Hydraulics Research
Wallingford

SLUDGE DISPOSAL IN LIVERPOOL BAY

Twelfth bed monitoring survey

December 1984 - March 1985

P R Kiff B Sc

Report No. SR 71
January 1986

Registered Office: Hydraulics Research Limited,
Wallingford, Oxfordshire OX10 8BA.
Telephone: 0491 35381. Telex: 848552

This report describes work funded by the Department of the Environment under Research Contract PECD 7/7/051. It was carried out under the management of Mr M F C Thorn by Mr P R Kiff of the Technical Services Department of Hydraulics Research Ltd, Wallingford. The report is published on behalf of the Department of the Environment.

ABSTRACT

This report describes the twelfth survey carried out in December 1984 and March 1985 continuing the long term monitoring of the bed sediments of Liverpool Bay. The objective of the programme is to determine whether any changes are occurring in the surface sediment characteristics as a consequence of changes in the rate of sewage sludge disposal since 1972.

CONTENTS

FIGURES

1 INTRODUCTION

The DOE programme of monitoring bed sediments in Liverpool Bay for possible effects of sewage sludge disposal was initiated in 1973 following publication of "Out of Sight, Out of Mind" (Ref.1). The desirability of maintaining this check on bed conditions was reaffirmed in 1978 by the DOE/NWC Sub-Committee on the Disposal of Sludge to Sea (Ref.3) and since then, six bed surveys have been carried out (Refs 4-8) by Hydraulics Research (HR).

The last, the subject of this report was started in December 1984 and finally completed in March 1985, weather conditions necessitating a second visit. The major part of the programme was undertaken on the second trip from the University College of North Wales survey vessel "Prince Madog". Dr S Rowlatt of the MAFF Burnham Laboratory joined HR staff on the sampling survey which was the twelfth in the overall series.

Samples were taken at sixty positions including twenty of the twenty-four standard sites visited on all occasions since 1973. The remaining four could not be sampled because of deteriorating weather conditions. 125mm diameter cores were taken at 16 sites, these being up to 300mm in length. 50mm diameter cores were taken in addition at 13 sites. These smaller diameter cores were up to 800mm in length and designed to seek the undisturbed basal strata so that baseline metal concentrations could be established. Previous endeavours to explore the depth of metal penetration were confined to the eastern half of the survey area (Ref 9). Grab samples were taken at 45 sites. The overall distribution of sampling positions is shown in Fig 1.

The top 25mm of each grab sample was removed with a flat scoop and brought back for analysis. The 125mm cores were extracted on board and split into 0 - 25mm, 25 - 100mm and 100mm - bottom fractions unless distinct layering was visible when the cores where spilt at the layer boundaries. In one case, the core was too loosely compacted to extract whole and a composite sample from the total was taken. The 50mm cores were returned to the laboratory intact, removed from their liners by compressed air and cut into 5 or 10 cm sections. All samples were stored at -20°C prior to analysis.

In the laboratory, the samples were split into sand and mud fractions by wet sieving at 63 μm. The sand fraction was not graded further and only the percentage mud by weight was recorded. The mud fraction was air dried followed by storage in a vacuum desiccator before sub-sampling for organic carbon and heavy metal determinations.

Organic carbon determinations were made by the standard wet oxidation method used previously (the organic carbon is reported as organic matter, a factor of 2.5 being used as in the past to convert carbon to the equivalent of dried organic residues).

Standard reference samples (NBS 1645) were included with the samples submitted to the commercial analytical laboratory for heavy metal determinations by atomic absorption spectrophotometry as in the previous two surveys. Corrections were made to the results where necessary to bring them within the $\pm$ 10% error previously established for these analyses (Ref 7). These corrections ensure that the results of the current survey are as comparable as possible to those of the previous four surveys for which the data is included in this report.

Data from the seventh survey (1978/9) included in the last report (Ref 8) have been omitted from this report partly because of lack of space but also because of the limited coverage of the seventh survey (30 site samples analysed compared with 40, 50, 63, 64 and 60 in Surveys 8 to 12 respectively). The last three years have reached probably the optimum number of sampling positions, more than doubling the number originally visited. Comparisons with past results must be tempered with consideration of the number and position of the sites visited and the variation between surveys. Each survey tends to show up special points of interest which may be substantiated or discarded in the light of results from the next survey and some sampling positions are selected so as to investigate further any peaks or anomalies in the current set of results.

2 MUD CONTENTS

The mud content of each of the 60 sampling positions is shown in Fig 2. Where 125mm and grab samples have been taken at the same site, the average of their mud contents has been taken. Mud contents of the top 25mm from the 50mm cores have not been included in the averages because it has not been established with this smaller vibro-corer, that the surface is completely undisturbed (Ref 2). The mud content from the 50mm core has been included for T14 however, because this was the only sample taken at this position.

The mud distribution is substantially the same as in the past four surveys with the exception of a mud pocket at G11 never before encountered. This almost certainly is another random rogue result derived from the limited accuracy of position finding between each survey.

3 ORGANIC MATTER

The distribution of organic matter in the mud fraction is shown in Fig 3. Two samples had too little mud to allow for organic carbon and heavy metal analyses so the organic analysis was omitted. The average concentration is a little lower than last year but similar to that of 1981/2 and 1982/3. The last survey (1984/5) contained three samples with significant amounts of coal which tended to raise the average value above those of previous surveys (mean 5.3, 5.8, 6.4, 5.4% organic matter from 1981/2 to 1984/5). The peak at M9, close to the apex of the dumping ground is similar to that of 1981/2 and the low values at T10 and T11 are similar to those of 1980/1.

The "total" organic content (Fig 10) calculated from the product of the mud and organic matter percentage abundances is similar to that of the previous four years and shows no evidence of any increase. Its distribution is similar to that of the mud (Fig 2) because the variation in mud content is considerably larger than the variation in organic mater. (Relative standard deviation 201% against 25%). The Mersey area again shows the greatest accumulation of organic matter and the only significant difference is the higher value at G11 due to the exceptionally high mud result from that site.

4 HEAVY METALS

The heavy metal concentrations have been illustrated as in previous reports. Figs 4 - 9 show the concentration of the metals in the mud fraction of the sediment expressed in micrograms metal per gram of mud. Figs 11 - 16 show the "total" metals expressed as the product of the metal concentration, the mud percentage, and a factor based on the mean dry bulk density of a number of cores. This "total" metal concentration is expressed as kilograms (mercury only) or tonnes of metal in the top 25mm per square kilometre of bed. If it is assumed that the metal content of the fine sediment (< 63 µm) is mainly derived from adsorption of metals from solution, then this "total" metal figure represents the input to the area from man-made sources together with any natural sources that produce soluble metals.

The peak concentrations of lead, nickel, copper and chromium recorded near the sludge dumping ground on the eleventh survey are not now apparent but a peak in the same metals has appeared at Q9, further to the east (Figs 6-9). The characteristic noted from earlier surveys of metal peaks corresponding with sediments having less than one per cent mud is again exemplified by the Q9 sample.

The high lead concentrations found to the west of the dumping ground on the previous survey have decreased slightly and the overall mean concentration of lead is down to the pre 1982 figure (means 349, 459, 266 µg/g for 1982/3, 1983/4 and 1984/5). The reason for this rise and fall is not clear other than as part of the general variation due to seasonal changes.

Mercury values have always been considerably more variable than the other metals; on the present survey, RSD 250% as against 20-90%. The three low mercury concentrations to the south of the Mersey outflow associated with low mud and low organic contents contrast with the above average values of most of the other metals.

Overall, mercury, zinc, copper and lead are lower than last year whereas the nickel and chromium are slightly higher in concentration. This increase in nickel and chromium is the fourth successive increase. The mean nickel concentration having risen from 43 to 66 µg/g from the 1981/2 survey and chromium having risen from 29 to 85 μg/g over the same period. These figures are surprising, especially as nickel has been taken in the past as of mainly natural origin and its variations have been small. Nevertheless, its distribution is still fairly even over the area compared with chromium which is showing a noticeable increase around the Mersey outfall although the "total" chromium is not so obviously high. Calibration standards for the two metals are slightly more erratic than for copper, zinc and lead and chromium extraction is subject to above average errors (Ref 5) but the corrections necessary to compensate for apparent variations in the concentration of the standard sediments have never exceeded 20% in any one year and generally are less than 10%.

"Total" metals are also down, with the number of peak results reduced. The exception is the peak at G11 based on the high mud value previously noted. The bulk of the metals are found in the muddy area north of Newcome Knoll (U19, YY3, YY4) as on all previous surveys. Of the five elevated concentrations of copper noted in the last report, only one remains and that is adjoining the new dredging spoil ground. The distribution of "total" metals over the area is very similar, and as pointed out in previous reports, is primarily a function of the abundance of mud in the bed sediment.

5 VERTICAL DISTRIBUTION

The two sets of cores (125mm and 50mm diameter) were split into sections and analysed in a similar manner to the surface sediments. The mud suspended in the water trapped above the 125mm core was also analysed and the results incorporated into the top 25mm totals. No mud was suspended above the 50mm cores because, as they were returned to the laboratory for analysis, the mud had settled again into the bed surface. The results are shown in Figs 17 and 18 respectively.

Results from the shorter 125mm core show little evidence of any basal strata having been reached. If mercury is taken as the chief pollutant metal not present to a significant extent naturally then the basal uncontaminated sediments may have been reached at G7 below about 100mm. The drop in metal content below 25mm at L9 is more likely to be caused by a disturbed core due to the difficulty of penetrating the gravel bed to the south of the sludge dumping ground. Other than that, a certain enrichment of the immediate sub-surface layer can be seen at several sites but no significant trend towards metals increasing or decreasing with depth down to the 200-300 mm level can be seen.

Compared to the last survey, when cores were taken at a few of the same sites, the basal strata at Q11 is substantially the same (150 v 100mm) but all other comparison cores did not reach any constant low metal concentrations.

The results from the longer cores suggest that the depth of penetration of anthropogenic metals is largely confined to 150mm at Q11 and S11, to 400mm at L10, N11 and P11, whereas the more eastern sites near the Mersey feature a greater depth of penetration, at least beyond 500mm (T14, U9, YY2, 3 and 4).

These variations between west and east of the survey area are generally consistent with the findings of the only other "deep" coring, that of February 1983 (Ref 9). However the vertical distributions and relative metal concentrations observed on the two surveys at any one site have little in common. It is apparent that the number of cores is still too low and the randomness of the metal contents of individual strata too great for any detailed coherence in patterns to emerge.

6 CONCLUSIONS

The twelfth survey repeated the close sampling pattern first adopted on the tenth survey. Comparison of the concentrations in the mud fraction of the top 25mm suggest that organic matter, lead, copper and zinc have decreased, mercury is much the same and nickel and chromium have increased. Lead concentrations, mentioned in the last survey as being exceptionally high west of the sludge dumping ground have come down slightly as have most of the lead values.

When organic carbon and metal concentrations are combined with mud abundance to yield the "total" organic matter and "total" metal per unit area, the result is similar in magnitude and distribution to previous years with the exception of the isolated peak to the west produced by an exceptionally high mud concentration at G11.

It is recommended that on the next survey, the 2 metre HR vibro-corer should be employed in an attempt to reach the basal uncontaminated strata in the mud area to the north of Newcombe Knoll.

7 ACKNOWLEDGEMENTS

Thanks are due to Mr J Binks for executing the sampling programme and to Dr S Rowlatt of the MAFF Fisheries Laboratory, Burnham-on-Crouch for his assistance during the course of the field operations. Thanks are also due to the captain and crew of the University College of North Wales survey vessel "Prince Madog".

8 REFERENCES

1. OUT OF SIGHT, OUT OF MIND. Report of Working Party on Sludge disposal in Liverpool Bay, Vol 1 and 2, 1972.

2. OUT OF SIGHT, OUT OF MIND. Report of Working Party on Sludge disposal in Liverpool Bay, Vol 4, 1976.

3. DEPARTMENT OF THE ENVIRONMENT/NATIONAL WATER COUNCIL STANDING TECHNICAL COMMITTEE. Sewage Sludge disposal in Liverpool Bay, Research into effects 1975-1977. Report No.16, April 1979.

4. HYDRAULICS RESEARCH STATION. Sludge disposal in Liverpool Bay, Seventh bed monitoring survey, October 1978 - April 1979. Report No. DE 49, October 1979.

5. HYDRAULICS RESEARCH STATION. Sludge disposal in Liverpool Bay, Eighth bed monitoring survey, September 1980 - January 1981. Report No. DE 54, August 1981.

6. HYDRAULICS RESEARCH STATION. Sludge disposal in Liverpool Bay, Ninth bed monitoring survey, November 1981 - January 1982. Report No. DE 58, September 1982.

7. HYDRAULICS RESEARCH STATION. Sludge disposal in Liverpool Bay. Tenth bed monitoring survey, September 1982. Report No. DE 64, August 1983.

8. HYDRAULICS RESEARCH. Sludge disposal in Liverpool Bay. Eleventh bed monitoring survey, November 1983. Report SR9 January 1985.

9. HYDRAULICS RESEARCH. Vertical distributions of heavy metals and organic carbon in Liverpool Bay (East). Report SR26 1985

DD(B) 650449 1/86

Figures

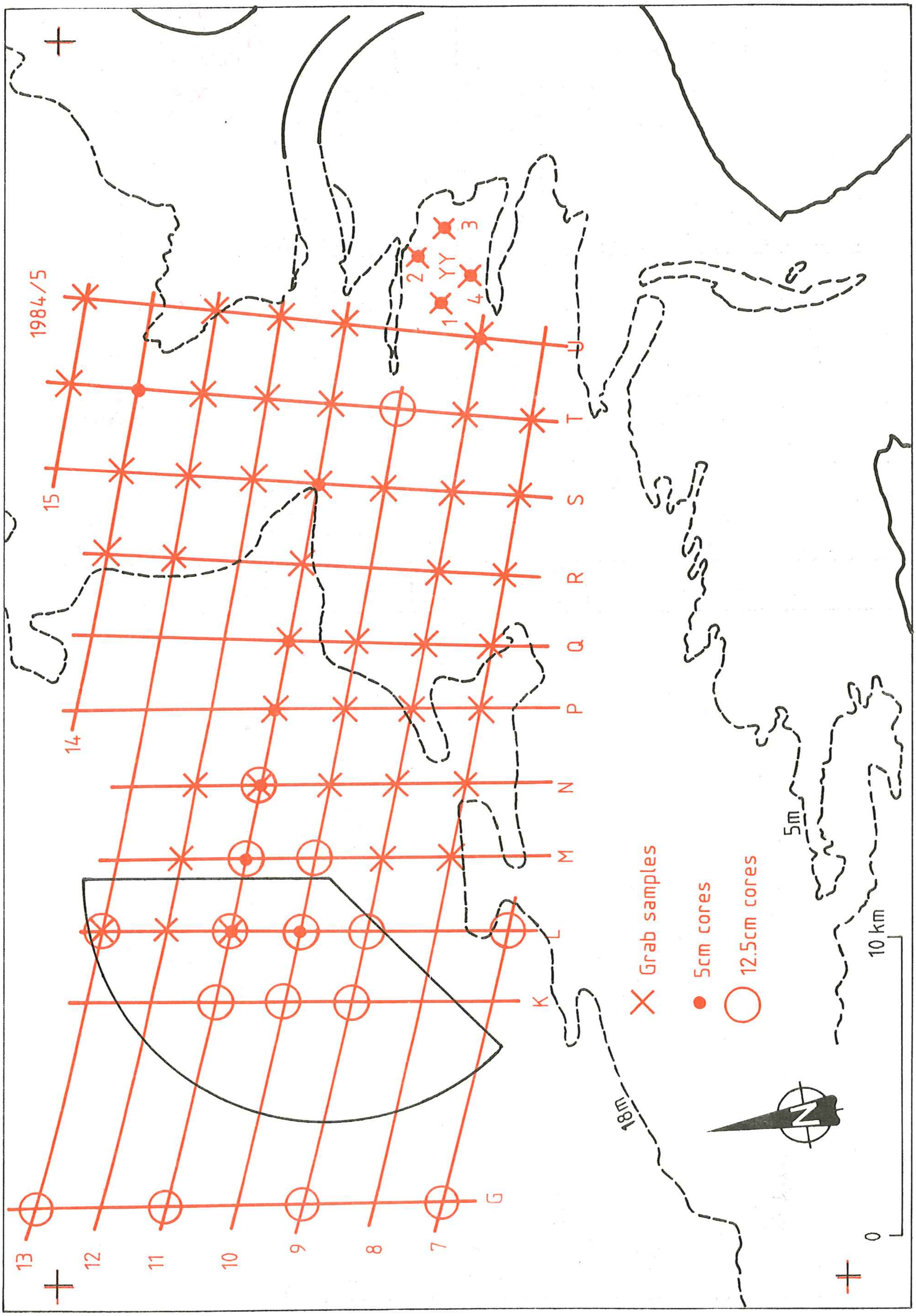


Fig 1 Monitoring positions

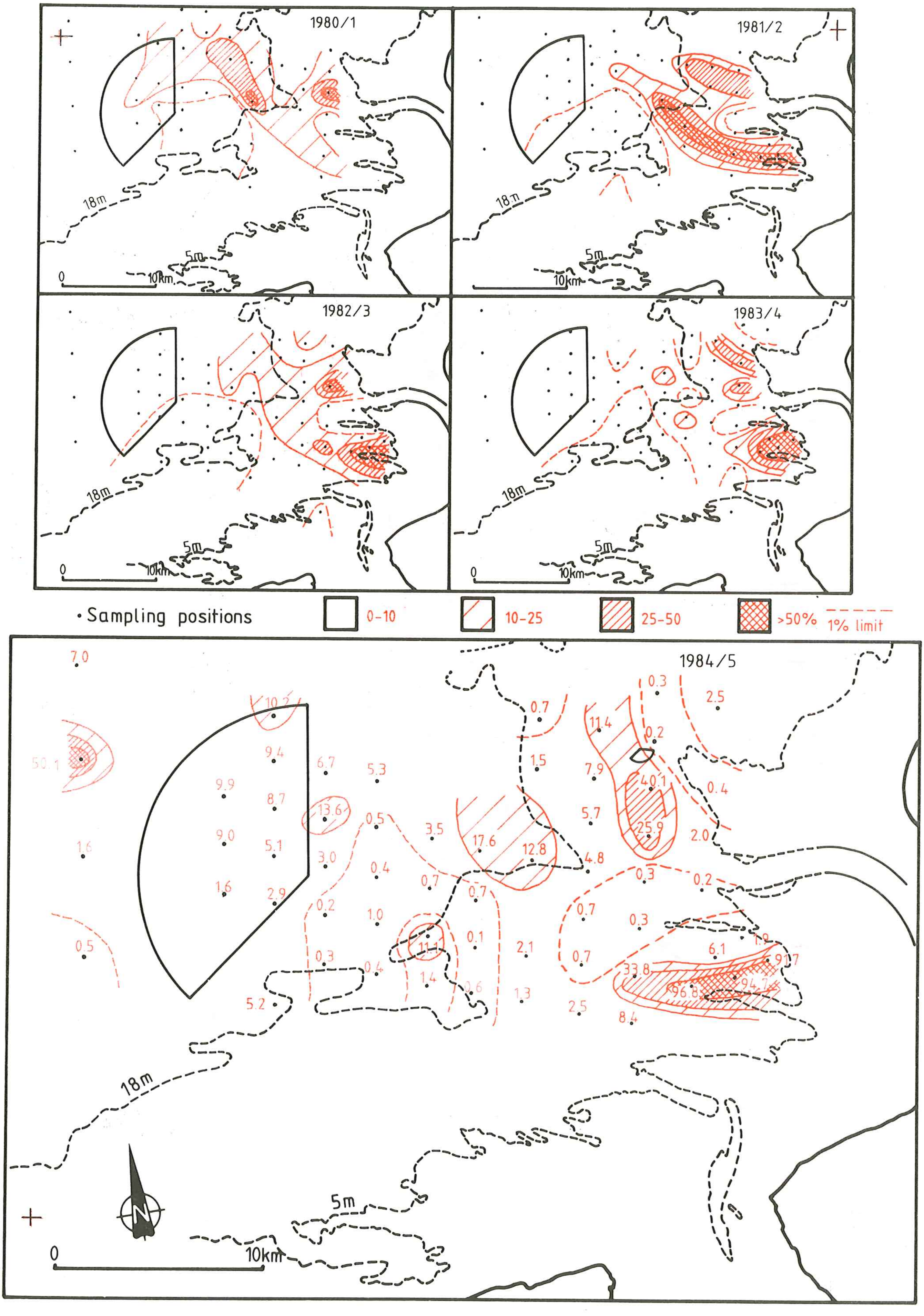


Fig 2 Mud content of the top 25 mm of bed

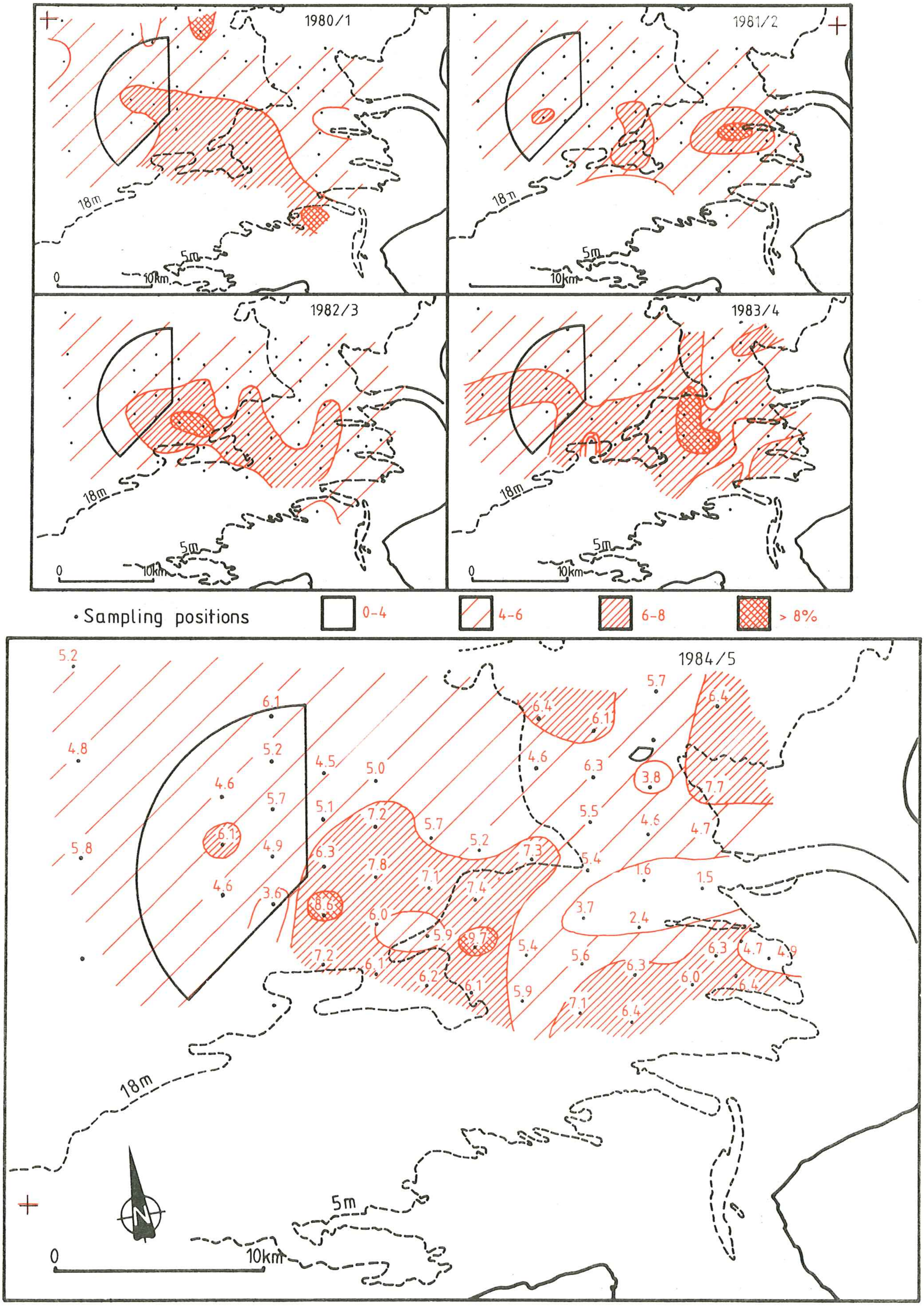


Fig 3 Organic matter content of mud from the top 25 mm of bed

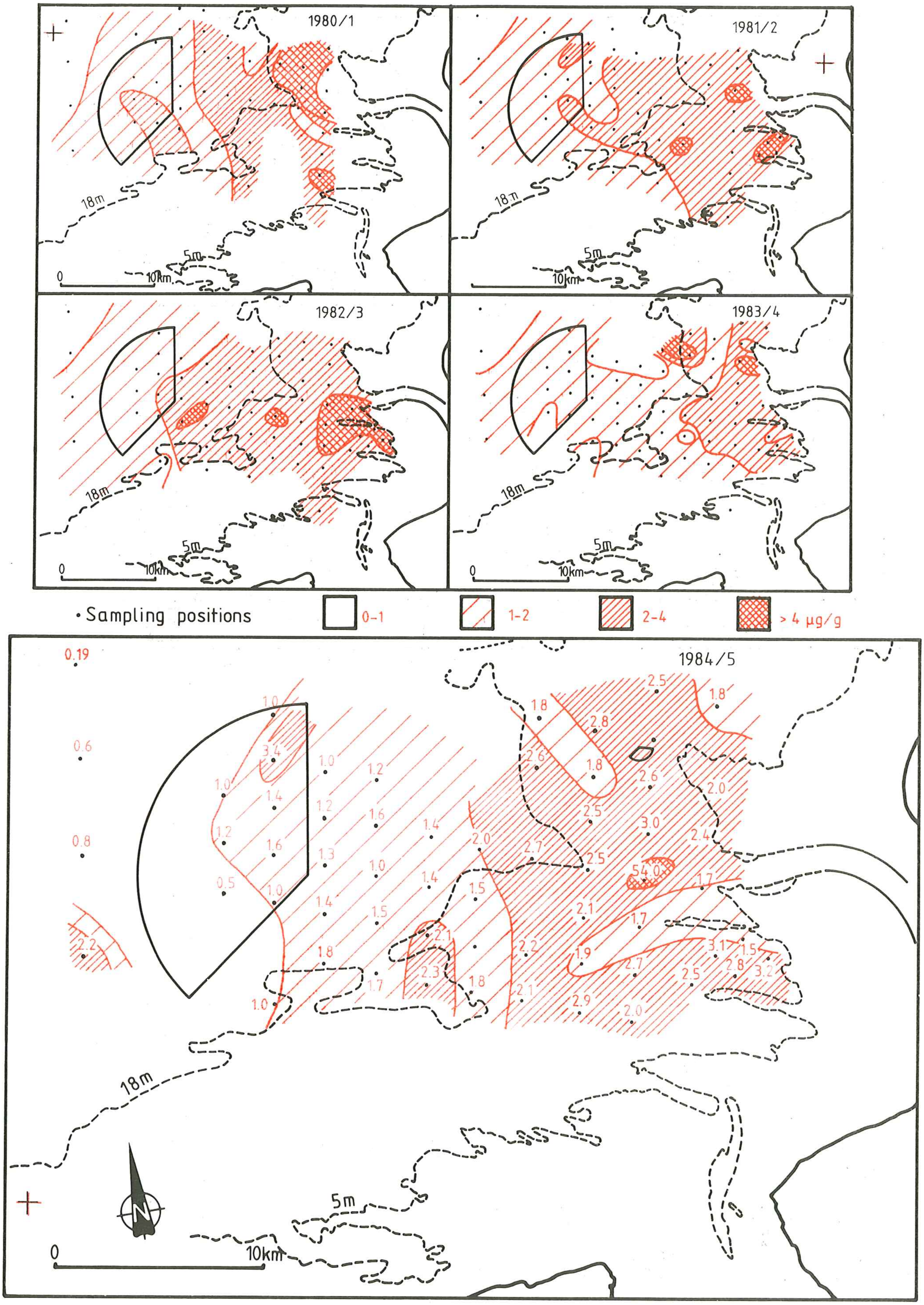


Fig 4 Mercury concentration in mud from the top 25mm of bed

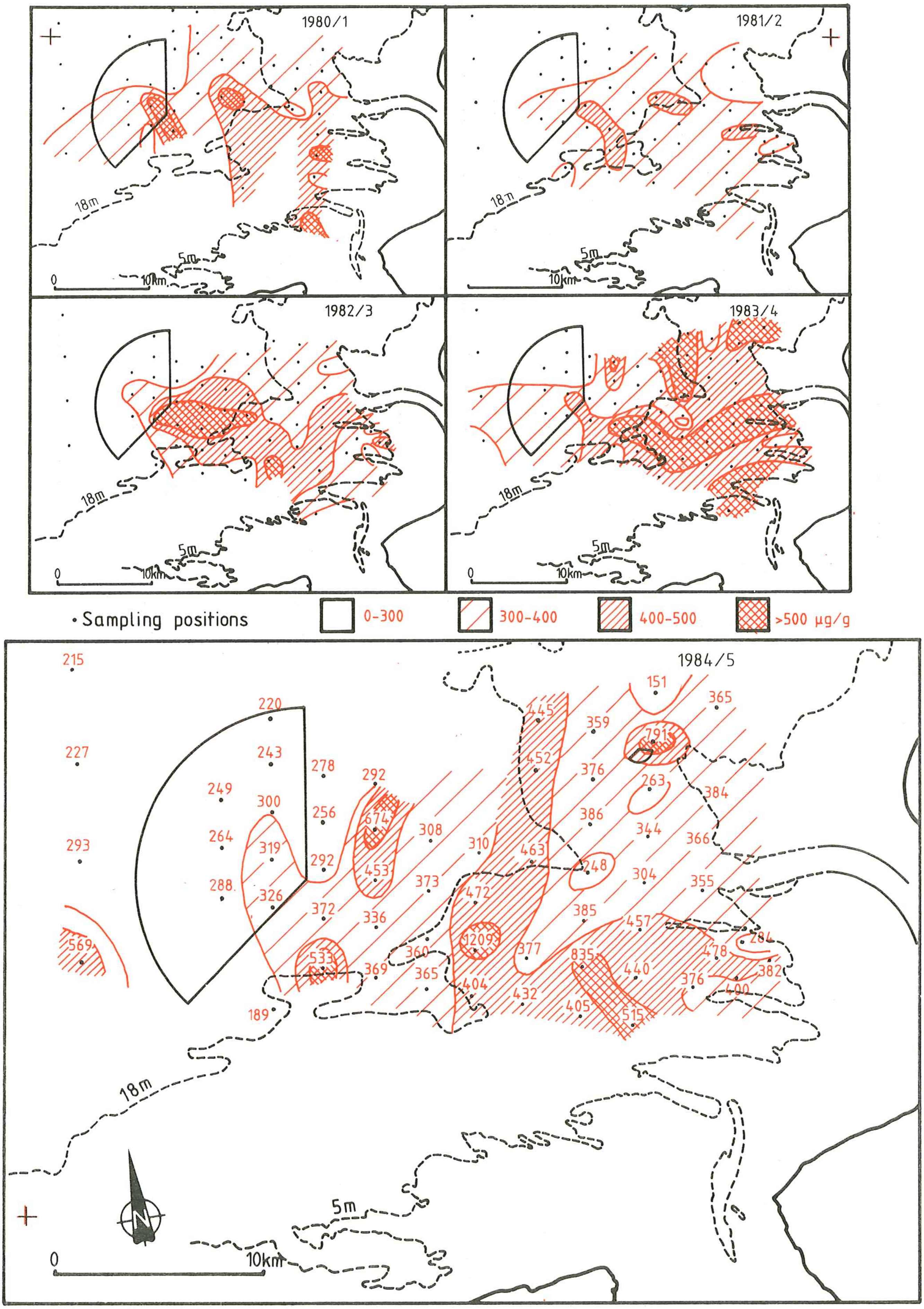


Fig 5 Zinc concentration in mud from the top 25 mm of bed

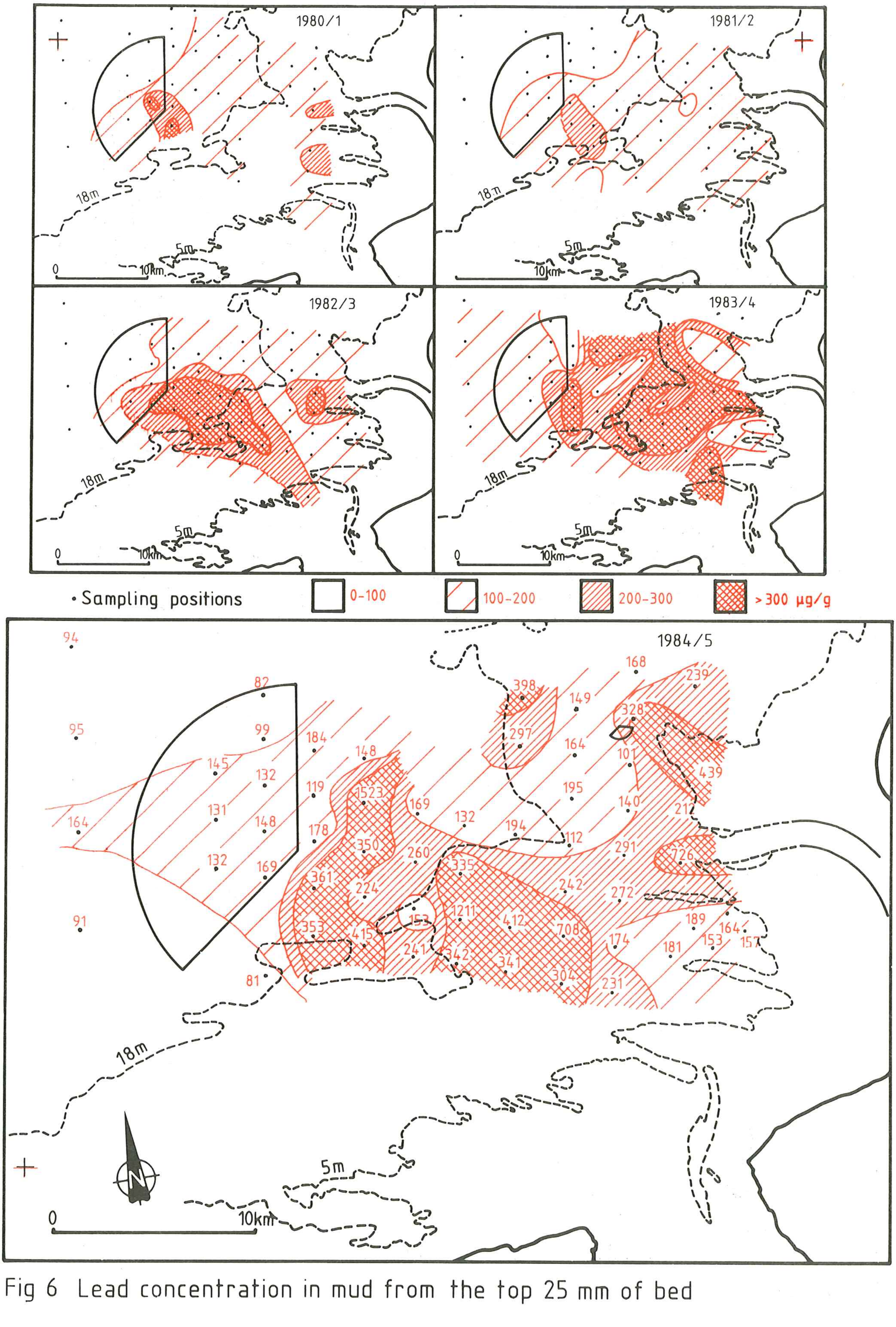


Fig 6 Lead concentration in mud from the top 25 mm of bed

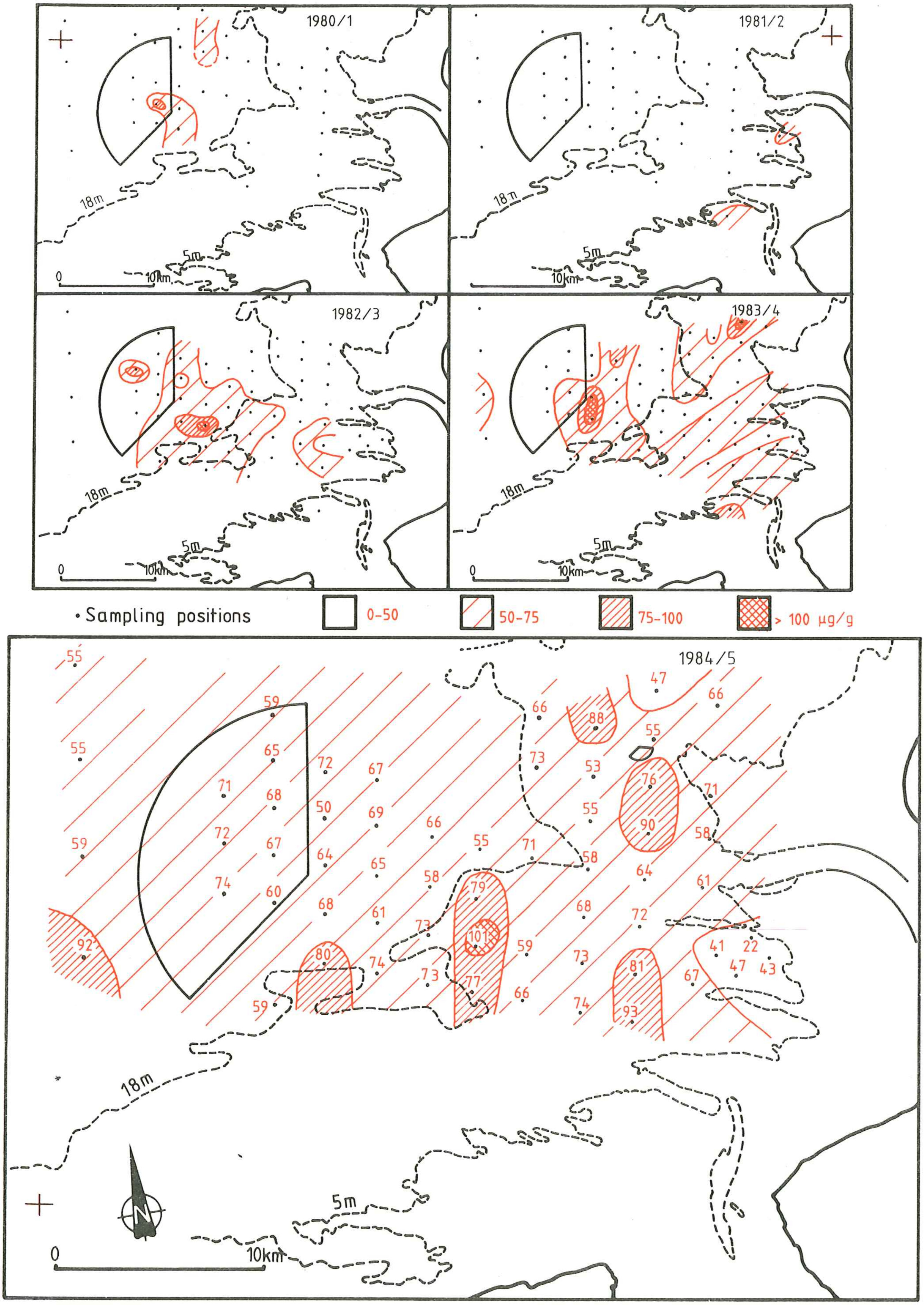


Fig 7 Nickel concentration in mud from the top 25 mm of bed

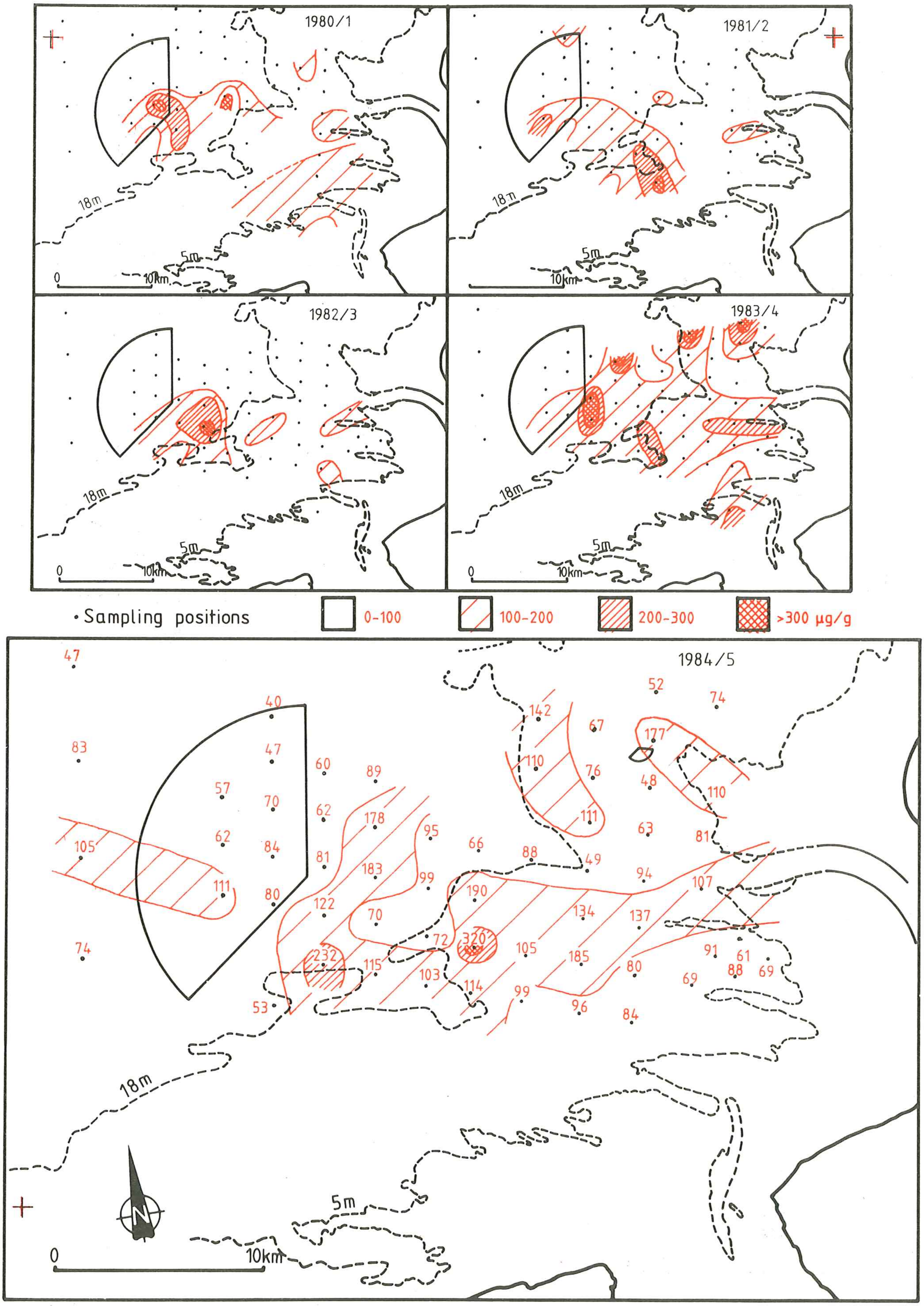


Fig 8 Copper concentration in mud from the top 25 mm of bed

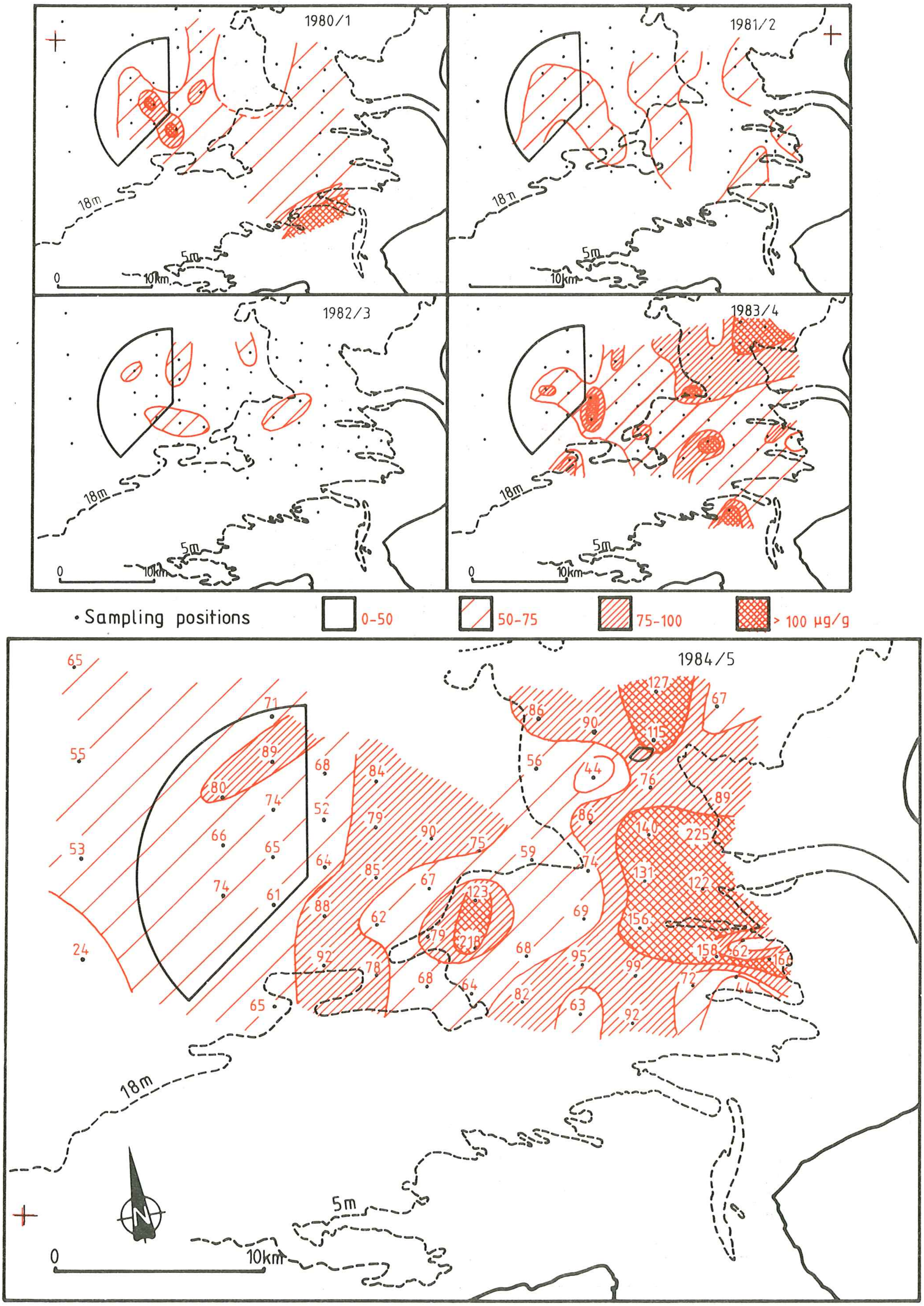


Fig 9 Chromium concentration in mud from the top 25 mm of bed

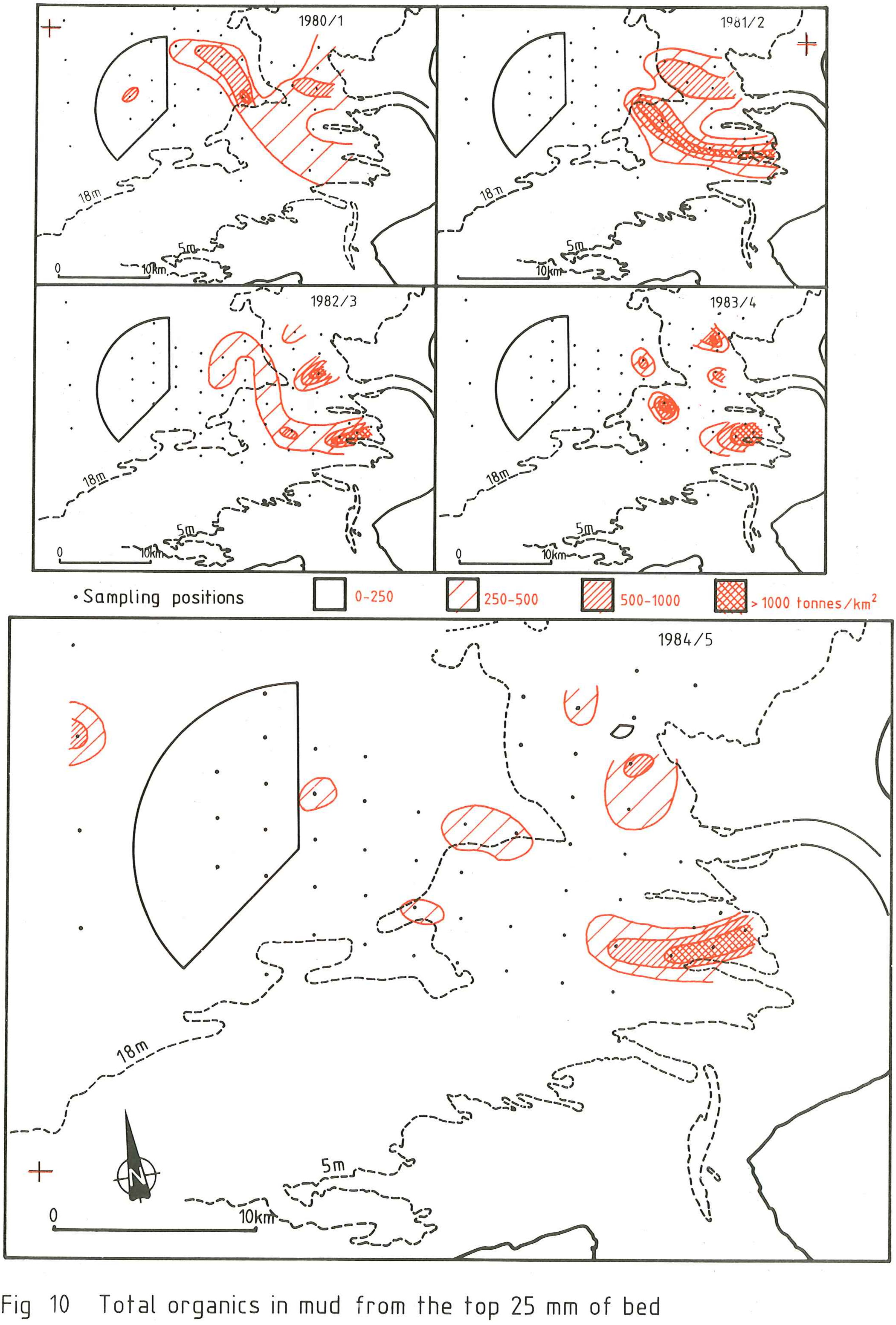


Fig 10 Total organics in mud from the top 25 mm of bed

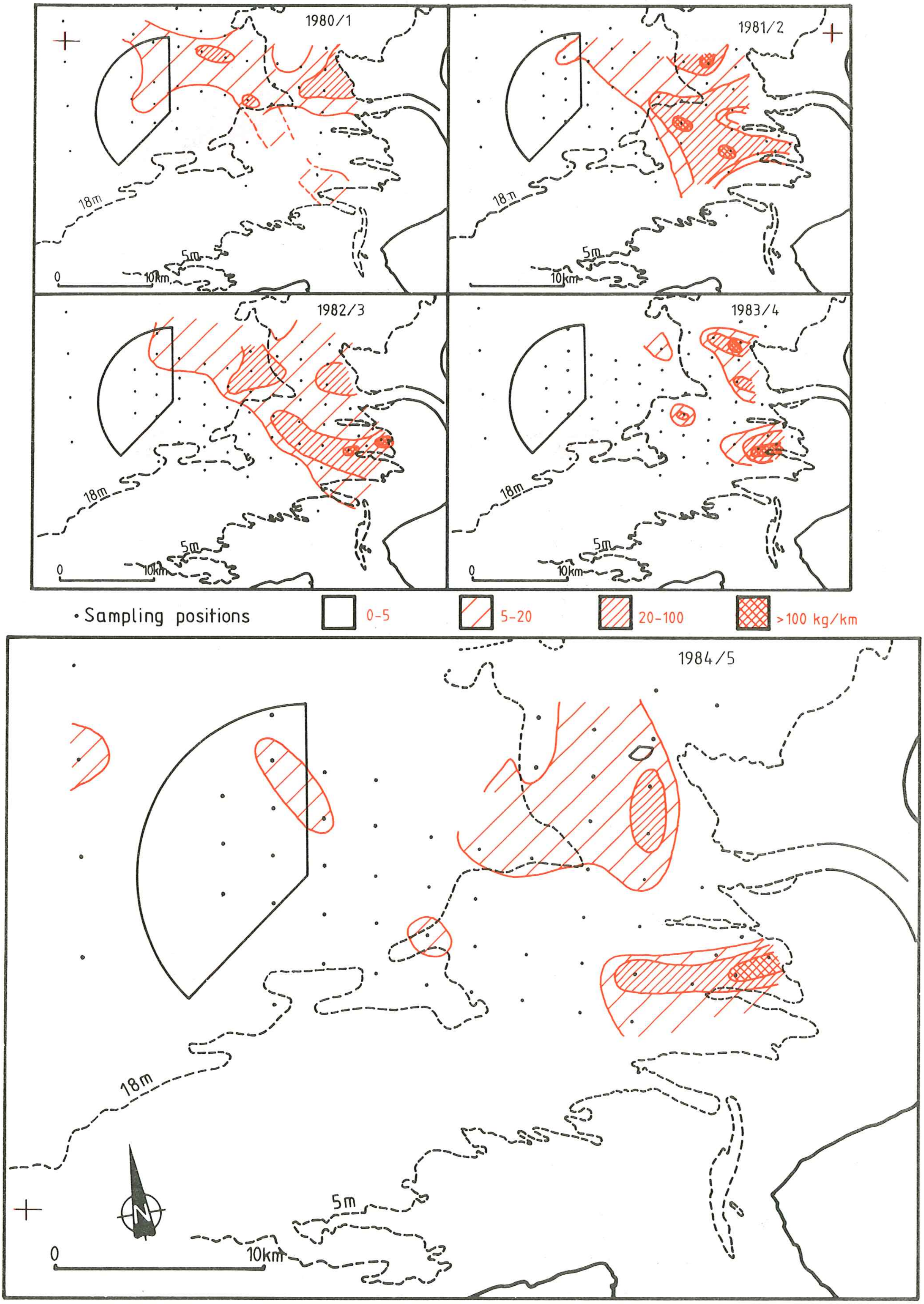


Fig 11 Total mercury in mud from the top 25mm of bed

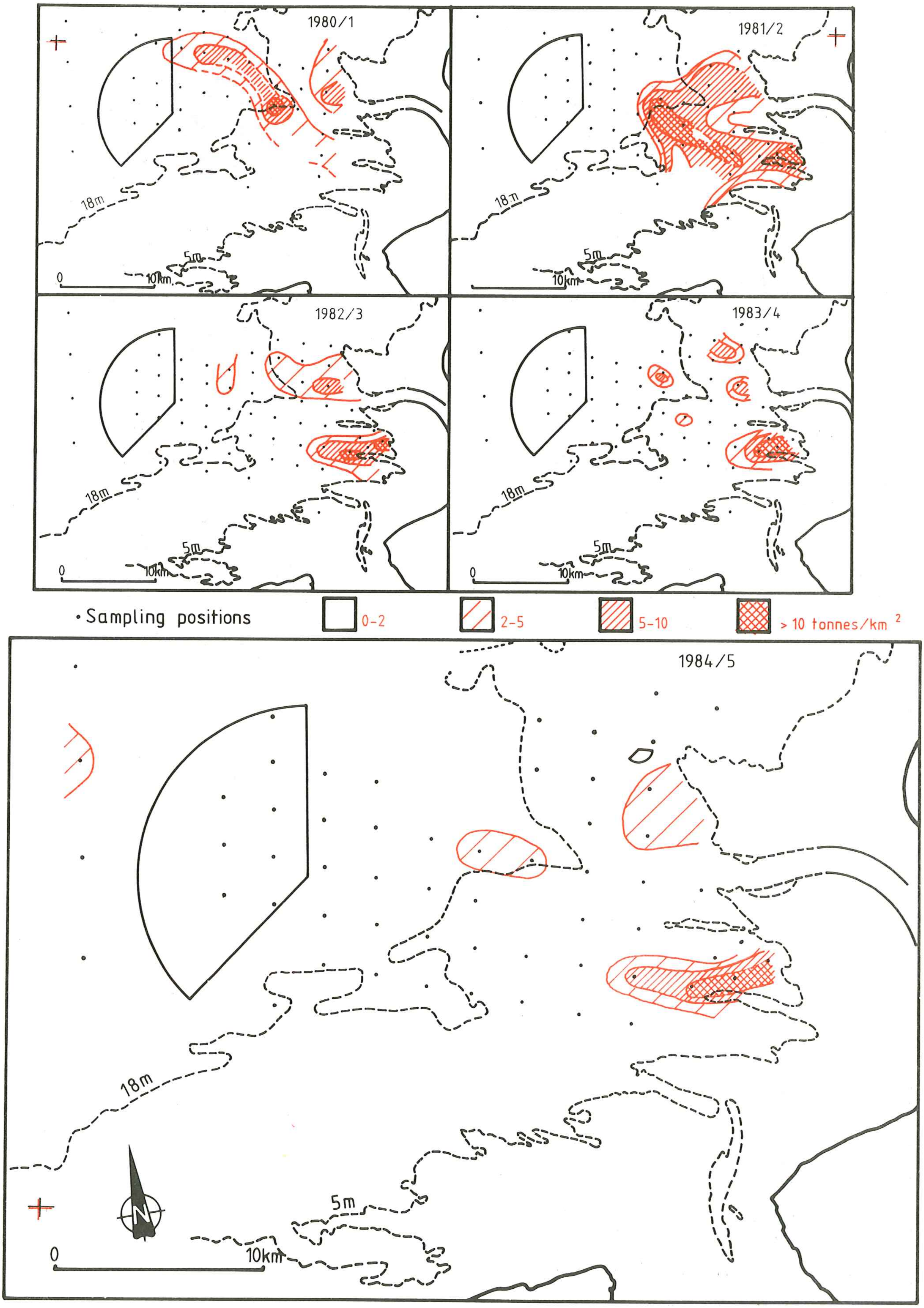


Fig 12 Total zinc in mud from the top 25mm of bed

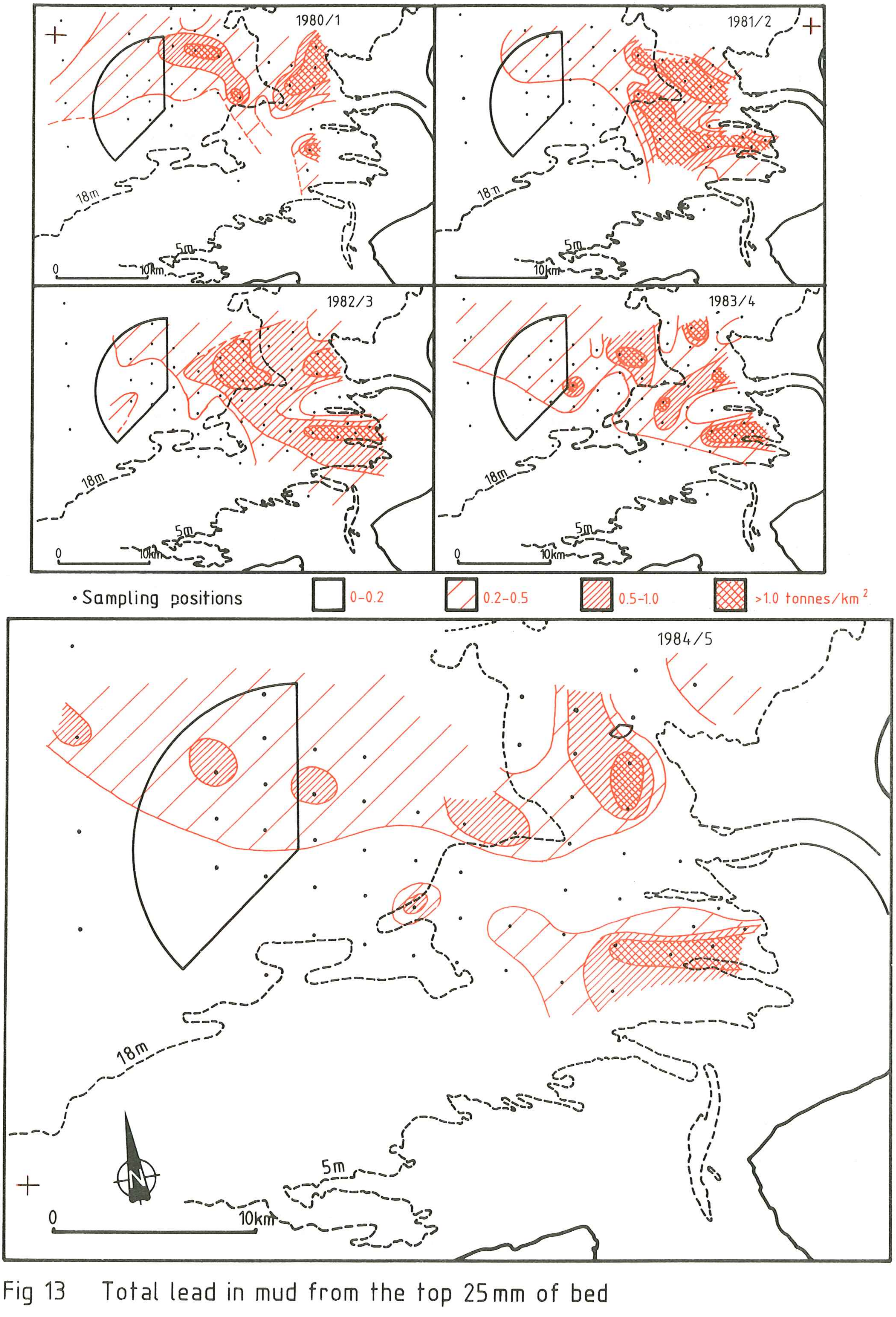


Fig 13 Total lead in mud from the top 25mm of bed

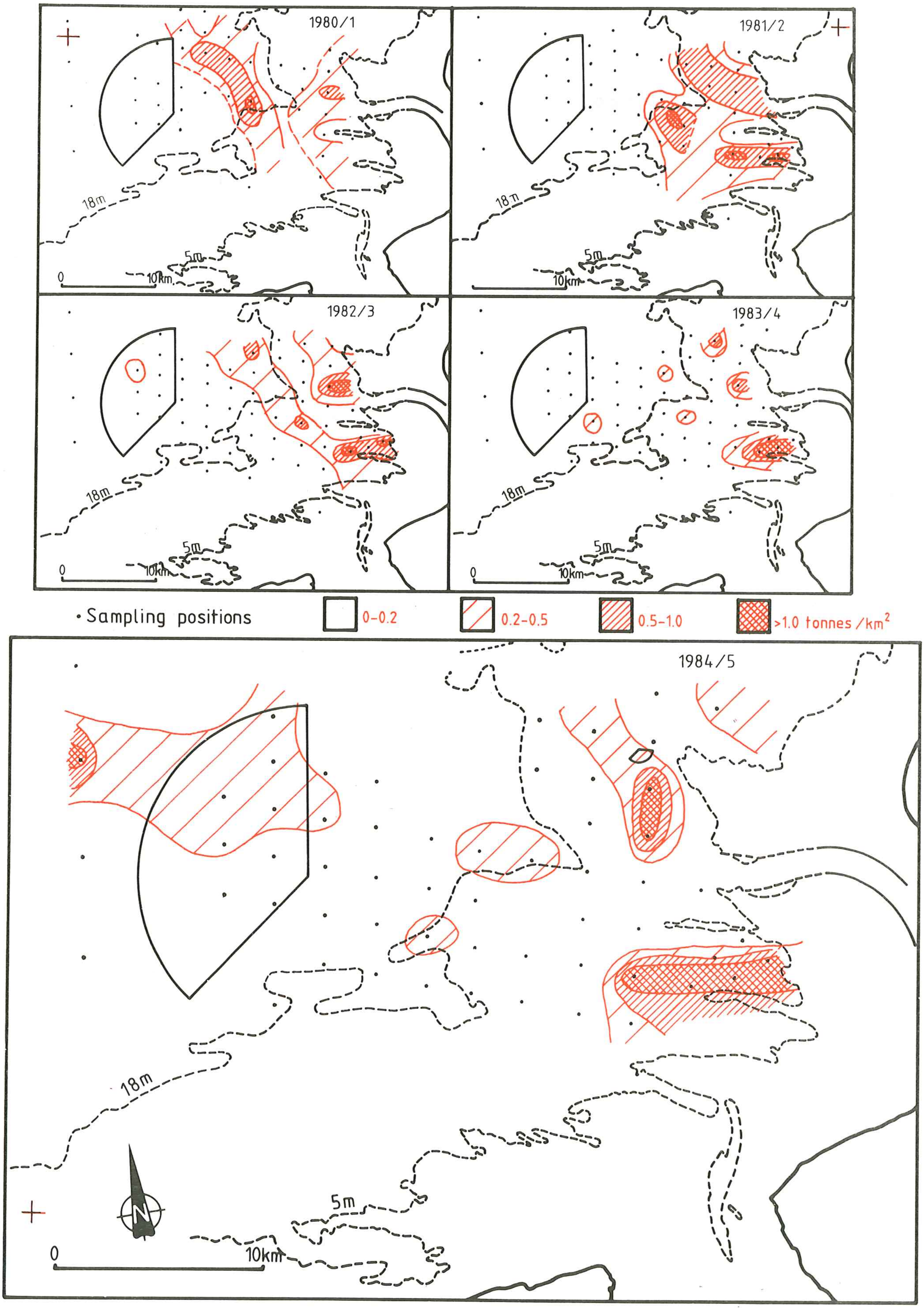


Fig 14 Total nickel in mud from the top 25 mm of bed

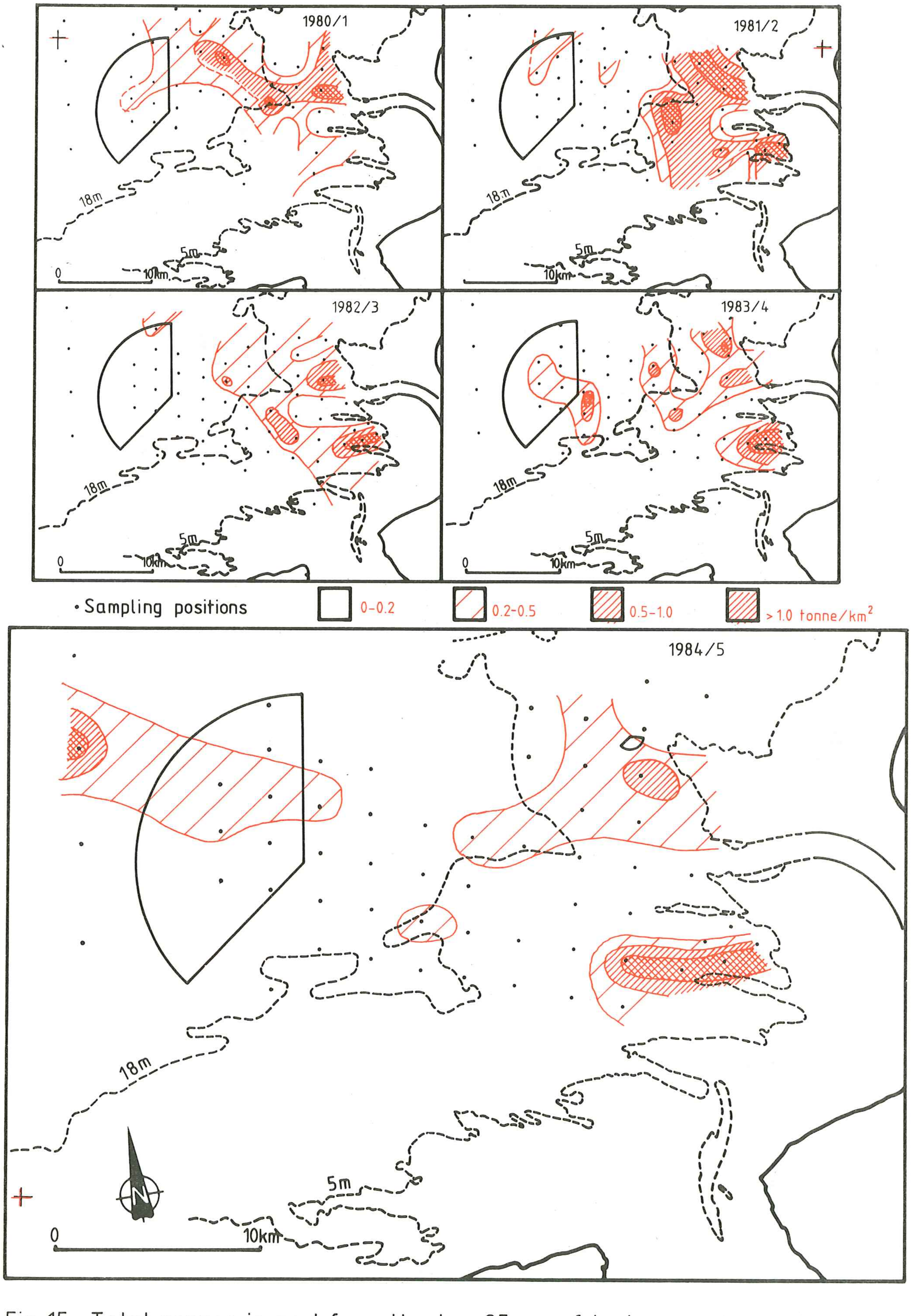


Fig 15 Total copper in mud from the top 25 mm of bed

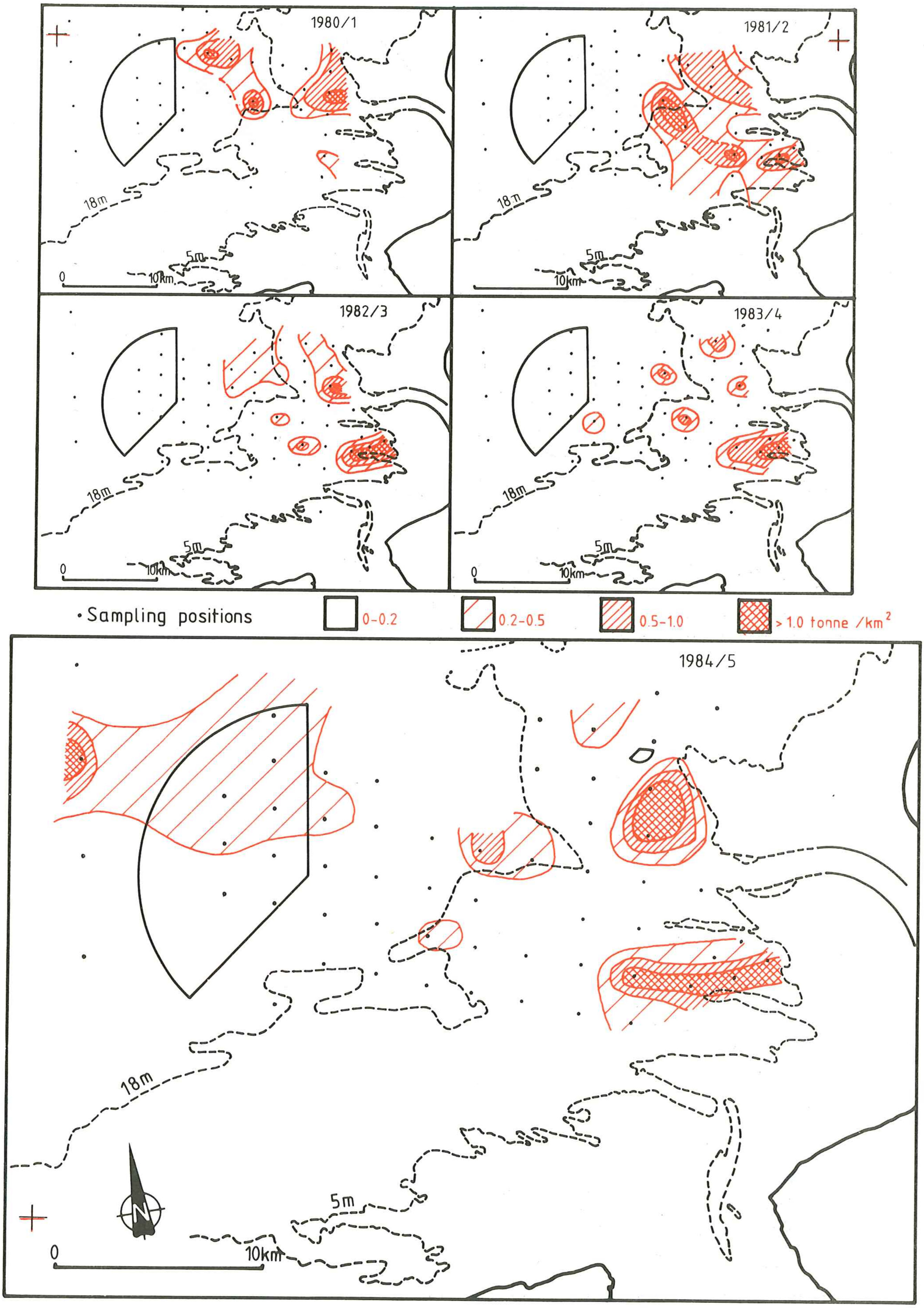
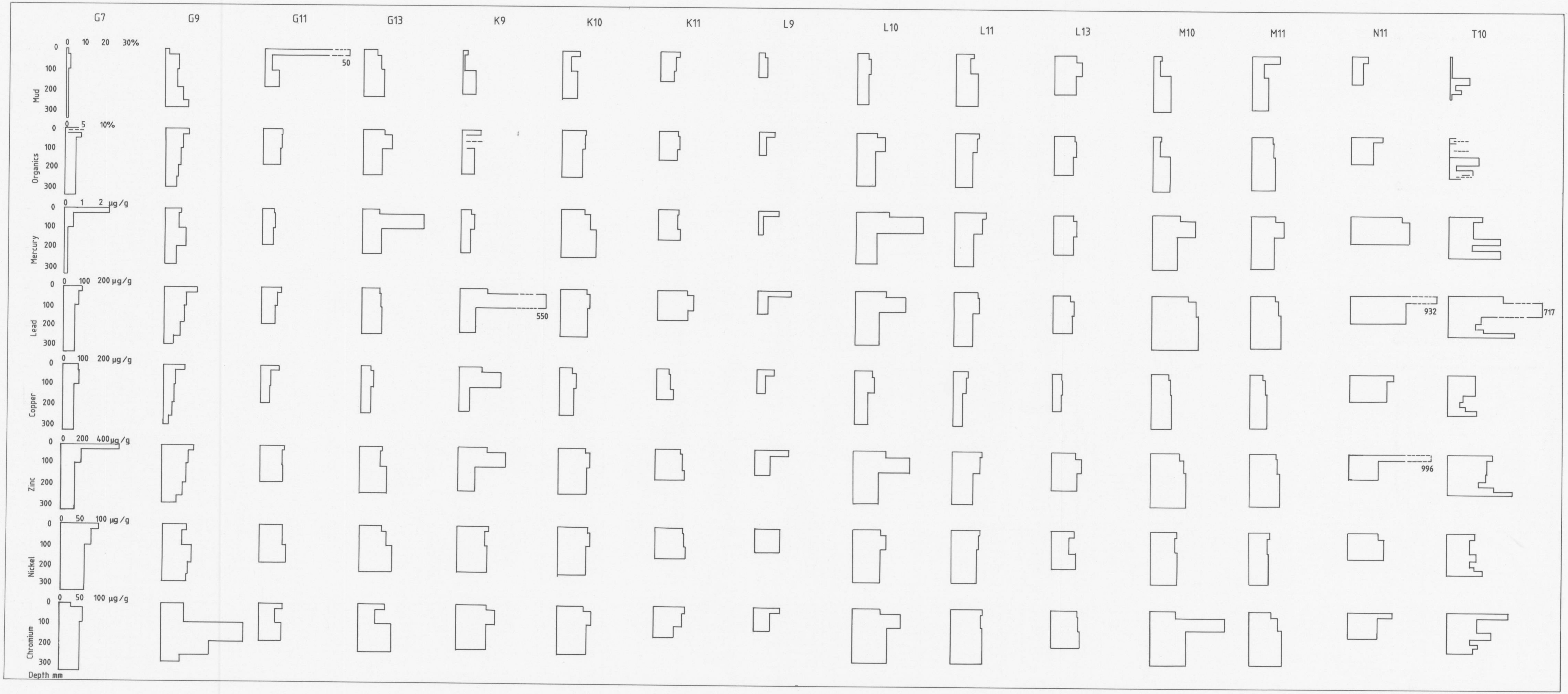


Fig 16 Total chromium in mud from the top 25 mm of bed



Depth profile of the 125mm diameter cores

Fig 17

Depth profiles of the 50 mm diameter cores

Fig 18