ENGLISH NATURE

LOAN SET

BioMar Life

Mapping the distribution of benthic biotopes around the Thanet coast

Jon Davies

ENRR No. 154

Maritime Team

English Nature Research Reports

No. 154

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ISSN 0967-876X

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BioMar is 50% funded by the Commission of European Communities under the Life programme

A collaborative study between English Nature and the BioMar programme

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Preface

The survey of the marine environment around Thanet was undertaken as part of the BioMar Project which is funded by the European Community through the LIFE Programme. The BioMar Project partners are Trinity College (Dublin), The Office of Public Works (Irish Republic), The Joint Nature Conservation Committee, AIDE Environment (The Netherlands) and Newcastle University. One of the main aims of the BioMar Project is to devise a classification system for marine biotopes of the north-east Atlantic seaboard and to produce information on their range and distribution to aid conservation assessment and the development of appropriate strategies for coastal zone management (CZM). The partners based at Newcastle University have the additional tasks of developing techniques for biotope mapping and applying them to specific management case studies in collaboration with other organisations.

Acknowledgements

The BioMar project wishes to acknowledge the financial support of English Nature (Nature Conservancy Council for England) to cover the costs of the field survey and reporting for the present project.

BioMar wish to acknowledge:

- Alistair Davidson for his help during the field survey.
- Paul Fletcher, the skipper of M.V. *Stella spei* for all his help and experience during the field survey;
- Dr Alexander Downie, English Nature for his help during the field survey, and for comments on an earlier draft of this report;
- Kate Northern and Ian Reach (Joint Nature Conservation Committee) for supplying data from the Marine Nature Conservation Review, Joint Nature Conservation Committee.

Synopsis

At Newcastle University, the BioMar project has developed a survey protocol for mapping the seafloor using acoustic techniques validated by biological sampling, with the data stored and analysed using geographic information systems (GIS). A *RoxAnn* processor samples the return echo from an echo sounder. These acoustic data have no biological meaning unless they are related to biological assemblages, determined from direct observations or samples of the sea bed at pre-determined point locations. Biological data were collected using a towed video recorder and by scuba diving.

Thanet forms the eastern corner of Kent and is the longest continuous stretch of coastal chalk in Britain. The chalk habitats and their associated communities are very uncommon in Europe and considered to be the best examples of their kind and of the highest international nature conservation importance. In recognition of this conservation value, the area has been put forward as a proposed Special Area for Conservation (pSAC) under the EC Habitats and Species Directive.

Thanet was surveyed by the BioMar team from May 10-12, 1995 to determine the main habitats and if possible, the offshore extent of the chalk reefs. The following data were obtained from this survey:

The area surveyed extended from Ramsgate to Birchington, to an approximate offshore limit of 5 km.

Video samples were collected from 10 sites; 20 sites were surveyed by scuba diving.

5 generic biotopes, with 2 minor variations, were identified from these samples.

A map of the **predicted biotope distribution** based on the acoustic characteristics of the sea bed was prepared for the survey area. Any reference to this map must make clear that these distributions were a prediction, and all judgements based on this map must take account of the limitations of the mapping technique.

The present mapping study demonstrated that chalk platforms extended into sublittoral areas, to an approximate offshore limit of 0.5 km to the north, and 1.5 km to the east of Thanet. These platforms were progressively overlain with sediment although outcrops were still present in predominantly sedimentary areas. Inclement weather posed a number of problems during the survey and subsequently to the data analysis. Nevertheless the BioMar survey strategy has provided an indication of offshore extent of the sublittoral chalk biotopes, particularly in relation to the pSAC.

Introduction

Management of the living resources and landscapes of the marine environment requires an inventory of these resources and their geographic location. Thus, mapping marine habitats (biotopes) forms a very useful basis for making decisions on the best approach for conserving the natural heritage of coastal waters.

Thanet forms the eastern corner of Kent, just below the greater Thames Estuary (Figure 1). It is the eastern-most outcrop of chalk in Europe with the exception of an area in northern Denmark. Thanet is the longest continuous stretch of coastal chalk in Britain, representing about 20% of UK coastal chalk and 12% of the coastal chalk exposure in Europe. Thanet's chalk habitats and their associated communities are very uncommon in Europe and considered to be the best examples of their kind and of the highest international conservation importance (English Nature, 1995). In recognition of this significant conservation value, Thanet has been put forward as a proposed Special Area for Conservation (pSAC), (Department of the Environment, 1995) under the *European Community Council Directive on the conservation of natural habitats and of wild fauna and flora* (EC Habitats and Species Directive) (European Community, 1992).

The following text is an excerpt from the *Thanet SAC marine consultation package* (English Nature, 1995).

> The soft nature of the Upper Chalk on the Thanet coast is characterised by a unique range of marine algal and lichen communities with some species which have not been recorded elsewhere. The full range of these communities is confined to the very restricted habitats on soft, shaded chalk cliff faces and inside partly submerged chalk caves and tunnels. Thanet is of international importance for these soft, Upper Chalk coastal exposures, as the type locality for two genera and seven species of algae, and for the exceptional recorded history and continuity of marine research undertaken here.
>
> Thanet is also of marine conservation importance for its characteristic sublittoral (extending into the littoral) chalk platforms which extend into deep water in a series of steps, dissected by gullies. Chalk reef species include an unusually rich intertidal algal flora for the region, but infralittoral kelp forests are characteristically absent due to the high turbidity of the Channel water. The range of species present on these reefs is considered unusual in the southern North Sea.

Conflicting data were available to determine the offshore extent of these chalk reefs with estimates ranging up to 30 km offshore. To implement effective management of the marine benthic resource, English Nature required data on the geographic extent of the biotopes around the Thanet coast and requested the BioMar project at the University of Newcastle to conduct a biotope mapping survey.

Objectives

A baseline resource survey of the Thanet coastline had three main objectives:

i Undertake an acoustic survey to determine the main habitats and if possible, the offshore extent of the chalk reefs.

ii Validate the acoustic survey using a video system to match the biological features with the physical habitats.

iii Produce colour maps of the geographic distribution, and an inventory of the major biotopes within the survey area.

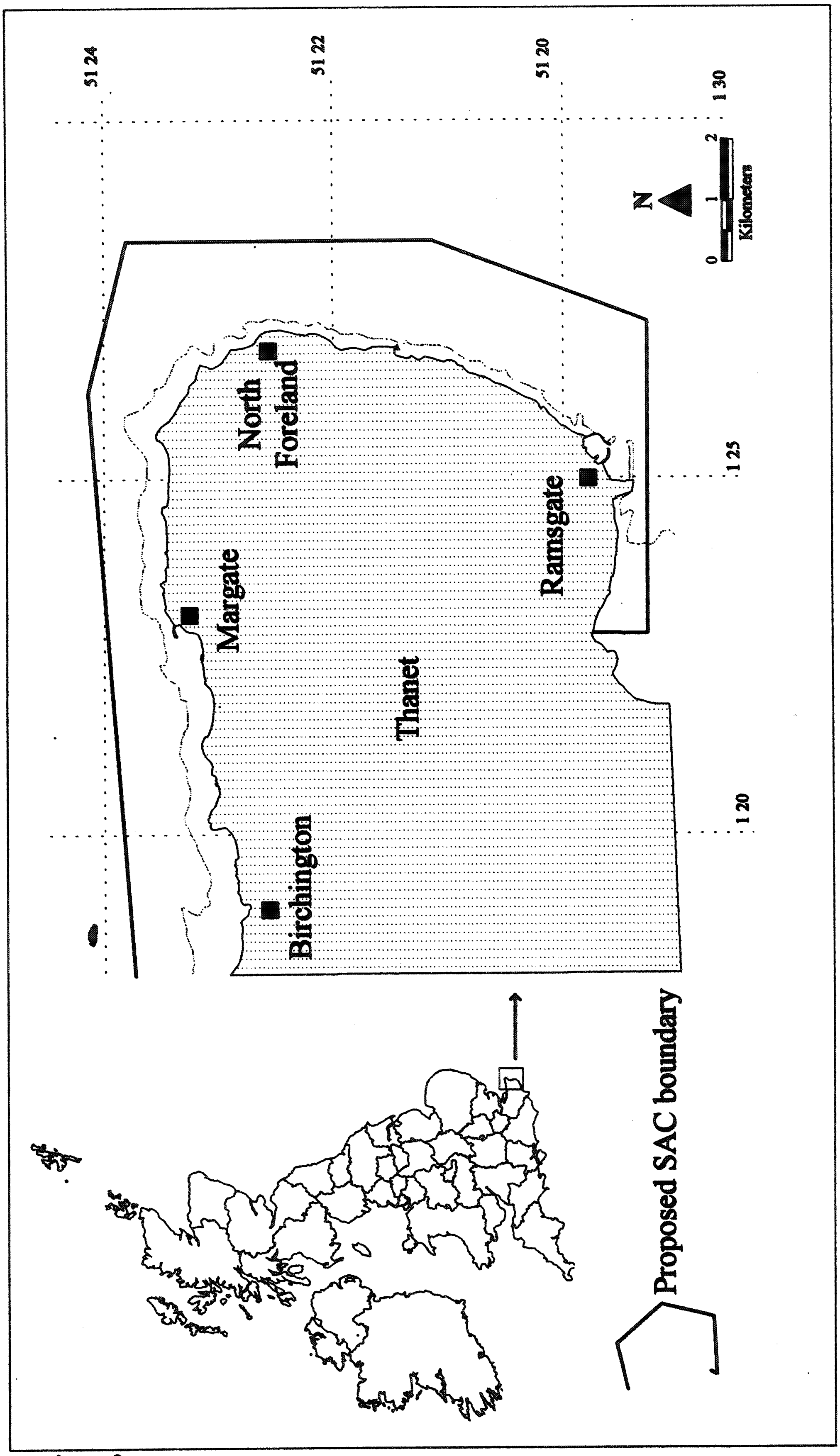

Figure 1 Location of survey area

Methods

At Newcastle University, the BioMar project has developed a survey protocol for mapping the seafloor using acoustic techniques validated by biological sampling, with the data stored and analysed using geographic information systems (GIS).

Acoustic surveying

There are a number of different types of sonar which vary in the area of sea bed sampled. Scanning type sonar such as side-scan sonar, transmit a wide bean of sound which samples a broad swathe of sea bed. In contrast, vertical sonar transmits a cone of sound which insonifies a small area of sea bed, the area increasing with depth. Scanning sonar are considerably more expensive than vertical sonar and the results more difficult to interpret.

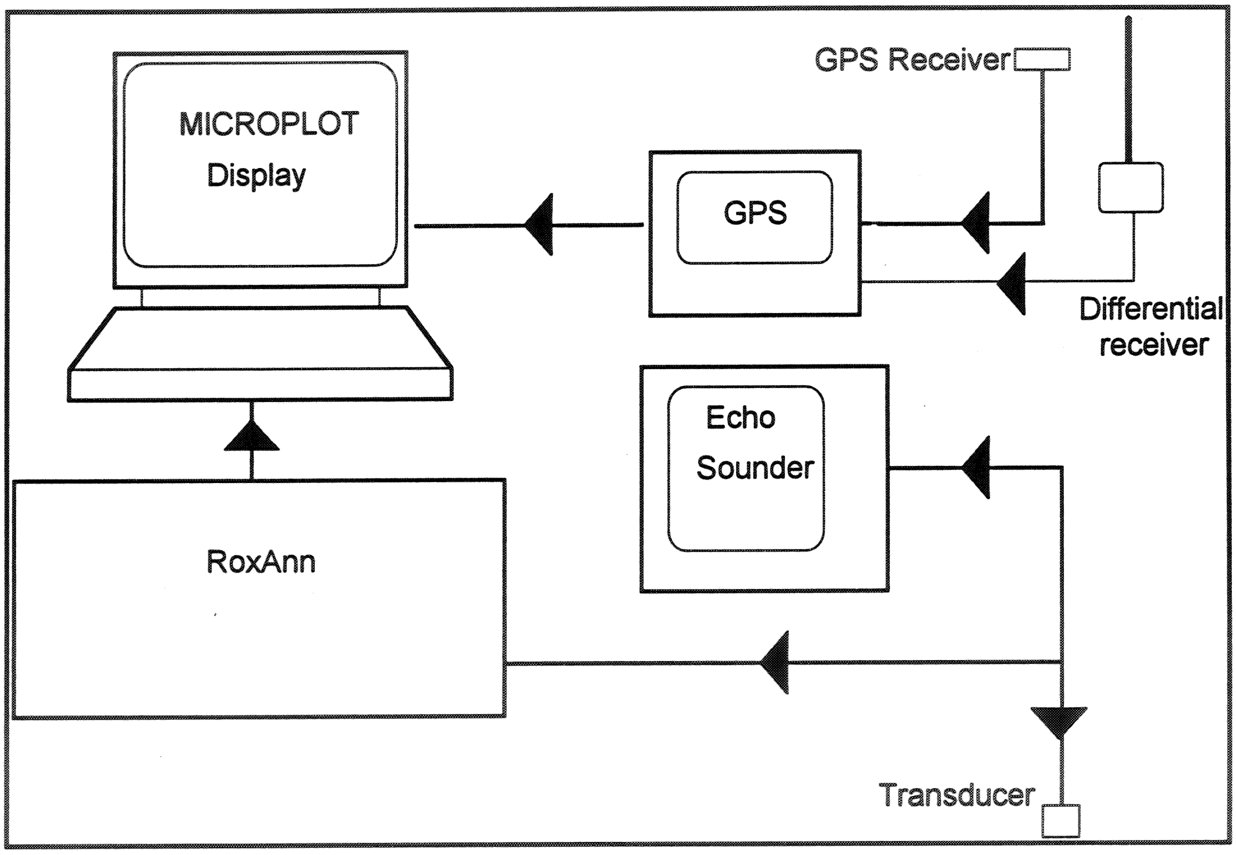

Figure 2 Schematic diagram of acoustic survey equipment

A *RoxAnn* processor samples the return echo from a 200 kHz echo sounder which has a 17° beam width; Chivers *et al* (1990) provide a detailed description of this system. Position data were provided by a Global Positioning System (GPS) using a differential receiver with an accuracy of ± 15 m (Trimble™ GPS with Scorpio Marine™ differential receiver). *RoxAnn* data were saved at 5 sec time intervals on a laptop computer; the computer also supplied time and date for each data point. Whilst the boat travels along a set path at a speed (over ground) of 4 kn., a continuous set of measurements (or track) of the physical nature of the sea bed were recorded and displayed on the computer using *Microplot* navigation software (Figure 2). *Microplot* displayed the track data on the computer screen coloured according to combinations of roughness (E1) and hardness (E2) or by depth, superimposed on a chart of the coast.

Using the hardware and software settings described above, it is possible to determine the area of sea bed sampled by the *RoxAnn* system:

- A beam with of 17° insonifies an area of approximately 7 m^2 at 10 m depth, increasing to approximately 170 m^2 at 50 m depth.
- At a save rate of 5 s and a boat speed of 7 kn., a data point was saved every 20 m horizontal distance.

Acoustic tracking

Information is obtained from a limited area under the survey vessel and a map of the acoustic properties of the sea floor built up from a series of parallel tracks: the closer the track spacing, the more complete is the coverage. Nearshore coastal geology combined with coastal geomorphic processes generally produce a heterogeneous assemblage of physical habitats and their associated natural assemblages. Further offshore where the sea bed is predominantly sedimentary, there is generally less heterogeneity with large areas of similar sediment types. Consequently an adaptive survey strategy (Simmonds *et al*, 1992) was employed where the whole survey area was tracked at a broad level (0.25 km apart) and then heterogeneous areas, or areas of specific interest, were tracked in more detail (0.125 km spacing) to determine the spatial organisation of sea bed characteristics.

Biological sampling

Acoustic mapping using a *RoxAnn* system provides data on the physical nature of the sea bed - depth, smoothness/roughness and softness/hardness. These acoustic data have no biological meaning unless they are related to biological assemblages, determined from direct observations or samples of the sea bed at pre-determined point locations. In remote sensing terminology, the acoustic data must be validated with *in situ* biological sampling and, if possible with additional 'collateral data' such as sea bed geology and tidal streams (Barrett & Curtis, 1992). *In situ* validation data may be existing sample data from previous investigations, although it is preferable to collect new data so its location is accurately matched to the acoustic tracks. New data can also validate existing data which may be valuable in dynamic environments subject to rapid change.

Biotope data were collected using a towed video recorder and by scuba diving; the Marine Nature Conservation Review of the Joint Nature Conservation Committee undertook the diving survey. The term biotope embodies both the physical habitat and the associated biological assemblage (Connor *et al.* In press). A small remote video system using a standard Hi8 camcorder in a waterproof housing mounted into a small sledge was the principle ground validation device. This system was connected by an umbilical to a monitor at the surface and was towed along the sea bed as the boat drifted.

Selecting stations to sample was undertaken on the basis of preliminary analyses of acoustic data (see below). Given ideal circumstances, it is desirable to sample all possible combinations of acoustic characteristics present within the survey area. In practice the final number of samples collected will be a trade off between the quantity of data required, allowing for the availability and suitability of existing data, and the financial resources and the time available for sampling. In addition it is desirable to spread the sample stations throughout the survey area - to allow for spatial variations, and if possible to collect replicate samples for each ground type.

Data analysis

All data analyses were undertaken using proprietary software on a desktop personal computer (PC): a central aim of the BioMar project is developing a cost effective PC based system which can be recommended to a wider audience as a tool for environmental management.

Preliminary analysis of acoustic data

Preliminary analyses were completed during the field survey both to select areas for more detailed tracking and to locate *in situ* samples. These analyses were completed within the *Microplot* software. Initially tracks were analysed to show small increments in the values of E1 (roughness), E2 (hardness) and depth by assigning colours to narrow ranges of data. Basic contour maps were prepared for each variable by contouring equal-value points (isopleths) and then overlaying these maps to produce a composite map which indicated areas with similar acoustic and bathymetric characteristics. During the field survey these maps were used to select sites for ground validation to represent the full range of E1, E2 and depth values within the survey areas.

Analysis of ground-validation samples

Biotopes descriptions were compiled from video recordings and direct observations (by diving), which were analysed for their physical and biological characteristics. The terminology used for describing physical characteristics followed the methods for the Marine Nature Conservation Review of the Joint Nature Conservation Committee (Hiscock, 1990). For biological description emphasis was placed on recognising various life forms where the terms have been developed from *Seasearch* methods (Foster-Smith, 1992) for the *BioMar Project*. All biotopes recorded were categorised according to a standard national classification system which is flexible enough to allow for local variation (Connor *et al,* In press).

Matching acoustic data to biotopes

Matching biotopes to acoustic properties of the sea floor enables the distribution of biotope categories to be shown on a map. Initial matching was undertaken within *Microplot* by adjusting the boundaries of the map of acoustic/depth properties through editing the display of the acoustic data. These data were then exported from *Microplot* and post-processed using the spreadsheet *Excel* (Microsoft Ltd), the contouring program *Surfer for Windows* (Golden Software Ltd), and the geographic information systems (GIS) *Idrisi* (Clarke University) and *MapInfo* (MapInfo Corporation). GIS provides the facility to accurately select track data adjacent to sample stations so acoustic limits can be determined for each biotope category. In addition, GIS has extensive cartographic facilities to produce the biotope maps.

Bathymetry

Acoustic track data were corrected to chart datum using tidal corrections calculated from the tidal prediction program using the simplified harmonic method produced by the UK Hydrographic Office (Anon, 1991). Corrections were applied hourly by taking the hour from 30 minutes before to 29' 50" after the hour: *i.e.* the correction for 12:00 would be applied to data from 11:30:00 to 12:29:59. These data were transferred to the contouring program *Surfer for Windows* to produce bathymetric maps for the survey areas. To convert the track data into a continuous coverage, it was necessary to interpolate adjacent track data to calculate values for intermediate areas. Standard geo-statistical procedures were employed for the interpolations; a review of geostatistics suggested that the procedure *krigging* was most suited to random data points (Rossi *et al.* 1992). *Surfer for Windows* provides a krigging algorithm to reduce the track data to a rectangular grid of data points for the survey area; a grid size of 100 m by 100 m was selected for the present project.

Results

The Thanet coast was surveyed by the BioMar team from May 10-12, 1995. Inclement weather severely restricted the data collection, particularly video sampling. Therefore ground validation of the acoustic data was undertaken using the data provided by the Marine Nature Conservation Review. The following data were obtained from the BioMar survey:

i The area surveyed extended from Ramsgate to Birchington, to an approximate offshore limit of 5 km. A *RoxAnn* track spacing of approximately 250 m was maintained throughout the survey area - see Figure 3

ii 10 video stations were surveyed (Appendix & Figure 5).

The Marine Nature Conservation Review provided data from 20 stations (Northern, In prep).

Bathymetry

A bathymetry map was prepared for the survey area (Figure 4).

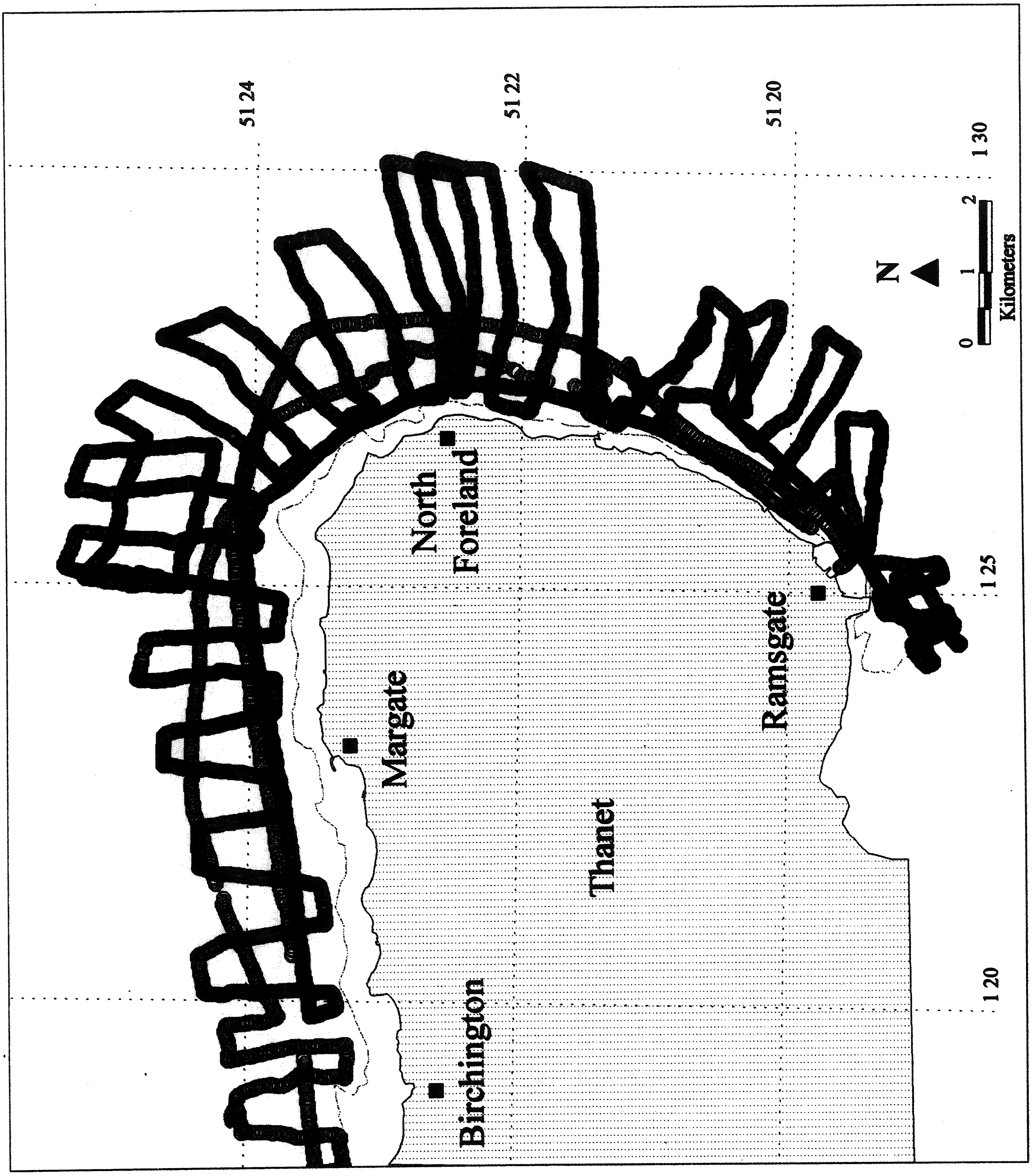

Figure 3 Location of the acoustic track around the Thanet coast

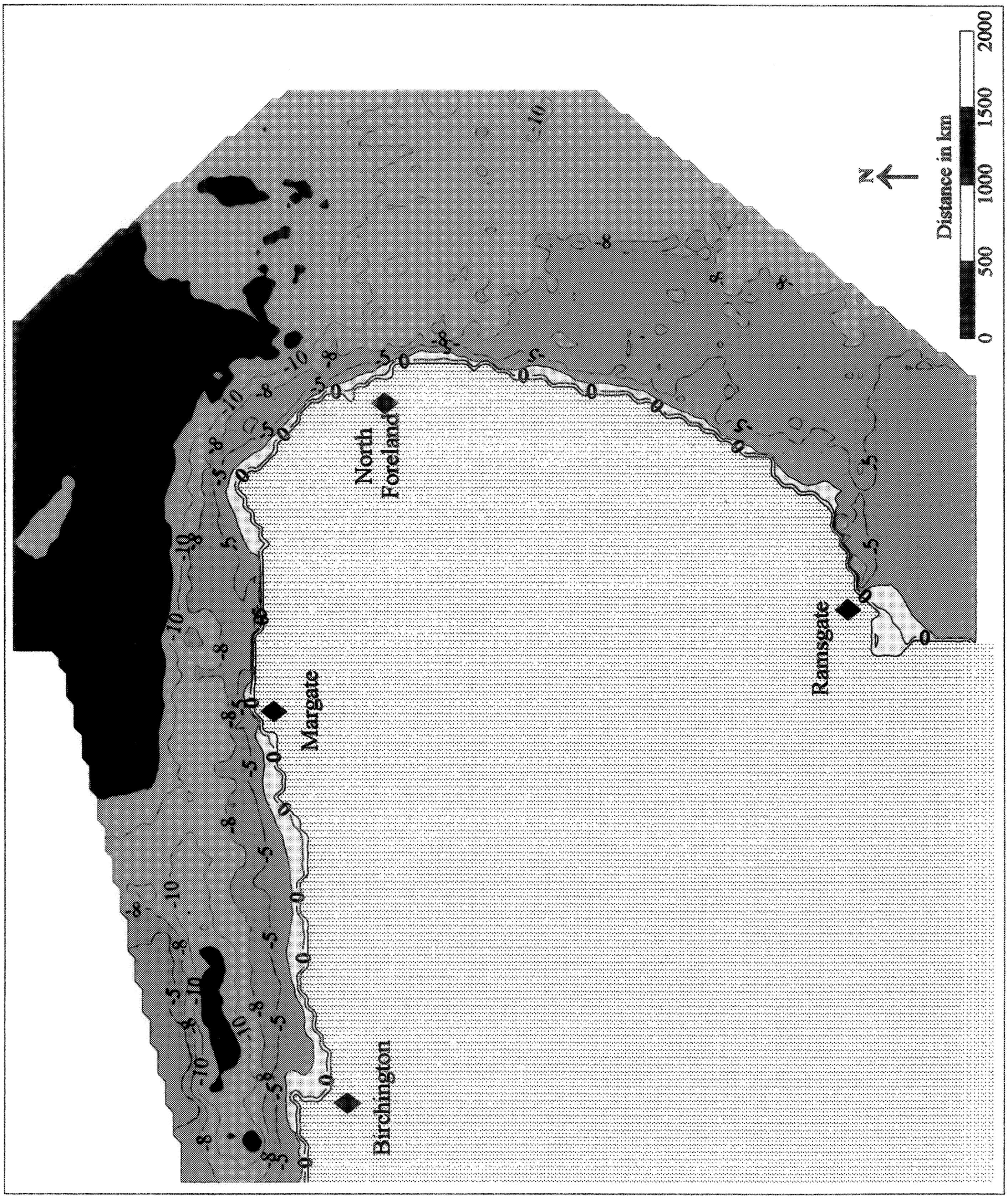

Figure 4 Bathymetry around the Thanet coast

Biotope descriptions

Data from all sample stations were analysed to determine the biotopes present at each station using detrended correspondence analysis (DCA) and cluster analysis. A total of 5 generic biotopes were identified from the video and dive stations (table 1); minor variations were determined for two of these biotopes. When the two principle axes of the DCA are plotted, it is possible to visualise how the sample stations were separated into the biotopes (Figure 5). Depth and the presence of chalk appear to be the dominant factors determining biotopes.

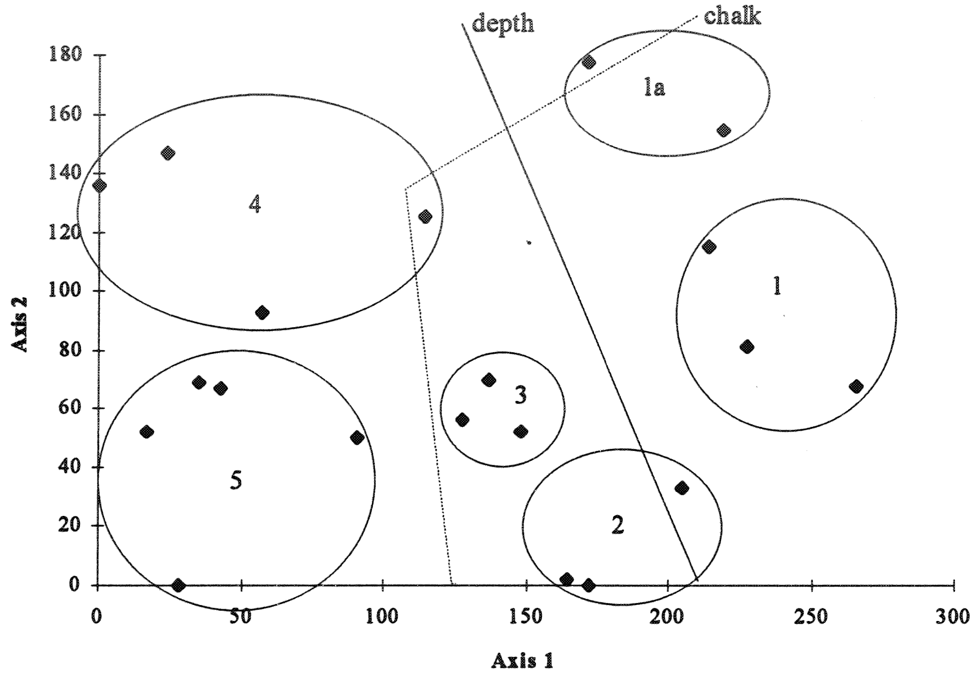

Figure 5 A plot of the two principle axes of the detrended correspondence analysis to determine biotopes; the numbers within each group of stations represent the biotopes.

Figure 6 shows the distribution of the sample stations coded by these biotopes

Table 1 Biotopes identified from ground validation stations. Sample code refers to the sample stations shown on Figure 6.

Code	Biotope	MNCR stations	BioMar stations
1	Low Infralittoral chalk bedrock with a mixed algae/hydroid turf	9; 10; 14	
1a	Low infralittoral/upper circalittoral chalk bedrock with barnacles	11; 12	
2	Circalittoral chalk bedrock & stones with hydroids & piddocks	13; 15; 16	5; 8; 9
3	Tide-swept circalittoral chalk bedrock with a hydroid and bryozoan turf	7; 17; 18	
4	Circalittoral chalk bedrock & stones overlain with sediment with hydroid turf	5; 8; 19; 20	1; 2; 4
5	Circalittoral stones overlain with sediment with sparse hydroid turf	2; 3; 4; 6	3; 6; 7; 10
5a	Tide-swept circalittoral stones overlain with sediment with sparse hydroid turf	1	

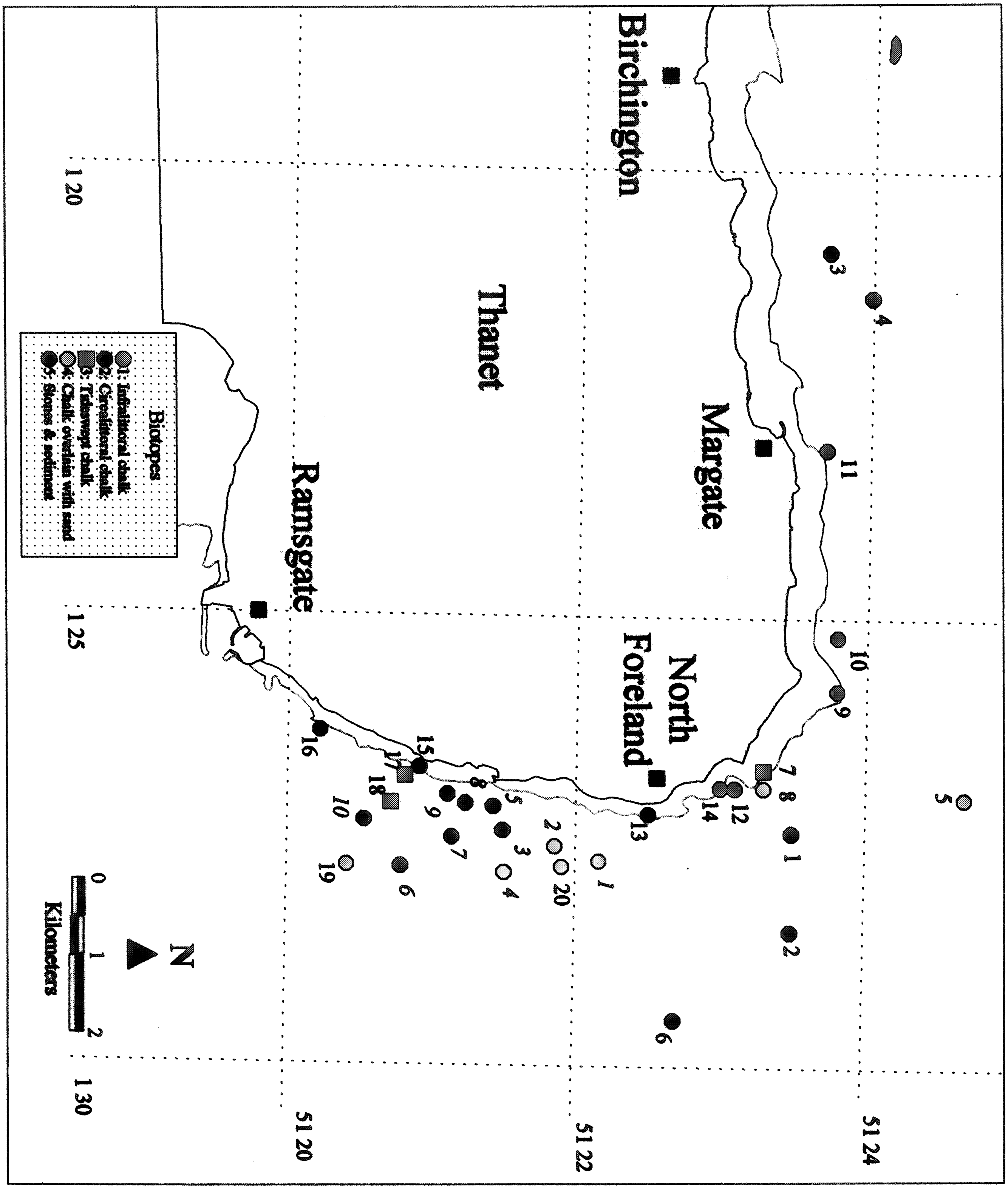

Figure 6 Location of video stations; BioMar station numbers are in italics. Stations are coded by generic biotope as listed in Table 1

Distribution of biotopes

Limitations of the mapping technique

Analysis of the acoustic data generates 'hard' boundaries between biotopes and does not allow for any gradual transition from one type to another. Plainly for some biotopes particularly sedimentary biotopes, there will be a transition from one type to another and thus consideration of any boundaries on these maps must take account of likelihood of a transition. It is also possible (even probable) that for some areas, the physical characteristics of the sea bed will result in acoustic signature that matches one biotope, whereas in reality, direct observation would reveal separate biotope is present.

Linking acoustic data with biotope data

Linking the ground validation data with the acoustic data proved extremely difficult for a number of reasons. Inclement weather during the acoustic survey prevented adequate ground validation by video sampling. Video sampling during the acoustic survey is the principle method for ground validation because it enables more accurate positioning of the sample in relation to the acoustic track. Experience has proved accurate linking of video and acoustic samples improves the correlation between the two data sets. Secondly, it is possible to collect many more samples by video than diving which allows the full range of acoustic data to be validated. Thirdly, inclement weather and very poor visibility adversely affected the data collection by the diving team. Consequently linking the biological data to the acoustic data was difficult and incomplete. For instance, on the basis of past experience the acoustic data indicated sedimentary areas although no sedimentary biotopes were sampled.

It was the intention to analyse the acoustic data using standard methods developed for analysis of remotely sensed images - satellite images, aerial photographs. Acoustic data were first analysed using a form of cluster analysis to build a classification based on the variables E1, E2 and depth. Each cluster represents data having similar values for these variables. These clusters can be represented on a map to build up an image of the acoustic signature of the sea-bed (Figure 7). It is then necessary to locate ground validation samples in each cluster to determine the actual biotope present on the sea-bed. Due to the variability of the acoustic data, and the biotopes themselves, it is most likely that groups of clusters rather than single clusters will represent an individual biotope. The second stage of the analysis uses the ground validation data to create acoustic signatures for each biotope which then form the basis of a second cluster analysis where the acoustic data are fitted to these signatures. A map of the second clusters is interpreted as a map of the biotopes present on the seabed. Unfortunately an *a priori* assumption of the second analysis is that the signatures represent the full range of data because all data are fitted to these signatures.

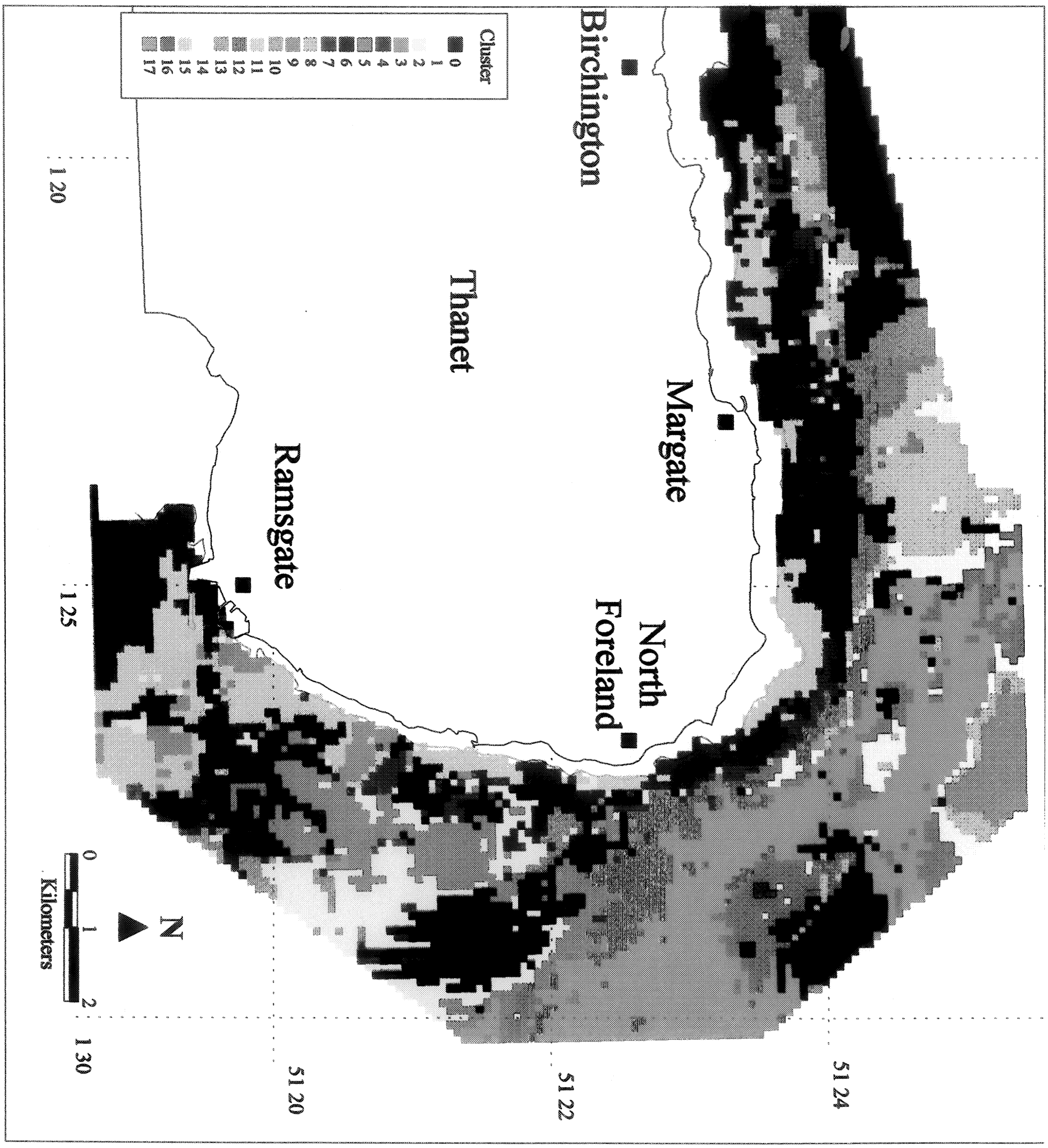

Figure 7 Areas of similar acoustic characteristics based on cluster analysis

Due to the problems listed earlier, it was not possible to sample the full range of clusters from the first analysis and thus the biotopes recorded do not represent the full range likely to be present within the area. This problem was particularly for sedimentary biotopes. Therefore it was not possible to complete the second stage of the analysis and a less satisfactory method had to be used. Sample stations were plotted onto Figure 7 to determine which clusters correlated with each biotope. Fifteen of the nineteen clusters were allocated to biotopes although there was some overlap. The range of E1, E2 and depth values was determined for each of the remaining clusters and their likely biotope predicted on the basis of past studies. Whilst this is unsatisfactory, it will present a more realistic picture than attempting to fit all the acoustic data into a limited range of biotopes. Spatial distributions of these biotopes within the survey area are shown in Figure 8.

Given the preceding text, it must be emphasised that this map represents the **predicted biotope distribution** based on the acoustic characteristics of the sea bed. Any reference to these maps must make this point clear, and all judgements based on these maps must take account of the limitations of the mapping technique and the problems associated with the data analysis.

Summary of biotope distribution

One of the central aims of the present survey was to determine the distribution of the sublittoral chalk reefs around the Thanet coastline, particularly their offshore extent in relation to the possible Special Area for Conservation (pSAC). Along the north coast of Thanet, the chalk extended into the shallow sublittoral for approximately 0.5 km and was progressively overlain with sediment. Small outcrops did occur within these sedimentary areas resulting in a heterogeneous mixture of biotopes. Beyond approximately 1 km offshore, the seabed was predominantly sediment.

To the north east of the Thanet coast, there was an extensive heterogeneous mixture of rock and sediment. Samples indicated that the rock was mostly stones (boulders, cobbles & pebbles) although chalk outcrops were present. Such heterogeneous areas posed considerable problems to acoustic mapping because the small scale variability was often beyond the lowest discrimination of the acoustic hardware. Therefore it is likely that chalk reefs do occur within the large area attributed to biotope 5.

To the east of Thanet, the chalk bedrock extended for approximately 1.5 km offshore, beyond the boundary of the pSAC. In particular, it should be noted that the area attributed to biotope 4 extended beyond the survey area and therefore is likely that chalk outcrops are present some distance offshore. Discussions with local fishermen suggested that there were chalk outcrops up to 30 km offshore - unfortunately it was not possible to survey these area during the present study.

In conclusion, the present mapping study has demonstrated that chalk platforms extended into sublittoral areas, to an approximate offshore limit of 1.5 km to the east of Thanet. These platforms were progressively overlain with sediment although outcrops were still present in predominantly sedimentary areas. Inclement weather posed a number of problems during the survey and subsequently to the data analysis. Nevertheless the BioMar survey strategy has provided an indication of offshore extent the sublittoral chalk biotopes, particularly in relation to the pSAC.

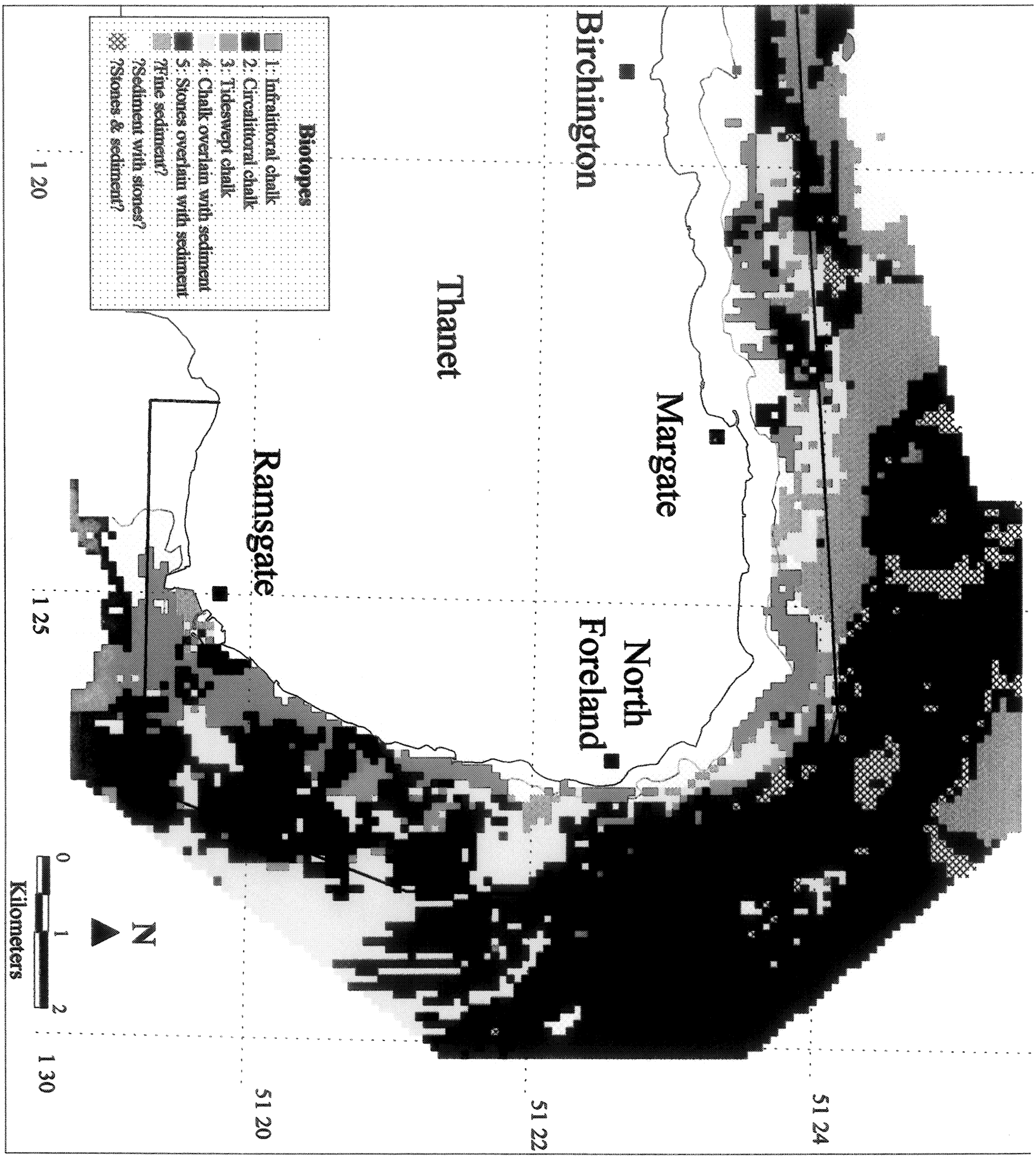

Figure 8 Predicted distribution of biotopes around the Thanet coast

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