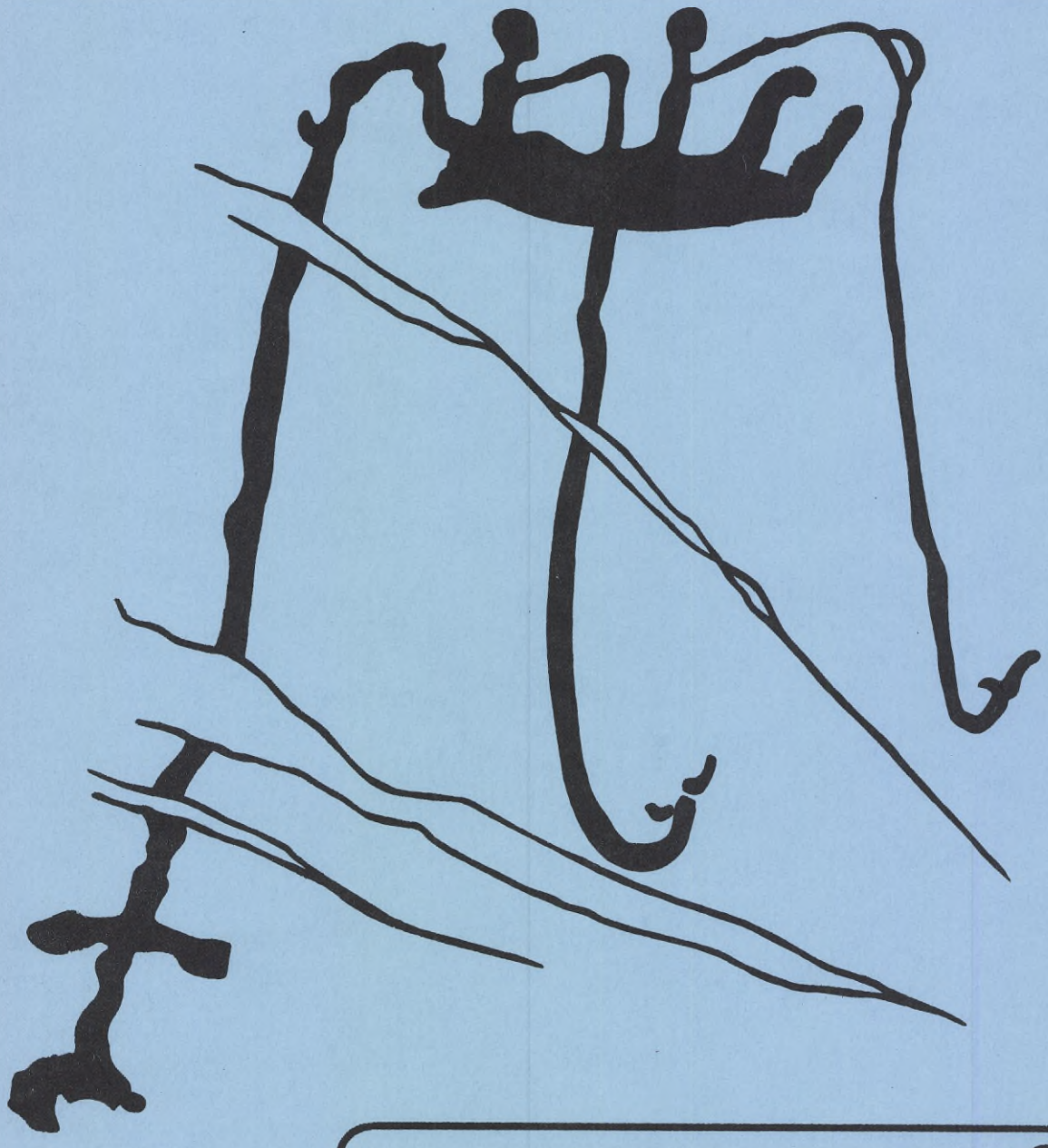
Ödsmål, Kville sn, Bohuslän

Hällristning
Fiskare från
bronsaldern

Rock carving
Bronze age
fishermen



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The Influence of Sampling Frequency on the Study of Time Variations of Hydrographic Parameters

by

Staffan Lööf

January 1979

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The hydrographic conditions in northern Kattegat were investigated in a 5 year project called "The Baltic Entrance Project: the GF Section". In this study two sampling series at the same location are compared. The sampling frequencies differ by a factor 15. The impact on mean values of salinity and total phosphorus is discussed. The high frequency data are thinned and reprocessed. Simulations of low frequency sampling are performed using high frequency data. The choice of sampling occasions and sampling frequency is important since it will influence both short and long term mean values, especially of surface salinity.

De hydrografiska förhållandena i norra Kattegatt har undersökts i ett 5-årsprojekt kallat "The Baltic Entrance Project: the GF Section". I detta arbete jämförs två mätserier från en och samma mätpunkt. Provtagningsfrekvenserna skiljer sig med en faktor 15. Inverkan på medelvärden för salinitet och totalfosfor diskuteras. Högfrekvensdata glesas ut och nya beräkningar utförs. Simulering av provtagning med låg frekvens utförs med hjälp av högfrekvensdata. Val av mättillfällen och -frekvens påverkar både kort- och långsiktiga medelv.

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The Influence of Sampling Frequency on the Study of Time Variations of Hydrographic Parameters

by

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Abstract

The sampling frequency of some hydrographical parameters is discussed. Data from the Danish lightvessel Läsö Nord/Trindel (daily observations) and from a station at a section between Göteborg and Frederikshavn (approx 20 observations per year) are processed. Annual means calculated from the two sampling series are compared. The information obtained from monthly means and single observations respectively is discussed. The consequences of a successively decreased sampling frequency is demonstrated. Total phosphorus measurements at the lightvessel and at the section station are compared. Finally, some simulations are performed: lightvessel data are used for simulated samplings.

Introduction.

The choice of a suitable sampling frequency is influenced by many factors. Economic and/or practical considerations are often limiting. Sometimes a choice must also be made between high resolution in time or space.

The sampling frequency is among other things governed by the time variations of the parameters to be studied in the area. The precision of the analytical method is also important. If the time variations are roughly known and the rate of concentration change is not too big, a lower sampling frequency may be sufficient. Of special importance is of course the use of the data. A quantification of transports e.g. usually puts a high demand on the frequency.

Origin of Data.

The data used below were collected in a project to investigate the hydrographic conditions in northern Kattegat. At a section between Göteborg and Frederikshavn (GF section, see map) 75 expeditions were carried out during August 1974 and December 1977. Up to November 1977 samples were also taken once a day at the Danish lightvessel positioned close to the section station designated GF-6. Unfortunately, the lightvessel was moved in March 1975 to a new position 5 nautical miles to the south-east. The name was then changed from Läsö Nord to Läsö Trindel. It was withdrawn permanently in November 1977.

The temperature and salinity data used in this study were supplied by the Danish Meteorological Institute. Samples for the determination of total phosphorus were collected on board by the crew and was analysed at the National Board of Fisheries in Göteborg.

The comparison of data from the lightvessel and station GF-6 in order to show the effect of varying sampling frequencies is not entirely correct since data originate from different populations of measurements. As mentioned earlier, the sampling sites are not quite identical after the move of the lightvessel. The bottom depth then decreased from 38 to 28 meters which necessarily must have influenced the hydrographic conditions. The bottom depth at GF-6 is approximately 40 meters. Besides, the recordings are not synoptical. At the lightvessel sampling took place at 0700 GMT (mostly), at GF-6 at noon.

The daily observations at the lightvessel give rise to 320-350 casts per year. This is about 15 times the frequency of the section measurements. Moreover, the section work was very much steered by the prevailing winds and the state of the sea. The work on board could hardly be carried out at wind velocities greater than 8-10 m/s. At the lightvessel, on the other hand, bad weather very seldom hampered the sampling.

Annual Means.

Table 1 gives a hint of the importance of sampling frequency for the investigation of time developments.

Table 1. Change in the annual mean of salinity (‰) from 1974/75 to 1975/76 (+ designates increased salinity).

Depth interval (m)	Station GF-6	Lightvessel
0 - 5	+ 2.50	+ 1.0
5 -10	+ 2.48	+ 0.8
10 -15	+ 1.44	+ 0.4
15 -20	+ 0.34	± 0

Lightvessel data give 2 to 3 times lower values for the difference between the two periods (the precision of the salinity

determinations on board the lightvessel is one figure less than for the section determinations). Apparently, there is an over-representation of situations with high salinities in the section data.

A similar comparison of temperature data reveals that according to lightvessel observations there was an increase of approximately one degree centigrade except for surface and bottom. The section data, however, show a decrease of the same size. Apparently, there is an over-representation of situations with low temperatures in the section data.

Mean values of temperature, salinity and total phosphorus have been calculated for all depths for the period July 1975 -- June 1976. They are displayed graphically in figure 1. The differences are considerable. Lightvessel data of temperature have a mean value a little more than one degree centigrade higher than the corresponding GF-6 value. The difference in salinity is about 0.8 ‰ in the surface, decreasing towards the bottom. Also for total phosphorus there is a difference of about 0.06 µgat/l at the surface.

Lightvessel Monthly Means versus Section Single Observations.

It is of course difficult to compare mean values with single observations - mean values naturally have a smoothing effect. Figures 2 and 3 show the time developments of salinity and total phosphorus both with single observations (approx. 20 per year) as well as with monthly means based on daily observations. Since the change of concentration per unit time is largest in the surface layer, the consistency increases towards the bottom. At depths below 15 or 20 meters the mean value curve is usually the smoothed counterpart to the single observation curve.

Mean Values of Thinned Lightvessel Data.

To demonstrate the consequence of lower sampling frequency monthly means were computed using a reduced number of daily observations of total phosphorus at 0 and 15 m depth at the lightvessel. First the observations were thinned by a factor 2: every second observation was omitted when the mean values were calculated. After that new calculations were performed with still more thinning of data: only every 7th and every 14th observation respectively was included in the calculations. This set of mean values is then based on 15, 4-5 and 2-3 observations respectively (see figure 4).

The curve representing mean values calculated from every second observation differs very little from the original one. However, slightly higher values were obtained for April 1976 at 15 m. The difference is approximately 0.04 µgat/l.

If only every 7th or every 14th value is used the curve gets a somewhat different character. At 15 m these new curves have fewer details than the original one and the monthly means are generally lower. This applies to 0 m also but here the month-to-month deviations are greater and more irregular. This is due to the larger variability in the surface layer.

Comparison of Total Phosphorus Measurements at GF-6 and at the Lightvessel.

Figure 5 shows the time development of total phosphorus at GF-6 and at the lightvessel. It is obvious that the choice of sampling occasions is of great importance. During some periods the section data curves display both higher and lower values than the corresponding lightvessel data curves. This was e.g. the case during October - November 1976. The variations in the daily observations are considerable with among other things two pronounced "spikes". If the lightvessel curves are

smoothed a little they will give values 0.10 - 0.15 µgat/l lower than the section measurements. During January and February conditions are opposite: lightvessel data suggests higher values than section data.

The international North Sea Project JONSDAP 76, which had its sea phase during March - June 1976 gave rise to an increased activity in the GF section work. From the middle of March to the beginning of May 8 cruises were carried out, i.e. on the average one per week. The total phosphorus concentration levels fluctuated considerably during this period which can be seen from the daily observations. Figure 5 a (0 m) shows that the section measurements nevertheless are rather nicely representing all these changes. From figure 5 b (15 m), however, it is obvious that occasions with high total phosphorus values did not coincide with any section measurements. Hence, section data give a false impression of lower concentrations during the JONSDAP period.

The conclusion is that as for total phosphorus it is rather accidental if a series of measurements of a low sampling frequency really describes the time development in northern Kattegat. Some pilot parameters of a high sampling frequency could perhaps be of some help in the evaluation work.

Simulated Data Series.

As already mentioned the choice of sampling occasions at the GF section was governed by among other things meteorological conditions. During periods of strong winds/rough sea it was not possible to carry out hydrographic expeditions with the vessel available. Furthermore, no sampling has been performed on certain days of the week or more frequently than once a week.

It is rather difficult to answer the question wether the choice of sampling occasions have influenced the final result of the investigation of the hydrographic conditions. Rough wind conditions areusually associated to large mixing and water exchange. But due to inertia the water movements do not stop abruptly when the wind ceases. So nevertheless, rough weather conditions may sometimes be represented in the section measurements.

In a previous paragraph (page 4) it was shown how the choice of sampling occasions influenced the result of a series of total phosphorus measurements. To study this problem closer some simulated cruise data were produced using the daily observations at the lightvessel. By means of certain criteria (see below) a number of section sampling occasions were simulated. Salinity and total phosphorus data for two depths were sorted out from the lightvessel data bank. These were plotted and mean values were also computed.

Criteria for simulations.

1) Invalid days: every Friday, Saturday and Sunday, holidays and some weekdays in association with holidays.

2) Only one sampling per week.

3) Number of sampling occasions per simulation: 72. This corresponds to the number of cruises at the section up to the withdrawal of the lightvessel.

4) Highest acceptable wind velocity (daily means) at the lightvessel: 8 m/s. A sampling occasion generated with a wind velocity exceeding this value was rejected and a new one was sought.

A simulation was accomplished according to the following procedure. First a time interval was defined within which all sampling occasions would lie. The first section cruise took place on August 7, 1974. Therefore August 5, 1974 was defined as the start of the period since this day was the first valid day in the first sampling week. This date is now transferred to a relative time scale and designated day no. 0 (zero).

The lightvessel was permanently withdrawn on November 24, 1977. The last day when complete casts were made was November 21, 1977 which constitutes the end of the period. This day is designated no. 1204.

With the aid of a computor a series of random numbers in the interval 0-1204 was now generated. Every number, equivalent to a day in the period 740805-771121, was compared with a table containing invalid days according to the criteria. If found, the generated number was rejected and a new one was sought. This was repeated until 72 valid numbers were obtained. They were thereafter sorted in ascending order (the only reason for this is that this will speed up the following processing). Then the numbers, being relative points of time, were translated into an absolute scale. The data of salinity and total phosphorus for the corresponding days were collected from the data bank and processed (plotting and calculation of mean values).

A complete simulation has now been carried out. The results of the processed data can be compared with the real measurements at the section, i e the first 72 expeditions up to the withdrawal of the lightvessel.

It is of course not sufficent with only one simulation in order to draw conclusions of how the choice of sampling occasions influences the results of the investigation. One simulation gives only one combination of sampling occasions.

Therefore several simulations were carried out. However, the grand mean of a number of simulations rapidly converges towards a constant value. A test with surface salinity data shows that a constant value of the grand mean (taking into account the precision of the measurements) is obtained after 25 - 30 simulations. Tables 2 - 5 display data from a run with 26 simulations (computor time was available for 26 simulations at the time).

For salinity sampling was simulated at 0 and 20 meters depth. Due to the great variability those curves describing the salinity variations at 0 m display a very irregular pattern. Figure 6 shows the first 12 months of the period. Only occasionally do the curves constract vertically to a narrow band which is the indication of periods of moderate variations (it is supposed that 26 simulations is enough to avoid statistical interference due to too small a material; compare e.g. with figure 5 showing the daily observations). Tables 2 and 3 show some statistical data from the simulations. At 0 m the value vary between 23.0 and 24.3 ‰, at 20 m between 31.7 and 32.2 ‰. The conclusionis that the mean values for the period could vary within these limits solely due to the choice of sampling occasions. The mean values calculated from real section measurements during this period (rounded to the first decimal place) are 23.8 and 32.1 ‰ respectively. These figures are to be found within the interval given by the simulations. This confirms the validity of the above conclusion.

For total phosphorus sampling was simulated at 0 and 15 meters depth. The great variations of this parameter is not, as was the case for salinity, restricted to the surface layer but includes all depths. This is the reason why the graphs in e g figure 7, showing the first 12 months of the period, constitute a range of concentrations which do not differ so much during the year. Tables 4 and 5 display statistics for the

simulations. At 0 m the mean values vary between 0.61 and 0.68 µgat/l, at 15 m between 0.61 and 0.69 µgat/l. The mean values calculated from real section measurements during this period are 0.62 and 0.65 µgat/l respectively. As was the case for salinity these values are to be found within the interval given by the simulations.

Table 2. 26 simulations of 72 sampling occasions for salinity, 0 m

Mean Value (‰)	Freq.	
23.0	2	Grand Mean: 23.6 ‰
23.1	1	
23.2	4	Stand. Dev.: 0.34 ‰
23.3	1	
23.4	1	Mean Value of real Section Cruises: 23.8 ‰
23.5	4	
23.6	3	Mean Value of Daily Observations at the Lightvessel: 24.1 ‰
23.7	2	
23.8	3	
23.9	2	
24.0	1	
24.1	1	
24.2	0	
24.3	1	

Table 3. 26 simulations of 72 sampling occasions for salinity, 20 m

Mean Value (‰)	Freq.	
31.7	3	Grand Mean: 31.9 ‰
31.8	10	Stand. Dev.: 0.12 ‰
31.9	4	Mean Value of real Section Cruises: 32.1 ‰
32.0	8	
32.1	0	Mean Value of Daily Observations at the Lightvessel: 31.9 ‰
32.2	1	

Table 4. 26 simulations of 72 sampling occasions for total phosphorus, 0 meter

Mean Value (µgat/l)	Freq.	
0.61	2	Grand Mean: 0.64 µgat/l
0.62	2	Stand. Dev.: 0.02 µgat/l
0.63	6	
0.64	7	Mean Value of real Section Cruises: 0.62 µgat/l
0.65	5	
0.66	2	
0.67	1	Mean Value of Daily Observations at the Lightvessel: 0.65 µgat/l
0.68	1	

Table 5. 26 simulations of 72 sampling occasions for total phosphorus, 15 meter

Mean Value (µgat/l)	Freq.	
0.61	1	Grand Mean:0.65 µgat/l
0.62	3	Stand. Dev.: 0.02 µgat/l
0.63	1	
0.64	4	Mean Value of real Section Cruises: 0.65 µgat/l
0.65	7	
0.66	3	
0.67	3	Mean Value of Daily Observations at the Lightvessel: 0.67 µgat/l
0.68	3	
0.69	1	

Summary of Results.

This investigation has shown that the choice of sampling occasions and sampling frequency influence both short and long term mean values of salinity and total phosphorus in northern Kattegat. It is questionable whether a low sampling frequency really gives a correct picture of the time variations.

A series of simulations have shown that the choice of sampling occasions influences the 3-year mean values of salinity and total phosphorus. The impact on salinity mean values is worth consideration since different combinations of sampling occasions gave markedly different values, especially in the surface layer. Evidently, the impact on total phosphorus is of minor importance. This applies to the surface layer as well as the underlying water column.

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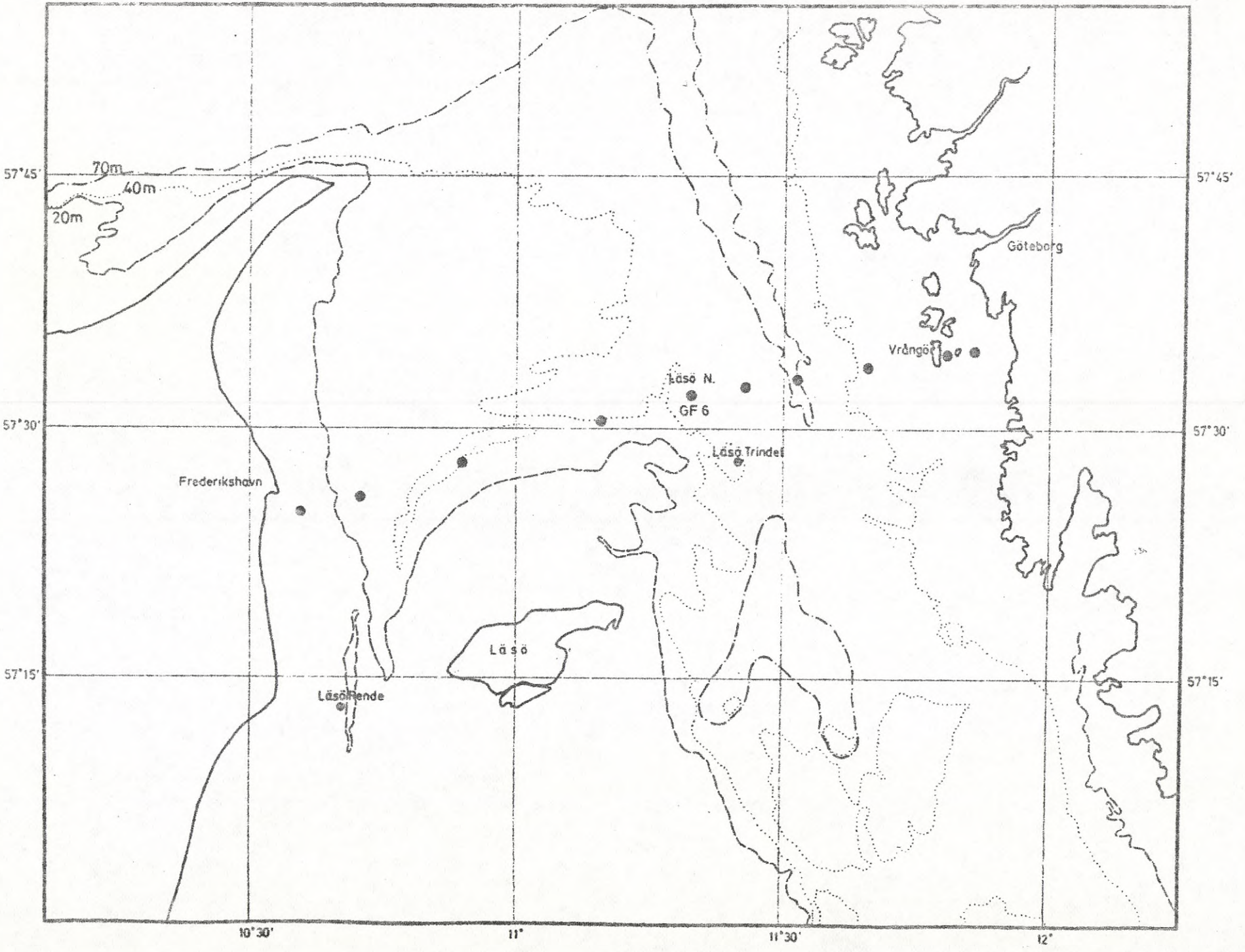
70m
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11°
11°30'
12°
Göteborg
Vrångö
Läsö N.
GF 6
Läsö Trindel
Frederikshavn
Läsö
Läsöhende

Mean Values 1975 / 76

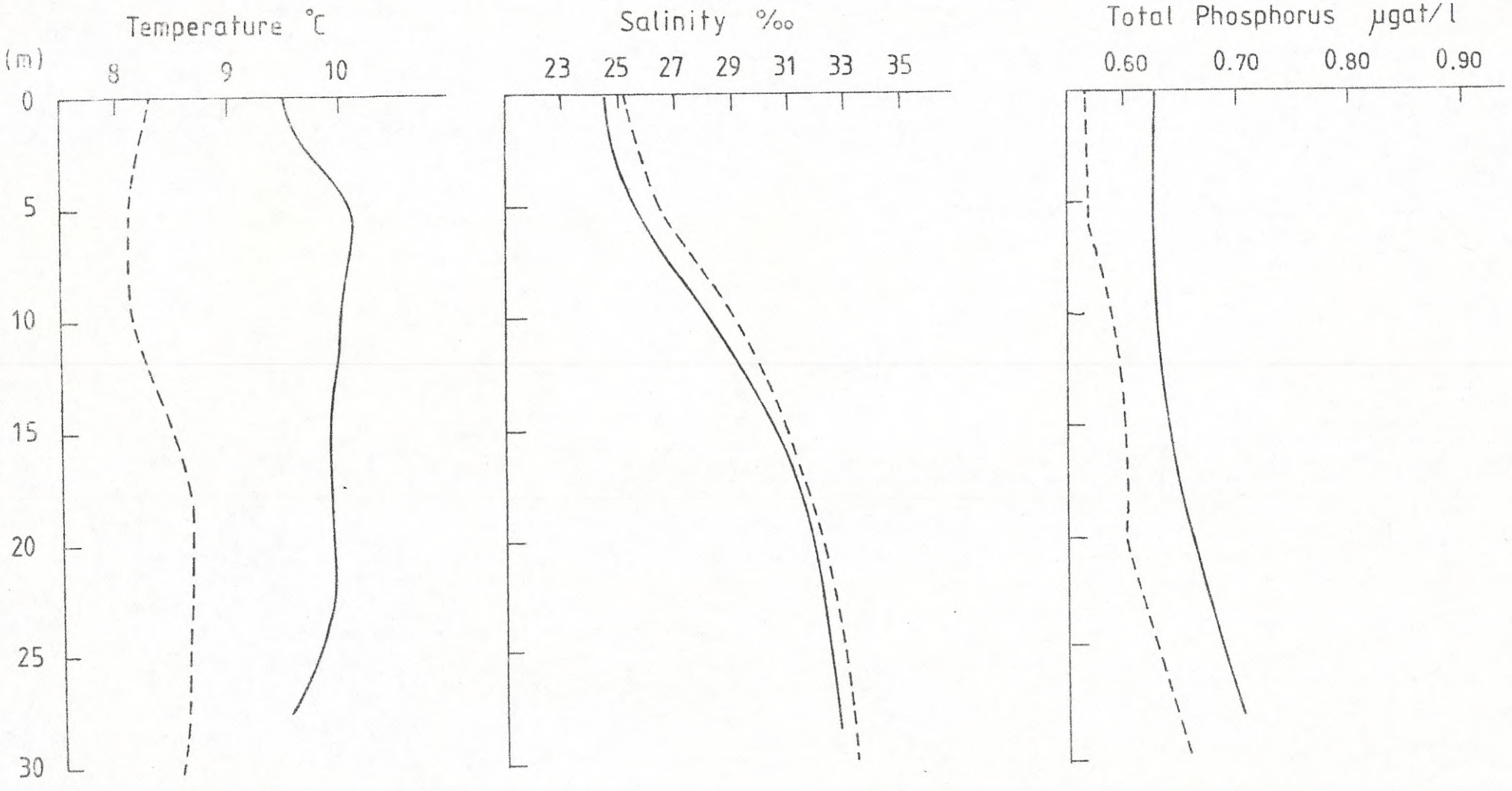

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FIG. 1

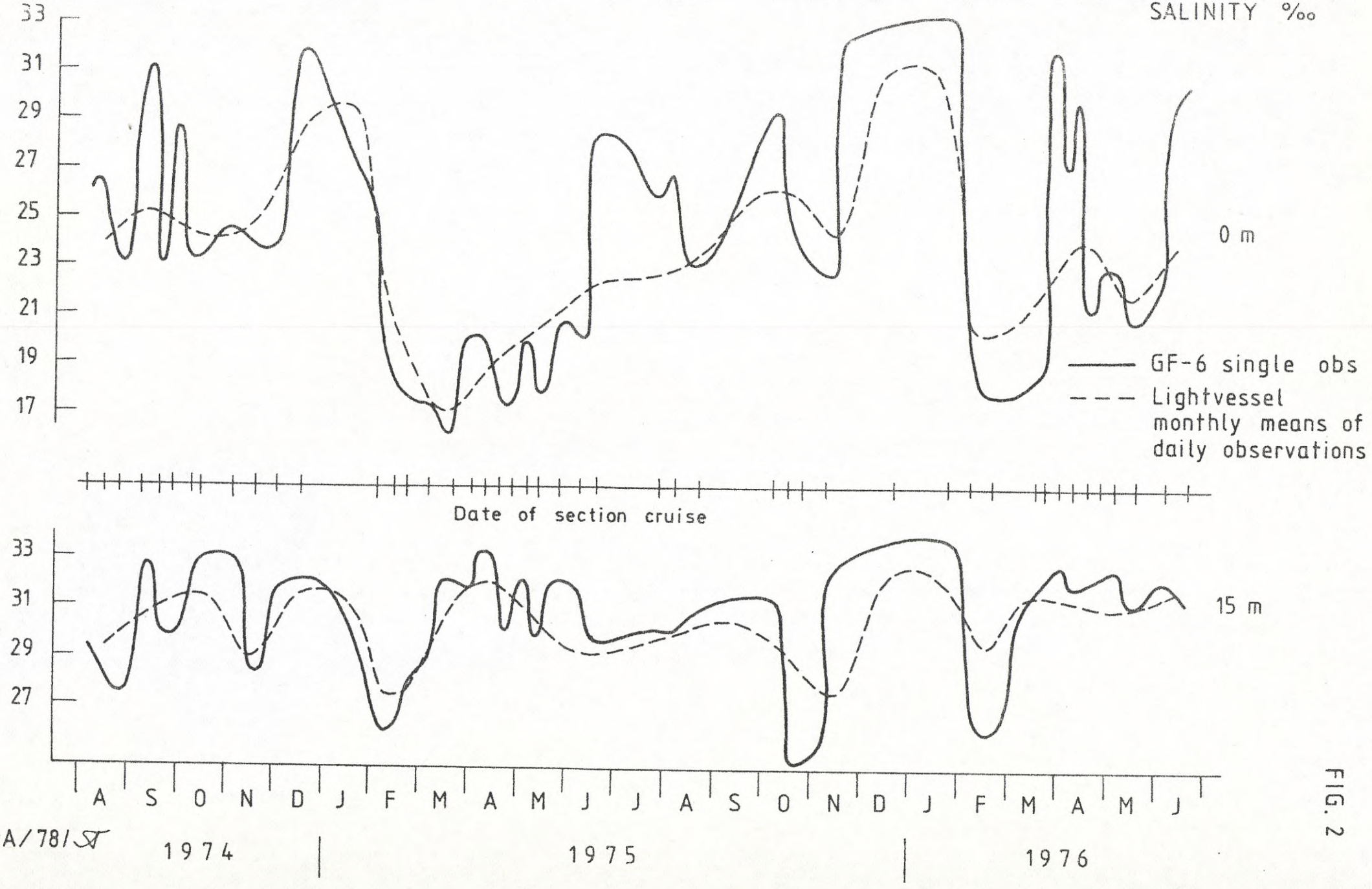

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FIG. 2

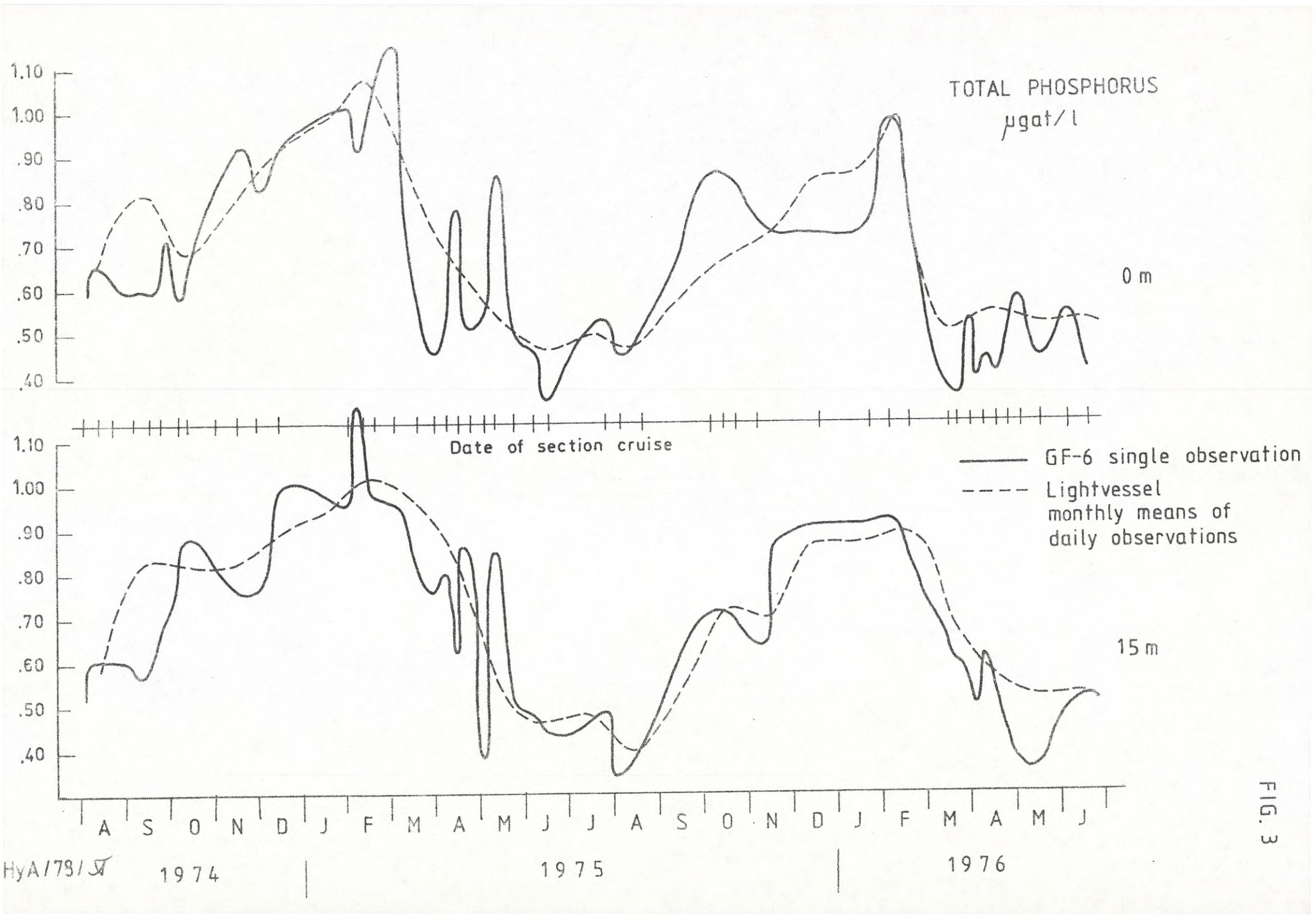

FIG. 3

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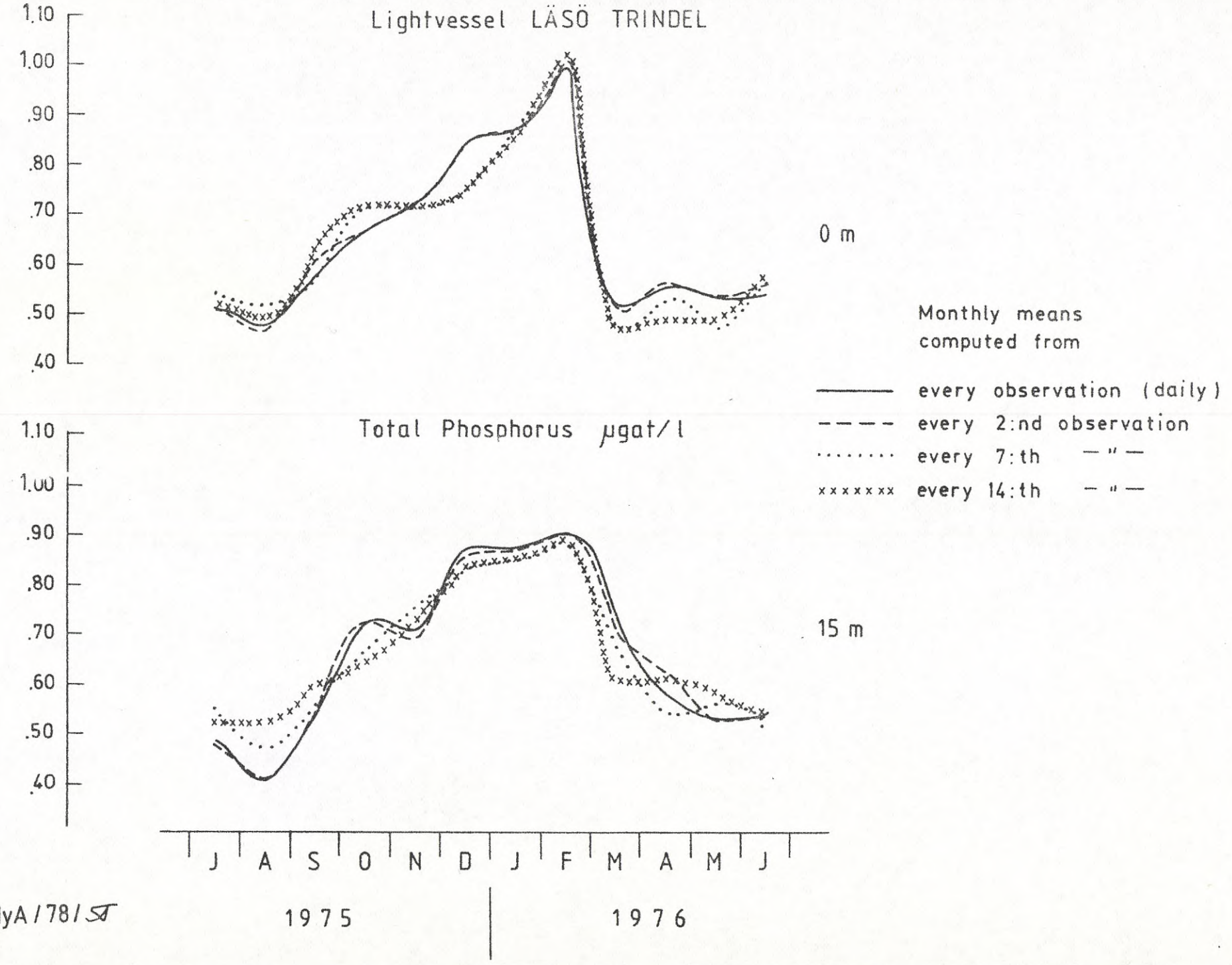

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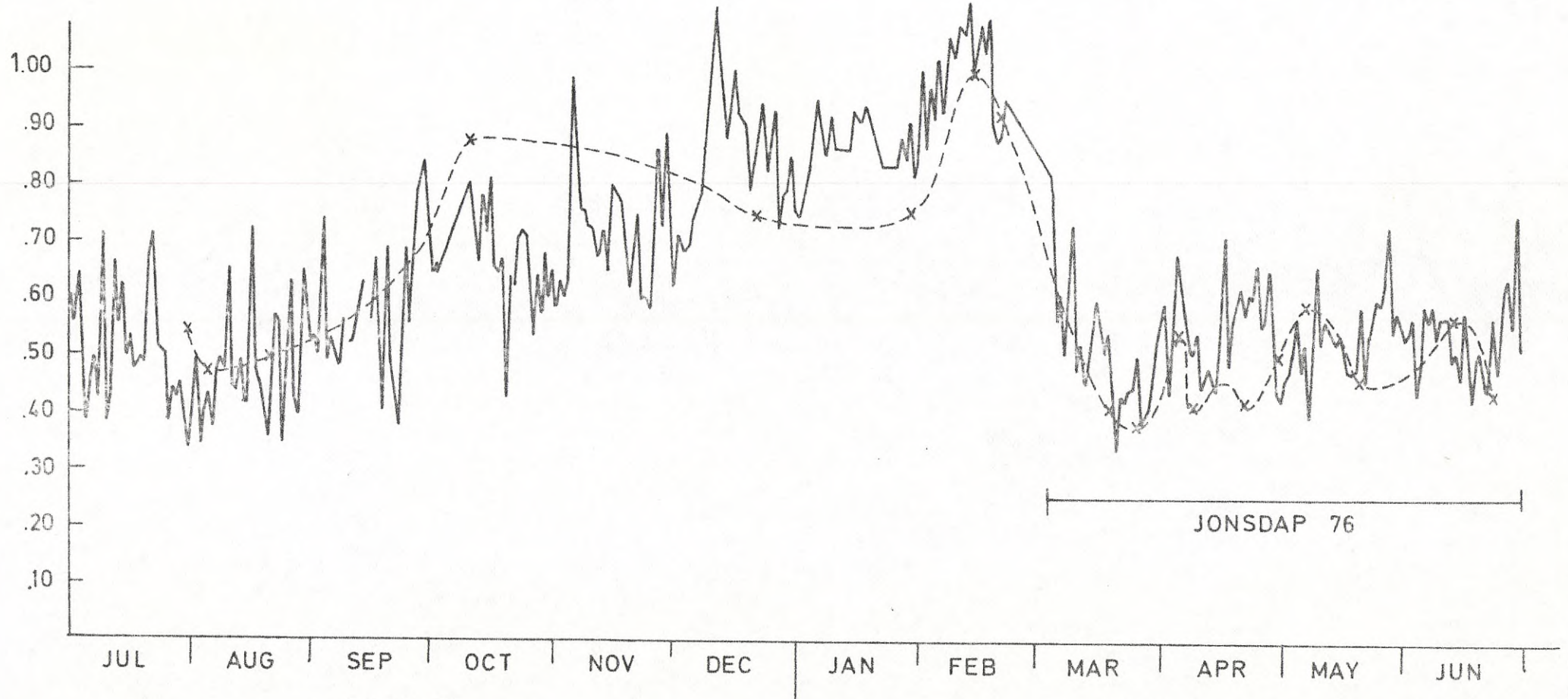
FIG. 4

Total Phosphorus µgat/l 0 m

——— LÄSÖ Lightvessel daily observations

x– –x– –x GF-6 Section cruises data



HyA / 78 / ST

FIG. 5a

Total Phosphorus µgat/l 15 m

—— LÄSÖ Lightvessel daily observations

x--x--x GF-6 Section cruises data

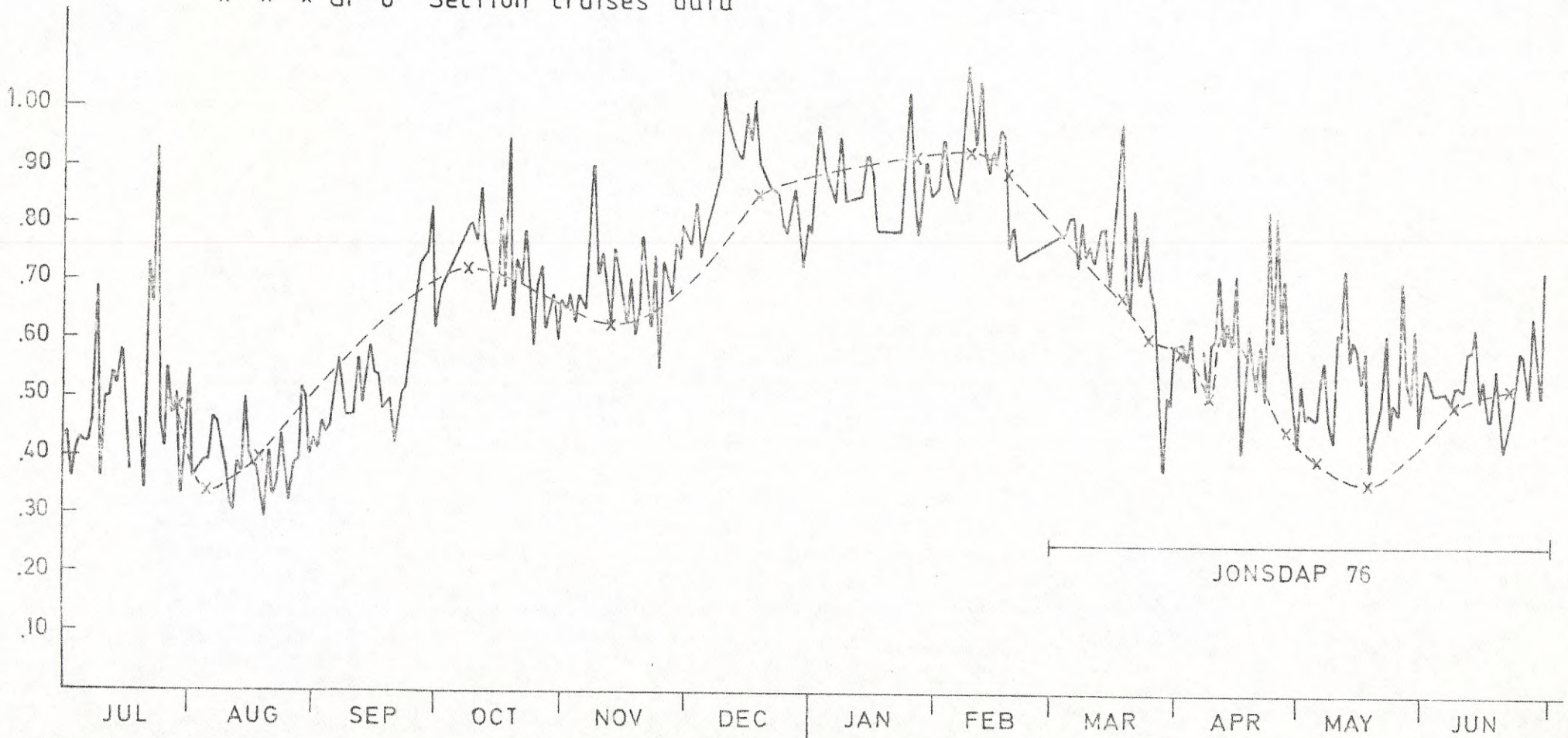


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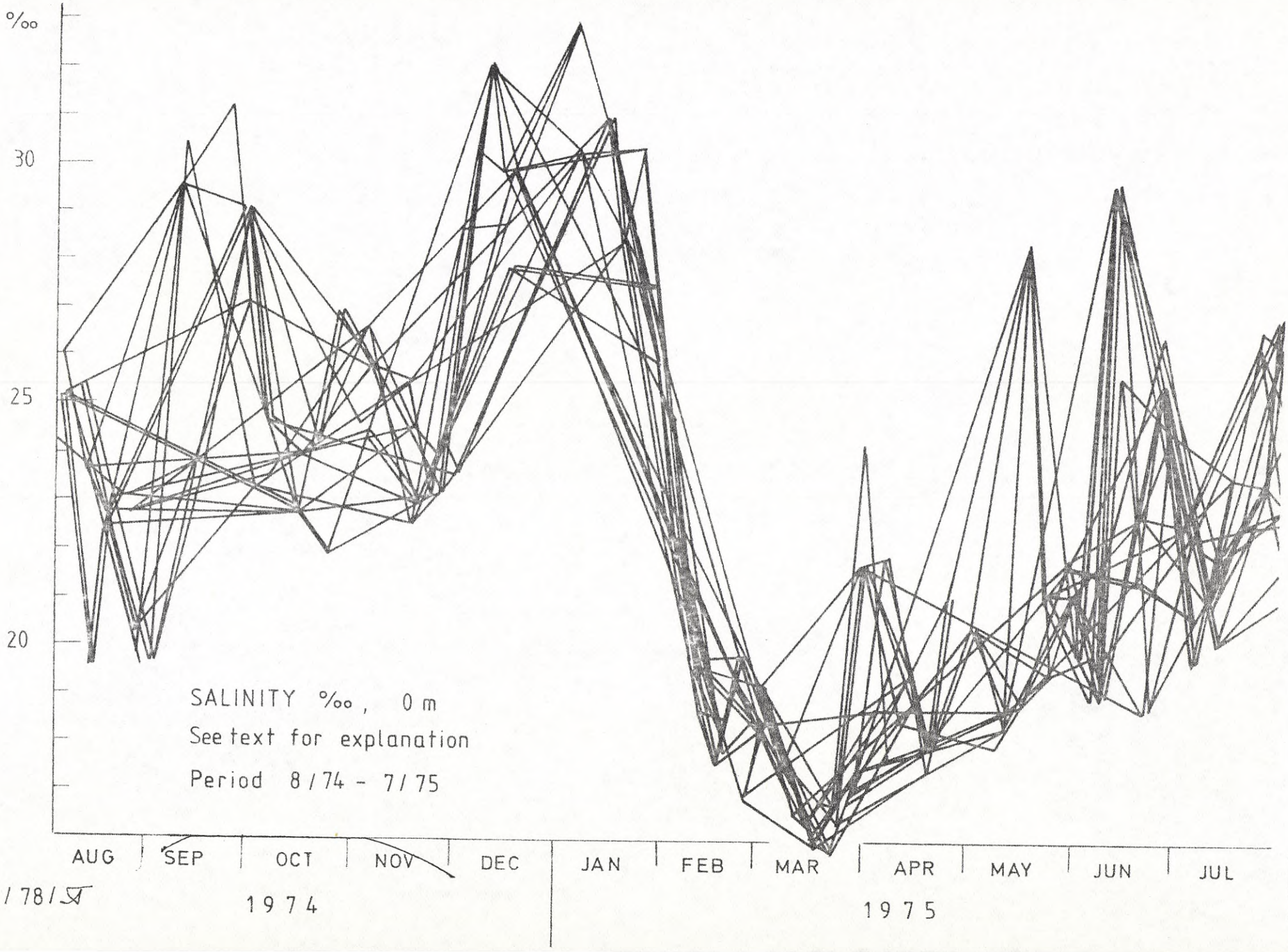
FIG. 5b


‰
30
25
20
SALINITY ‰, 0 m
See text for explanation
Period 8/74 - 7/75
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SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
1974
1975

HyA/78/S

FIG. 6

Total Phosphorus µgat/l, 0 m

See text for explanation

Period 8/74 - 7/75

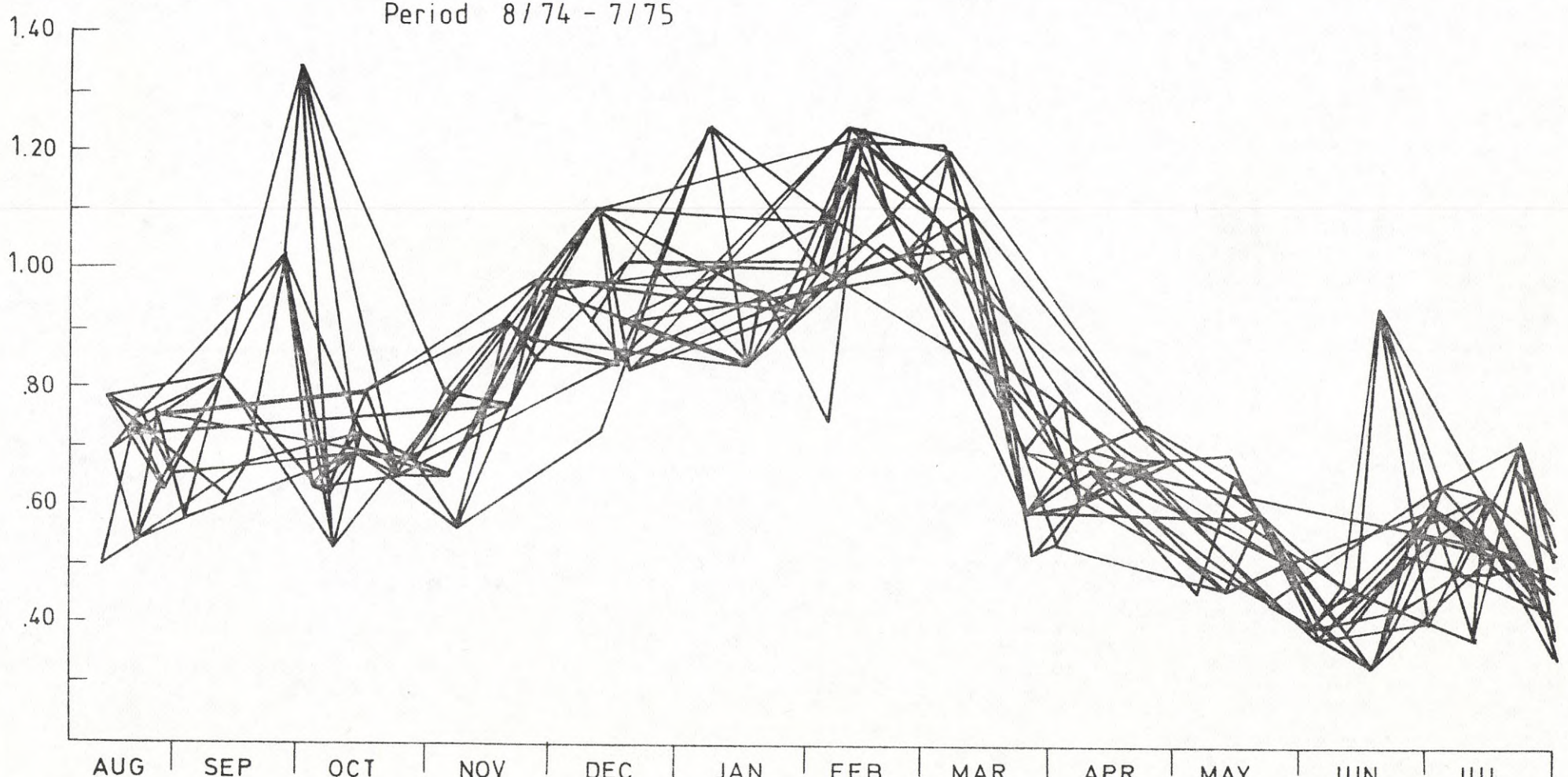

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FIG. 7