Hydraulics Research
Wallingford

SLUDGE DISPOSAL IN LIVERPOOL BAY

Thirteenth bed monitoring survey

December 1985

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ABSTRACT

This report describes the thirteenth survey carried out in December 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, seven bed surveys have been carried out (Refs 4-9) by Hydraulics Research (HR).

The last, the subject of this report, was undertaken in December 1985 from the M.V. Branding with the assistance of Mr D Limpenny of the MAFF Burnham Laboratory and is the thirteenth in the overall series.

Grab samples were taken at 66 sites and a 50mm core at one other site (Fig.1). The core sample at YY4 was the only success in a plan to seek undisturbed basal strata so that the depth of metal penetration could be determined. Unfortunately a malfunction of the vibro-corer prevented recovery of further cores. However, further cores were successfully taken in March 1986 and the results from the single core obtained in December 1985 will be combined with our report on the 1986 coring exercise. Of the grab sample sites, twenty-three were from the group of twenty-four standard sites visited on each occasion since 1973. The remaining one, T6, the closest to the Dee estuary, was omitted on this occasion.

The thirteenth survey included positions in the north (P12, Q12, Q13 and T12) which were not covered last year because of adverse weather conditions. Site R12 was of particular interest because of the coal/clinker deposits found there in the past. U14, a site visited for the first time, and U12 and U13 visited initially last year, were included to examine any effects of the neighbouring dredged spoil ground.

In the laboratory, the top 25mm of each grab sample was separated and the top 25mm of the one core taken were split into mud and sand fractions by wet sieving at 63μm. A modification to our normal laboratory routine was to dry the mud fraction at 50°C instead of the much slower air drying used previously. It had been found that no significant differences could be found between samples which had been air dried and those which had been dried at 50°C. The saving of time allied to the possibility of contamination when the samples were left air drying for a period of several weeks caused us to revise this part of the analytical procedure. The sand fraction was dried at 110°C and the percentage dry weight recorded.

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 (NBS 1645) and our own reference samples were included with the samples submitted to the commercial analytical laboratory for heavy metal determinations by atomic absorption spectrophotometry as in the previous three surveys. Correction factors were derived and applied to ensure that the results of the current survey are as comparable as possible with those of the previous four surveys for which the data is included in this report.

The factors used on this occasion were:

Hg	1.085	Pb	0.935
Cu	0.907	Ni	0.884
Zn	1.000	Cr	0.902

They are typical of those used in the past and in most cases are within the ±10% claimed accuracy for this method of analysis.

Data from the eighth survey (1979/80) included in the last report (Ref.9) has been omitted from this report partly because of lack of space but also because of the limited covereage of the eighth survey (40 site samples compared with 51, 63, 64, 60 and 67 in Surveys 9 -13 respectively).

The last four 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 67 sampling positions is shown in Fig 2. The mud distribution is similar to that found in past surveys although there is a peak to the north, close to the new spoil ground, that has not been detected before. The value of 85% mud at R14 this year compares with 2.9, 0.2, 0.7% on Surveys 10 - 12.

The mean values and relative standard deviations over the past four years when similar coverage was maintained are as follows:

Survey No.	10	11	12	13
Mean %	11.0	10.8	10.8	10.8
RSD %	173	210	201	203

These show remarkable agreement and indicate that although the peaks may move from year to year, the overall mud content is relatively unchanged.

3 ORGANIC MATTER

The distribution of organic matter in the mud fraction is shown in Fig 3. Three samples had too little mud to allow for organic carbon and heavy metal analysis so the organic analysis was omitted. The average concentration is a little higher than last year but similar to that found in 1983/4 (Survey 11). The number of extreme values is much reduced and for the first time for ten years there are no concentrations exceeding 8%.

The mean values and the relative standard deviations for the last four surveys are as follows:

Survey No	10	11	12	13
Mean, %	5.8	6.4	5.5	6.3
RSD %	18	32	25	14

The "total" organic matter content (Fig 10) calculated from the product of the mud and organic matter percentage abundances, and a factor for the average dry bulk density of the top 25mm of bed sediment, is similar to that of the past four years except for the fact that the high mud content in the north of the area mentioned previously results in a high total organic figure in that area.

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 (63μ m) 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.

As noted with the organic matter, there are generally fewer peaks in the metal concentrations on this survey than for any time in the past seven years that HR has been analysing for heavy metals. Mercury has no concentration exceeding 4μ g/g (Fig 4) whereas most previous surveys have shown peaks, sometimes greatly exceeding 4μ g/g.

Zinc and copper also show fewer excessive values than average (Figs 5 & 8) although the extent of the coverage of moderate concentrations of zinc seems to be extending, although the present survey is not significantly different from that of two years ago.

Lead shows a very noticeable drop in peak values, only one in excess of 700μ g/g whereas in the previous three years there were 6, 13 and 4 respectively (Fig 6). The survey area in general and the Mersey outfall area in particular display a fall in lead concentrations compared with those of the last three years.

Nickel and chromium (Figs 7 & 9) show similar patterns. Nickel having no peak above 100μ g/g and more uniform coverage of the area. Chromium showing the same grouping of peaks as last year but the concentration and area of these high levels has decreased.

The mean values and relative standard deviations for the last four surveys are as follows:

Survey No	10		11		12		23	
	M mg/g	RSD %	M mg/g	RSD %	M mg/g	RSD %	M mg/g	RSD %
Mercury	3.8	135	2.0	97	2.8	249	1.9	39
Zinc	388	45	497	47	386	43	465	25
Lead	349	158	459	120	266	93	172	56
Nickel	51	37	56	51	66	20	55	17
Copper	86	65	165	116	99	50	90	43
Chromium	43	24	73	50	85	43	69	25

"Total" metals are again closely correlated with the mud content. The four main areas of high concentrations are to the north and south of the Mersey outfall, to the far north around R14, and lastly the northern sector of the sludge dumping ground. The abundance of mud in areas between the Mersey outfall and Newcome Knoll apparently results in the region being the major sink of heavy metals. North of the Mersey outflow there is the other zone of metal accumulation that has been consistently present since our measurements began. The high concentration in the neighbourhood of R14 has only appeared this year and is due to the higher mud content mentioned previously. The high in the northern part of the sludge dumping ground, which has concentrations only just above background, has been seen occasionally in the past although the extent of the area is quite variable.

The existence of metal concentrations well above average at certain positions is not easy to attribute to any one cause. Some possibilities are noted below.

(a) We have found in past surveys that high metal concentrations are often associated with low mud concentrations. This has now been attributed to a shift in the equilibrium towards high metal concentration on the mud when the mud content is limited and soluble metals are abundant. The video record made in 1973 (Ref.2) showed erosion of a layered bed when individual mud layers are "rolled-up" by the action of the current and swept away to become mud pellets which may be buried some distance away from their original point of deposition. Depending on the layer structure, the average mud content of a layered bed could be quite low.

(b) Metals are concentrated in the finer fraction of the sediment (Ref.10) when adsorption from solution takes place on the large surface area of clay particles. Although such particles are flocculated in sea water it is possible that a combination of currents and bottom topography could cause sorting of sediment sizes to give a higher concentration of clay particles in certain areas. The particle size distribution measurements made in earlier surveys did not differentiate between clay and silt sizes below 63 μm.

(c) Deposition of sediments originating from polluted waters of the Mersey or resuspension and deposition from spoil grounds before the sediments had a chance to mix with the surrounding mud of lower metal concentration.

Most peaks do occur in areas of low mud concentration and it is likely that small variations in mud content when the concentration is of the order of 1% or below can result in large variations in metals adsorbed when expressed in terms of the weight of metal per unit weight of mud.

Continual reworking by whatever cause would eventually result in an reduction of the higher concentrations with the mean values remaining roughly constant whilst the peaks (measured by the R.S.D.) decrease. This would be the case if no further input to the area occurred but if more metal containing sediments are coming into specific areas then these variations are likely to recur and be part of the natural fluctuation of surface sediments.

5 CONCLUSIONS

The thirteenth survey repeated the close sampling pattern first adopted on the tenth survey. Comparisons of the concentrations in the mud fraction of the top 25mm of bed suggest that, since last year, organics and zinc have increased. Copper, nickel, chromium and especially lead have decreased whereas the mud content itself has remained constant. The relative increases and decreases are within the range of the previous four years. The most significant conclusion from this year's results is the reduction in number and magnitude of the peak values giving a more uniform spread of metal concentrations.

One value of this extended monitoring of Liverpool Bay sediments is in determining the natural fluctuations of mud, organics and metal concentrations. No significant trend, upwards or downwards, is obvious. If there is a trend, it is still masked by the natural fluctuations. However, as the number of surveys increase and consistent methodology maintained it is beginning to be possible to quantify these variations and make it easier to detect an irregular pattern of results.

The deployment of the 2m vibro-corer recommended in last years report (Ref.9) was delayed until March 1986 and the results will be the subject of a further report.

In the next survey, attention will be given to examining the size grading in detail at any sites where peak metal values occur with the aim of distinguishing between the various causes of peak values.

6 ACKNOWLEDGEMENTS

Thanks are due to Mr J Binks for executing the sampling programme and to Mr D Limpenny of the MAFF Fisheries Laboratory, Burnham-on-Crouch for his assistance during the course of the field operations.

8 REFERENCES

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Figures

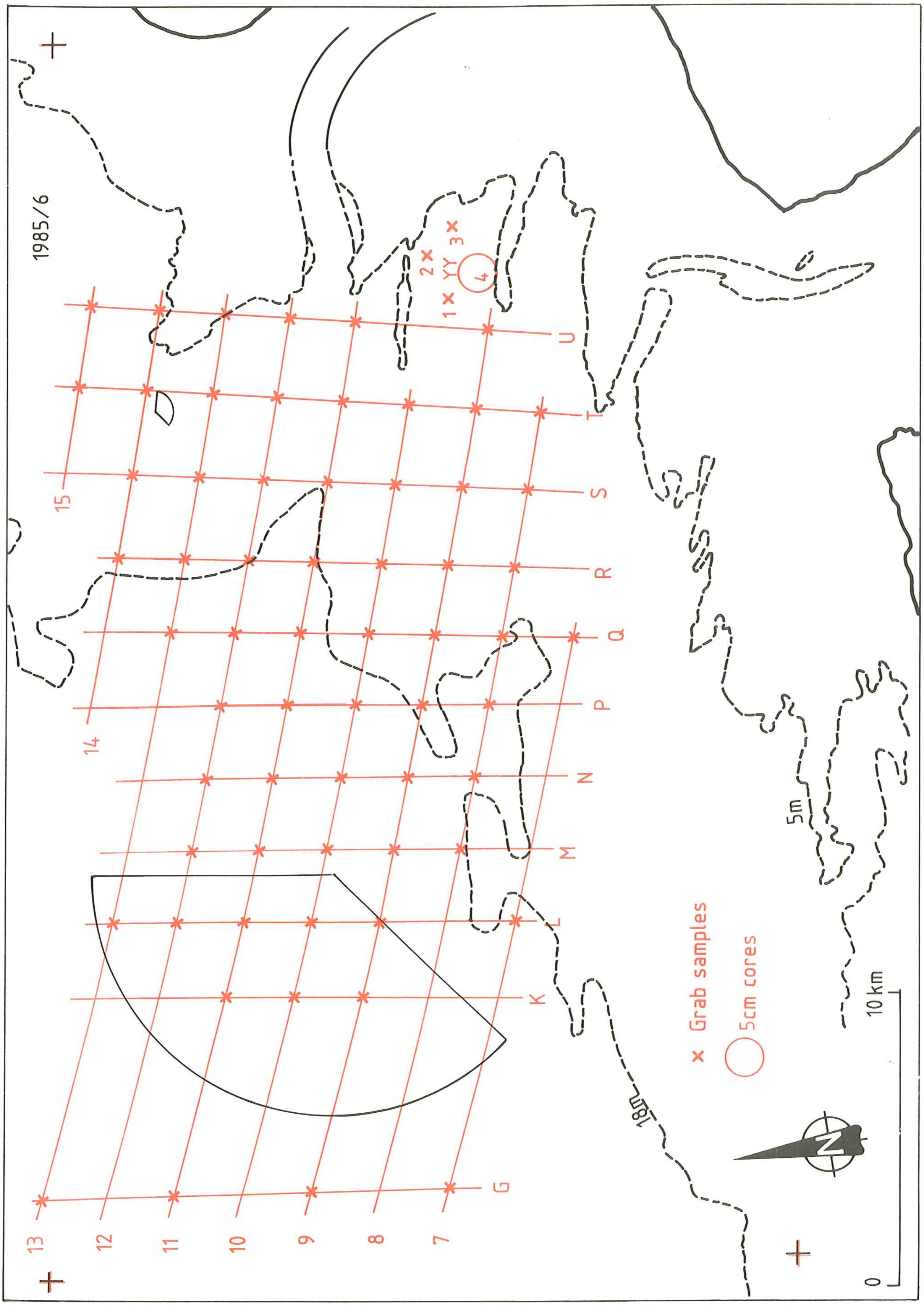

Fig 1 Monitoring positions

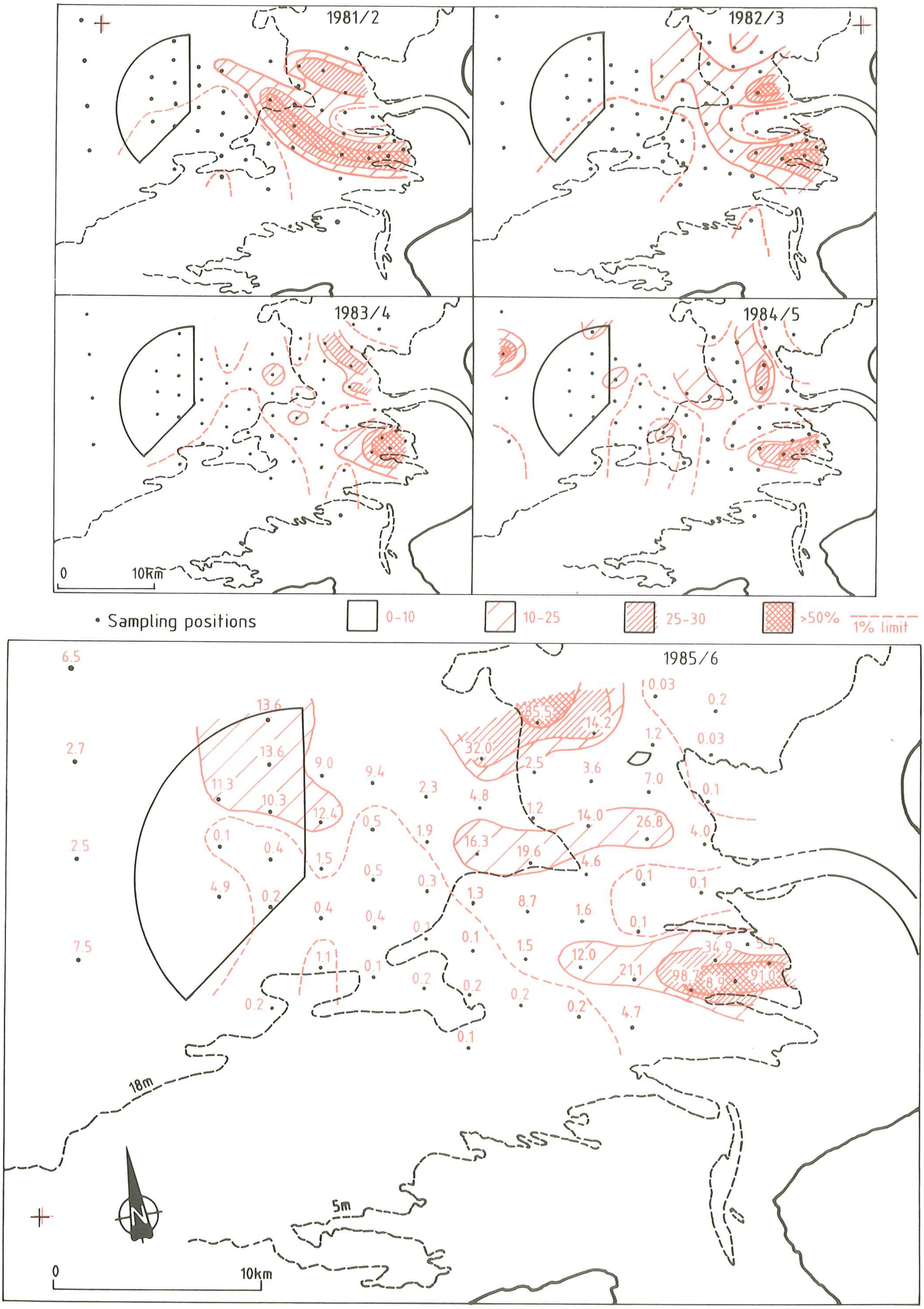

Fig 2 Mud content of the top 25mm of bed

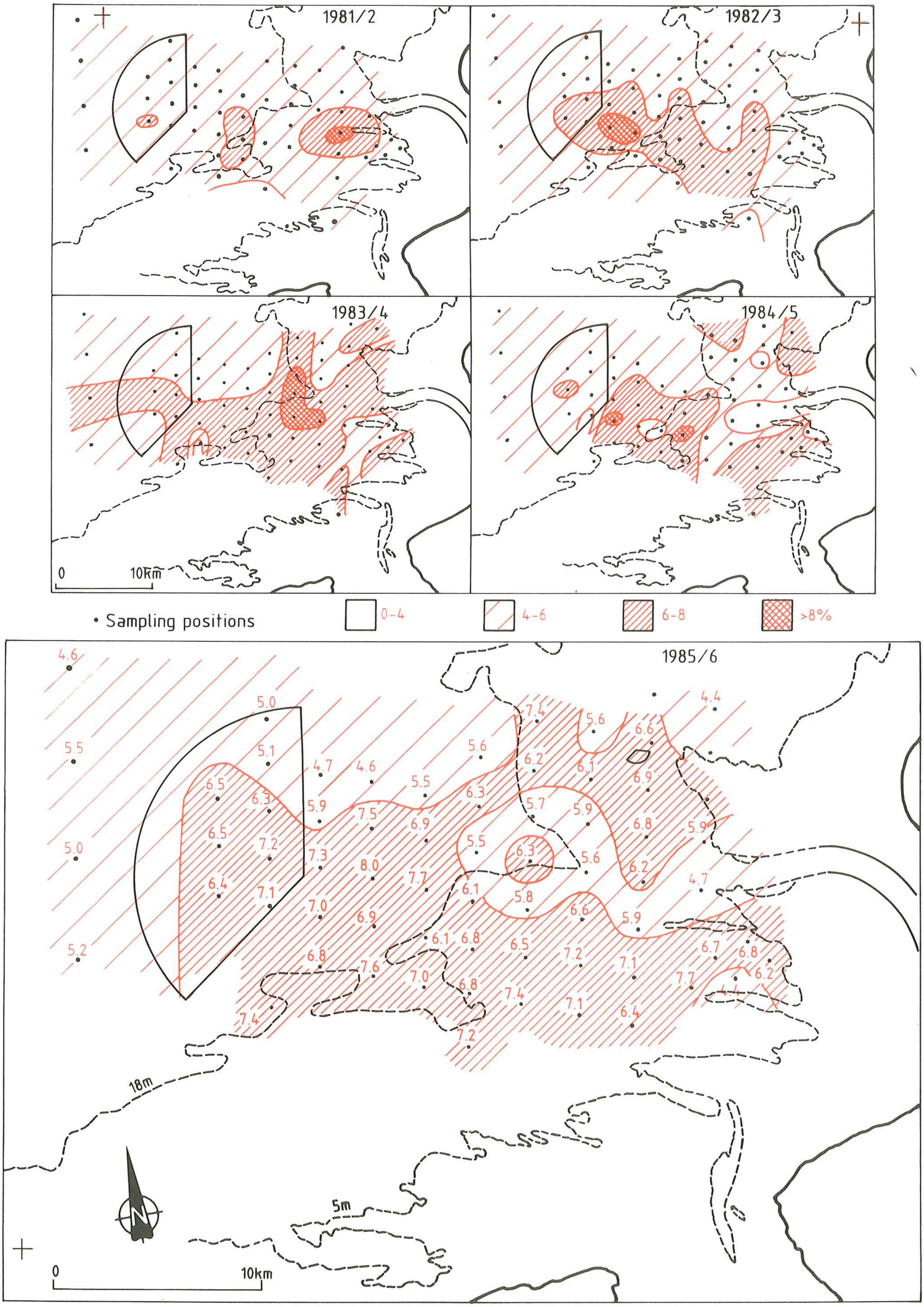

Fig 3 Organic content on the top 25mm of bed

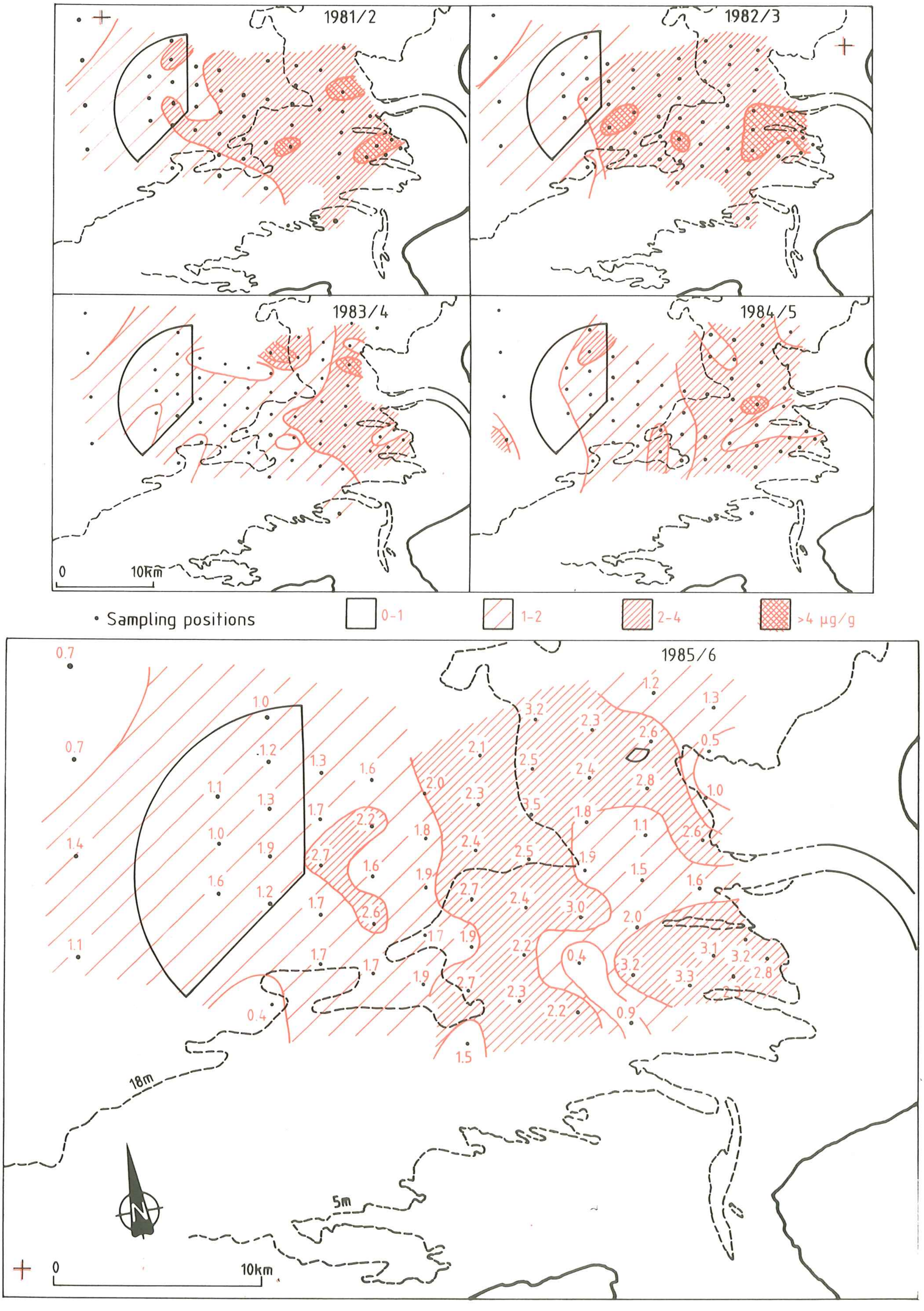

Fig 4   Mercury concentration in mud from the top 25mm of bed

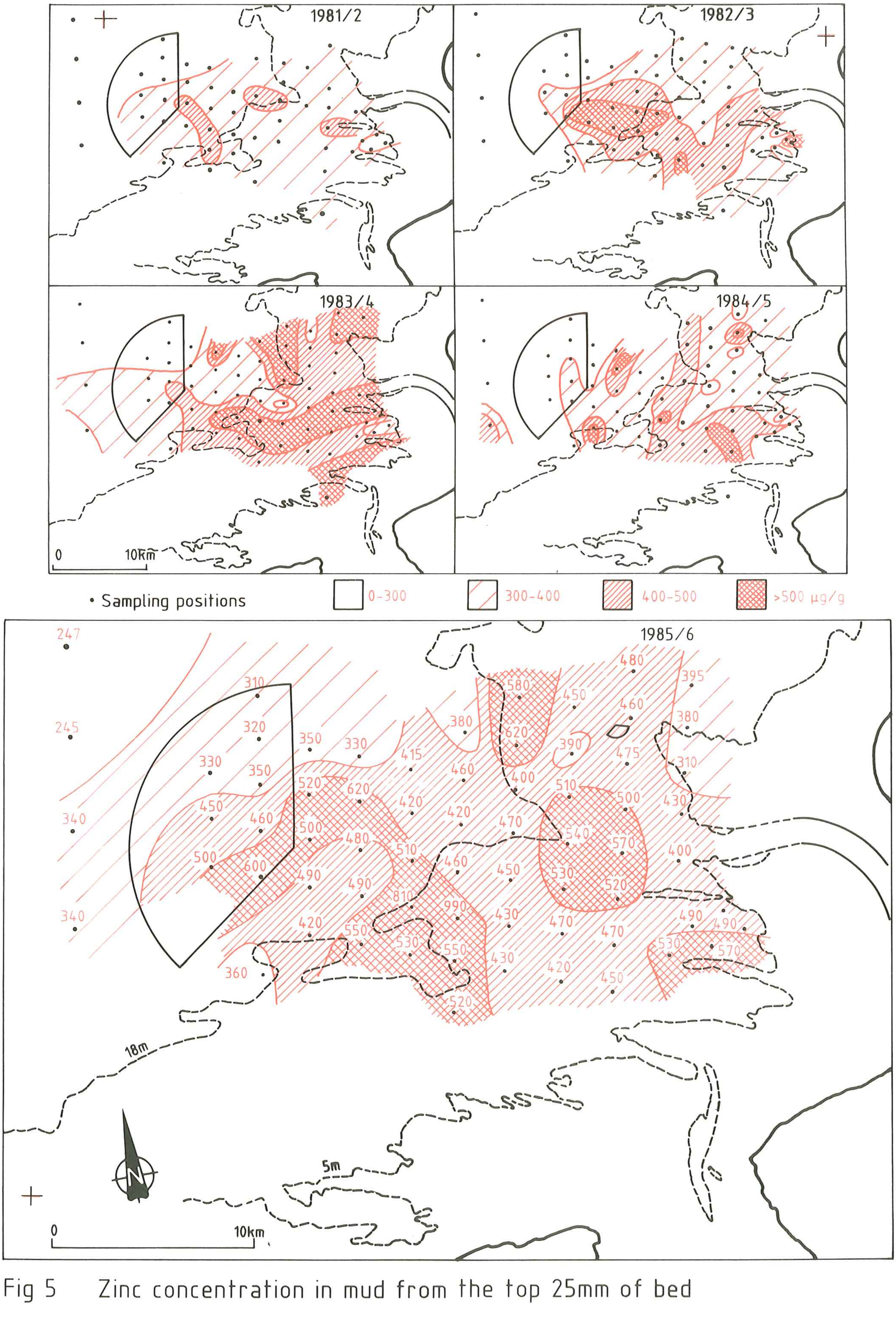

Fig 5 Zinc concentration in mud from the top 25mm of bed

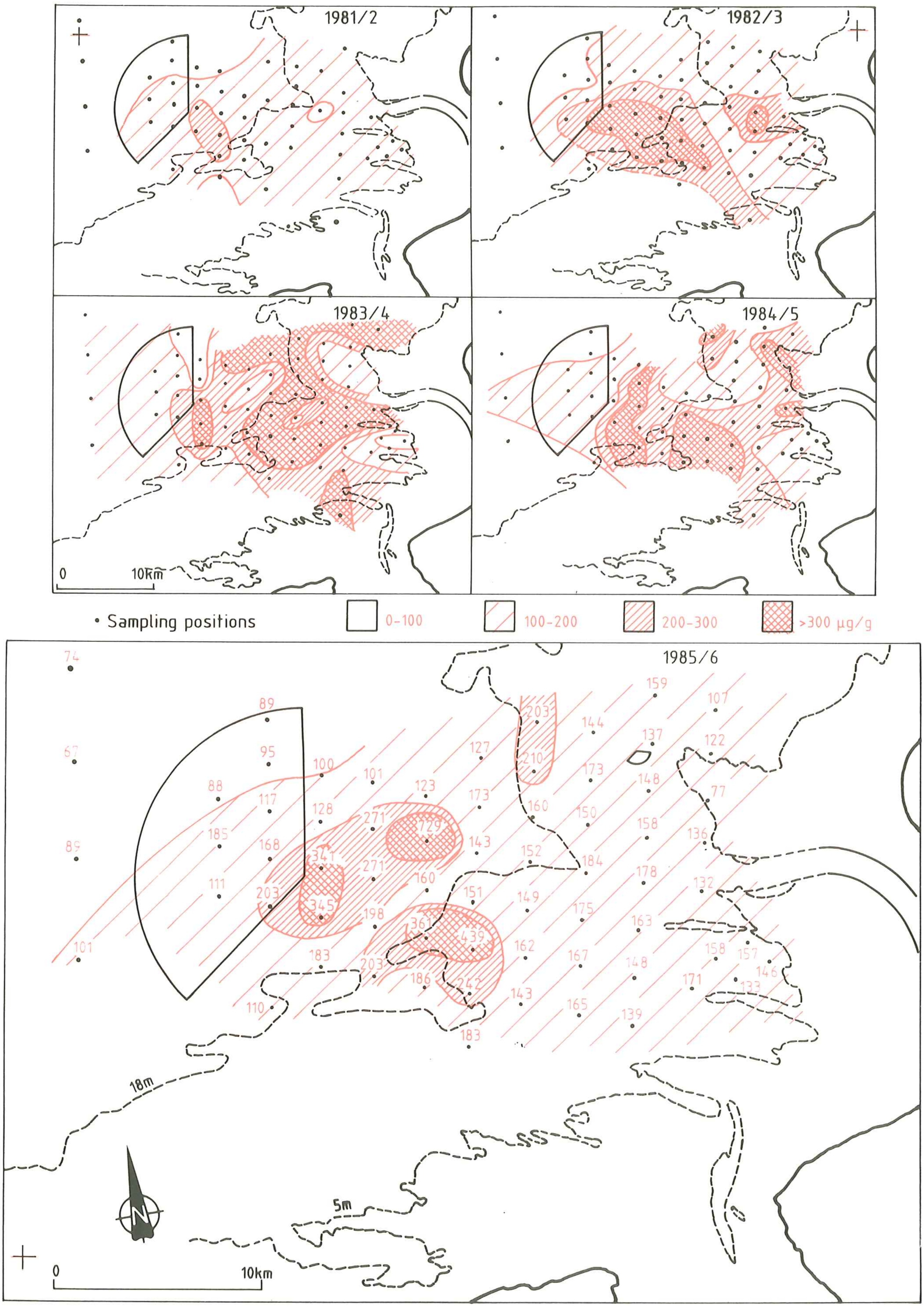

Fig 6 Lead concentration in mud from the top 25mm of bed

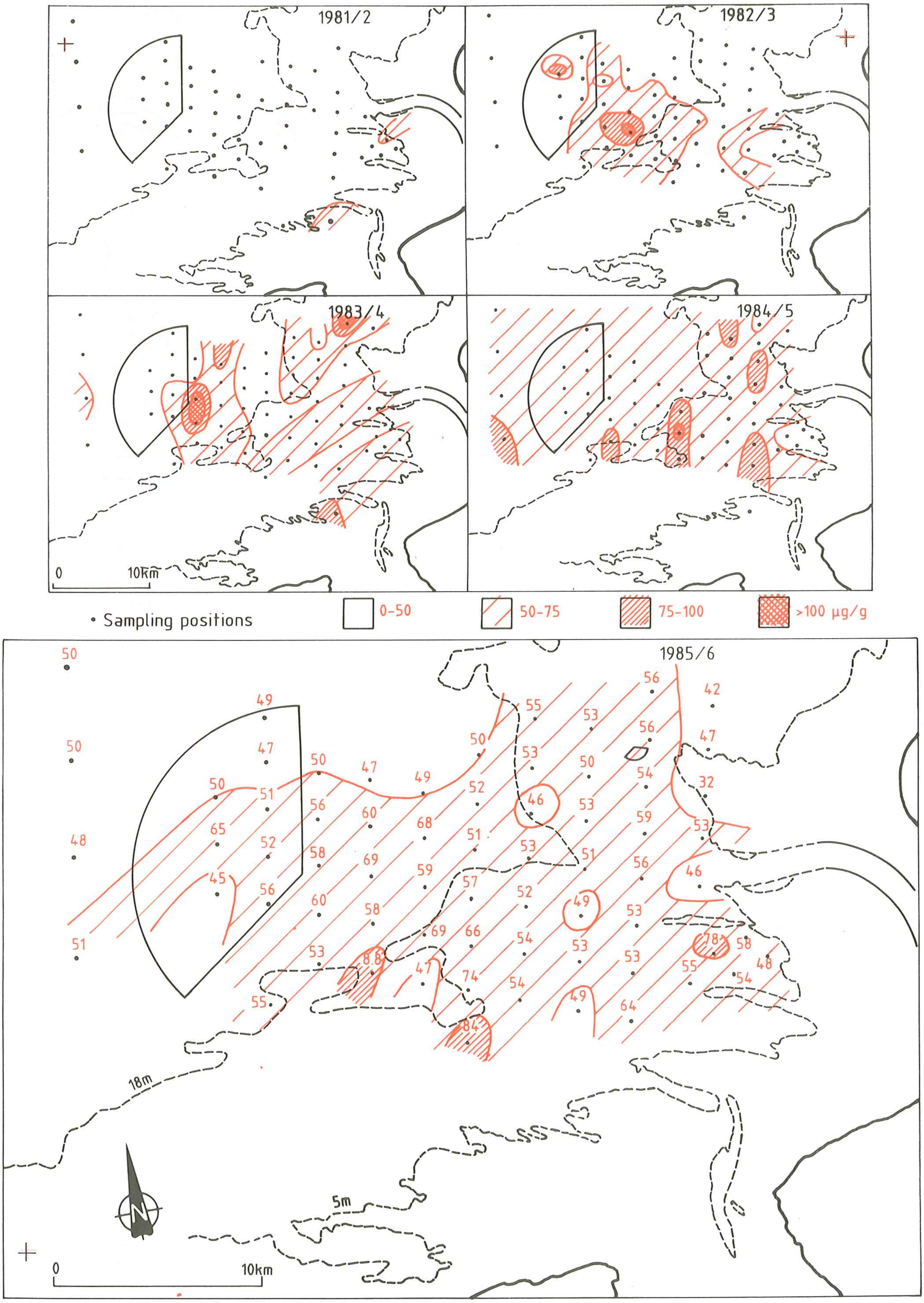

Fig 7 Nickel concentration in mud from the top 25mm of bed

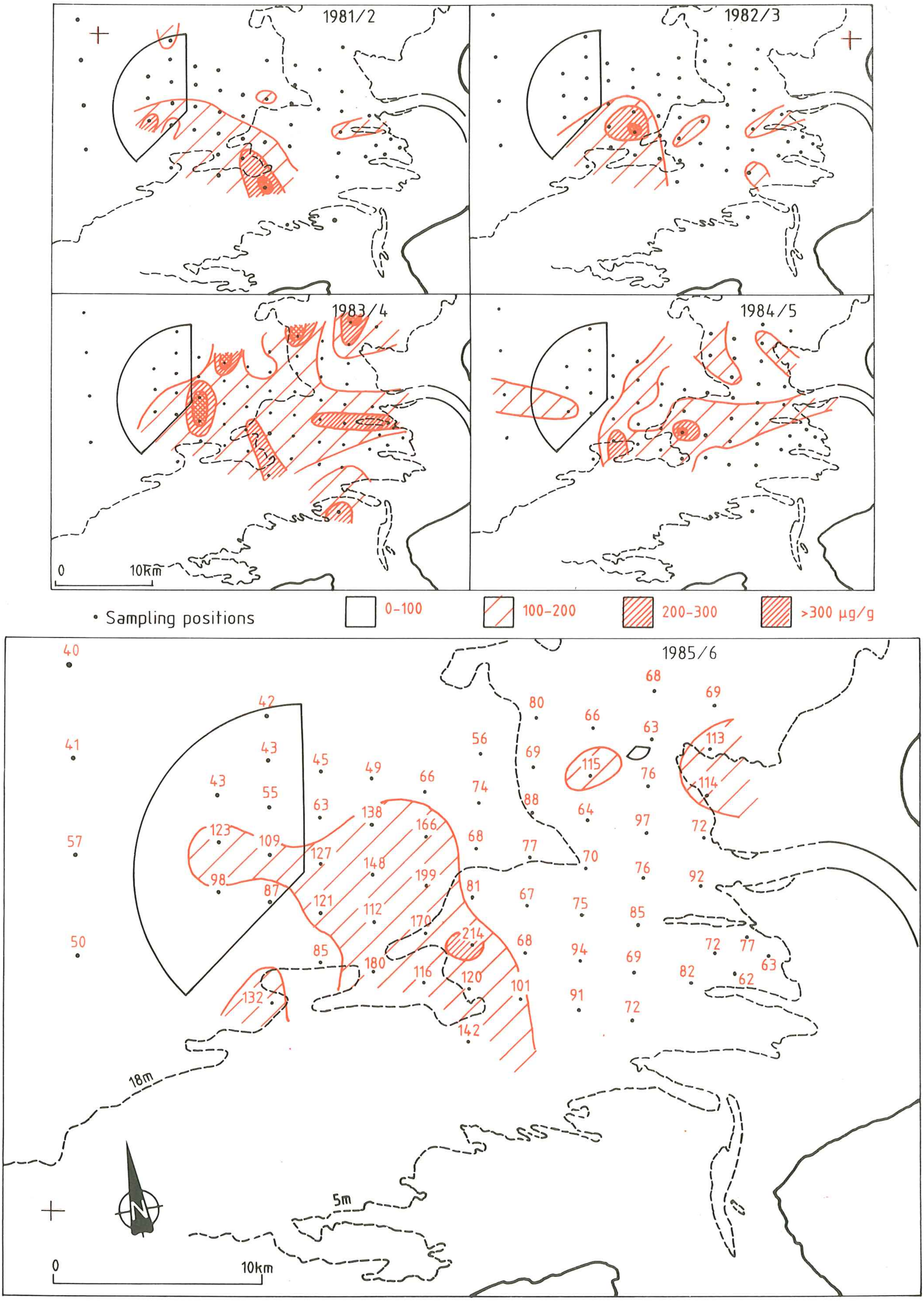

Fig 8 Copper concentration in mud from the top 25mm of bed

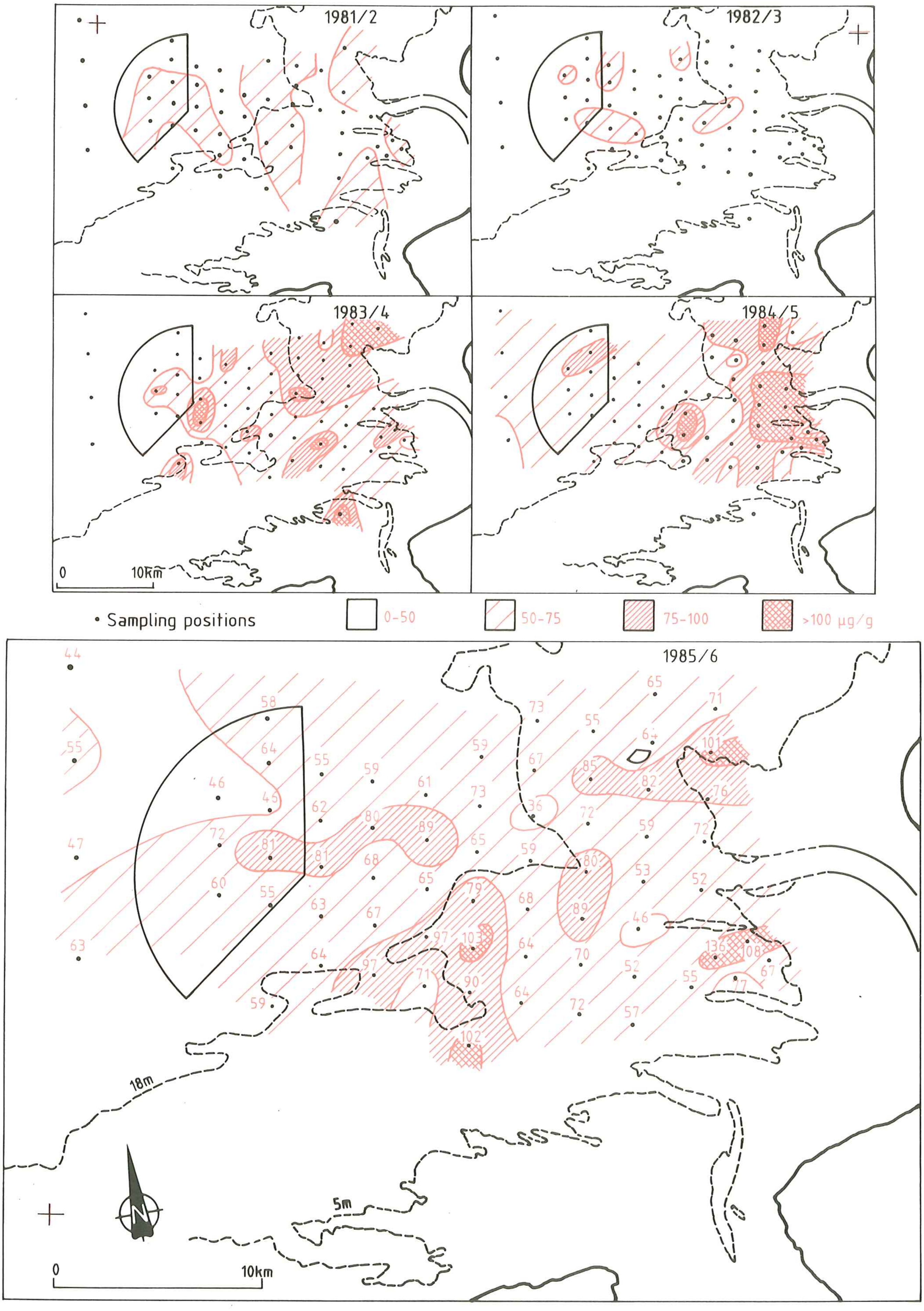

Fig 9 Chromium concentration in mud from the top 25mm of bed

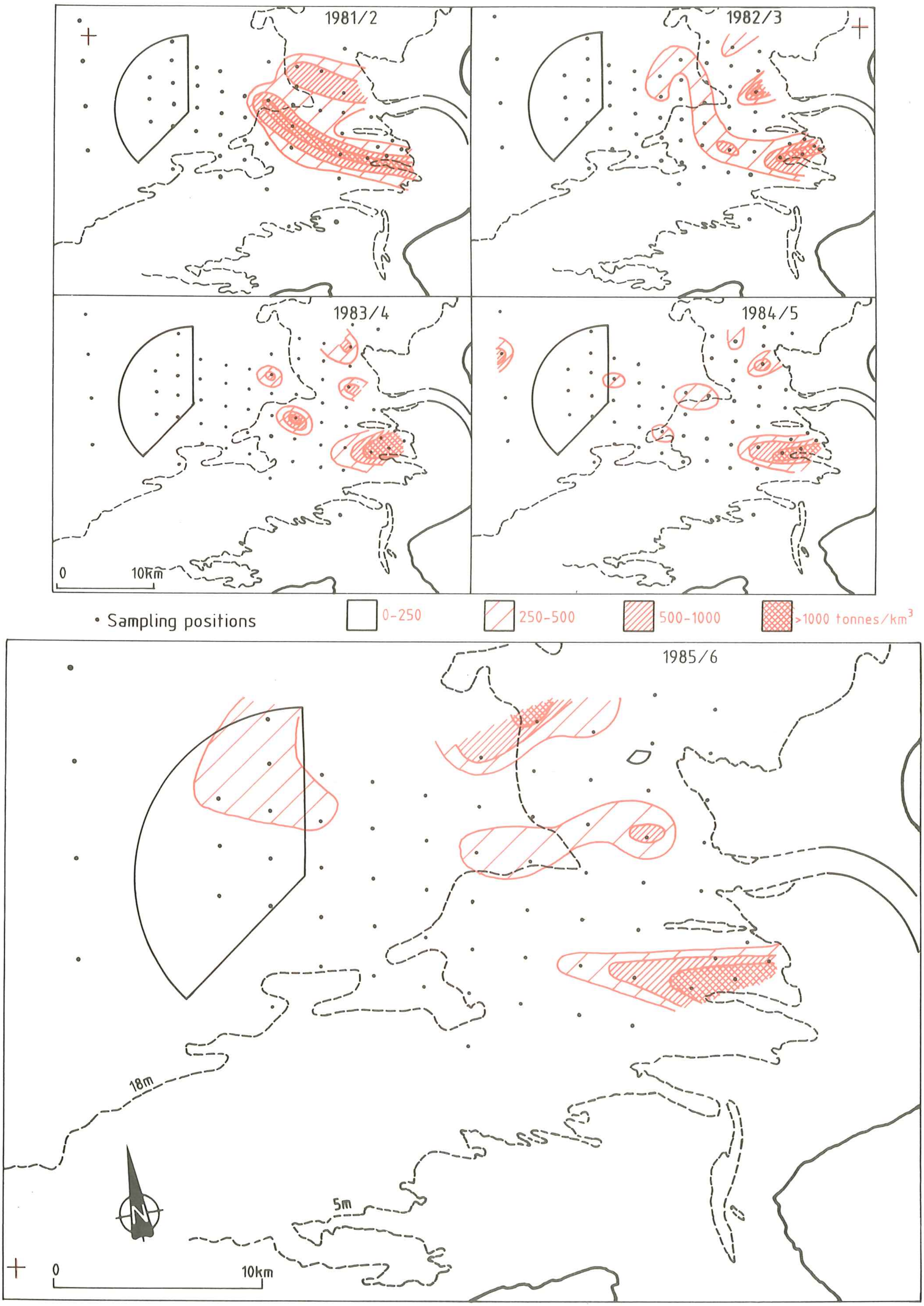

Fig 10 Total organics in mud from the top 25mm of bed

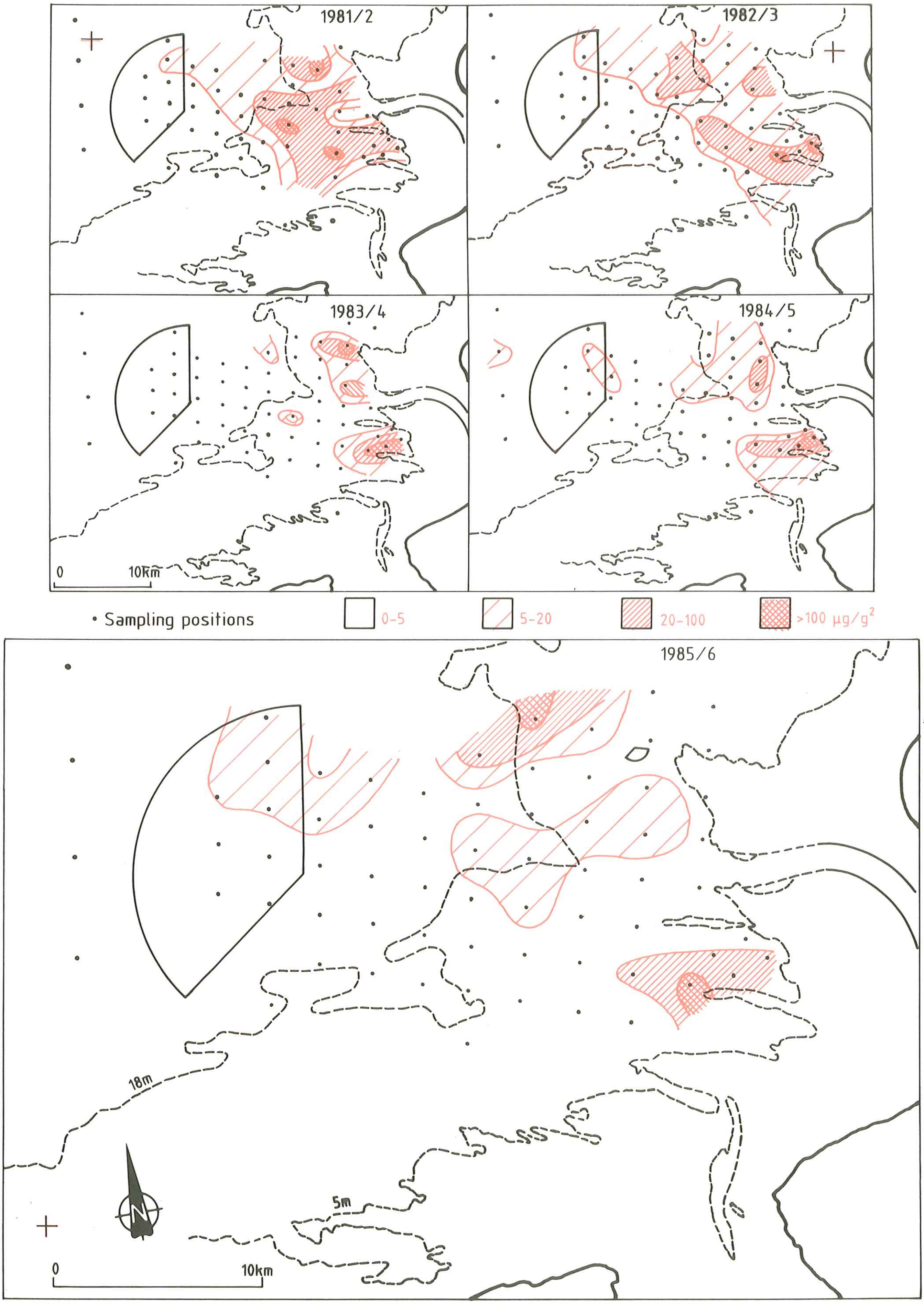

Fig 11 Total mercury in mud from the top 25mm of bed

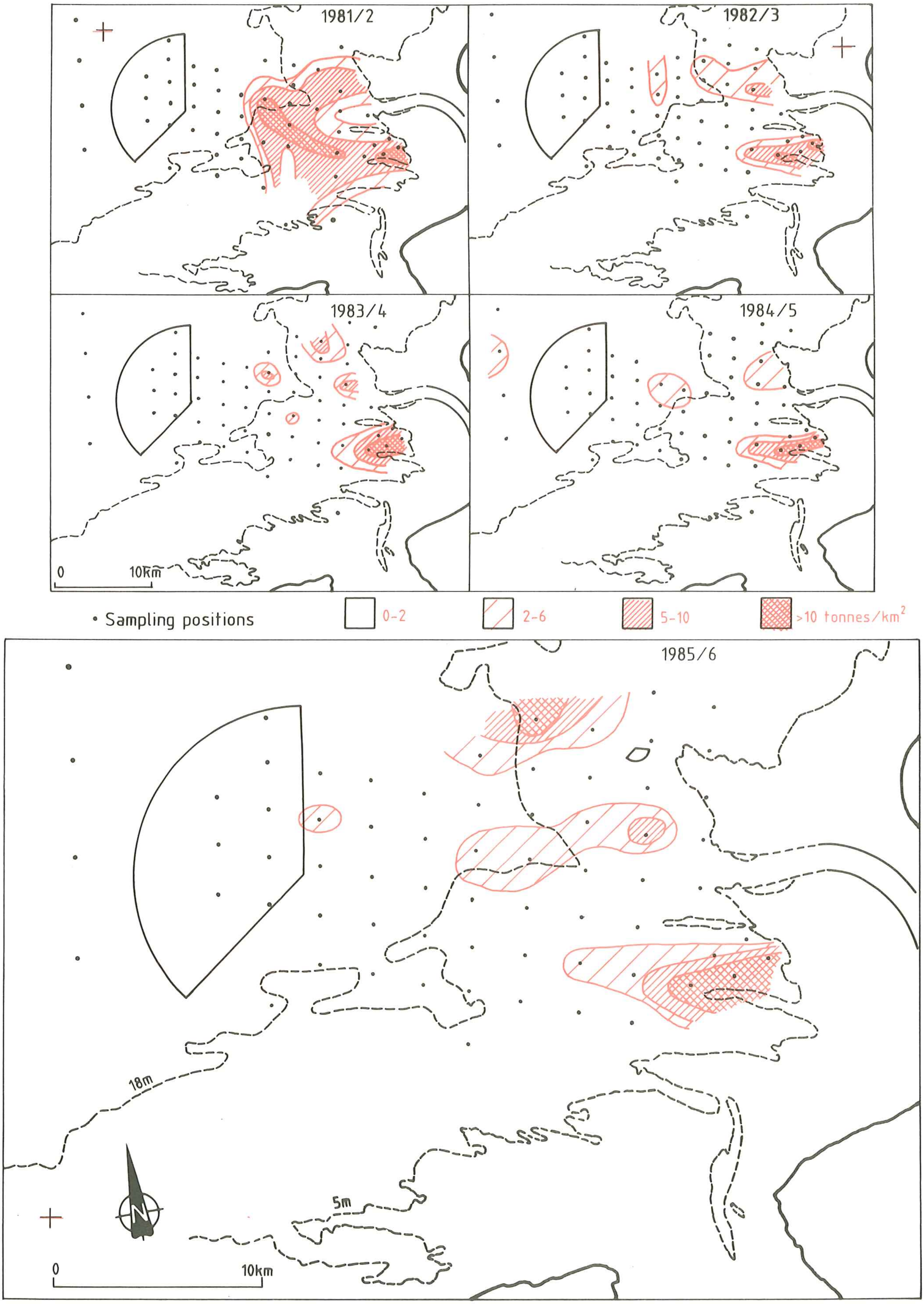

Fig 12 Total zinc in mud from the top 25mm of bed

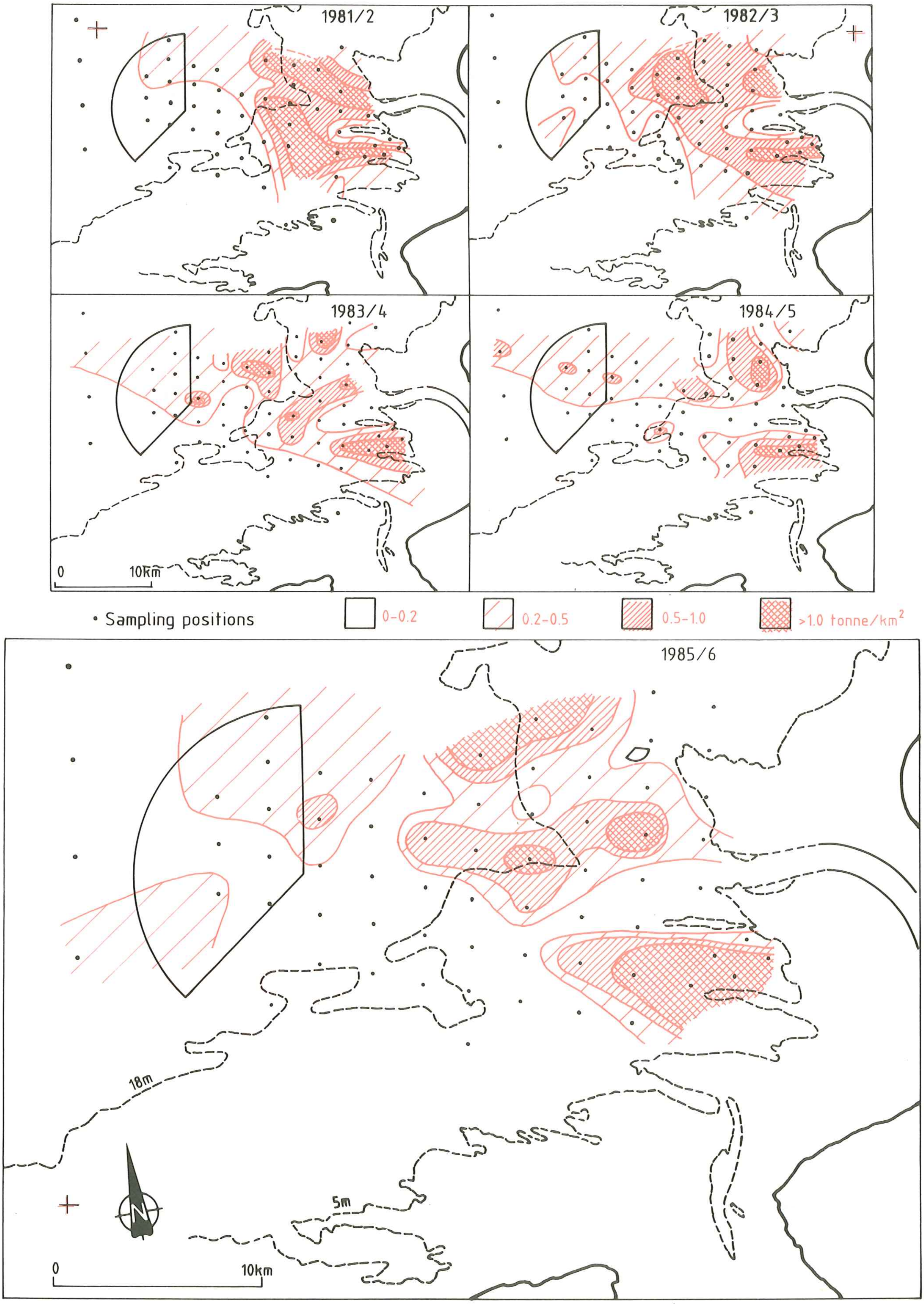

Fig 13 Total lead in mud from the top 25mm of bed

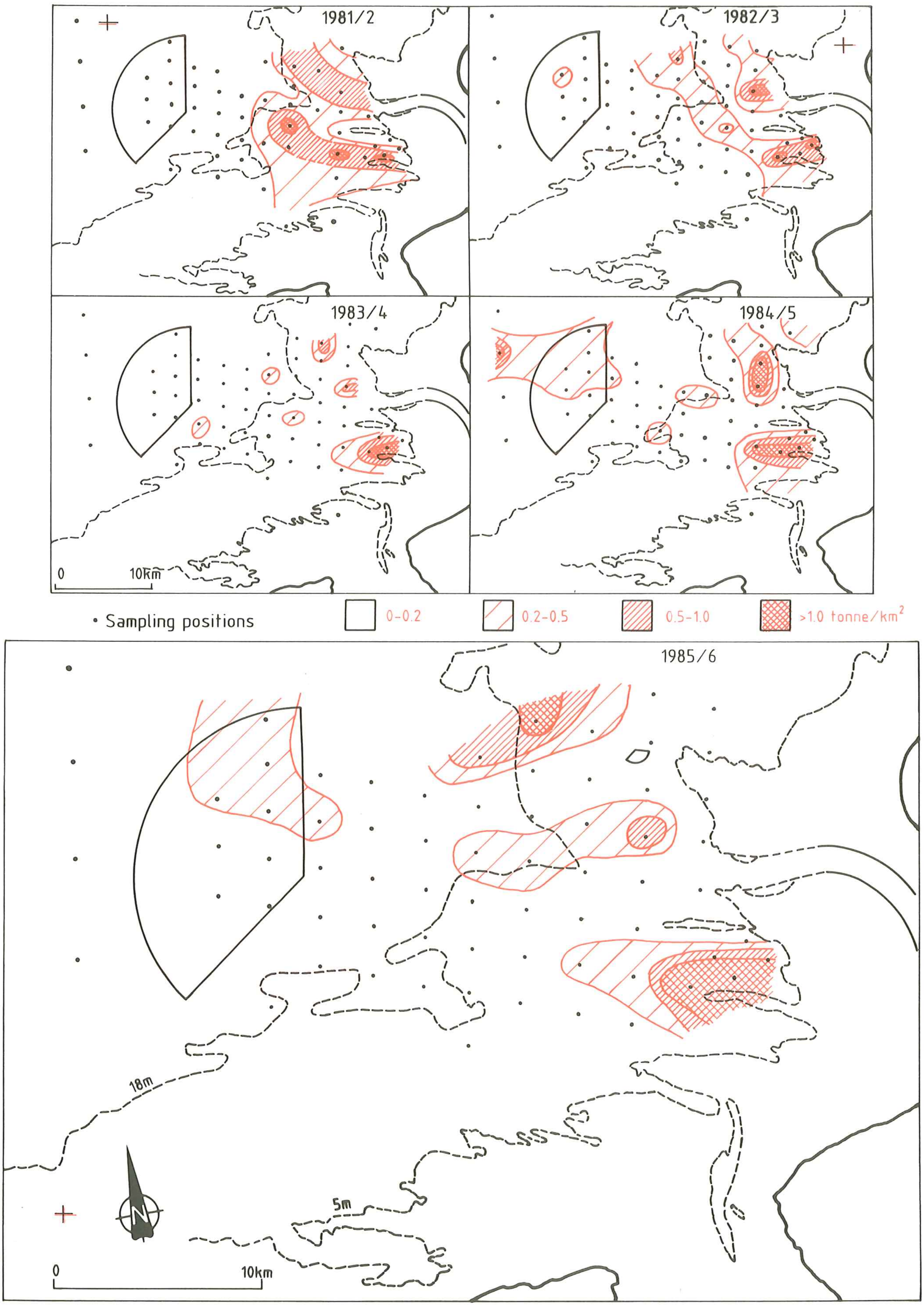

Fig 14   Total nickel in mud from the top 25mm of bed

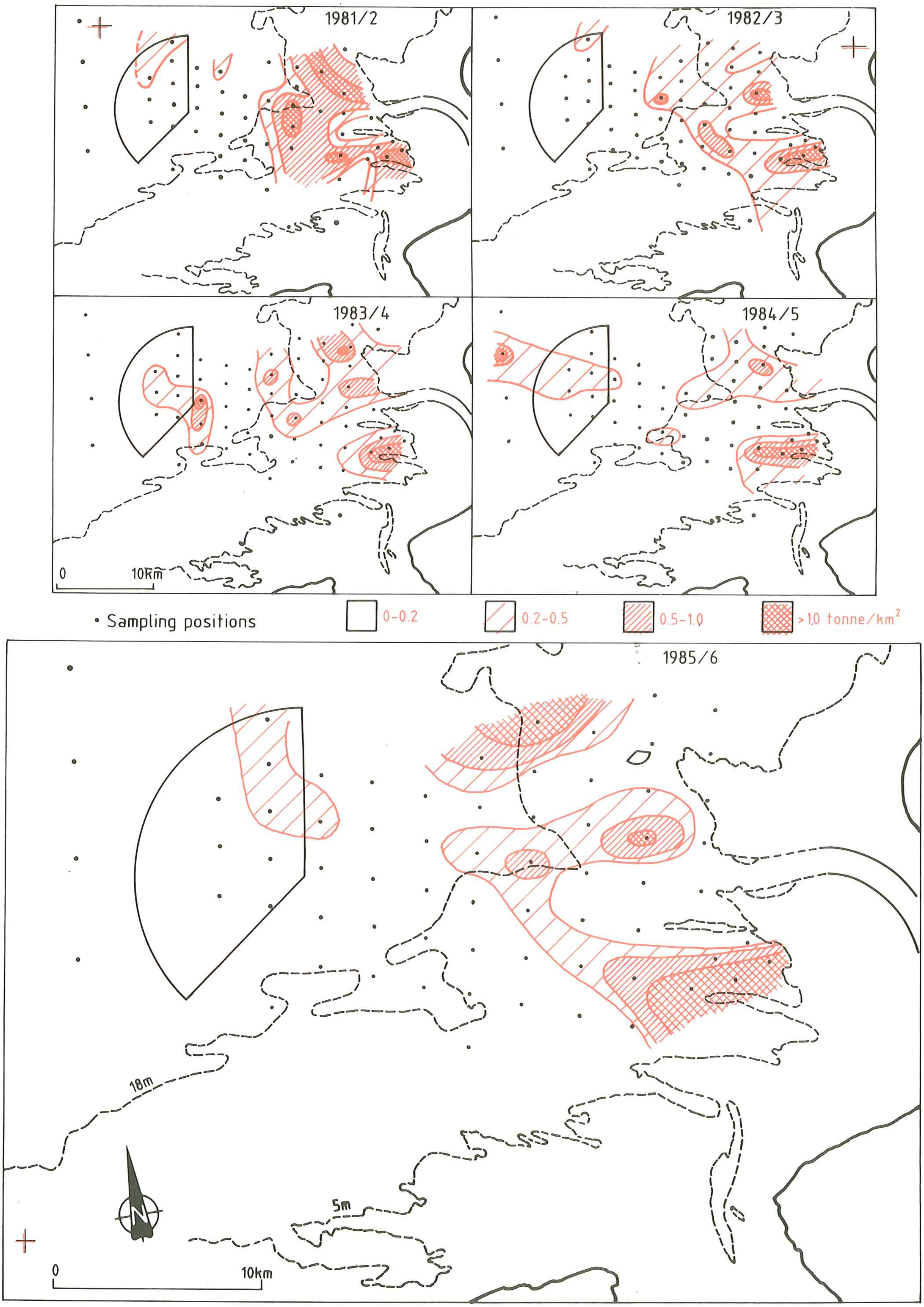

Fig 15 Total copper in mud from the top 25mm of bed

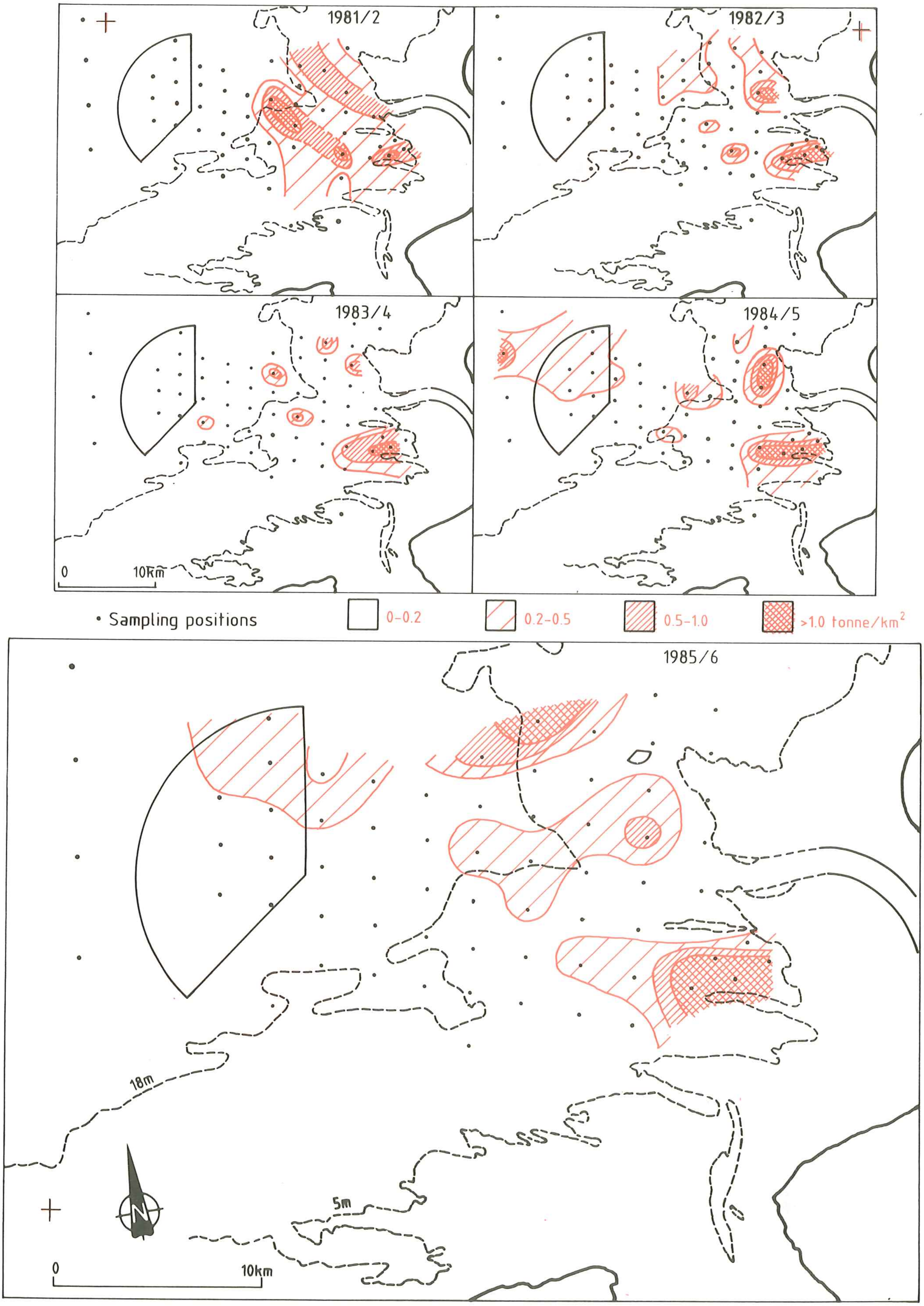

Fig 16 Total chromium in mud from the top 25mm of bed