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DISPOSAL OF WASTES AT SEA IV. THE ROLE OF SEDIMENTOLOGY IN THE ASSESSMENT OF EFFECTS OFF THE NORTHEAST COAST OF ENGLAND

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SUMMARY

Studies of sediments are undertaken at the Fisheries Laboratory, Burnham-on-Crouch, as part of the programme to assess the ecological effects of dumping at sea. Knowledge of sediment characteristics and dynamics is relevant to many aspects of the chemistry and biology of the benthic environment. Brief discussion of the analytical techniques used is followed by a description of preliminary results of a survey of an area where colliery waste is dumped.

INTRODUCTION

Since the passing of the Dumping of Sea Act (1974) the Ministry of Agriculture, Fisheries and Food has assumed responsibility for controlling the disposal to sea from vessels of a wide variety of wastes into numerous areas off the coasts of England and Wales. A considerable effort is being made to assess the suitability of proposed dumping grounds and to determine the effects of existing disposals on the fisheries and general ecological state (White, Rolfe and Hardiman, 1974). An increasing awareness of the necessity for knowledge of sediment characteristics and dynamics within the zones of disposal has led to the implementation of a sedimentological programme at the Fisheries Laboratory, Burnham-on-Crouch. This programme has been allocated two major tasks:

a) Sediment description: An accurate description of the physical and chemical fractions that comprise the sediment, from a dense network of stations within and surrounding the dumping grounds, allows a comprehensive assessment of the spatial variations in sediment characteristics to be made. From this appraisal key stations can be chosen to allow annual monitoring with greater precision. A study of variability should allow separation of natural and man-induced fluctuations. Data from these surveys should also enable other variables to be more readily interpreted, for example, trace metal concentrations and many benthic distributions.

b) <u>An understanding of the mechanisms and directions of sediment movement</u>: aspects of sediment movement may be interpreted from particle size analyses, but field observations will be made of sediment dynamics later. Such knowledge is imperative in assessing the dispersive properties of each ground, and in identifying paths of transport which may carry wastes away from the dumping sites.

This paper describes briefly the analytical techniques and results obtained from a preliminary survey of an area off the northeast coast of England.

BACKGROUND TO SURVEYS OFF THE NORTH EAST COAST

This stretch of coastline (Fig 1) has a highly industrialised hinterland, and there is a demand for large quantities of inert minerals to be disposed of at sea. These include colliery wastes, fly ash, rock and soil from civil engineering projects and harbour dredging. The local fishery resources are extensively exploited, notably by inshore trawling for both fish and <u>Nephrops</u>, and by potting for crabs and lobsters. There exists an obvious need for close monitoring of the effets of sea dumping.

The locations of six dumping grounds in this area and sampling stations are shown in Figure 1.

METHODS

<u>Grabbing</u>: Samples were obtained using a $1/10\,m^2$ Day grab, which is effective except in sediments with an appreciable gravel content. In such situations there is often an appreciable loss of fines, and other grabbing techniques are being investigated. A subsample (approximately 250 ml) of the surface 2 cm of sediment was collected, a larger amount being taken where the sediment contained appreciable quantities of coarse gravel.

<u>Particle size fractionation</u>: Particle-sizing techniques in general follow the recommendations laid down by the Hydraulics Research Station, Wallingford. (Kiff, 1973). The following is a brief summary of the methods used:

a) The entire sample was separated whilst wet on a 0.063 mm sieve.
b) The fines were settled, decanted, dried at $105^{\circ}C$ and stored in airtight jars.
c) The coarse fraction was dry sieved. A 200 mm diameter sieve nest set up at $\frac{1}{2}$ phi intervals was used. The nature of the material coarser than 4 mm was noted by visual inspection only.

It is hoped that later a model TA Coulter Counter will be employed for rapid and accurate analyses of the particle-size distributions less than 0.063 mm.

<u>Chemical fractionation</u>: For purposes of these initial surveys an approximation of the relative quantities of organic materials, carbonates and silicates was obtained by measuring the loss on ignition. It is known that most organic material is associated with the fine fraction (Trask, 1932). To analyse this relationship further, each sample was divided into three fractions (below 0.063 mm, 0.063 mm -

0.5 mm and 0.5 mm - 4.0 mm) which were treated separately. Oxidisable carbon content was determined by ignition at 550°C over eight hours. Further heating to 800°C gave an estimate of carbonates present.

Analysis was complicated by the presence in the sediments of appreciable quantities of coal material; this presence can be established by inspection under the microscope. Loss on ignition procedures were still carried out, but the results from heating at 550°C reflected the combustion of both coal and other organic matter. This was of little importance for the sand fractions, where levels of organic material rarely exceed 2%. The percentage of organics within the fines, however, is a variable with which many benthic and trace metal attributes can be correlated, apart from being itself an invaluable index in monitoring the possible accumulation of wastes of an organic nature. In consequence it was necessary to seek an alternative method for determining the variability in organics bound to the finer particle sizes. The hydrolysable protein content of the organic fraction was determined using a spectrophotometric technique (Buchanan and Longbottom 1970); the result were expressed as percentage of nitrogen of protein origin. Further work is in progress to explore the relationships between protein-derived nitrogen and the oxidisable carbon content of coal-free marine muds.

Data manipulation: A computer program is partially developed for handling the quantities of data from these analyses. An initial objective of the program was simply to calculate the percentages of the three artificially defined components, gravel (> 4 mm), sand (< 5 mm -> 0.063 mm) and siltclay (< 0.063 mm), that comprise each sample. For the two finer fractions the chemical (silicates/carbonates/organics) composition was computed. The simple approach will in future be extended to include the identification of the component normally-distributed particle-size populations within each sample, several authors having demonstrated that the identification of individual modes within polymodal sediments can yield much information regarding sediment dispersal and provenance (Curray 1960, Oser 1972, Van Andel 1973). (In this survey modes were isolated by visual inspection of data.) A full description of each sediment sampled will eventually be fed into a comprehensive data bank containing the biological, chemical and hydrographic attributes determined at the same stations.

RESULTS AND DISCUSSION

Some analyses have been completed and various characteristics of the sediments are plotted in Figures 2, 3 and 4. At this stage only brief comments can be made upon the mechanisms of sediment dispersal that may be active in the area.

Figure 2: The arbitrary subdivision of the sediment into gravel, sand and siltclay fractions is presented. The percentage distribution of material coarser than 4 mm (Fig 2a) reflects the presence of relict sediments, derived from localised bedrock outcrops and from the winnowing of the original veneer of boulder clay. These coarse, immobile stones and cobbles are stained and encrusted. In contrast, the quantities of grey slate ('minestone') which predominates the gravel fraction in

the two areas indicated in Figure 2a are of unweathered appearance: these two zones are a product of the dumping of colliery waste.

The contours plotted in Figure 2b define the percentage of siltclay ($<$ 0.063 mm) in that fraction of the sediment finer than 4 mm. The remainder of each percentage therefore consists of sand. There is a general increase in the siltclay content offshore, but this pattern is confused by localized inshore areas with a high content of fines. There are two explanations to account for this:. (i) echo sounder records reveal the irregular nature of the sea bed, with rock outcrops and the suggestion of a bench feature in the offshore slope: this relief can produce sheltered trap areas where fines may accumulate, (ii) several of the samples collected from these areas were permeated with leaf material, suggesting dumped harbour dredgings as a likely origin.

Figure 3: The figures were derived by plotting the mean sizes of all the component populations identified within the sand fraction. Seven particle size groups were identified, having distributions which could not be easily related to well-defined sources of sediment or obvious patterns of dispersal. The two coarsest groups of populations (Figure 3a) were an exception, being restricted to the inshore zone of hard grounds from which they are derived. The finest sands tended to be distributed furthest offshore.

Figure 4: The sediments off the north east coast frequently contains copious amounts of coal. Figure 4a shows the distribution of oxidisable carbon (percentage loss on ignition) in the sand fraction. In coal-free areas these values rarely exceed 2%. Taking this level as a baseline, zones of negligible coal content can be defined both inshore and offshore of a wide belt extending north to south through the disposal grounds. Within and close to the dumping areas coal content exceeds 20%. Localized zones of high coal content to the south of the disposal grounds are probably a result of the dumping of coal-rich harbour dredgings, as previously discussed. In Figure 4b the loss on ignition in the fine/medium sand fractions ($<$ 0.5 mm) is expressed as a percentage of the loss in thes sand fraction as a whole, ie the higher percentages represent a finer sediment composition. This distribution suggests that dumped colliery waste is being dispersed southwards along a path lying parallel to the coastline, with a tendency for the finest material to be redistributed furthest offshore.

CONCLUSIONS

The necessity to monitor numerous dumping grounds around England and Wales on a regular basis imposes severe limitations on the intensity and frequency of sampling and analysis. The methods described in this paper have been developed as a compromise between the need to carry out detailed scientific investigations and the need to answer specific questions relatively quickly.

A spatially intensive survey, at a relatively superficial level, off the northeast coast of England has illustrated the value of sedimentological studies in the assessment of the effects of dumping. Enough information is provided to allow suitably accurate description of the most useful sediment characteristics and to enable eventual interpretation of the complex mechanisms of the dispersal of both natural and dumped materials. Further surveys off this coast will be confined to key stations, allowing examination in greater detail.

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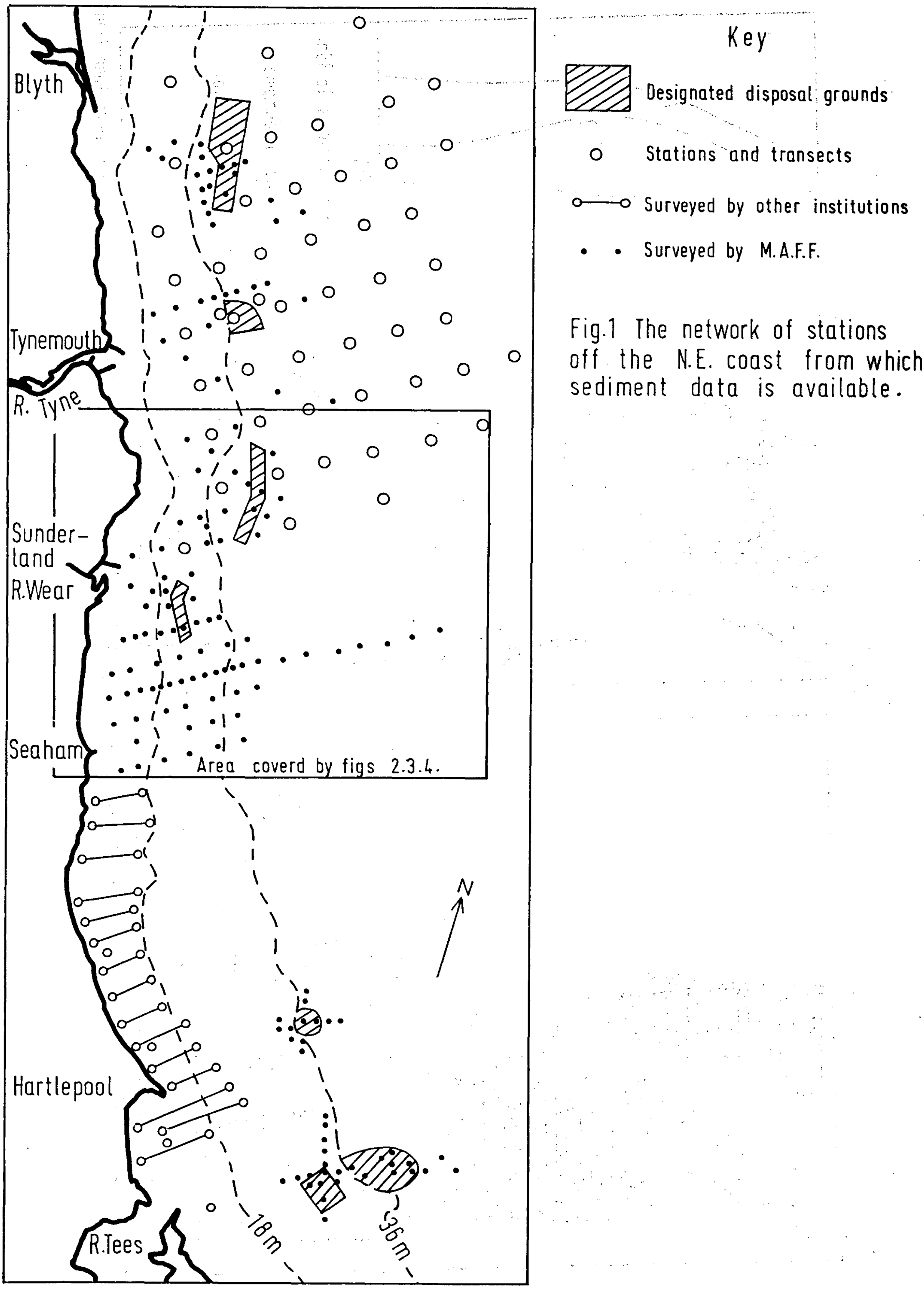

Fig.1 The network of stations off the N.E. coast from which sediment data is available.

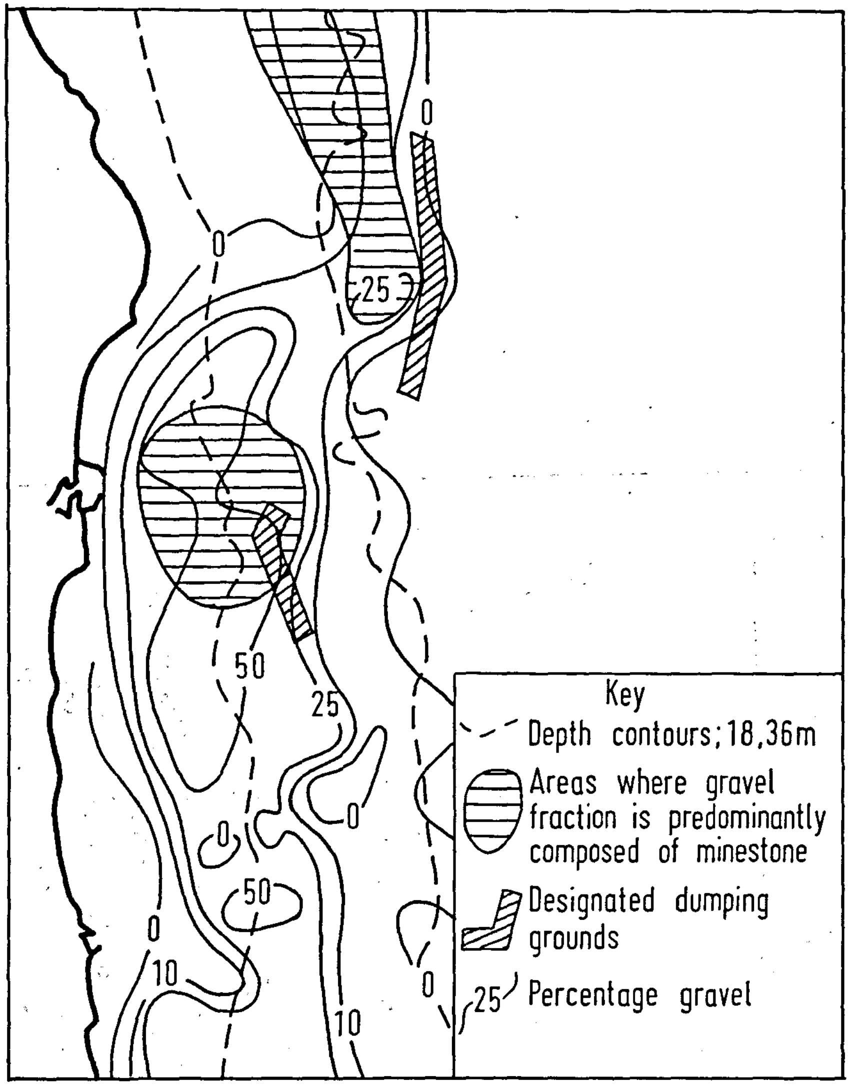

Fig 2a Percentage of the total sediment coarser than 4mm

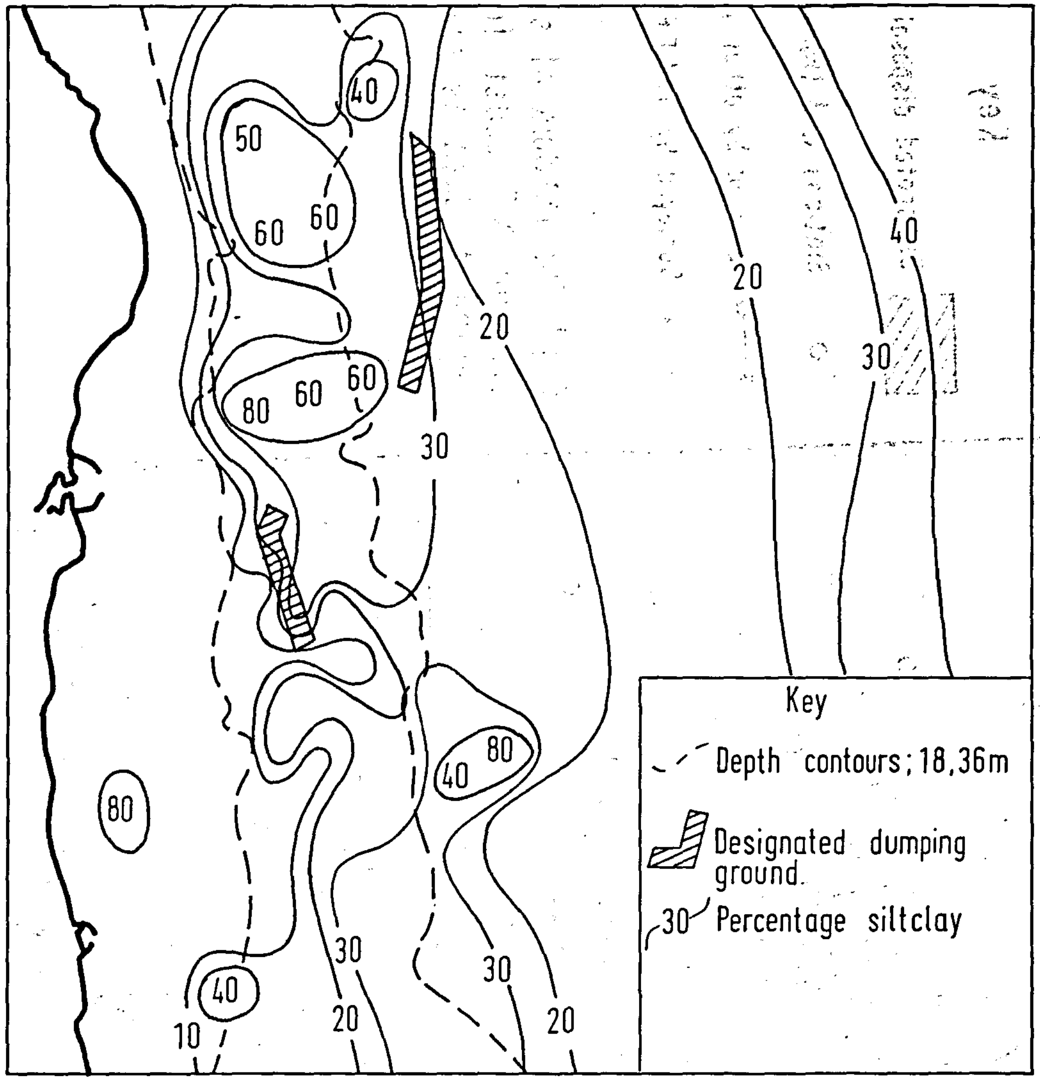

Fig 2b Percentage of siltclay (<0·063mm) in the sediment finer than 4mm

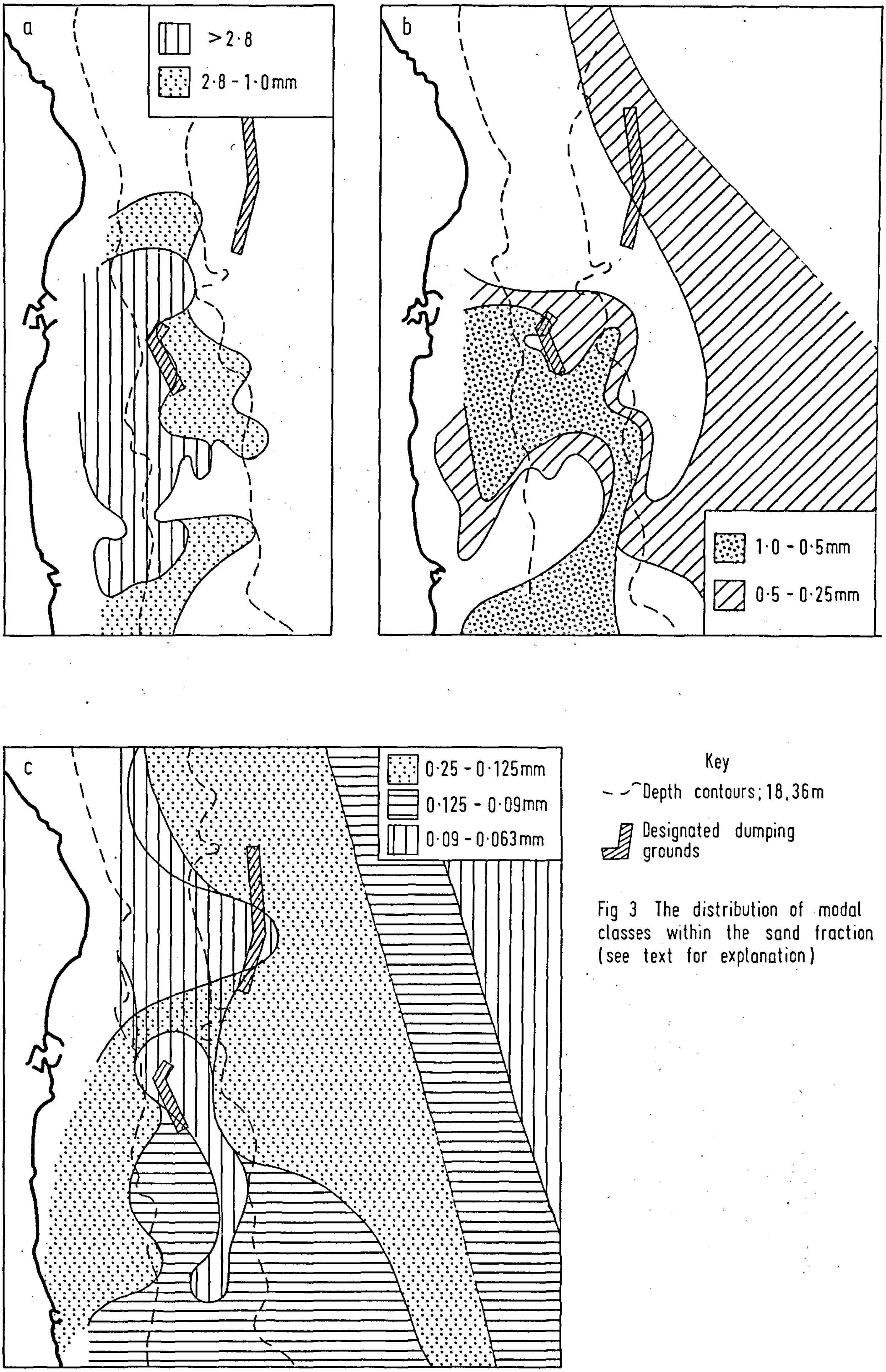

Fig 3 The distribution of modal classes within the sand fraction (see text for explanation)

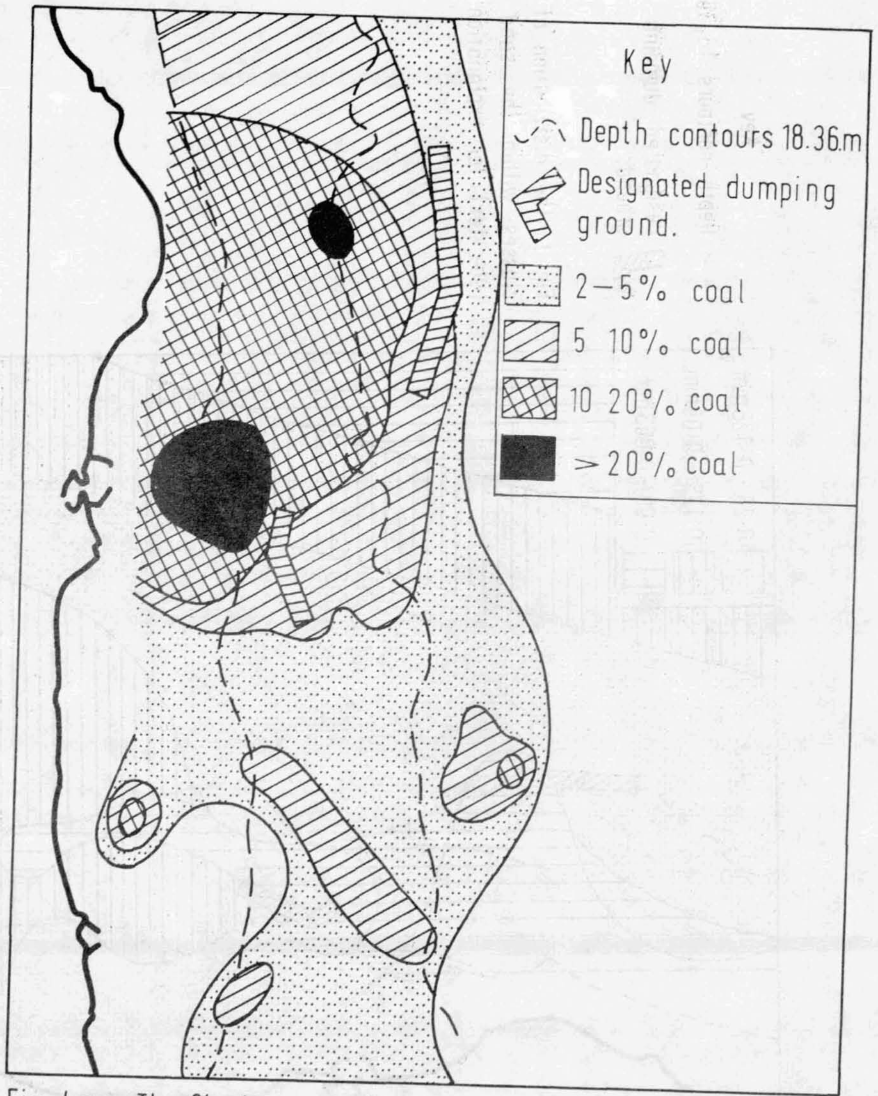

Fig 4a The % loss on ignition (coal content) of the sand fraction (4·0–0·063 mm)

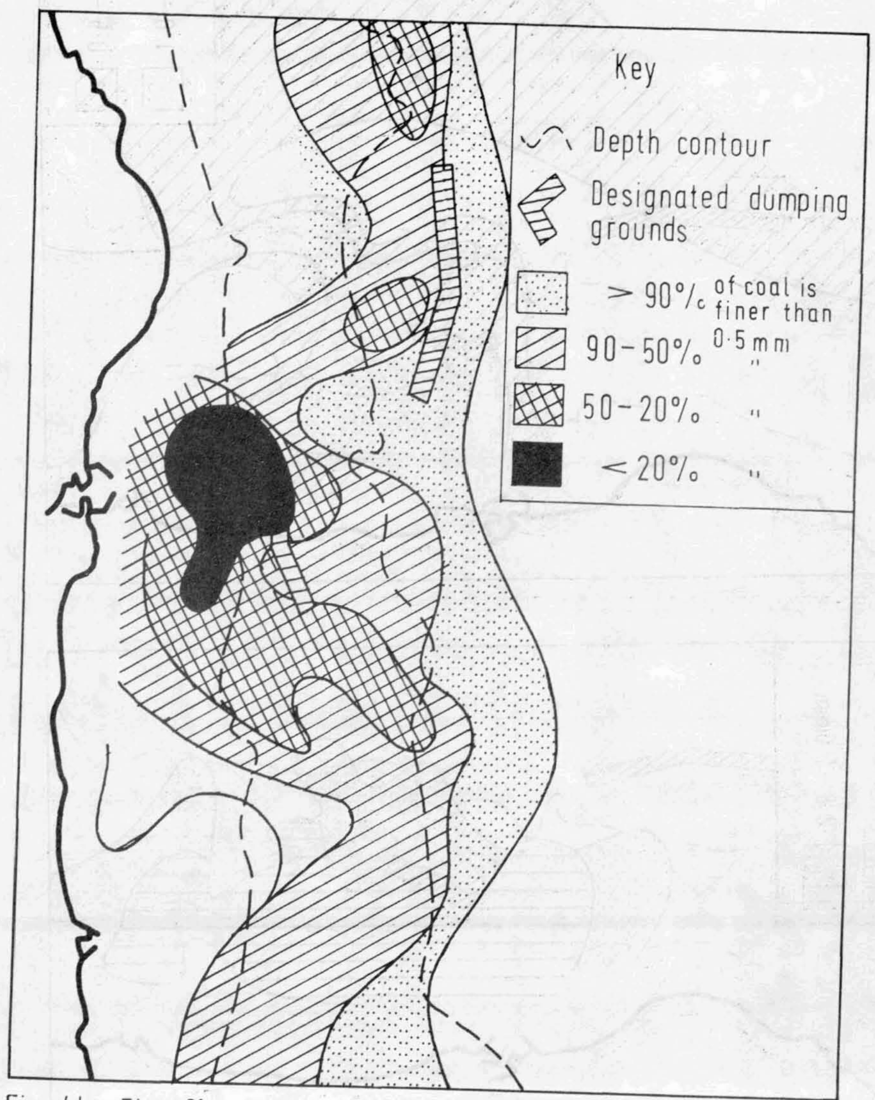

Fig 4b The % percentage of the sand sized coal fraction finer than 0·5 mm