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A REVIEW OF BEACH SURVEY DATA FOR THE UNITED KINGDOM

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ABSTRACT

This report describes a review of beach survey data from around the coast of the United Kingdom. The extent of coverage has been established and the methods of analysing the data reviewed. Recommendations are made for further beach monitoring which would be of use to coastal managers both locally and from a national viewpoint.

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1 INTRODUCTION

Cost-effective management of coastal defences requires a good understanding of the processes affecting them. In turn, measurements and monitoring are vitally important to understanding the complex phenomena involved. As an example, the deployment of wave-rider buoys has greatly improved the understanding of wave growth and propagation, as well as providing data for direct use in design calculations.

Recent decades have seen great advances in the understanding and numerical modelling of waves, tides and currents. The movement of beach material, however, has proved much more difficult to comprehend. In many circumstances, it is the lack of information on the response of a beach to wave or tide action, either in the short term or over a longer period, which frustrates progress towards a practical understanding.

Even more importantly, beach monitoring provides information to the engineer on the "health" of a coastline. If a beach is stable, or gaining material, then the data collected will provide reassurance that all is well, and that no strengthening of defences is necessary. Around the coast of the United Kingdom, however, such situations are distinctly uncommon. It is much more likely that monitoring will record an eroding beach, and an accurate, quantatative estimate of likely beach changes is vital to a coastal manager. On a natural beach, such information will allow an early decision on whether intervention works are needed. On a beach already affected by the installation of defence works, monitoring also provides a useful guide to the performance of those defences.

In future years, it seems certain that global warming will cause a rise in sea-level relative to the land. As a result, the importance of monitoring will increase still further as more beaches start to erode, and those already receding will do so more rapidly. Despite this there is little in the way of a co-ordinated policy of beach data collection around the UK coast, nor any generally accepted guidelines for the methods or frequency of monitoring.

The objectives of the research reported here are to assess the extent of coverage of the UK coastline by beach survey data, and to identify gaps where such information would be useful for coastal engineering management. In addition, a brief review of survey methods is presented and recommendations made on methods of analysing the data obtained.

2 EXTENT OF BEACH SURVEY INFORMATION AROUND THE UK COASTLINE

It has not been possible in the present study to contact all the organisations and authorities in the United Kingdom which may hold beach survey data. Responsibility for coastal protection and sea defences is divided between a large number of authorities, especially in England and Wales. Information has been sought from almost all of these district and borough councils together with 7 of the 9 NRA regions who have substantial lengths of coastline within their care.

In Scotland, all the regional councils have been canvassed, together with the three offshore island councils. In the course of such enquiries, and from previous studies, it has also been possible to find other sources of data, for example various

universities and the Property Services Agency. Given the diversity of the organisations involved and of the great differences in lengths and character of the coastline for which each organisation has responsibility, it is not surprising that survey standards vary substantially. It is easiest first to review the results of our survey by concentrating on the methods used.

2.1 Visual inspections

Virtually all the authorities contacted carry out visual inspections of the coast. The extent and frequency of coverage, however, vary considerably depending on the length of coast, its accessibility and its tendency to erode. Highland Regional Council, for example, has thousands of kilometres of coast, much of it rocky and remote. Here inspection is concentrated on those frontages where the coastline is 'soft', eg where there are sand beaches, and where erosion may cause problems to property, roads etc.

Contrast this situation with certain local district or borough councils along the south coast of England (eg Brighton, Hove, Torbay) where the beaches are of great importance to the local economy, are easily accessible and can be inspected within a few hours by a engineer walking their length. In such areas, inspection is typically much more frequent, and is sometimes combined with beach patrols looking for pollution etc. One authority carries out such inspections daily.

Since the present research project is concerned with data, the standard of the visual inspections was not specifically investigated. In areas where coast protection and sea defence works have rarely if ever been carried out, it seems that the inspections are often cursory, with beach changes being assessed on

the basis of comparison between the observed situation and the engineer's memory of the coast in previous years. Structural damage, for example to groynes or sea walls, is easier to detect.

For those authorities who spend significant amounts on coastal defences and their maintenance, the visual inspections appear more detailed, although there is often no written information on how the inspections are carried out or on what was observed.

2.2 Ground photography

A distinction has to be drawn immediately between photography of coasts aimed at providing numerical information on beach levels (ie photogrammetric methods) and photographs taken to provide visual comparisons. The former type of survey appears still to be in its infancy in terms of regular use by coastal authorities. The photo-radiation method developed at the Polytechnic of Wales (Ref 1) for example has been used at several locations around the UK coast but largely in connection with particular defence schemes. Carrying out such surveys, and analysing and storing the data obtained seem to be specialist tasks which most authorities would only undertake on a contract basis.

Less specialized ground level photography is sometimes carried out by coastal authorities, although routine, repeated surveying by this method is still very uncommon. Many authorities have a collection of photographs of their coast. These may be of a historical nature (eg postcards) or of the construction of defence schemes. Photographs are also taken during severe weather, and the use of video cameras seems likely to increase for the same purpose. Usually, however, differences in camera type and

position make it difficult to directly compare photographs or to estimate beach levels even approximately.

Annual or bi-annual photographs taken from fixed positions with the same camera would appear to be a cheap method of improving visual inspections. As an example, Strathclyde Regional Council have monitored a beach on the Isle of Arran for many years taking both conventional beach cross-sections and photographs. While the analysis of the surveyed sections is more useful to the engineering staff, the fears of the public when beaches fall (temporarily) to a low level are more easily allayed by use of historical photographs. Despite such advantages, and minimal cost, only a handful of UK authorities use such a technique.

2.3 Beach cross-section levelling

The most common method used to obtain quantatative information on beach levels is to survey along cross-sections set roughly perpendicular to the contours of a beach. About 25% of the authorities contacted had no such profile information, although some of the coasts concerned has been surveyed by other institutions, eg Universities.

On the more positive side, about 35-40% of authorities carry out regular surveys of part or all of their frontage, using more or less conventional surveying methods. A similar number of authorities have had some conventional surveying done in the past (often in connection with particular schemes) or obtain information on beaches from other more general surveys.

As one would expect, the likelihood of finding beach survey data for any coast depends strongly on the character of the coast itself. Beach profiles from Devon, Cornwall, west Wales, Cumbria, western and northern Scotland and the offshore islands (Orkney, Sheltand, Isle of Man and the Hebrides) are distinctly rare. Coverage is better but patchy in west Dorset and Somerset, south Wales, north-eastern England and eastern Scotland.

Generally speaking this coverage reflects the likelihood of property being at risk from coastal erosion. It is therefore not surprising to find the most intense coverage in the south-east of England (Poole Bay to the Humber) and in north Wales and north-west England (Great Ormes Head to Morecambe Bay).

As always with such overviews, there are notable exceptions. Together Tayside Regional Council and the Property Services Agency carry out regular surveys of the whole of the coast of that region. Whilst parts of this coast are eroding, the decision to embark on a general monitoring programme reflects on a enlightened attitude to understanding the process affecting the coast.

Conversely there are a few areas of the coast in south-eastern England where erosion is serious and considerable investments have been made in coastal defences, but where no regular beach monitoring is being carried out.

The accessibility of the coast, and the type of beach can also affect the amount of survey data available. For example there are very few profiles taken across salt-marshes although erosion of such features is widespread and serious. Similarly sand dunes are very

difficult to survey using conventional levelling techniques, although they still form the only defence against flooding in some areas.

The frequency of surveying cross-sections typically lies in the range once per year to four times per year. A few authorities have surveyed more frequently (eg monthly on the Lincolnshire coast from 1959 to 1976) or have obtained beach profiles after major storm events. This more frequent data collection will be valuable not only in recording beach changes but also in understanding the complex relationship between such changes and the wave and tidal conditions.

It appears that once the period between beach surveys extends to more than one year, there is every chance that enthusiasm for continuing the monitoring diminishes. This is a danger in any event; a surprisingly high number of authorities have discontinued surveying within the last 5-10 years. However, rather more authorities have recently started or are planning to start surveying than those who have recently abandoned such exercises.

There is also a growing trend for coastal authorities to carry out analysis of beach profile data using computers. The analysis packages range from powerful bespoke software developed in-house (eg Canterbury City Council) or by consultants (eg NRA - Anglian Region) to basic spreadsheet programs adapted for the purpose.

This development is particularly important for two reasons. First the analysis of the profile data to provide information on beach development will help justify continuation of surveying. Second the use of computers to analyse survey data makes it essential to convert that data into digital form. This is a great

improvement on the traditional storage system where profiles were plotted manually onto prepared sheets. Subsequent conversion into digital format for processing was tedious and prone to introduce errors.

The present trend towards storage and analysis of beach profiles in digital form is reinforced by modern survey instruments which store data internally and transfer it directly to a computer. Once beach survey data is stored digitally, subsequent re-analysis, or transfer to other computers is more easily achieved. Co-operation between neighbouring authorities in terms of sharing technical information will be able to profit from this.

2.4 Aerial Surveying

In the Netherlands, where beach management is both more vital and more organised than in the UK, aerial photogrammetry is the major weapon in long term beach monitoring. Southern Water, and now NRA-Southern Region have carried out a similar monitoring exercise for the counties of Kent, Sussex and Hampshire. Apart from this however, the use of aerial photography for quantatative beach monitoring is rare within the UK. Several local authorities (eg Rhuddlan BC, New Forest DC and Torridge DC) have made use of this technique, and others are actively investigating it.

Other authorities use aerial surveys to gain a good visual impression of the coast and have extracted information on cliff-top recession, for example, without going to the considerable further expense of extracting beach level information in digital form.

In terms of survey data, therefore, the NRA-Southern Region aerial photogrammetry appears to be the only substantial source in the UK. Beach profiles are

measured from the photographs at a spacing of about 175m along the coast, the exact position depending on the positions of structures such as groynes and slipways. For some parts of the coast, data is available from 1973, although only one survey is carried out each year. Many of the local district councils in the area covered rely on these surveys alone for information on beach trends. At least one authority, however, has been disappointed with the data quality and withdrawn from the scheme.

The key to successful aerial photogrammetry appears to be in adequate ground control. If this is established then there is every hope that beach data from this source will be a valuable asset in years to come, particularly for the more remote stretches of coast.

2.5 Other survey techniques

It is worth reporting other survey techniques encountered during this project, since they highlight some of the weaknesses of the methods described above.

(a) Hydrographic Surveying

Even if surveys are carried out at low water of spring tides, and the staff-person is willing to continue some distance into the sea, only a part of the active beach profile will be measured. As a consequence winter surveys will typically show less beach material than summer surveys, because some sand and shingle will have temporarily moved seawards beyond the survey limits.

In addition, changes in beach levels can, in some locations, be intimately linked with changes in

the offshore sea bed. The only way to overcome these shortcomings of topographic surveying is to carry out a linked hydrographic survey of the sea bed. This is now an area of increasing activity, although fewer than 10 of the authorities consulted have any regular programme of hydrographic surveying. Normal practice in the UK is to use shallow draft boats equipped with an echo sounder. In Belgium, in contrast, a large hovercraft is used.

(b) Beach 'dipping'

A rapid method of beach surveying, requiring only one person, is to record levels by measuring vertically downwards from fixed (and previously levelled) marks. Levels of the beach at the base of a seawall or alongside a groyne can be gauged in this way. This provides precisely relevant information for assessing the interaction of the beach with a structure, although it has the disadvantage of not necessarily giving 'average' values for the beach face as a whole. Few authorities use such a technique, however, and this is surprising.

(c) 3-D surveying

The overwhelming majority of historical beach data in the UK is in the form of cross-sectional profiles. Occasionally longitudinal surveys (eg along the base of a sea wall) are encountered. One advantage of either method of data collection is that surveys from different dates can be quickly displayed with little manual effort.

The recent arrival of cheap computer software to process data taken at random over a surface area

(such as a beach face) is now encouraging a more adventurous approach to surveying. Data can be obtained from aerial photographs in this format and also from modern survey instruments which use laser beams and can store the survey results in an internal memory. When beach contours are markedly curved, for example in the lee of an offshore breakwater, then a much better appreciation of the beach dynamics may be obtained using a 3-D mapping system. A disadvantage is the difficulty in comparing more than two such surveys on a screen or a sheet of paper.

For conventional topographic surveys, there is also the difficulty of travelling over a large area of inter-tidal foreshore to obtain sufficient spot values to provide the data required. Since the time spent by surveyors is one of the major elements in the cost of data gathering, attention is turning towards the use of vehicles. Lancaster County Council, for example, use an 8-wheeled amphibious vehicle to help survey the large inter-tidal foreshore at Morecambe.

As noted previously, the Belgian coast is surveyed by hovercraft (but only using echo-sounders) and this method may be useful for salt-marshes. Rough terrain motor-tricycles have also been used to speed up surveys on long stretches of coast.

3 REVIEW OF BEACH SURVEY DATA ANALYSIS TECHNIQUES

There is no value or point in continuing regular beach surveys if the data obtained is not inspected and analysed. Any numerical analysis of beach survey information prior to about 1970 is difficult to

uncover. It appears that a visual appraisal of profiles plotted on the same graph was the most common analysis technique. An experience engineer would have been able to derive useful qualitative guidance from such study. However beaches whether of sand or shingle undergo considerable changes in level as a result of changing wave conditions. This volatility of beach levels is often very large compared to, say, a slow underlying trend of erosion. Some authorities consulted during this study have been so discouraged by these rapid profile changes that they have decided against undertaking any monitoring. Other authorities, having recognised the problem, have improved their analysis techniques to ensure that useful results can be obtained.

The simplest, and often most useful technique is to calculate a single parameter indicating the state of a beach and then produce a time-history plot of that parameter. The quantity most often examined is the volume of beach material revealed by the survey. This may be an 'absolute' volume, or more commonly the volume change from some baseline quantity determined by an initial survey. This latter type of calculation is commonly used for monitoring beach nourishment schemes (and often for calculating the payment due to the contractors providing the material).

If beaches are surveyed by cross-sectional profiles then an intermediate step is to calculate the cross-sectional areas for each profile. A typical plot of beach cross-sectional areas against time is presented in Figure 1 (courtesy of the National Rivers Authority - Anglian Region), for a site on the coast of Lincolnshire.

Despite the considerable variability it is clear that there is an underlying trend of material being lost.

A sensible next step, taken by some of the authorities canvassed, is to include a least-square regression routine to identify the long term trend. This type of analysis is illustrated later in this report.

There are some problems associated with the calculation of beach cross-sectional areas or total volumes, however, which need to be mentioned. First the calculated areas shown in Figure 1 were limited to the beach profile lying above 0m ODN (approximately mean sea level) since many of the surveys did not extend much further seaward than this contour. It is certain that a great deal of the fluctuation in the calculated areas is the result of material temporarily moving to and fro across this datum level in response to wave conditions. Typically material is shown drawn down from the upper part of the local profile in winter storms, and carried back up the beach face by more gentle waves in summer. The length of a survey down a beach face therefore limits the amount of the beach behaviour that can be observed, and this may mislead the inexperienced, particularly after a violent storm.

Another point worth making is that the volume calculated above some datum level may not all be granular beach material. Canterbury City Council have surveyed the rock substrate underlying their beaches and calculated cross-sectional areas above this stratum face. This provides a much more accurate assessment of volume changes, and also leads to the consideration of whether beach erosion is due to loss of the superficial sand and shingle or erosion of the underlying stratum.

Other parameters can also be considered, of course. The level of a beach directly in front of a sea wall, whilst not being necessarily typical of upper beach

levels as a whole, is vitally important if it is comparable to the wall foundation level. Figure 2, again by courtesy of NRA-Anglian Region, shows a time history of beach levels at a fixed position just in front of the seawall at Trusthorpe. Here, for the purpose of illustration, both a mean trend and an analysis of seasonal variations in levels has been super-imposed on the raw data. Clearly much of the beach behaviour is not explained by the trend analyses. Without recourse to analysis of wave conditions, these unexplained variations have to be treated statistically as scatter in the data. This leads to an alternative presentation of data where a mean beach profile is calculated from a number of surveys, together with information on trends, the standard deviation of levels at any location, estimates of the likely lowest and highest values, and actual maximum and minimum recorded levels. An example of such a presentation is shown in Figure 3. This sort of figure is a much more satisfactory version of the sweep zone concept suggested by Professor C A M King many years ago (Ref 2).

In this figure, analysis has been carried out by fixed chainages. Alternatively a similar analysis could have been made examining distances to fixed levels (eg the distance to the mean sea level mark), although there can be some problems if a beach has bars and troughs. In either case, care has to be taken in defining a zero chainage point from which distances are recorded seaward, particularly if sea walls are likely to be rebuilt or have sloping or stepped front faces.

Other more sophisticated methods of analysing beach profile data can be found in the scientific literature, for example the use of eigen-functions (Ref 3). Apart from use in the NRA-Anglian Sea

Defence Management Study, however, such more advanced mathematical techniques do not seem to have been applied by other local authorities.

For other survey techniques, similar types of analysis can generally be applied, although adaptions are necessary. As an example, a sequence of three-dimensional beach surveys derived by aerial photogrammetry can be transformed into a mean surface with a trend analysis, maximum and minimum values etc at each (chosen) point. No such analysis was uncovered, however, during the present survey.

4 THE CASE FOR FUTURE MONITORING

Most beach surveying around the United Kingdom was apparently started as a consequence of local problems (erosion or flooding) or to monitor specific coastal defence works. A few examples of more general monitoring aimed at understanding the behaviour of a substantial length of coastline have been found. The long term monitoring of the Wirral and the Lincolnshire coasts are two noteworthy examples.

Given the fragmented responsibility for coastal defences, it is not surprising to find gaps in the data coverage. In some places, no beach survey data is available for sites where erosion has necessitated the construction of coast protection or sea defence works, despite the fact that access is easy and surveying technically straightforward. A first suggestion arising from this study is therefore that beaches should be monitored preferably before and certainly after the installation of any substantial coastal defence works. Ideally such surveying should be continued for five years, and cover the coast on each side of the works, as well as directly in front

of them, so the effects on the adjacent beaches can be assessed. Once an authority has been encouraged to begin monitoring, is is much more likely to be extended (in space or time) than surveying being started without this suggested initial stimulus.

Other areas of coastline have not been surveyed for more obvious reasons. Typical factors are that beaches are apparently stable or accreting, that erosion of the coast is of little economic consequence, or that surveying is technically difficult (and hence expensive), usually because of difficulty of access. Against this background, the need for any further monitoring has to be considered carefully.

The case for further monitoring is best illustrated by particular examples, for three different types of coast.

(a) Saltings and saltmarshes

Very little beach survey information was discovered which sheds light on the processes affecting saltings and saltmarshes. Exceptions are the monitoring of Dengie Flats, Essex in the vicinity of a series of barges placed as offshore breakwaters by NRA Anglian Region and also the aerial photogrammetry of the Hampshire coast undertaken by NRA Southern Region. This latter surveying, however, is not designed to give accurate levels for such foreshores.

There is no doubt, however, that many saltings and saltmarsh areas are eroding, and in some places it is is giving rise to concern. Clay banks at the shoreline are having to be

reinforced to prevent erosion, and even then flooding remains a serious threat.

Engineering works to combat this threat have been undertaken already in Somerset, Hampshire and Essex. The situation in these areas generally continues to worsen. There is therefore a clear need for surveying to understand what is happening and how successful intervention works have been.

The main problem, however, is of designing and carrying out suitable surveys. Access is often difficult and sometimes perilous. Conventional level and staff surveying is not appropriate since the areas are large and simple cross-sections are unlikely to be sufficient because of the tendency of tidal gullies to meander on the foreshore. In addition, since vegetation is vital in helping such foreshores to re-build following damage in winter storms, any surveying of levels should really be complemented by a survey of vegetation as well. This is a major area for further study, beyond the scope of the present report.

However it is clear that suitable methods need to be established quickly and at least some sites monitored. Such coasts are likely to be the most vulnerable to sea level rise or increased storminess as the result of climate changes, and are also the sites where coastal managers have very little experience in repairing or forestalling damage.

(b) Sand beaches and dunes

Much less of the UK coastline is defended by natural sand beach and dune systems than in other countries in continental Europe or around the world. Nevertheless there are substantial lengths of coast where sand beaches are eroding and the hinterland is at risk. As with saltmarshes, vegatation plays an important role in stabilising dunes, and hence sandy coasts are also vulnerable to global climate changes. Increased pressure due to recreational uses of sand beaches is another important factor.

Problems are being experienced on all the coasts of England and Wales as sand beaches erode, but this is not well reflected in the survey data coverage.

Where dunes form the main flood defence on a coast, a combination of conventional topographic surveying of the beach and dune toe combined with aerial photogrammetry of the dunes appears the best survey method. This should ideally be accompanied by hydrographic surveying of the nearshore sea bed and underwater bed face. This has already been suggested to NRA Anglian Region and would be appropriate for stretches of coast such as that between Haisborough and Winterton Ness in Norfolk. Other sites where such monitoring would be valuable include the Northumberland coast (particuarly in the Druridge Bay area), the coast of Lincolnshire north of Mablethorpe and parts of the Welsh coast especially in the Camarthen Bay and the Gower areas. There are also considerable lengths of sandy beach with dunes in Scotland where monitoring would produce information on natural

beach processes. However similar data has already and continues to be collected in other countries. It seems appropriate, therefore, that further surveying of UK sand beaches would best be restricted to those areas where erosion is known to be occuring and where defence works are likely to be needed in the not too distant future.

(c) Shingle beaches

The widespread protection of coastal towns and land by shingle beaches (or mixed sand and shingle beaches) is rare outside the United Kingdom. Information on how a shingle beach behaves under storm wave action, for example, is only therefore likely to be obtained by monitoring efforts in this country.

For the most part, shingle beaches are reasonably well surveyed, particularly in the south-east corner of England. There are some gaps, however, particularly on wholly natural beaches as opposed to those fronting seawalls.

The storm events of winter 1989/90 have drawn attention to the role of some of these natural beaches and the limited extent to which they can protect the hinterland. Any long term decay in the effectiveness of such beaches could have very serious implications for coastal managers. This is well demonstrated by the current interest in Hurst Castle Spit in Christchurch Bay.

Coastal works have already been put in place at the ends of Chesil Beach (Chiswell Village, Portland and West Bay near Bridport). The large

part of the beach between these points however, is in a natural state.

Historically this beach has been overtopped quite regularly and on occasions virtually breached. Crest levels are believed to have dropped over the last century and there is little new material of worth being added to the beach. The consequences of a sudden major failure would be very severe. This therefore is a beach where continual detailed monitoring would be very wise, especially in areas where the hinterland would be seriously affected by, say, a sudden drop in crest level. Apart from anticipating any management work, and helping understand the response of a natural beach to particular wave conditions, such monitoring would also help in detecting the effects of climate change. Existing topographic and aerial surveys should be brought together as a first step.

Similar arguments can be put forward for monitoring other important shingle beaches, for example in Start Bay (Beesands to Strete Gate, Slapton), and along the Suffolk coast (Southwold to Shingle Street including Orford Ness). In all these examples, responsibility for the beaches is shared by local authorities and the National Rivers Authority so that some co-operation and joint funding funding would be required. Shingle beach monitoring is relatively straightforward technically and can be carried out rather accurately by aerial photogrammetry given good ground control.

5 CONCLUSIONS AND RECOMMENDATIONS

The review of beach survey data has shown that less than half of the authorities responsible for coastal protection and sea defences are regularly surveying some or all of their shoreline. In the areas of worst erosion (in the sense of the greatest consequent damage), the coverage is rather better. Such areas include the south-east of England (Poole Bay to the Humber) and the coast of Liverpool Bay (Great Ormes Head to the Ribble Estuary). For the most part surveys have been carried out in response to particular problems, or to monitor defence schemes. A few authorities have undertaken wider surveys, however, aimed at understanding coastal behaviour over the whole of the frontage.

Topographic surveying of cross-sections using staff and level methods is still the most common method of obtaining beach level measurements; modern instruments being used now allow information to be transferred directly into computers in digital form. Other methods of surveying used include aerial photogrammetry, hydrographic levelling from shallow draft boats, ground level photogrammetry and 'dipping', ie measuring downwards from fixed marks on seawalls and groynes. Some progress is being made towards alternatives to collecting data on fixed cross-sections for several of these survey methods. Several authorities are carrying out surveying over the whole of a beach face, and this is particularly useful if the beach contours are strongly curved.

Such advances in data collection require corresponding advances in analysis methods. There is certainly a growing tendency for local district councils and NRA regional offices to carry out numerical analysis of

beach survey data, and this has encouraged the conversion of data into digital format. Any transfer or subsequent analysis of the data is greatly aided as a result.

The piecemeal responsibility for coastal defences in the United Kingdom has resulted in substantial gaps in the data coverage. In some areas, despite defences having been installed to prevent coastal erosion or flooding there has been no beach surveying. This is more surprising than the lack of data on coasts where access or surveying is difficult, such as saltmarshes, or where beaches are stable or accreting.

As a result of this review and the above conclusions, the following recommendations have been drawn up:

1. In order to encourage further beach data collection, and to ensure that information on the effectiveness of defences is obtained, it is suggested that monitoring should be carried out as part of the installation of any such works. Ideally such monitoring should be started before new defences are built and continue for five years afterwards. Not only the beaches in front of the defences should be surveyed but also the coast on either side to assess the effects of such defences on adjacent beaches.

2. A major gap in the beach data coverage of the United Kingdom results from the lack of surveying saltmarshes. Since many saltmarshes are already eroding, and are likely to be adversely affected by sea level rise or any increase in storminess, the lack of data is disappointing. It is recommended that research should be carried out with the aim of defining suitable monitoring at

sites on the coasts of Hampshire and Essex. Such monitoring should seek to understand the erosion of saltmarshes in storms, and the recovery of levels, with the assistance of vegetation, in more favourable conditions.

3. Surveying sand beaches in the UK to gain information about their response to wave conditions is less important than similar monitoring of shingle beaches. It is therefore recommended that priority be given to monitoring of those shingle beaches which fulfil an important role in limiting flooding or erosion of the coast. Specifically every encouragement should be given to local district councils and regional offices of the National Rivers Authority to ensure the surveying of beaches such as Chesil, Slapton and Orford Ness. This will not only provide information on the health of these beaches as coastal defences, but also scientific data on the effects of wave conditions and climate change.

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Figures

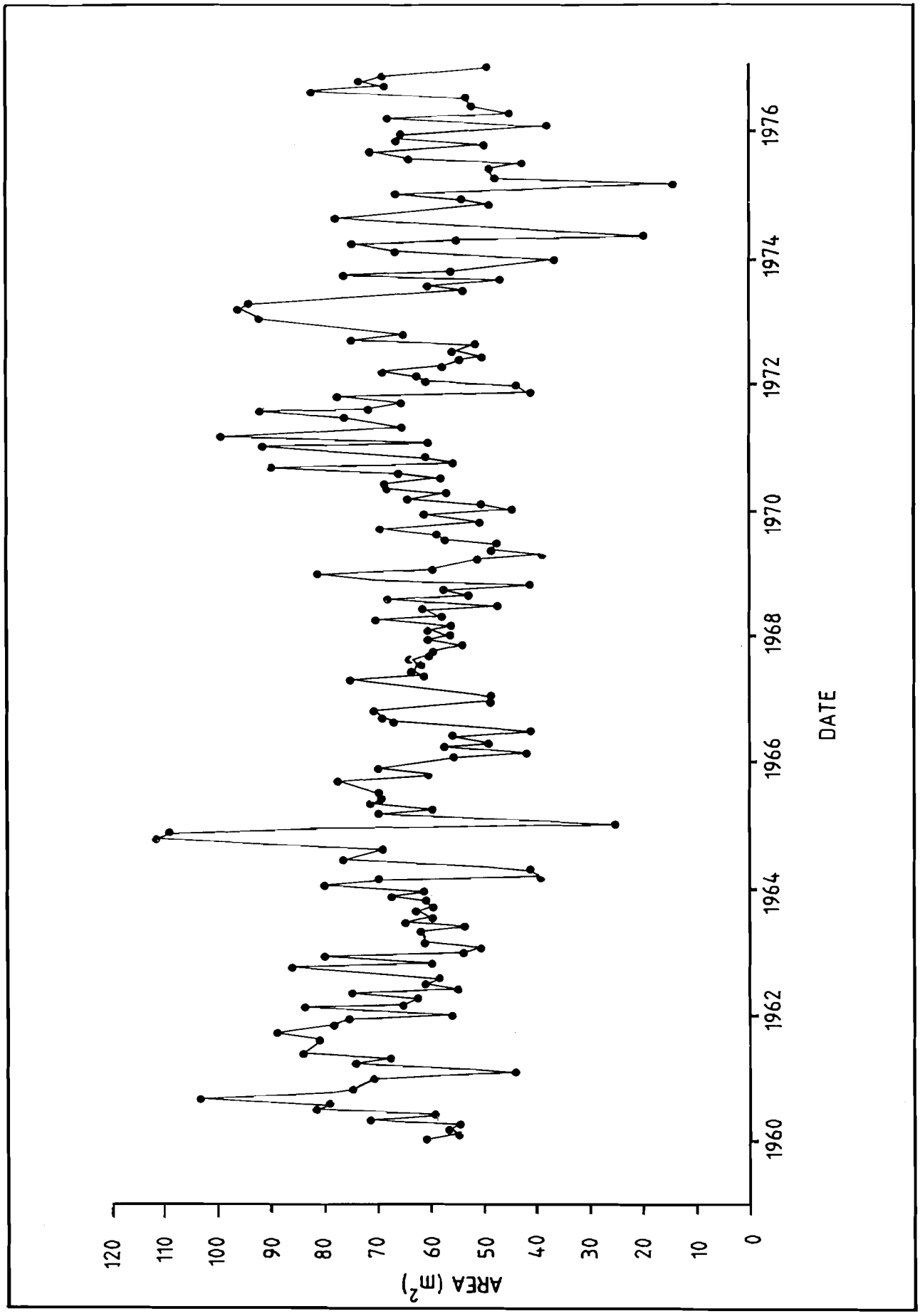

Fig 1 Time history of cross-sectional areas - Trusthorpe.

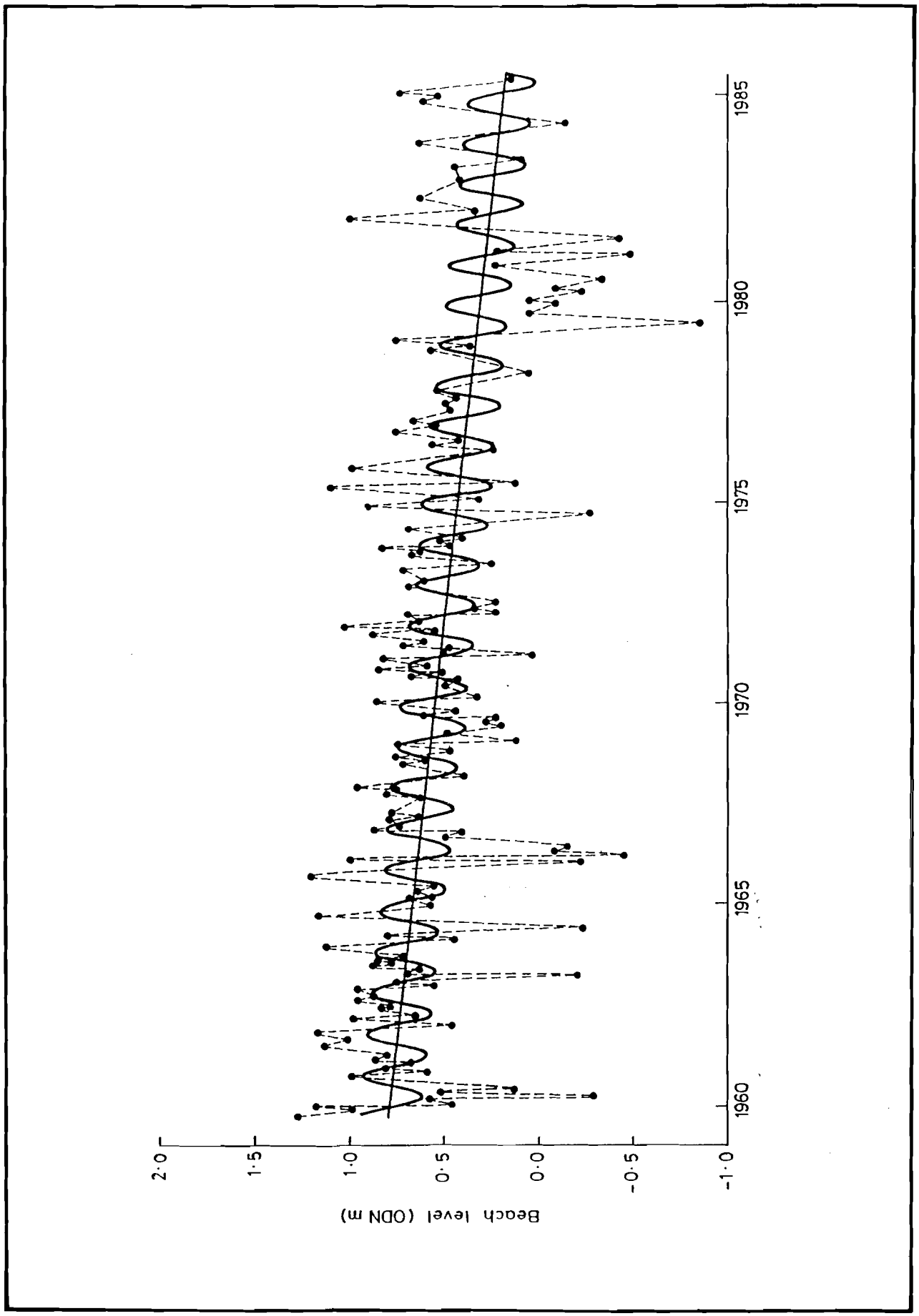

Fig 2 Time history of beach levels - Trusthorpe.

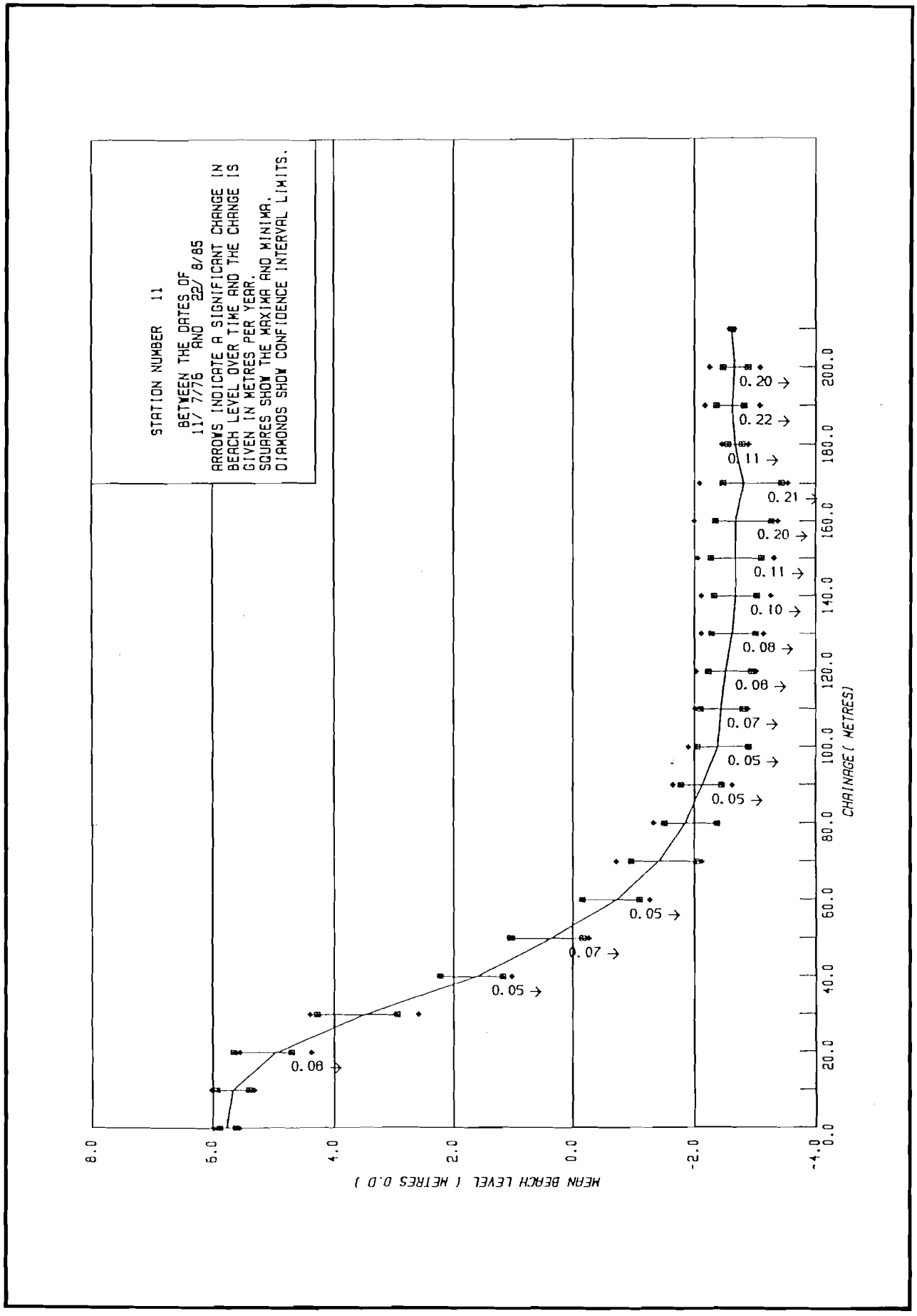

Fig 3 Mean beach profile with trends.