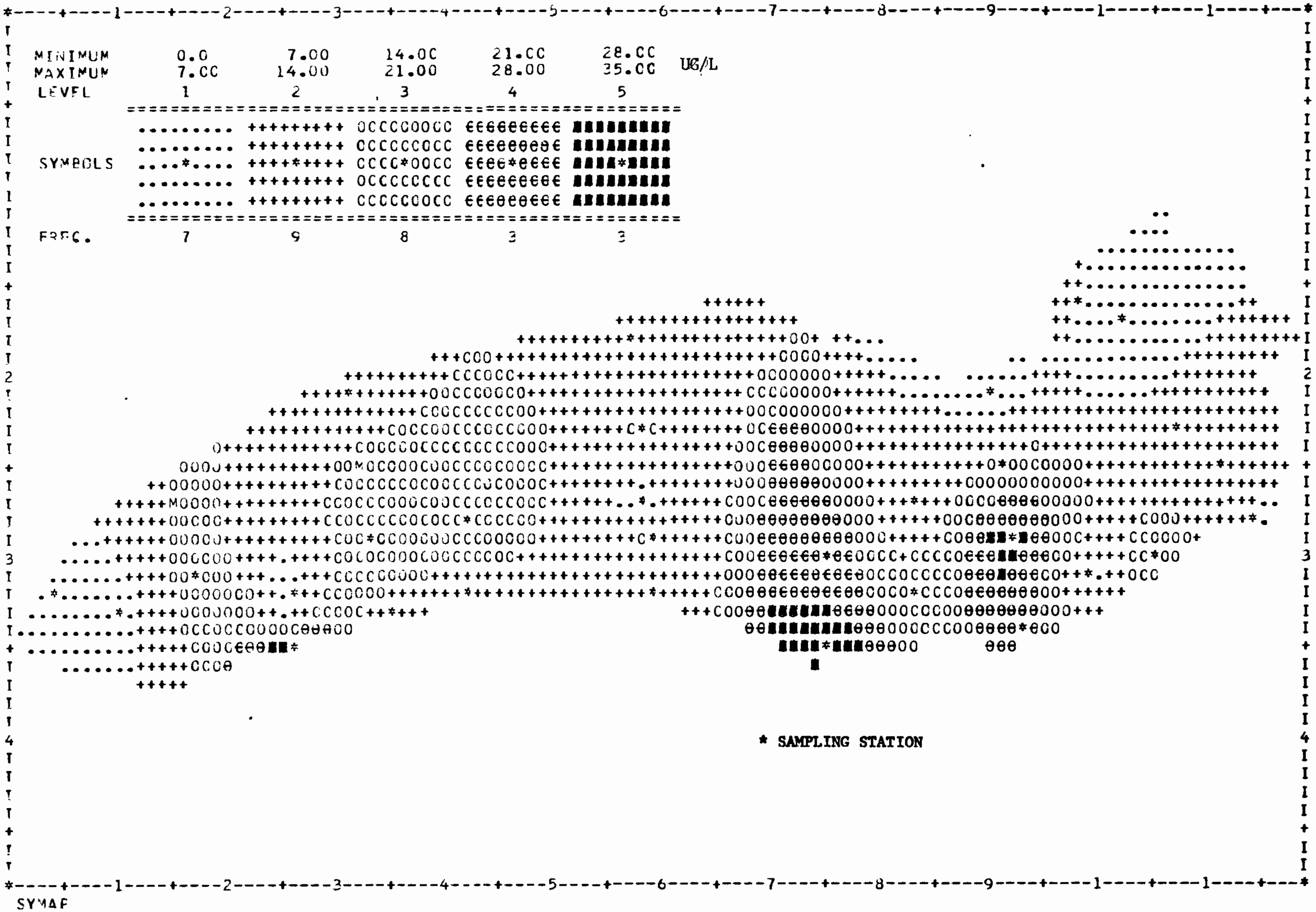


Figure 4.23b Contours of Constant Surface Zinc

CRUISE NUMBER 9: MARCH 18, 1973 TC MARCH 23, 1973

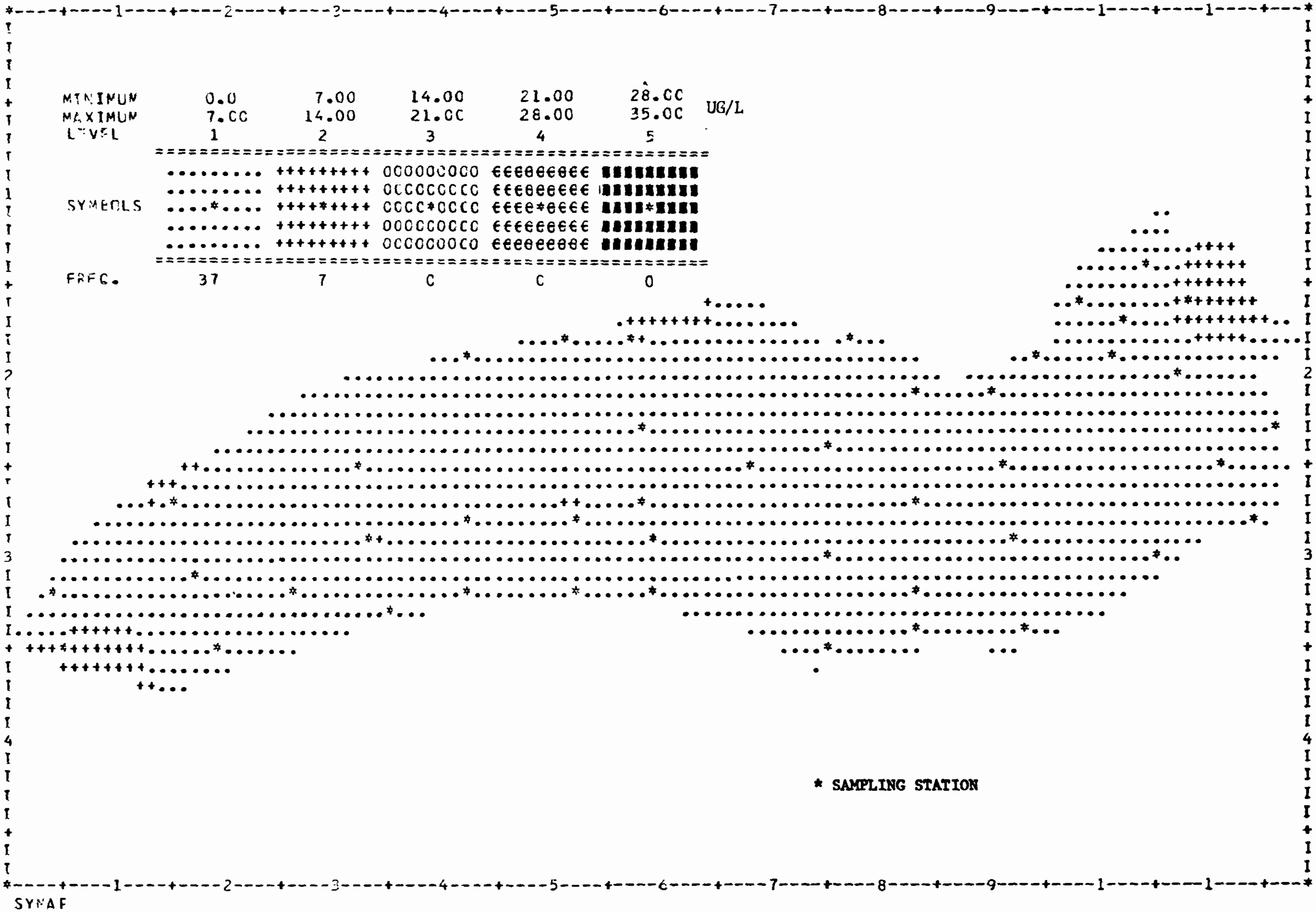


Figure 4.23b Contours of Constant Surface Zinc

CRUISE NUMBER 10: APRIL 24, 1973 TO APRIL 30, 1973

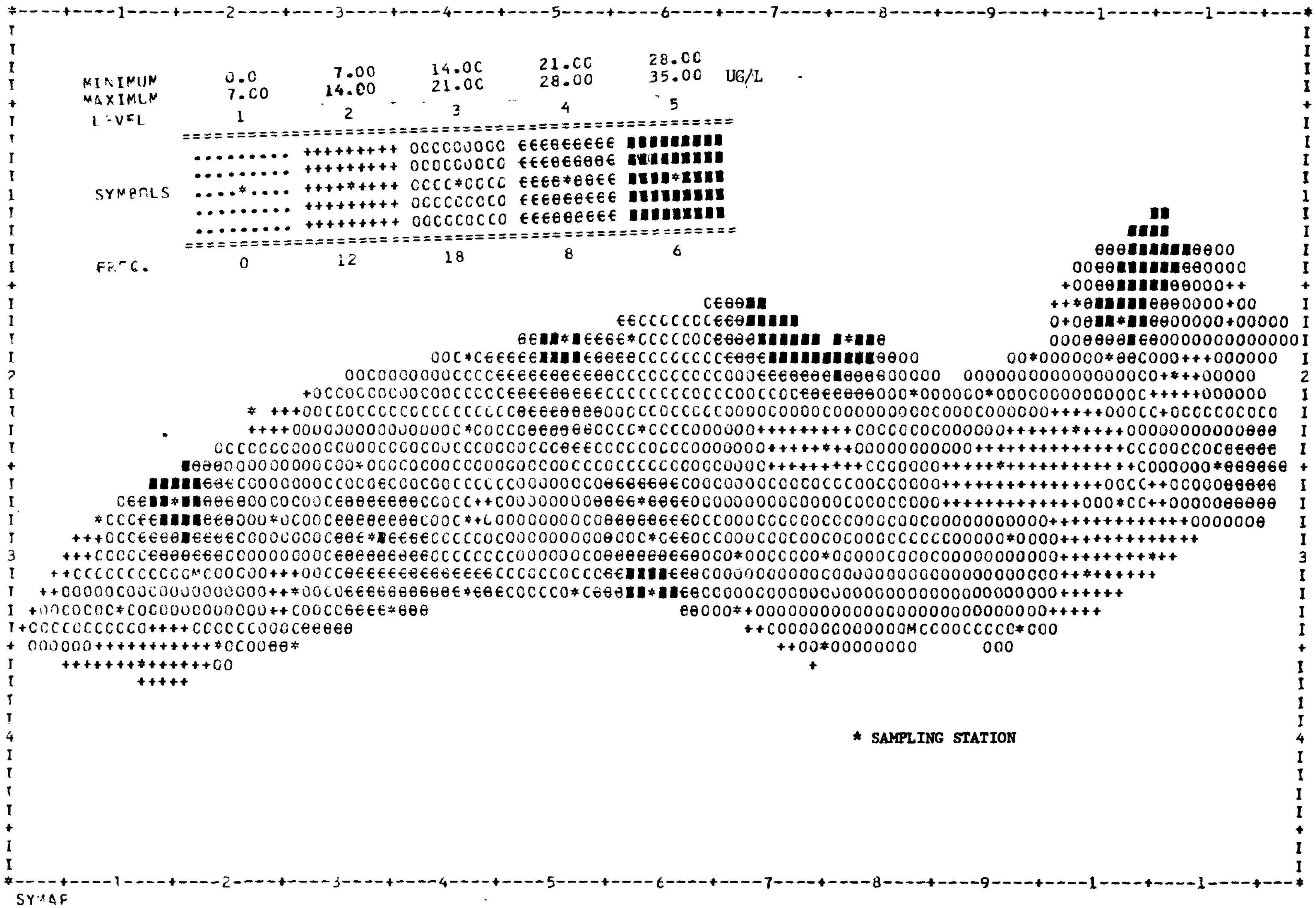


Figure 4.23b Contours of Constant Surface Zinc

CRUISE NUMBER 11: JUNE 11, 1973 TO JUNE 15, 1973

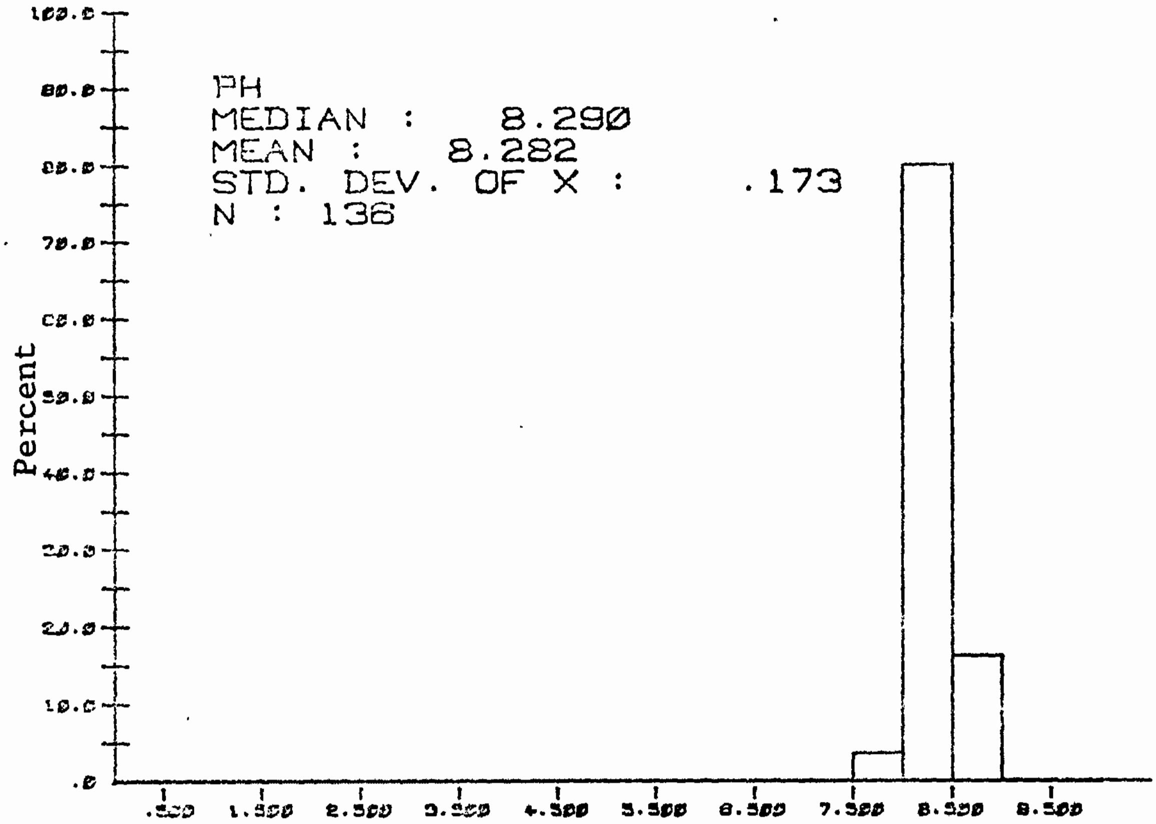


Figure 4.24a Histograms for PH -
Cruise 1

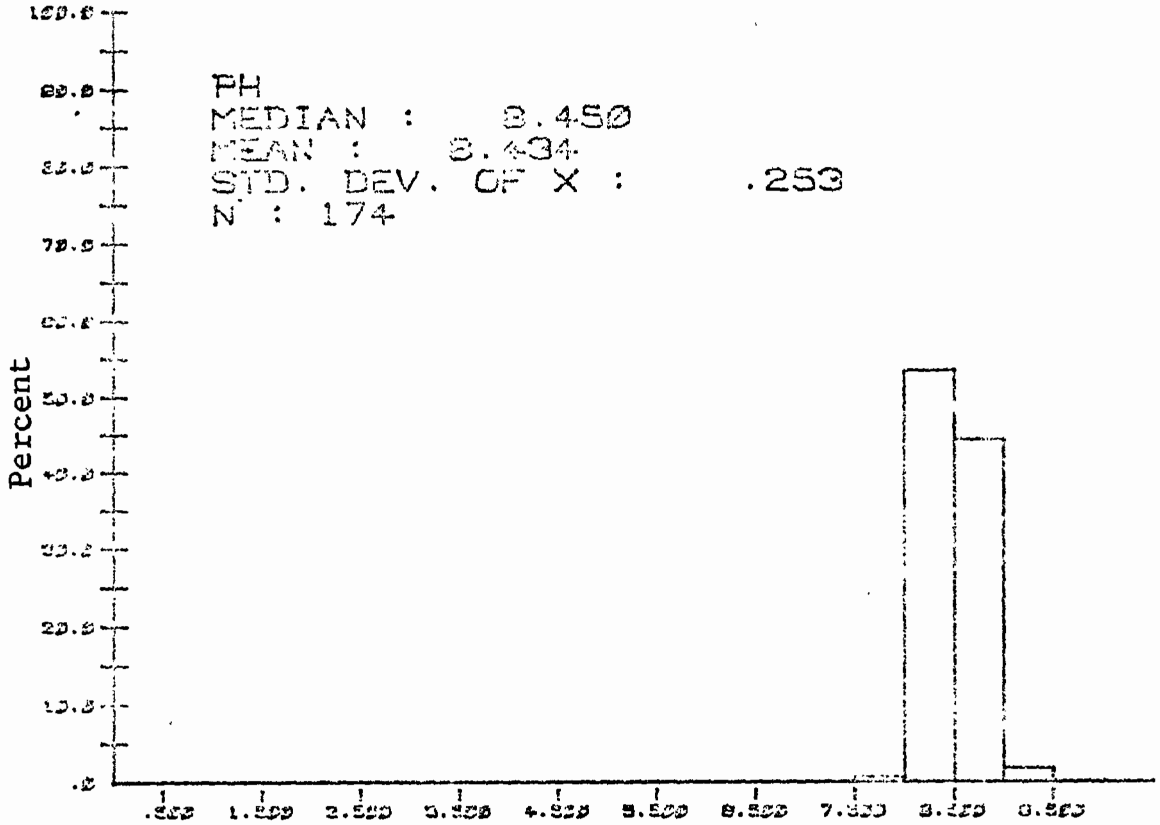


Figure 4.24a Histograms for PH
Cruise 2

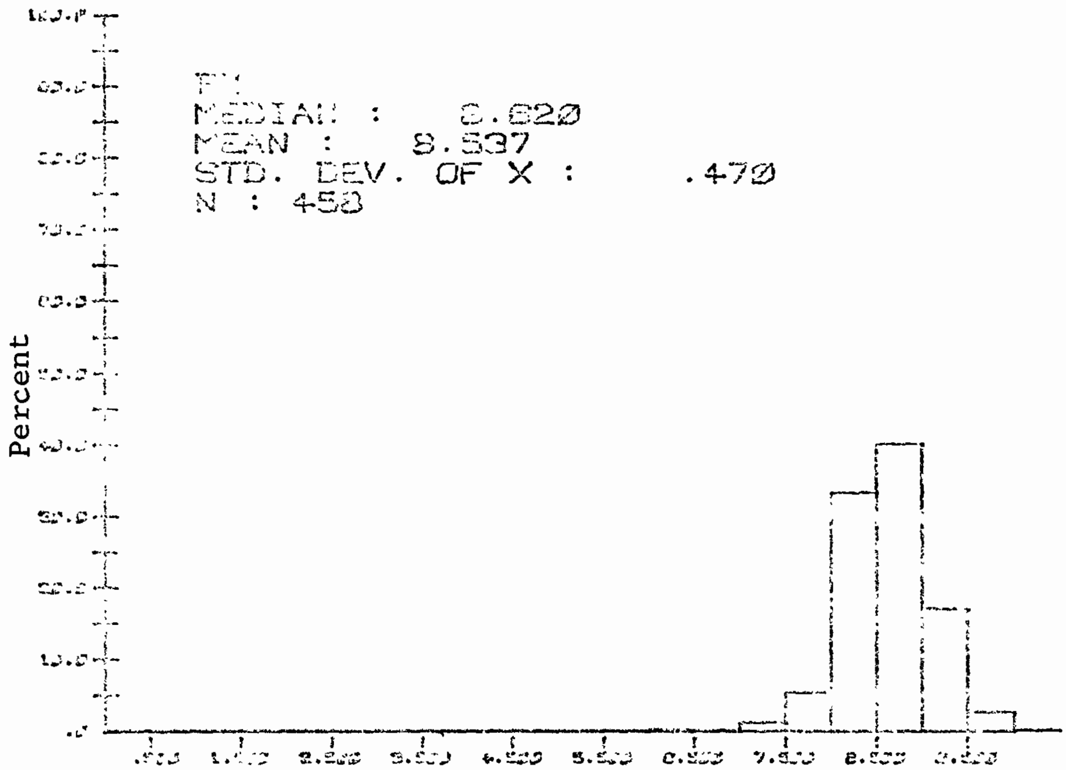


Figure 4.24a Histograms for PH -
Cruise 3

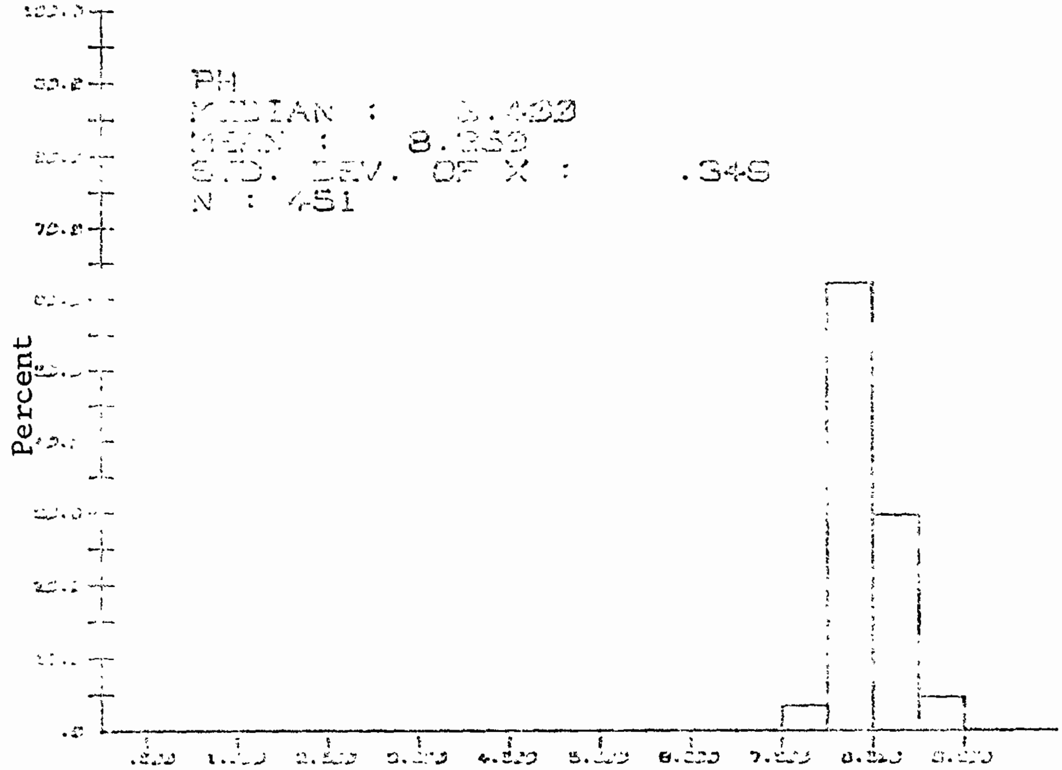


Figure 4.24a Histograms for PH -
Cruise 4

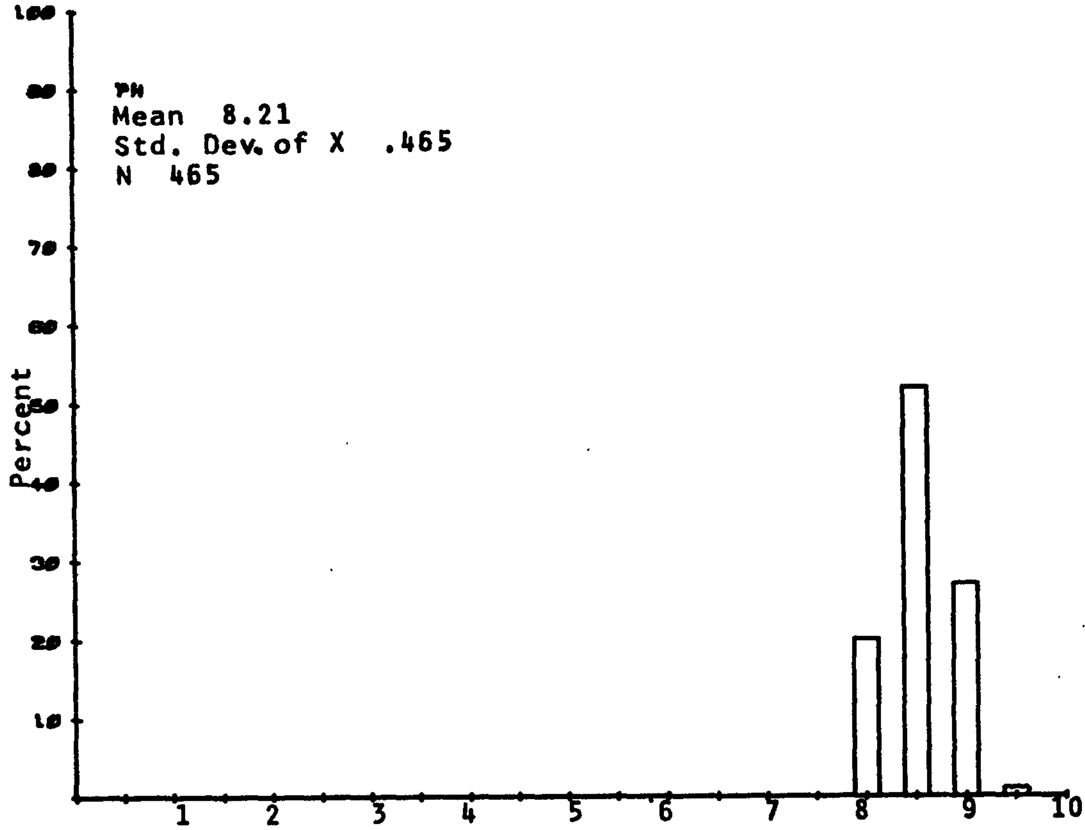


Figure 4.24a Histograms for pH
Cruise 5

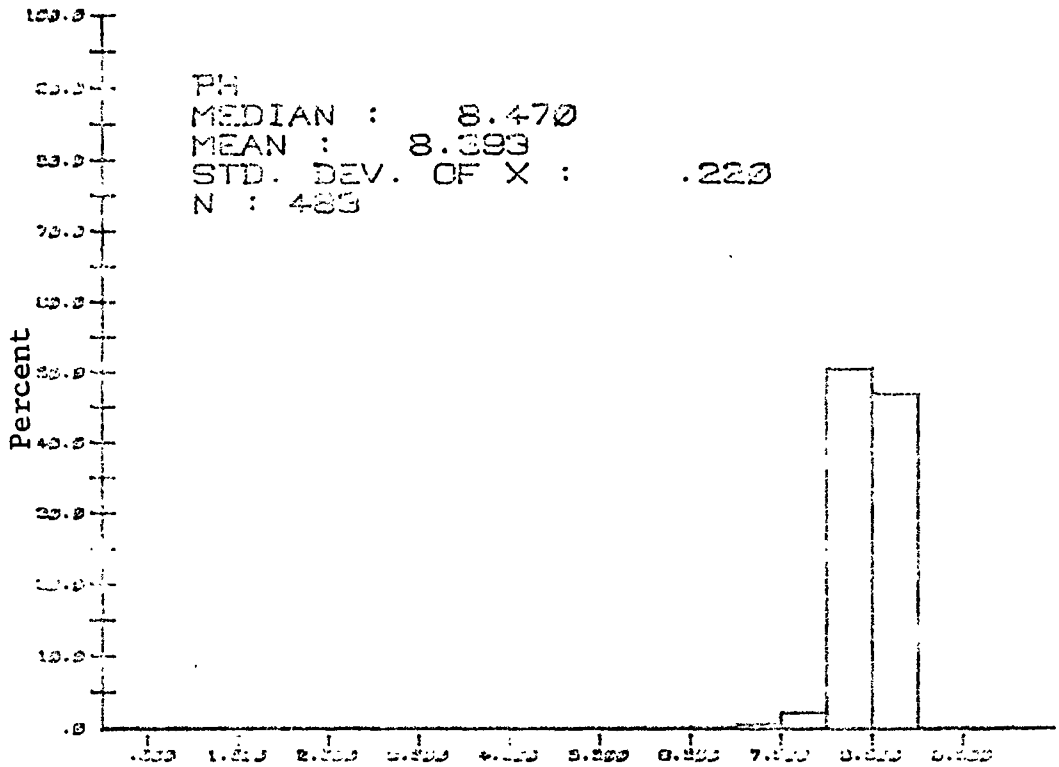


Figure 4.24a Histograms for PH -
Cruise 6

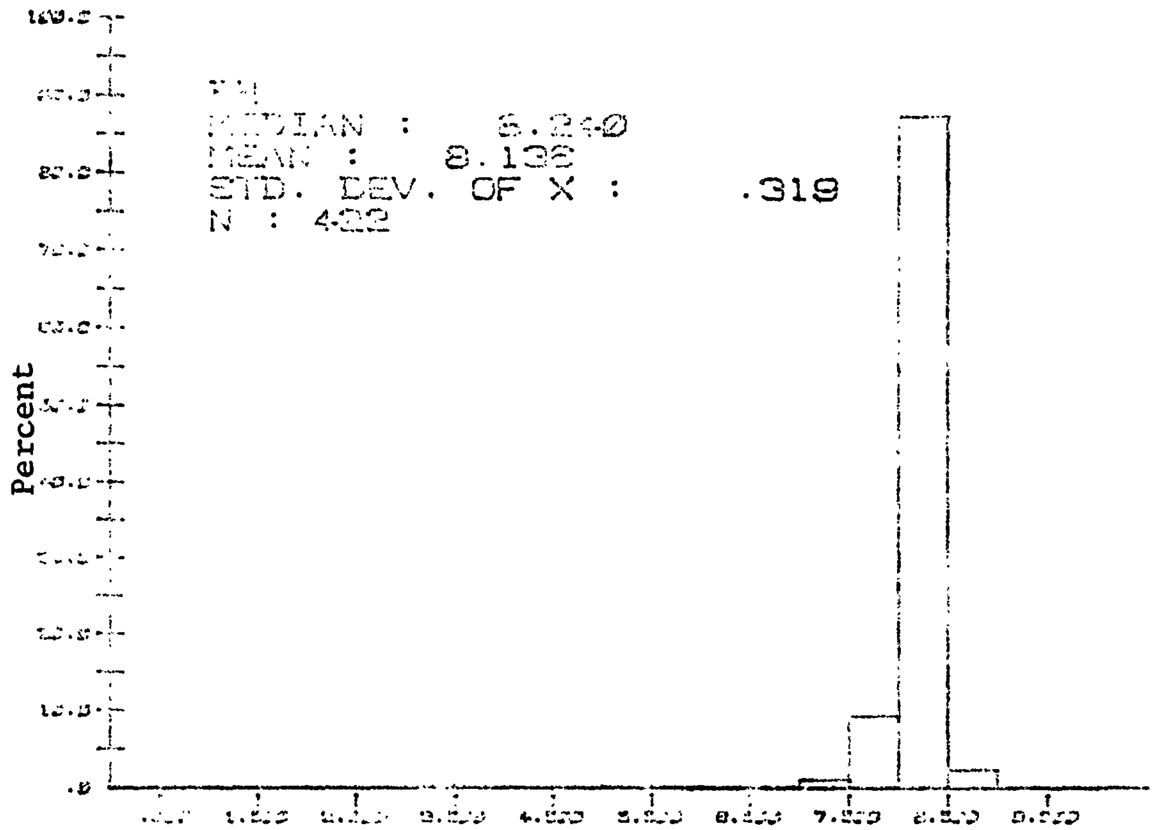


Figure 4.24a Histograms for PH - Cruise 7

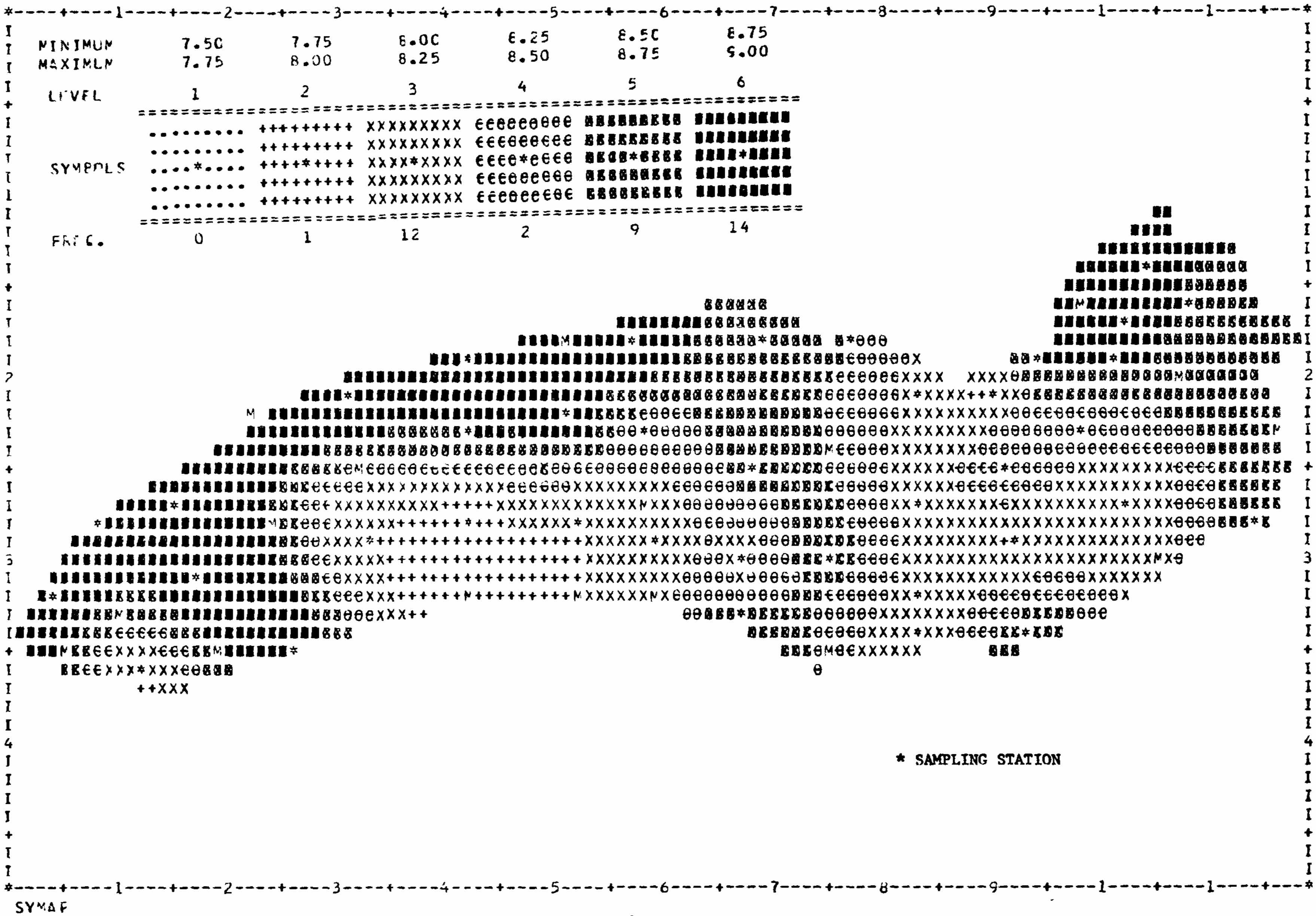


Figure 4.24b Contours of Constant Surface pH

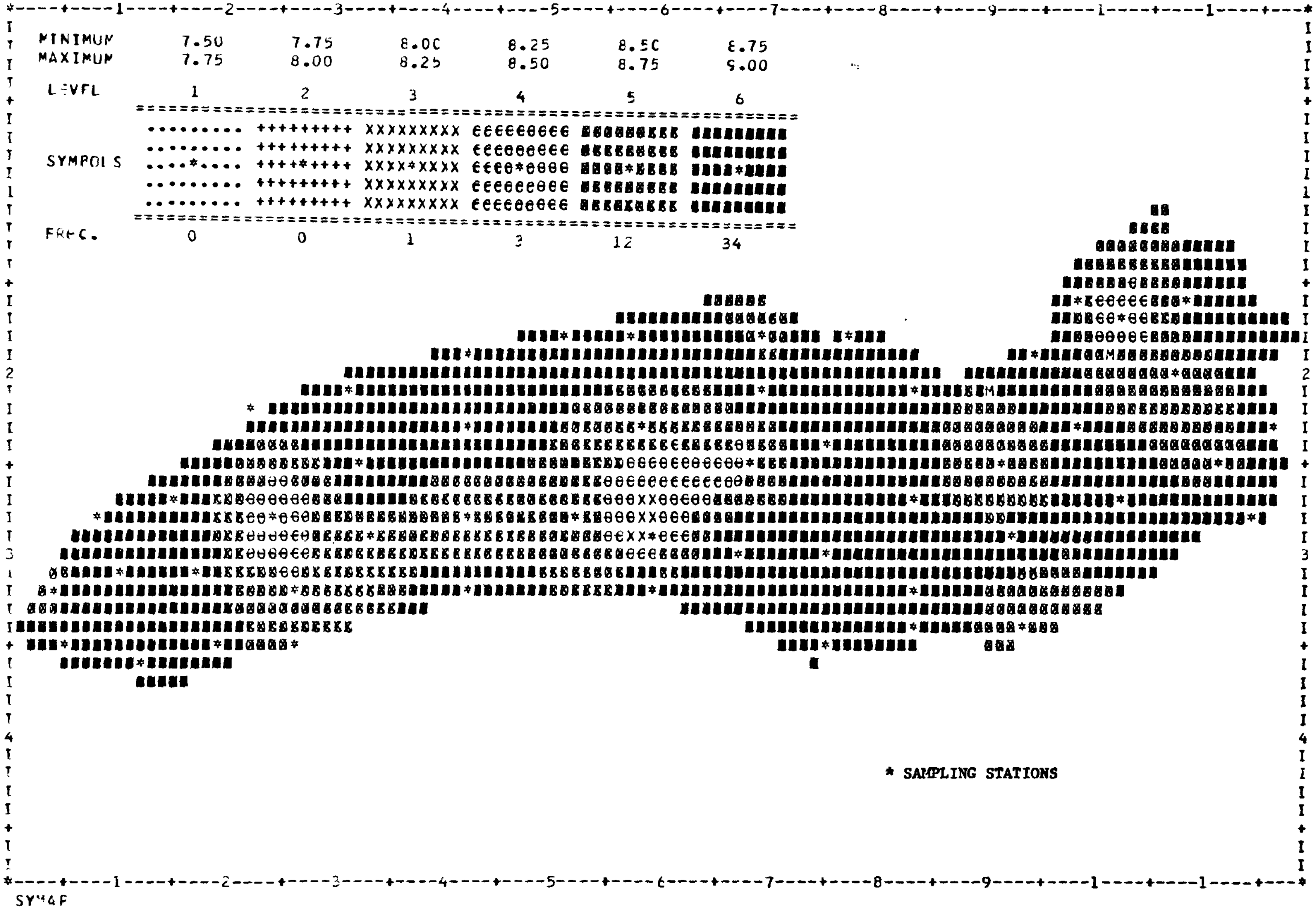
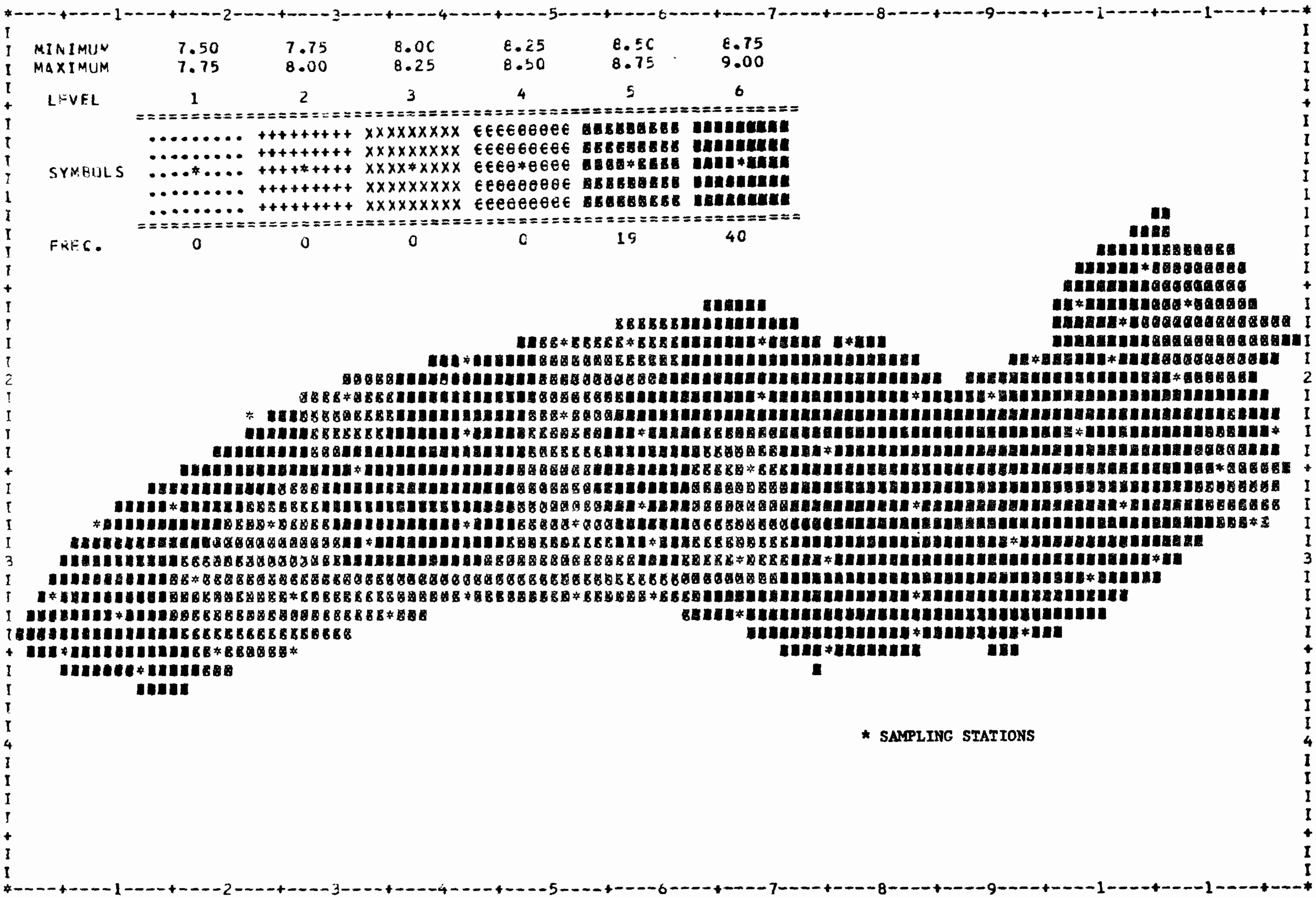


Figure 4.24b Contours of Constant Surface pH

CRUISE NUMBER 4: JULY 10, 1972 TO JULY 14, 1972

MINIMUM	7.50	7.75	8.0C	8.25	8.5C	8.75
MAXIMUM	7.75	8.00	8.25	8.50	8.75	9.00
LEVEL	1	2	3	4	5	6
FREQ.	0	0	0	C	19	40

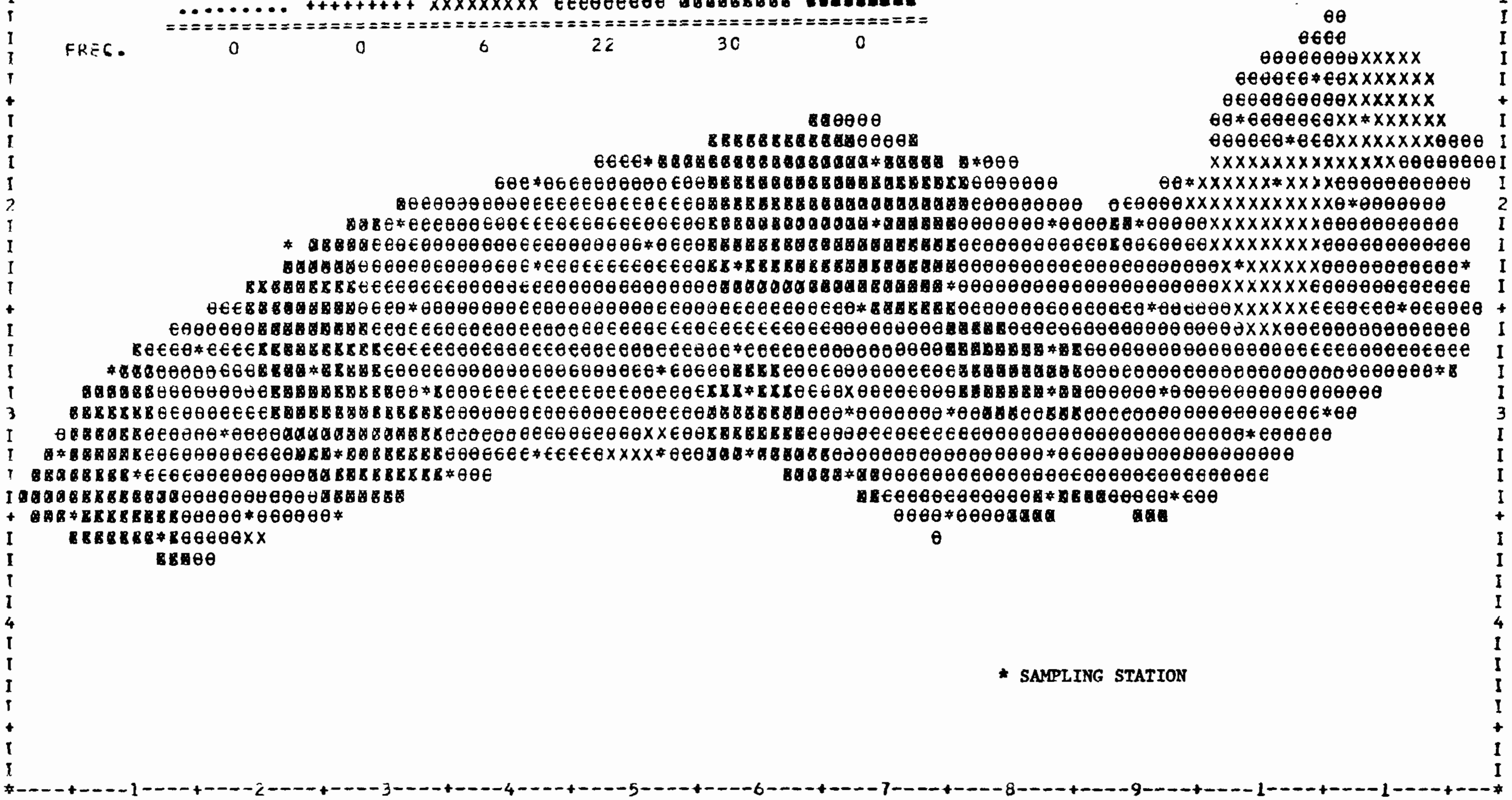


SYMAF

Figure 4.24b Contours of Constant Surface pH

CRUISE NUMBER 5: AUGUST 21, 1972 TC AUGUST 25, 1972

MINIMUM	7.50	7.75	8.00	8.25	8.50	8.75
MAXIMUM	7.75	8.00	8.25	8.50	8.75	9.00
LEVEL	1	2	3	4	5	6
SYMBOLS	....	+++++++++	XXXXXXXXX	€€€€€€€€€	⊕⊕⊕⊕⊕⊕⊕⊕⊕	▇▇▇▇▇▇▇▇▇
FREQ.	0	0	6	22	30	0



SYMAP

Figure 4.24b Contours of Constant Surface pH

CRUISE NUMBER 6: OCTOBER 30, 1972 TO NOVEMBER 3, 1972

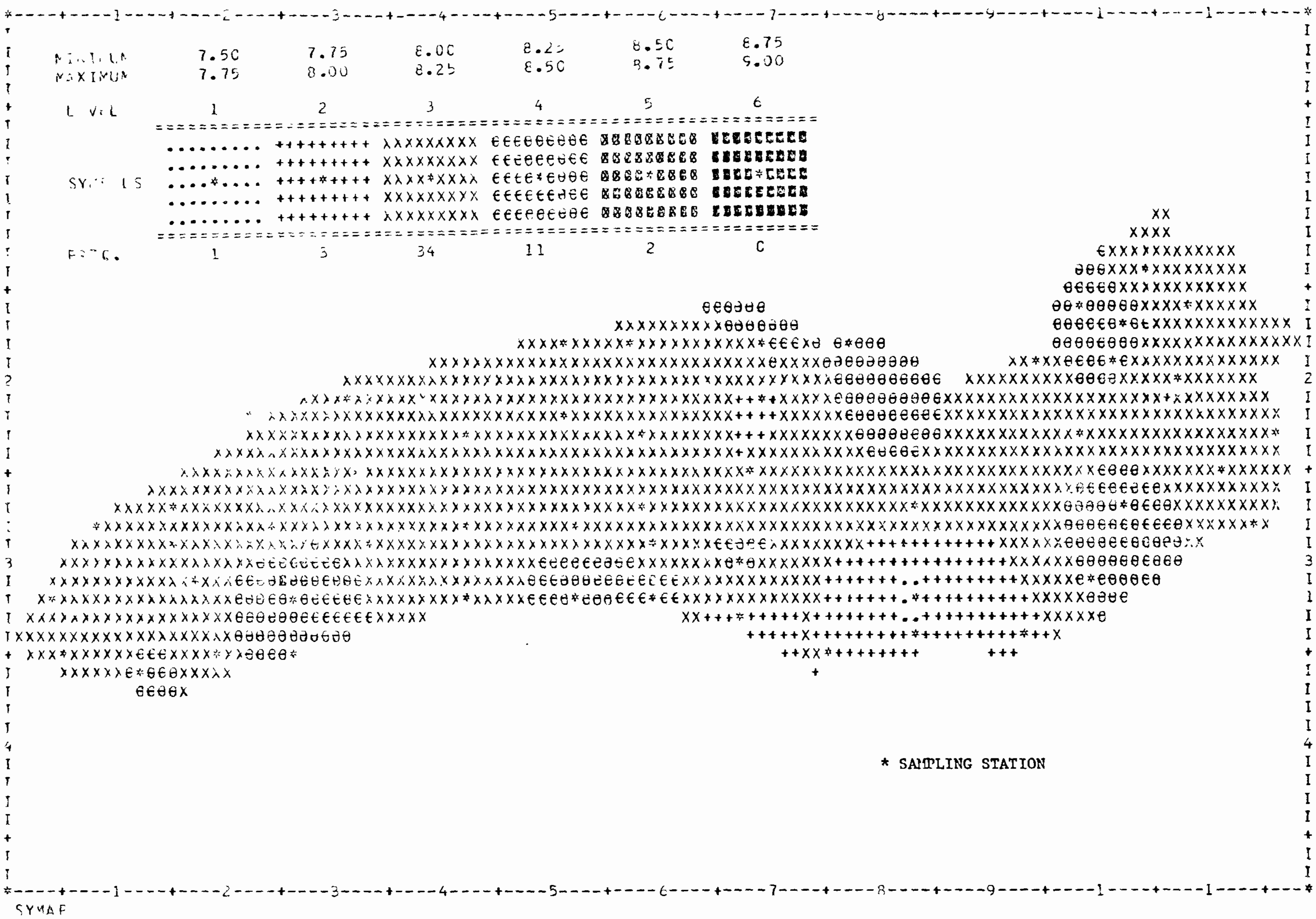
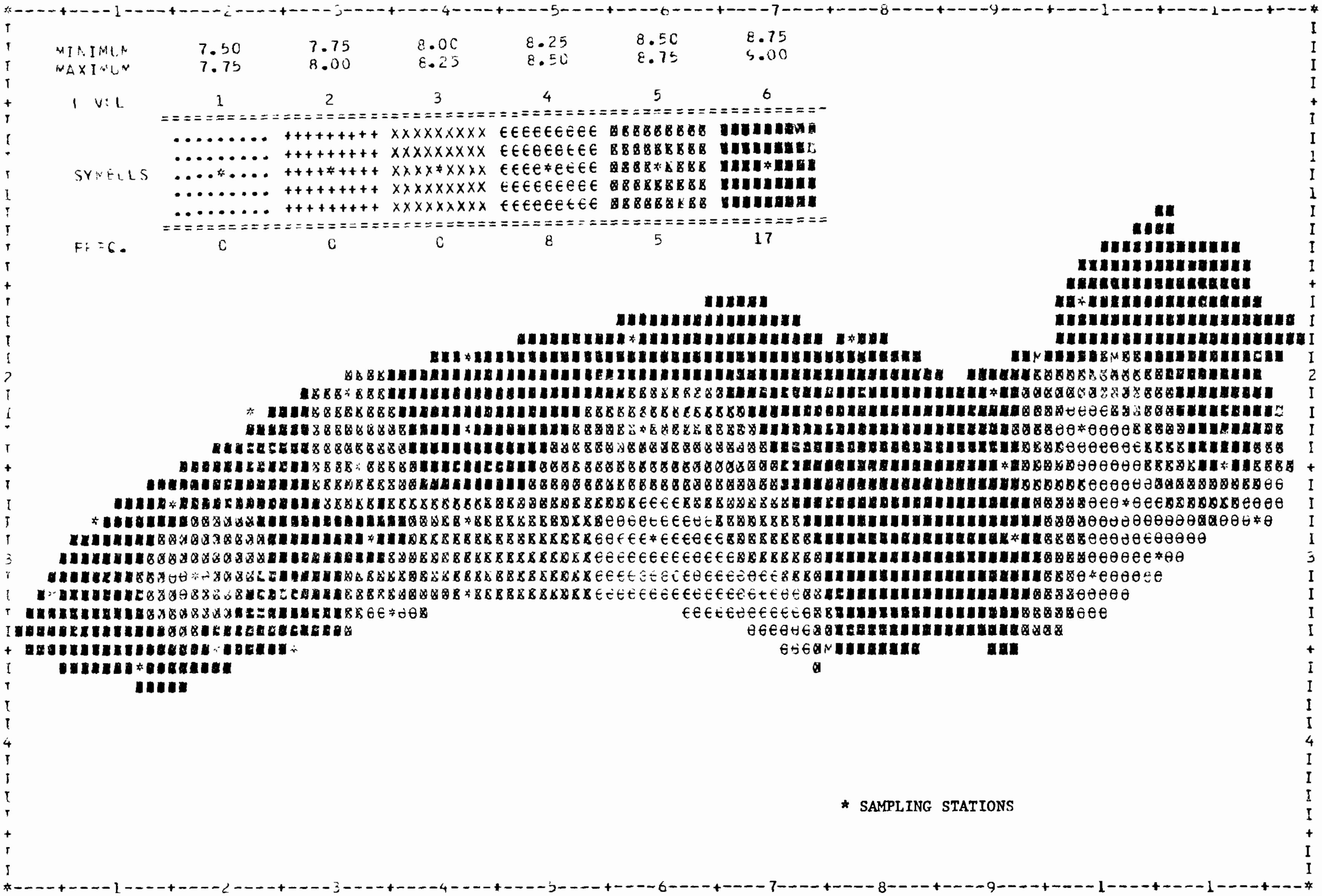


Figure 4.24b Contours of Constant Surface pH

CRUISE NUMBER 7: NOVEMBER 27, 1972 TO DECEMBER 2, 1972

MINIMUM	7.50	7.75	8.00	8.25	8.50	8.75
MAXIMUM	7.75	8.00	8.25	8.50	8.75	9.00
LEVEL	1	2	3	4	5	6
SYMBOLS	....	+++++++++	XXXXXXXXX	€€€€€€€€€	BBBBBBBBB	█████████
FREQ.	0	0	0	8	5	17



SYMAP

Figure 4.24b Contours of Constant Surface pH

CRUISE NUMBER 8: FEBRUARY 5, 1973 TO FEBRUARY 9, 1973

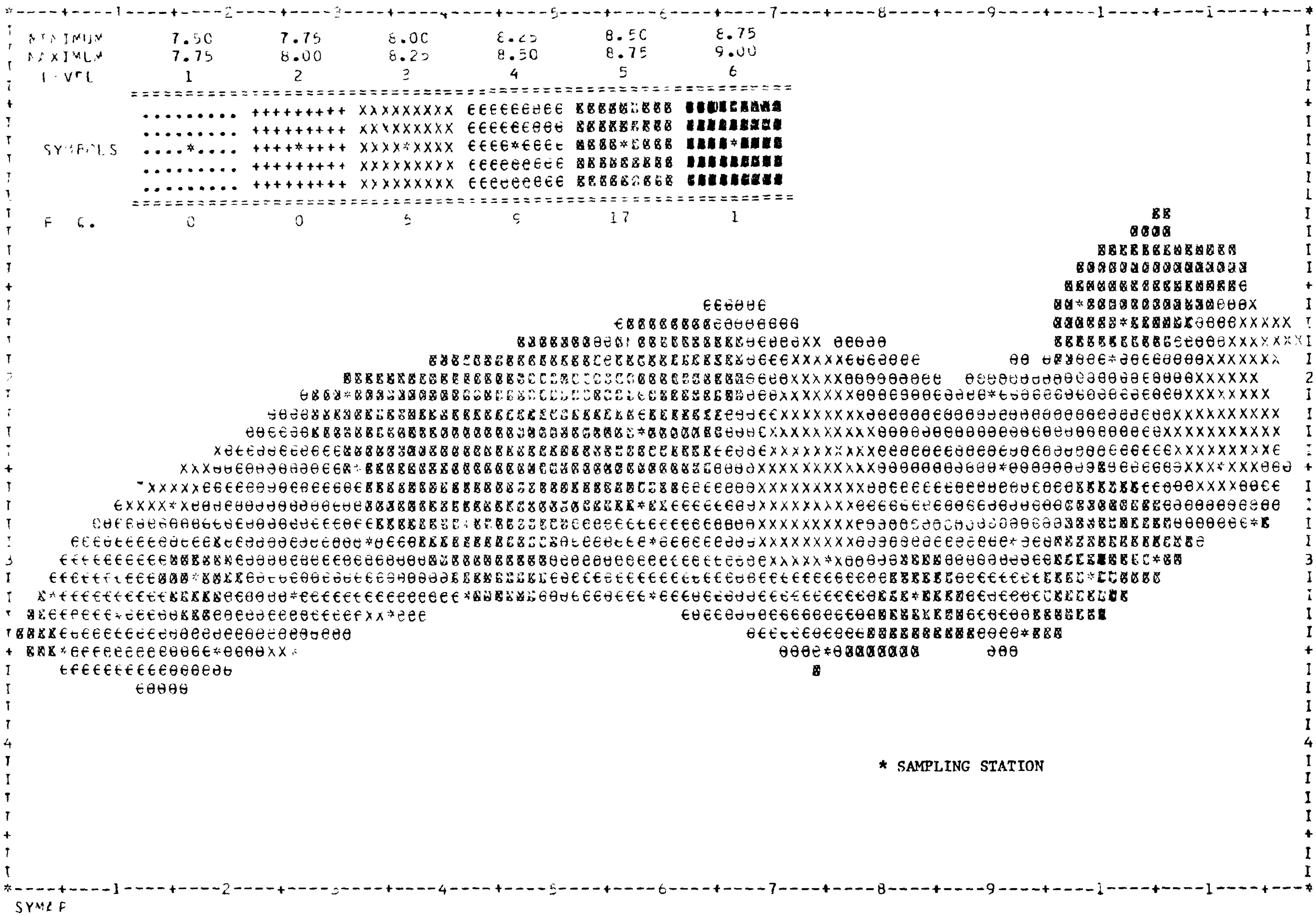


Figure 4.24b Contours of Constant Surface pH

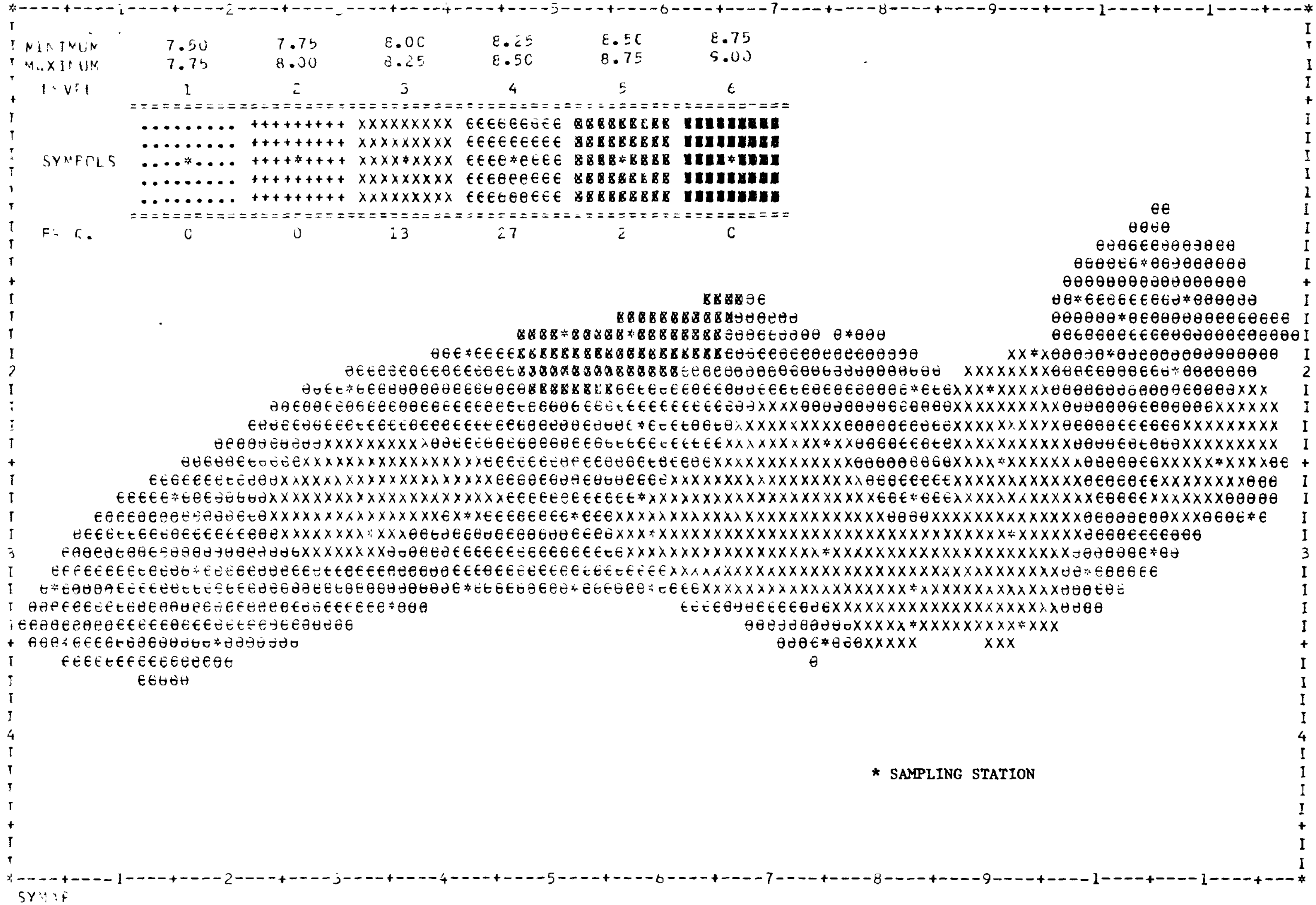


Figure 4.24b Contours of Constant Surface pH

CRUISE NUMBER 10: APRIL 24, 1973 TO APRIL 30, 1973

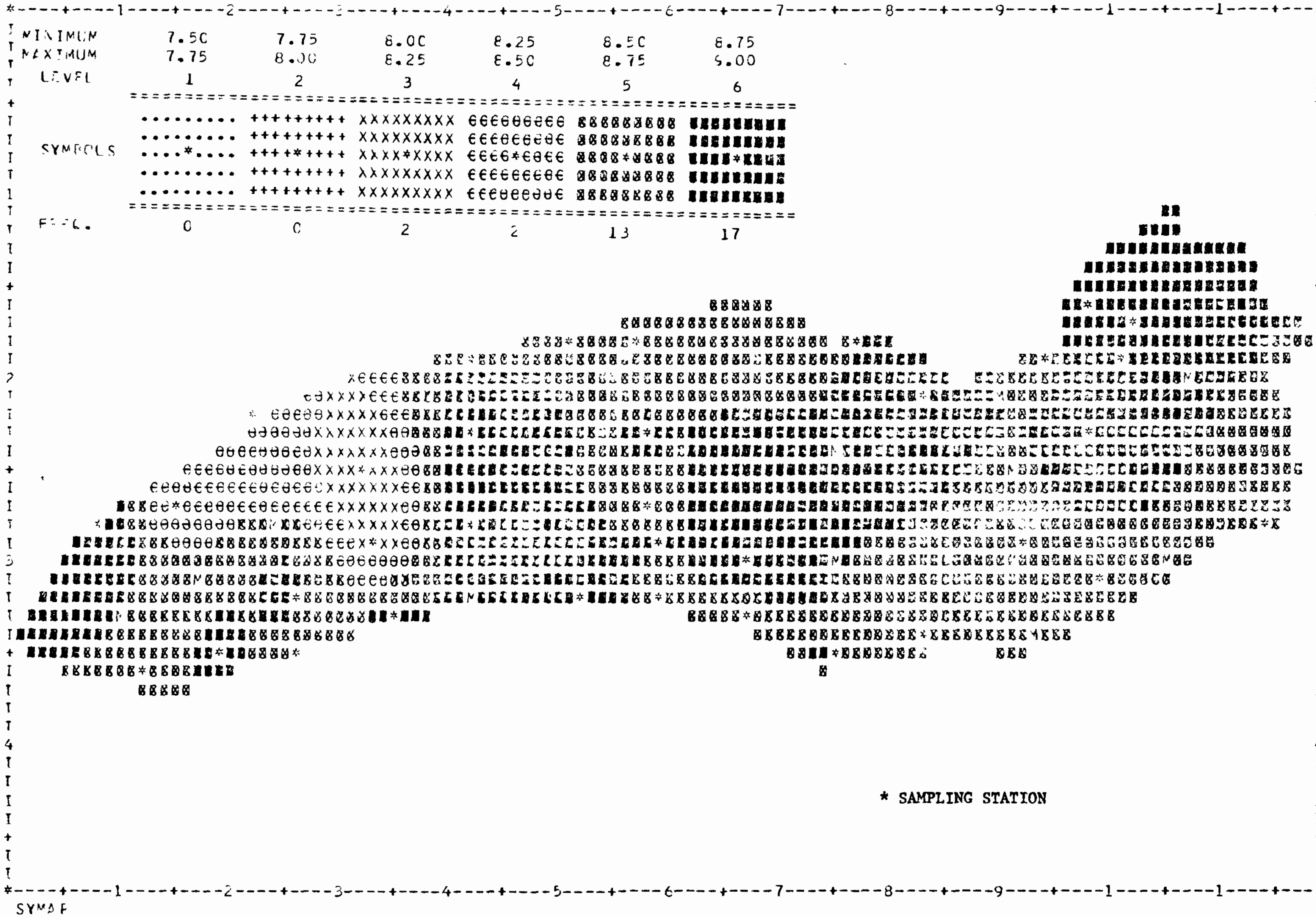


Figure 4.24b Contours of Constant Surface pH

CRUISE NUMBER 11: JUNE 11, 1973 TO JUNE 15, 1973

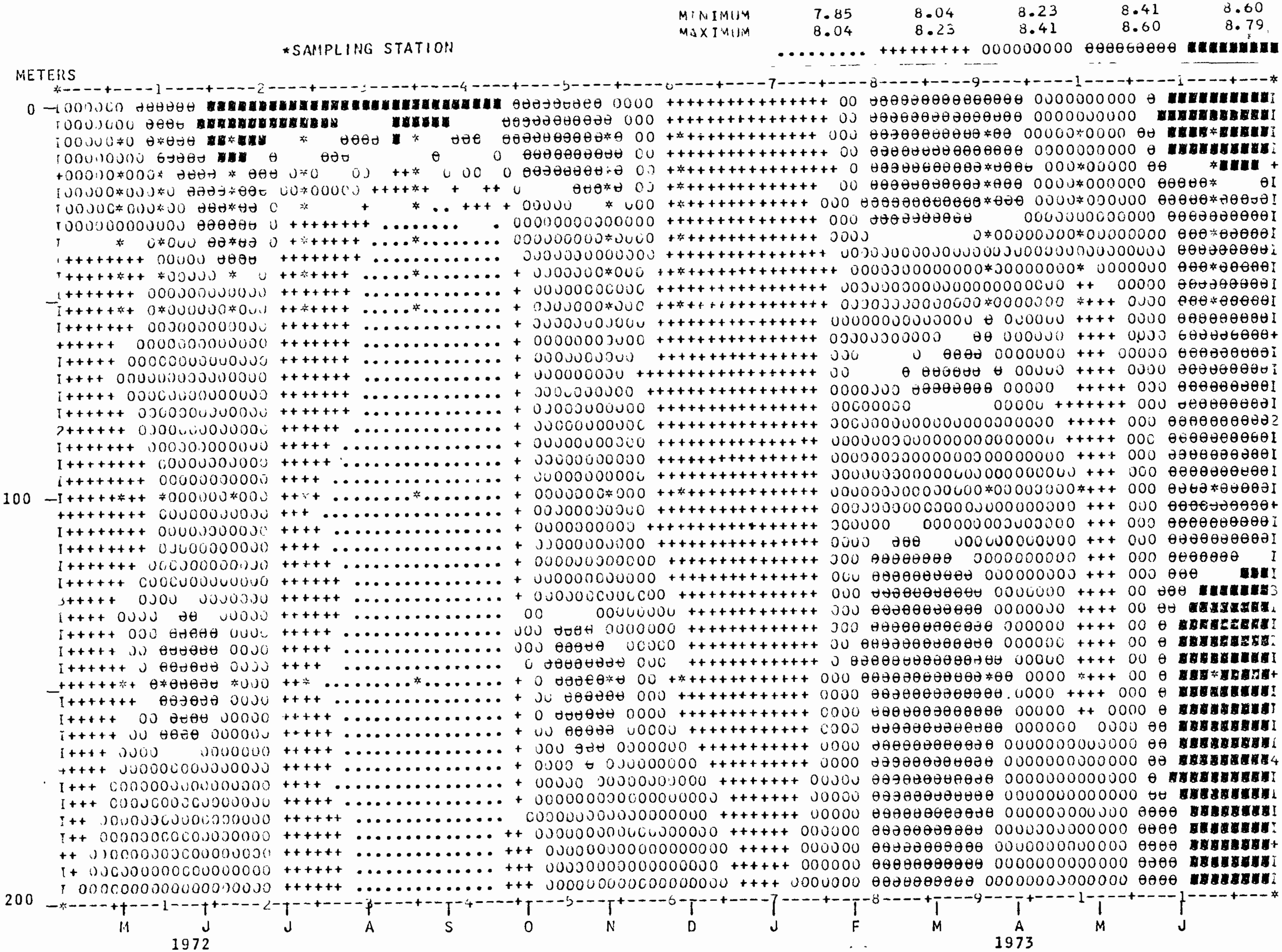


Figure 4.24c Depth Versus Time Contours of Constant pH

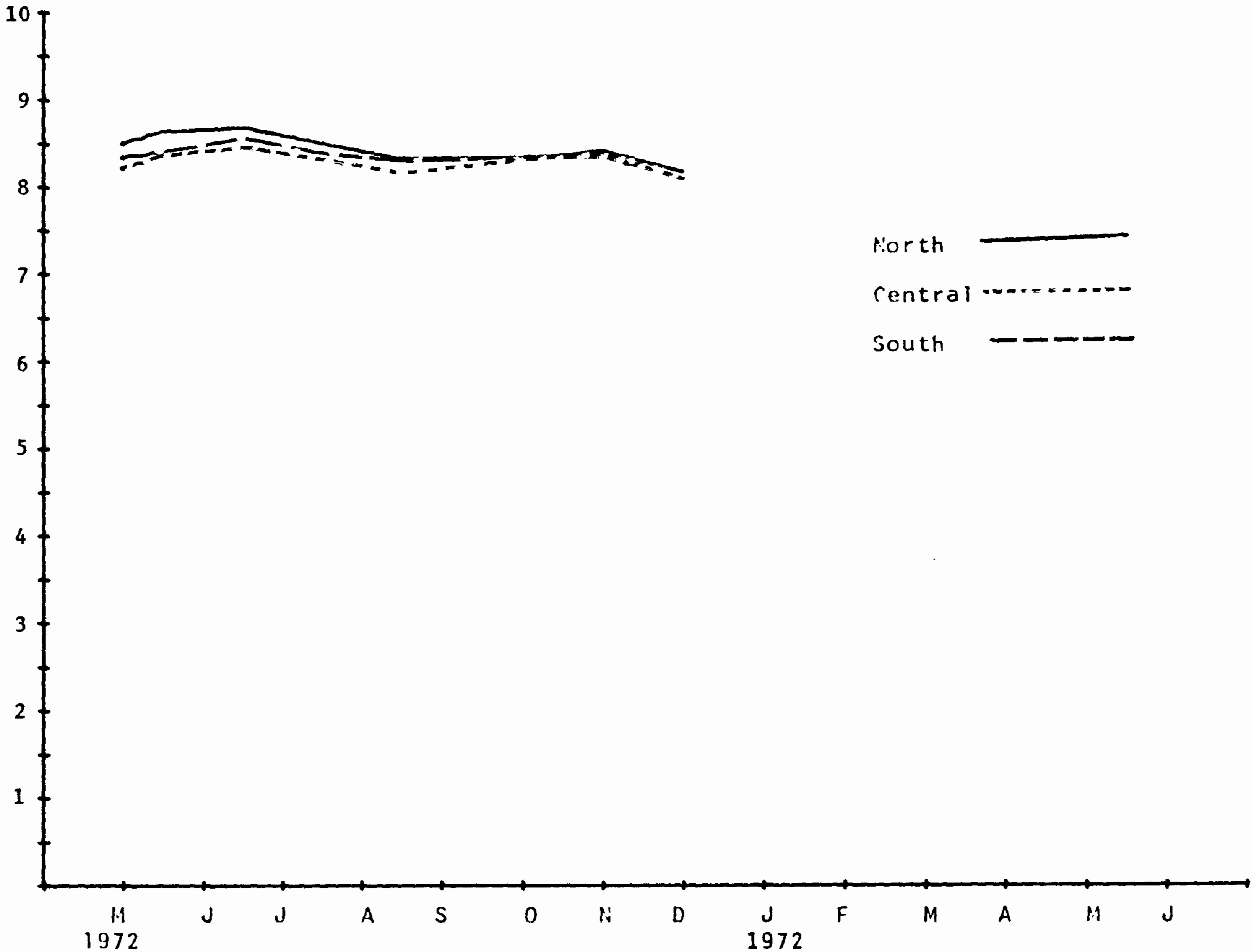


Figure 4.24d North-south variation of pH

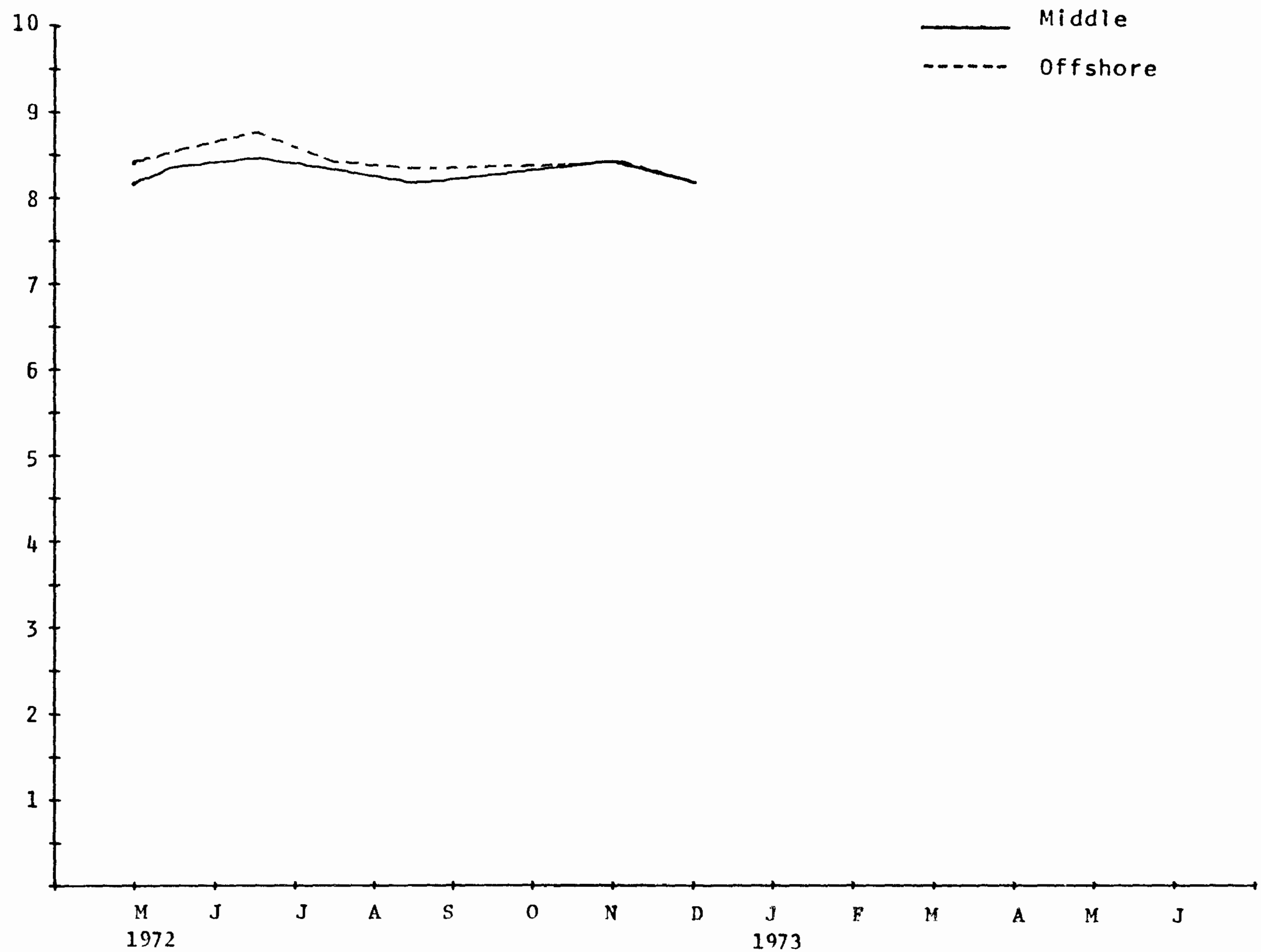


Figure 4.24e Middle Lake-Offshore Variation of Mean pH

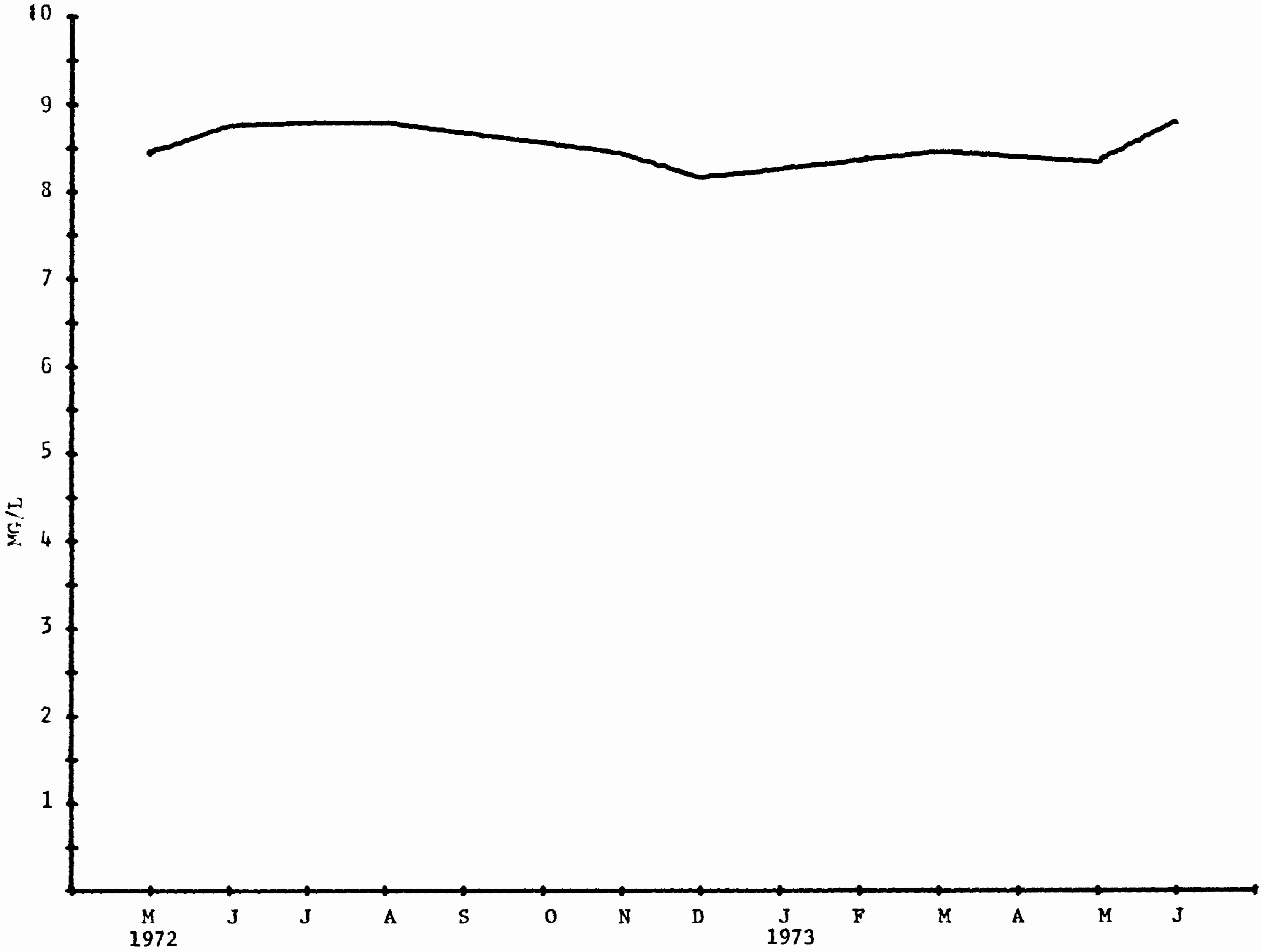


Figure 4.24f Mean surface variation of pH during the field year.

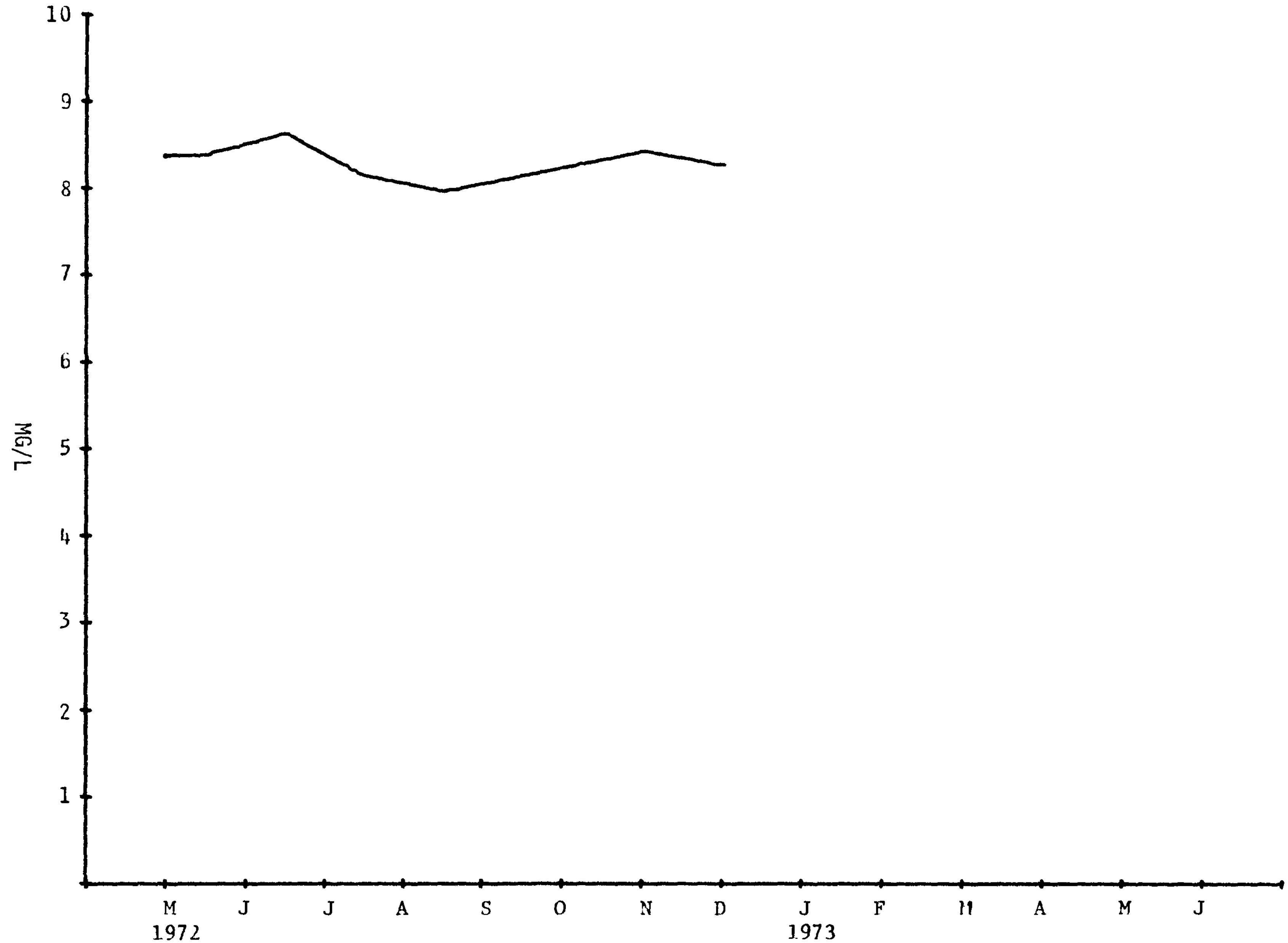


Figure 4.24g Mean Bottom Variation of pH
During the Field Year

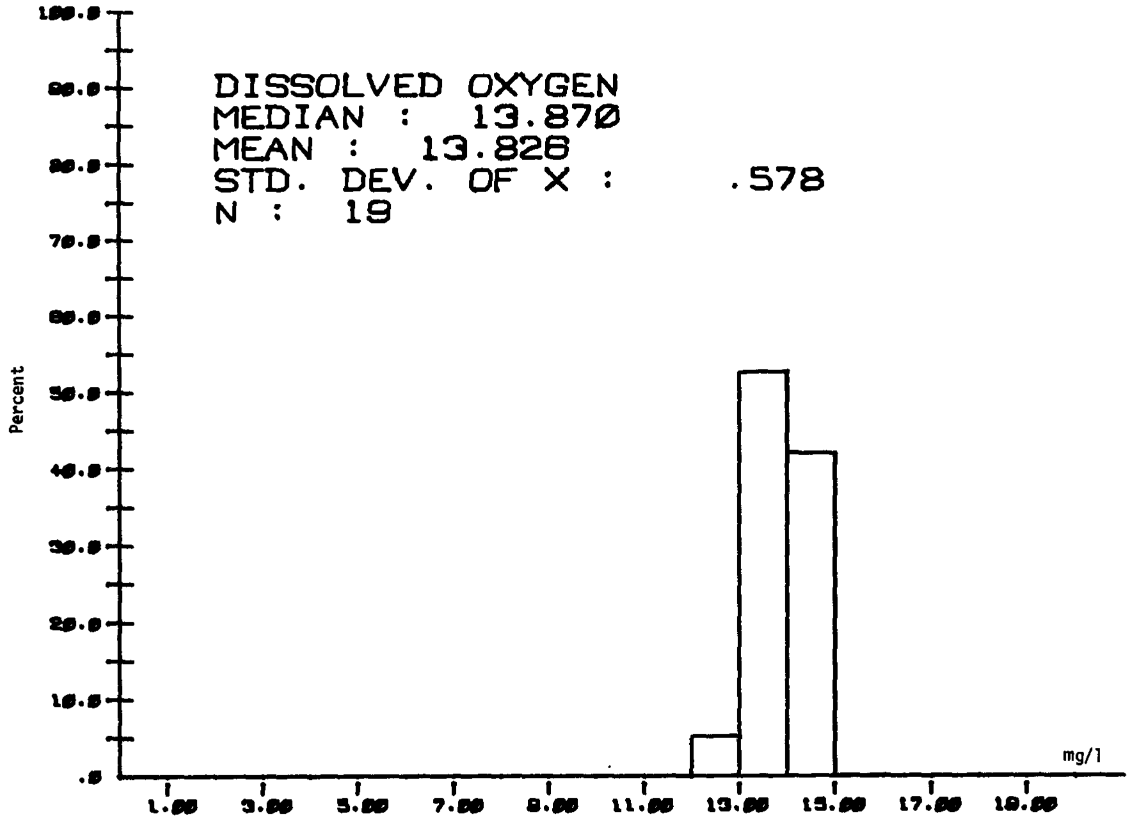


Figure 4.25a Histograms for Dissolved Oxygen - Cruise 1

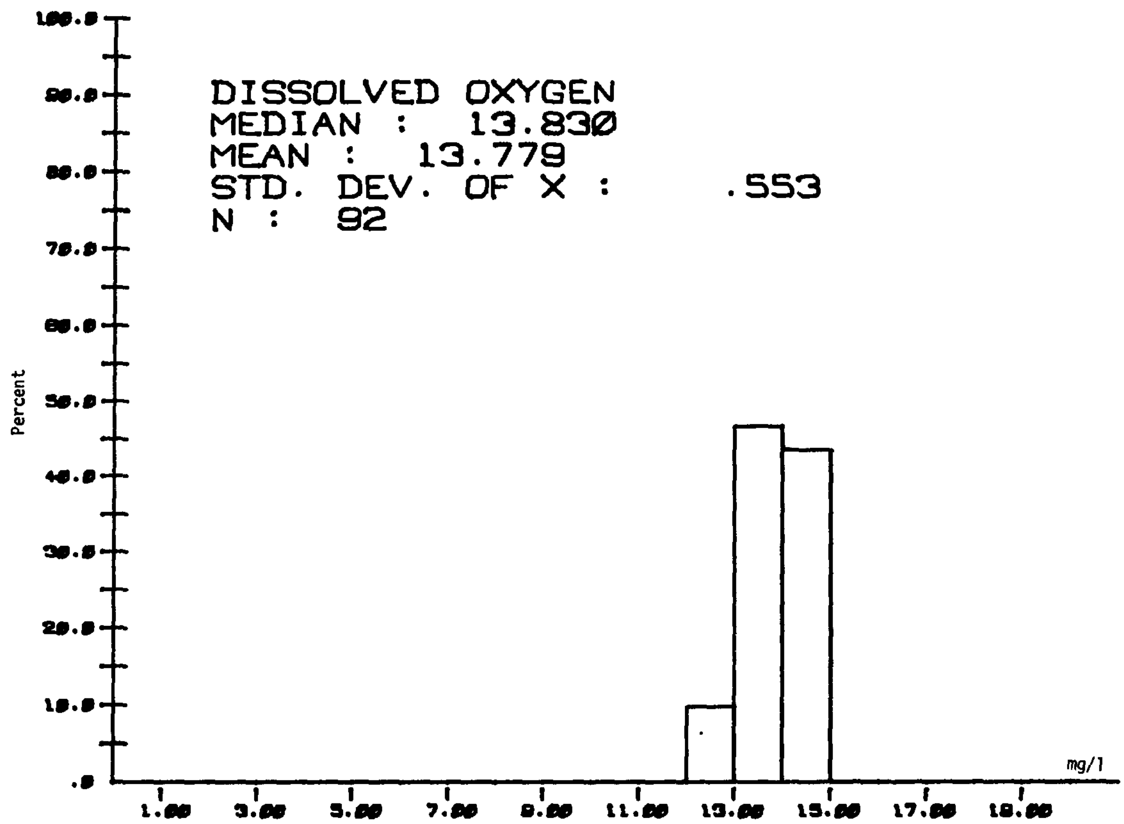


Figure 4.25a Histograms for Dissolved Oxygen - Cruise 2

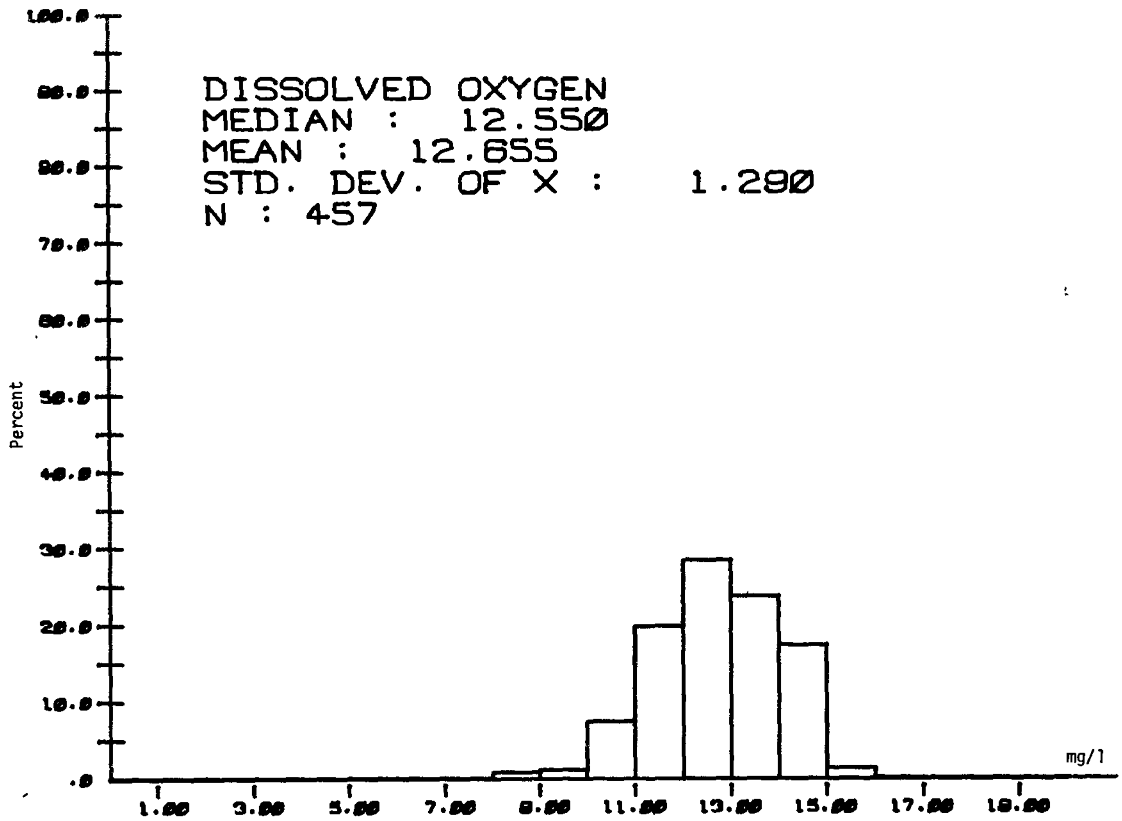


Figure 4.25a Histograms for Dissolved Oxygen - Cruise 3

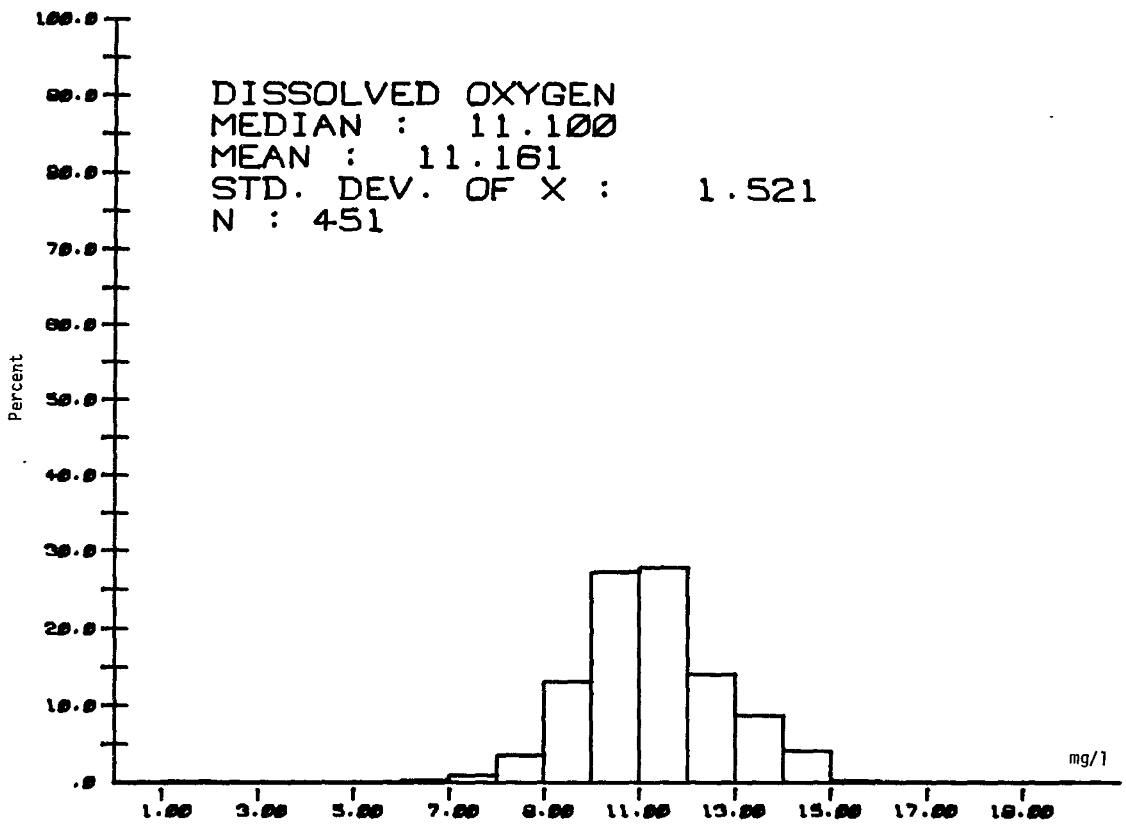


Figure 4.25a Histograms for Dissolved Oxygen - Cruise 4

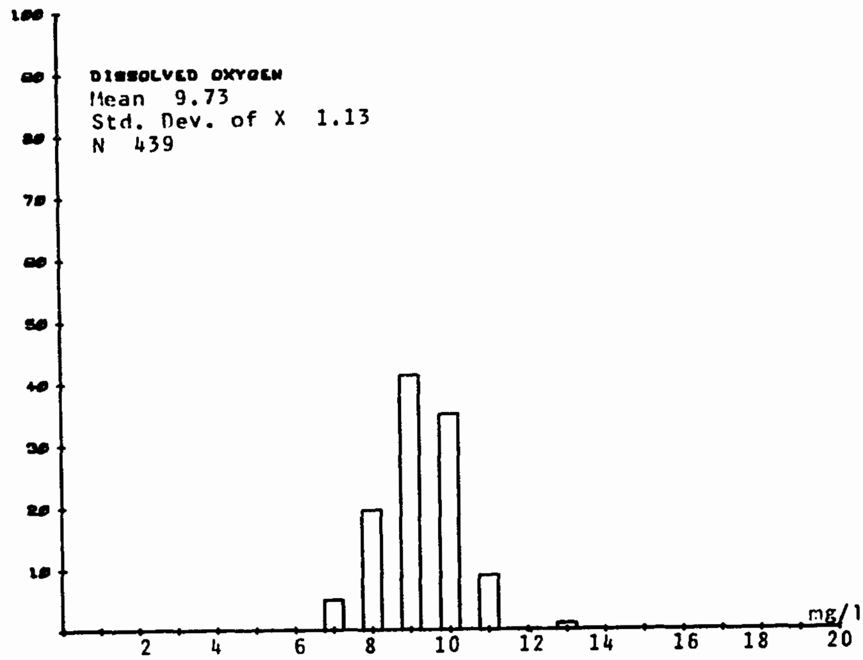


Figure 4.25a Histograms for Dissolved Oxygen - Cruise 5

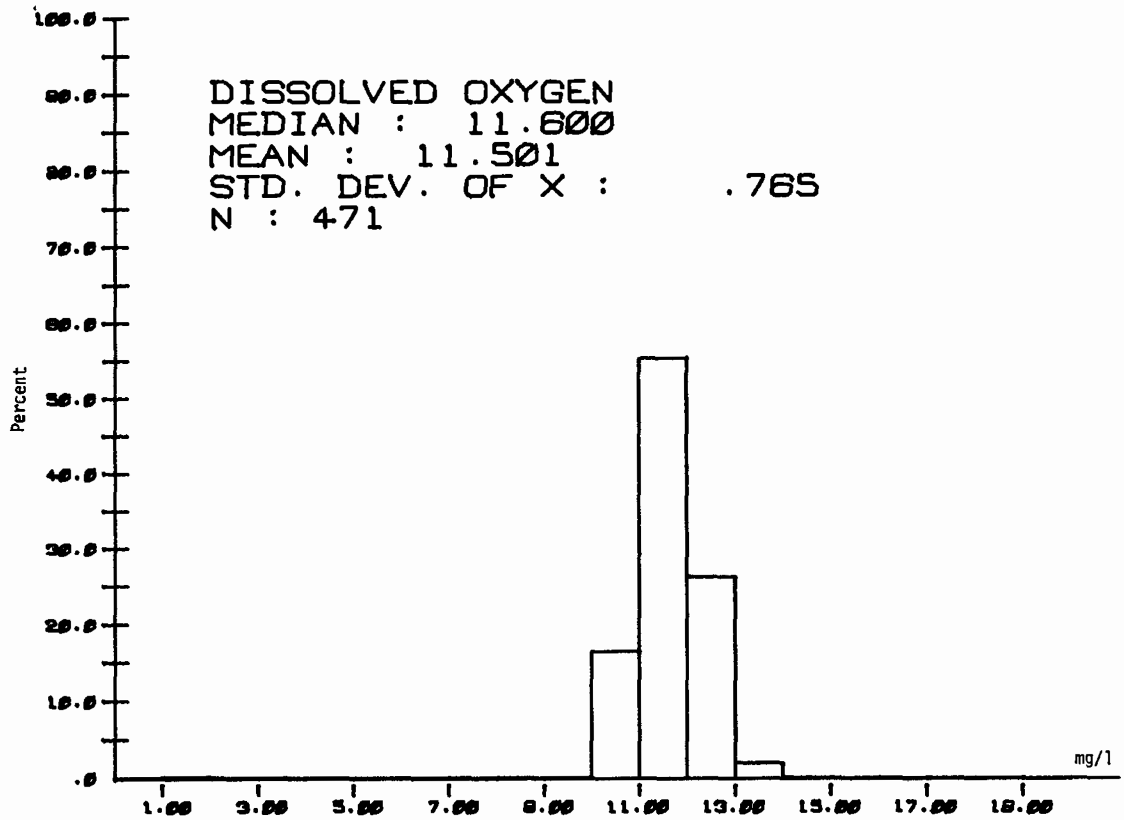


Figure 4.25a Histograms for Dissolved Oxygen - Cruise 6

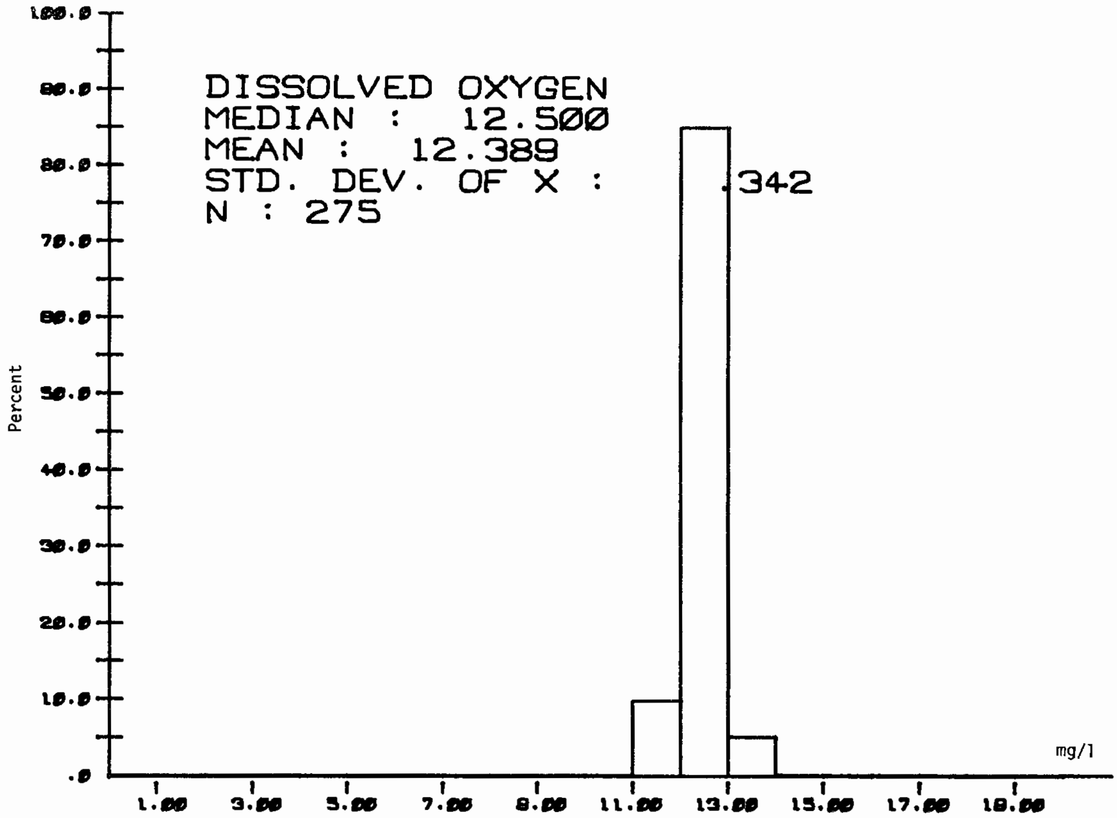


Figure 4.25a Histograms for Dissolved Oxygen - Cruise 7

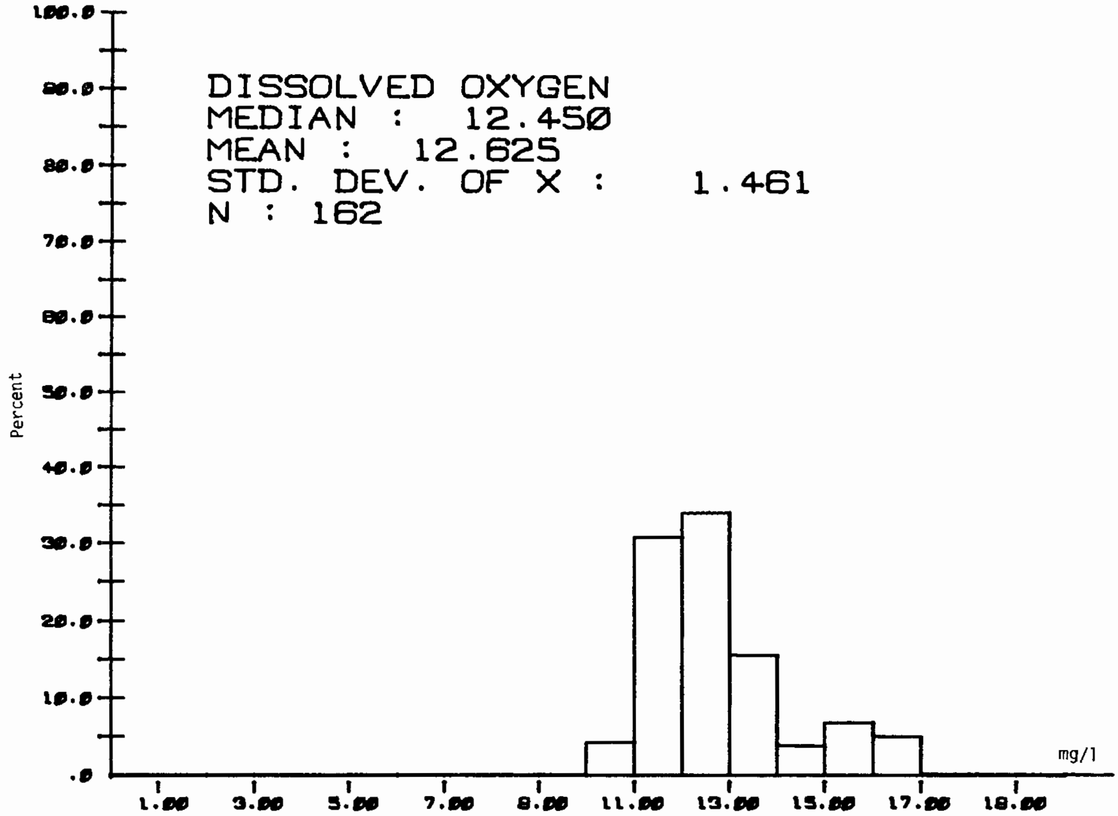


Figure 4.25a Histograms for Dissolved Oxygen - Cruise 8

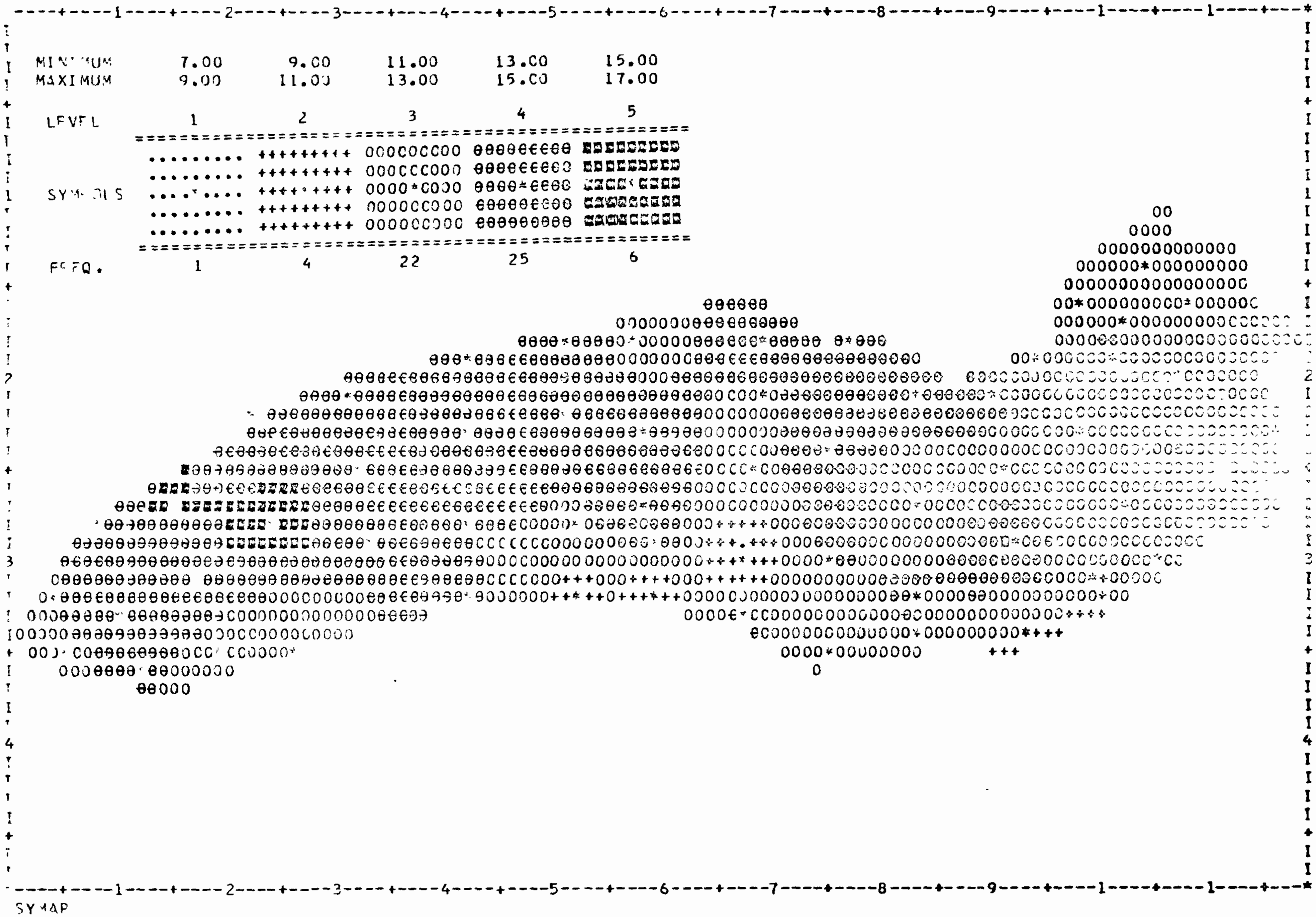


Figure 4.25b Contours of Constant Surface Dissolved Oxygen

CRUISE NUMBER 3: JUNE 12, 1972 TO JUNE 16, 1972

MINIMUM	7.00	9.00	11.00	13.00	15.00
MAXIMUM	9.00	11.00	13.00	15.00	17.00
LEVEL	1	2	3	4	5
SYMBOLS	....	+++++++++	000000000	θθθθθθθθθ	■■■■■■■■■
FREQ.	4	12	24	13	1

SYMAP

Figure 4.25b Contours of Constant Surface Dissolved Oxygen

CRUISE NUMBER 4: JULY 10, 1972 TO JULY 14, 1972

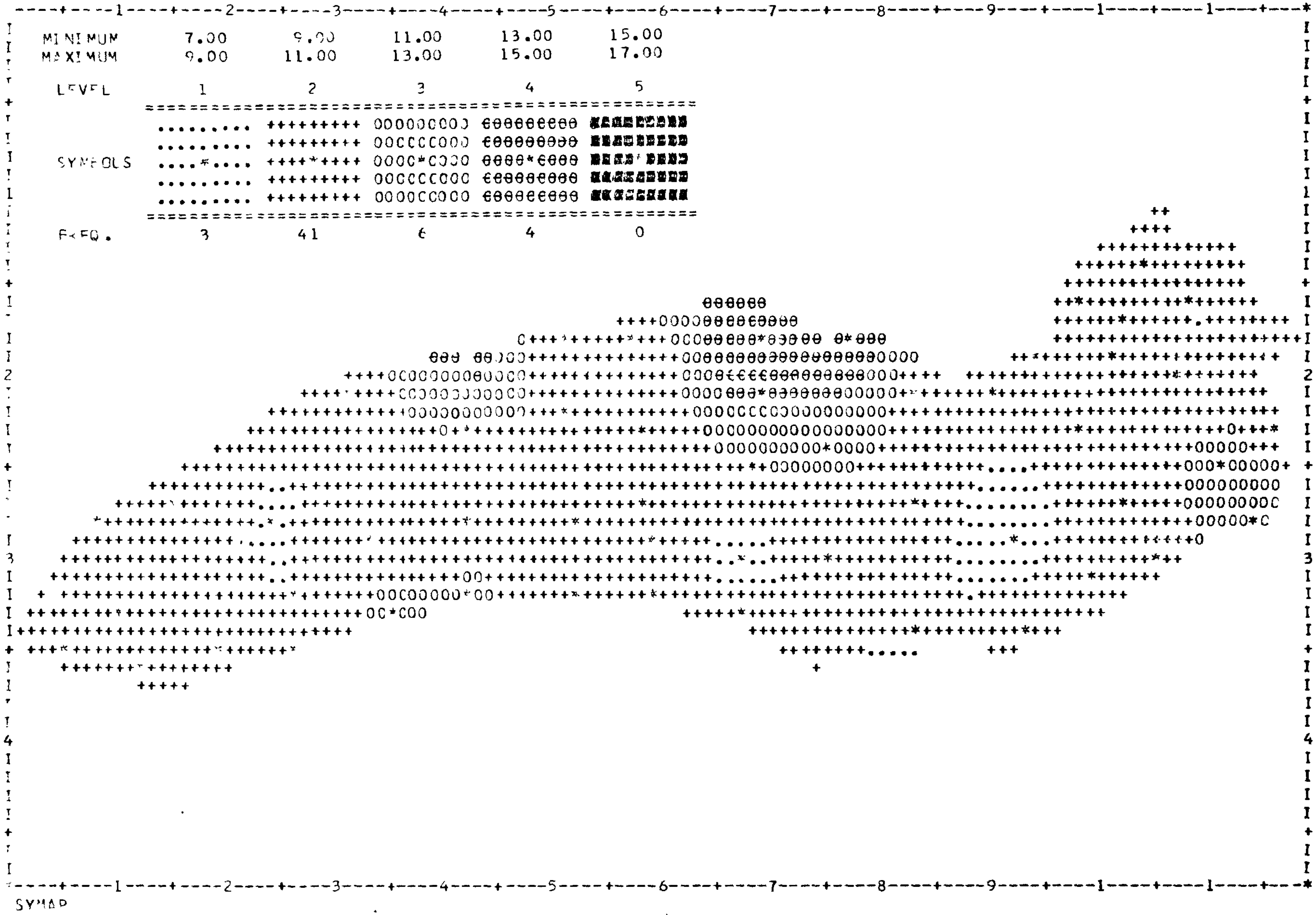


Figure 4.25b Contours of Constant Surface Dissolved Oxygen

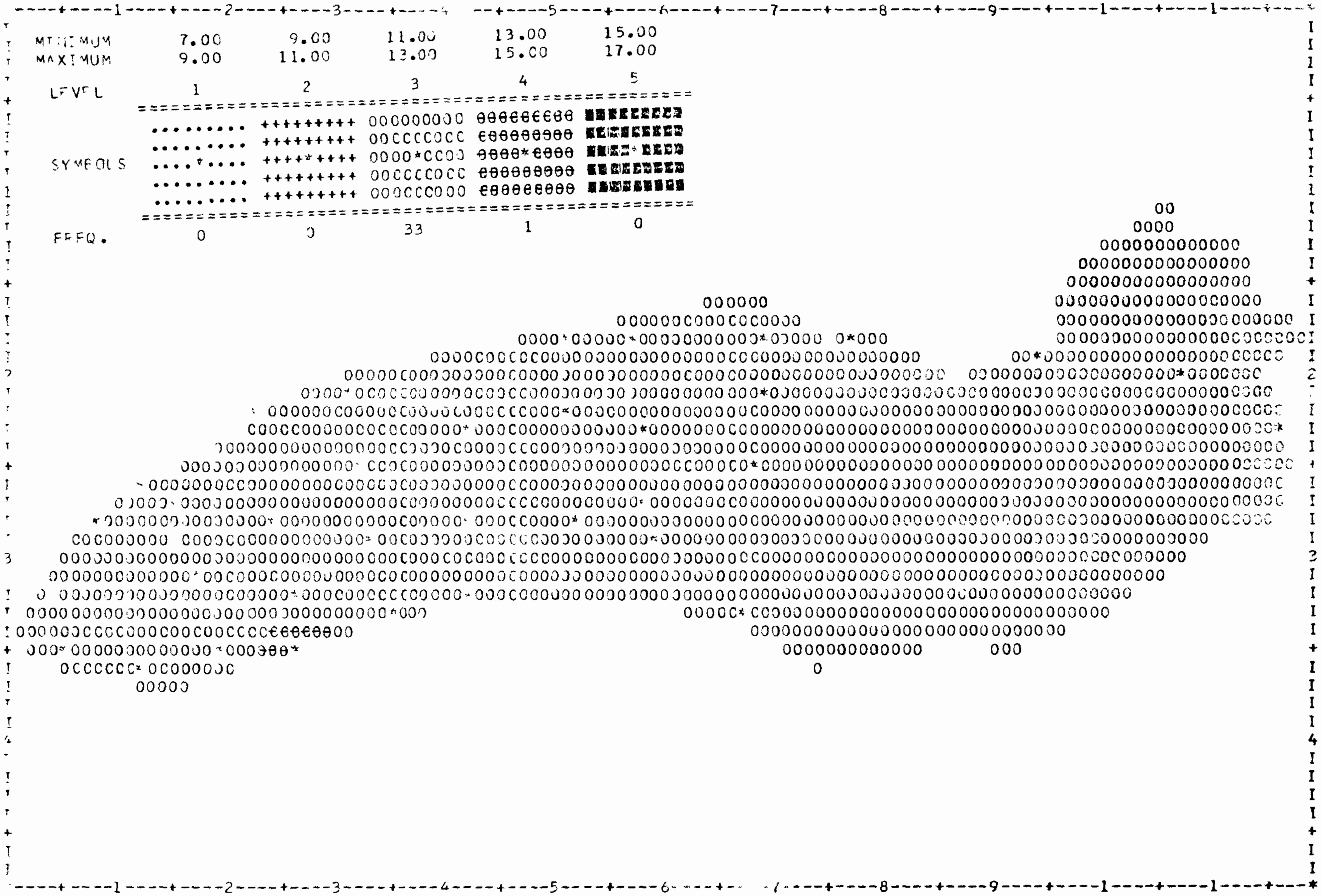
CRUISE NUMBER 5: AUGUST 21, 1972 TO AUGUST 25, 1972

MINIMUM	7.00	9.00	11.00	13.00	15.00
MAXIMUM	9.00	11.00	13.00	15.00	17.00
LEVEL	1	2	3	4	5
SYMBOLS	....	+++++++++	000000000	ΘΘΘΘΘΘΘΘΘ	■■■■■■■■■
FREQ.	0	9	46	2	0

SYMAP

Figure 4.25b Contours of Constant Surface Dissolved Oxygen

CRUISE NUMBER 6: OCTOBER 30, 1972 TO NOVEMBER 3, 1972



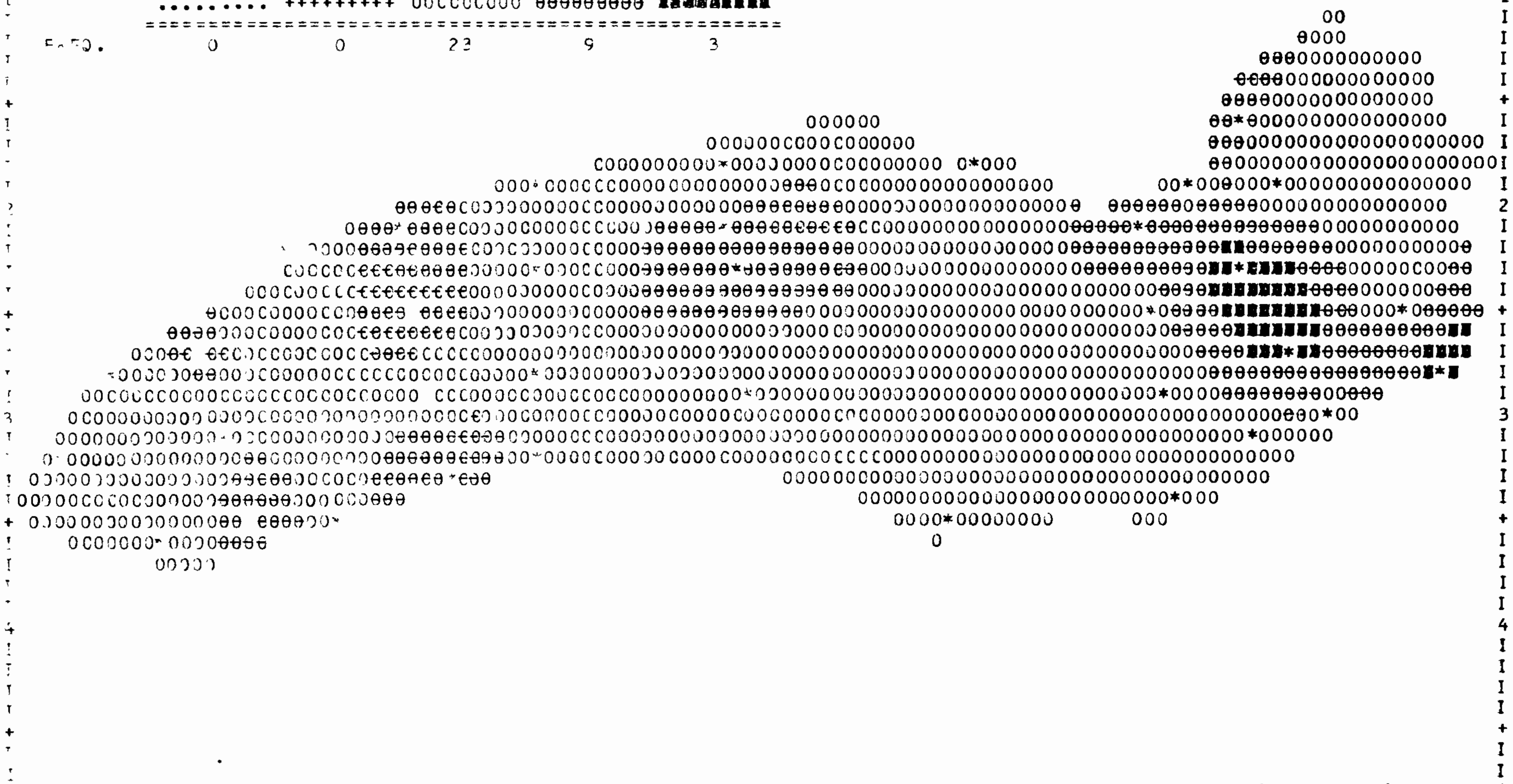
MINIMUM	7.00	9.00	11.00	13.00	15.00
MAXIMUM	9.00	11.00	13.00	15.00	17.00
LEVEL	1	2	3	4	5
FREQ.	0	0	33	1	0

SYMAP

Figure 4.25b Contours of Constant Surface Dissolved Oxygen

CRUISE NUMBER 7: NOVEMBER 27, 1972 TO DECEMBER 2, 1972

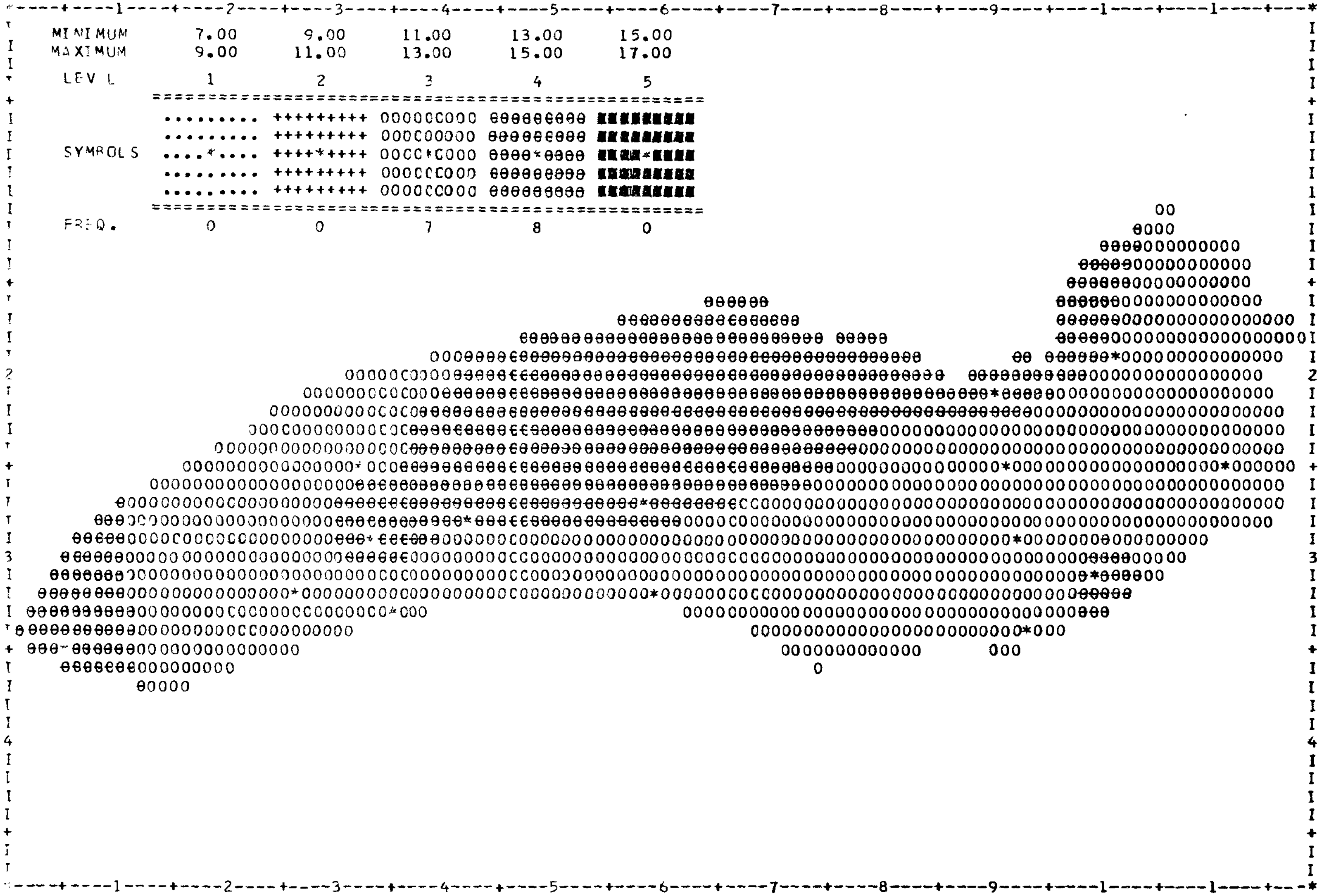
LEVEL	1	2	3	4	5
MINIMUM	7.00	9.00	11.00	13.00	15.00
MAXIMUM	9.00	11.00	13.00	15.00	17.00
SYMBOLS	....	+++++++++	OOOOOOOOO	ØØØØØØØØØ	■■■■■■■■■
FREQ.	0	0	23	9	3



SYMAP

Figure 4.25b Contours of Constant Surface Dissolved Oxygen

CRUISE NUMBER 8: FEBRUARY 5, 1973 TO FEBRUARY 9, 1973



MINIMUM	7.00	9.00	11.00	13.00	15.00
MAXIMUM	9.00	11.00	13.00	15.00	17.00
LEVEL	1	2	3	4	5
SYMBOLS	....	+++++++++	000000000	θθθθθθθθθ	■■■■■■■■■
FREQ.	0	0	7	8	0

SYMAP

Figure 4.25b Contours of Constant Surface Dissolved Oxygen

CRUISE NUMBER 9: MARCH 18, 1973 TO MARCH 23, 1973

MINIMUM	7.00	9.00	11.00	13.00	15.00
MAXIMUM	9.00	11.00	13.00	15.00	17.00
LEVEL	1	2	3	4	5
SYMBOLS	....	+++++++++	000000000	000000000	■■■■■■■■■
FREQ.	0	1	5	1	0

SYMAP

Figure 4.25b Contours of Constant Surface Dissolved Oxygen

CRUISE NUMBER 10: APRIL 24, 1973 TO APRIL 30, 1973

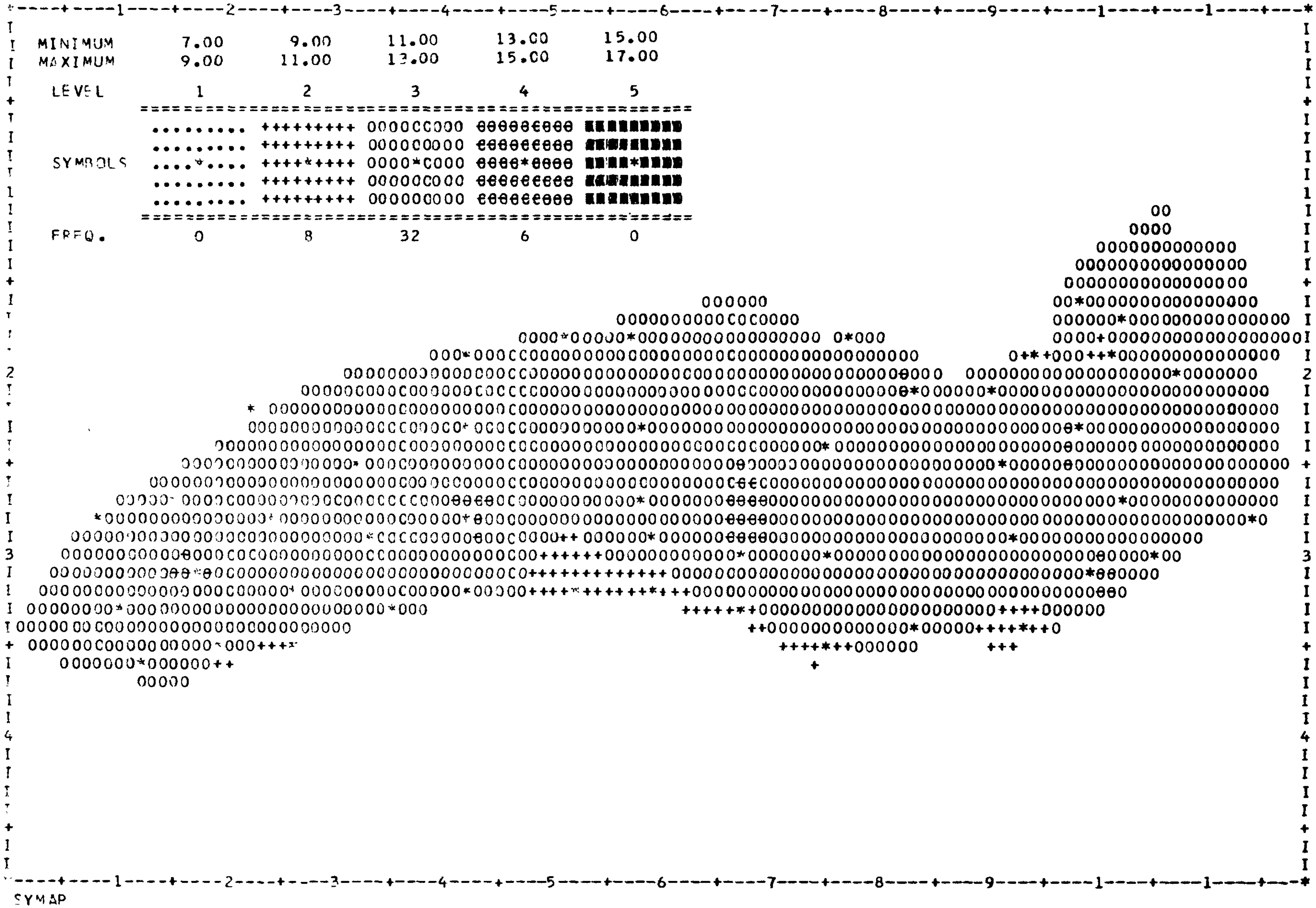


Figure 4.25b Contours of Constant Surface Dissolved Oxygen

CRUISE NUMBER 11: JUNE 11, 1973 TO JUNE 15, 1973

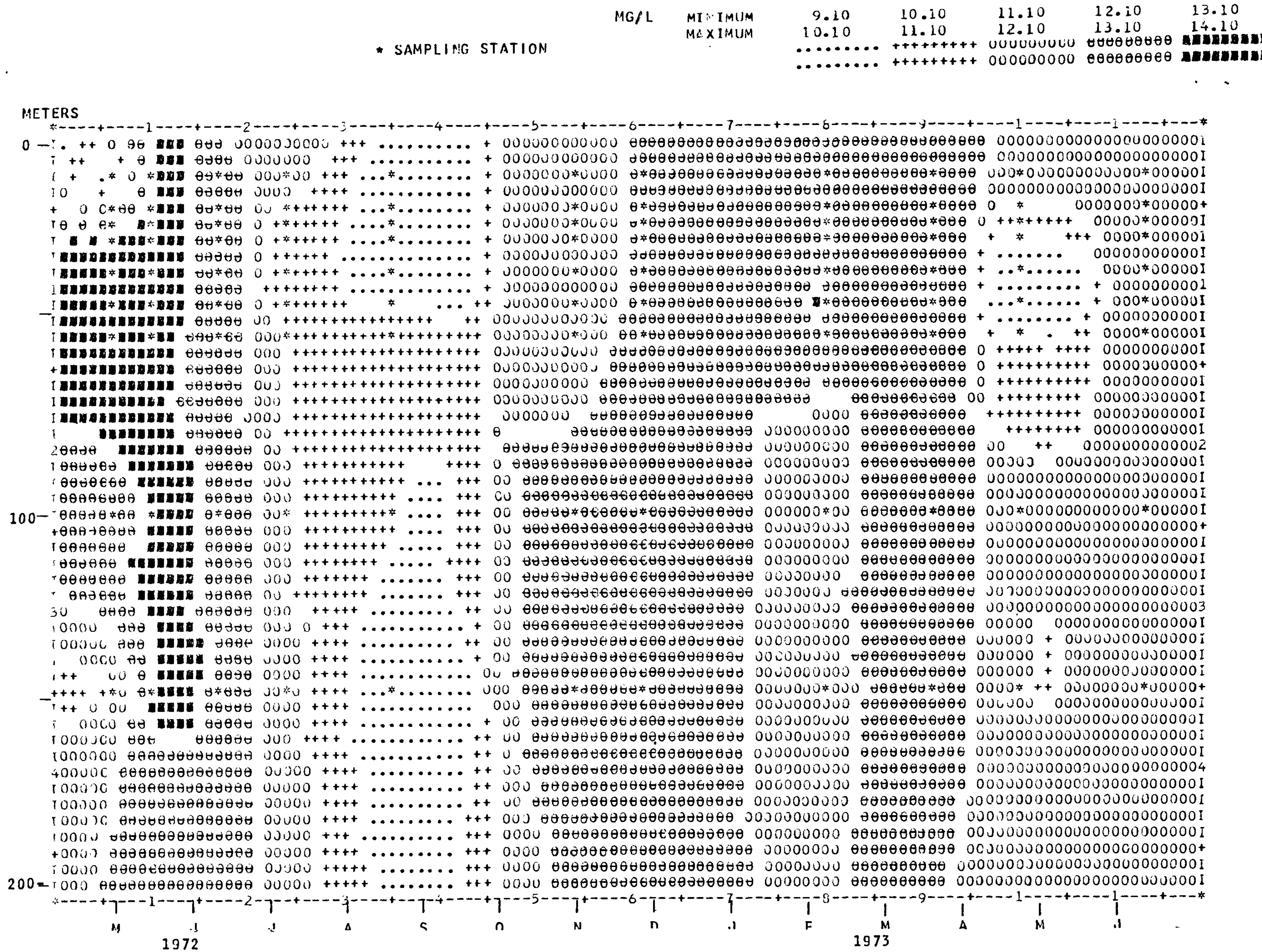


Figure 4.25c Depth Versus Time Contours of Constant Dissolved Oxygen

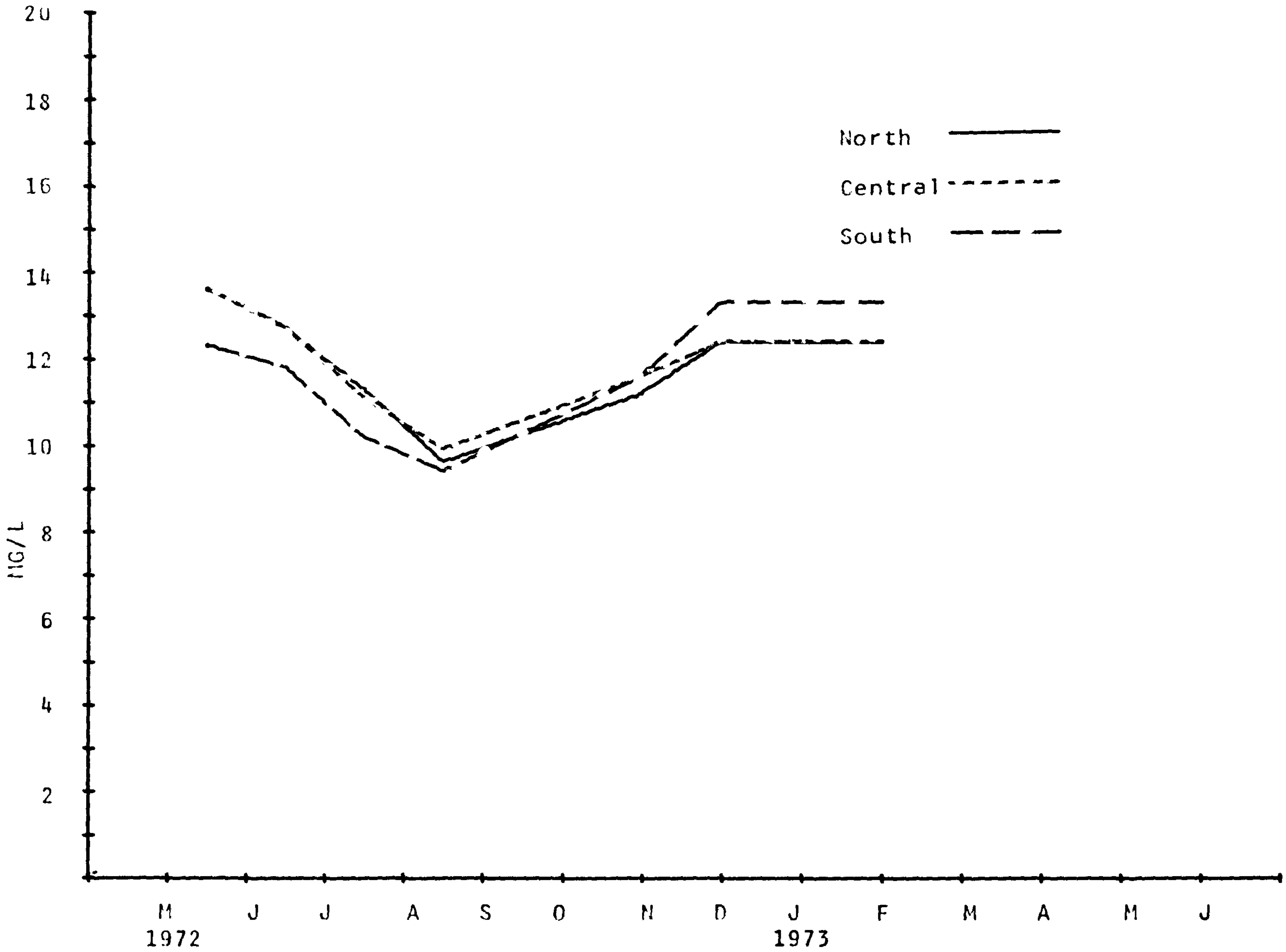


Figure 4.25d North-south variation of dissolved oxygen

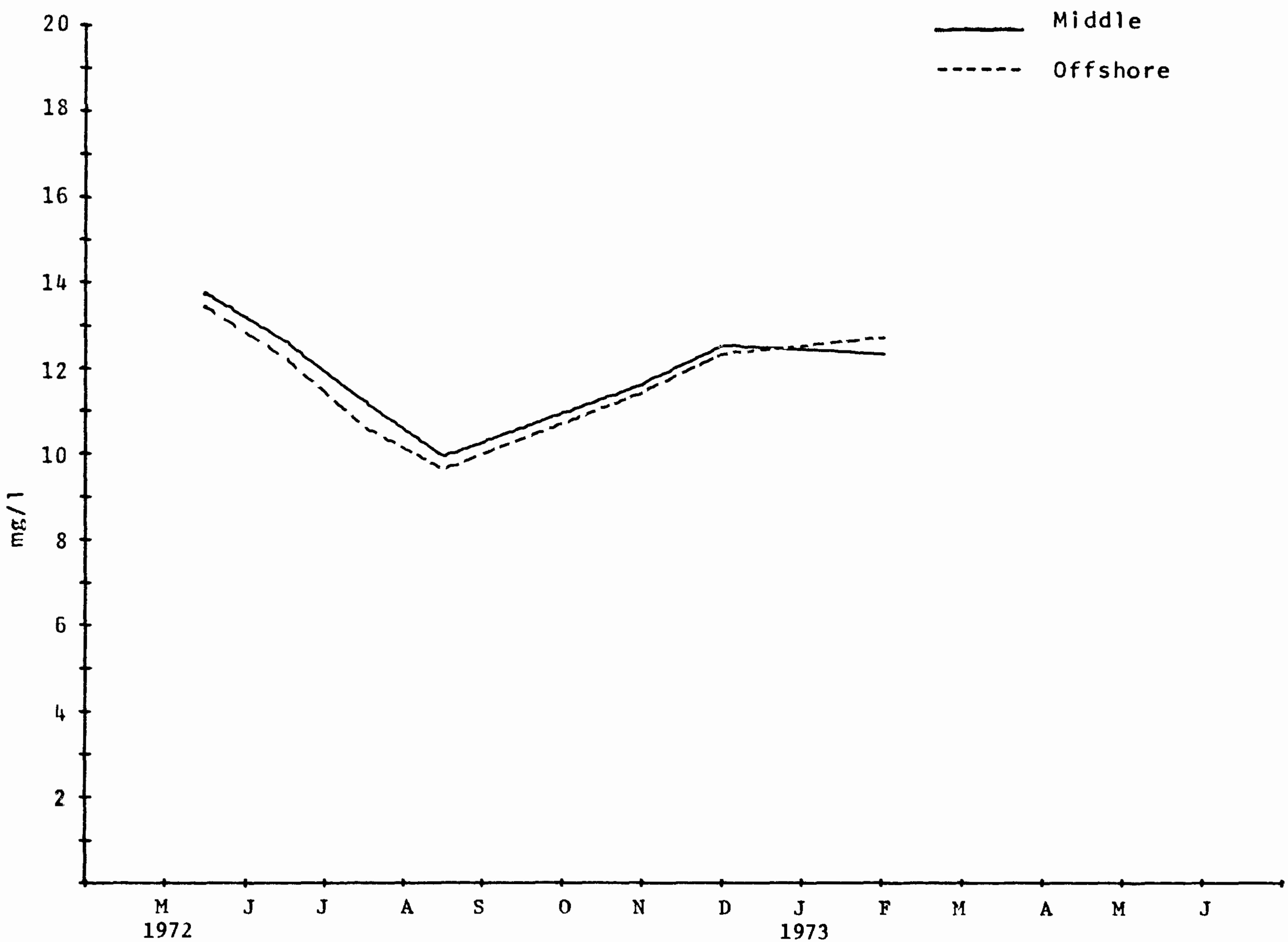


Figure 4.25e Middle Lake-Offshore Variation of Mean Dissolved Oxygen Concentration

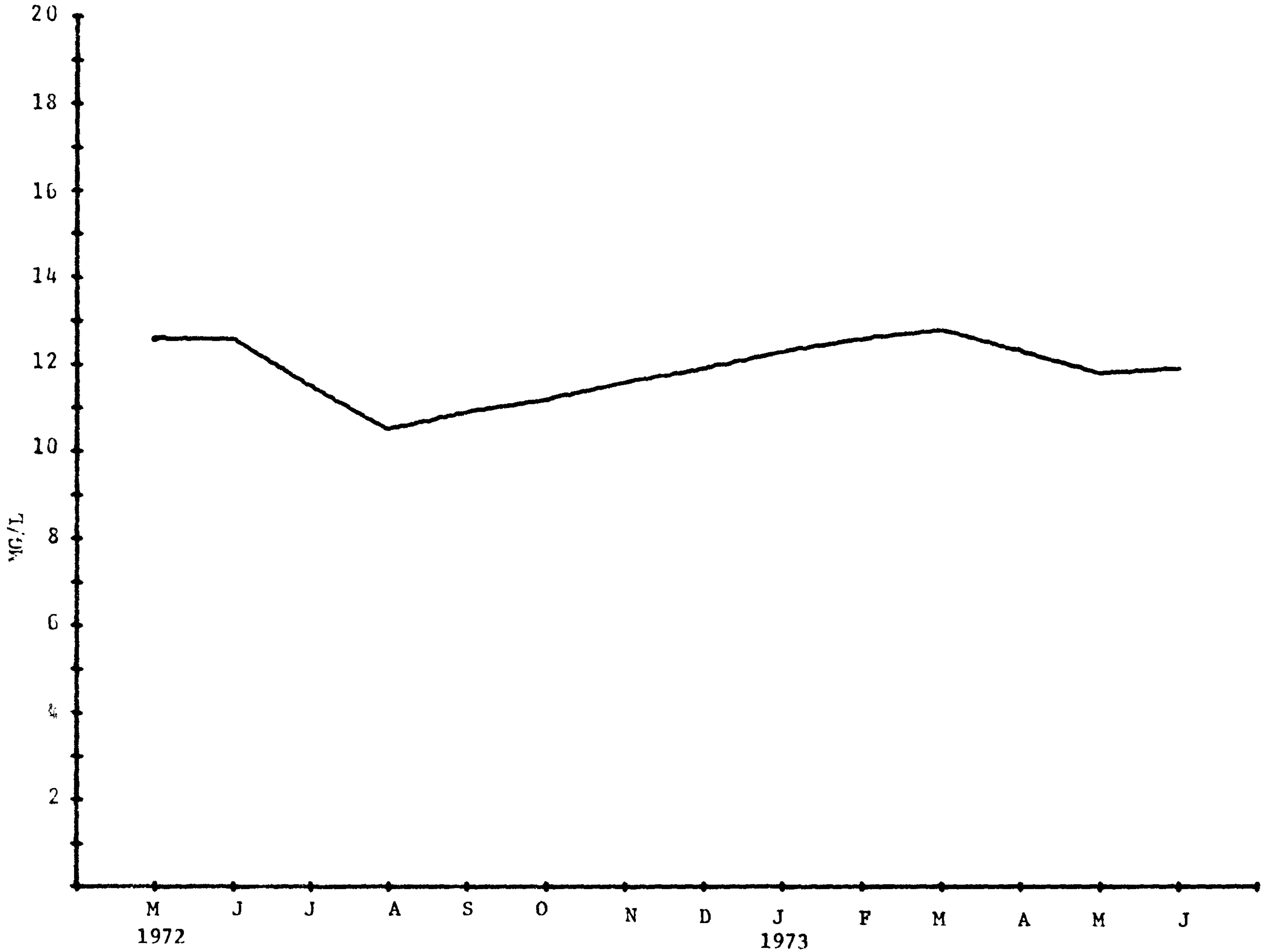


Figure 4.25f Mean surface variation of Dissolved Oxygen concentration during the field year.

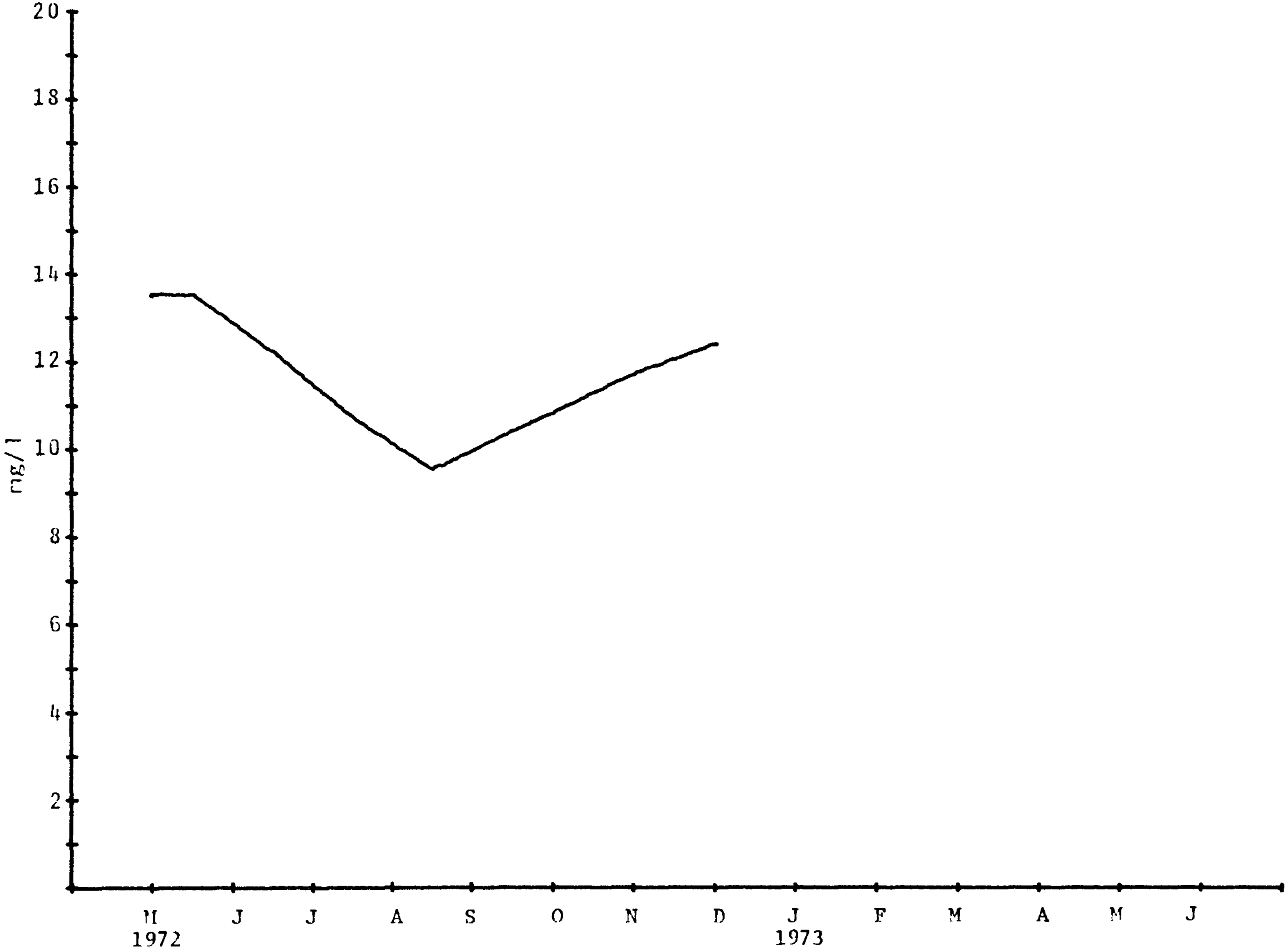


Figure 4.25g Mean Bottom Variation of Dissolved Oxygen Concentration During the Field Year

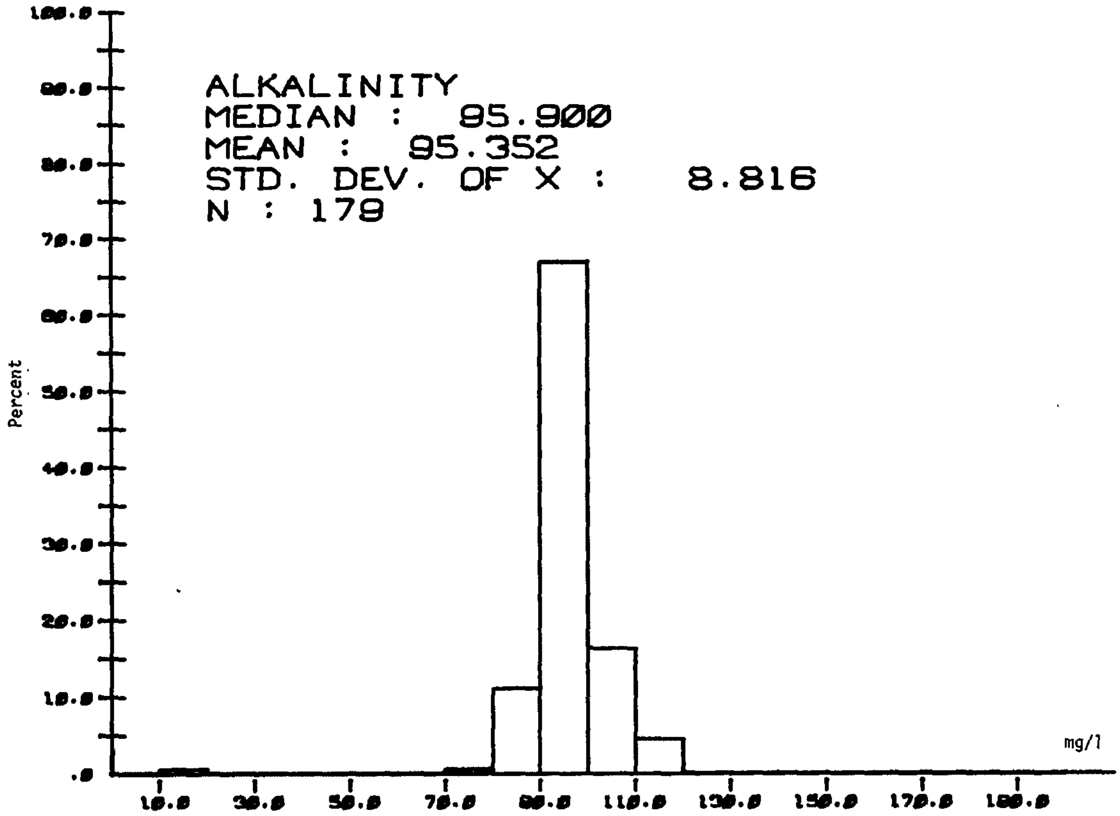


Figure 4.26a Histograms for Total Alkalinity - Cruise 2

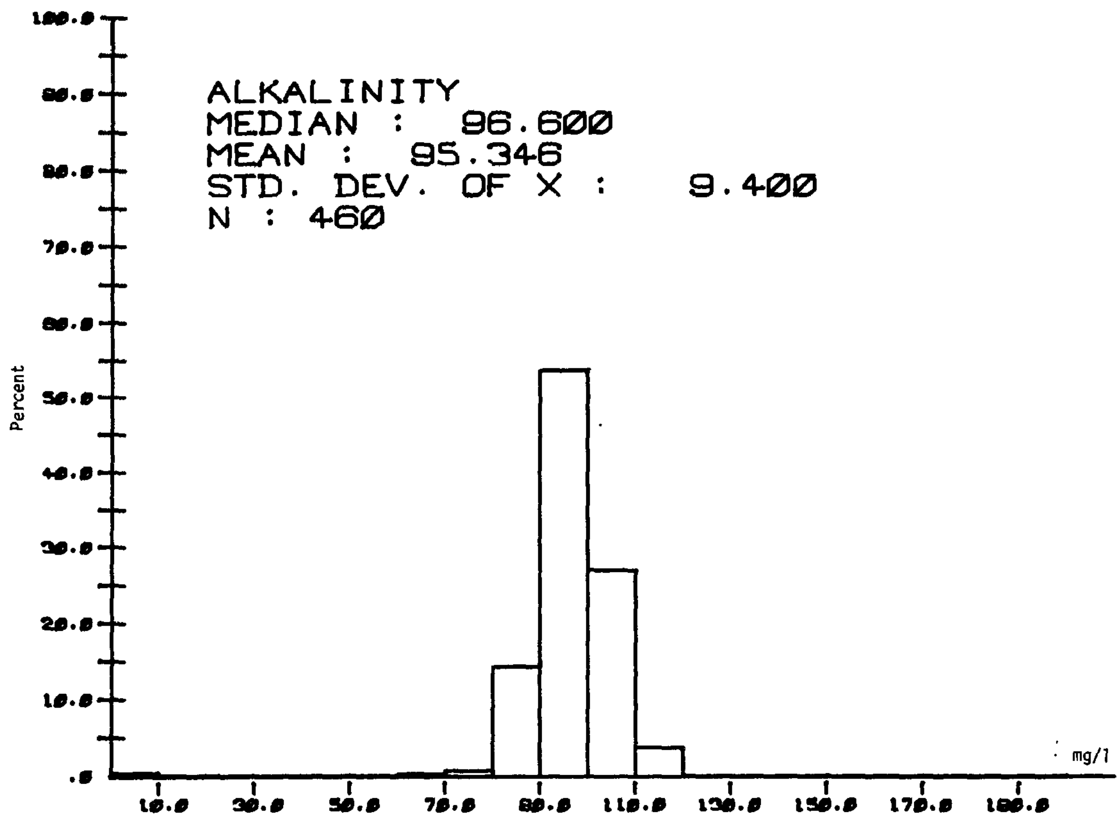


Figure 4.26a Histograms for Total Alkalinity - Cruise 3

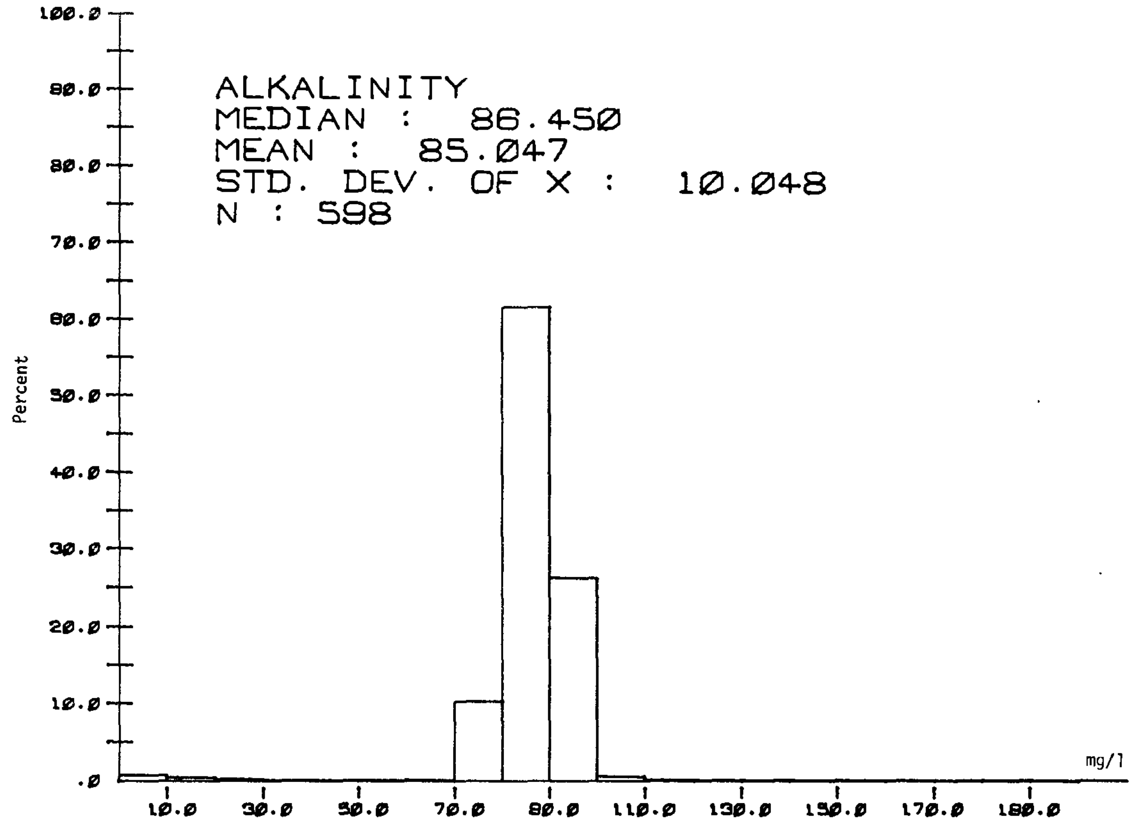


Figure 4.26a Histograms for Total Alkalinity - Cruise 4

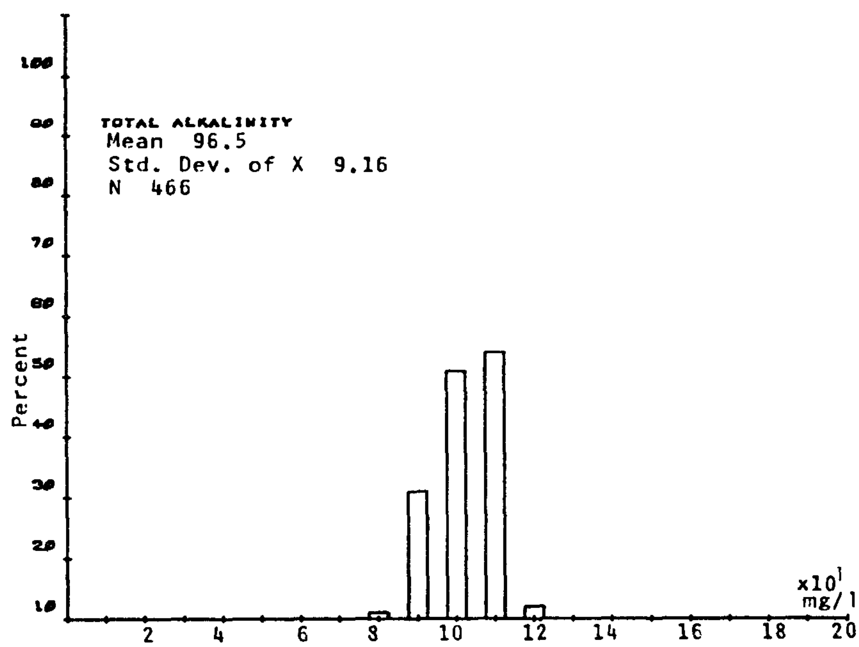


Figure 4.26a Histograms for Total Alkalinity Cruise 5

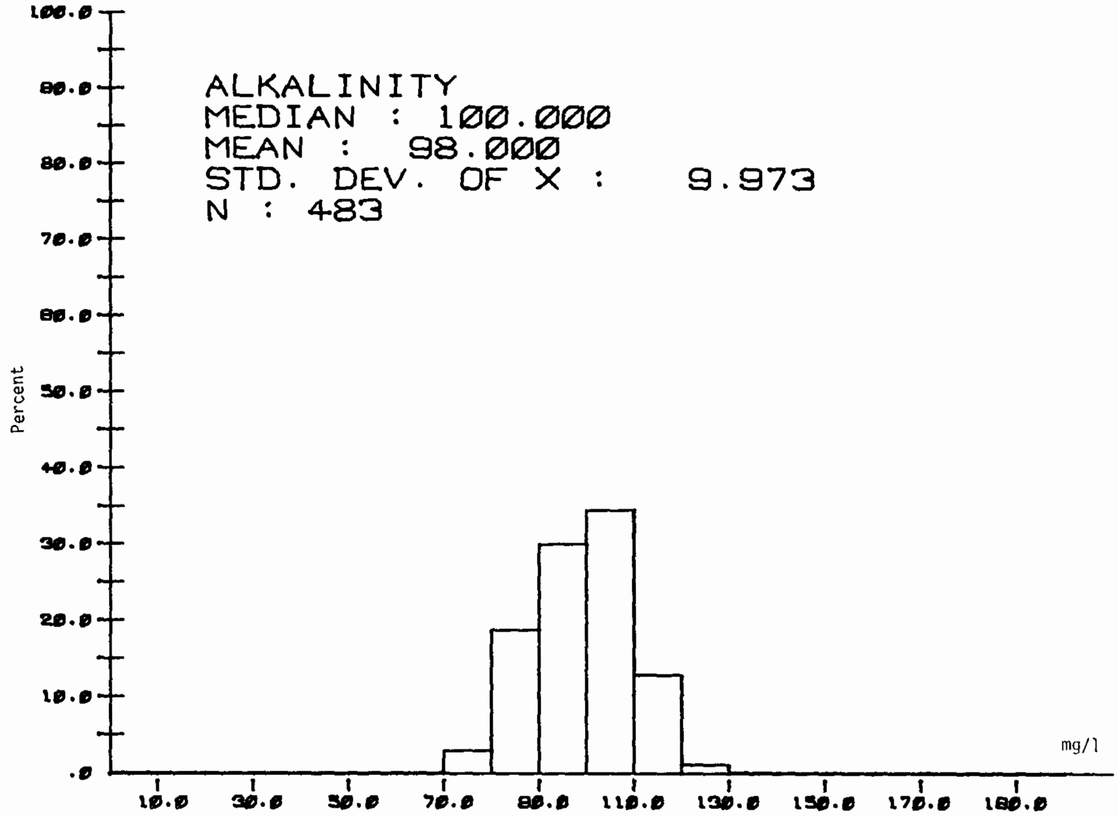


Figure 4.26a Histograms for Total Alkalinity - Cruise 6

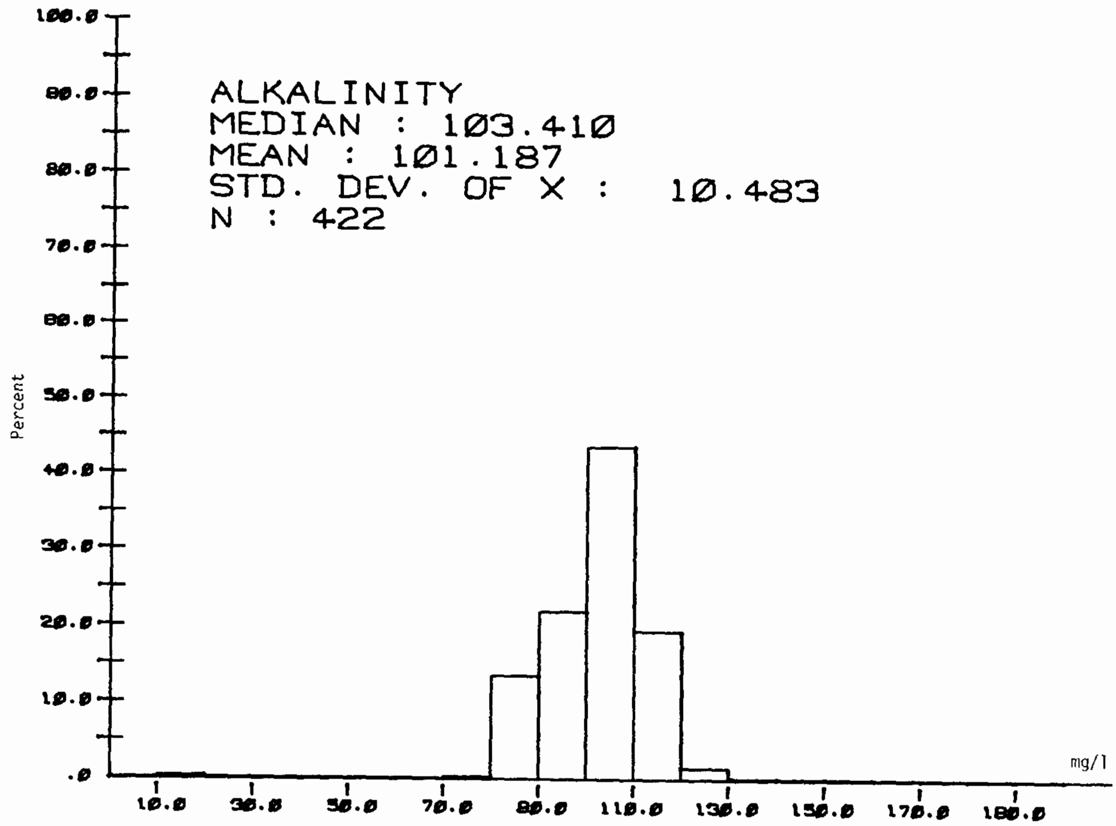


Figure 4.26a Histograms for Total Alkalinity - Cruise 7

Figure 4.26b Contours of Constant Surface Total Alkalinity

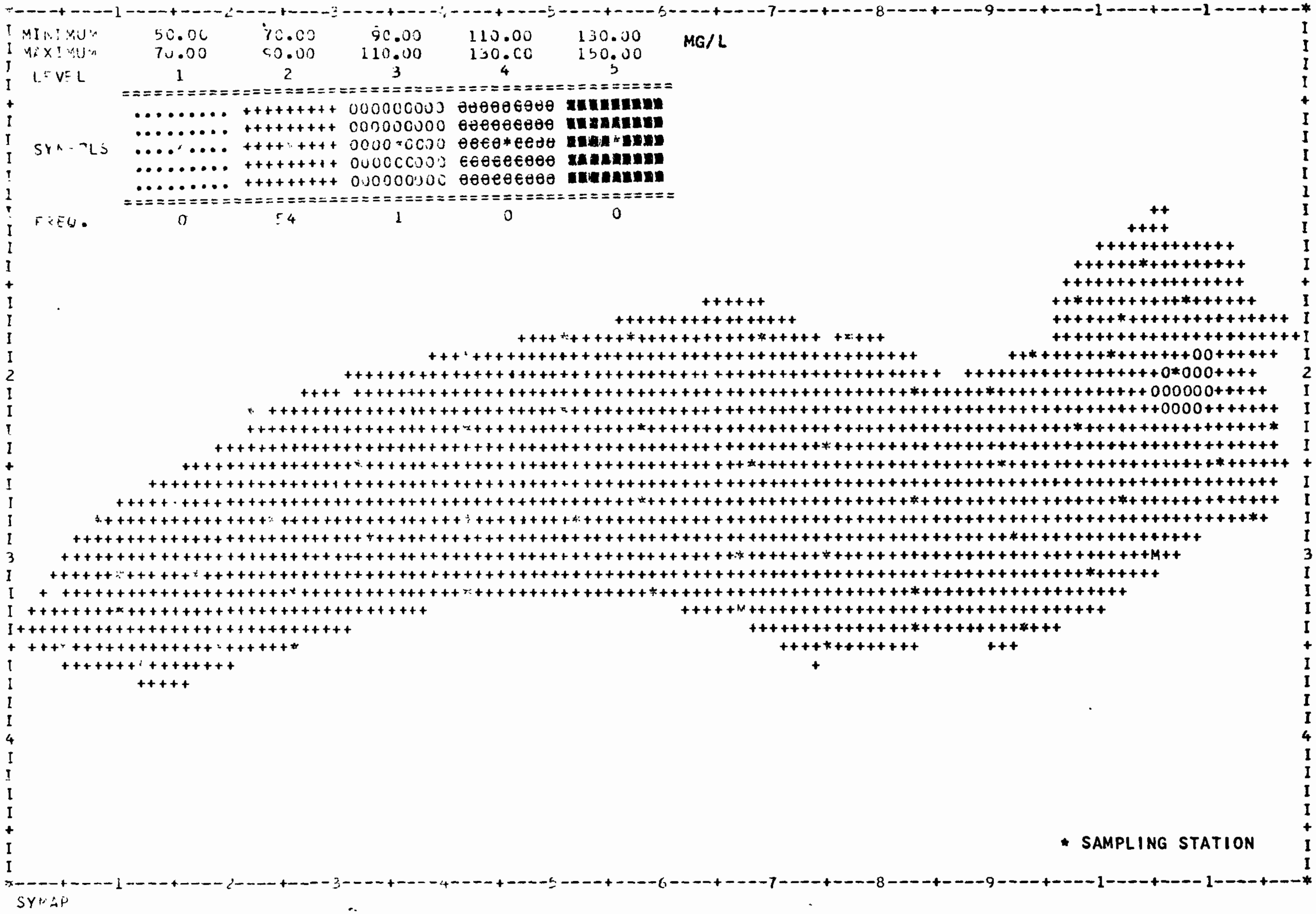
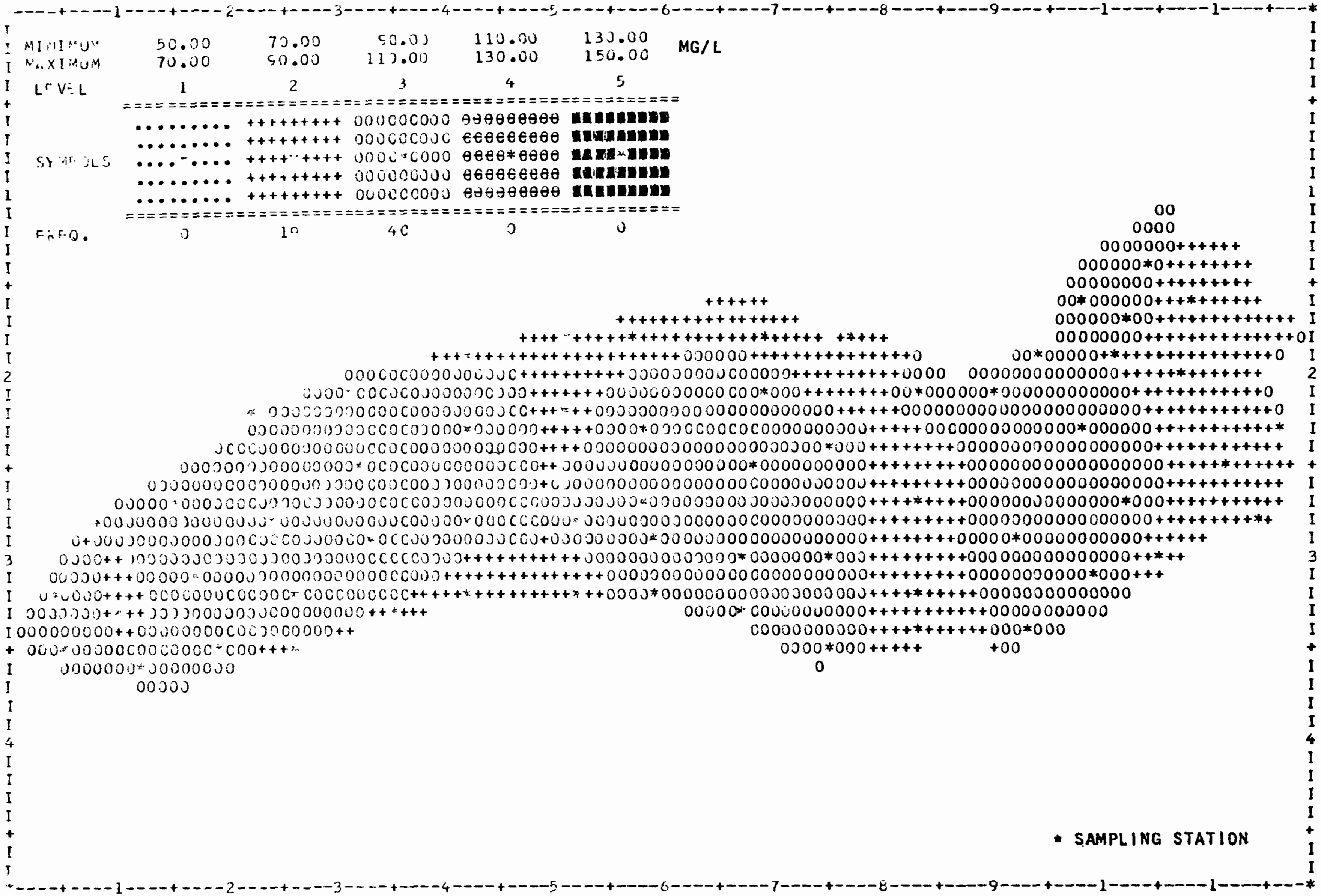


Figure 4.26b Contours of Constant Surface Total Alkalinity

CRUISE NUMBER 4: JULY 10, 1972 TO JULY 14, 1972



SYMAP

0.0 MINUTES FOR MAP

Figure 4.26b Contours of Constant Surface Total Alkalinity

CRUISE DONE : AUGUST 21, 1972 TO AUGUST 25, 1972

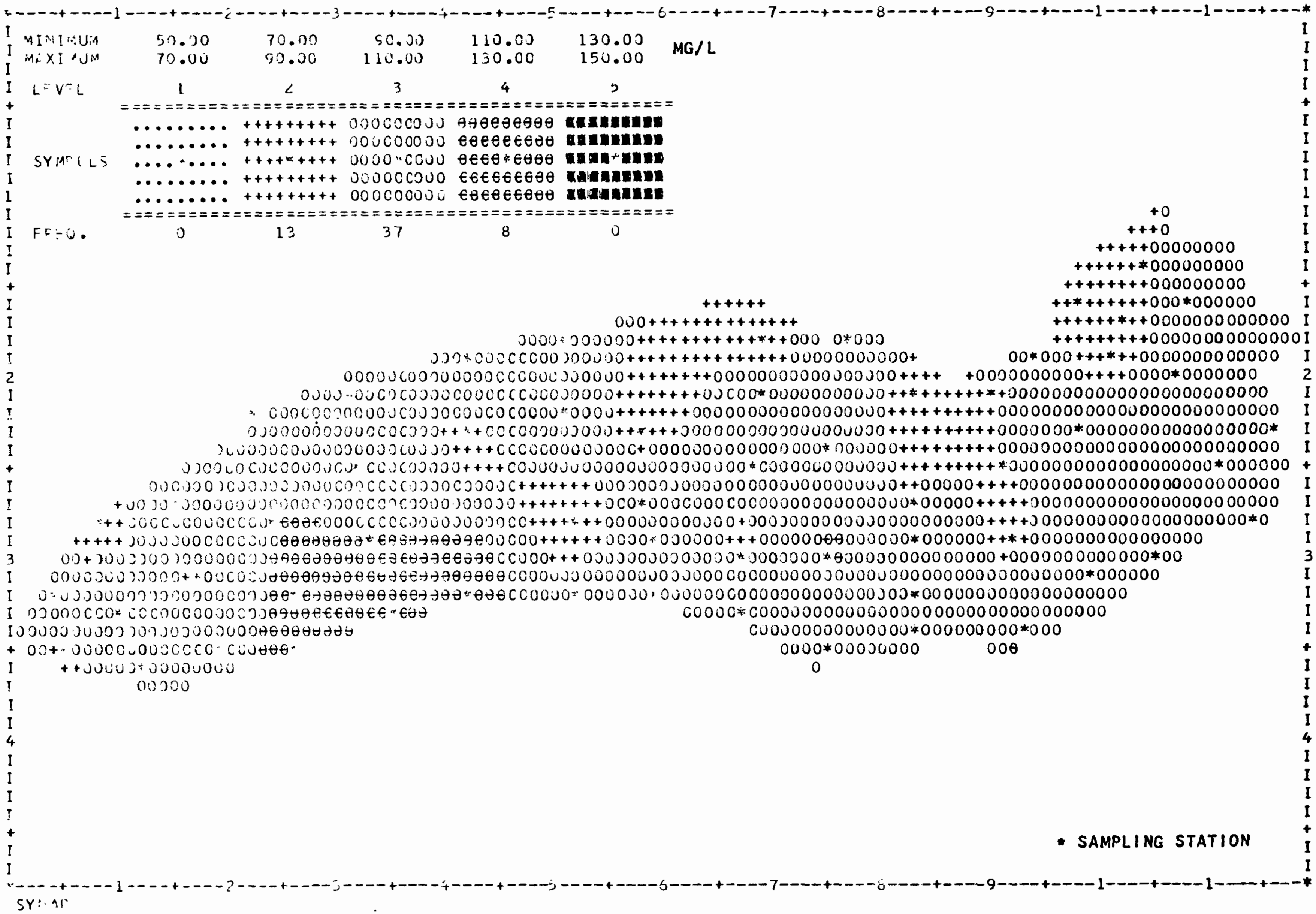


Figure 4.26b Contours of Constant Surface Total Alkalinity

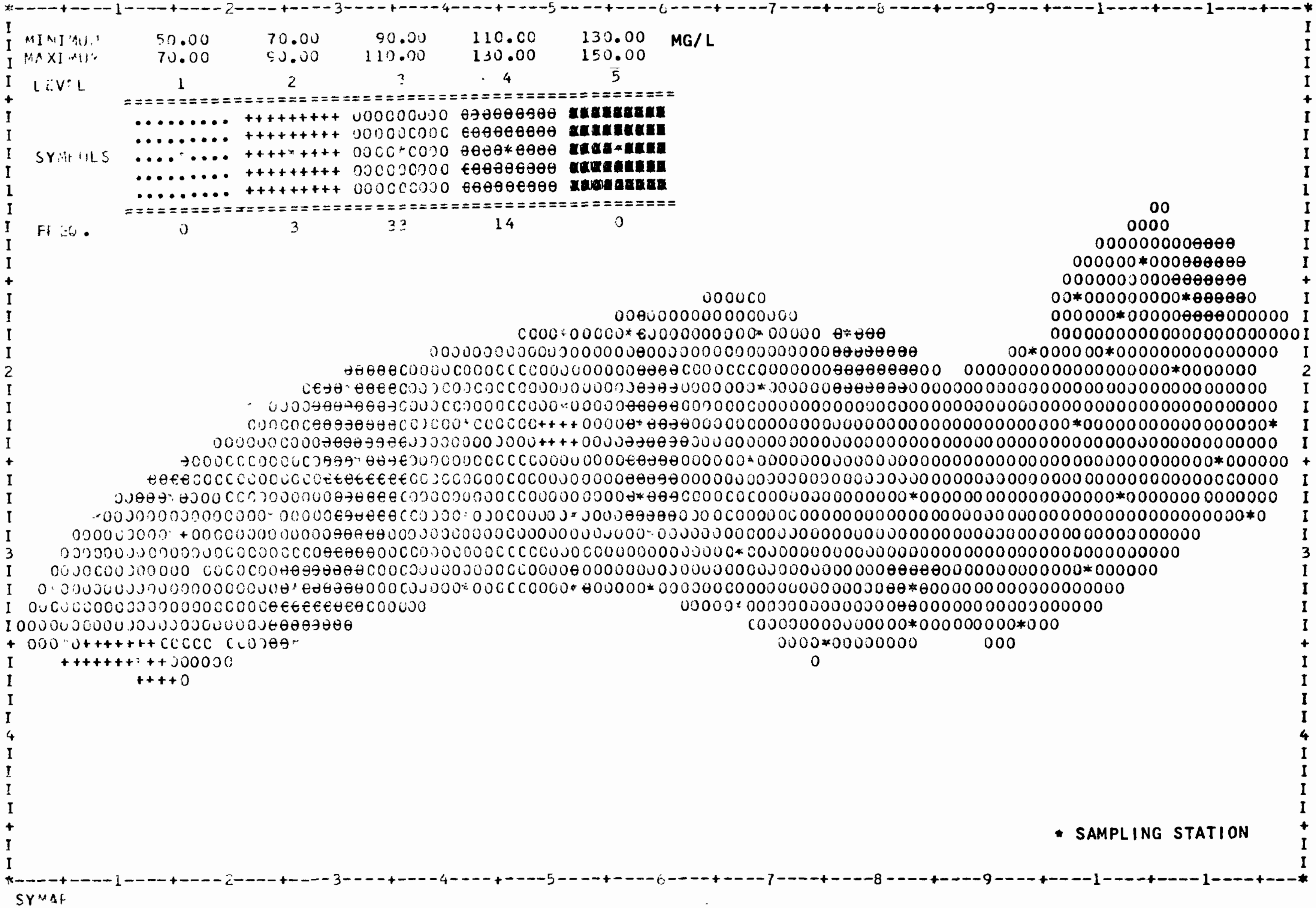
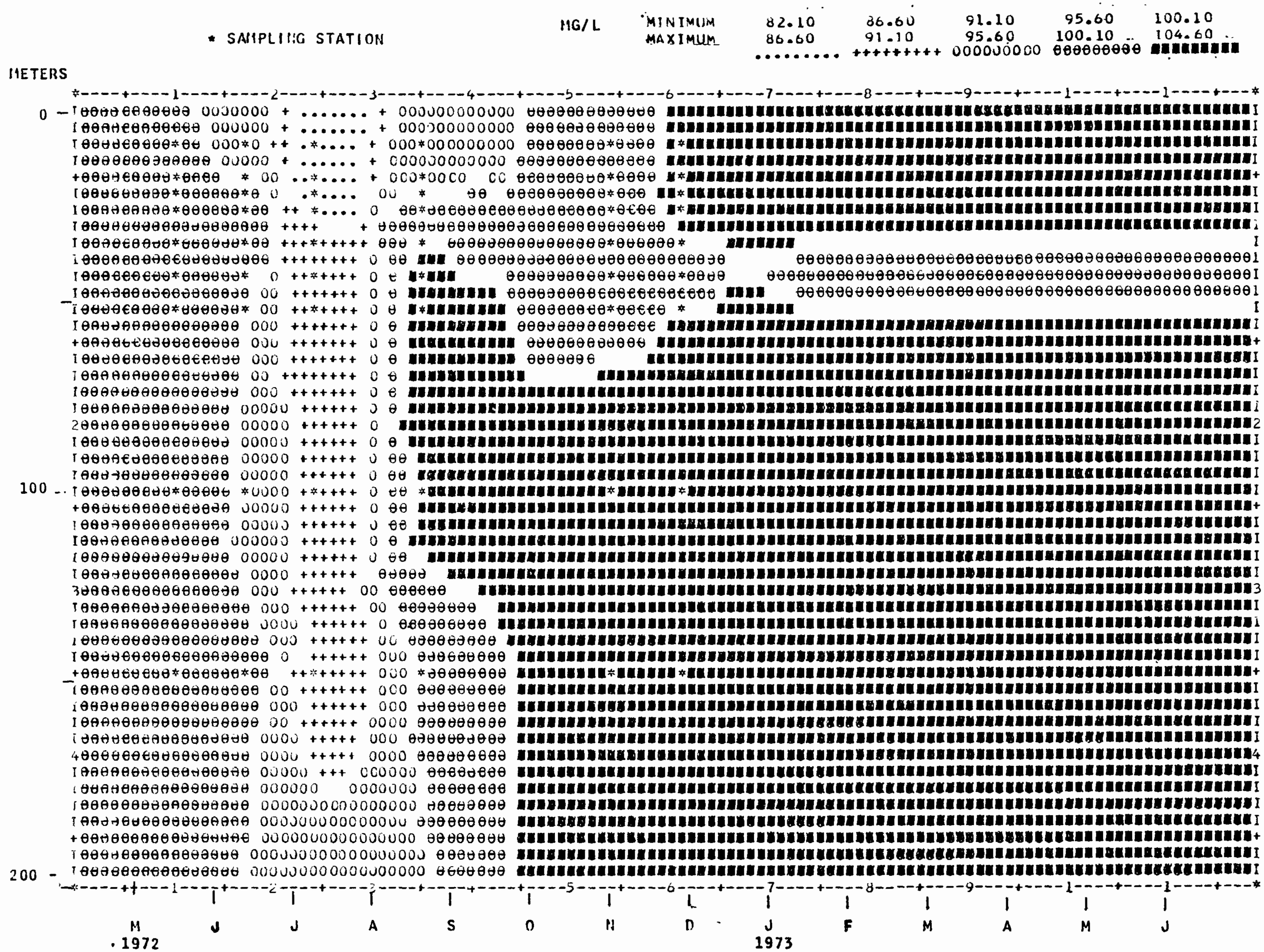


Figure 4.26b Contours of Constant Surface Total Alkalinity

CRUISE NUMBER 7: NOVEMBER 27, 1972 TO DECEMBER 2, 1972



Time Contours of Constant Total Alkalinity

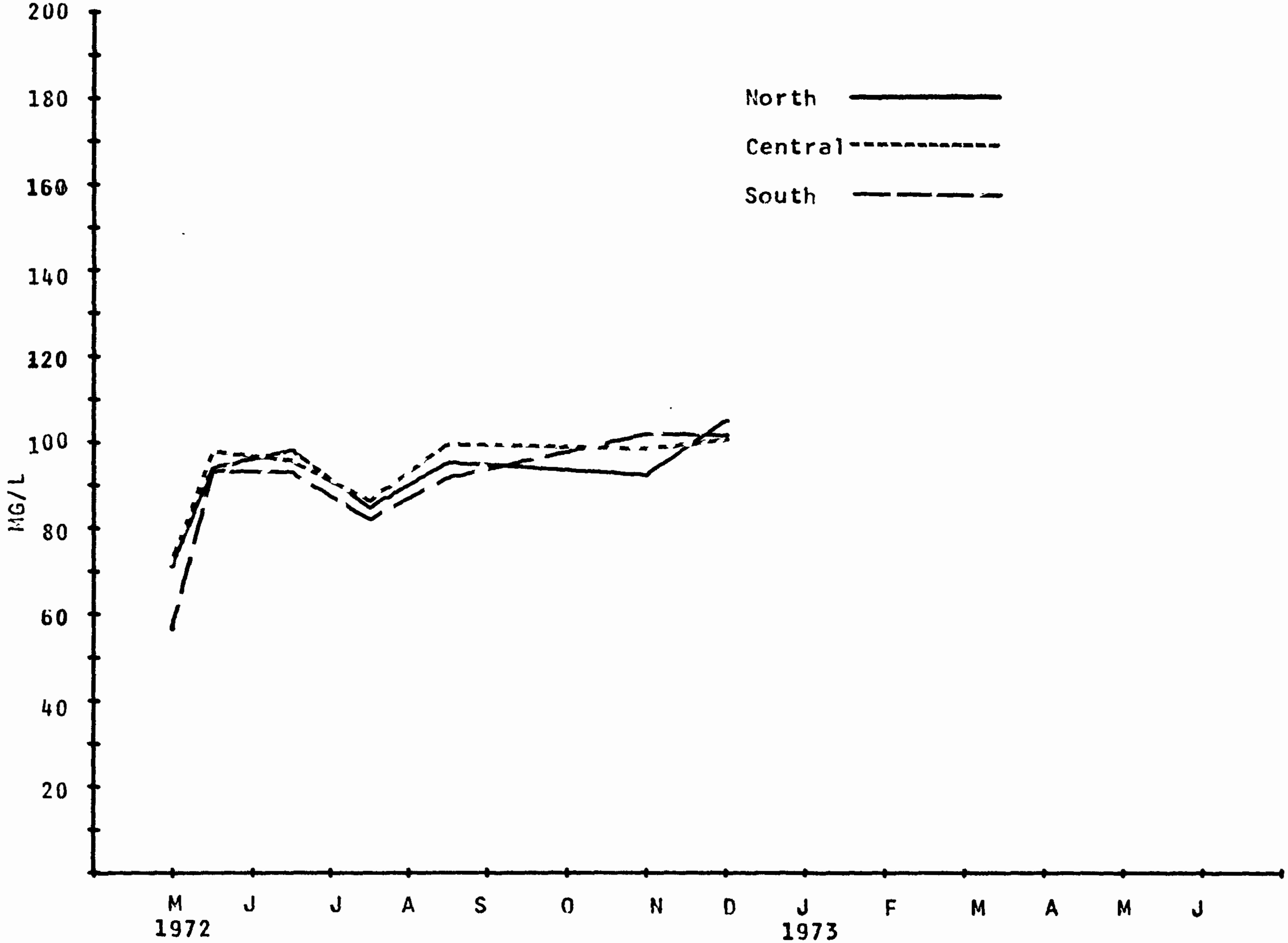


Figure 4.26d North-south variation of total alkalinity

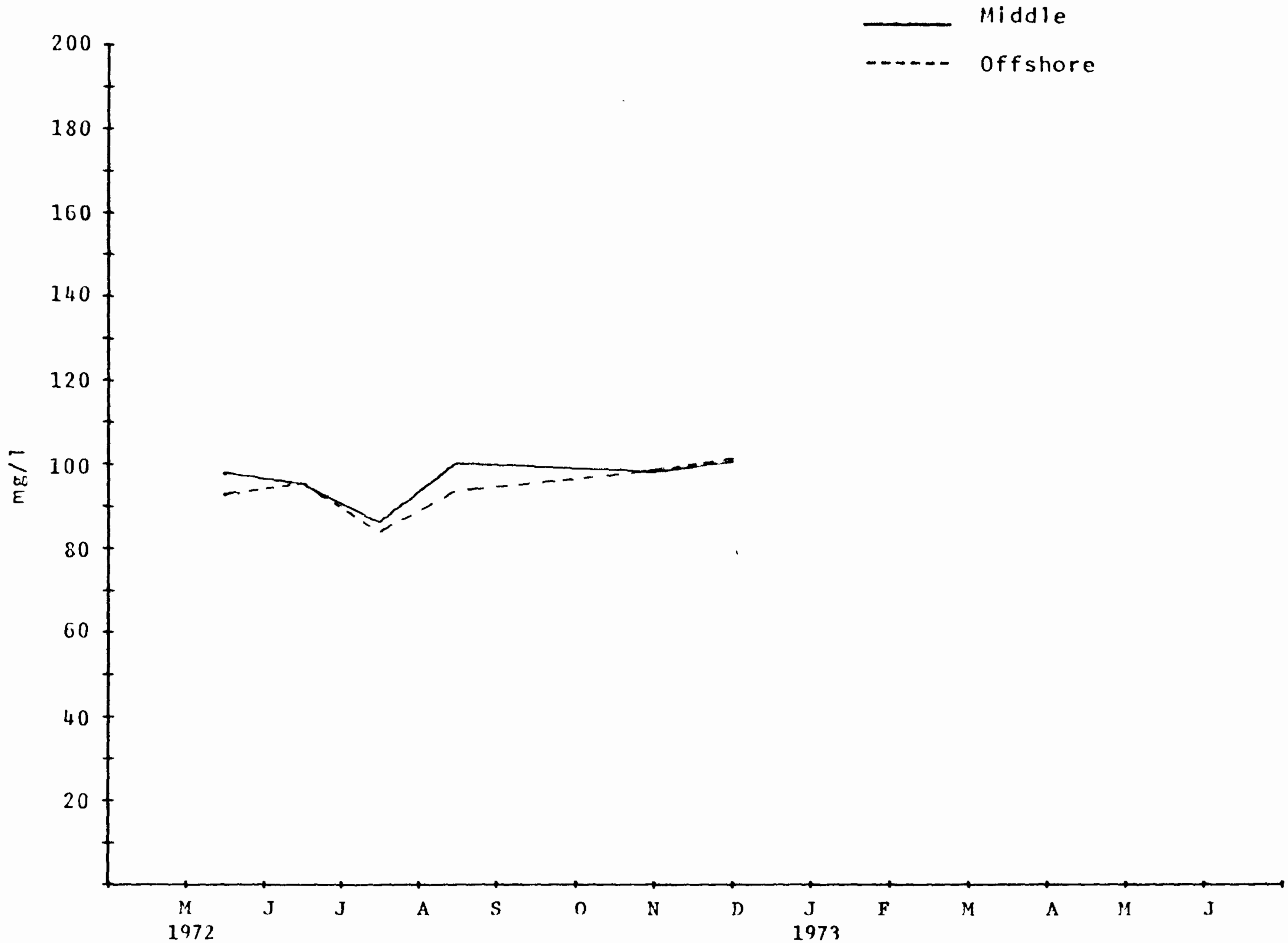


Figure 4.26e Middle Lake-Offshore Variations of Mean Total Alkalinity Concentration

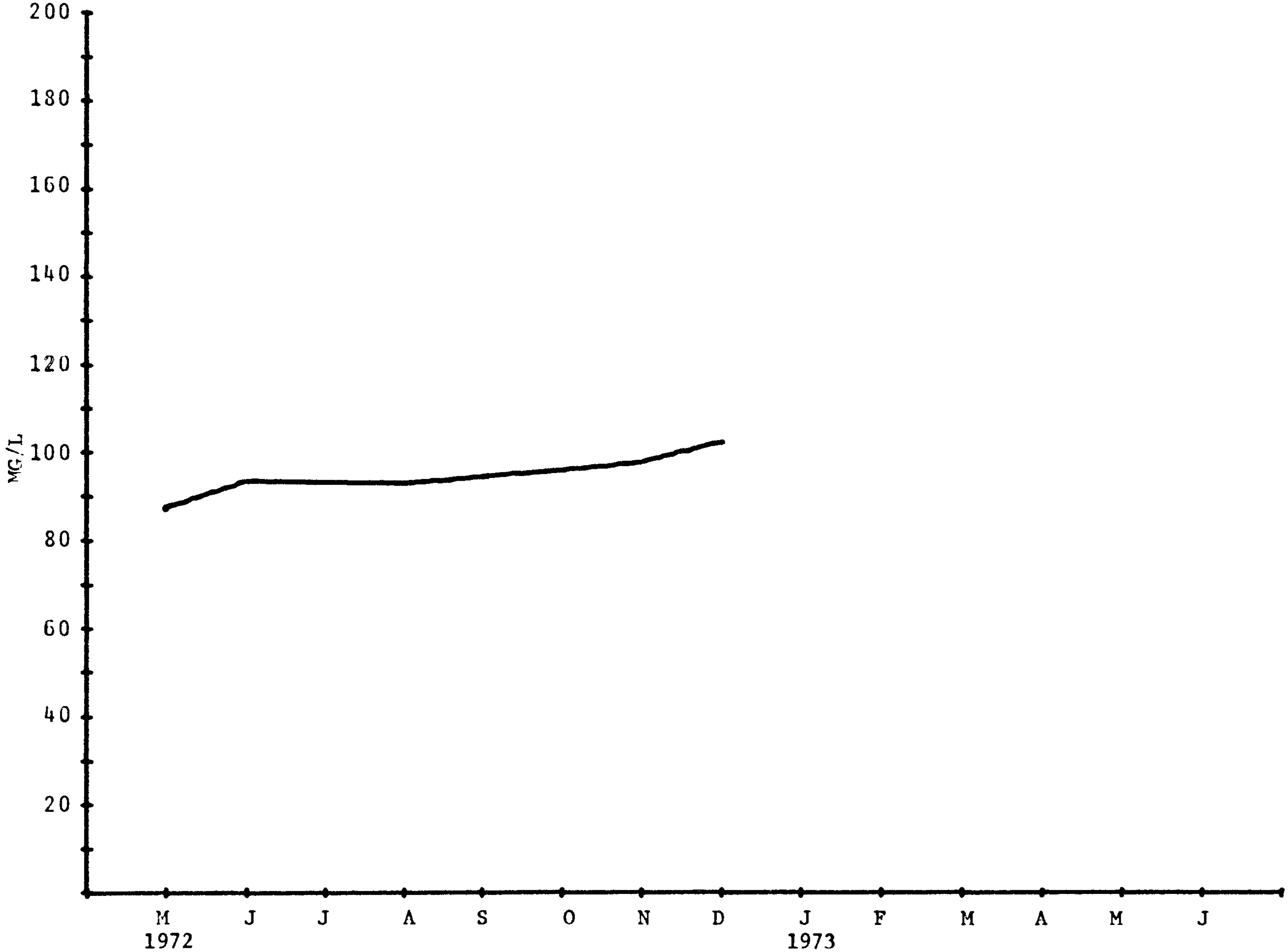


Figure 4.26f Mean surface variation of Total Alkalinity during the field year.

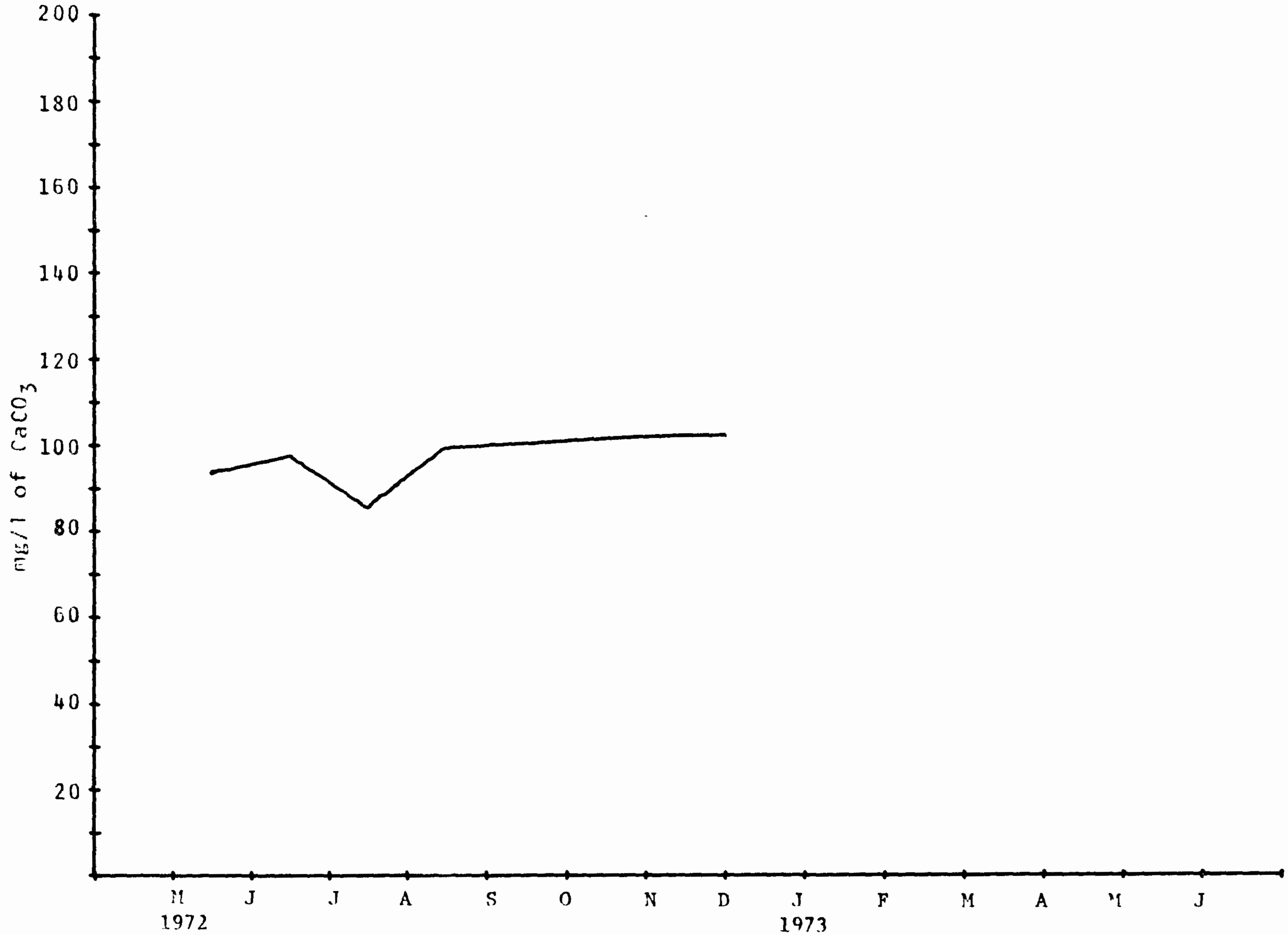


Figure 4.26g Mean Bottom Variation of Total Alkalinity Concentration During the Field Year

Chapter 5

5.1 Derivation of chemical mass balance

Based on the chemical concentration data collected on the 11 materials balance cruises, monthly average rates of chemical accumulation have been determined for total phosphate (TP), dissolved orthophosphate (DOP), total nitrogen (TN), nitrite-nitrate (NO2-NO3), ammonia (NH3), total Kjeldahl nitrogen (TKN), organic nitrogen (ON), total organic carbon (TOC) and sulfate (SO4). The accumulation rates are the consequence of such processes as biochemical transformation processes, sediment exchanges and loading rate variations. The model relates the accumulation rate of a particular substance with the rate of change of the total mass of that substance in the lake and with the net total loading rate to the lake (tributaries, direct municipal and industrial, and on-lake precipitation).

The total masses of each chemical substance for each of the cruises (see Table 5.1) have been calculated using the numerical integration computer program SPLOTCH (Boyce 1973) with the input of concentration measurements which were collected from about 75 stations on the lake at depths of 1, 5, 10, 20, 25, 30, 40, 50, 100, 150 meters (where possible) and at the lake bottom. The monthly sum of the tributary net loading rates, the direct municipal and industrial loading rates and the direct precipitation loadings are tabulated in Chapter 3 (see Tables 3.1, 3.3 through 3.9 and 3.15).

The mass balance will be derived next. Since all other quantities in the mass balance equation can be evaluated directly on the basis of the measured lake chemical concentrations and the measured loading rates, the accumulation rate can then be calculated.

It is convenient to begin with the hydrodynamic equation for the conservation of mass, written in its integral form (see, for example, Batchelor 1967),

$$\iiint_V dV \frac{\partial \rho_i}{\partial t} = \oiint_S \rho_i \underline{v} \cdot \underline{n} \, dS + \iiint_V \mathcal{S}_i \, dV \qquad (1)$$

where ρ_i is the concentration of chemical species i, $\underline{v}$ is the flow velocity and $\mathcal{S}_i$ is the rate of accumulation (or loss) per unit volume of the same species. V is the volume of the fluid (in this case, the volume of Lake Ontario). S is the total surface (top and bottom) of the lake.

The term on the left hand side of eq. (1) can be written as

$$\iiint dV \frac{\partial \rho_i}{\partial t} = \frac{d}{dt} \iiint_V dV \rho_i - \iiint_V \rho_i \, d\left(\frac{\partial V}{\partial t}\right)$$

$$= \frac{dM_i}{dt} + C_i \qquad (2)$$

where M_i is the total mass of chemical species i in the lake at time t. C_i designates the second term on the right of eq. (2). This term can be neglected whenever $(\Delta \rho / \rho) \gg (\Delta V/V)$. The U. S. Army Corps of Engineers measured a change of about 1 meter in the level of Lake Ontario (Monthly Bulletin of the Lake Levels, 1972 and 1973). This corresponds to a volume increment of about 20 km so that $\Delta V/V \sim .012$. If this is compared with $(\Delta\rho/\rho) \sim .20$ for total phospnate, which shows about the smallest concentration variation of any of the chemical substances studied (see Table 5.1), it is apparent that $(\Delta\rho/\rho) \gg (\Delta V/V)$ will hold for all substances.

The second term in eq. (1) is the net loading rate

$$\oiint_S \rho_i \, v \cdot n \, dS \doteq L_i^T + L_i^R + L_i^S \tag{3}$$

where L_i^T is the net loading rate (inflow minus outflow) due to tributary stream flow, L_i^R is the loading rate due to rainfall directly on the lake surface and L_i^S is the net loading rate due to sediment exchange. L_i^S must be either estimated or calculated.

The third term in eq. (1) is the total net rate of production of species i,

$$\iiint_V \mathscr{L}_i \, dV = T_i \tag{4}$$

where T_i is a function of time.

Substituting eqs. (2), (3) and (4) into eq. (1) yields

$$\frac{dM}{dt} = L_i^T + L_i^R + L_i^S + T_i \tag{5}$$

All quantities in eq. (5) can be determined from measurements except the sum $L_i^S + T_i = S_i$ so that this sum can be obtained from eq. (5). Eq. (5) may be rewritten as

$$\frac{dM_i}{dt} = L_i + S_i \tag{6}$$

where

$$L_i = L_i^T + L_i^R$$

Thus S_i may include either or both a volume rate of production (or loss) or a surface exchange term, depending on the particular substance considered. The importance of surface terms in the case of phosphates has been emplasized by Dillon and Kirchner (1975), Kirchner and Dillon (1975), Dillon (1975) and Chapra (1975) in their applications and extensions of Vollenweider (1969). After obtaining the terms in equation (6), the equation will be compared with the Vollenweider (1969) model.

The dM_i/dt term in eq. (6) has been obtained by means of numerical differentiation of the time varying substance masses $M_i(t)$. The $M_i(t)$ were calculated by means of the SPLOTCH computer program. It is assumed that the chemical masses so obtained are characteristic of the average chemical masses in the lake for the month during which the cruise occurred. The assumption seems justified on the basis of the relatively smooth progression of mass determinations from cruise to cruise. For those months for which no cruises took place, linearly interpolated values have been obtained. The monthly variations in the chemical mass contents of the lake are plotted in Figs. 5.1-5.9 and will be discussed in section 5.2. Numerical differentiation of M_i with respect to t has been performed by passing a parabola through 3 successive monthly mass values $-M_1, M_2, M_3$. The derivative at the mid-point is given by

$$\frac{dM}{dt} = \frac{M_3 - M_1}{2h} + O(h^2) \tag{7}$$

where h = one month (see, for example, Wylie 1951). For convenient comparison, dM/dt has been expressed in units of metric tons per day. The monthly values of dM/dt for each substance are provided in Tables 5.2-5.5 , together with the loading rate L and the calculated value of the monthly accumulation rate, S. The latter quantity was obtained by substitution of dM_i/dt and L_i into eq. (6). Before continuing with a discussion of the variations of dM_i/dt, and S_i , the mass balance equation (6) will be compared with the Vollenweider

(1969) model equation.

Vollenweider's model is

$$\frac{dm_w}{dt} = J - \frac{Qm_w}{V} - \sigma m_w \qquad (8)$$

m_w is the total amount of substance w in the lake at time t, J is the rate of tributary loading of substance w to the lake, Q is the mean discharge of the lake, V is the lake mean volume and is the sedimentation rate coefficient. In comparing eqs. (6) and σ (8) L_i is the net loading rate (inflow minus outflow) obtained directly from measurement. The comparable terms $J-Qm_w/V$ in eq. (8) involve an assumed model for the outflow. The measured outflow and the Qm_w/V model term are compared in Table 5.6. It is apparent that the model is quite useful for total nitrogen, nitrite-nitrate, total Kjeldahl nitrogen, organic nitrogen, sulfate and total organic carbon while for total phosphate, dissolved orthophosphate and ammonia the model predictions deviate considerably from the measured values.

In Table 5.7 , the use of the $-\sigma m_w$ term in eq. (8) (where is a constant) to represent the S_i term in eq. (6) has been explored. For none of the substances examined does this representation seem useful.

5.2 Chemical accumulation rates

In this section, the variations of mass content ($M_i(t)$), the rate of change of the mass content (dM_i/dt), the total net loading

(L_i), and the source term (S_i) are discussed for each of the substances.

TOTAL PHOSPHATE

The total phosphate content of the lake shows an average deviation of 9.5% from the mean with a maximum deviation of 19%. The maximum deviations occurred in the springs of 1972 and 1973, and the early winter of 1972, reflecting seasonal perturbations from the mean (see Fig. 5.1). Table 3.1 lists the various contributions and the net total loading rate of total phosphate by month. The net total loading rate to the lake varied by a factor of 10 reaching a maximum in the December 1972 through March 1973 period and a minimum in the August through October 1972 period.

Having obtained the mean monthly values of the numerical derivative, dM/dt, and using the net loading rate, L, eq. (6) yields the source function, S. S varied from positive to negative during the field year, with a phosphate build up in the sediments during the fall and winter and a release in spring and summer. The field year average was 4 metric tons per day for S.

DISSOLVED ORTHOPHOSPHATE

Strong seasonal variations in the total dissolved orthophosphate content of the lake are apparent in Figure 5.2. Low values of the total mass of DOP are characteristic of the summer and fall with winter and early spring values higher, by a factor of two. The loading also peaks in the winter to early spring period with summer and fall being minimums. Except in the late summer-fall period when dM/dt, L and S in eq. (6) exhibit comparable magnitudes, the L values are considerably smaller than dM/dt and S. During this period, the changes in the DOP mass content of the lake occur more as a result of biochemical transformations than as a result of loading variations. The field year mean of the accumulation rate (see Table 5.2) appears to be very small and possibly zero.

TOTAL NITROGEN

The total nitrogen characteristics are derived from a sum of total Kjeldahl nitrogen and nitrite-nitrate measurements. Figure 5.3 illustrates the seasonal variation in the total nitrogen mass content of the lake which exhibits higher values in summer 1972 and spring 1973. A factor of 5 variation in the total net loading rate, L, will be noted from Table 3.8. However, L was generally smaller in order of magnitude than either dM/dt or S, so that changes in the total nitrogen content of the lake occur mainly as a consequence of sediment exchange processes, rather than loading variations. In addition, there appears to be a mean net loss to sedimentation of total nitrogen (see Table 5.3).

NITRITE-NITRATE

The total nitrite-nitrate content of the lake showed a very definite seasonal variation, see Fig. 5.4. Maximum mass content is characteristic of the early summer 1972 and spring 1973 periods with a low occurring in the late summer through fall period. The range of variation is a factor of about 2.3. In Table 3.4 a compilation of the partial and net total loading rates for NO2-NO3 is provided. This net total loading rate varied by a factor of more than 20 during the field year, but is typically more than an order of magnitude smaller than dM/dt and, therefore, also S. This indicates that a major source of nitrite-nitrate is the result of biochemical transformations rather than loading rate variations.

The source term changes sign during the year with losses due to biological assimilation in the spring and summer and production due to the ammonification and nitrification sequence during the winter months. Table 5.3 shows a mean value of S which is 1-2 orders of magnitude smaller than the magnitudes of the individual monthly values of S, indicating no net accumulation of nitrite-nitrate in the sediments.

AMMONIA

The total ammonia content of the lake also shows a strong seasonal variation, see Fig. 5.5. Highest mass content occurred in late summer through fall of 1972. Reaching a mid-winter minimum, the mass content climbed with the onset of spring 1973. Provided in Table 3.5 are the loading rate contributions of ammonia which show a variation, by a factor of about 3, during the field year.

Because of the comparable sizes of dM/dt and L and thus S (in eq. (6.)), the variations in the ammonia content of the lake are more complicated. From Table 5.4 the mean value of S, -83 metric tons/day, indicates a net accumulation of ammonia in the sediment.

TOTAL KJELDAHL NITROGEN

Fig. 5.6 shows the seasonal variation of the total Kjeldahl nitrogen content of Lake Ontario during the field year. Higher values characterized summer and fall of 1972, followed by lower levels during the winter and spring of 1973, a maximum variation factor of about 2.5 times. In the total net loading rate (Table 3.6), the highs exceeded the lows 20 times in magnitude. As is indicated in Table 5.4, considerable differences in the relative sizes of dM/dt, L and S were noted during the field year. In spring 1972 and winter and spring 1973, the magnitudes of the 3 terms are comparable while during the summer and fall, L is an order of magnitude smaller than dM/dt and thus, also S. This may be the result of the biochemical ammonification processes and sedimentation during this period. Fall and spring turnovers appeared to be responsible for some return of TKN from the sediments to the lake, however, there is a net TKN loss to the sediments (see Table 5.4).

ORGANIC NITROGEN

Although organic nitrogen was not measured directly, it has been obtained by subtracting ammonia contributions from those of total Kjeldahl nitrogen. The organic nitrogen content of the lake, see Fig. 5.7, was high during the summer (growing season) and dropped by a factor of 3 with the onset of fall-winter and the decay processes. Table 5.5 shows the loading rate, L, to be an order of magnitude smaller than dM/dt and S, indicating that the variations of the organic nitrogen content of the lake are mainly a consequence of biochemical transformations within the lake. The source function, S, indicated organic nitrogen assimilation in the late summer through fall and production in the winter-spring period. Table 5.5 shows a field year mean loss to sediments of $S = -3.7 \times 10^2$ metric tons/day.

TOTAL ORGANIC CARBON

Strong seasonal variations in the total organic carbon content of the lake are illustrated in Fig. 5.8. Peaking in the summer-fall 1972 period, the TOC content fell to a mid-winter minimum before beginning a gradual spring rise. A comparison of the terms in eq. (6) as shown in Table 5.5 shows that the main balance was between dM/dt and S, since L was an order of magnitude smaller. Thus, changes in the total organic carbon content of the lake are mainly a consequence of the biochemical carbon transformations rather than the loading rate variations. From Table 5.5, it is apparent that the mean source term is very small, thereby indicating no net sediment enrichment in total organic carbon.

SULFATE

Spring and summer 1972 measurements are missing because of difficulties in the chemical analysis of these samples. The sulfate mass content of the lake (Fig. 5.9) remained fairly uniform throughout the field year so that $dM/dt \approx 0$. This then requires the balance to be between S and L in eq. (6). The mean value of S over the period of measurement is very small as compared with individual monthly values indicating a nearly conservative character for sulfate in Lake Ontario (see Table 5.5).

Table 5.1 Total Substance Masses in Lake Ontario
(metric tons)

Substance	Cruise Numbers 1	2	3	4	5	6	7	8	9	10	11
TP	1.6861E4	2.6953E4	2.8087E4	2.7821E4	2.9444E4	3.5288E4	2.3852E4	2.3852E4	2.6424E4	3.4942E4	2.7923E4
DOP	2.6054E3	7.0418E3	3.5007E3	5.3558E3	5.4716E3	7.0165E3	6.0097E4	1.0878E4	8.0761E3	1.1338E4	5.9945E3
TN	---	9.0455E5	7.0428E5	1.0593E6	---	6.3336E5	4.8645E5	---	7.3529E5	5.3154E5	4.6598E5
NO2-NO3	8.5759E5	5.9432E5	4.2698E5	7.0170E5	4.4533E5	3.7012E5	3.2218E5	4.4123E5	5.5186E5	4.0983E5	3.0237E5
NH3	6.8551E3	8.7711E3	2.0448E4	3.5929E4	3.0459E4	3.3787E4	1.6189E4	8.2708E3	1.0415E4	1.7642E4	1.8701E4
TKN	---	3.1025E5	2.7730E5	3.5761E5	---	2.6324E5	1.6427E5	---	1.8343E5	1.2171E5	1.6461E5
ON	---	3.0148E5	2.5565E5	3.2169E5	---	2.2945E5	1.4808E5	---	1.7302E5	1.0407E5	1.4591E5
TOC	4.1462E6	4.2716E6	5.6926E6	7.5721E6	---	7.2444E6	---	2.9104E6	4.2861E6	4.2826E6	5.4311E6
SO4	---	---	---	---	---	4.2706E7	3.7750E7	4.3663E7	4.3321E7	4.3819E7	3.6687E7

Exponential notation has been used: 1.6861E4 = 1.6861 x 10

Cruises: 1-May 1-5, 1972; 2-May 15-19; 1972; 3-Jun 12-16, 1972; 4-Jul 10-14, 1972; 5-Aug 21-25, 1972; 6-Oct 30-Nov 2, 1972; 7-Nov 27-Dec 2, 1972; 8-Feb 5-9, 1973; 9-Mar 18-23, 1973; 10-Apr 24-30, 1973; 11-Jun 11-15, 1973.

Table 5.2 Total Phosphate and Dissolved Orthophosphate Mass Balance Equation Terms (metric tons/day)

	Total Phosphate			Dissolved Orthophosphate		
Month	dM/dt/10[1]	L/10[1]	S/10[1]	dM/dt/10[1]	L/10[1]	S/10[0]
May 1972	---	---	---	43.0	10.5	39.7
Jun	.88	3.21	-2.33	-14.1	10.6	-20.5
Jul	.33	2.10	-2.11	15.9	4.6	11.9
Aug	.13	.72	-0.69	5.9	6.4	-0.78
Sep	.19	1.15	-1.11	10.3	8.4	2.41
Oct	.65	1.76	-1.15	10.0	9.9	.33
Nov	.55	3.12	-2.45	-16.8	11.2	-29.1
Dec	.02	5.55	-5.52	39.3	17.2	25.0
Jan 1973	-1.25	3.52	-4.65	39.3	12.5	29.9
Feb	.07	2.93	-2.80	-32.2	8.4	-38.0
Mar	1.19	4.53	-3.21	2.5	9.9	-3.48
Apr	.92	2.62	-1.59	36.2	---	---
May	.08	1.58	-1.00	-59.4	---	---
Mean	.39	2.76	-2.38	6.15	10.0	1.58

Table 5.3 Total Nitrogen and Nitrite-Nitrate
Mass Balance Equation Terms
(metric tons/day)

	Total Nitrogen			Nitrite-Nitrate		
Month	$dM/dt/10^3$	$L/10^3$	$S/10^3$	dM/dt^3	$L/10^3$	$S/10^3$
May 1972	-5.07	.27	-5.34	-5.60	.09	-5.69
Jun	1.71	.41	1.34	.87	.26	.59
Jul	-0.28	.12	-0.44	-0.28	.03	-0.31
Aug	-4.06	.13	-4.21	-3.19	.01	-3.20
Sep	-2.73	.08	-2.81	-1.63	.06	-1.69
Oct	-2.86	.07	-2.93	-1.11	.06	-1.17
Nov	-2.92	.32	-3.23	-1.61	.14	-1.75
Dec	-0.07	.40	-0.47	.03	.18	-0.14
Jan 1973	3.24	.31	2.93	3.06	.15	2.91
Feb	2.92	.20	2.72	3.14	.07	3.07
Mar	-1.10	.29	-1.38	-0.34	.10	-0.43
Apr	-2.71	.34	-3.03	-2.50	.12	-2.61
May	-1.83	.28	-2.11	-2.31	.10	-2.41
Mean	-1.21	.26	-1.46	-0.88	.11	-.99

Table 5.4 Ammonia and Kjeldahl Nitrogen
Mass Balance Equation Terms
(metric tons/day)

	Ammonia			Total Kjeldahl Nitrogen		
Month	$dM/dt/10^2$	$L/10^2$	$S/10^2$	dM/dt^3	$L/10^3$	$S/10^3$
May 1972	.93	.91	.02	.53	.18	.35
Jun	3.62	1.32	2.30	.84	.22	.75
Jul	.81	.75	.07	.00	.08	- .08
Aug	- .10	.66	- .76	- .87	.12	-1.01
Sep	.25	.65	- .40	-1.10	.02	-1.12
Oct	-1.10	.76	-1.86	-1.75	.01	-1.76
Nov	-3.15	1.60	-4.75	-1.31	.18	-1.48
Dec	-2.38	1.14	-3.52	- .10	.23	- .33
Jan 1973	- .84	.78	-1.62	.18	.15	.02
Feb	.13	.57	- .44	- .22	.13	- .35
Mar	1.01	.90	.11	- .76	.19	- .95
Apr	1.17	.90	.27	- .22	.22	- .42
May	.56	.75	- .19	.48	.18	.30
Mean	.07	.91	- .83	- .33	.15	- .47

Table 5.5 Organic Nitrogen, Total Organic Carbon and Sulfate
Mass Balance Equation Terms
(metric tons/day)

	Organic Nitrogen			Total Organic Carbon			Sulfate		
Month	$dM/dt/10^3$	$L/10^3$	$S/10^3$	dM/dt^3	$L/10^3$	$S/10^3$	dM/dt	L^4	S^4
May 1972	0.44	0.09	0.35	13.5	2.0	11.5	---	---	---
Jun	.48	- .09	.52	46.3	.3	45.9	---	---	---
Jul	- .08	.01	.14	27.6	1.2	26.1	---	---	---
Aug	- .86	.05	- .93	2.3	1.6	.5	---	---	---
Sep	-1.13	- .05	-1.08	- 3.1	-.1	- 2.9	---	---	---
Oct	-1.64	-.06	-1.57	-13.9	-.3	-12.8	---	---	---
Nov	-1.00	.02	-1.01	-36.9	1.7	-37.2	0	.0	.00
Dec	.13	.11	.02	-46.6	3.2	-48.9	0	.5	- .5
Jan 1973	.26	.08	.18	-27.6	2.4	-3 .0	0	.3	- .3
Feb	- .23	.07	- .31	8.9	1.8	7.0	0	.1	- .1
Mar	- .86	.05	- .90	14.8	3.2	11.6	0	.2	.2
Apr	- .33	.13	- .45	8.9	2.4	6.5	0	.0	.0
May	.42	.11	.32	18.5	1.9	16.7	0	.0	.0
Mean	- .32	.06	- .37	.98	1.7	- .46	0	.02	- .02

Table 5.6 Comparison of Measured Outflow, Loading and Vollenweider Model Term

(Q/V) = 3.6088 x 10 day

	TP Outflow		DOP Outflow		TN Outflow		NO2-NO3 Outflow		NH3 Outflow	
	Model	Measured	Model	Measured	Model	Measured	Model	Measured	Model	Measured
May 1972	8.04	19.8	1.78	2.36	342	245	236	159	3.9	4.4
Jun	9.36	21.7	1.59	3.49	296	268	181	62.6	7.6	12.5
Jul	9.94	27.2	1.83	8.10	345	376	221	223	11.7	29.2
Aug	10.1	33.6	2.00	4.46	288	298	174	170	11.4	32.8
Sep	10.2	21.6	2.20	1.87	255	240	140	29.0	11.5	13.0
Oct	10.5	16.9	2.42	1.84	230	258	139	60.3	12.0	11.3
Nov	11.7	15.8	2.35	2.11	191	209	125	90.9	9.0	11.1
Dec	11.7	13.3	2.61	4.07	165	214	104	108	5.1	13.0
Jan 1973	9.64	12.9	3.49	4.15	188	224	125	136	3.7	19.2
Feb	8.92	20.4	3.53	6.49	238	303	173	182	3.2	26.5
Mar	9.77	25.4	3.16	9.32	248	321	189	258	4.0	36.4
Apr	11.6	27.0	3.70	---	213	264	165	199	5.5	27.8
May	11.8	28.0	3.45	---	189	279	135	227	6.5	16.5

	TKN Outflow		ON Outflow		TOC Outflow		SO4 Outflow	
	Model	Measured	Model	Measured	Model	Measured	Model	Measured
May 1972	106	85.7	102	81.3	1612	1921	---	17075
Jun	115	205	107	193	2082	2604	---	18006
Jul	124	153	112	124	2614	1894	---	18072
Aug	114	128	103	95	2699	2233	---	18394
Sep	105	211	93.5	198	2665	3320	---	20110
Oct	90.7	198	78.7	187	2631	3562	14615	21043
Nov	65.6	118	56.6	107	2354	1935	14518	21446
Dec	61.3	106	56.2	93.0	1832	813	14157	17529
Jan 1973	63.2	99.1	59.5	79.9	1311	615	15224	16340
Feb	65.2	130	62.0	104	1216	1002	15716	17795
Mar	58.8	132	54.8	95.6	1491	647	15667	19521
Apr	48.1	98.7	42.6	70.9	1546	1591	15754	20680
May	54.2	89.7	47.7	73.2	1684	1812	14956	19771

Table 5.7 Calculation of (= -S/M) from Vollenweider Model
(day)

Month	TP	DOP x10	TN	NO2-NO3 x10	NH3 x10	TKN x10	ON x10	TOC x10	SO4 x10
May 1972	-0.184	-8.01	+0.173	+8.70	-0.02	-0.12	-0.40	-0.256	---
Jun	-0.070	4.66	-0.522	-1.18	-1.09	-0.24	-0.54	-0.796	---
Jul	-0.014	-2.35	-0.052	+0.51	-0.02	+0.04	-0.12	-0.360	---
Aug	-0.006	0.14	+0.162	+6.62	+0.24	+0.32	+1.01	-0.006	---
Sep	-0.008	-0.40	+0.119	+4.06	+0.13	+0.39	+1.25	+0.040	
Oct	-0.051	-0.05	+0.143	+3.04	+0.56	+0.70	+2.24	+0.176	-0.183
Nov	-0.028	4.47	+0.184	+5.06	+1.90	+0.81	+1.99	+0.571	+0.052
Dec	+0.042	-3.46	+0.028	+0.48	+2.48	+0.19	-0.10	+0.963	-0.069
Jan 1973	+0.222	-3.09	-0.177	-8.37	+2.48	-0.02	-0.39	+0.825	-0.159
Feb	+0.018	-3.89	-0.117	-6.42	+1.58	+0.19	+0.47	-0.210	-0.048
Mar	-0.099	---	+0.059	+0.82	-0.49	+0.58	+1.89	-0.279	0.000
Apr	-0.071	---	+0.151	+5.71	-0.10	+0.32	+1.07	-0.152	+0.076
May	-0.001	---	+0.124	+6.44	+0.18	-0.20	-0.74	-0.357	+0.270
Mean	-0.019	-1.20	0.029	2.32	0.602	0.23	0.59	0.012	-0.008
Stan. Dev.	0.093	3.86	0.199	4.34	1.14	0.34	1.05	0.505	0.145

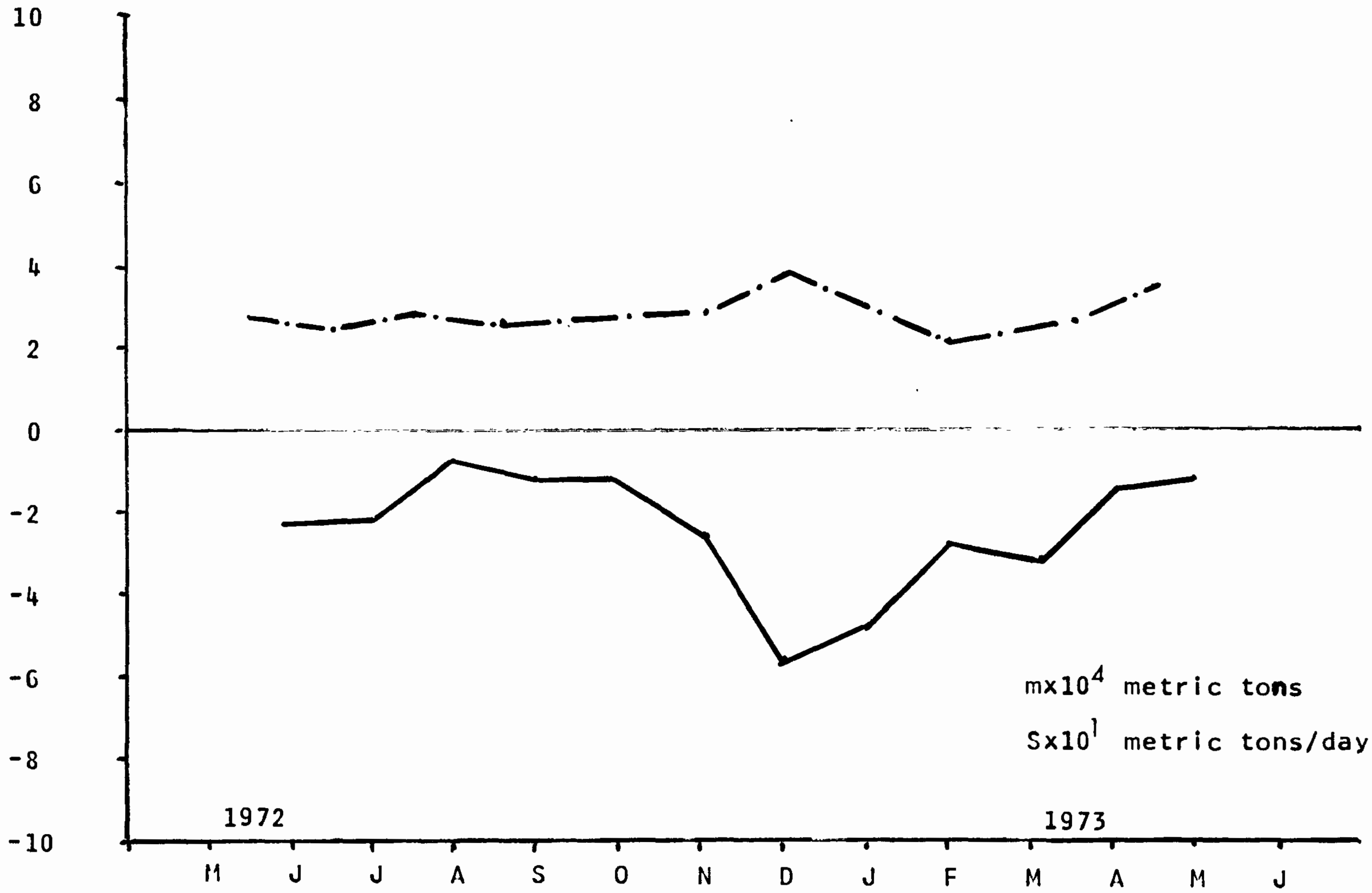


Figure 5.1 The mass content (m) and the production rate (S) of Total Phosphate during the field year

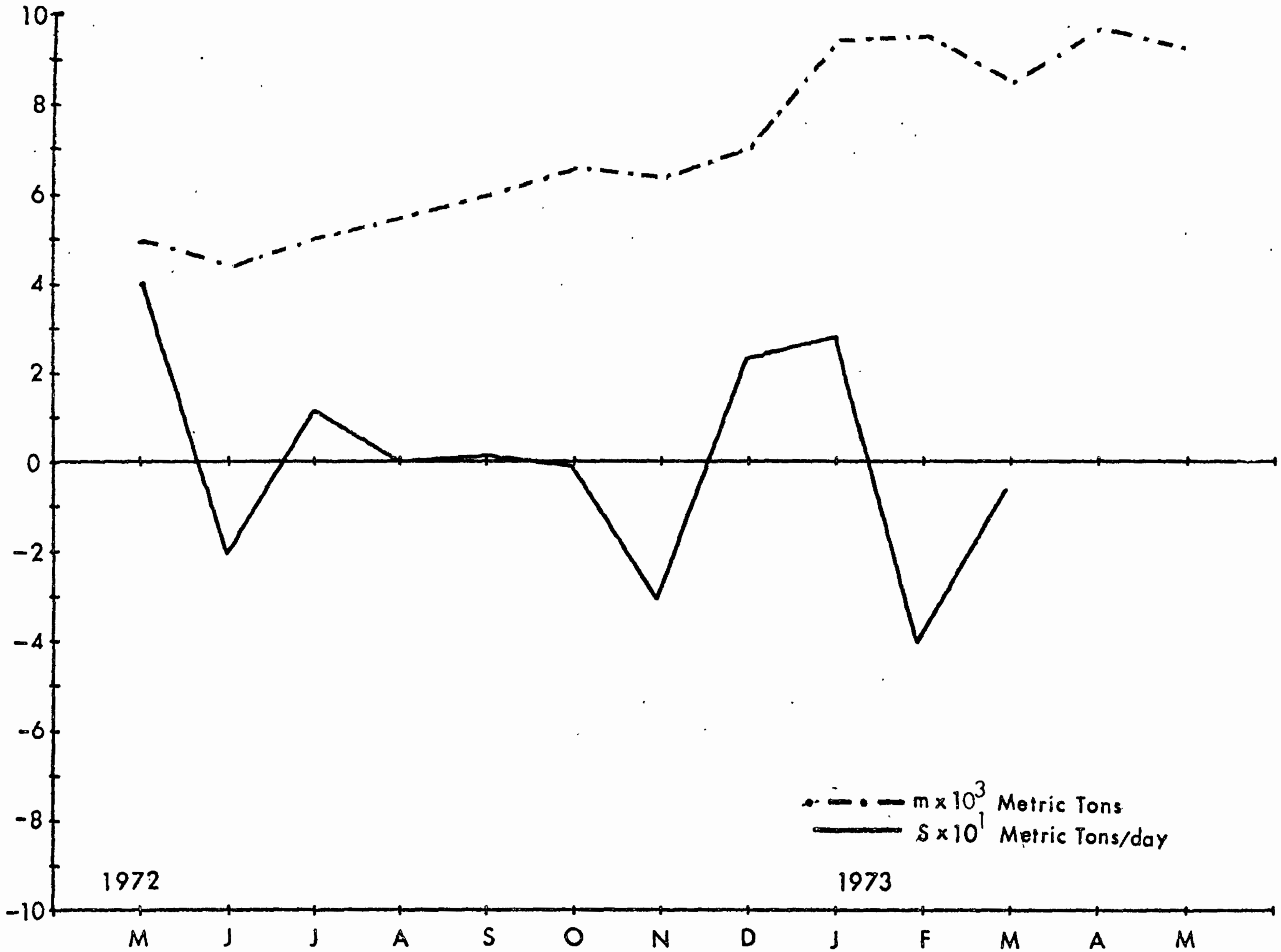


Figure 5.2 THE MASS CONTENT (m) AND THE PRODUCTION RATE (S) OF DISSOLVED ORTHOPHOSPHATE DURING THE FIELD YEAR.

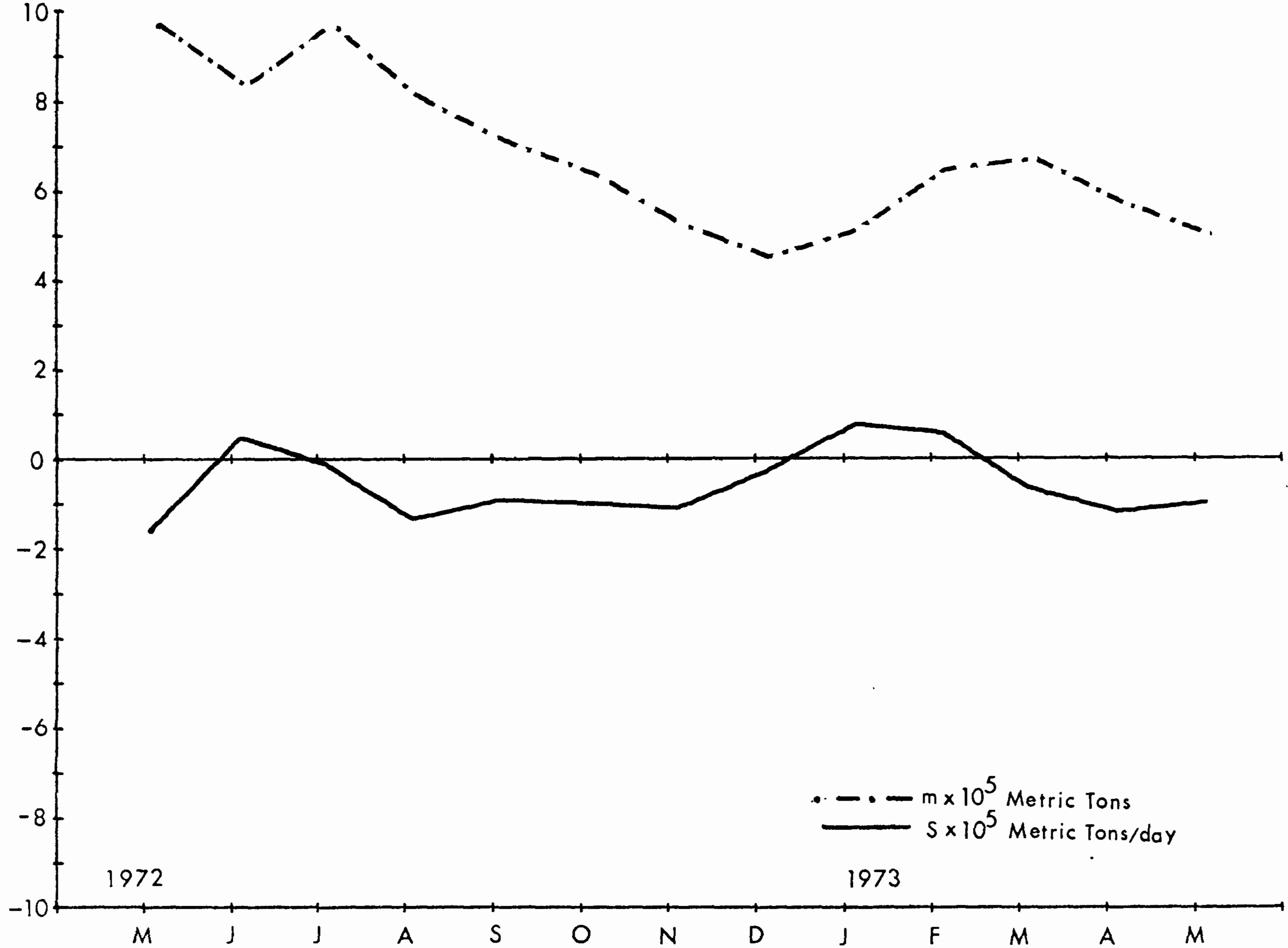


Figure 5.3 THE MASS CONTENT (m) AND THE PRODUCTION RATE (S) OF TOTAL NITROGEN DURING THE FIELD YEAR.

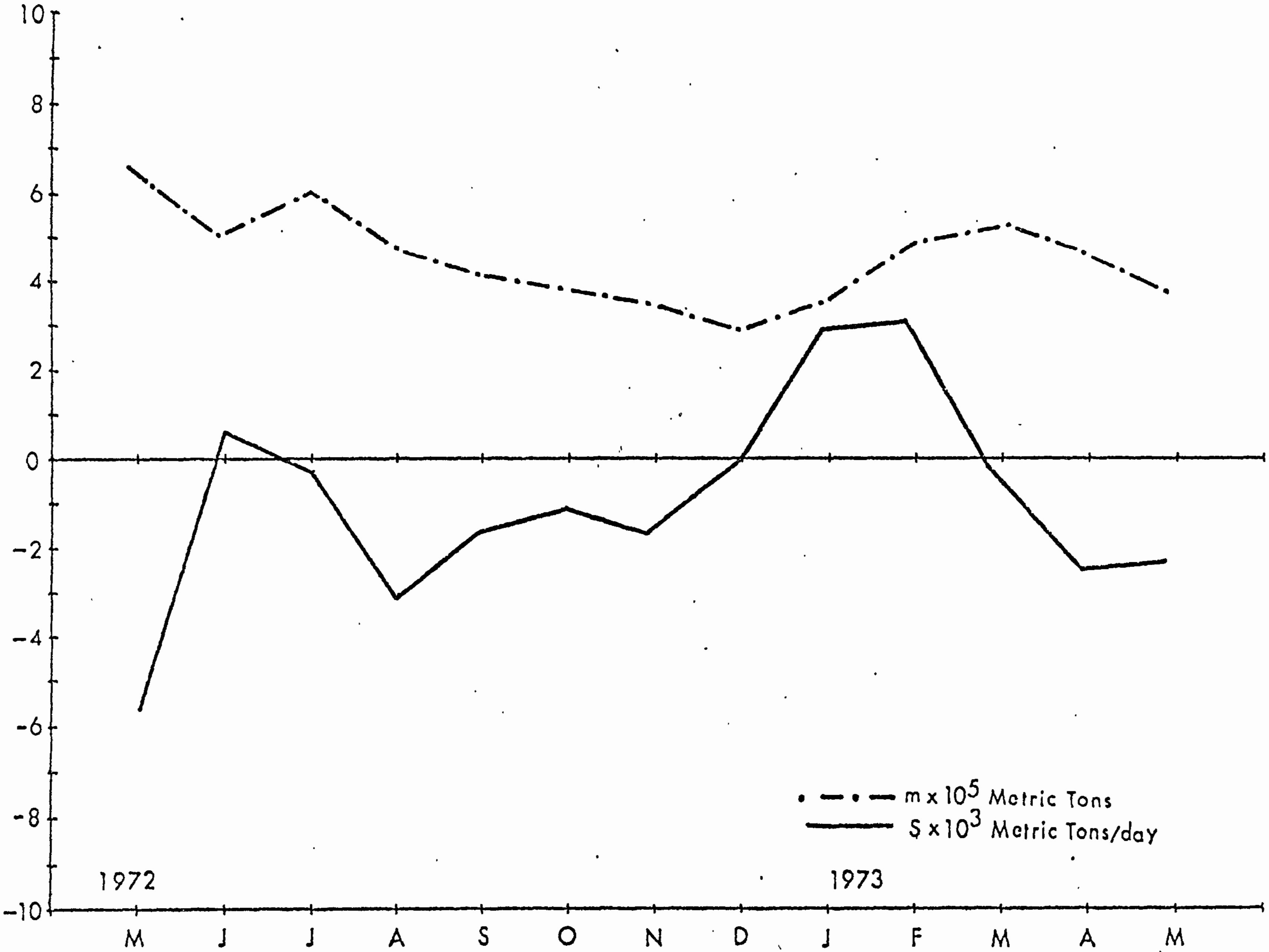


Figure 5.4 The mass content (m) and the production rate (S) of Nitrite-Nitrate during the field year

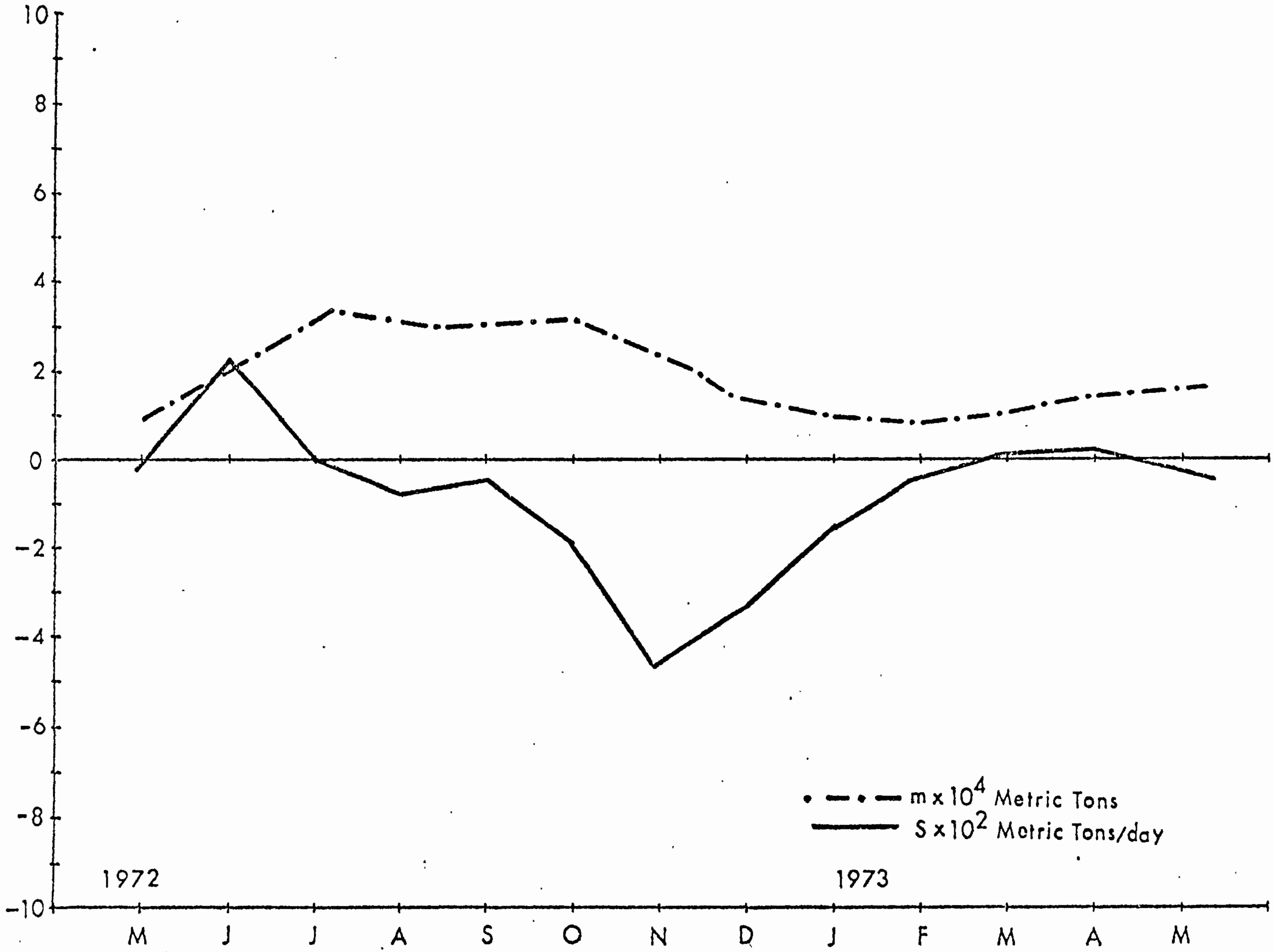


Figure 5.5 The mass content (m) and the production rate (S) of Ammonia during the field year

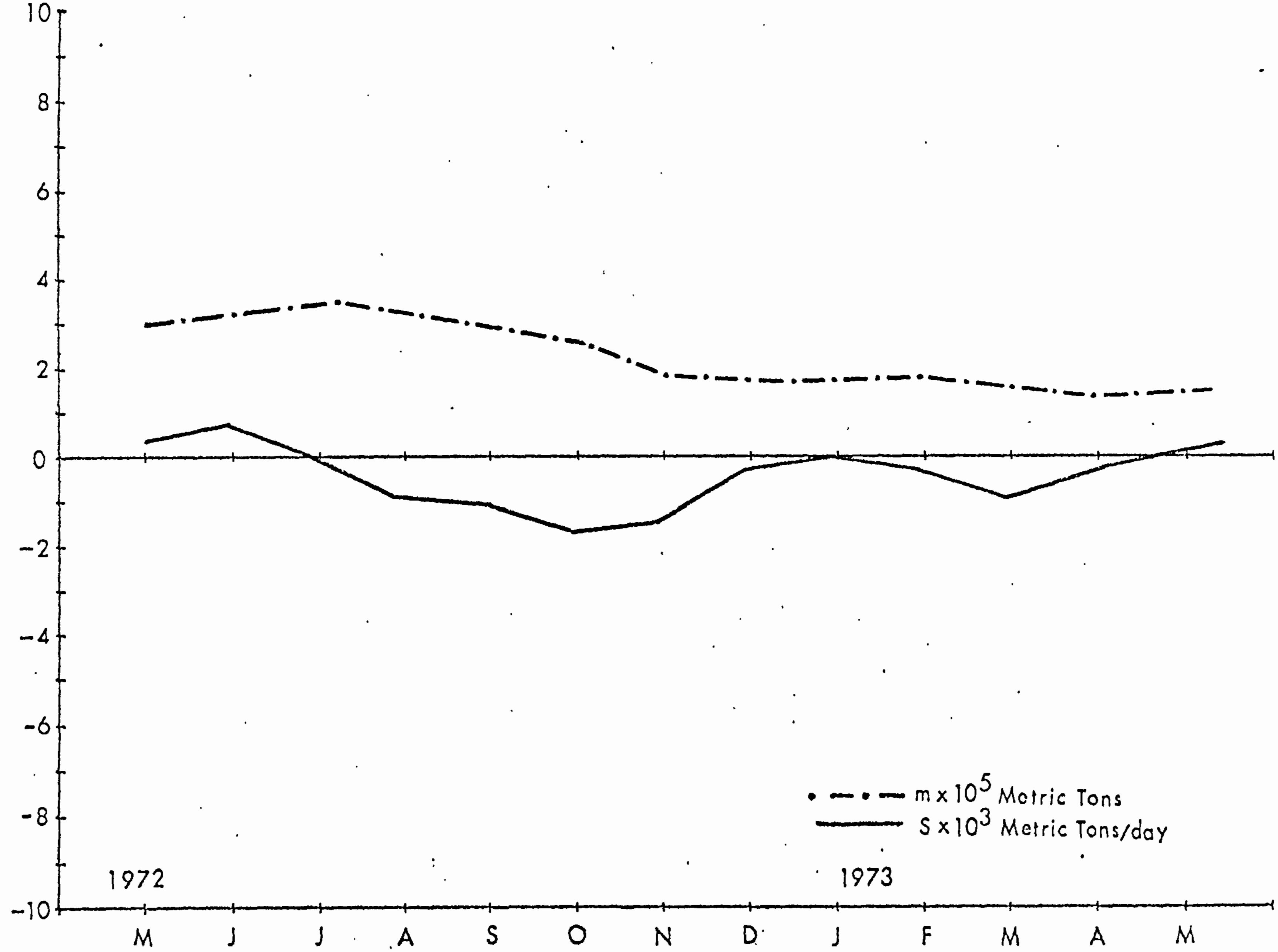


Figure 5.6 The mass content (m) and the production rate (S) of Total Kjeldahl Nitrogen during the field year

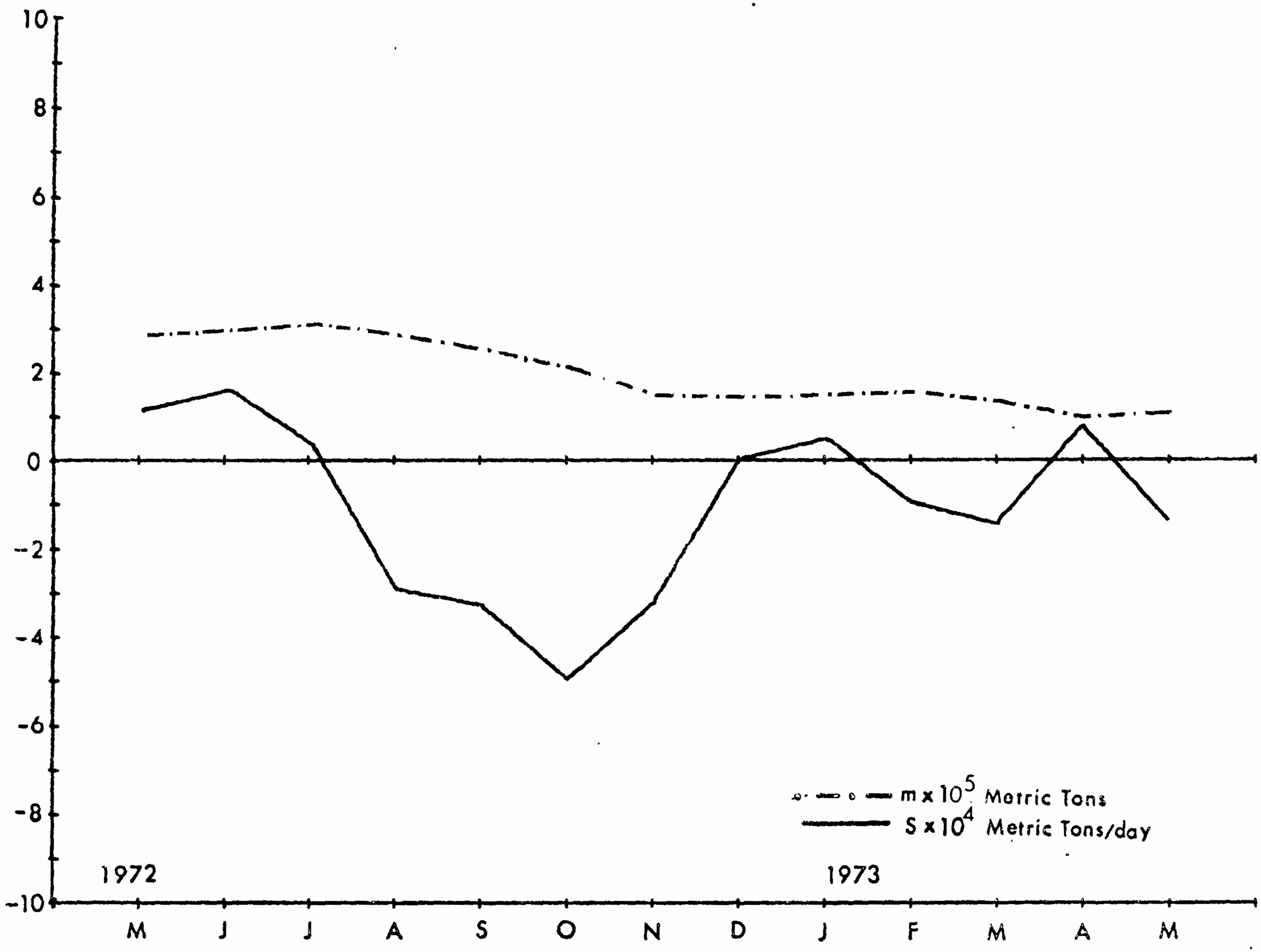


Figure 5.7 THE MASS CONTENT (m) AND THE PRODUCTION RATE (S) OF ORGANIC NITROGEN DURING THE FIELD YEAR.

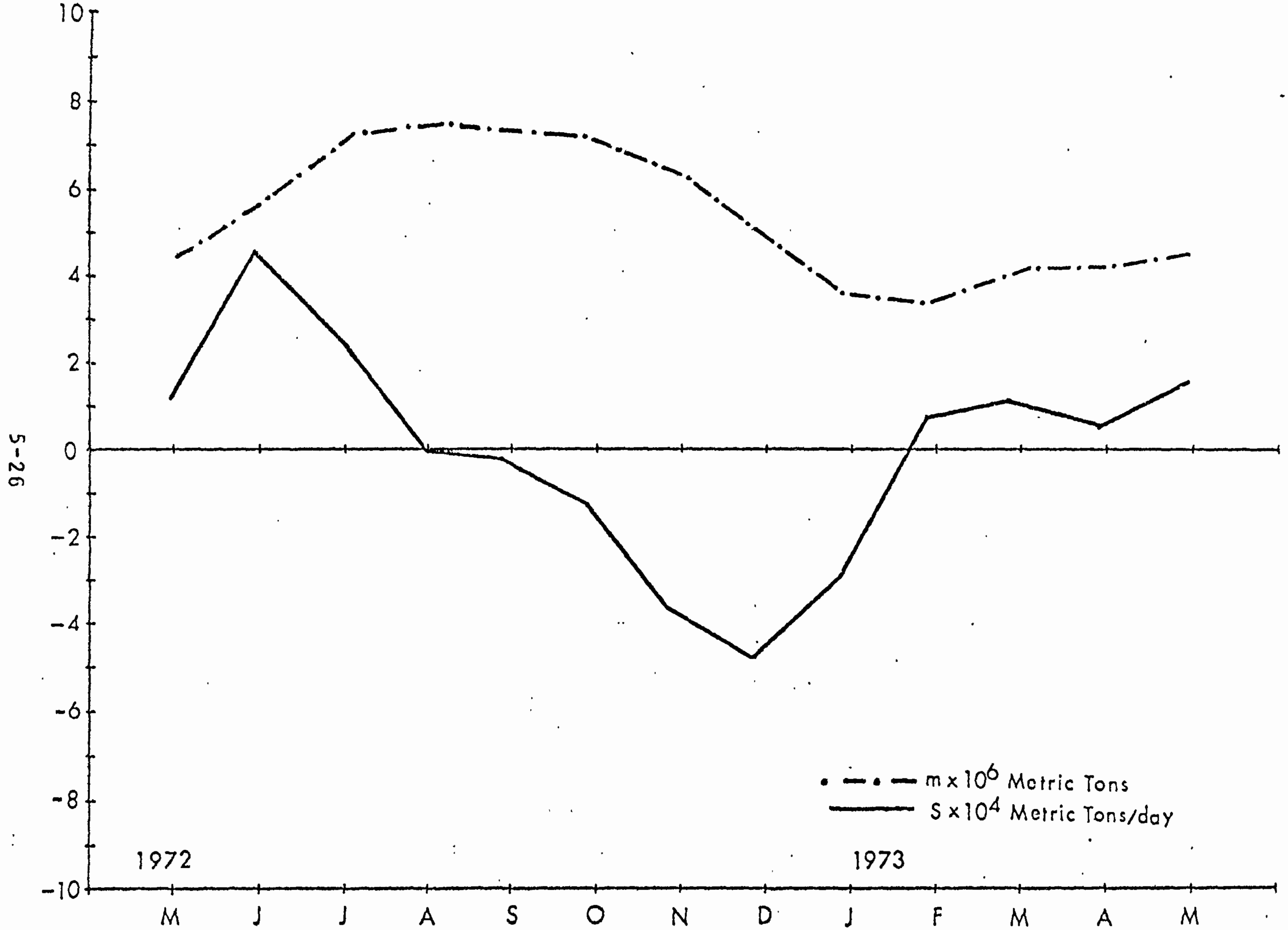


Figure 5.8 The mass content (m) and the production rate (S) of Total Organic Carbon during the field year

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