ENGLAND'S COASTAL HERITAGE

A survey for English Heritage and the RCHME

Edited by Michael Fulford, Timothy Champion, and Antony Long

ROYAL COMMISSION ON THE HISTORICAL MONUMENTS OF ENGLAND

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Edited by Michael Fulford, Timothy Champion,
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with contributions by
J R L Allen, M Bell, R J Bradley, T Champion,
S Crutchley, A Firth, M G Fulford, A J Long, S J Mithen,
D O'Regan, S J Rippon, D H Roberts, and H J Tyson

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Contents

List of illustrations

List of tables

Preface

In order to address the issues of characterising the archaeological resource in the intertidal zone, and the development of appropriate management strategies for it in the context of sea-level change, English Heritage and the Royal Commission on the Historical Monuments of England commissioned the Universities of Reading and Southampton to prepare a report. The project was initiated in 1993. The investigation of the archaeological resource in the intertidal zone (Chapters 3-7) was the responsibility of Professor Michael Fulford at the Department of Archaeology of the University of Reading with the assistance from the inception of the project of Jane Tyson and, latterly, Jenny Stevens. The study of sea-level change (Chapter 2) has been under the direction of Dr Antony Long, then at the Department of Geography of the University of Southampton and now at the Department of Geography of the University of Durham, and Professor Timothy Champion at the Department of Archaeology of the University of Southampton has been responsible for the preparation of reports on the nature of the threat towards the archaeology in the intertidal and coastal zone and the development of appropriate management strategies (Chapter 8). The final chapter summarising the potential of the archaeological resource and the priorities for management and survey has been written by the principal investigators. The authorship of the individual chapters has been acknowledged at their start, but it is inevitable in the compilation of such a collaborative work that some parts may originally have been written by another contributor.

The scope of the present survey encompasses a study of sea-level change (Chapter 2), the development of a theoretical model for understanding archaeology in the intertidal and coastal zones (Chapter 3), a review of the environmental potential of the intertidal and coastal zones (Chapter 4), an assessment of the contribution of survey in the intertidal and coastal zones (Chapter 5), an assessment of the archaeological record in the intertidal zone, which includes a regional review of the prolific prehistoric and Roman evidence (Chapters 6–7), and a review of the threats towards the archaeology in the intertidal and coastal zones and proposals for the management of the resource (Chapter 8). The report concludes with an assessment of the potential and priorities with regard both to the further investigation of the archaeological resource and to the further development of management strategies (Chapter 9). The principal conclusions and recommendations of the report set out below represent a formal statement from English Heritage (EH) and the Royal Commission on the Historical Monuments of England (RCHME).

Acknowledgements

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We gratefully acknowledge the following individuals and organisations for permission to reproduce illustrations: Professor J R L Allen, Martin Bell, Professor Richard Bradley, Phil Clarke, Cornwall Archaeological Unit, Essex County Council, Steve Godbold, Richard McDonnell, Peter Marsden, National Maritime Museum, Greenwich, The National Trust, Northumberland County Council, Professor Charles Thomas, Dr David Tomalin (Isle of Wight County Council), Rick Turner.

Policy statement

Summary

England's coastal zone contains an important legacy of historic assets which includes a complex array of fragile and irreplaceable archaeological remains. In order to improve the management of these remains and to identify priorities for future survey initiatives, English Heritage and the Royal Commission on the Historical Monuments of England (RCHME) commissioned a desk-based nationwide assessment of coastal archaeology from the Universities of Reading and Southampton. Although the survey had regard to the general significance of the subtidal archaeological resource, it was primarily concerned with archaeological remains situated above low water mark, particularly with those in the intertidal zone, and it did not attempt a detailed examination of the character of marine archaeology or its specific management requirements. The full results of the survey are published in this volume.

Introduction

The coast of England, comprising in-shore waters, the intertidal zone, the sea shore, river estuaries, and a ribbon of land subject to climatic and other oceanic influences, contains a rich and diverse archaeological heritage which is vital for the understanding of Britain's emergence as an island, her developing relationship with the sea, and those maritime influences which have contributed to the forging of our identity as a major mercantile, industrial, and imperial nation.

The severing of our land link with the continent began about 10,500 years ago as sea-levels rose by more than 130 metres to flood the North Sea basin in the wake of the retreating ice sheets of the last glaciation. What we can hope to learn of this critically important process, its related environmental change, and the early prehistoric communities which lived through this transitional period, depends on the surviving archaeological record preserved in association with contemporary land surfaces. As these land surfaces have been largely destroyed by agricultural and other erosive processes on land, particularly in southern and eastern England, and are still comparatively inaccessible at sea, opportunities to record this slender source of evidence are mostly confined to the estuaries of our major rivers like the Humber, the Severn, the Solent, and the Thames.

In later times, with encirclement of our island complete, it was coastal communities which articulated our relationships with our neighbours: ports and harbours have provided the principal foci for the movement of people, goods, and ideas between England and the wider world and defensive installations from the prehistoric period to the present indicate the changing character of diplomatic relations with Europe. Our seaboard now preserves the complex evidence for this kaleidoscopic pattern of contacts and influences. Recorded evidence includes prehistoric features such as trackways, houses, and fishtraps, frequently in a better state of preservation than their terrestrial counterparts; drowned villages and towns; industrial and extractive sites such as quarries and salterns; shipwrecks and lost cargoes; shipyards, ropeworks, and breakers; harbour installations, wharves, warehouses, and navigation aids; historic sea defences and land reclamation works; and an elaborate defence heritage of emplacements, forts, and batteries.

In contrast to defensive installations, whose very massiveness has often ensured sufficient survival of successive remodellings to provide a good record of changing priorities in architecture and technology through time, the continuing evolution of the slighter remains which comprise ordinary coastal settlements, harbours, and ports has often resulted in earlier evidence being swept away or concealed within the archaeological building record or as part of the buried archaeological resource. In our major city ports like Bristol, Hull, London or Southampton, and in the many small towns and villages which typify England's coastline, it is in this archaeological record that evidence may be found to characterise the distinctive way that coastal communities have exploited the opportunities and resources provided by the sea. Our major coastal cities specialise in large-scale trade and passenger traffic, in heavy industry dependent on sea communications, in naval and defence affairs, and in the construction of ships, boats, and oil and gas rigs, while our smaller harbours often support fishing fleets and shellfisheries, leisure and tourism, and the extraction of accessible minerals such as ballast or coal.

Although their intimate involvement with the sea and its resources has allowed such communities to flourish, it has also often threatened their survival and they have frequently had to develop strategies to cope with the forces of the sea: the effects of erosion, storm, flood, and continuing rise in sea-level have led, from the Roman period onwards, to the building of protective works as sea defences.

Equally, pressures to take more productive land as population and its demands increased have led to deliberate efforts to embank and drain low-lying areas for farming. The success and failure of all these activities have left some imprint in the archaeological record and, in some places, it is still these historic works which serve to protect our coasts.

Not only is archaeology our principal means of examining the early history of communities living around our shores, it also provides us with the best means for gaining insight into recent sea-level movement, coastal changes, and their causes. The material remains which have been reported from the intertidal zone around England are, in many cases, direct evidence of the failure to withstand the effect of storm and the erosional force of the sea, set against an underlying trend of continued rising sea-level. Although we may have developed a clearer understanding of the major developments in sea-level since the last glaciation, the differential effect on coastal erosion of sea-level rise as opposed to the development of stormier and thus more erosive conditions is poorly understood on the shorter timescale. Equally, the extent to which fluctuations in sea-level over a shorter and more recent timespan can be identified may help us to understand the causes of change. The study of the archaeological record in the intertidal zone provides an opportunity for a greater resolution and understanding of these processes over the last two millennia.

Since the antiquarian William Borlase's observations about the Isles of Scilly and Cornwall in the mid-eighteenth century, the number of records relating to archaeological discoveries around the shores of England has continued to increase. In the nineteenth century, interest developed around the evidence for submerged forests and peats which were discovered as the leisured classes took their holidays at the seaside, the geology of the British Isles was mapped, and new dock and wharf installations were built to develop the major ports. The obvious context for archaeological discoveries was the beach, or the intertidal zone in general, where the erosive action of the sea had revealed what otherwise might lie buried inland. Discoveries were individually reported to museums or local archaeological or natural history societies, and some were researched or published in detail. Prior to the 1980s, therefore, the majority of known sites and finds in the intertidal zone had resulted from chance discoveries, and planned investigations and research were very much the exception. Since then, a variety of systematic surveys carried out on a local scale and sometimes involving small-scale excavation have been carried out, often as an ad hoc response to a perceived threat. Examples include work in the Isles of Scilly, on both the Welsh and English shores of the river Severn, in the Humber and Blackwater estuaries, and on both shores of the Solent. Although the majority of these projects await definitive publication, they have already served to underline the extremely high potential of the archaeology of the coastal zone.

The survey

These archaeological remains are a finite and non-renewable resource which is frequently highly fragile and vulnerable to the wide variety of industrial, commercial, and recreational activities which take place at the coast, including mineral extraction, oil and gas production, fishing, navigational dredging, port and harbour works, marina construction, etc. In addition, because the coast is subject to powerful natural forces, archaeological remains may be adversely affected by the processes of sea-level change and erosion or by the measures taken to defend the coastline. The Government's stated strategic aim is to promote the sustainable use of the coast and as part of that approach it has recognised, in Planning policy guidance note 20: coastal planning, the need to protect and enhance the built and archaeological coastal heritage.

Given the complexity of interests which meet at the coast and the tension that may exist between the needs of economic development and conservation, the Government has identified a need for an integrated approach to coastal zone management and planning which seeks to reconcile conflicts of interest where they arise. In order to promote this approach, it intends to provide guidance on best practice in the preparation of coastal management plans.

As a contribution to this and other initiatives aimed at improving the management of the coast, and in order to raise awareness of the importance of the coastal archaeological resource, English Heritage and the RCHME commissioned a nationwide desk-based study of coastal archaeological issues. The study was undertaken by the Universities of Reading and Southampton with additional work carried out by the Aerial Survey Section of the RCHME.

It is clear that a fundamental requirement in achieving the effective management of coastal archaeological remains is access to reliable data on the character of the archaeological resource. This was recognised by English Heritage in *Exploring our past: strategies for the archaeology of England* (English Heritage 1991) and by the RCHME in *Recording England's past* (RCHME 1993), where it was recommended that the enhancement of the intertidal record should be undertaken. The study therefore also sought to identify clear priorities for future survey programmes by both organisations and by others.

The aims of the study were as follows:

- to review and consolidate recorded archaeological information from coastal areas and to seek to characterise the nature of the resource
- to assess the nature and severity of threats to coastal archaeological remains
- to synthesise available evidence for historic sea-level change and assess implications for future change
- to examine the management frameworks for the coast and management initiatives established by other authorities and agencies
- to recommend future survey and data collection priorities based on an assessment of the importance and vulnerability of coastal archaeological remains

- to make recommendations on ways to integrate heritage interests effectively into coastal zone management plans

- to review survey methodologies adopted in the intertidal zone including the application of aerial photography

The scope of the archaeological remains included in the survey was primarily confined to those which have been reported as eroding from the present coastline and those in the intertidal zone proper. The built heritage, including post-medieval and modern fortifications and industrial remains, was generally excluded from the scope of the survey as this is currently the subject of other survey initiatives and work by the English Heritage Monuments Protection Programme. In addition, although the survey had regard to the broad implications presented by archaeological remains in the immediate subtidal zone, it did not attempt a comprehensive survey of marine remains and it is recognised that more detailed consideration will need to be given to the specific survey, recording, and management needs of this resource in future, following the completion by the RCHME of the basic national record of maritime archaeology.

Following completion of the survey, it is possible for English Heritage and the RCHME to set out five key principles which can be applied to the management of the coastal archaeological resource and to identify a number of general and more detailed recommendations on survey, recording and research, and on management of the resource.

Key management principles

- The coastal zone of England includes a finite, irreplaceable, and, in many cases, highly fragile archaeological resource which by virtue of its value, variety, and vulnerability justifies a presumption in favour of the physical preservation *in situ* of the most important sites, buildings, and remains.

- Although archaeological remains situated within intertidal and subtidal areas may be less visible and accessible than remains on dry land, this does not affect their relative importance and they should be managed in accordance with the principles which apply to terrestrial archaeological remains.

- As historic landscapes can extend seamlessly from dry land, through the intertidal zone, and into subtidal areas, effective management of the coastal archaeological resource cannot be achieved without due consideration of marine as well as terrestrial archaeological remains.

- Comprehensive and sustainable management of the coastal archaeological resource will be best achieved through effective integration of archaeological interests within wider Coastal Zone Management initiatives.

- Where economic development in the coastal zone is likely to impact on important archaeological remains, decisions should be taken with regard to the best available information and the precautionary approach should be adopted wherever possible.

General recommendations

In order that they may provide integrated advice to government on the intertidal and subtidal resource, the statutory remits of English Heritage and the RCHME should be harmonised by extending the remit of English Heritage to cover the territorial sea adjacent to England.

Although it remains government policy not to extend the Town and Country Planning system to the territorial sea, the principles set out in Planning policy guidance note 16, *Archaeology and planning*, should be applied to the treatment of subtidal archaeological remains in order to secure best practice.

Appropriate consultation procedures should be established for sectoral consents likely to affect archaeological remains.

As the archaeological resource extends beyond the territorial sea, due consideration should be given to the need for consultation on the archaeological impacts of consents and licences issued for works to be undertaken outside territorial waters.

Strategic advice on the recording and management of the coastal archaeological resource will be offered by English Heritage and the RCHME to coastal management agencies both directly and through the Coastal Forum.

Since only the National Monuments Record of the RCHME and a small number of local authority Sites and Monuments Records can at present provide integrated data on archaeological remains in the coastal and subtidal zones, the ability of coastal SMRs to acquire and gather new information locally and to offer expert advice based on reliable records should be enhanced.

More detailed consideration should be given to the specific survey, recording, and management needs of the subtidal archaeological resource.

The record of coastal archaeology held nationally and locally should continue to be actively developed and enhanced in order to permit effective management of the resource and to facilitate understanding of England's development as a maritime nation. English Heritage and the RCHME will continue to coordinate their efforts to promote this development in line with the following detailed recommendations.

Detailed recommendations on survey, recording, and research

Developing the record of coastal archaeology

The record of coastal archaeology held at national and local levels should continue to be developed through consolidation of existing information and through new survey and recording projects.

The breadth of the existing record of coastal archaeology should be increased to include information on a greater range of remains of all periods and, where appropriate, the depth of the existing record should be selectively improved through more detailed thematic or period-based study of certain types of monument and classes of material. It is particularly important that, in enhancing existing records or creating new records, careful attention is paid to the environmental, geological, and topographical context in which archaeological material occurs.

As a result of our desk-based national survey of England's coastal archaeology, a number of broad themes for research and record enhancement have been identified. Generally these apply to all periods, although a particular weakness in the existing record of medieval and post-medieval remains has been identified. The themes are as follows:

- palaeo-environments and the creation of the coastal landscape (including the distribution and condition of submerged land surfaces; cultural and environmental evidence present in the remains of submerged forests and peats and their relationship with contemporary coastlines; sea-level change, shoreline evolution, and their chronology)

- historic management of the coastal landscape (including coastal and flood defences and the management of alluvial wetlands at the coast)

- coastal settlement (particularly the relationship between such settlements and their contemporary coastlines, the implications of coastline changes on settlement patterns, and the origins of modern coastal settlements)

- coastal trade, transport and communication (including the development and character of smaller ports and harbours, distribution and condition of hulked vessels in the intertidal zone)

- coastal industry (the development of and surviving evidence for coastally situated industries such as shipbuilding, quarrying, and mining)

- exploitation of marine resources (the development and surviving evidence for this exploitation including prehistoric middens, salt workings, and fishing) and the relevance to that exploitation of changes in coastal vegetation and sedimentary environments

- major port and harbour installations and modern military remains (although largely beyond the scope of the survey, these topics require careful attention)

- dendrochronology (establishment of tree-ring reference sequences for dating timbers at the coast and inland, development of chronologies for species other than oak)

In addition to these broad thematic headings, certain areas of particularly high archaeological potential have been identified in the survey. These include the major estuaries such as the Severn, the Thames, particularly the north Kent coast, and the Solent, and coastal wetland areas with complex histories of sea and flood defence such as the Wash, the Humber Basin, and Romney Marsh. However, given the limited amount of detailed survey that has occurred in the intertidal zone, few areas should be exempt from consideration for future programmes of survey and data collection and there is a need to balance studies in the major estuaries with investigations of other distinct coastal regions and environments.

Within areas of identified potential, survey priorities will be determined through a consideration of the level of threat to important archaeological remains and the need to contribute adequate archaeological data to wider coastal zone management initiatives such as Coastal Zone Management Plans, River Catchment Management Plans, Estuary Management Plans, Shoreline Management Plans, and Coastal Planning Strategies, in partnership with other agencies.

The impact of sea-level and coastline change

PPG 20 encourages local authorities to gather data which illustrate the nature, scale, and pace of coastal change within a coastal zone which extends both landward and seaward. Steps should be taken to ensure that the evidence offered by archaeological remains should be fully assimilated into predictive studies of coastal change. Palaeogeographic maps depicting changes in shoreline position are central to an understanding of archaeology at the coast. Closer collaboration between archaeologists and sea-level researchers should be promoted in order to obtain such data.

In addition, monitoring of the rates of coastal erosion in areas of recognised archaeological potential should be undertaken and research should be directed towards the analysis of the impact of sea-level change and coastal erosion on the integrity of archaeological deposits, in both low and high energy environments, with the aim of identifying options for mitigation and in situ conservation. Research should also address the behaviour of archaeological material once released from its matrix in the coastal zone in order that the context of isolated finds from this environment can be better understood.

Survey methodology

The rapid and cost-effective development of the coastal archaeological record should entail careful consideration of appropriate survey and data-collection methodologies. Attention should also be given to the effectiveness with which national and local bodies can respond to new exposures of important archaeological remains at the coast.

The use of targeted reconnaissance flights in areas of high archaeological potential, such as estuaries, has been shown to be an extremely successful and cost-effective means of discovering and recording new archaeological sites. As the intertidal zone can be inaccessible for ground-based survey, aerial survey should be continued on a regular basis.

Working from photography taken largely for non-archaeological purposes from the 1940s to the present day, the RCHME's National Mapping Programme has proved the most effective means of recording large sites such as fish weirs, oyster pits, and early coastal defences. Its comprehensive approach to examining the photography, looking at archaeological sites in terrestrial, intertidal, and subtidal environments in an integrated manner, makes it the obvious choice for the continued systematic mapping of the coastal zone from aerial photographic evidence.

Detailed recommendations on managing the resource

The following recommendations are intended to lead to improved management of the coastal archaeological resource. For ease of reference, they are arranged under a series of sectoral headings.

Coastal defence

The desirability of preserving important archaeological remains is a material consideration in the preparation of Shoreline Management Plans and early consultation of County Archaeological Officers or their equivalents should be undertaken during the preparation of these strategic plans. This consultation should include the development of plans for winning minerals for 'soft' coastal engineering works which may threaten the submerged archaeological resource. In addition, MAFF environmental guidance on flood and coastal defence should be followed when capital works and major maintenance programmes are being planned, with appropriate consultation on and, where appropriate, detailed assessment of the impact of specific works on archaeological remains.

The Environment Agency and Coast Protection Authorities should also undertake early consultation with County Archaeological Officers or their equivalent regarding strategic plans for new works and extensive improvement and maintenance works.

Further consideration should be given to the archaeological implications of managed set-back and to the full integration of archaeological information on historic sea-level and coastline change within strategic plans.

Coastal zone management

English Heritage and the RCHME will provide advice on coastal archaeology through the Coastal Forum, and offer guidance on the inclusion of archaeology in coastal management plans, and will continue to support the inclusion of archaeological interests in Coastal Zone Management information products, for example the Joint Nature Conservation Committee Coastal Directories and United Kingdom Digital Marine Atlas. Local Authorities may also wish to give consideration to the extended use of by-laws to obtain the protection of archaeological remains, as part of the wider consideration of the use of by-laws to meet environmental objectives.

Support and advice will continue to be offered to the Countryside Commission for its Heritage Coast initiatives and to efforts to secure best management of coastal archaeological remains through Countryside Stewardship Agreements.

At a local level, County Archaeological Officers or their equivalent should be included within the membership of regional coastal forums.

Nature conservation

English Heritage and the RCHME will continue to work closely with English Nature across the spectrum of its coastal interests and will offer support in its pursuit of integrated coastal and marine conservation and advice on the production of coastal management plans which benefit ecological and archaeological resources.

Development control and environmental assessment

Coastal archaeological interests should be adequately reflected in structure and local plans, and consistently and comprehensively included in Environmental Assessment procedures for coastal and marine developments (including harbour works, mineral extraction, oil and gas related projects, capital dredging projects, cable projects, and waste water treatment and disposal) and other activities requiring sectoral consent.

Where appropriate, local authorities should consider using existing statutory instruments such as the Coastal Protection Act 1949 to extend their control over works in the intertidal and near-shore areas, particularly in estuaries and harbour areas, as a means of securing the protection of important archaeological remains.

Harbours

Many of England's major ports and historic harbours have been in use for many centuries and consequently have a high archaeological potential which needs to be considered when harbour works are being carried out. Where appropriate English Heritage and the RCHME will seek to alert relevant authorities to the archaeological potential of harbours (including fishery harbours, marinas, and dockyard ports) and will offer advice on the preparation of Harbour Management Plans. We will seek to ensure that archaeological interests are adequately recognised in the consultation of local authorities carried out by the Department of Transport prior to the approval of harbour revision and empowerment orders and enactments empowering harbour authorities to license and carry out works, and by MAFF prior to the approval of orders for improvement and maintenance of fishery harbours and grants for the improvement of harbour infrastructure.

Minerals

Pending the outcome of the review of marine minerals licensing procedures, adequate consultation procedures for archaeological interests during the granting or renewal of licences should be promoted and, where appropriate, local authorities should consider the use of their powers under Section 18 of the Coastal Protection Act 1949 to prohibit or licence extraction of aggregate from the foreshore and seabed in order to secure the preservation of important archaeological remains.

Oil and gas

Appropriate consultation procedures should be established prior to the approval of consent for development, production, and pipeline works and controlled pipeline authorisations which may affect important archaeological remains. Where appropriate, provisions relating to archaeology should be included in conditions and restrictions applied to future rounds of licensing.

Proprietary interests

English Heritage and the RCHME will encourage, support, and advise upon best practice in the managing of archaeological remains by the principal coastal landowners including the Crown Estate, the Duchy of Cornwall, the National Trust, and the Ministry of Defence.

Tourism, access, education, and recreation

English Heritage and the RCHME, in collaboration with tourist authorities, the Countryside Commission, and local authorities, will seek to promote public enjoyment of the coastal heritage and awareness of the need for its conservation by contributing towards the provision of improved interpretation facilities. Appropriate levels of public access must be based on the sensitivity of archaeological remains and English Heritage will offer advice and presentation grants where appropriate.

1 The coastal zone

by T Champion and D O'Regan

England's coastal zone provides a rich resource of archaeological and historical evidence for our past, but some basic problems have to be addressed before that resource can be properly assessed. Even the very idea of the coast can be a problematic one, and this introduction discusses some of these preliminary theoretical problems.

1.1 Defining the coast

The coast is the line where land and water meet. Where the coast is hard-rock cliff, the line may be easy to define and comparatively stable; elsewhere the line may vary with the daily and annual cycle of tides, the longer-term processes of erosion and accretion, and changes in land and sea-levels. The simple concept of the coast, therefore, gives rise to many different definitions, and for many purposes the idea of a coastal zone is more appropriate (Gubbay 1991). The coast or the coastal zone may be described in terms of physical, biological, and cultural criteria, which seldom coincide exactly (Carter 1988). Definitions are therefore highly variable, and related to the purpose behind the definition: some are academic, and appropriate to the nature of the phenomena or processes being studied; some are jurisdictional, being formulated to set limits to the exercise of statutory powers; and others are managerial, and determined by the pragmatic nature of the problem to be solved.

In English common law there is no specific legal recognition of a coastal zone (Pickering 1993). Other concepts apply, in particular a threefold classification of *terra firma*, foreshore, and sea-bed. The foreshore lies between high-water mark and low-water mark, defined as the lines of mean ordinary high and low tides; *terra firma* (dry land) lies above high-water mark and the sea-bed below low-water mark.

Jurisdictional definitions are necessary to demarcate the limits of authority for many different purposes, and are to some extent determined by the nature of the power and responsibility concerned. For example, mean low-water mark is the normal seaward limit of the powers of planning authorities; the Environment Agency has responsibility for water quality in controlled waters, that is to a distance of 3 nautical miles from mean low-water mark, though its powers in respect of salmon and migratory trout extend to 6 nautical miles.

Managerial definitions of the coast tend to stress the spatial scale of the managerial problem and the factors affecting it. Many of these definitions were usefully collected by the House of Commons Environment Committee (1992b). Thus, the Countryside Commission emphasises that the limits of the coastal zone are determined by the geographical extent of the relevant natural processes and human activities, and that coastal zone management should extend as far inland and seaward as is required by the management objectives. A more complex, three-tiered approach to defining the coastal zone for management purposes has been proposed by Rendel Geotechnics (Department of the Environment 1993). This comprises:

- a broad coastal activity zone, or interactive zone, where human activities are influenced by or can influence the quality of the whole coastal zone. This zone may extend as far inland or seaward as necessary to control activities which may have an impact on the coast.
- a narrow coastal process zone, the dynamic zone (within the interactive zone), which is directly affected by offshore and nearshore natural processes (eg storm surges, erosion, deposition, flooding, and landslides)
- a narrow hazard zone defined as the landward area potentially susceptible to damage from coastal processes

For the purposes of the management of the archaeological resource, any definition of the coast or coastal zone must be linked to the management task in hand, and specifically to the spatial extent of the resource itself and of the processes which may affect it now or in the future. This also means that a tiered approach to the definition of the coastal zone may be appropriate. Even if attention is confined to the coastline that has evolved since the last Ice Age, the mobile nature of the coast means that the evidence of human activity can be distributed over a wide zone. Many areas that were previously near high-water mark are now much further inland, whereas others are to be found in the contemporary foreshore or submerged. These form a continuous zone of archaeological interest and should be managed as such.

We can therefore offer an archaeological definition of the coastal zone as a dynamic natural and human system which extends seawards and landward of the coastline, the limits of which are determined by the geographical extent of the natural processes and human activities of the present, and the natural processes and human activities that have taken place in the past. Within this zone it is possible to define a narrower zone in which natural processes and human activities are playing an active role in the modification of the archaeological resource and where more positive management measures may therefore be required.

It must, however, be recognised that this managerial definition is unlikely to coincide with the jurisdictional definitions relevant to the powers exercised by many of the local and national agencies which have a direct interest in the coastal zone.

1.2 Measuring the coast

It is notoriously difficult to measure such an infinitely complex and ever-changing line as that of the coast. The different techniques of estimating its length, and the different purposes for which such a figure is needed, can produce startlingly different results. The Countryside Commission (1968) measured the coast of England and Wales from 1:63,360 maps, including inlets only where they were considered 'arms of the sea', and the result for England was a length of 3229km. The Joint Nature Conservation Committee Coastwatch Project (quoted by DOE 1992a: Annex 1) included estuaries, inlets, and rivers to the tidal limit and their figure was 8520km. It is clearly advisable to use extreme caution when comparing measurements derived from different sources.

1.3 Classifying the coast

England's coastline is enormously varied, and many different systems have been devised to classify it. Coastal variability may be due to physical morphology, sedimentary regime, exposure to wave energy, current evolutionary trends, human activities on land or sea, or many other variables. Classificatory schemes, sometimes of great complexity, have been devised using one or more of these variables as the basis for division. Though the archaeological importance of the coastal zone has seldom been a factor in such schemes, some of them are useful for archaeological concerns. The usefulness of a classification is dependent on the context for which it was devised, and some of the more geological or geomorphological schemes are not well suited to the problems of archaeological resource management.

One scheme, devised particularly for the purpose of coastal defence, classifies coasts according to their type, exposure to wave energy, and the nature of sediment involved. Three basic types of coast are recognised:

- open coasts: high energy environments, characterised by rocky platforms on the lower shore and rocky cliffs on the upper shore
- bays: medium energy environments, characterised by shingle and sand beaches on the lower shore and shingle ridges and sand dunes on the upper shore
- estuaries: low energy environments, with mudflats backed by saltmarshes

These types are in turn classified by the nature of the dominant processes at work, with sediment transport and deposition on the lower shore, and erosion and flooding on the upper shore. Though this scheme is potentially useful for archaeological concerns, it is not based directly on archaeological evidence or concerned primarily with the processes that are most likely to affect the resource.

Another scheme starts from the nature of the current evolutionary processes, and divides coasts into three broad types, which have a clearer relevance to archaeological concerns:

- eroding coasts: where processes are leading to shoreline retreat
- stable coasts: where there is no significant change at present
- aggrading coasts: where there is net accumulation of material, and the coastline is advancing

The European Commission's CORINE (CoORdinated INformation on the Environment) Coastal Erosion Project (Quelennec 1990) has adopted a more complex scheme. This uses three variables to classify segments of the coast: morpho-sedimentological characteristics, evolutionary trend, and presence or absence of coastal defence. The first criterion divides coasts into rocky coasts, beaches, muddy coasts, artificial shorelines such as ports, embankments and defences, and fictitious coasts such as the line drawn for administrative reasons across estuaries; some of these groups are then subdivided. The second criterion includes stable, eroding, and aggrading coasts.

More complex schemes such as this are of more relevance to archaeology, in particular because they are concerned with the nature of the processes that affect the archaeological resource and their impact on the coastal zone. They are, however, almost exclusively concerned with natural processes, whereas the archaeological evidence is the product of cultural factors and is threatened by human as well as natural processes. On the other hand, classificatory schemes concerned with human activities, such as those for land use or sea use, have little direct relevance for coastal archaeology.

Perhaps the most useful approach in the context of archaeological management is a scheme explicitly aimed at archaeological concerns, though drawing on the relevant features of the classifications described above. Such a scheme would recognise two types of area:

- areas of varying archaeological potential, based on the nature of coastal morphology, past human activity, and the past and present coastal processes that have produced the current state of preservation

- areas of varying survival potential, based on contemporary or predictable factors such as land form, exposure, coastal processes, and human activity

Some schemes of this sort have already been devised in various forms. Dorset County Council (1994) has recognised special areas of archaeological sensitivity or potential along their coast. The survey of the coastal archaeology of Northumberland classified the coast into areas of high, medium, and low archaeological potential, and high, medium or low levels of risk from erosion, whether natural or humanly induced (Northumberland County Council 1994). In this way, sensitive areas can be recognised, the most critical being those that score highly on both scales, and this can serve as a basis for the formulation of priorities for management decisions and resource allocation.

An alternative method of applying such a scheme would be through the use of computerised Geographical Information Systems technology, such as the Shoreline Management System developed by the Anglian Region of the former National Rivers Authority (now part of the Environment Agency) (Legget and Jones nd; NRA and Halcrow 1991).

Such an approach to classification also needs to be linked to a scale of analysis appropriate to the specific demands of archaeology. The size of archaeological sites and the small scale of the microenvironmental processes affecting them demand a scale of analysis which is much finer than that adopted for some geographical purposes. A suitable scale of analysis is offered by the concept of littoral cells, or coastal cells as they are more commonly known (see Motyka and Brampton 1993). Eleven cells have been defined along the coast of England and Wales, each divided into subcells in which sediment transport moves in one direction and is of comparatively small volume. The scale of these subcells is appropriate to the variability and distribution of archaeological remains, and to the physical processes that affect them. Such a scale of analysis thus offers a suitable approach to the study of the coastal zone, as defined above, and particularly to the narrower intertidal zone where the interplay of natural processes and human activities demands the consideration of positive management measures.

2 Sea-level change

by A J Long and D H Roberts

2.1 Introduction

This chapter examines the processes and patterns of past and future sea-level change and, in particular, considers the relationship between sea-level change and England's coastal heritage. The chronological framework of this study spans the Quaternary period (which covers the last 2.5 million years), including the Pleistocene (up until 10,000 years before present (BP)), the Holocene (the last 10,000 years), and the recent past and near future. Spatially, this chapter concentrates on the sea-level history of England, although it includes examples from elsewhere where appropriate.

This chapter describes the evidence for Pleistocene and Holocene sea-level changes, followed by an examination of the contribution of coastal archaeology to our understanding of Holocene sea-level changes. It then considers models of future sea-level change and possible coastal responses, and finally assesses the likely impact of future sea-level rise on England's coastal heritage.

2.2 Past sea-level change

2.2.1 The spatial and chronological framework

At their simplest, changes in sea-level may be considered as the product of changes in oceanic and crustal variables. The oceanic (or eustatic) variables control the global volume of water in the ocean basins; these include changes caused by the build-up and decay of land-based ice masses (glacio-eustasy), changes in the distribution of ocean water under the influence of gravity (geoidal-eustasy), and long-term changes in the size of the ocean basins (tectono-eustasy). Crustal variables include the factors of glacial and water loading and unloading (known as glacio-isostasy and hydro-isostasy respectively), the effects of sediment loading, and tectonic movements (such as those due to faulting and folding of the Earth's lithosphere). Shorter-term local to regional changes in sea-level are caused by oceanographic, meteorological, and hydrological factors, such as changes in tidal regime, ocean temperature, air pressure, and river discharge. Spatially, global factors influence one or more ocean basins, regional factors affect hundreds to thousands of kilometres of coastline, and local factors exert limited influence over tens of kilometres or less (Table 1).

2.2.2 The Pleistocene sea-level record

Pleistocene changes in sea-level have been dominated by the alternating cycles of ice build-up and decay that have accompanied the glacial/interglacial cycle. In England, lengthy records of Pleistocene sea-level change are relatively few, partly because the repeated glaciation of northern England's coastline has

Table 1 Long- to short-term controls on sea-level

LONG-TERM CONTROLS ON SEA-LEVEL	SCALE
Glacio-eustasy loss or gain of water from ice sheet build-up and decay	Global
Geoidal-eustasy adjustment of the equipotential surface of the earth due to fluctuating gravity fields	Global – varies regionally
Tectono-eustasy ocean ridge spreading, tectonic uplift altering basin configuration	Global to regional
Glacio-isostasy crustal movements due to ice loading and unloading	Regional
Hydro-isostasy crustal movements due to water loading and unloading effects	Regional
SHORT-TERM CONTROLS ON SEA-LEVEL	
Meteorological factors changes in air pressure and winds, the magnitude and frequency of storms	Regional to local
Tides daily, monthly, annual, and decadal tidal cycles	Regional to local
Oceanographic changes in ocean temperature, shifts in ocean currents	Regional to local

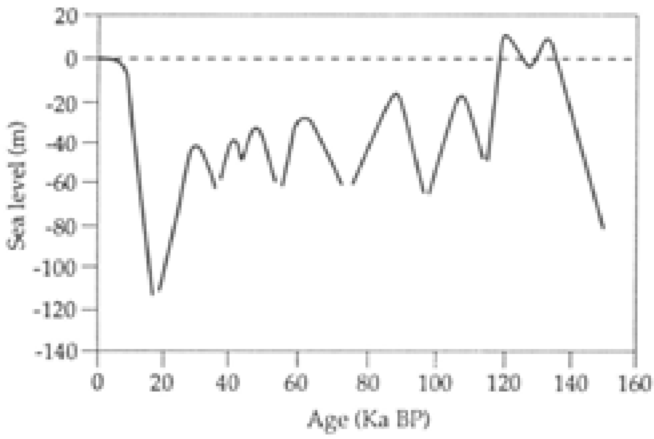


Fig 1 Sea-level curve based on the Huon coral reefs spanning the last 160,000 years (Aharon 1984). The high sea-level stand c 120,000 years ago dates from the last interglacial, when sea-level was >5m above current levels

partially destroyed earlier records of former sea-level position, but records spanning the last 200–500,000 years do exist (see Bowen *et al* 1985; Bowen *et al* 1989; Preece *et al* 1990; Gamble 1994). At a global level, the most complete sea-level records are derived from coral reefs which have been raised by long-term tectonic uplift several hundreds of metres above present sea-level, although even these records span only the upper part of the Pleistocene (the last 400,000 years or so). These reefs form staircases of raised marine deposits, each reef forming when the rates of sea-level rise and crustal uplift were similar. Such conditions typically occurred when sea-level rise was relatively fast (at the beginning of interglacial periods, as temperatures warmed and land ice melted rapidly). By dating these coral reefs, and allowing for the long-term rate of crustal uplift, the pattern of sea-level rise can be deduced (eg Bloom *et al* 1974; Aharon 1984; Bard *et al* 1990).

An example of these reef sea-level records is given in Figure 1, which depicts the general trend in sea-level over the last 160,000 years based on an analysis of the coral terraces of the Huon Peninsula, Papua New Guinea (Aharon and Chappell 1986). The major falls in global sea-level recorded by these data coincide with periods of global glaciation (eg 170,000–150,000 BP and 30,000–18,000 BP), while the main rises in sea-level relate to periods of meltwater release during interglacial periods (eg 150,000–120,000 BP and 18,000–8000 BP). Between major glacial episodes world sea-level has fluctuated with lower amplitude oscillations, probably due to smaller climatic changes.

2.2.3 The Holocene sea-level record

The evidence for Holocene sea-level changes is much better preserved than the Pleistocene record. At a global scale the dominant control on late Pleistocene and Holocene sea-level changes has been the release of meltwater to the world's oceans due to ice melt following the end of the last glaciation. Fairbanks (1989) has examined the drowned coral reefs of Barbados and, by allowing for the pattern of local crustal movements, has proposed a sea-level curve which documents the rise of glacio-eustatic sea-level change since 18,000 BP (Fig 2).

During much of the 1960s and 1970s sea-level studies sought to generate a single composite sea-level curve which would allow global correlation of sea-level change through time and space. It was hoped that such a curve would improve understanding of sea-level processes, particularly in response to long-term climate change, and one of the main aims of the International Geological Correlation Programme (IGCP) Project 61, which lasted from 1974 to 1982, was the development of such a graph. However, as detailed investigations were completed in different coastal settings, it became apparent that the interaction of oceanic and crustal variables at regional and local scales was so varied that the generation of a single global sea-level curve was a fruitless quest.

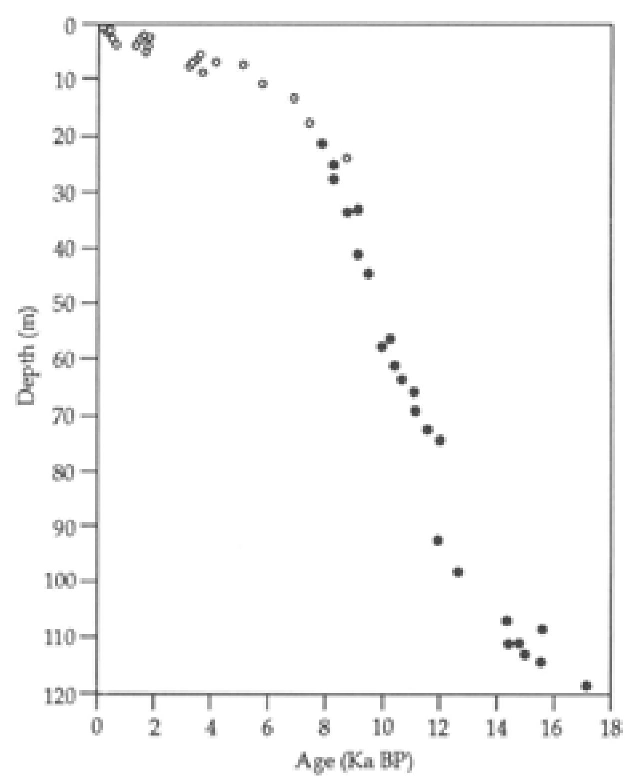


Fig 2 Glacio-eustatic sea-level curve since the maximum of the last glaciation (18,000 BP), based on the ages and altitudes of submerged coral reefs from Barbados (Fairbanks 1989). The solid circles are radiocarbon dates from the reef crest coral Acropora palmata *from Barbados; open circles are dates from* Acropora palmata *from four other sites in the Caribbean. Data are corrected for an estimated mean uplift of Barbados of 34cm per thousand years*

The variability in Holocene sea-level change is well illustrated by Pirazzoli's (1991) atlas of sea-level curves, and a good overview of this variability can also be seen in geophysical model predictions of global sea-level change (eg Clarke 1980; Peltier 1987). Clarke, for example, identified six types of sea-level curve (I–VI) which reflected the range of sea-level histories recorded in coasts which have emerged, submerged, or are in transitional areas and record a combination of both uplift and subsidence (1980; Fig 3). The latter, so-called 'transition curves', record a number of sea-level histories which are typical of those experienced by areas close to the centre of the former ice sheets, such as the UK, where the sea-level history has been strongly influenced by glacio-isostatic rebound following deglaciation. For north-west Europe, Shennan (1987) has presented a series of curves based on empirical data from sites adjacent to the North Sea basin which reveal such spatial variations at a European level (Fig 4).

The sea-level graphs described above by Fairbanks (1989), Clarke (1980), and Shennan (1987) depict the changing altitude of the sea by a single line, the 'sea-level curve'. Although this graphical approach provides a general impression of the rate and direction of sea-level change, it does not reflect the real uncertainties associated with estimates of the altitude and age of past sea-level. For higher resolution studies Shennan (1982) has argued that a 'sea-level band' should be used, the width of which reflects the errors associated in estimates of a former sea-level altitude and age.

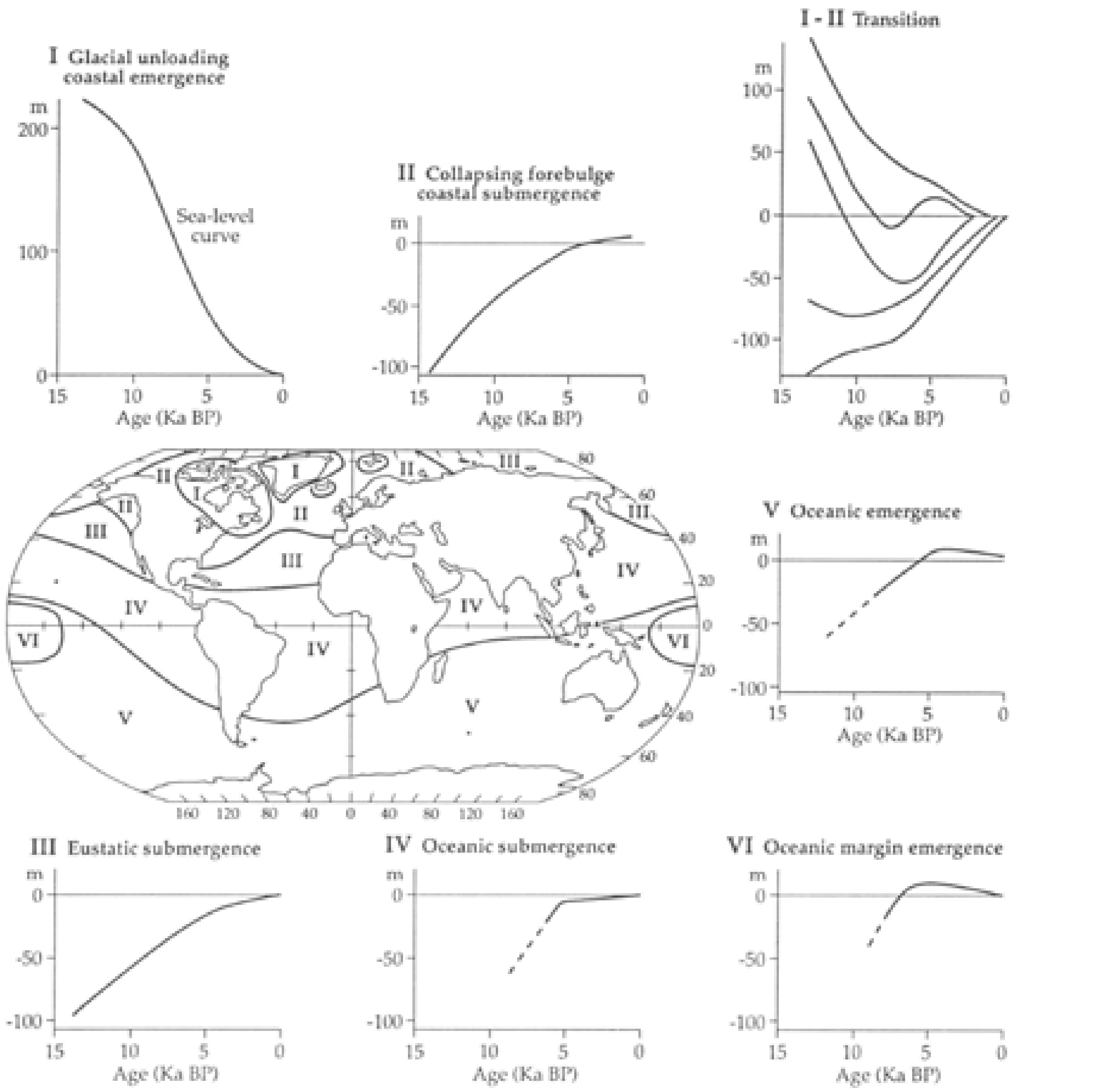


Fig 3 Patterns of global sea-level change during the Holocene (Clarke 1980). Six types of sea-level history are recorded (I–VI), depending on the relative contribution of ice and water loading and unloading

Typically, oscillations in sea-level with a magnitude of less than one or two metres cannot be identified by graphical representation of time/altitude data by this means, although this will vary through time depending on the prevailing rate of sea-level change (Heyworth and Kidson 1982).

2.2.4 Shoreline responses to sea-level change

Documenting a chronology of shoreline responses to sea-level change may be achieved by constructing either palaeogeographic maps or chronologies of 'sea-level tendency' (see below). Simple regional palaeogeographic maps can be constructed by lowering sea-level by known amounts using an established sea-level curve and assuming that the current sea-bed contours of a region have not changed greatly (eg D'Olier 1972). However, the resolution of such maps is poor, especially during the mid and late Holocene when the magnitude of sea-level change was small and shoreline movement was often controlled by local coastal processes. During these periods, the development of high-resolution maps of local coastal change demands extensive ground investigations, such as those completed in the Fenlands of East Anglia (Waller 1994).

A sea-level tendency can be either positive or negative depending on whether it records an increase or decrease in the proximity of marine conditions (Shennan 1982). A change in sea-level tendency may be recorded by a change from a semi-terrestrial organic unit to a brackish or marine minerogenic unit (rich in clay, sand or silt). A change in tendency can also be revealed by more subtle changes in the biostratigraphic record preserved within stratigraphic units. For example, the onset of a positive tendency may be recorded by a change in pollen assemblages found within a peat bed, indicating the replacement of a freshwater reedswamp by saltmarsh communities (Fig 5; Long and Shennan 1994). Such changes in sea-level tendency may be the result of vertical changes in sea-level (perhaps less than the width of a sea-level band), or changes in local coastal processes.

Graphical representation of sea-level tendencies involves classification of radiocarbon dates from coastal deposits into those indicative of either positive or

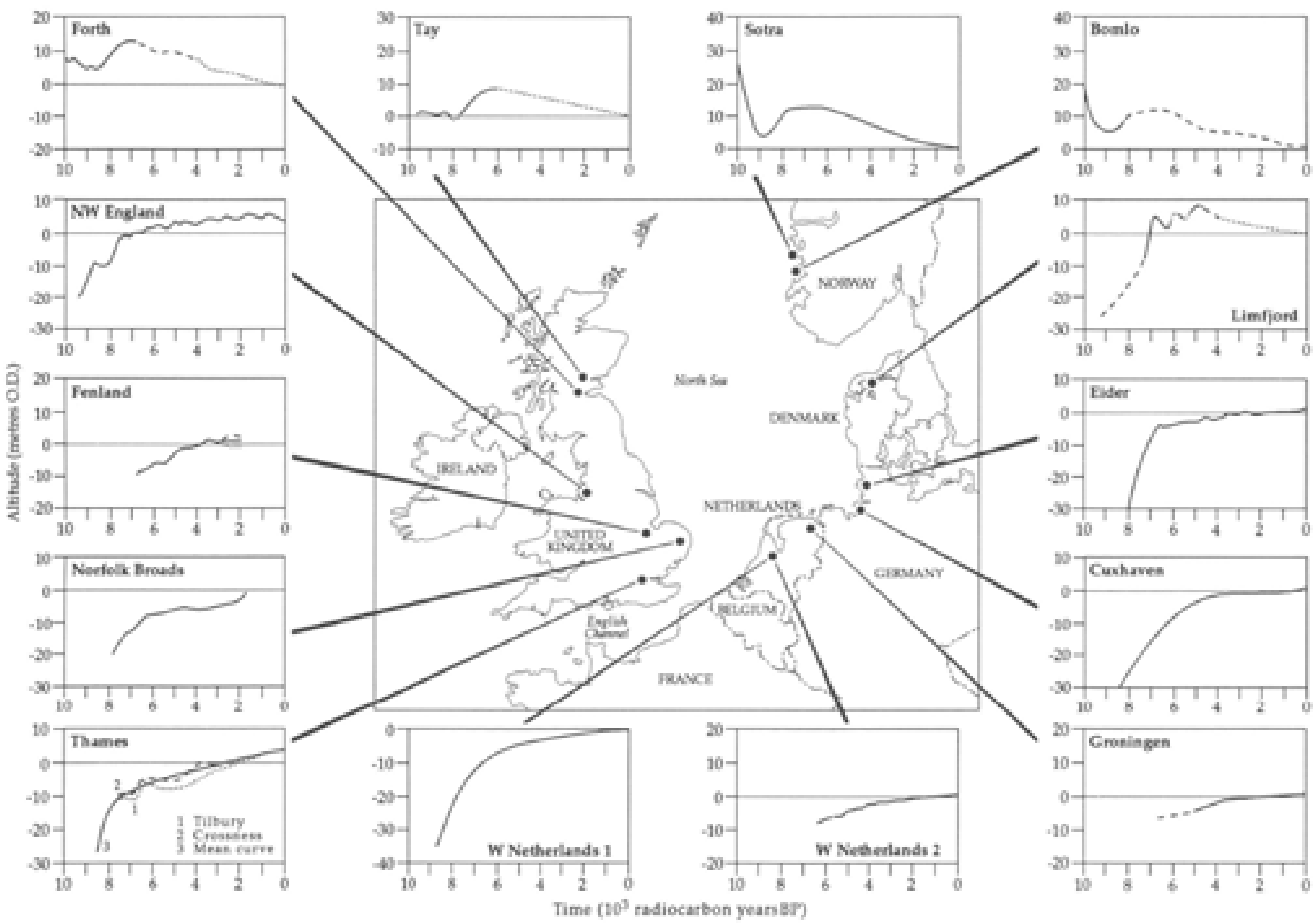


Fig 4 Spatial variations in sea-level change recorded around the coast of Europe (Shennan 1987). These sea-level graphs are typical for areas within the I–II transitional zone identified by Clarke (1980) (see Fig 3). Sites to the north of the area record a fall in sea-level due to land uplift for much of the Holocene, while net sea-level rise is recorded in areas to the south

negative sea-level tendencies (eg Tooley 1982a; Shennan 1982). An analysis of the cumulative frequency distribution of these dates through time may then be made to construct chronologies of local and regional sea-level tendencies (eg Tooley 1982a; Shennan *et al* 1983; Long and Innes 1993). This approach has grown in popularity since the 1970s and is of special value from a coastal archaeological viewpoint, since tendency chronologies may be related to changes in shoreline position and watertable elevation.

2.2.5 Holocene sea-level changes in England

The rate of Holocene sea-level change in England has varied considerably. This variability has primarily been due to differential crustal movements caused by the effects of loading and unloading on the Earth's surface by ice and water following the end of the last glaciation. The centre of ice loading (and maximum crustal depression) during the last British glaciation was in Scotland and consequently this area (together with much of northern England) experienced crustal rebound (uplift) for much of the Holocene. Accompanying the crustal depression of Scotland and northern England was a compensatory zone of crustal uplift (or 'forebulge') beyond the ice limit which probably extended across southern England. Following deglaciation, this forebulge collapsed with the consequence that much of southern England has experienced crustal subsidence during the Holocene. This trend led to a net rise in sea-level in this region, which has probably been enhanced by tectonic subsidence of the southern North Sea basin.

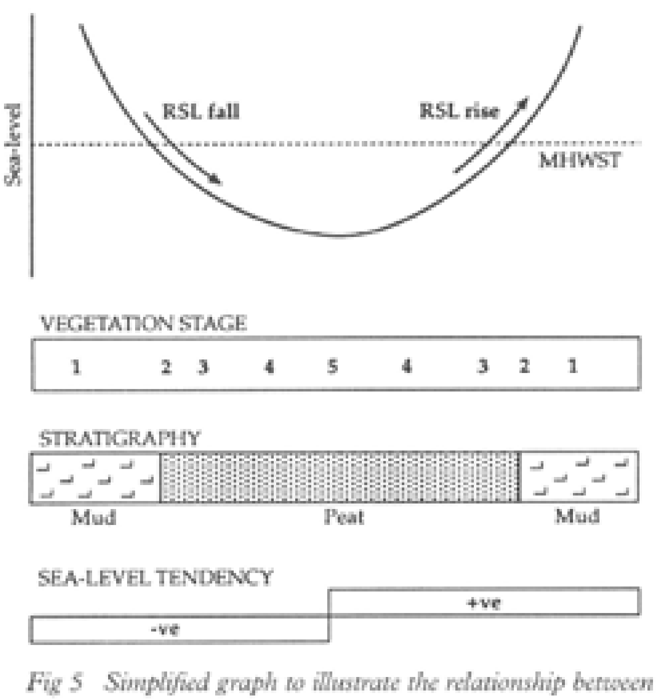


Fig 5 Simplified graph to illustrate the relationship between relative sea-level change (RSL), vegetation succession, and sea-level tendency (modified from Long and Shennan 1994). As RSL falls and then rises, so there is a change from a negative to a positive sea-level tendency. This is shown by a switch in the vegetation succession recorded by pollen analysis within the peat. The stages in the vegetation succession are: (1) mudflat, (2) saltmarsh, (3) freshwater reedswamp, (4) swamp carr, (5) fen carr. Peats form when sea-level falls below Mean High Water of Spring Tides (MHWST)

The spatial and chronological variations in sea-level change in England are now illustrated with reference to five contrasting regions; the north-west, the north-east, the east, the south-east, and the south-west. Each area description begins with a summary of existing knowledge regarding crustal movements for the region based on the analysis of Shennan (1989), which is discussed in more detail later. The locations of sites discussed in the following section are shown in Figure 6.

The north-west coast of England

The rate of crustal movements within the north-west of England has varied markedly during the Holocene. Shennan (1989), for example, estimates that south Lancashire experienced crustal uplift between *c* 9000 and 5000 BP which was followed by crustal stability from 5000 BP to the present. In contrast, further north in Morecambe Bay crustal uplift has persisted for most of the Holocene, estimated at *c* +0.35mm/yr over the last 6000 years BP. This difference reflects the closer proximity of Morecambe Bay to the former centre of ice loading.

The most detailed and comprehensive analysis of sea-level change in the north-west of England was undertaken by Tooley (1974; 1978a; 1982a). Although aspects of Tooley's original work have been criticised or revised (eg Huddart 1992; Zong 1993), the record of vertical changes in sea-level initially proposed by Tooley (Fig 7) remains the most definitive work in the region to date. Tooley's graph of time/altitude changes in sea-level shows that sea-level rose rapidly up until about 6000 BP with two periods of particularly rapid sea-level rise, the first ending at *c* 8575±105 BP and the second occurring between 7800±60 and 7605±85 BP. The most widely known stratigraphic investigations in the north-west of England are those from Downholland Moss (Tooley 1974; 1978a, b; 1980; 1985a, b), and data from this site have been combined with those from elsewhere in the north-west to identify a series of positive and negative sea-level tendencies for the region as a whole (Shennan *et al* 1983) (Fig 8).

The north-east coast of England

The pattern of sea-level and crustal movements in the northern part of this area has been examined by Shennan (1989; 1992) and Plater and Shennan (1992). In general, the north-east experienced crustal uplift during the early part of the Holocene but since 6000 BP has been relatively stable. Spatial variations in crustal

Fig 6 Location of sea-level sites discussed in the text from north-west, north-east, east, south-east, and south-west England

movements exist within the area, with more southerly sites experiencing reduced rates of crustal uplift. Thus, Shennan (1992) has estimated that over the last 5000–4000 years BP the Northumberland area has experienced crustal uplift of *c* 0.2mm/yr more than sites from the Tees or Hartlepool regions. As in the north-west of England, this spatial variability is commensurate with a model of crustal movements controlled by distance from the former centre of ice loading. Indeed, for the most southerly sites in this region there is a suggestion that minor crustal subsidence may have occurred during the last 5000 years (Shennan 1992).

A sea-level graph for this region has recently been proposed by Plater and Shennan (1992) (Fig 9). Sedimentation rates in this area at 6000 BP were probably less than 1mm/yr, as the rate of sea-level rise diminished following the early Holocene maximum. However, after 6000 BP relative sea-level changed little both in rate and magnitude. This is because crustal uplift approximated changes in ocean volume, and as a result the regional sea-level signature has been heavily influenced by local sediment supply factors. A chronology for sea-level tendencies has not been proposed for this area.

The east coast of England

The Fenland of East Anglia is the largest area of coastal lowlands in the UK and for much of the mid and late Holocene has experienced net crustal subsidence. During the last 5000 years this subsidence has averaged *c* 0.91m/1000yr (Shennan 1989). Shennan (1982, 1986a, b; 1994a) has described the coastal stratigraphy from this area and produced a series of graphs depicting Holocene relative sea-level change (Fig 10).

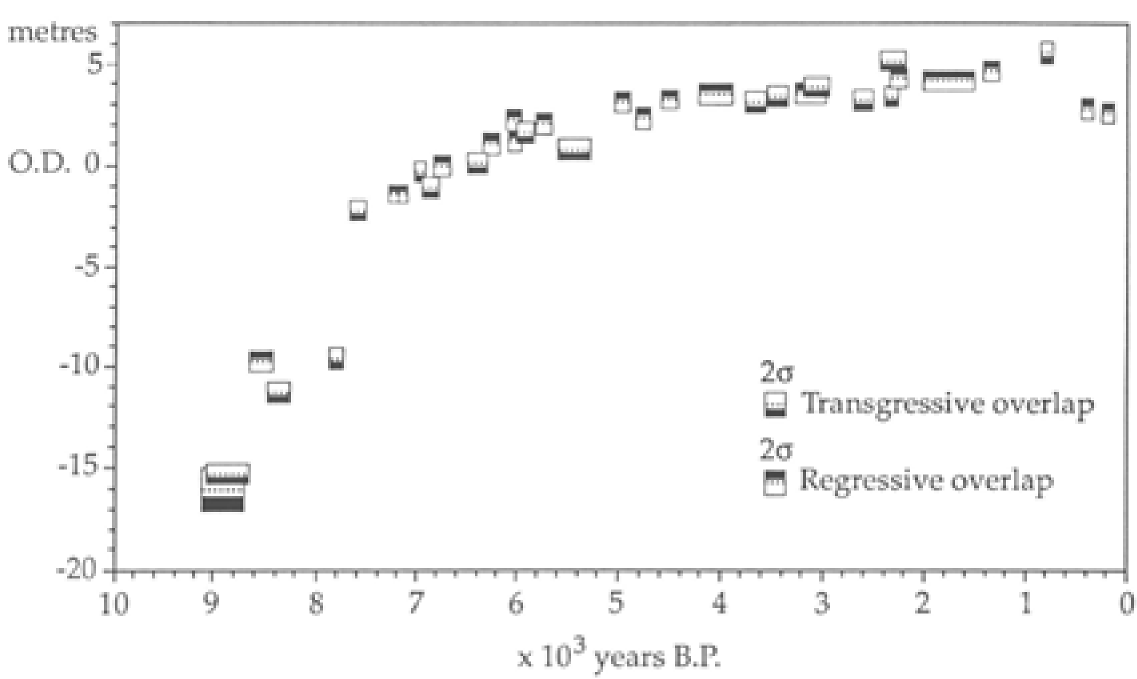


Fig 7 Sea-level curve from north-west England (Liverpool Bay, south-west Lancashire and the south Fylde (after Tooley 1978a)). The width of each box is equivalent to the 2 sigma standard error associated with each date, and the height of the box reflects the vertical uncertainty in relating each date to a former sea-level. The index points record the former position of mean high water of spring tides

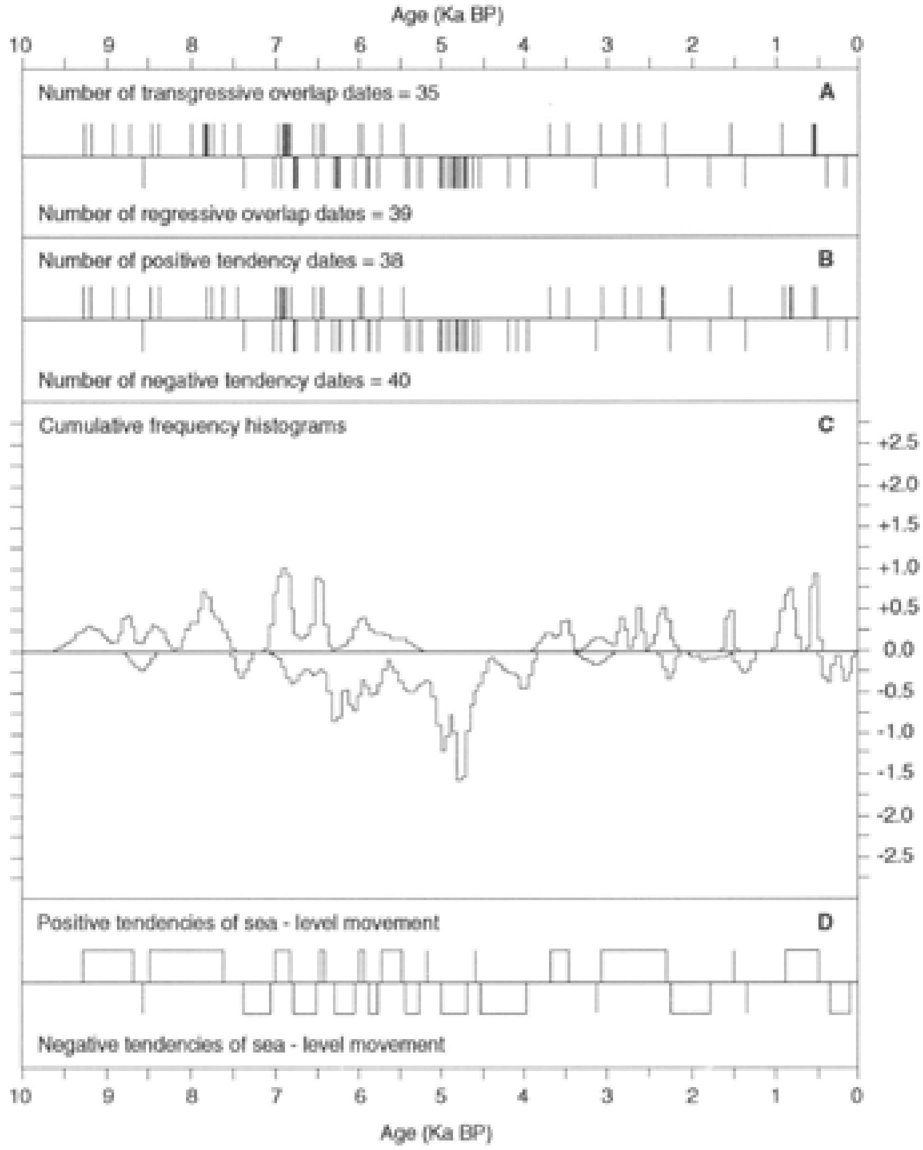


Fig 8 Chronology of regional sea-level tendencies in north-west England (after Shennan et al *1983). The chronological distribution of 74 radiocarbon dates on transgressive and regressive overlaps are shown in A), and 78 dates showing positive or negative tendencies of sea-level in B). A cumulative frequency histogram of the radiocarbon dates in B) is shown in C), while a chronology of positive and negative sea-level tendencies is shown in D)*

Because of the errors associated with estimates of the former age and altitude of sea-level in this region, small-scale oscillations in sea-level cannot be resolved. This is despite the fact that this region has perhaps the highest resolution record of past vertical sea-level changes recorded in England and Great Britain as a whole.

In 1982, Shennan used 46 radiocarbon dates to develop a chronology of positive and negative sea-level tendencies known as Wash and Fenland tendencies respectively. This chronology has been modified on a number of occasions and in Figure 10 one version of this chronology (from Shennan 1986b) is shown together with the Fenland sea-level band. Shennan (1987) correlated the Fenland sea-level tendencies with increases and decreases in the rate of sea-level rise. In his most recent study, Shennan (1994a, b) argued that there is a clear link between periods of negative sea-level tendency and shoreline advance, and periods of reduced sea-level rise. Waller (1994) has combined new and previously published palaeoenvironmental data to produce a series of palaeogeographic maps for the Fenland (eg Fig 11). On the basis of these, Waller (1994) has suggested that positive sea-level tendencies have persisted throughout much of the Holocene and that there is little evidence to support the chronology of sea-level tendencies proposed by Shennan (eg Shennan 1986b). Waller (1994) identified only a few brief negative sea-level tendencies which occurred for the most part on the western side of the Fenland. Shennan (1994b) argued that the lack of agreement between the palaeogeographic maps and the chronology of sea-level tendencies is to

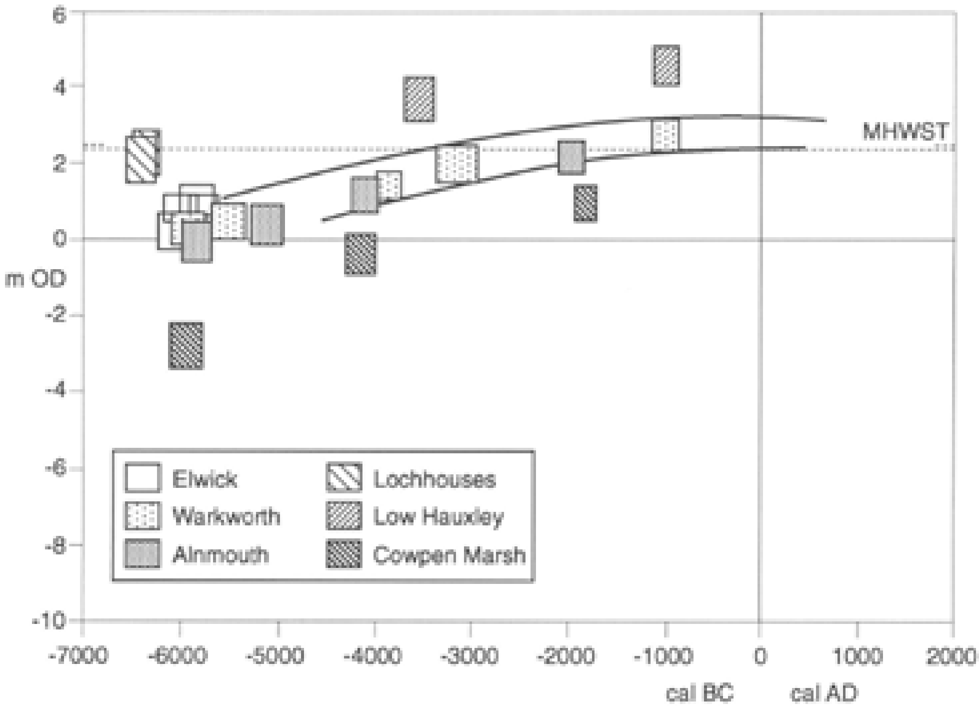


Fig 9 Sea-level graph from north-east England (Plater and Shennan 1992). Error limits are calculated from the two sigma age range of the calibrated radiocarbon dates. Each index point approximates the former altitude of MHWST. The trend of MHWST during the Holocene is highlighted

be expected; different coastal environments will have responded to vertical changes in sea-level in different ways and only some (perhaps spatially limited) sedimentary environments will record certain sea-level changes.

The south-east coast of England

Sea-level investigations in south-east England have been completed in Essex (Greensmith and Tucker 1973, 1976, 1980; Wilkinson and Murphy 1988a, b; 1995), the Thames Estuary (Devoy 1979, 1982), the East Kent Fens (Long 1992), Romney Marsh (Waller *et al* 1988; Tooley and Switsur 1988; Plater 1992; Plater and Long 1995; Long and Innes 1993; 1995; Long and Hughes 1995), and in East Sussex (Jennings and Smyth 1987, 1990). The general pattern of vertical changes in sea-level from these sites is shown in Figure 12. As with the Fenlands, south-east England has experienced a net rise in sea-level throughout the Holocene, although the rate of rise has varied.

Important spatial variations can be seen in Figure 12. For example, the timing of the mid-Holocene fall in rate of sea-level rise varies; in the Thames Estuary and the East Kent Fens it occurred at *c* 4500 BP but in Romney Marsh and East Sussex it did not occur until 600–800 years later. During this intervening time, mean sea-level continued to rise in the latter areas to *c* -2.5m OD. Furthermore, during the last 2000 years mean sea-level must have risen by a greater amount in the Thames Estuary and the East Kent Fens than in Romney Marsh

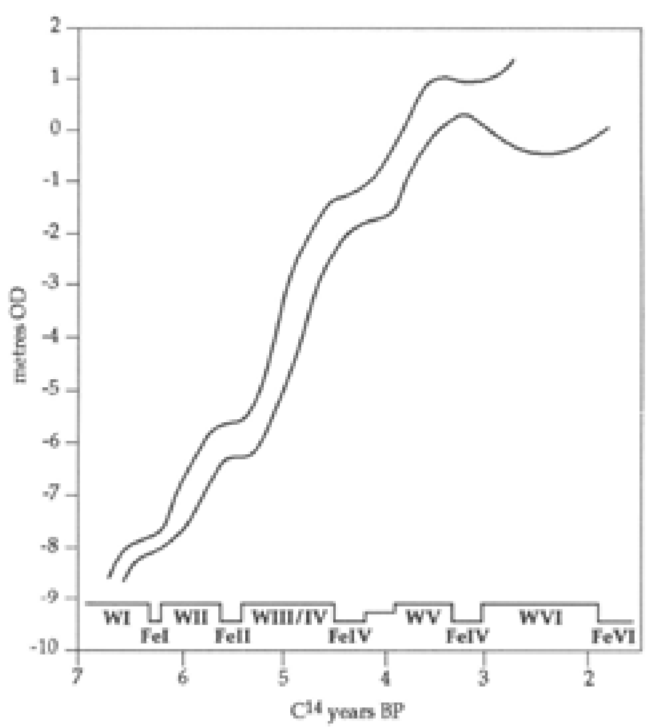


Fig 10 Sea-level band of MHWST for the Fenland (Shennan 1986b). A sequence of alternating positive (Wash I-VI) and negative (Fenland I-VI) sea-level tendencies is also shown

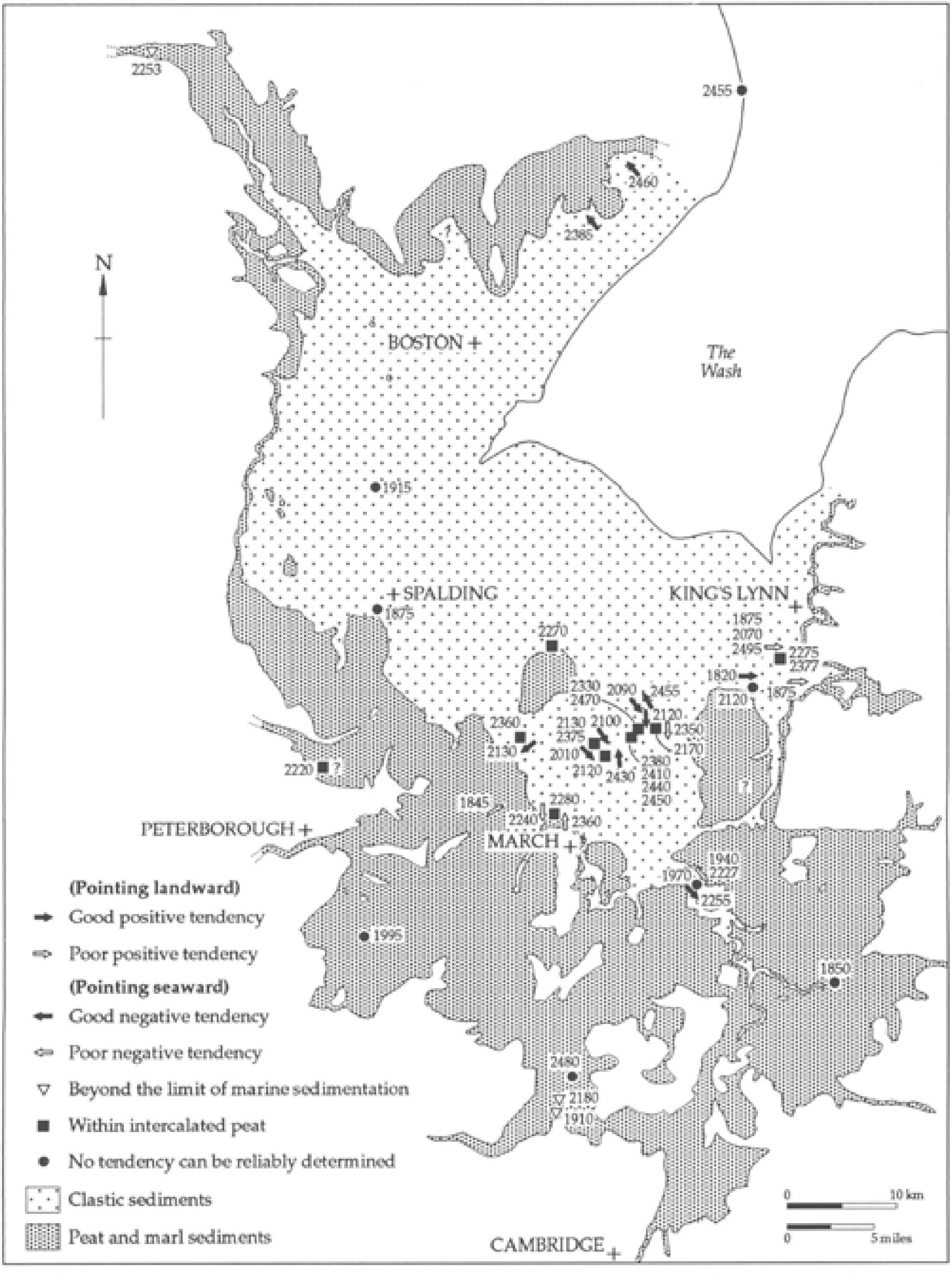


Fig 11 Palaeogeographic reconstruction of the Fenland c 1800 BP based on a combination of stratigraphic and archaeological data (Waller 1994, fig 5.22). Other radiocarbon dates from between 2500 and 1800 BP are also shown. The clastic (minerogenic) sediments are presumed to be marine or brackish in origin, while the peat and marls formed under freshwater conditions

and East Sussex, although data from this period are lacking. These differences may reflect differential crustal movements between these areas, or the effects of changes in tidal range and/or sediment compaction (Long 1992; Long and Shennan 1993). There is little agreement in the chronology of sea-level tendencies between these areas. Indeed, Long (1992) has argued that a similar (negative) sea-level tendency is recorded in all areas in south-east England during only 1000 of the last 7500 years. Long (1992) suggests that regional processes have controlled the altitude of sea-level index points, but that more local factors have influenced patterns of shoreline advance and retreat, and sea-level tendency.

The south-west coast of England

A number of studies have attempted to construct both regional and local sea-level records for this region, based on research in the Somerset Levels (Kidson and Heyworth 1976), the Bristol Channel and Severn Estuary (Allen 1987, 1990a, b, c, d, 1991; Allen and Fulford 1986; Allen and Rae 1988; Butler 1987; Kidson and Heyworth 1973, 1976, 1978; Heyworth and Kidson 1982), and Barnstaple Bay (Balaam *et al* 1987b). Heyworth and Kidson (1982) provided a broad overview of this work and compiled the radiometric dates available at that time (Fig 13).

The Heyworth and Kidson (1982) curve provides no information from the last 2000 years, but by using sea-bank and geochemical indicators, Allen (1991) has

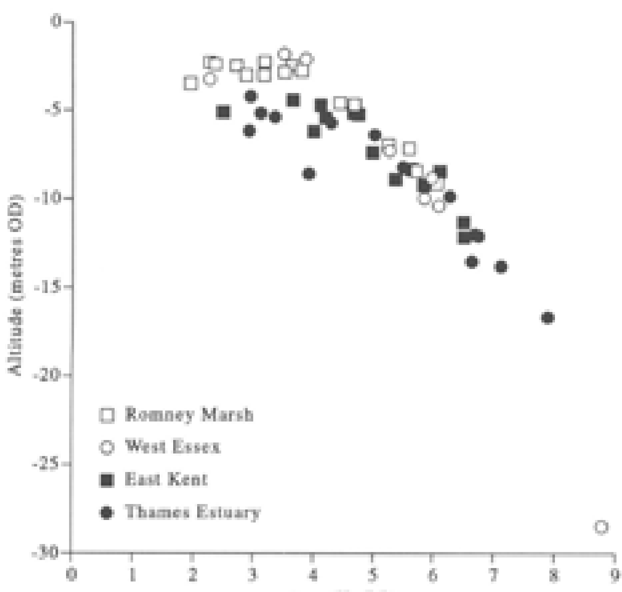


Fig 12 Sea-level graph for south-east England based on transgressive and regressive contacts. Because of variations in the tidal range within the study area, all altitudes have been reduced to a common datum (mean sea-level). Symbol sizes approximate an age range of c 200 years and an altitude range of c 0.5m

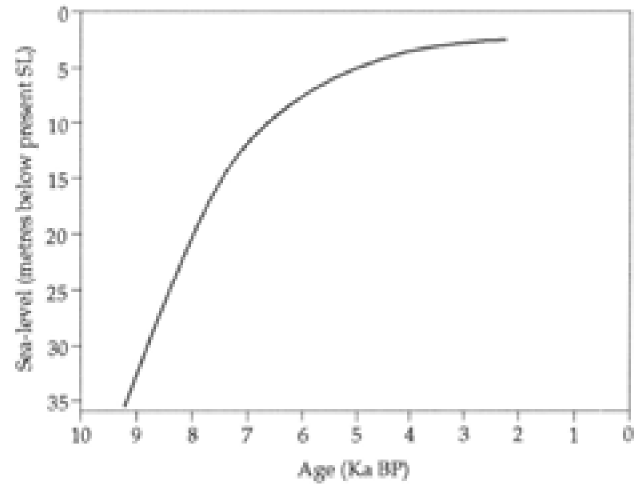


Fig 13 Sea-level graph from the south-west of England showing altitudinal changes in the height of mean sea-level, SL (after Heyworth and Kidson 1982)

shown that the rate of sea-level rise in this area varied markedly during this period. Overall sea-level has risen approximately 1.30m since Roman times, at a rate of 0.40mm/yr between AD 238 and AD 1327, 0.79mm/yr between AD 1327 and AD 1797, 1.49mm/yr between AD 1797 and AD 1945, and 4.65mm/yr since AD 1945 (Allen 1991). World eustatic sea-level movements, subsidence, and fluctuating tidal amplitudes within the estuary have all contributed to these changes. A chronology of sea-level tendencies has yet to be produced for this area.

2.2.6 Coastal archaeology and sea-level investigations

During the last 20 years a series of major coastal archaeological investigations have been completed in England's coastal zone. These include the North-west Wetlands Project, the Humber Wetlands Project, the Fenlands Project, the Hullbridge Survey, the Wootton Quarr Project (Isle of Wight), the Somerset Levels Project, and the Severn Estuary Project (Fig 14). Without exception these surveys have involved teams of interdisciplinary researchers and have considerably extended our understanding of prehistoric activity and Holocene palaeoenvironmental change in the coastal zone. The last 20 years have also witnessed significant developments in the methodology of Holocene sea-level research. In particular, a standardised approach to the collection and analysis of sea-level data has been developed which has allowed the compilation and correlation of spatially disparate data, often collected by different researchers (eg Tooley 1978a; Van de Plassche 1986; Shennan 1982, 1986a, b). One example of this is to be found in the methodology used in the reconstruction of vertical changes in sea-level, where emphasis is routinely placed on the analysis of radiocarbon-dated transgressive or regressive contacts. These contacts are the stratigraphic boundaries between predominantly

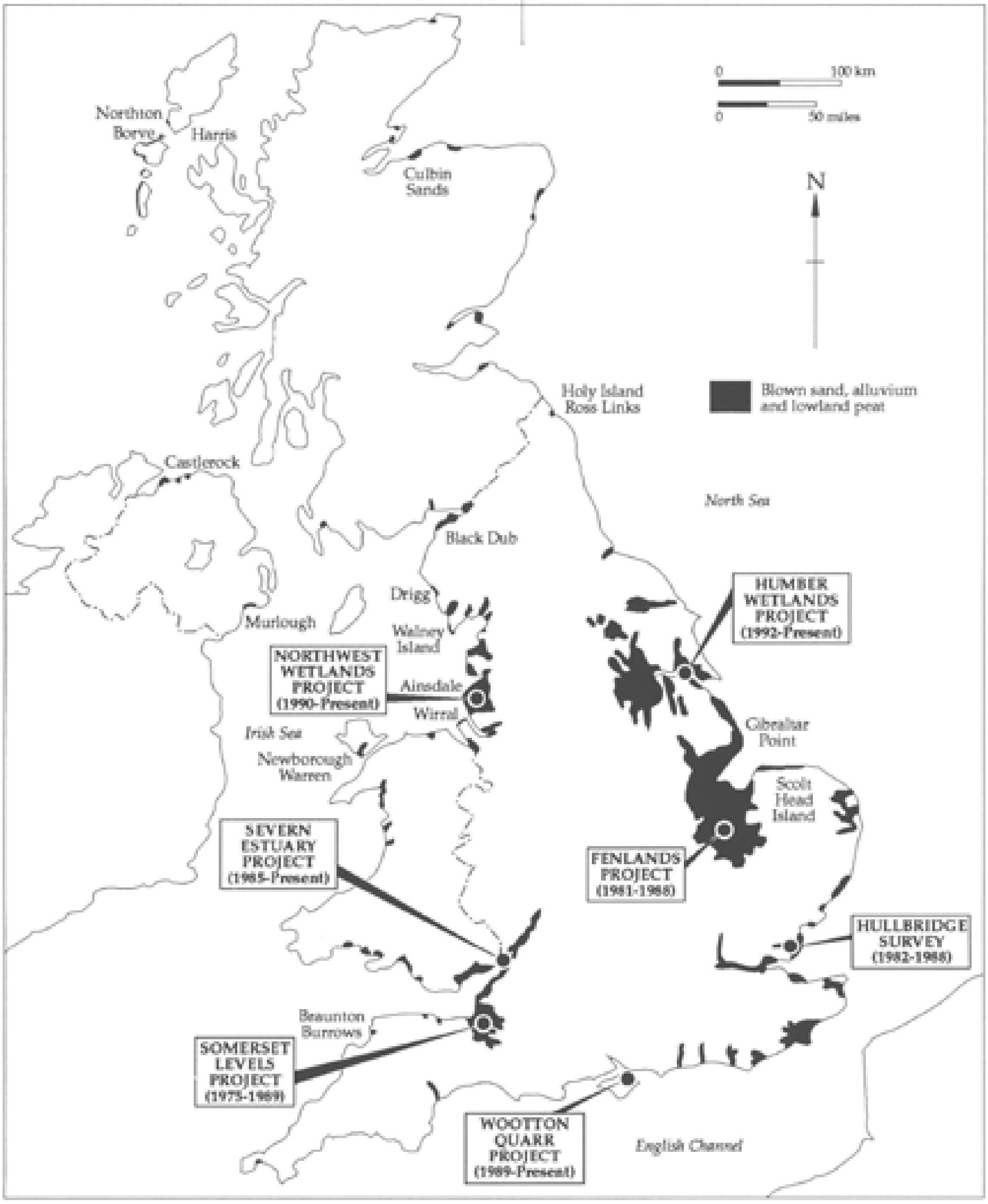


Fig 14 Location of major coastal archaeological investigations in England undertaken during the last 20 years

freshwater deposits and brackish or marine deposits, normally the tops and bottoms of peat beds (see Tooley (1978a) and Shennan (1982), for example). The development of the tendency methodology for analysing periods of increased or decreased marine influence is a further example of this refinement of approach.

A review of all but the most recent (Waller 1994) publications arising from the various wetland surveys mentioned above reveals that a gap has opened between some of the aims and approaches employed by coastal archaeologists and those employed by sea-level researchers. For example, although the wetland projects have often generated large numbers of radiocarbon dates, these have rarely been collected from transgressive or regressive contacts. The Hullbridge and the Somerset Levels projects illustrate this well. In the former at least 30 radiocarbon dates were collected from coastal archaeological material, many of which were used in the generation of a sea-level curve for the area (Wilkinson and Murphy 1988a, b; 1995). However, few of these dates were from transgressive or regressive contacts, many lacked supporting biostratigraphic data, and not all were levelled into the national Ordnance Datum. Consequently, whereas archaeological material was once routinely used in the analysis of Holocene sea-level changes (eg Churchill 1965; Akeroyd 1972), recent publications such as the final national reports of IGCP Project 67 UK Working Group (Greensmith and Tooley 1982) and IGCP Project 274 (Shennan *et al* 1992) reveal how rarely UK sea-level researchers now use coastal archaeological data in their analysis of sea-level changes.

Just as the earlier wetland projects made only a limited contribution to the analysis of vertical changes in sea-level during the course of the last 20 years, so sea-level researchers have rarely generated palaeogeographic maps depicting changes in shoreline position, although such maps are central to an understanding of coastal archaeology. In part this reflects a strong interest in determining vertical changes in sea-level and crustal movements in the UK. The approach to data collection demanded for palaeogeographic reconstruction (in terms of stratigraphic data and sampling strategies for radiocarbon dating) is very different from that required for the analysis of vertical changes in sea-level. Although much information may be obtained regarding vertical changes in sea-level through the detailed analysis of a small number of cores which contain critical stratigraphic sequences, many hundreds of cores are required to reconstruct palaeoshorelines if the spatial reconstruction of distinct land surfaces is to be attempted. Moreover, the

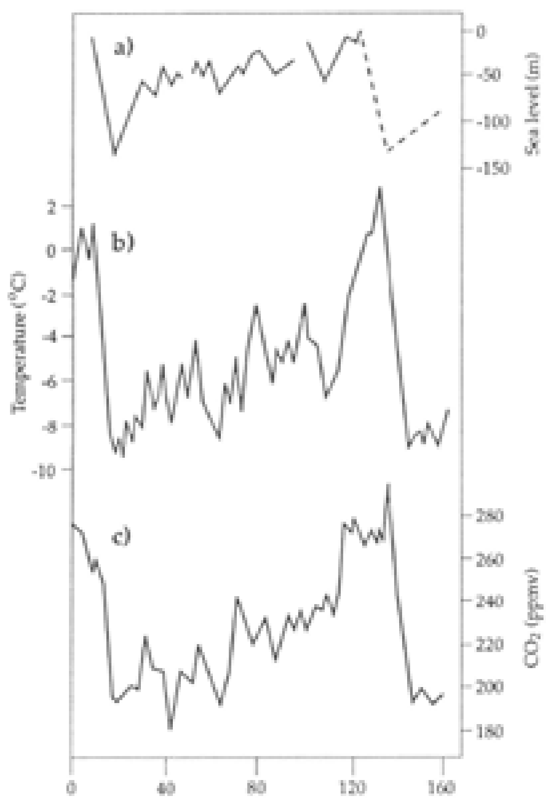


Fig 15 Changes in sea-level, atmospheric temperature, and CO_2 (parts per million volume) during the last 160,000 years (Warrick 1993)

numbers of radiocarbon dates required, and their geographical distribution, also differ from what is necessary for studies of vertical sea-level changes.

In recent years this picture has begun to change and coastal archaeologists and sea-level investigators have worked in increasingly close cooperation. The work of Allen (1990e, f, g, h; 1991), Allen and Rae (1988) and Allen and Fulford (1986; 1990a, b) in the Severn Estuary provides a good example of this, with detailed correlations made between estuary and saltmarsh response to fluctuations in sea-level, land reclamation, and settlement patterns. The Fenlands Project (Waller 1994) and the current research associated with Wootton Quarr on the Isle of Wight also highlight a new trend in close cooperation. Beyond these major projects, other groups also seek to further such linkages, for example the Romney Marsh Research Trust, which has promoted collaborative research between archaeologists and sea-level investigators (eg Eddison and Green 1988; Eddison 1995).

2.3 Future sea-level change

Current concern regarding future sea-level rise is based on the assumption that fluctuations in atmospheric CO_2, global temperatures, and sea-level are linked. The long-term context for this concern stems from the Pleistocene record of atmospheric and temperature changes recorded in the chemical composition of the ice sheets and their correlation with the sea-level record, particularly over the last 160,000 years (Fig 15). In addition, changes in temperature and CO_2 levels during the last *c* 200 years, based on high resolution ice core data augmented by more recent direct measurement of atmospheric CO_2 and sea-level change, also show an equally close relationship between these variables (Fig 16).

2.3.1 Global sea-level change

In 1990, the Intergovernmental Panel on Climate Change (IPCC) produced a comprehensive review of global sea-level change during the last 200 years, and predicted future global sea-level change until AD 2100 (Warwick and Oerlemans 1990). IPCC 1990 sea-level projections were based on a range of greenhouse gas forcing scenarios consisting of a 'business as usual' scenario and three lower scenarios, in each of which greenhouse gas emission totals were reduced. Three projections were made for each scenario, based on low, high, and best estimates for the contributory factors used to formulate the models.

For the 'business as usual' scenario, best estimates for future global sea-level rise rose from 18cm by 2030, to 66cm by 2100. Warwick and Oerlemans (1990) stressed that even with immediate implementation of strict emission controls, sea-level will continue to rise well into the next century, and that there already

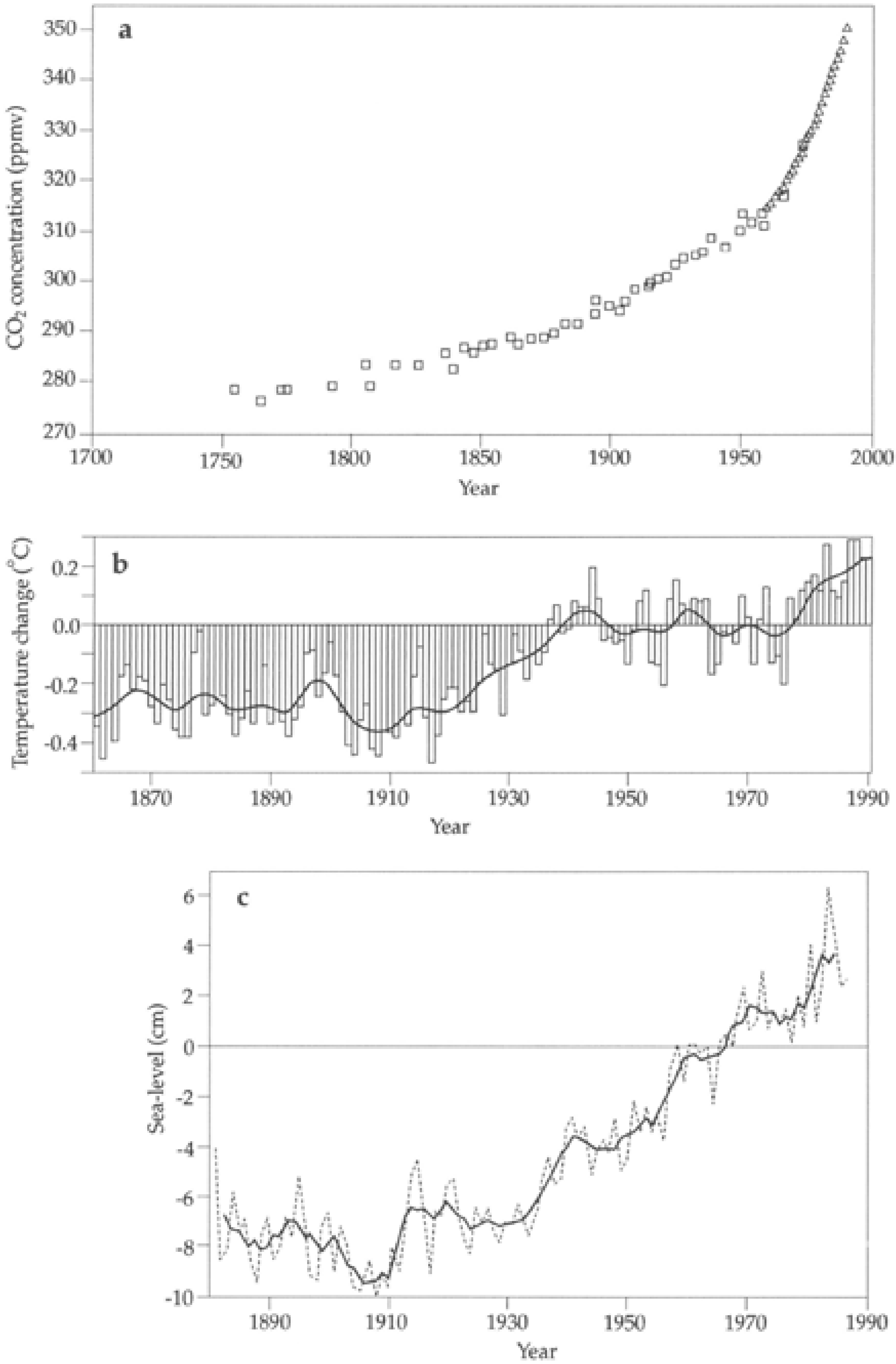


Fig 16 (a) Atmospheric concentrations of CO_2 since AD 1700 based on observations from ice core data (squares) and direct observations (triangles) (Watson et al *1990), (b) global air-sea surface temperatures, 1861–1989, relative to the average 1951–80, (Folland* et al *1990) and (c) global mean sea-level rise over the last century, relative to the average for the period 1951–1970 (Warwick and Oerlemans 1990)*

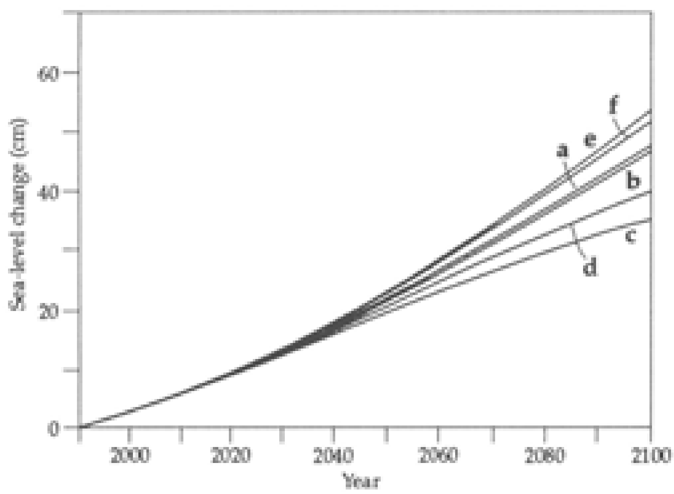


Fig 17 Revised best guess estimate for sea-level rise until the year AD 2100 (Wigley and Raper 1992)

exists a 'commitment' to future sea-level rise. This is due to the strong lag effects which operate between ocean warming, ice melt, and climate change in response to past greenhouse gas build-up. Thus, even if greenhouse forcing were stabilised by 2030, sea-level would continue to rise at the same rate for the rest of the century.

Warwick and Oerlemans (1990) also considered the likelihood of increased storm frequency and intensity related to global warming, and concluded that although mid-latitude storms may weaken and change track as a result of reduced temperature contrasts between the northern hemisphere and the equator, there was insufficient evidence to assess changes in storm frequency and paths. More recently, Tooley and Jelgersma (1992) have emphasised the threat of possible increased storminess to European coasts, in association with sea-level rise and increased tidal amplitudes.

In 1992 the IPCC produced a revised set of emission scenarios which were used by Wigley and Raper (1992) to recalculate future sea-level changes. The new projections suggested that changes in temperature and sea-level were not as severe as those previously predicted by Houghton *et al* (1990). This time each of the scenario projections was considered with and without CO_2 fertilisation feedback, with and without ozone depletion feedback, and for low, middle, and high aerosol forcing. The climate model was also designed to generate thermal ocean expansion predictions, possibly the most important factor in future global sea-level rise. Contributions to sea-level from small terrestrial glaciers and the Antarctic and Greenland ice sheets were also incorporated.

The results of Wigley and Raper's analysis are summarised in Figure 17, where sea-level projections (Scenarios a-f; best guesses) are shown for the updated 1992 scenarios. For scenario a, which most closely approximates to IPCC SA90 (business-as-usual, best estimate; see Wigley and Raper 1992 for details), the 'best guess' scenario for temperature change is 1.7°C–3.8°C for 1990–2100, which results in a corresponding 'best guess' sea-level rise of 48cm, compared with the 66cm predicted by Warwick and Oerlemans (1990). This estimate has recently been slightly modified to 49cm (Warrick *et al* 1996). Although the differences between these more recent estimates and the 1990 estimate are large, the projected half metre rise in sea-level by 2100 still corresponds to a rate of sea-level rise approximately four times that estimated for the last century.

2.3.2 National future sea-level change

Shennan (1989) has used sea-level data to estimate the current rates of vertical crustal movements in Great Britain (Fig 18a). These estimates are now combined with Wigley and Raper's (1992) estimates of future global sea-level rise, to approximate the magnitude and rate of future sea-level rise in Great Britain by 2100. This analysis assumes that rates of future crustal movements remain constant, and that global sea-level rise will accelerate towards the end of the next century. Shennan's (1989) values for crustal subsidence are based on the radiocarbon timescale, but for the purpose of this study no correction to sidereal years has been made.

From Figure 18b it can be seen that by 2100 relative sea-level in Scotland is likely to have risen by at least 25cm. Away from this centre of maximum rebound, uplift rates decrease southwards, with the region between Lancashire and Newcastle-upon-Tyne recording 'eustatic' sea-level rise only. Subsidence south of this line will enhance the effects of future sea-level rise. This is particularly noticeable in the south-east of England, where the total rise in sea-level by 2100 will approach *c* 70cm. The rate of rise will accelerate towards the end of the next century, particularly between 2070 and 2100, and in the south-east the rate of relative sea-level rise may approximate 8mm/yr by 2100 (Fig 18c). In general, rates of sea-level rise throughout the next century do not exceed the highest rates recorded during the Holocene (Shennan 1993), at least not until after 2070.

2.3.3 Difficulties in estimating future sea-level rise

Although the above analysis illustrates the general trends of sea-level change expected over the next 100 years, it should be stressed that the accuracy of these predictions depends on the accuracy of the crustal model and the predictions of Wigley and Raper (1992), each of which are now discussed.

Shennan's (1989) model of crustal movements is obtained through the subtraction of a 'regional eustatic sea-level curve' from local sea-level data derived from a range of sites within Great Britain. Potential problems associated with this procedure relate to the eustatic curve and the local sea-level data. The rates of crustal movements calculated by Shennan (1989) will be incorrect if the eustatic curve is in error. This is possible, given the wide range of data used in the calculation of the original eustatic curve. Moreover, the likelihood of significant errors increases as one goes back in time, because the rate of sea-level rise was much higher in the past and small errors in age estimates may therefore cause large differences in inferred rates of crustal uplift or subsidence. More fundamentally, Lambeck (1993) has argued against the concept of a single eustatic curve, citing the complex effects of changes in gravitational potential caused by the combined effects of ice and water unloading and loading. However, where sea-level index points are distant from the

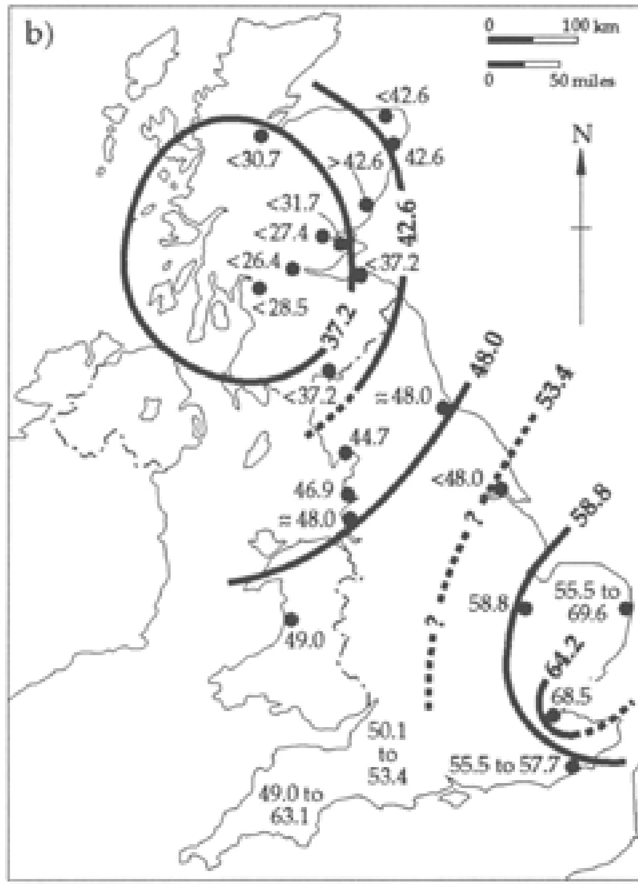
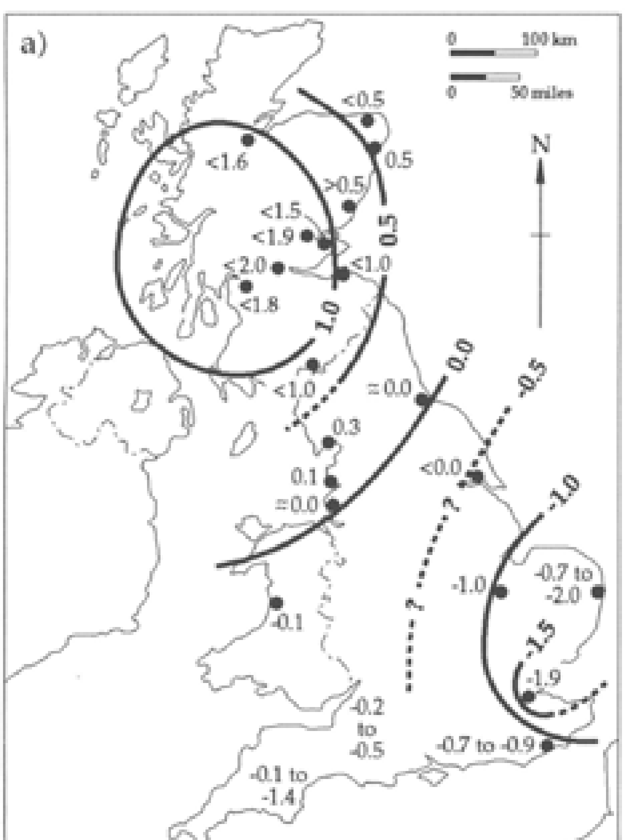
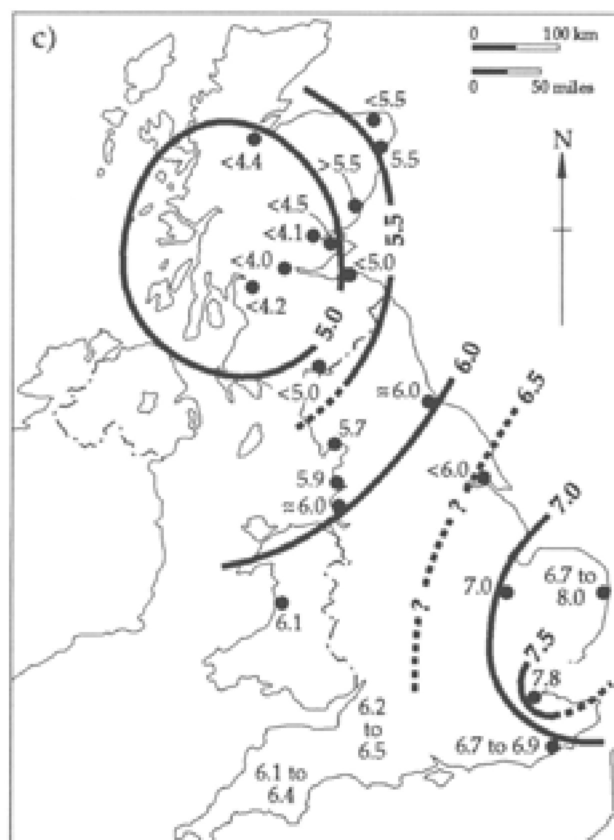


Fig 18 (a) Current rates of crustal uplift/subsidence in Great Britain (mm/yr) (Shennan 1989), (b) net sea-level rise (cm) by AD 2100. Calculations are based on a combination of the crustal (Shennan 1989) and best guess sea-level values (Wrigley and Raper 1992), and (c) rates of sea-level rise (mm/yr) by AD 2100 assuming an acceleration in global sea-levels towards the end of the next century and constant rates of crustal uplift/subsidence





gravitational effects of ice sheets (as is the case for most of England during the last 5000 years), it is unlikely that the regional eustatic sea-level signature will have been significantly affected. Most of the rates of crustal movements calculated by Shennan (1989) are based on calculations which span the last 5000 years and this problem is therefore to some extent reduced.

Errors are also associated with the local sea-level data, caused by a range of processes such as the unquantified effects of local sediment compaction as well as palaeotidal fluctuations. In addition, there is a strong geographical bias in the spatial distribution of the sea-level index points which formed the basis for Shennan's (1989) analysis. Although Shennan (1989) was careful to consider only those areas where high quality sea-level data existed, there were nevertheless large parts of England for which data coverage was weak (such as along the south coast of England, although this has been rectified to some extent) (Long and Tooley 1995).

With regard to future sea-level, Wigley and Raper (1992) and Warrick *et al* (1996) stress that the wide range of sea-level scenarios reflects extreme uncertainties in attempting to model future climate and sea-level change. In addition to greenhouse gas forcing, the effects of CO_2 fertilisation, feedback from stratigraphic ozone, and the radiative effects of sulphate aerosols are now known to complicate the picture of climate change. In particular, the cooling effects of sulphate aerosols, causing increased atmospheric reflectivity of incoming solar radiation, have only recently been incorporated into climate models (Wigley 1994), and may lead to reduced estimates of climate warming and sea-level rise. Finally, recent advances in computer models which seek to couple the atmosphere and the oceans suggest that regional responses to global sea-level change may be highly variable, due to regional differences in heating and changes in ocean circulation (Warrick *et al* 1996).

2.4 The impact of sea-level change on the archaeological resource

Future sea-level rise will have an impact on England's coastal archaeology in a number of ways, depending on the nature of coastal processes and the character of the archaeological resource. Most previous research on coastal archaeology has concentrated on the survey and rescue of material under threat from natural or artificial agents, and the impacts of sea-level change and coastal processes on the archaeological resource have been little studied (Chapter 8; Schiffer 1987; Firth 1990). Although the impact of sea-level change will depend on the interaction of local and regional factors, thereby making small-scale generalisations difficult, some general types of impact anticipated under future sea-level change can nevertheless be proposed.

The following section considers:

- how these processes are likely to change under future sea-level change in different coastal environments (low, medium, and high energy)
- how different types of archaeological material respond to these processes

2.4.1 Coastal processes

This section summarises physical coastal responses to future sea-level rise and identifies the main physical, chemical, and biological processes that may affect archaeological material within different coastal environments.

Low energy coastal environments

At its simplest, sea-level rise in low energy environments will cause a landward movement of the shoreline and a lowering of the shoreface. Pethick (1993) has argued that in estuaries, as water depth increases, so bed friction will fall and the velocity of tidal currents in tidal channels will increase. This will encourage the erosion of channel banks (upper intertidal mudflats and saltmarsh edges), and material eroded by this process may subsequently be deposited in the base of the tidal channels, causing them to shallow. Pethick (1993) provides examples of this process operating in the Blackwater Estuary, Essex, since 1805. These processes of erosion and deposition will tend to expose archaeological material in the upper part of the intertidal zone, and submerge material in the lower part.

The detailed response of saltmarsh and mudflats to sea-level rise is likely to vary depending on a number of site-specific and regional factors including the rate of minerogenic sediment supply, long-range sediment compaction, organic sediment supply, and sea-level rise. Allen (1990e) has suggested that the upward-growing mudflat-marsh surface varies with time according to the following equation:

$$\frac{dE}{dt} = \frac{dS_{min}}{dt} + \frac{dS_{org}}{dt} - \frac{dM}{dt} - \frac{dP}{dt}$$

where dt is time, dE is the change in marsh elevation, dS_{min} is the thickness of added minerogenic sediment, dS_{org} the thickness of added organic material, dM the change in relative sea-level and dP the shortening of the sediment column between the surface and the base of the mudflat-marsh sequence caused by long-range sediment compaction (ie that caused by load).

Saltmarsh response to sea-level rise is likely to be highly variable, to such an extent that even saltmarshes which are within the same estuary may respond to a similar trend in sea-level in differing ways. Such variable responses are highlighted by Vanderzee (1988), who has argued that saltmarshes may respond to future sea-level rise in one of four ways: by drowning, by receding and accreting, by prograding (advancing seawards), or by maintaining height below extreme tide level and keeping pace with sea-level rise (Fig 19). Using Allen's model described above, the drowning of a marsh would require high rates of sea-level rise (d*M*) and compaction (d*P*) combined with low rates of organic and inorganic sedimentation (dS_{min} and dS_{org} respectively). The receding and accreting model assumes that sediment accretion on the back of the marsh keeps pace with (or exceeds) the rate of sea-level rise, while the front of the marsh is unable to keep pace and suffers erosion and retreat. The prograding marsh condition will occur when dS_{org} exceeds the rate of sea-level rise and sediment compaction (d*M* and d*P* respectively). Finally, maintaining marsh height with sea-level rise requires that $dE/dt = 0$. Under this scenario, once maturity has been reached the marsh surface will increase in height at a very similar rate to the change in sea-level.

Finally, changes in saltmarsh vegetation, notably due to the expansion and more recent 'die-back' of *Spartina anglica* during the last century (Doody 1990; Nyman *et al* 1994), are also having a significant impact on saltmarsh development and sediment dynamics in low energy settings, where this plant is an important element of the saltmarsh flora. Where die-back is leading to a loss of saltmarsh (such as in Poole Harbour), archaeological material formerly buried by saltmarsh sediments may be increasingly exposed to physical, chemical, and biological processes. Conversely, a release of fine-grained inorganic sediments into intertidal channels may accompany saltmarsh loss (Gray *et al* 1990), thus encouraging the burial and protection of archaeological material in such settings.

Medium to high energy environments

Medium to high energy environments include sand and gravel coasts, as well as dunes and cliffs. In general the higher wave energy and increased attrition which typify these environments are likely to promote rapid destruction of archaeological material following exposure.

The response of sandy beaches to future sea-level rise is largely dependent on sediment supply. Where the volume of longshore sediment transport increases due to local cliff erosion acting as a feeder mechanism, beaches may prove resistant to changes brought about by sea-level rise. In contrast, beaches which do not receive more sediment are likely to experience an acceleration in the rate of coastal retreat. Different types of sand and gravel barriers will respond to sea-level rise in different ways. For example, a swash-aligned barrier (which parallels the incoming wave crests) may retreat landwards due to the combined effects of erosion and offshore sediment accumulation, and also rollover processes. Eventually, drowning may occur, depending on local conditions and the rate of sea-level rise (Carter 1988).

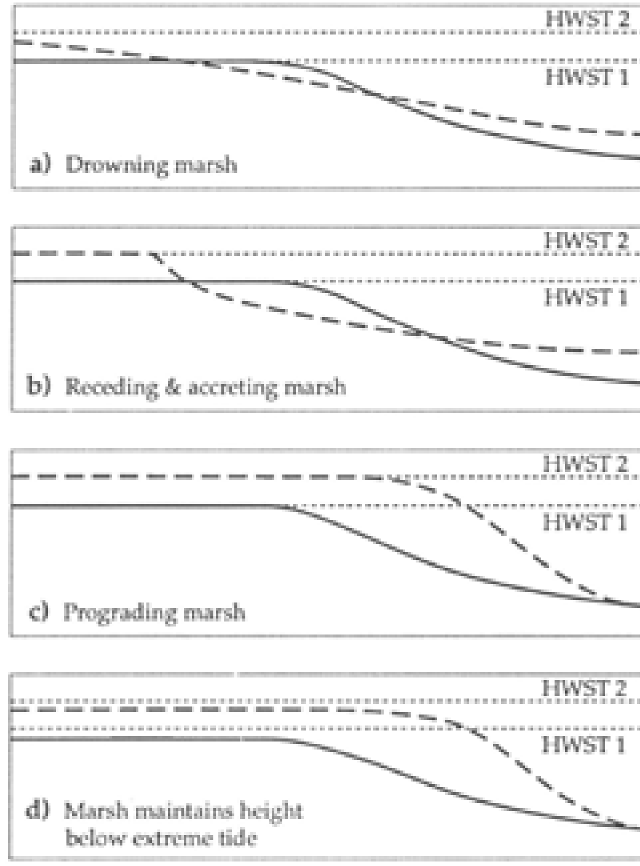


Fig 19 Different models of saltmarsh response to sea-level rise (after Vanderzee 1988)

Drift-aligned barriers (which are fed by longshore sediment movement) are heavily dependent on sediment supply, and if a rise in sea-level increases sediment supply then these types of barrier may extend. If sediment supply falls, however, perhaps as a result of management strategies in sediment source areas, then such barriers will undergo updrift erosion, barrier steepening and thinning, and may ultimately break down and realign themselves into new structures (Orford *et al* 1991).

Archaeological material in these types of coastal settings will undergo rapid removal, modification or destruction once exposed by rollover or barrier reworking and erosion. The exposure on the seaward side of coastal barriers of fine-grained sediments which originally accumulated in the sheltered landward side of the barrier is a common feature of sites around England's coast (eg on the foreshore of Dungeness and at Westward Ho!). Such sediments have often been compressed and distorted by overburden loading (caused by the weight of the barrier overriding the finer-grained sediments), and tend to be quickly removed from the shoreface. In contrast, where a rise in sea-level releases sediment and prompts barrier expansion, archaeological material may receive increased protection. However, sand or gravel barrier migration and subsequent burial may be detrimental to any exposed archaeological material (owing to abrasion, attrition, and compaction processes).

Dunes

Dune systems act as beach stabilisation mechanisms during storms and surges, through the release of sand onto the beach, while during calmer conditions aeolian processes (wind action) return sand to the dune system. During a rise in sea-level and/or an increase in storm frequency dunes will play a vital role in coastal stabilisation, especially for the large areas of coastal lowland currently protected by extensive sand dunes, such as in south-west Lancashire (Atkinson and Houston 1993). Where large amounts of sediment are released through dune erosion, aeolian processes may remobilise sediment, leading to renewed vertical dune accretion, particularly where landward dune areas are well vegetated and act as sediment traps. However, where vegetation is damaged owing to shore processes or anthropogenic impact, mobile travelling dunes may develop. If dominant winds cause sand migration away from the coast, a vital sediment supply for shoreline stabilisation in response to rising sea-level will be lost.

Future sea-level rise may be accompanied by the exposure and loss of archaeological material from the coastal fringe of dunes as well as from considerable distances inland, depending on the nature of dune breakdown. Catastrophic dune breakdown can potentially expose large areas of archaeologically rich coastal landscapes. Such landscapes are likely to deteriorate rapidly following exposure, and wind will be a particularly efficient abrasive, leading to the damage, alteration or destruction of archaeological material. Although this may be counterbalanced by burial processes, burial could also be a degradational process, since damage to archaeological material may occur through attrition and abrasion as sands are transported into a site. In addition, dune re-vegetation (commonly with marram grass) may lead to root disturbance, and further damage may be created by burrowing. Finally, burial mechanisms hinder access to archaeological sites for the purposes of both research and management.

Cliffs

Cliff retreat may pose a serious threat to archaeological sites which were once some distance from the shoreline. Cliff response to future sea-level rise will vary depending on cliff hardness, cliff height, and the supply of sediment to the foot of the cliff (Trenhaile 1987). If a rise in sea-level increases wave attack to the foot of the cliff, material from the base of a cliff will be removed and cliff retreat will accelerate. This is especially likely if updrift sediment supplies have been reduced, perhaps due to coastal defence measures. For the toughest, plunging cliffs, the deep water which often fronts such cliffs will ensure that future sea-level rise will not substantially alter the wave energy reaching the cliff face.

2.4.2 Physical, chemical, and biological processes

The fact that delicate archaeological material is still preserved in coastal deposits indicates the high preservation potential and relatively stable chemical and biological nature of certain protected coastal settings. Sea-level change is likely to disturb this situation, principally by exposing the material to direct physical processes, but also by changing its chemical and biological context.

The physical processes which operate in the coastal zone are controlled primarily by winds, waves, and tidal currents which have an impact on the archaeological resource through intrusion, exposure, extraction, compaction, and burial. Intrusion occurs when waves intrude water and/or sediment into a sediment body. In some cases lenses of inorganic material may be intruded some distance into a sediment body. For example, storm surges may cause freshwater peats to separate from their underlying units and float upward, allowing thin beds of inorganic material to be deposited under the floating peat before it is lowered at the end of the surge (Streif 1982). More commonly, intrusion may occur vertically, as a result of natural processes (eg root penetration and burrowing) as well as artificial processes (eg piling; see Chapter 8).

Sediment removal by current or wave scour, or by aeolian processes which strip sand from dunes or directly from the beach, will expose material. Sediment will be moved when the stress applied exceeds the sediment yield strength, which will vary for different types of material. For example, clays and silts may form a cohesive sediment body and thus require relatively high shear stress velocities (as high as those needed to erode non-cohesive sands and fine gravel) before they can be eroded. Consequently, under certain conditions, silts and clays which are strongly cohesive will afford greater protection to an artefact than a less cohesive body of coarser sediment consisting of sand or gravel.

Under a future rise in sea-level and landward movement of the shoreline, beach profiles will typically lower, exposing sediment and artefacts previously below sediment or water depth. Following exposure, the chemical and biological attack of organic material will accelerate dramatically (see below). Extraction may follow exposure, and once material is incorporated as a mobile element of the nearshore zone coastal sediment, attrition will encourage further physical damage.

Compaction and distortion may be caused by the loading of a sediment (and contained artefacts) by water and/or sediment, but may also occur as a result of dewatering of previously saturated sediments. The latter form of compaction is common in areas which have been subjected to artificial drainage and land reclamation, such as the Fenlands of East Anglia, where peat wastage of several metres has occurred in the last century (Godwin 1978). The impact of wet/dry cycling (Mathewson and Gonzalez 1988) due to tidal fluctuation across freshly exposed artefacts is also likely to be highly detrimental in coastal archaeological environments, as constant shrinkage and expansion influence artefact porosity and molecular structure, leading to accelerated structural disintegration.

Subaerial exposure will change following sea-level rise, due to erosion in the upper intertidal areas and increasingly prolonged submergence in the lower intertidal zones. In general, sediments and archaeological material (particularly wood, leather, faunal remains, and other organic matter) suffer more rapid decay once they have been exposed to aerobic conditions, due to increased microbial and fungal activity. Biodeterioration occurs as a consequence of degeneration initiated by micro-organisms and their by-products (eg Simpson 1994). There are several types of fungi that degrade organic material through cellulose and lignin breakdown, and bacterial organisms behave in similar fashion, destroying cell structure (Boyle and Mitchell 1981).

In addition to microfauna, boring macrofauna such as mollusca and crustacea can also cause widespread biodegradation. Subtidal molluscan borers may be cause for future concern as intertidal zones migrate landward, leaving material exposed in the present intertidal zone to be attacked in the subtidal zone (cf Ferrari and Adams 1990). Crustacean borers will be active throughout the intertidal zone and will have a heavy impact upon any freshly exposed organic archaeological remains. In contrast, the anaerobic reducing environments experienced during burial and submergence generally promote conditions favourable to preservation, although new research is attempting to evaluate the impacts, if any, of anaerobic organisms on buried artefacts (M Jones, pers comm).

The effects of bioturbation (sediment disturbance by animals and plants) in the intertidal zone are also an important consideration in sediment stability and hence artefact disturbance. Grant *et al* (1982) have illustrated how seasonal controls on faunal activity affect sediment coherence, with several types of biological activity (bacterial and algal adhesion; metazoan reworking) acting together but varying widely in time and space. Sediment stability can be induced by mucus binding and other extracellular products of micro-organisms, particle agglutination, and modification of flow adjacent to the bed due to disturbance by faunal tubes and filaments. Destabilisation can also occur, however, due to elevation of sediment particles into the shear flow zone above a substrate, and increased bed roughness due to bioturbation.

Changes in water chemistry will also affect artefact preservation, particularly owing to elevated water tables in the backshore zone in response to sea-level rise, but also through changes in water quality caused by sewage. Rising sea-level will change the chemical composition of the interstitial water within which an artefact is preserved. The chemical process which causes most damage to organic material is hydrolysis, which involves the chemical decay of cellulose in water (Simpson 1994). In addition, physical damage may be caused by chemical action in areas with a fluctuating water table. For example, if saline groundwater penetrates wooden artefacts, salt crystal growth may cause physical damage to the cellular structure of the wood as it dries (Simpson 1994). Changes in pH are also important, since low pH (<pH4) will accelerate hydrolysis and depolymerisation of organic material, whereas higher pH (>pH8) also causes breakdown of cellulose chains. Saline water intrusion into upper intertidal areas is likely to give rise to higher pH values.

2.4.3 Site and artefact character

When assessing the effects of various coastal processes and their related impacts upon a range of archaeological sites, it is important to consider the coherence of the site as a whole as well as the coherence of individual artefacts within the site. It is also vital that the geological and environmental context of the site should be understood, in order to comprehend fully the process/response mechanisms that will operate in response to fluctuating coastal conditions.

Artefact character

Defining the specific competence of different archaeological artefacts is difficult, as the coherence of an artefact can be strongly influenced by the degree of degradation which it has already undergone. Lenihan (1981) highlights the ability to resist erosion of a range of archaeological material that upon initial inspection might be thought of as fairly robust (eg bone, ceramics, shell, and pollen) but which under certain conditions may degrade easily. Although Lenihan (1981) mainly discusses freshwater degradation processes, many of the processes can be cross-correlated to a saline intertidal environment. The following examples relate largely to wet/dry cycle impacts.

Bone subjected to wet/dry cycles will crack, distort, and shrink, and cortical lifting is common. Bone structure is also affected by hydrolysis of protein constituents, which promotes degradation by weakening the mineral and protein phases in the bone. The larger the surface area of a bone and the greater its porosity, the faster degradation will occur. However, many of these processes are typical of more acidic conditions (freshwater), and bone is best preserved in an alkaline environment. Thus, bone degradation may not be as severe in the marine intertidal zone as in freshwater conditions, although freshwater input from fluvial sources (in an estuarine setting) may upset this balance.

Ceramics subjected to wet/dry cycles become more porous and hence weaker. This is mainly due to the leaching out of potassium, sodium and magnesium which occurs rapidly within a few wet/dry cycles. Ceramics with the lowest firing temperatures will tend to disintegrate fastest, after as few as 20 wet/dry cycles, and leaching of calcium is known to reduce tensile strength.

Pollen grains are also degraded by wet/dry cycles, and experiments show *c* 70% and *c* 83% degradation of unacetylated pollen and acetylated pollen respectively. This might be an important consideration when attempting palaeoenvironmental reconstruction from intertidal stratigraphy which has been repeatedly wetted and dried.

Shell material (oysters, clams) is generally unaffected by wet/dry cycles although a slight reduction in porosity can occur, and surface textures (growth rings) can be destroyed.

Geological and environmental site context

The geological and environmental context of a site is also an important consideration in site appraisal, as substrate competence ultimately determines overall site cohesion. Lenihan (1981) investigated the impacts of reservoir inundation on a range of archaeological sites and formulated a Relative Sediment Impact Prediction Index (Table 2). Although this index relates sediment competence to a variety of freshwater erosional processes, they can be adequately applied with some adaptation to a marine intertidal zone, providing an index with which to gauge sediment response to changing coastal conditions.

Case study of local coastal responses: Wootton Quarr, Isle of Wight

As discussed above, assessing the threat of future sea-level change on the archaeological resource depends on the interaction of local and regional coastal processes as well as the nature of the archaeological resource itself. The importance of the more local controls is now illustrated with reference to research undertaken as part of the Wootton Quarr Project on the Isle of Wight.

Dowell (1994) has identified two causes of coastal erosion along the Wootton coast, ferry surges and tidal currents. In the last 30 years local ferry traffic has accelerated erosion because of increased surge activity from bow wave swash. In particular, ferry surges have eroded the upper, more competent intertidal sediments (which have a high yield strength). The weaker underlying sediments have been eroded by less powerful tidal currents.

Simpson has examined the impact of chemical and biological processes on wood exposed in the intertidal zone of this area (1994). He concluded that the wooden structures were primarily affected by wave and current action. However, once exposed through physical erosion, chemical processes and aerobic organisms combine to degrade them. These processes are particularly marked in the upper intertidal zone because of increased exposure times. Considerable damage to the stakes was also inflicted by the crustacean borer *Limnoria*, as well as possibly by the ragworm, *Nereis.* Boring damage in the samples examined was highest in the waterlogged wood exposed above the sediment surface, while the extent of damage to the stakes varied according to the exact nature of the stakes (eg size, wood type, position in intertidal zone, depth of burial). The physical strength of the stakes was also affected by their moisture content, and in general enhanced degradation was recorded at the bottom end of stakes due to narrowing of the wood. Table 3 gives a summary of the impact processes discussed above, and their modification of the archaeological resource.

2.5 Discussion

England's coast has attracted people throughout the Holocene for a variety of reasons connected with food collection and the exploitation of mineral resources, as well as for trade, transport, and defence. Because of the dynamic nature of coastal change and the demands of prehistoric people, the spatial and functional relationship between human beings and the coast has changed through time. The sediments and archaeological heritage of England's coastal zone provide an important record of this changing relationship, which is now under increasing threat from future sea-level rise and other human activity in the coastal zone.

Much of England's coast is protected by coastal defences of one sort or another, and archaeological material behind these defences is currently protected from most (but not all) of the physical, chemical, and biological effects of future sea-level rise. However, in many parts of the coast, such as on the Isle of Wight or in the Essex coastal marshes, or in the Severn Estuary and the Bristol Channel, Holocene coastal deposits are either unprotected or lie seaward of defences, and are already being damaged or destroyed by coastal erosion.

Studies such as the Wootton Quarr Project reveal the complexities involved in assessing the impact of future sea-level rise on England's coastal heritage. Not only are many of the biological, chemical, and physical processes responsible for damage to the resource poorly understood, but the range of local site processes makes simple predictions at a national level almost impossible. Thus, although projections of national and regional rates of future sea-level change highlight the spatial variations expected, they are of limited value in assessing local site impacts until

Table 2 Environmental sediment matrix index

Environmental matrix	EROSION FACTORS						
(Sediment type)	*Wave, boat wash, and wind action*	*Site located on the inside of meander bend forming part of tidal creek system*	*Site located on the outside of meander bend forming part of tidal creek system*	*Water velocity in channel controlled by slope and nature of delivery mechanism*	*Water with high carrying capacity eg in tidal channel*	*Periodic drawdown of site – daily wet/dry cycles*	*Freeze/thaw activity*
Well graded gravels; gravel-sand mixture; little or no fines	1	1	1	1	1	1	1
Poorly graded gravels sand-gravel mixtures; little or no fines	1	1	2	1	1	1	1
Silty gravels; poorly graded gravel-sand-silt mixtures	1	1	2	2	2	1	2
Well graded sands; gravelly sands; little or no fines	2	1	2	2	2	2	1
Poorly graded sands; gravelly sands; little or no fines	2	1	2	2	2	2	2
Silty sands, poorly graded sand-silt mixtures	3	2	3	3	3	2	3
Clayey sands; poorly graded sand-clay mixtures	2	1	2	2	2	2	2
Inorganic silts and very fine sands; rock flour; silty or clayey fine sands with slight plasticity	3	2	3	3	3	3	3
Inorganic clays of low to medium plasticity; gravelly clays; sandy clays, silty clays	1	1	2	1	1	2	2
Organic silts and organic silt-clays of low plasticity	3	2	3	3	3	3	3
Inorganic silts, micaceous or diatomaceous fine sandy or silty soils; elastic silts	3	2	3	3	3	3	2
Inorganic clays of high plasticity	1	1	1	1	1	2	2
Organic clays of medium to high plasticity	3	1	1	2	1	3	3
Peat and other highly organic soils	3	2	3	3	3	3	3

Numerical weighting predictions courtesy of Bureau of Reclamation Engineering and Research Center, USA (Adapted from Lenihan, 1981)

1=minimum impact; 2=moderate impact; 3= maximum impact combined with local coastal geomorphology and coastal processes. Moreover, when considering local coastal responses to sea-level rise, the commonly cited adage that the past is a key to the future does not necessarily hold true, given the changes in the coastal zone brought about by land reclamation, urban expansion, and the construction of sea defences.

Table 3 Summary of impact processes

IMPACT PROCESS	MODIFICATION OF ARCHAEOLOGICAL RESOURCE
PHYSICAL	
Wave action – increased impact energies and shock pressures. Physical breakdown and removal (swash, backwash, drift aligned) of shoreface material	Exposure/extraction – damage, alteration, destruction
Current action – increased attrition and abrasion of shoreface material, primarily during erosion and transport of material ***Deposition*** of sediment will eventually occur	Exposure/extraction – damage, alteration, destruction, redeposit, loss of context Burial – protection
Suspended sediment deposition – increased rates of erosion will lead to increased rates of suspended sediment deposition either within the intertidal zone or offshore	Burial – protection
CHEMICAL	
Anaerobic conditions – generally associated with burial environments and tend to preserve organic artefacts ***Aerobic conditions*** – once exposed, aerobic macro- and microfauna, bacteria, and fungi rapidly attack organic remains leading to biodegradation. Metal artefacts will undergo oxidation leading to degradation	Preservation Exposure – damage, alteration, destruction
Water chemistry – controlling factors include: nutrient levels, pH and salinity leading to cell degradation and breakdown of organic artefacts	Exposure – damage, alteration, destruction
BIOLOGICAL	
Marine borers Molluscan – *Teredo, Bankia, Martesia* Crustacean – *Limnoria, Chelura* and *Sphaeroma* ***Fungi*** *Basidiomycetes, Merulius Lacrymans, Coniphera cerbella* ***Bacteria*** *Aeromonas, Pseudomonas, Acinetobacter*	Macro- and microfaunal activity tends to lead to biodegradation of organic material, with wooden structures particularly prone to cellulose and lignin breakdown

2.5.1 Holocene sea-level changes and coastal archaeology

The general pattern of vertical changes in sea-level in England is well known; spatial differences during the mid and late Holocene are largely a product of differential crustal movements due to the effects of ice unloading. However, our knowledge of the spatial response of England's coastline to these vertical changes in sea-level is poor. In particular, palaeogeographic reconstructions depicting shoreline movements during critical time periods for the Holocene have been produced for only one area, the Fenlands of East Anglia (Waller 1994). Consequently, the dynamics of coastal vegetation communities and sedimentary environments, and their relevance to human occupation and exploitation of the coastal zone, are not known for much of England's coastline. Future sea-level research must address this issue if we are to improve our understanding of the causes of and responses to shoreline movement throughout the Holocene. From an archaeological point of view, reconstructing the dynamics of different types of shoreline (low, medium, and high energy) is likely to reveal different types of interaction between human cultures and their coastal environments. Obtaining such data is in practice relatively straightforward; standard techniques of stratigraphic data collection combined with our existing knowledge of vertical sea-level changes can allow the identification and lateral tracing of coastal landscapes of different and definable ages over wide areas (eg Long and Innes 1995).

On a national basis, a key objective if we are to improve future predictions of sea-level rise is to develop our knowledge of vertical sea-level changes during the last 2000 years. Direct and proxy sea-level data are available, but there are few high-resolution investigations for this most recent time period (although see Allen and Rae 1988; Allen 1991). This is because there are few near-surface sediments which have not been disturbed by deep ploughing, surface sediment wastage, or the construction of extensive sea defences. For archaeologists and sea-level researchers, there is more to be gained from collaborative studies of the last 2000 years than for any other period in the Holocene.

2.5.2 The impacts of sea-level rise on England's coastal heritage

The impacts of sea-level rise and the options for management of coastal archaeology are now considered in the light of the above discussion. Chapters 8 and 9 contain a further discussion of some of these themes (and others). Managing a resource as diverse as England's coastal heritage requires information at national, regional, and local levels. Without such data, the classification, prioritisation, and protection of the coastline in the face of future sea-level rise cannot proceed coherently. Chapters 6 and 7 describe this information, but to contribute fully to an understanding of coastal protection in the future sites must be evaluated in two dimensions:

1 Spatial and chronological variability in the nature of England's coastal heritage

It is clearly not possible to protect all coastal archaeological sites from future sea-level rise, and the decision to protect a site or not will depend on its nature and the likelihood of its destruction. Consequently, the spatial and chronological distribution of different types of site as well as the nature of their accompanying coastal palaeoenvironments must be established. Furthermore, this record must take account of the history of human occupation, recognising that there tend to be specific chronological and spatial links between cultures and sea-level change.

2 Risk of destruction of coastal heritage sites

Not all coastal heritage sites will be detrimentally affected by future sea-level change; some may already be protected by natural or artificial sea defences and others may be protected by future changes in sediment supply. The sites identified in 1 above must therefore be assessed in terms of the threat from site-specific coastal processes in the face of future sea-level change. For example, classifying coastal erosion on a simple qualitative basis through inspection in the field and the use of historical sources (eg Smith forthcoming) will not provide the detailed information required to assess specific on-site process/response mechanisms; a more accurate way to do this may be through the adoption of a modified preservation/threat index similar to that employed by the Humber Wetlands Project (Van de Noort and Davies 1994) (discussed further in Chapter 9).

Similar indices have been developed for terrestrial archaeological sites, and it is worth considering alternative environmental scenarios where the impacts of physical, chemical, and biological processes overlap with coastal zone processes to some degree. Mathewson and Gonzalez (1988) have categorised site decay mechanisms and devised a site decay and preservation matrix that considers individual site type response to various physical, chemical, and biological impact mechanisms (Table 4). Burial response is qualified in terms of enhanced preservation, accelerated decay or neutral effects. With the exception of crystalline lithics, most archaeological material suffers accelerated decay in wet aerobic environments. The consideration of preservation potential in this way can be used to determine management response to site threat and the cost-effectiveness of excavation or burial preservation. Thus, if a site is to be buried the design plan of any burial works can incorporate burial strategies likely to enhance artefact preservation (see Mathewson and Gonzalez 1988, 525).

2.5.3 Artefact and site preservation following future sea-level change

As we have noted above, very little work has looked at the physical, chemical, and biological impacts of sea-level change on coastal archaeological material. Only the Wootton Quarr Project has explicitly sought to examine these processes. However, the Wootton survey has provided only a brief snapshot of the processes operating in the intertidal zone, and there is no information on the medium-term (ie decadal) impact of sea-level change on coastal archaeology. In addition, no-one has investigated medium and high energy coastal settings. The ideal conditions for assessing such medium-term impacts would be in a coastal zone where the coastal heritage has previously been surveyed in detail, but which has experienced coastal retreat or advance since the survey.

Research currently under way may cast some light on the rate and nature of the loss of the resource in the coastal zone. The MARS project (Monuments At Risk Survey; English Heritage in association with the RCHME), for example, seeks to assess the rate and nature of monument decay and to determine the effect of management strategies on different archaeological sites (Darvill and Wainwright 1994). Where MARS study areas cross the coastal zone, information about the impact of sea-level change and coastal management strategies on coastal archaeology may be assessed. The MARS project also complements the English Heritage Monuments Protection Programme (MPP) (Darvill and Wainwright 1994), and should help in directing MPP resources towards monuments and landscapes under threat.

An alternative approach to this problem is to re-examine coastal areas which have previously been studied under one of the wetland projects described above. For example, the Hullbridge Survey in Essex mapped the intertidal archaeological resource during the 1970s and 1980s, and this area has since experienced rapid coastal erosion. In addition, parts of the Blackwater Estuary are currently trial sites for the much discussed 'managed retreat' strategy of coastal management (Pethick 1993). Resurveying a number of sites identified by the original Hullbridge Survey would be an informative and cost-effective way of assessing the medium-term impact of sea-level rise on different types of archaeological resource, in an area experiencing both natural coastal retreat and managed retreat. Moreover, comparison of material removed during the survey with material which has remained in the intertidal zone might enable a further assessment of the type and rates of degradation which accompany sea-level change. The Wootton Quarr Project also provides an opportunity for assessing the impacts of sea-level change and coastal erosion on a monthly and annual basis, through the monitoring of different artefacts using high-precision surveying techniques.

Table 4 Archaeological component decay and preservation matrix

	ARCHAEOLOGICAL SITE COMPONENTS												
PROCESSES	Animal bones	Shell	Plants	Charcoal	Crystalline Lithics	Granular Lithics	Ceramics	Archaeo features	Soil attributes	Metals	Context	Isotope content	Topography
Acid environment	A	A	E	N	N	A	N	N	A	A	N	A	N
Basic environment	E	E	A	N	N	E	N	N	A	A	N	N	N
Dry (continuous)	E	E	E	E	N	E	N	N	N	E	N	E	N
Wet anaerobic (continuous)	E	E	E	A	A	A	A	A	A	A	N	A	A
Compression	A	A	A	A	N	N	A	A	A	N	A	N	A
Movement	N	N	N	A	N	N	N	A	A	N	A	N	A
Wet/dry	A	A	A	A	A	A	A	A	A	A	N	A	A
Micoorganisms	A	N	A	A	N	N	N	N	N	A	A	A	N
Macroorganisms	A	A	A	A	N	A	N	A	A	N	A	N	N
Wet aerobic	A	A	A	A	N	A	A	A	A	A	N	A	N
Freeze/thaw	A	A	A	A	A	A	A	A	A	N	A	A	A
Freeze	A	A	A	A	N	A	A	N	E	N	A	E	N
Thaw	N	N	N	N	N	A	N	N	A	N	A	A	N

E = enhanced preservation A = accelerated decay N = neutral or no effect

2.5.4 Protection strategies

Protection of archaeological material on dry land sites generally has limited environmental 'knock-on effects', and criteria already exist for determining whether such sites should be scheduled for protection or not. However, in the coastal zone a sedimentary body containing archaeological material is as much a part of the natural sedimentary dynamics of a coast as one which is archaeologically barren. In this situation, any attempt to protect the coastal heritage is likely to interfere with the natural processes operating in the coastal zone, and therefore potentially has extensive knock-on effects on adjacent coastal environments.

At present, cost-benefit analysis is routinely undertaken by coastal managers before deciding whether or not a coastal protection scheme should proceed. Almost inevitably, therefore, issues surrounding the management of England's coastal heritage will depend to varying degrees on the 'value' of different types of archaeological resource. Some may argue that the intrinsic value of England's coastal heritage is such that its assessment in monetary terms is inappropriate, and that it is meaningless to assign value to discrete units of a coastal system when that system can only be understood as an integrated entity. Moreover, it may be inappropriate to value on the same scale a range of individual sites, when the archaeological and landscape components of each site have differing contributions to make to our overall understanding of England's coastal heritage. However, it is clear that failure to attempt such an exercise may ultimately count against the case for protection. Turner *et al* (1994) argue that in the 'real world' of environmental economics, play-offs between different choices have to be made. Consequently, if we are to argue cogently for the preservation of England's coastal heritage, we must define both the 'value' of what is to be lost as well as the processes that threaten it.

3 A conceptual model for the archaeology of the English coastal zone

by J R L Allen

3.1 Introduction

As we have seen in Chapter 2, the coastal zone is a somewhat indefinite zone of land and sea that straddles the shoreline and includes the intertidal zone, that part of the sea-bed directly accessible from the land at low tide. In the coastal zone the natural resources of the land are combined with those of the shoreline itself and with those of at least the shallower and nearer parts of the sea. There is the potential for trade into and out of settlements located on the coast, together with related industrial developments.

Geologically, the coastal zone is a generally very dynamic environment, in a manner perceptible in many areas over a time-scale of decades and even years. The natural processes of sediment erosion, transport, and deposition bring about the horizontal displacement of the shoreline, either landward or seaward, together with the shoaling or deepening of bays and estuaries, and consequently may profoundly influence human activities in the coastal zone. The coastal zone, lying unprotected on the margins of the open sea, is also a harsher environment than the more sheltered hinterland, with its woods, heaths, and fields. Wind speeds are on the whole greatest in the coastal zone, and wind-driven salt spray can affect crops and vegetation for substantial distances inland from the shore.

Any conceptual model for the archaeology of the English coastal zone must be founded on the geological composition and structure of the zone, and on the processes, and particularly their rates and tendencies, that have most recently affected it. The character of the coastal zone as we see it now represents an integration of the consequences of many natural processes in action over a period of time. In some parts of the zone, the relevant period is to be measured at least in hundreds of thousands or even millions of years. In other parts, the time-scale reduces to thousands of years only.

It is useful to focus discussion on three principal cases:

Case 1 the retreating upland coast (paragraph 3.2)

Case 2 the advancing lowland coast (paragraph 3.3)

Case 3 the retreating lowland coast (paragraph 3.4)

The timescale relevant to the first of these ranges beyond the start of the Holocene and, in many instances, beyond the beginning of the Pleistocene. The Holocene is generally a sufficient frame for Cases 2 and 3.

Case 2 can be usefully subdivided on the basis of whether relative sea-level is moving upwards or downwards in the longer term. Although the above three cases will be examined separately, none can be considered or applied in strict isolation, since changes in external factors can force radical shifts in the response of the coastal zone and there are circumstances where one case may arise as a subset of another.

3.2 The retreating upland coast (Case 1)

The retreating upland coast is exemplified by a cliff cut in rocks of Pleistocene or earlier date which has a height above sea level, profile, and configuration determined by events that occurred over tens of thousands to millions of years. The cliff may vary in height from a mere 10–20m, as in parts of north-east England and East Anglia, to the towering edifices topped by steep, vegetated slopes of 300m or more found in Devon and Cornwall. At intervals along cliffs there are valleys and other low places where access to sea-level, although not necessarily settlement, is possible. The rate of retreat of cliffs in response to weathering and erosion is a function of the lithology and structure of the rocks that form them, and of the local wave-climate. The Palaeozoic rocks of England are in most places indurated, folded, and faulted; as a result, they are relatively strong and have a high resistance to marine erosion, affording cliffs that retreat under present conditions at an average rate of the order of a centimetre per year. The Mesozoic rocks are for the most part little deformed and only moderately lithified mudrocks, sandstones, and limestones. These beds at the coast create cliffs with a moderate resistance to erosion, retreating at a rate of the order of a decimetre per year. The clays and sands of Tertiary age, together with the tills and glaciofluvial gravels and sands which predominate in the Pleistocene sequence, are poorly lithified, with only a low resistance to marine erosion. Cliffs formed in these deposits can retreat at an average rate measured in metres annually.

Consider the distribution and fate of settlements of a single size introduced into a retreating upland coastal zone during a single cultural period (Fig 20). The 'first-line' settlements situated at or close to the shoreline at time t_0 draw heavily and possibly

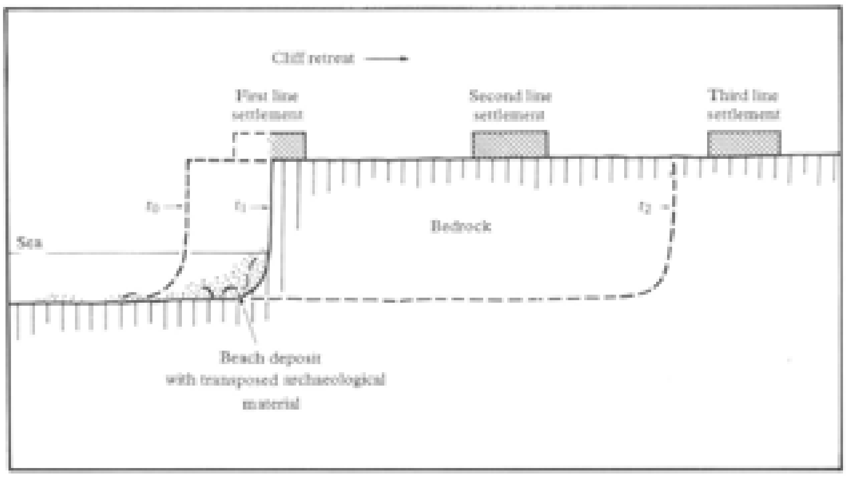


Fig 20 The response of settlements of a single period and size to different rates of cliff retreat at an upland coast. Schematic and not to scale

predominantly on the resources of the sea and shore. 'Second-line' settlements depend less on the sea, and settlements of the 'third line', lying well back from the coast, may rely exclusively on the immediately surrounding land. A small retreat of the cliff (time t_1) sees the destruction of the seaward part of a first-line settlement and the descent or transposition of archaeological deposits and structures to the foot of the cliff below. The loss of its seaward part means that the settlement itself has become diminished. At the foot of the cliff, the more durable of the transposed archaeological materials – masonry, pottery, bones and teeth from food preparation or burials, industrial residues, and the larger metal objects – become incorporated by tidal and wave action as 'archaeological pebbles' into whatever kind of beach deposit is accumulating there. These beach deposits vary from strews of boulders derived from the cliff above to spreads of gravel or sand, according to circumstances. Under the severest conditions, all of the transposed archaeological materials may experience a degree of longshore transport away from the immediate site of the settlement from which they originated. The retreat of the cliff to an even more inland position (time t_2) sees the transposition of a second-line as well as the first-line settlement. Consequently, a third-line settlement is displaced by the coastal movement into a potentially misleading juxtaposition with the shoreline.

What happens to an individual settlement depends on the area it covers, the distance to nearest neighbours of a similar size (generally increasing with size), and the rate of cliff retreat. Figure 21 is an attempt to show whether equal-sized settlements are likely to be diminished/transposed, transposed or displaced, as a function of settlement size and rate of cliff retreat. It is convenient here to describe a settlement as small if it is a single farmstead, a group of a few huts, or a minor to modest military installation occupying an area of the order of 0.25ha (50 x 50m). One of medium size, a small village or large encampment, would have an area of about 5ha (225 x 225m). A large settlement or town would take up an area of the order of 100ha (1000 x 1000m). We see from Figure 21 that diminution is likely to be the fate of large settlements on upland coasts with a low rate of retreat, whereas transposition and displacement will prevail where settlements are small and the rate of retreat is high.

A brief comment is appropriate on some of the patterns to be expected when settlements which are active during a single period are established on a retreating upland coast during each of a number of cultural periods, or where a site is occupied continuously through several periods. In the first case, and choosing small settlements for the purpose of illustration, sites of the later period 2 are interspersed with displaced settlements of the earlier period 1 (Fig 22a).

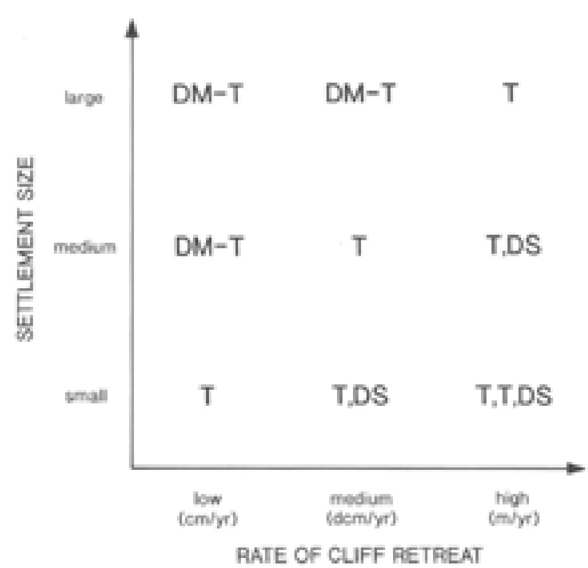


Fig 21 Response of settlements at an upland coast to cliff retreat. T – settlement wholly transposed into sea. DM-T – settlement partly diminished and partly transposed. DS – settlement displaced. A symbol such as T, T, DS records in sequence the effect of retreat on first-, second-, and third-line settlements

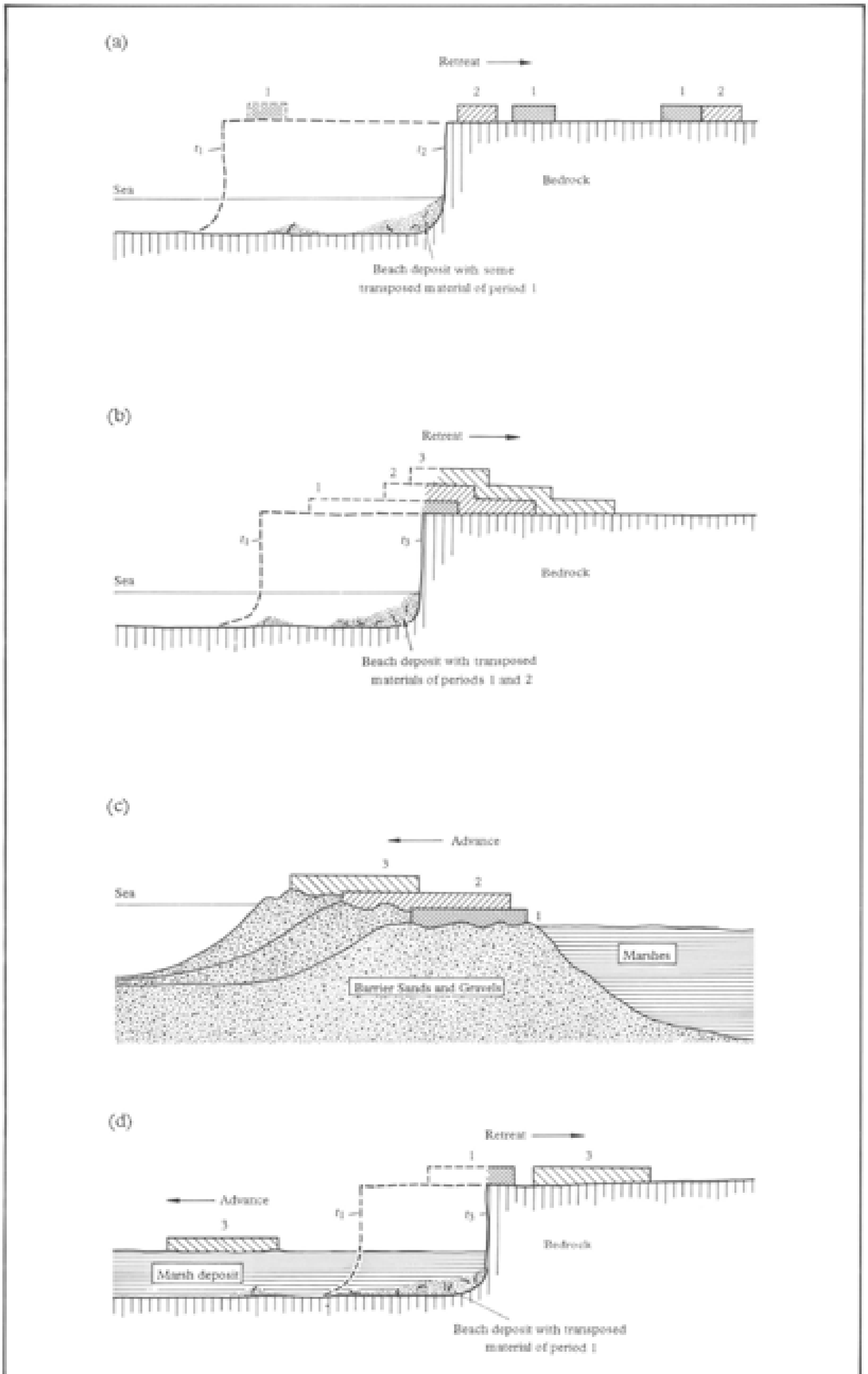


Fig 22 The response of settlements to coastal movement. Schematic and not to scale. (a) Interspersed settlements at a retreating upland coast, (b) landward overlap of settlements in a large, continuously occupied settlement at a retreating upland coast, (c) seaward overlap of settlements in a continuously occupied settlement at an advancing coast, and (d) settlements at a retreating upland followed by an advancing lowland coast

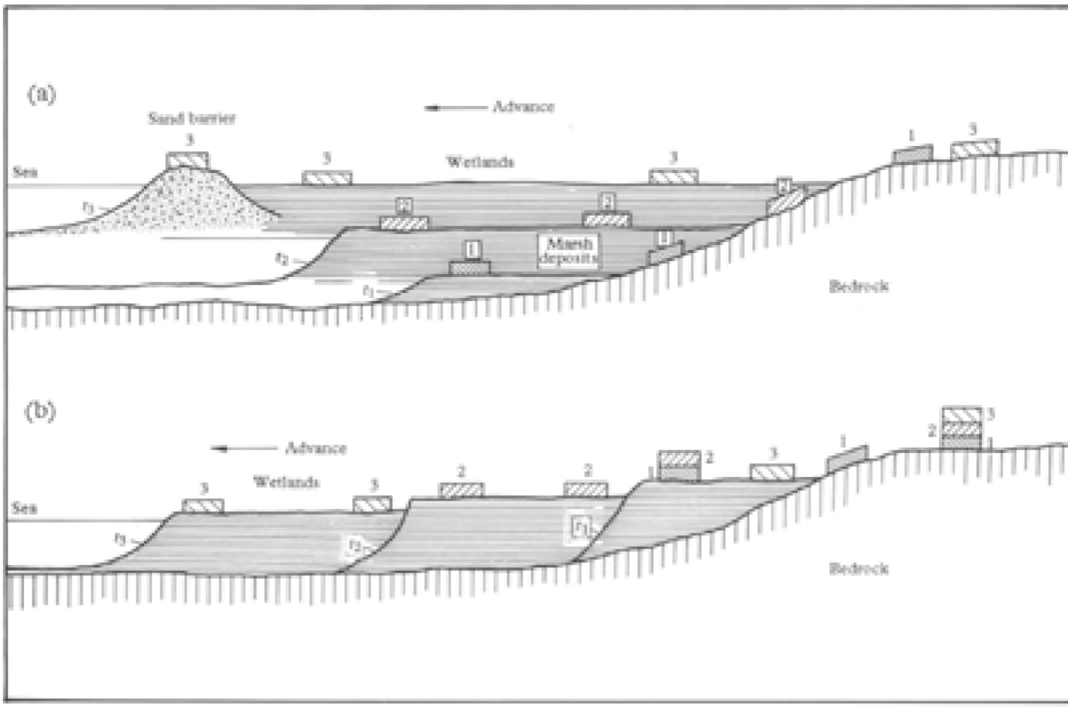


Fig 23 Settlement at an advancing lowland coast. Schematic and not to scale. (a) During a period of rising relative sea-level with abundant sediment supply; (b) during a period of falling relative sea-level with abundant sediment supply

The juxtaposed settlements of the two periods, because of cliff retreat, could have drawn on a substantially different balance of resources. Where there is continuous occupation over a number of successive periods at a coastal site (Fig 22b), we may see a regressive diminution and transposition of the sites on a period-by-period basis; that is, a landward overlap of the occupied areas and a consequent landward upward reduction in the date range of the archaeological deposit.

3.3 The advancing lowland coast (Case 2)

The sustained upward movement of relative sea-level, such as occurred in southern England during the Holocene, creates space which can be filled with sediment from rivers draining into the coastal zone, and from sea-floor scour and the erosion of marine cliffs. Where the sediment supply is sufficiently great, a lowland coastal zone will develop that advances seaward away from the coastal uplands. On the more exposed parts of the coast, this zone typically consists of intertidal flats and extensive tidal marshes protected by narrow bars, spits or barrier islands composed of gravel and/or sand. Where sand is available on an exposed shoreline, chains of wind-blown dunes may arise above tidal levels to cap the barrier islands, spits or bars. In areas which are more sheltered from wave activity, notably estuaries and tidal embayments, the shoreline is typically muddy, and very few or no barriers of coarser sediment develop between the sea and the tidal wetlands.

Although the long-term movement of relative sea-level is envisaged as upward, the character of the tidal marshes in an advancing lowland coastal zone is particularly sensitive to short-term fluctuations over a period of the order of 500–1000 years, such as seem to have occurred during the Holocene. These wetlands obtain sediment through tidal inundation (mineral supply) and from the growth of indigenous plants (organic supply). A temporary downward trend of relative sea-level reduces or even terminates the mineral supply, with the result that only the organic contribution remains and a peat can form. The peat may become rain-controlled or even stop growing and experience loss due to biological and chemical processes, if the downward movement of relative sea-level is sufficiently deep. An upward fluctuation, however, accentuates the tidally dependent supply of mineral sediment which, overwhelming the organic supply, creates a rapidly accreting, mineralogenic marsh. Fluctuations of relative sea-level superimposed on the general upward trend may therefore introduce significant 'pauses' into the vertical build-up of wetland sediments in the lowland coastal zone, without much affecting the outward movement of the shoreline. These fluctuations may also affect the systems of tidal creeks that provide an access to and from the marshes; a creek system may become blanketed by peat and destroyed during a downward movement of relative sea-level, only to be born again in a new configuration when upward movement recommences.

Figure 23a illustrates three stages in the settlement of a lowland coastal zone which is growing upward and outward under the impact of a rising relative sea-level.

Occupation can occur at any stage in the construction of the complex, but is most likely to take place, and to be permanent as opposed to occasional or seasonal, during the pauses identified above. Permanent settlement can occur during episodes when the external geological conditions would otherwise dictate seasonal occupation (relatively rapid sea-level rise) only if there is a parallel land-claim involving the erection and maintenance of flood defences. The main effect of the upward growth of the sediment complex is that the archaeological deposits are fully preserved (cf Case 1) but become progressively more deeply buried within a stratigraphy of non-archaeological origin. The settlements of period 1, with the exception of that established on the margins of the upland bordering the wetlands, represent temporary activities controlled by tidal and seasonal constraints. Although one of these lies well back from the shore, the activities there could have been wholly related to the sea if the chosen site had been the banks of a substantial tidal creek, features encountered in virtually all saltmarshes. Period 2, coinciding with a substantial pause in the build-up of the wetlands, saw permanent settlements and land-claim. Settlement occurred again (period 3) after a disadvantageous change in relative sea-level led to the sites of period 2 being abandoned and overwhelmed by tidal deposits. As with period 1, a settlement of period 2 on the margins of the uplands was eventually buried beneath wetland sediments.

The settlements depicted in Figure 23a are implicitly of small or medium size. Where a large settlement occupied through several periods occurs on an outward-building coast, an archaeological deposit exhibiting seaward overlap of settlement may arise (Fig 22c) in response to the movement of the shoreline (cf Fig 22b).

As in north-west England and the Scottish Borders since the mid Holocene, a descending, terrace-like flight of offlapping wetland and other coastal deposits can be expected in places where sediment is abundantly supplied to the coastal zone, and the long-term tendency of fluctuating relative sea-level is downward (Fig 23b). In contrast to the previous case, there is no longer the risk in this advancing lowland coastal zone that archaeological deposits will become buried more deeply than normal for 'dry land' sites. One-period settlements introduced over a number of periods into such an environment may be expected to display interspersion and displacement, but in a different manner to Case 1 (Fig 20). First-line settlements of periods 1 and 2, established at contemporaneous shorelines, lie well inland from the coast by period 3. If there was continuous occupation during a number of periods, a significant change of resources and activities over time may be expected. Traversing the area from the original uplands to the sea in period 3, the occupation sites may be expected to exhibit an upward reduction in overall date range.

Changes in marine circulation and in the availability of sediment can occur in such a way as to permit an advancing lowland coast to replace a retreating upland one (Fig 22d). These circumstances provide the best chance for the long-term burial and preservation in beach sediments of archaeological materials transposed from partly or wholly destroyed settlements established earlier on the uplands.

3.4 The retreating lowland coast (Case 3)

Here we need consider only the effects of upward movements of relative sea-level. Where there is little sediment available, the shore will retreat across a gently sloping bedrock plain, leading to settlements established there being abandoned and becoming either intertidal or submerged (subtidal) (Fig 24a). No more than thin and incomplete burial of archaeological structures and materials need be expected, but some dispersion of occupation debris away from sites by wave and tidal currents is likely on the more exposed coasts. Note how longer-lasting settlements with progressively younger additions appear, as the former land surface is ascended inland. Note also that the first-line settlement of period 3, drawing its resources largely from the sea, is associated with sites of the earlier periods 1 and 2 established well inland of the coasts at the time.

Even under conditions of upward-moving relative sea-level, the regime of a lowland coast can change from advance to retreat for a lengthy period. The archaeological consequences of such a change are in many respects the same as with the retreating upland coast (Case 1) except that, because the regressing coastal zone is now at sea-level, the burial as well as the diminution and transposition of settlement sites can arise (Fig 24b). In the situation illustrated, the settlements of period 1 were established after land-claim of part of the wetlands. The retreat of the coast caused the destruction of the flood defences and the abandonment of these sites, which were either transposed into the intertidal zone or became buried under new deposits of silt under the influence of the rising sea. Stratigraphically, the wetland sequence within the area of land-claim includes a buried soil, marking the surface of the marsh which was stabilised as the result of the construction of the flood defences. Should the retreat continue, the innermost settlement of period 1 could become exhumed in the intertidal zone, in addition to that of period 2 being transposed.

3.5 Aeolian effects

In the exposed environment of the coastal zone, the wind can be a potent agent of sediment transport when climatic conditions change appropriately, carrying sand inland for several kilometres away from the

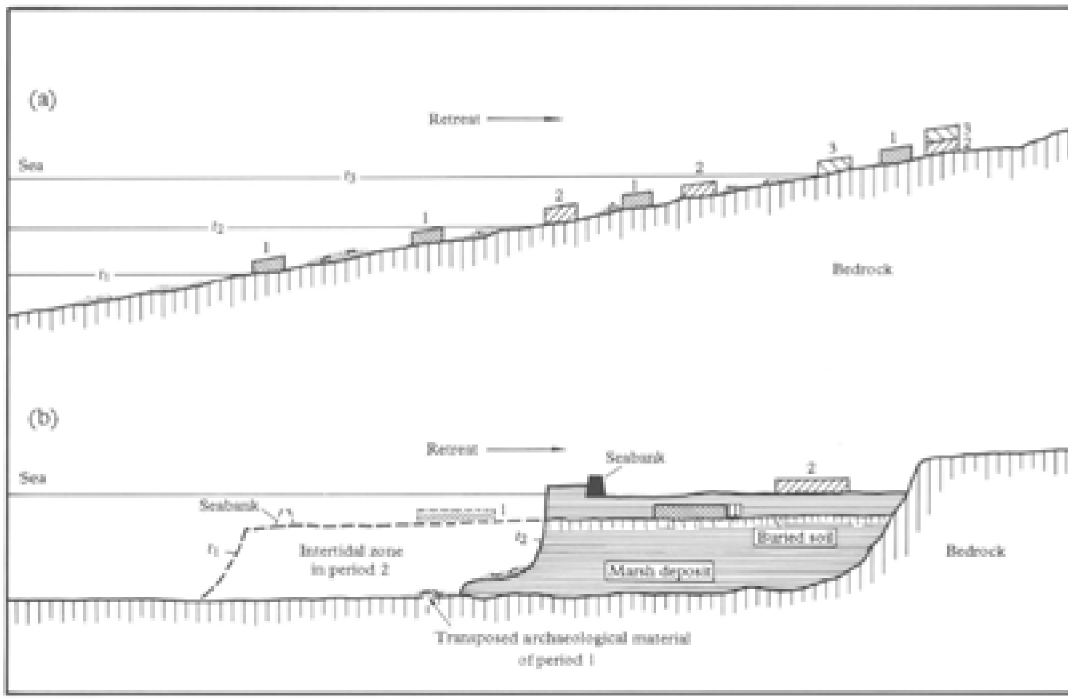


Fig 24 Settlement at a coastline retreating during a period of rising relative sea-level. Schematic and not to scale. (a) Landward migration of settlements of three periods when there is little sediment supplied and (b) the effect of retreat on a lowland coast subject to landclaim

open shore. Chains of tall dunes develop closest to the coast, giving way at a greater distance to rolling mounds and sheets of sand. The presence of a sandy shore is a necessary condition for the formation of these spreads of wind-blown sand. Blown sand can occur on the more exposed lowland coasts, as well as inland from bays and the mouths of valleys on upland shores. The wind as a transporting agent does not depend on gravity, so that blown sand can be found on uplands lying tens of metres above sea-level. Lengthy periods of sand blow can lead to the partial or complete burial of settlements situated at or near the coastline. The repetition of the circumstances favouring sand blow can permit the preservation of settlements and related activities of a number of periods.

4 Environmental archaeology in the coastal zone

by M Bell

4.1 History of research

Evidence for past landscapes and environmental change exposed on the foreshore has long excited interest and curiosity. Gerald of Wales (*c* 1191: 1908 edition) records a storm at Newgale, Wales in 1172 which exposed a forest submerged, perhaps, he speculated, by Noah's flood. During the eighteenth and nineteenth centuries many submerged forests were noted by those with a geological or antiquarian interest (Fig 25); early observers include Borlase (1758) at Mounts Bay, and Joseph Banks who visited submerged forests in Lincolnshire in 1796 (Robinson 1984). Nineteenth-century fascination with these finds was linked with an interest in the antiquity of man and the geological occurrence of extinct animals (see Boyd Dawkins 1872; Lucy 1877). As observations accumulated some of the sites were dated to prehistoric periods, for instance by the discovery of a Neolithic axe at Hunstanton (Smith 1919). The Cromer forest beds were clearly of much earlier date, having exotic assemblages of extinct animals and plants (Lyell 1885, 157).

Chance coastal exposures by storms were supplemented during the later nineteenth century by observations during major engineering projects. Submerged forests, some associated with faunal material, were noted during construction of docks at Portsmouth in 1847 (Codrington 1869), Hull and Grimsby (Wood and Rome 1868; Hawkshaw 1871), the Gloucester and Berkeley Canal (Lucy 1872), Boston, Lincolnshire in 1882–4 (Robinson 1984), Southampton Docks (Shore and Elwes 1889), Heysham (Reid 1913, 50), and Liverpool and Wallasey (Morton 1891). Comparable evidence was recorded during tin streaming in Cornish estuaries (Johnson and David 1982).

Reid (1913) reviewed the evidence for submerged forests in a work that shows some confusion about how the deposits formed, advocating a theory of sinking land between 3000 and 1600 BC which contrasts with the presently accepted model of Flandrian sea-level rise (Chapter 2). Nonetheless his preface highlights the interdisciplinary significance of these sites. Much of what had been done, he argued, was from a geological perspective, whereas 'the deposits should be examined bed by bed, nothing should be overlooked, whether it belongs to geology, archaeology, or natural history' (Reid 1913, 10).

By comparison with the wealth of nineteenth-century references, those of the later twentieth century are less numerous and confined to a few areas where more detailed work has been done. To some extent this probably reflects a move away from the polymathic scientific interest of the amateur to the more specialised and narrowly demarcated academic disciplines of archaeology, geology, and zoology, etc, to which these curious intertidal sites may not have appeared so directly relevant as they did in the last century. Many coastal sites, being exposed only episodically, are less likely to be recorded by the professional than by the scientifically curious local person who is able to go

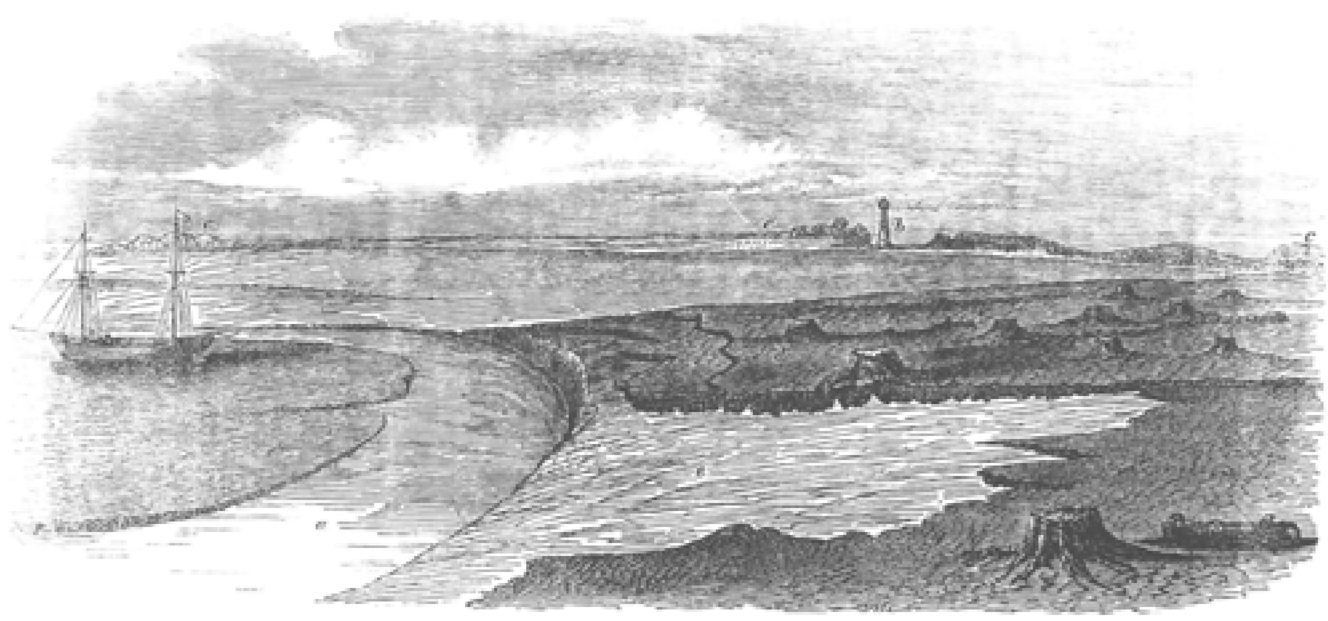


Fig 25 Submerged forest at the mouth of the river Alt (de Rance 1877, fig 18)

frequently into the field and observe the results of exceptional natural events. This may partly explain why the intertidal sites have not received the archaeological emphasis which the nineteenth-century records, and recent discoveries, suggest they deserve. Twentieth-century interest has focused particularly on vegetation history, Quaternary studies (Godwin 1943), and sea-level change (Chapter 2).

4.2 Coastal change: general models

The coastal zone is an environment of ecological contrasts and dynamism reflecting the interplay of fluctuating terrestrial and maritime influences. Spatially there are the ecological contrasts, seen in a transect moving from open sea to dry land which might include the following:
sea→mudflats→saltmarsh→reed swamp→sedge fen→fen carr→raised bog→transitional woodland→dry land.
That sequence is basically as reconstructed for the Fenland (Hall and Coles 1994, fig 12) with the addition of the raised bog stage, which is represented during some periods in coastal wetlands such as the Somerset Levels and Severn Estuary.

Temporally the extent of these various zones would have varied greatly depending on the degree of marine influence, and on factors such as plant colonisation and succession, local hydrology, etc. Far from representing static and stable systems, coasts are characterised by constant change on many intersecting and overlapping timescales. In the short term we have the regular cyclical and predictable changes of the tidal cycle, with its twice-daily inundations, fortnightly spring tides, and cyclical variations in spring tide level during the year (see Bell 1990, fig 160 for a Severn Estuary example). Then there are longer-term changes, such as sea-level change related, for instance, to climate change. In addition to predictable and gradual changes there are events such as storm surges arising from particular conjunctions of weather patterns and tidal factors. Coastal barriers in the form of shingle or sand bars, often both, will have developed and grown over long periods as a result of longshore drift and deflation from the intertidal area. Individual storms may, depending on conditions of wind, tide, etc, enhance a barrier or sweep parts of it away, leading to dramatic inundation of wetlands behind. Many coastal changes must have occurred as a result of just such high-intensity and low-frequency events. Even gradual trends must often have registered on the human perception in the form of sequences of specific events such as storm inundations.

Certain coastal changes will reflect geographically widespread changes, others more local events on various spatial and temporal scales. Establishing the relative significance of global, regional, and local signals in the pattern of coastal environmental change is an important aspect of the research agenda, which will be advanced by increasingly precise dating of more sequences. Notwithstanding the inherently local nature of many changes, it would seem worthwhile to outline a very general model of Holocene coastal change. This is based partly on the specific case of the Severn Estuary (eg Allen and Rae 1987), some aspects of which may prove more widely applicable, while others may reflect the particular circumstances of that estuary.

Stage O At the base of the sequence is solid geology. This may be mantled locally by Quaternary sediments which sometimes contain biological evidence of interglacial or glacial environments.

Stage A In the early Holocene, before sea-level encroachment at specific altitudes, dry land soils formed on top of the sediments.

Stage B With the Holocene sea-level rise (Chapter 2), these soils became waterlogged and organic material began to form on their surface, representing the basal Holocene peat. This is diachronous, that is to say the date of its formation on one continuous sloping surface varies according to OD height.

Stage C Organic accumulation was overtaken by sea-level rise, resulting in a transition from organic to mineralogenic sediments, substantial thicknesses of which were deposited during the Mesolithic. Within the upper part of these mineralogenic sediments in particular, thin peat bands represent episodes of reduced marine influence and/or reduced mineralogenic sedimentation.

Stage D With a reduction in the rate of sea-level rise, by the later Mesolithic such peats formed extensively, initially as reed peats, then as fen woodland, leading ultimately to the development of raised bogs in the inner margins of some wetlands. The Severn Estuary has produced evidence for extensive peat formation between *c* 5000–600 cal BC. Peat formation was occasionally interrupted by the deposition of mineralogenic bands.

A further consequence of the reduced rate of sea-level rise after about *c* 5000 cal BC is likely to have been the increasing formation and growth of coastal dune or shingle barriers, which insulated many estuaries and bays from the direct influence of marine conditions to an extent which varied according to episodic barrier breaching and reformation.

Stage E Peat growth was halted in much of the Severn Estuary, Somerset Levels, and Fenland by renewed mineralogenic sedimentation under marine conditions around *c* 600 cal BC. Elsewhere deposition of mineralogenic sediments probably occurred at various dates as a result of both freshwater and marine inundation.

Stage F Reclamation, drainage, and the construction of sea defences. Reclamation apparently first occurred in the Roman period (Chapter 6). In some areas there is evidence that reclamation was interrupted by subsequent phases of marine inundation.

The identification of broad trends in this model is not intended to play down the significance of the many transgressive and regressive episodes represented at a wide variety of dates in many areas. Tooley (1978a) has, for instance, identified ten transgressive phases in the north-west, where he associated them with sea-level change and suggested that they were coeval with transgressions in other parts of the British Isles.

4.3 Coastal change: spatial manifestations

The extent of coastal environmental change during the Holocene is illustrated by peats exposed in the intertidal area and below low water. Inland, marine conditions extended over most of the areas now covered by coastal alluvium and lowland peats (Fig 26). The extent of these areas, formerly under marine influence and now alluviated, is particularly great in the East Anglian Fenland, the Somerset Levels, and the major estuaries, particularly the Humber, the Thames, and the Severn. Before Holocene alluviation, marine influence also extended up the lower courses of many smaller river valleys, for instance the Sussex rivers Ouse and Adur. In Essex, Iron Age and Romano-British saltworking sites mark the former extent of marine influence and are now well inland (Fawn *et al* 1990, map 1).

The period of maximum marine influence, Stage C, occurred in many areas of southern Britain in the later Mesolithic and Neolithic. Holocene sea-level had risen to within about 5m of its present level, but major alluviation had not yet occurred in recently flooded coastal valleys and lowlands. In the Somerset Levels, Kidson, and Heyworth (1976) established that maximum marine influence occurred *c* 4900 cal BC. Later in the Holocene marine conditions extended almost as far inland during phases of marine transgressive tendency, particularly Stage E.

Marine sedimentation and alluviation in the later Holocene have converted the complex indented coast (indicated by shading on Fig 26) to the smoother outlines of today's coast. This has been further reinforced from Romano-British times onwards by the construction of stabilising sea-walls and drainage works. What was in many of the shaded areas a very broad zone across which marine influence extended at various stages in the tidal cycle, has been converted into a narrower coastal band. As a result a great complexity of ecological niches and ecotones (transitional zones between ecosystems), each with its own resources for exploitation, has often been very greatly reduced in extent.

Research relating to past human activity in the coastal zone must necessarily consider the whole zone across which coastal conditions have fluctuated during those parts of the Quaternary when people were present. Those portions of the Holocene sequence which happen, at the moment, to be revealed by erosion in the intertidal zone are, in a sense, random transects across a spatially much more extensive and in principle equally rich resource. Discoveries made in the entire area of former marine influence are therefore in a general sense relevant when it comes to establishing the potential for long-term coastal discoveries. Thus, in the Humber Estuary, where marine sediments were deposited well inland up each of the valleys, palaeoenvironmental evidence from prehistoric boats at Brigg and Hasholme is relevant in helping to establish the palaeoenvironmental potential of coastal contexts.

Examples of changes associated with the formation and episodic breaching of shingle and sand spits are found at Hartlepool Bay (Tooley 1978b), Orford Ness, Suffolk, and Spurn Head at the mouth of the Humber. The growth of shingle barriers at Dungeness eventually transformed a former Holocene bay into the present promontory some 18km from the former cliff line (Cunliffe 1980). Even greater coastal changes are documented in the Scilly Isles, where Thomas (1985) argues that most of the islands formed part of a single landmass until the inundation of the central area, apparently in post-Roman times. This hypothesis is currently being tested by radiocarbon dating and levelling of intertidal peats (Ratcliffe and Sharpe 1991).

4.4 Human environments: resources

The environmental changes described would have created contrasting sets of opportunities for human activity. Stage A essentially offered the resources of normal dry wildwood for hunting, raw materials, and possibilities for early agriculture, albeit enhanced by the gradually encroaching marine resources. The peat stages (Stages B and D) are likely to have reflected a much greater diversity and concentration of resources, which would vary considerably in terms of the raw materials, hunting and fishing, and grazing opportunities offered by reed swamp, fen woodland, and raised bog. Environmental evidence shows that the peat surface was relatively dry, sufficiently so on occasion to allow settlement on it, albeit probably seasonal, in the Severn Estuary. Phases dominated by minerallogenic sedimentation (Stages C and E) would offer a more restricted resource base, chiefly fishing, fowling, and some seasonal grazing at the margins. Present evidence suggests that only with the

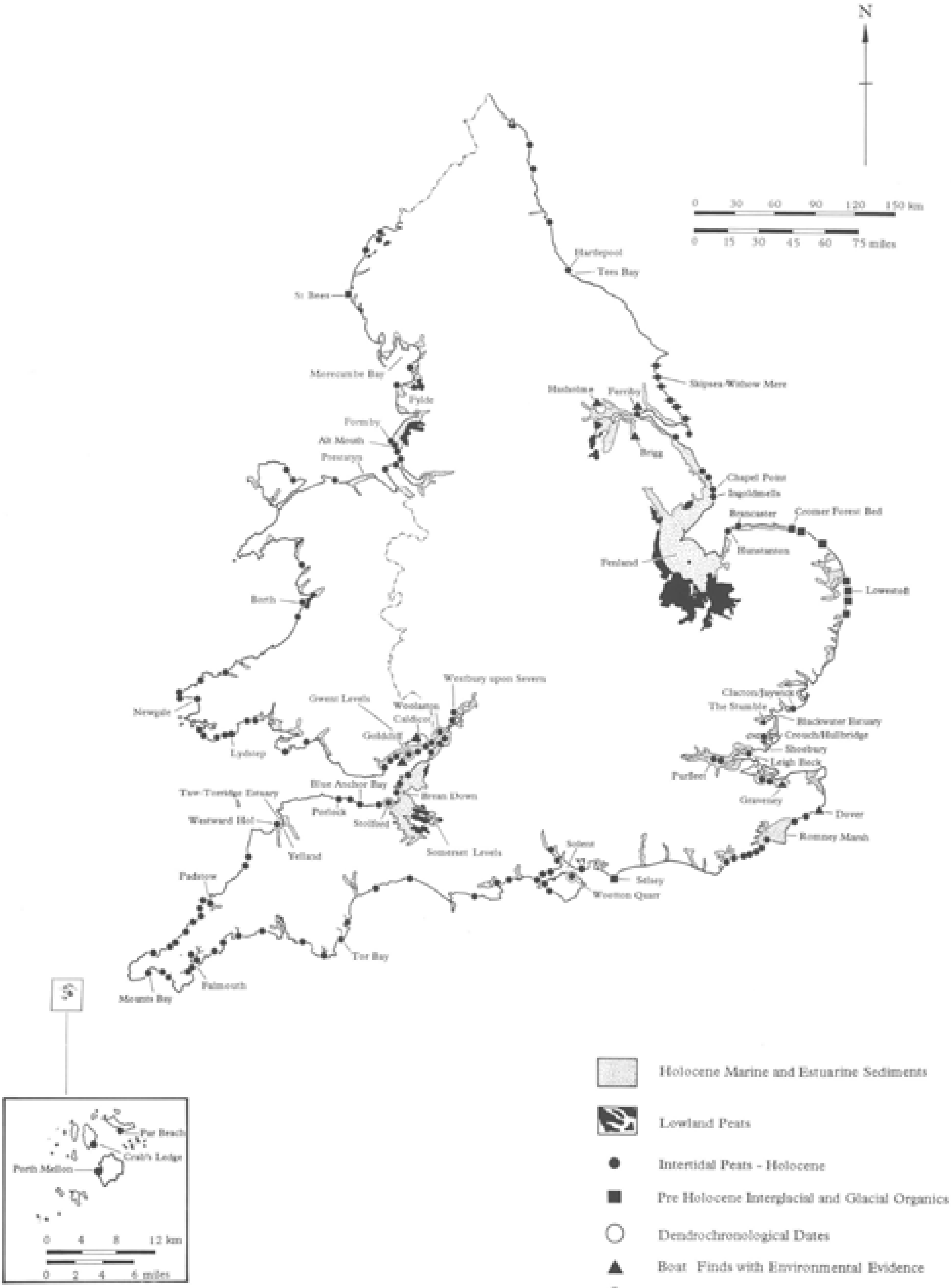


Fig 26 The English and Welsh coastal zone showing the distribution of intertidal peat sites and coastal sedimentation

drainage and reclamation of coastal levels in Roman and later times did human communities succeed in insulating themselves to some degree from the effects of coastal change, thereafter pursuing a wide range of agricultural and craft activities in former coastal wetland on a year-round basis.

4.5 Human environments: theoretical perspectives

The existence of resources, however, does not allow us to infer that they were used. Resources, like environments and hazards, are defined in relation to a subject; some may be favoured, others eschewed, for no very obvious reason. This is one of several possible explanations for a relative paucity of fish bones on some coastal prehistoric sites. It is also likely that there are non-functional explanations for many coastal archaeological sites; these were often wild and wet places of the kind favoured for ritual and symbolic deposition in many prehistoric periods.

Archaeological discussion of coastal wetlands has sometimes had a somewhat deterministic emphasis. Recent work in the Netherlands (Brandt and van der Leeuw 1987; Abbink 1986) has highlighted the value of giving equal consideration to both social and environmental factors in considering the explanation for individual changes or events. Trackway construction in the Somerset Levels and elsewhere is often shown by environmental evidence to be a response to wetter conditions. One way of looking at it, therefore, is as human action determined by an environmental change. More relevant, perhaps, in terms of understanding people's relationship with nature, might be an interpretation which viewed trackway construction as a coping strategy by which people altered nature to maintain existing networks of social communication despite significant environmental changes. This emphasis on social communication gains a measure of support from the deposition of exotic items, such as axes of jadeite and flint, in association with the Sweet Track (Coles and Coles 1986).

Prehistoric communities would have been well aware of the constant changes occurring in coastal environments. To varying extents their ways of life are likely to have been adapted accordingly. Some changes are short-term and predictable, such as the tidal cycle; others much more long-term or episodic. Knowledge about episodic changes is likely to have varied according to the timescale of their recurrence, and the time and spatial scales of a community's environmental knowledge, which would relate for instance to the social mechanisms for the communication of knowledge between groups and generations. None of these issues is straightforward, given the nature of archaeological evidence, but in favourable contexts it should be possible to make some progress. The recurrence interval of events of given magnitude is most straightforward and can be obtained from a well dated sequence. Spatial scales of human environmental knowledge might be inferred from communication routes, such as trackways and artefact distributions, and chronological scales of knowledge, perhaps, from continuities of material culture and land use. Although clearly difficult, such objectives may be more realisable in the coastal zone and other wetlands with a high quality palaeoenvironmental and archaeological record, as well as the potential for precise dendrochronological dating to provide timescales for change which are relevant in terms of human perception and decision-making.

Such research needs to be informed by the historical record of more recent people/environment relationships in the coastal zone, by hazards research, and by an understanding of human perception of environmental changes. This would help to engender a more broadly based multiple working hypothesis approach which should help to identify, and thus to evaluate, a greater range of possible human reactions to, and interactions with, coastal change than has generally been the case.

Part of the inevitable paradox of archaeology is that, as our technical capacity to reconstruct the past increases, so we become more remote from the perceptions and concerns of the past communities we are studying. This applies particularly strongly in the coastal zone where, in the last two millennia, people have increasingly insulated themselves from the effects of episodic change by drainage and the construction of sea-walls. The fact that this seems to have happened about a millennium earlier in Britain than it did in the part of the Netherlands which lay to the north of the Roman world emphasises the importance of social factors and the scale of social organisation. Once sea-walls were in place, communities were largely insulated from the effects of predictable and minor events and could carry out a much wider range of activities in low-lying coastal areas. They then, however, became vulnerable to the effects of rare events such as the 1606 floods in the Severn Estuary (Boon 1980) or those of 1953 on the east coast (Steers 1971). With time, people acquire an understanding of the frequency of events which can demonstrate that a given specific reclamation is not viable in the long term, or at least under existing economic conditions. Recent examples are Pagham Harbour, reclaimed in 1876 but inundated and abandoned in 1910 (Robinson and Williams 1983), an event which historical sources suggest was the most recent of a series of attempted reclamations and subsequent inundations (Cavis-Brown 1910). Similarly, attempts on the north Norfolk coast to reclaim and farm Lodge Marsh had subsequently to be abandoned (Jefferies 1976).

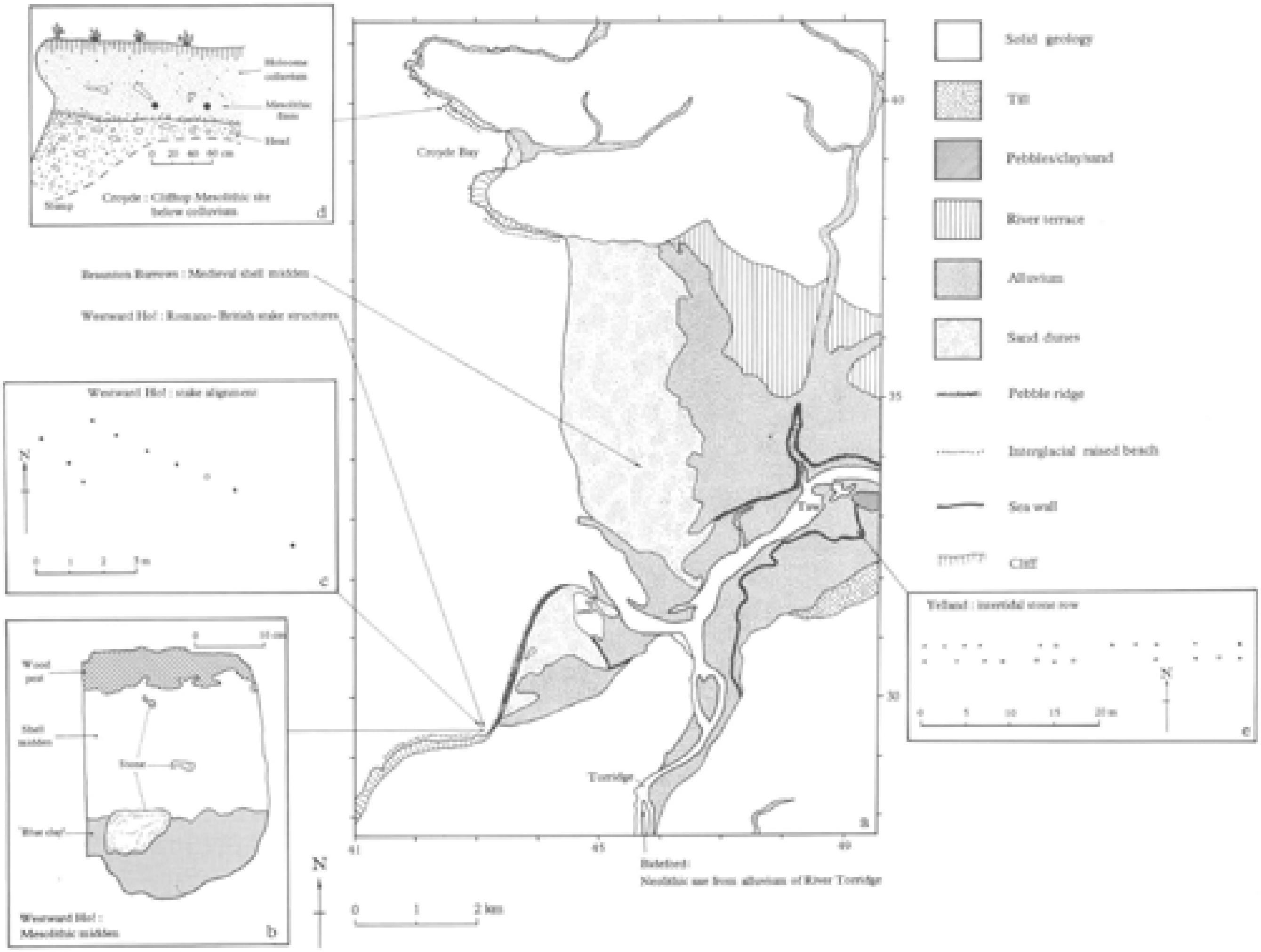


Fig 27 The Taw-Torridge Estuary in Devon as a case study of the coastal contexts in which palaeoenvironmental and archaeological evidence may be preserved: (a) Quaternary sediments (after Geological Survey Sheet 292); (b) Westward Ho!, section of Mesolithic midden; (c) Westward Ho!, plan of stake alignment on peat surface (b and c after Balaam et al *1987a); (d) Croyde, sketch section of clifftop colluvial deposit over head; (e) Yelland, intertidal stone row (after Grinsell 1970)*

4.6 The geography of preservation and research

This section outlines some of the main contexts in which palaeoenvironmental evidence may be preserved in the coastal zone. Some contexts are exemplified by reference to the specific case of the Taw-Torridge Estuary in Devon (Fig 27). In the sections below on contexts and sources, the main emphasis is on the palaeoenvironmental resource as revealed in foreshore and cliff exposures in England; however, some use will be made of evidence of former coastal environments which are now inland in sedimented valleys and estuaries, and there is also some reference to evidence from Wales which helps to establish the potential of individual contexts.

4.6.1 Cliff exposures

Coastal erosion may reveal good sections through environments of deposition containing sequences of sedimentary or biological evidence, some of which did not originally form as a result of coastal processes. Cliff exposures are important sources of pre-Holocene deposits, as exemplified by the valley fill with Acheulian handaxes and some fauna at Doniford, Somerset (Wedlake and Wedlake 1963; Gilbertson and Mottershead 1975). Interglacial raised beaches are present in many areas; the Taw-Torridge Estuary, for instance, is flanked by fine examples (Fig 27), some of which are overlain by early Devensian dunes, then head, and at Croyde a truncated soil with Mesolithic artefacts overlain by Holocene colluvium (Fig 27d).

Some cliff and foreshore exposures reveal pre-Holocene organic deposits (Fig 26). The main concentration is in the Cromer Forest Bed and associated deposits in East Anglia. These are of Lower and Middle Pleistocene date; they lack archaeology, but have been the subject of extensive palaeoenvironmental study (summarised in Jones and Keen 1992). Other examples are the Ipswichian interglacial deposits at Selsey (West and Sparks 1960), Devensian organic sediments on the Isles of Scilly (Scourse 1991), and the fill of a late glacial hollow with Coleoptera at St Bees in Cumbria (Coope 1994). The earliest deposits in Skipsea-Withow Mere are also of late glacial date. These deposits and others at Hornsea and Grimston formed in lakes or meres occupying kettle holes in till. The Skipsea-Withow example has revealed some archaeology and an important palaeoenvironmental sequence from the late glacial period until recent times (Gilbertson 1984). Earlier discoveries of lake dwellings and pile structures in inland meres (Van de Noort and Davies 1993; Varley 1968) highlight the need to monitor the rapidly eroding coastal exposures of Holderness.

4.6.2 Intertidal environmental contexts

The distribution of coastal peats and other types of coastal sedimentary context round the coast of England and Wales is shown in Fig 26. In all there are about 114 documented intertidal and cliff exposure peat sites in England, of which at least 9 are pre-Holocene and the remainder are apparently Holocene. Wales has at least a further 27 Holocene sites. The greatest concentration of documented examples is in the Severn Estuary, followed by Cornwall, with other concentrations in Merseyside, the Solent, East Sussex, and Holderness.

An idealised section showing some typical relationships between the main sediment types is shown in Figure 28 which is based partly on profiles derived from Bridgwater Bay (Kidson and Heyworth 1976, fig 5), south-west Lancashire (Tooley 1978a, fig 14) and Lincolnshire (Swinnerton and Kent 1976, fig 20).

The earliest contexts in many areas are dry land sites (Stage A; see section 4.2 above) which have been buried by marine sediments. Mesolithic to Beaker intertidal sites tend to be of this type in Essex, exemplified by the Neolithic palaeosol at the Stumble (Wilkinson and Murphy 1986). Because they are sealed, such sites are better preserved and more profitable contexts for palaeoenvironmental studies than the truncated sites on inland gravel terraces (Murphy 1988) (see also this volume, Chapter 6). The contribution of the intertidal area to the preservation of archaeology is highlighted by the Yelland stone row (Fig 27e), which is associated with an old land surface with a Mesolithic to Bronze Age lithic scatter (Grinsell 1970; Rogers 1946). Stone rows are generally found on moorland and often owe their preservation, at least partly, to upland peat formation. But this example is below high tide level in another form of relict landscape created by marine inundation. This serves to remind us of the gaps in the archaeological record at intermediate altitudes where land has been enclosed and intensively farmed for millennia, with the result that monument survival is poor.

The basal peat of Holocene stratigraphies often mantles the weathered surface or soil developed on pre-Holocene geology (see Stage B, above). The peat tends to be diachronous and reflects organic preservation by rising sea-level; generally, the higher the level, the later its date. The growth of this basal peat was often overtaken by continuing sea-level rise, and it

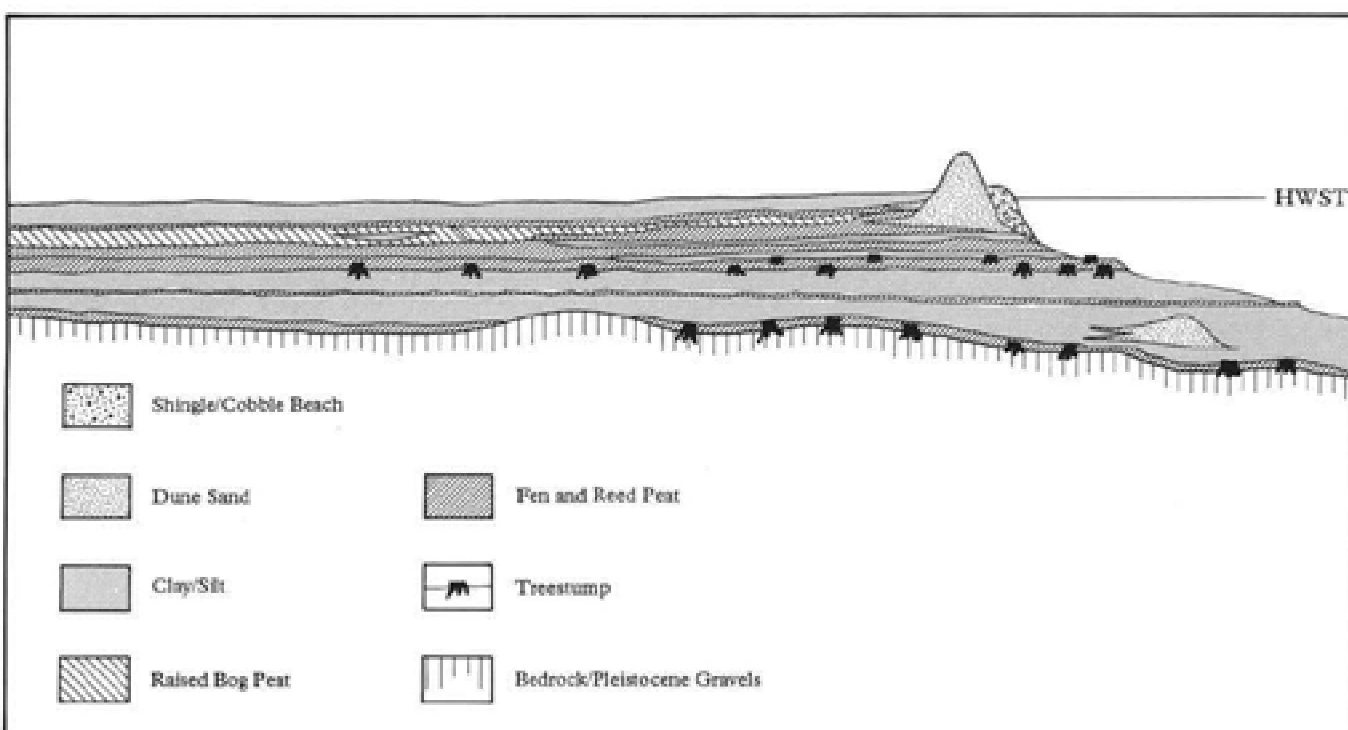


Fig 28 An idealised transect through a coastline of Holocene sedimentation showing typical relationships between the main types of deposit

became buried by marine clays (Stage C, above). Thereafter, sites often show a number of marine regressive phases when mineral sedimentation was reduced and peat-forming plant communities colonised the area (for further discussion of mineral/organic transitions and *vice versa*, see Chapter 3, above). This transition is one which is associated with evidence for human activity on a number of sites, for instance Westward Ho! (Figs 27 and 29; Balaam *et al* 1987b) and Hartlepool (Trechmann 1936). At Purfleet, Essex, mineral sedimentation declined between about 3700–2400 cal BC, and weathering and some soil development took place (Wilkinson and Murphy 1995). Neolithic activity on this surface was associated with dry woodland; the site subsequently became wetter and peat formation occurred.

Peats relate to various stages in a hypothetical succession from reed swamp through fen woodland in some cases to raised bog. Successions were halted or put back to an earlier stage by increased marine influence or freshwater flooding. Heyworth (1978) demonstrates that the submerged forests in southern Britain date from the period *c* 5500–600 cal BC. However, north of about Morecambe Bay and Tees Bay, the effects of glacio-hydro-isostatic uplift have been considerable, with the result that earlier submerged forests dating between *c* 7400 and 5700 cal BC are today exposed in the intertidal area.

Under erosion, peat outcrops prove more resistant than intervening mineralogenic sediments and form shelves ending seaward in low cliffs (Fig 30). Peats are particularly productive contexts for archaeological structures and palaeoenvironmental evidence, as shown by work at Westward Ho! (Figs 27 and 29; Balaam *et al* 1987b) and Goldcliff, Wales (Bell 1993a) (below, Fig 37). Detailed stratigraphic work and coring will often be necessary to establish whether exposed peats represent a full original sequence or the truncated base of an eroded sequence, as hypothesised for instance at Crab's Ledge, Tresco (Ratcliffe 1993).

Mineralogenic clays and silts representing periods of saltmarsh formation and episodes of marine transgression do not have the self-evident palaeoenvironmental potential of peats. They may, however, preserve a comparable range of waterlogged biological evidence of considerable value in interpreting associated archaeology, which often relates to foreshore activities such as hunting, fowling, fishing, and boatworking.

The alternating coastal sequences of peats and mineralogenic deposits have been attributed to a range of factors. Tooley (1978a) favours fluctuations in sea-level. Comparable sequences could result when sediment built up to a level at which inundation was infrequent and a surface became vegetated, later to be inundated by continuing sea-level rise. Likewise, the formation and breaching of coastal barriers has often been

Fig 29 Air photograph of intertidal peats at Westward Ho!, Devon (English Heritage)

Fig 30 Eroding peat beds at Lower Hauxley, Northumberland (Northumberland County Council)

identified as an important factor. Many intertidal peats are emerging from the toe of shingle or dune bars as they migrate inland, as at Westward Ho! (Fig 27). Elsewhere there is palaeoenvironmental evidence for the existence of bars which have now been completely eroded, leaving formerly protected coast in Lincolnshire, for example, subject to dramatic erosion (Swinnerton 1931). However, beach bars are not prerequisites for alternating peat/clay sequences. On the north side of the Severn Estuary in south Wales and Gloucestershire there are extensive intertidal peats without evidence for the former existence of an onshore bar, although offshore bars could have played a part.

4.7 Intertidal contexts and the Mesolithic-Neolithic transition

Many intertidal peats in southern Britain date to the period *c* 4350–2500 cal BC when a period of reduced marine influence within the general Holocene rise allowed the growth of extensive coastal forests which were subsequently inundated. Many of these sites produce lithics and charcoal. Such contexts have potential for the study of relationships between human groups and the environment at the critical transition from hunting and gathering to farming. Where charcoal is present there is the question of whether it relates to domestic hearths or larger-scale environmental manipulation, which is widely attested for Mesolithic communities in upland Britain (Edwards 1988). The possibility of comparable changes in the coastal environment remains to be investigated. Widespread charcoal and flints at the base of the Westward Ho! peat are not associated with major woodland clearance at the time of the Mesolithic midden (Fig 27b). There is later evidence for wooden stake alignments (Fig 27c) on top of the peat dated 3790–3380 cal BC (HAR-5642: 4840±70 BP). Peats in Hartlepool Bay show two periods of forest recession before the elm decline, associated with charcoal, and another much larger recession following the elm decline (Tooley 1978b). Sites with good preservation of environmental evidence are also key contexts for establishing whether sedentary late Mesolithic communities existed in any particularly rich coastal areas of Britain, as they did elsewhere in Europe (see also below, 6.2.3.3).

In relation to the origins of farming in Britain, is there evidence for precocious agriculture in coastal zones where environmental instability, resulting from the effects of storms or flooding, may have created a more open landscape? To what extent were natural episodic openings in coastal wildwood extended or perpetuated by the effects of hunter-gatherer burning? If coastal sedentism occurred, did it preadapt people to agriculture or, as in Denmark, did the inhabitants of coastal settlements not adopt farming at once because other resources were sufficient? The degree of continuity or change in the natural or manipulated coastal environment on either side of about 3800 cal BC is also relevant to the origins of farming.

4.7.1 Aeolian sand dunes

The distribution of wind-blown dunes (see also Chapter 3) round the coast of England is illustrated in Figure 31. Beneath and within dunes, buried soils and prehistoric landscape can be preserved, particularly on the fringes of dune systems where they abut solid geology and may not have been subject to repeated Holocene reworking. An example is the stump of a former dune with molluscan evidence at Towan Head, Newquay (Spencer 1975). Numerous archaeological sequences around the coasts of Scilly and Cornwall are preserved within dunes. This capacity for site preservation is illustrated by the burial of Bronze Age and later fields on the inland edge of dunes at Gwithian, Cornwall (Megaw *et al* 1961), and by the long dune sequences at Brean Down, Somerset, where the late Devensian and Holocene sequence is 30m thick (ApSimon *et al* 1961; Bell 1990). Here, the top 5.5m above a Holocene palaeosol is a sequence of blown sands and colluvial deposits containing five distinct Bronze Age occupations relating to periods of dune stability and separated by periods of sand deposition. The sediments preserved prehistoric structures and activity areas with a wide range of palaeoenvironmental evidence including charred seeds, Mollusca and bones, as well as less common evidence such as eggshell and minerally replaced coprolites of dogs and possibly people. The chemical environment within a dune is an important factor in preservation. As Figure 31 indicates, most British coastal dunes are largely calcareous, because of the presence of shell debris, and thus are likely to preserve bone and molluscan evidence, although decalcified horizons often reflect leaching during periods of stability; one estimate indicates that the top 10cm can be decalcified within 300–400 years (Jefferies 1976).

The burial of an early medieval settlement and its fields below the great dune complex on the north side of Lindisfarne, Northumberland (Walsh 1993), exemplifies a phenomenon found at this date in several parts of coastal Britain. It is particularly common in the Bristol Channel with a probable example associated with a shell midden in the dune complex at Braunton (Fig 27a) and examples on the South Wales coast at Gower and Kenfig (Toft 1988).

Alternating sequences of dune-blow and stabilisation have variously been attributed to sea-level change, frequency of storm incidence, and local coastal change (Tooley 1985b). Burial of medieval settlements in particular has often been attributed to stormier conditions during the Little Ice Age which produced its most severe effects in the period AD 1550–1850. This hypothesis needs to be tested in the context of more precise chronologies for the development of specific dunes, which will also help to clarify the extent to which dune sequences may themselves provide palaeoclimatic evidence.

4.8 Sources of palaeoenvironmental evidence

Coastal sites are of special importance because of the wide range of biological evidence that may be preserved, especially in waterlogged contexts. Integration of a range of data sources from various spatial catchments allows interpretation to be refined. In particular, interpretation derived from one dataset can be tested against other evidence, both archaeological and biological. A hypothesis will be strengthened when a range of datasets points to an essentially similar interpretation, albeit often with some specific anomalies which highlight areas for further enquiry; examples are the Mesolithic site at Westward Ho! (Balaam *et al* 1987b) and the Ferriby boat (Buckland *et al* 1990). Recent sea-level studies have been based on the integration of several sources of palaeoenvironmental evidence, for instance identification of ten transgressive phases between *c* 7500 cal BC and 650 cal AD on the Fylde coast of Lancashire (Tooley 1978a). On the Essex coast Wilkinson and Murphy (1988a, 229) argue that 'the development of coastal and estuarine peats reflects a range of depositional environments and may also relate to different stages in the cycle of advancing or retreating sea level'. Thus, meaningful interpretation in terms of sea-level relationships can often hinge on detailed analysis of the biological evidence.

The formation processes and taphonomic factors specific to coastal environments also need to be considered. When considering accumulations of biota (biological evidence – plant and animal remains), the relative contributions of inwashed material sorted by water and material deposited by human agency need to be evaluated. Burrowing organisms may be responsible for intrusion of biota; sometimes this is comparatively easy to identify (Murphy 1988), in other instances less so (Crabtree 1990). In submerged forest contexts, consideration is also needed of the effect of disturbance and contortion by tree roots, and of the effects of tree-throw, on pollen and macrofossil stratigraphy. In relation to dune sites the effects of winnowing, dune blow-outs, and bioturbation were evaluated in the context of work at Brean Down (Bell 1990).

In the following review of the various sources of palaeoenvironmental evidence, no attempt has been made to include everything. The aim is to identify key pieces of work which demonstrate the application of a technique and draw attention to sites of particular importance, or future potential.

4.8.1 Dendrochronology

Resolution of many of the environmental archaeological issues in the coastal zone requires a precise chronology which is increasingly being provided by dendrochronology. There is, for instance, the question of the synchronism of environmental change from one area to another and its implications for palaeoclimatic and sea-level studies. Dendrochronology can also clarify the duration of submerged forest phases and the chronological relationships between them and archaeological structures. Dendrochronology is also of special significance because it can provide a timescale for environmental change which is far more relevant to issues of human environmental perception and knowledge than are chronologies provided by radiocarbon and prehistoric artefacts.

Although many submerged forests contain species such as alder, which is not suitable for dendrochronological dating, some also contain oaks which, when they are a century or so old, can be suitable for dating. The important role of these sites is shown by the contribution which wood from submerged forests at Stolford, Somerset, and Woolaston, Gloucestershire, made to the dating of the Sweet Track to 3807–3806 BC (Hillam *et al* 1990). Existing intertidal submerged forest chronologies are Stolford 4052–3779 BC,

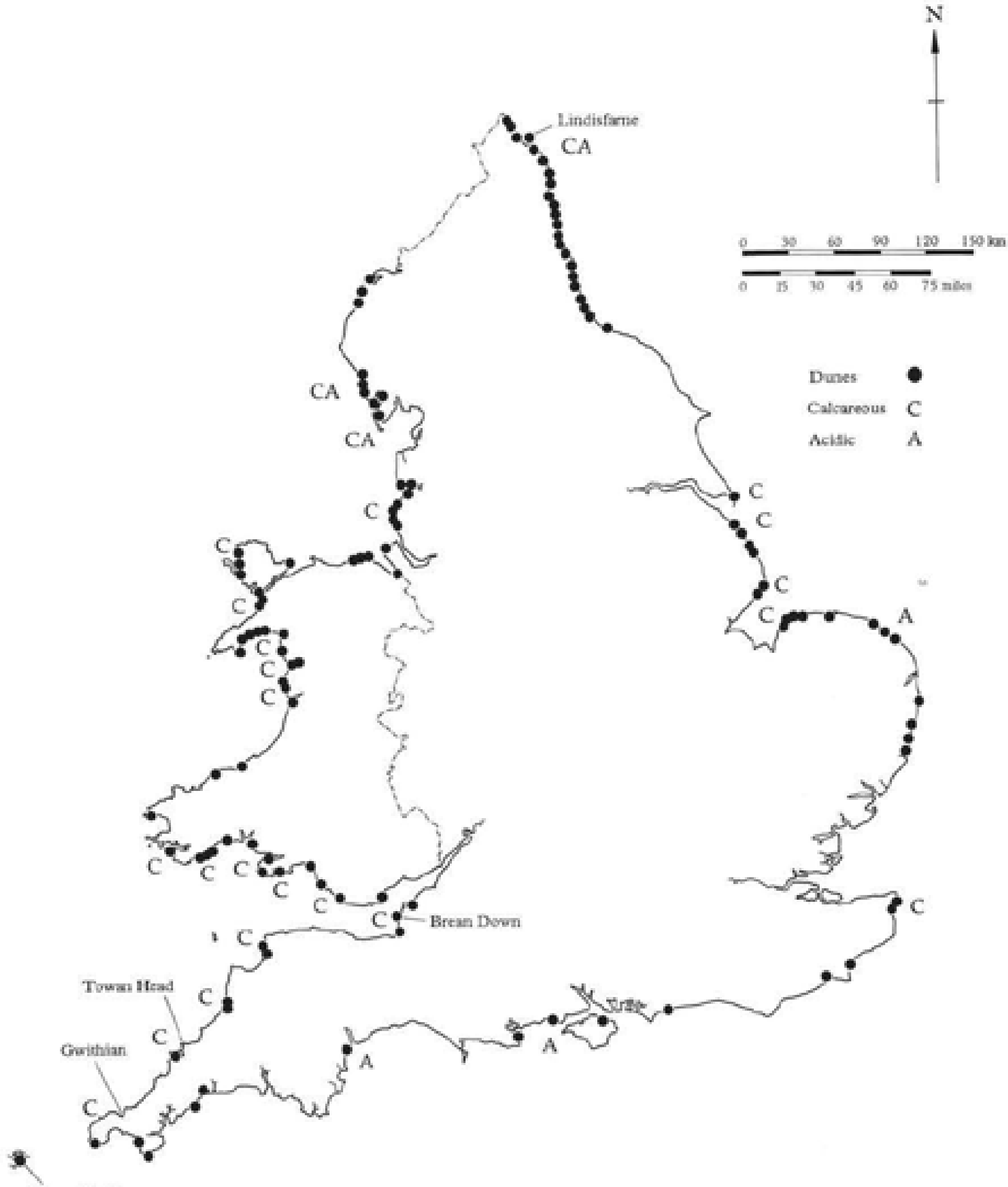


Fig 31 The distribution of aeolian coastal dunes in England (after Goudie and Brunsden 1994, fig 31)

Woolaston 4096–3869 BC and 2843–2692 BC, and Wootton Quarr 3463–2694 BC (Hillam 1994). The Stolford and Woolaston forests died, and the Sweet Track was constructed in response to flooding, at a time between 4000–3800 BC when oaks are absent from terrestrial bogs. This absence of bog oaks, at a stage when submerged forests were being engulfed, has been interpreted as evidence of wet, stormy conditions (Morgan *et al* 1987; Hillam *et al* 1990). Heyworth (1978) had previously drawn attention to apparent matches between floating chronologies at Stolford, Alt Mouth, Lancashire, and Borth, Wales, indicating that these submerged forests had all been inundated within less than 50 years. Much more complex histories of inundation are, however, attested at Wootton Quarr, where tree death occurred, not in a single event, but in at least 7 events over 536 years.

The potential for dating archaeological structures and artefacts in the intertidal area is illustrated by Goldcliff, Wales, where two boat planks provide a tree-ring sequence from 1139–1027 BC and two rectangular buildings provide a sequence from 518–392 BC (Hillam 1993; Bell *et al* forthcoming b). Wooden structures at Wootton Quarr and the Blackwater Estuary have been sampled but have not yet been dated (Hillam 1994). It is clear that dendrochronological dating and palaeoenvironmental studies have much to gain from close integration of their research strategies in the coastal zone.

4.8.2 Pollen

Since pioneering investigations by Godwin and Godwin (1934; and see also Godwin 1943), pollen has been a key technique for the study of environmental change in the coastal zone. The technique has been extensively employed on the inland margins of coastal peats, especially in the Somerset Levels (Caseldine 1984) and the Fens (Hall and Coles 1994), but to a lesser extent in the intertidal area. Where analysis has been done it suggests that conditions in intertidal peats are usually suitable for preservation.

Pollen played a key part in the definition of environmental changes associated with alternating sequences of peats and clays in sea-level studies on the Fylde coast (Tooley 1978a). In combination with plant macrofossils and other techniques, it allows reconstruction of the spatial relationship between archaeological sites and the main vegetation zones, reflecting varying degrees of marine influence.

In chronological terms pollen contributes not only to broad-scale vegetation history, but at a more detailed level to investigation of the relationship between human activity and sequences of vegetation change, reflecting, for instance, hydroseral succession (that is, plant succession in water, for example as a result of gradually shallowing or sedimenting conditions). Thus a regressive phase might typically produce a sequence of plant communities moving from mudflats to saltmarsh to reed swamp to sedge fen to fen carr, this last stage sometimes progressing to raised bog as a result of increasingly nutrient-poor conditions. The unstable nature of the coastal environment is such that the succession is often halted, or put back to an earlier stage, by flooding. As a result, most successions in intertidal zone peat do not progress as far as the raised bog stage, a stage more often reached on the inland margin of coastal wetland which is more remote from marine influences. In the Gwent Levels, Wales, however, erosion has cut back into the bog, exposing on the foreshore at Goldcliff a long peat sequence from 5900–1250 cal BC (Smith and Morgan 1989) with a number of flooding horizons and a raised bog stage from 3800–1700 cal BC.

Pollen and associated macrofossil analyses from three intertidal peats in the Bristol Channel illustrate varying stages of hydroseral succession and degrees of dryness during regressive phases. Brean Down peat dated *c* 4450 cal BC was a freshwater reed community subject to occasional marine influence (Crabtree 1990). Blue Anchor Bay peat dated *c* 5600 cal BC was an alder-carr woodland (Kerney 1976). At Westward Ho! the Mesolithic midden was dated *c* 5900–4900 cal BC and lay in an oak, elm, and hazel woodland with wetter willow carr nearby (Balaam *et al* 1987).

Pollen helps to establish not only the setting of coastal archaeological activity but also the effect of communities on the wetland and neighbouring dry land vegetation. On the Scilly Isles pollen analysis of inland peat sites has shown that, contrary to earlier opinion, the islands were wooded until Bronze and Iron Age clearance (Dimbleby *et al* 1981). That work is now being followed up by analysis of the intertidal peat resource (V Straker pers comm; Ratcliffe and Straker 1996). Westward Ho!, despite having much evidence of charcoal, produced only possible evidence for very limited Mesolithic effects. High values for ivy and hazel (for which, elsewhere, an anthropogenic cause has been suggested) are more likely in this case to have natural explanations because of the duration of their occurrence. At Goldcliff, Wales, charcoal deposition occurred in the Mesolithic and Bronze Age, and Smith and Morgan (1989) identified a series of Neolithic and Bronze Age agricultural episodes, the earliest at the elm decline. The sites of Westward Ho! and Goldcliff, together with other intertidal peats of comparable date in Pembrokeshire which have charcoal horizons at their base (Lewis 1992), highlight the already noted potential of the coastal zone for investigations of the Mesolithic/Neolithic transition.

At Ferriby, pollen, macrofossil, and beetle studies collectively established that the Bronze Age boat (Buckland et al 1990) had been abandoned and partly dismantled, perhaps in a sort of boat yard, on saline mudflats below contemporary high tide and beyond saltmarsh. Inland was a wet oak and alder forest

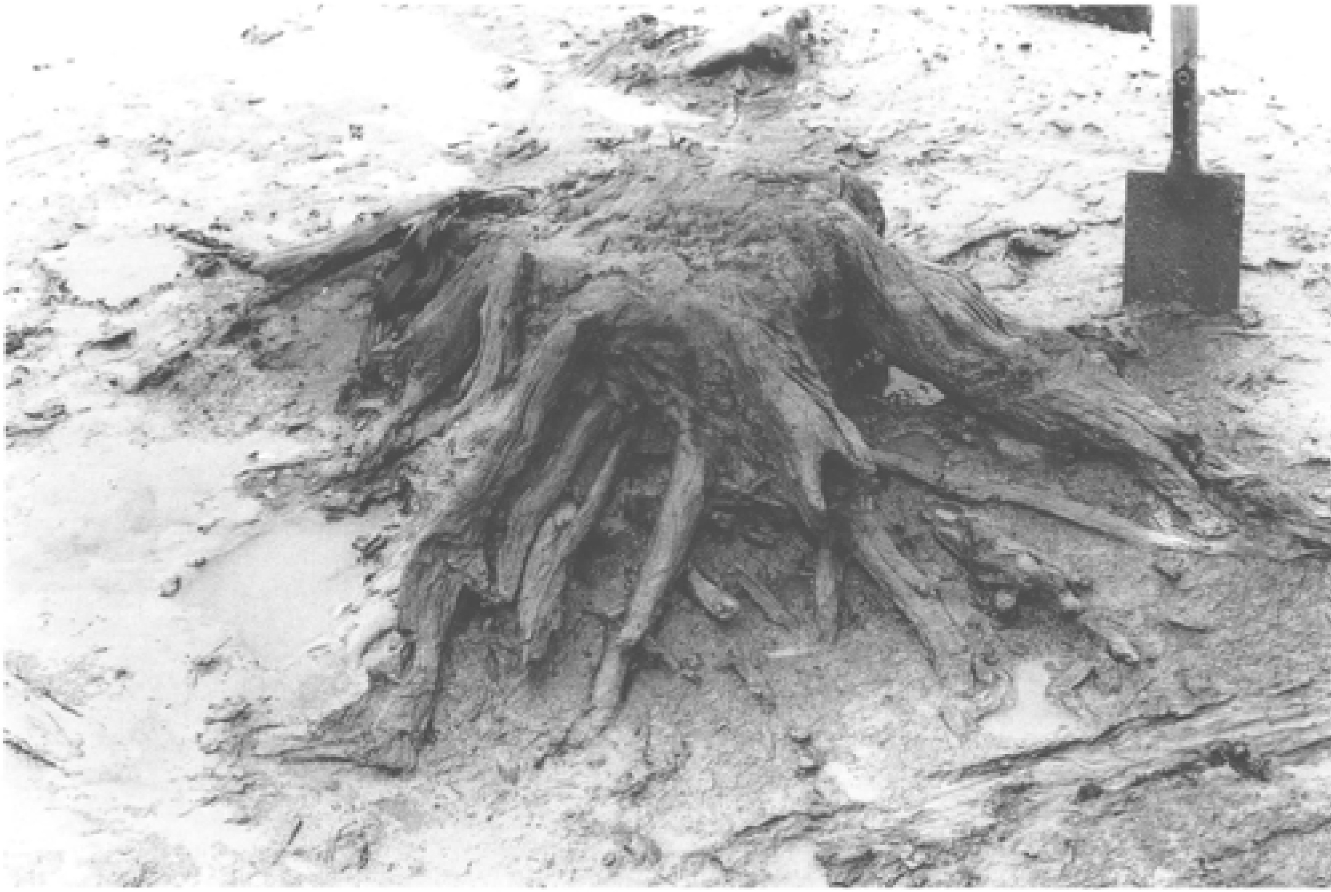


Fig 32 Submerged forest: stump of oak with radiating, buttress-like roots, Grange Pill, Gloucestershire (J R L Allen)

fringing the Humber Estuary, with some hints of cultivation. Earlier studies in the Humber wetlands by Smith (1958) used pollen to establish an environmental framework for the Brigg boat finds, trackways, and artefact finds in the Ancholme valley, and to clarify their relationships to marine flooding horizons. Part of this study was the intertidal peat site of Ingoldmells, Lincolnshire, with evidence for Iron Age and Romano-British salt extraction. Limited pollen and macrofossil analysis indicated open water with fringing fen and fencarr. The sequence would, however, repay more detailed investigation because greater marine influence might be anticipated during the period of the salt industry itself.

4.8.3 Plant macrofossils

Plant macrofossil studies are frequently conducted on a complementary basis with pollen analysis, and together they provide evidence of the kind outlined above for spatial distribution of plant communities and vegetation succession.

4.8.4 Wood

Although most accounts of submerged forests contain some information on the tree types represented, quantified results are rare. Exposures of submerged forests provide opportunities for mapping areas of ancient woodland (Figs 32–3) and looking at issues of spatial variation, as is being done at Goldcliff, Wales (Bell 1993a). Such studies do, however, need to bear in mind the possibility that presently exposed surfaces may to some extent be diachronous, being eroded to a lower level to seaward. Diachronicity, or otherwise, in exposed submerged forest surfaces could be investigated dendrochronologically.

Analysis of the morphology of trees can contribute to our understanding of coastal wildwood (Figs 32–3). Trees from peats can be characterised by long straight trunks indicative of former dense forest (Robinson 1984), contrasting with the low-branching trees familiar from parkland or managed woodland (Rackham 1986). Very long oaks between 18 and 27m long have been recorded from coastal peat contexts at Sharpness Docks (Lucy 1877), Hull Docks (Hawkshaw 1871), Lincolnshire (Robinson 1984), and the Fenland (Godwin 1978). The Hasholme log boat, dendrochronologically dated to 322–277 BC, also provides evidence of the longevity of trees in the wildwood, being 600–820 years old when felled (Hillam 1987). Studies of the direction of tree-throw can provide information on storm wind direction (Allen 1992b) and also highlight natural episodic regeneration processes in the wildwood. The recurrence interval of these events could be assessed dendrochronologically. Intertidal peats also represent important sources of information about human use of wood, as for instance in rectangular Iron Age structures and trackways at Goldcliff, Wales (Bell 1993a). There is also the potential demonstrated by the inland peat sites of the Somerset Levels for information on woodland management (Morgan 1982) (see also below, 6.3.3).

4.8.5 Seeds

Pioneering analysis of seeds from submerged forests by Reid (1913) revealed a rather limited range of species. More recent work on seeds and other plant macrofossils has made important contributions to an understanding of coastal sequences at such sites as Westward Ho!, Brean Down peat, and the setting of the Ferriby boat (Buckland *et al* 1990). In Essex, plant macrofossil evidence has complemented a range of other evidence indicating that the dry land palaeosol of Neolithic date was buried by marine deposits. Plant material associated with the wooden paddle at Crouch site 26 indicates that it was deposited with the remains of saltmarsh plants at the strandline (that is, the shore where detrital material such as seaweed is washed up by the tide) (Wilkinson and Murphy 1986).

Macrofossils from the Graveney boat dated 970–1160 cal AD (BM-715: 1003±40 BP) included plants of saltmarsh and material derived from both local and regional vegetation, indicating that the boat cargo was hops (Wilson 1975).

A dry land soil subsequently buried by marine sediments at the Stumble, Essex, has produced the largest assemblage of Neolithic plant material from eastern England. The presence of cereals with nuts and rosaceous fruits, and evidence for the use of roots, tubers, and rhizomes is particularly interesting (Murphy 1988). It thus confirms evidence from other recent studies (Moffett *et al* 1989) for the significant use during the Neolithic of wild plant foods, which suggests that the transition from a hunting and gathering way of life to an agricultural one, was more gradual than has generally been hypothesised. Cereal macrofossils are also reported from a Beaker pit at Jaywick and a late Bronze Age briquetage site, Crouch Site 2, where there are also cereal impressions on briquetage (Wilkinson and Murphy 1986). A midden context at Leigh Beck, Canvey Island, has produced charred macrofossils of cereals, arable weeds, and halophytes; this is interpreted as debris from crop processing which was dumped in a saltmarsh context (Wilkinson and Murphy 1995).

Dry land dune sites are suitable contexts for the preservation of charred macrofossils, and at Brean Down they produced evidence of Bronze Age crop

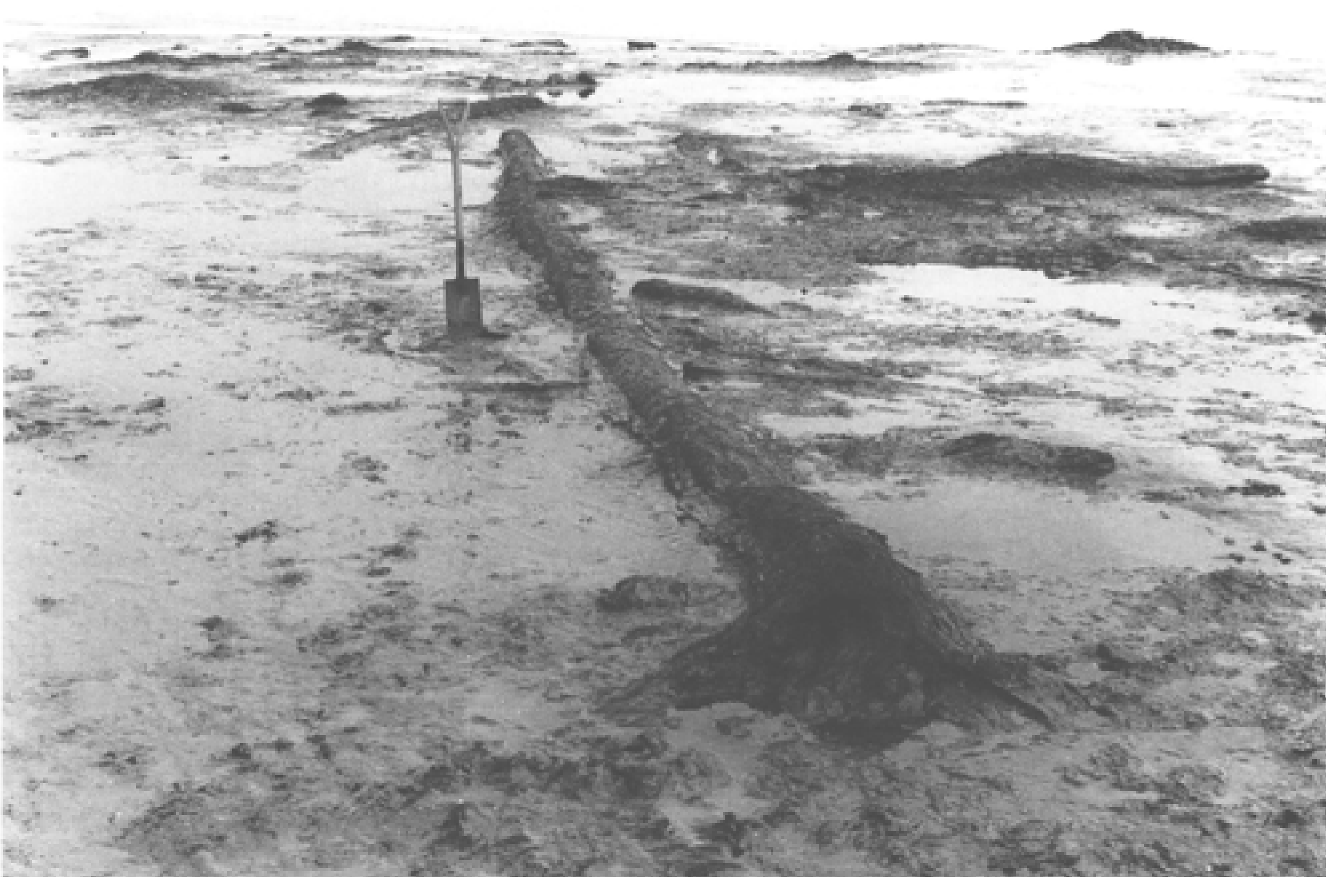


Fig 33 Submerged forest: windblown alder with rootball, Goldcliff, Gwent (J R L Allen)

husbandry and environment and even one piece of charred seaweed (Bell 1990). Cliff exposures at Porth Killier, in the Scilly Isles, have also been productive of macrofossils, both charred and mineralised, the latter probably the result of replacement in the calcium-rich environment of the midden (Ratcliffe 1993). Charred cereals from this site have been accelerator-dated to the mid to late Bronze Age and a cache of almost pure barley associated with prehistoric field walls below dunes at East Porth, Samson, has been accelerator-dated to the early Bronze Age (Ratcliffe 1993).

4.8.6 Other microfossils (diatoms, ostracods, and forams)

These have been employed in a number of studies where they have demonstrated changing water conditions, in particular the changing extents of marine and freshwater influences. Examples include Downholland Moss, Lancashire (Tooley 1978a), key contacts above and below peats at Crouch site 8, and contacts at Jaywick between a buried soil and overlying clays which proved to be marine (Wilkinson and Murphy 1988). Ostracods and diatoms at Brean Down helped to establish the environmental conditions associated with the deposition of peats and estuarine sediments (Crabtree 1990; Robinson 1990).

4.8.7 Bones and other evidence of animals (see also below, 6.3.3)

Unusual preservation in the intertidal area is shown by the recent find of footprints in intertidal clays at Formby, Merseyside (Cowell *et al* 1993). These represent human adults and children, deer, aurochs, and crane. Their likely date is Neolithic or early Bronze Age. Similarly, human footprints of Mesolithic date are reported from two sites in the Welsh Severn Estuary (Aldhouse-Green *et al* 1993), where animal footprints are also widespread and cattle footprints are associated with Iron Age structures (Bell 1992, fig 18). Another form of indirect evidence for animal activity is wood with evidence of beaver gnawing, from a log jam in a cliff exposure at Withow Gap, Holderness (Van de Noort and Davies 1993). A beaver bone and some gnawed wood have also been found at Caldicot, Wales (Nayling 1993).

Calcareous dune sands frequently preserve animal bones, and much of the evidence for the vertebrate fauna of the Scilly Isles and Cornwall comes from dunes and middens. Intertidal peats also preserve bones excellently. Together, dunes and peats represent a key source of information relating to Britain's wild and early domestic fauna, especially from western Britain where, as a result of acid soils, other contexts for bone preservation are few. Many of the older accounts of intertidal peats refer to finds of bones but sometimes these older identifications may not be reliable and, judging by the experience of Westward Ho! (Levitan and Locker 1987), older collections may have amalgamated material from contexts of different dates.

Discoveries of aurochs (wild cattle) are recorded from the Severn Estuary near Lydney (Lucy 1877, 115) and Southampton Docks (Shore and Elwes 1889), and there are many old antiquarian and geological records that mention finds of deer. Many of these animals must have floundered naturally in swampy ground. Elsewhere bones are interpreted as debris from human activities, as with bones of aurochs, pig, red deer, and roe deer in the Westward Ho! Mesolithic midden (Levitan and Locker 1987).

The potential of intertidal fauna is highlighted by the discovery of a wild pig at Lydstep, Wales (Jacobi 1980a; Lewis 1992), with the microliths of the weapon apparently responsible for its death. Presumably it escaped the hunter but died in the swamp. The bones have been accelerator-dated to 4320–3980 cal BC (5300±80 BP OxA-1412; Lewis 1992). There is also the record of a giant late glacial deer (*Megaceros giganteus*) with a barbed point from the sediments of Skipsea-Withow Mere (Gilbertson 1984).

Cut antlers were found at Sharpness Docks (Lucy 1877) and antler mattocks are known from at least five coastal sites: three in Wales, all dated to the Mesolithic (Aldhouse-Green *et al* 1993), one in the Ribble Estuary, Lancashire, and another found during the making of the Manchester Ship Canal. Their contexts suggest that the mattocks may have been used for specialised purposes in the exploitation of coastal resources. Perforated antler implements are associated with the bones of whales in the Firth of Forth (Evans 1975; Clark 1952). Whale bones were found during construction of Preston Dock and in tin works at Pentuan, Cornwall (Reid 1913, 97), but there is no direct evidence for their exploitation in the English intertidal zone. Exploitation clearly took place, even so, because the bones of whales and other large marine mammals are not infrequently found at coastal prehistoric settlements (eg Bishopstone, Bell 1977; Kingston Buci, Curwen 1931; Scilly, Turk 1978).

Evidence for fishing in prehistory seems to be surprisingly limited from the coastal zone in England in comparison with, for instance, sites in Scotland. Scilly seems to be an exception, with fish bones on several sites (Ratcliffe 1993). Westward Ho! produced only four fish bones (Levitan and Locker 1987). Wilkinson and Murphy (1995) record very sparse evidence of fishing at Shoeby, Southend. Fish of 11 species were present in Bronze Age contexts at Brean Down (Levitan 1990). It remains to be established whether the paucity of fish on some sites reflects taphonomic factors, inadequate sieving programmes, or the limited use of this resource.

Fig 34 Limpet midden at Porth Killier, Isles of Scilly (Cornwall Archaeological Unit)

4.8.8 Marine molluscs

Although accumulations of marine Mollusca are frequently found in coastal cliff and dune exposures (Fig 34), well dated middens which have been studied in any detail are few in England, and new discoveries deserve a high priority. At Westward Ho! a Mesolithic midden (Bell 1987) largely comprised mussels (*Mytilus edulis*), peppery furrow shell (*Scrobicularia plana*), cockle (*Cerastoderma*), and carpet shell (*Venerupis*). Sample size was relatively small and the shells were comminuted and therefore unsuitable for studies of seasonality. The need for constant vigilance in the coastal zone is highlighted by the recent discovery of eight small middens of late Mesolithic and Neolithic date on the now-reclaimed margins of coastal wetland at Prestatyn, Wales (Thomas 1992). Analysis of a Roman and medieval midden-type deposit at Leigh Beck, Canvey Island (Wilkinson and Murphy 1995), indicated that the assemblage was partly a result of human activities, but also perhaps of natural processes of accumulation.

There are many more coastal sites where there is some evidence for the use of marine Mollusca. Probably the greatest concentration is on Scilly (eg Porth Killier, Ratcliffe 1993) and in the south-west, and this has been conveniently reviewed by Coy (1987). It is frustrating that, in the past, too little of this evidence has been saved and analysed in detail. Not only can it provide information on the human exploitation of coastal resources but, if due care is taken to consider issues of human selectivity, it may also help to identify evidence of environmental changes as suggested by the composition of the late Mesolithic and Neolithic middens at Prestatyn, Wales (Bell *et al* forthcoming a). An issue which needs to be considered is oyster culture and transport, which was clearly important from Roman times (Coy 1987) to judge by the numbers of shells reaching inland sites (below, 6.4.3).

4.8.9 Land molluscs

These occur in two main types of coastal context: intertidal sediment sequences and cliff exposures. The most frequent context in the intertidal zone is estuarine minerogenic sediment with a very restricted assemblage often dominated by *Hydrobia*. Such an assemblage may confirm marine influence but may not permit a very detailed environmental reconstruction. Molluscs do not appear to be preserved in most intertidal peat, although in some specific areas conditions are sufficiently calcareous, as, for instance, the marine mollusc midden at Westward Ho!. Here land molluscs supported the evidence from pollen, beetles, plant macrofossils, etc for woodland conditions and small pools on the site (Bell 1987). Similar fen woodland conditions are indicated by a combination of Mollusca and pollen at Blue Anchor Bay, Somerset (Kerney 1976). At Purfleet, Essex, a woodland mollusc fauna represents colonisation during a regression phase and prior to peat initiation. It suggests mostly dry woodland at the time of Neolithic activity, but with occasional freshwater flooding (Wilkinson and Murphy 1995). A fen woodland assemblage is also present in 'marl' below intertidal peat at Hartlepool (Trechmann 1936). A list of land and freshwater molluscs is recorded from intertidal exposures at Westbury on Severn, Gloucestershire, but it is not very specific about the contexts sampled (Kennard and Woodward 1901). Other contexts with special potential include tufa exposures on the coast, which have been recorded during construction of the New Docks at Southampton (Shore and Elwes 1889) and on the Humber coast between Sunk Island and Spurn Head (Van de Noort and Davies 1993, 19). The potential of tufas is exemplified by sequences further inland in the Humber wetlands in the Ancholme valley (Preece and Robinson 1984).

Cliff exposures have provided late Devensian and early Holocene molluscan evidence from Skipsea-Withow Mere (Gilbertson 1984), and late Devensian and Holocene molluscan sequences from chalkland dry valleys at Folkestone, Eastbourne (Kerney 1963), and the Isle of Wight (Preece 1979; 1980). Such sites have contributed significantly to knowledge of molluscan biozones and introduction dates and there is a strong archaeological connection, because in these contexts environmental conditions and sedimentation rates in the later Holocene are strongly influenced by human activity.

Coastal dune exposures are often calcareous and preserve Mollusca. Evidence relating to conditions before sand accumulation is rarer but did survive at Towan Head, Newquay, where it demonstrated that scrub or light woodland extended right down to the coast. At Harlyn Bay and Perranporth, Cornwall, on the other hand, open conditions obtained from the earliest preserved levels (Spencer 1975). Dune sequences in western and northern Britain are important contexts for dating the introduction of continental mollusc species into Britain (Evans 1979). Thus in a number of stratified dune sequences (eg Brean Down, Bell and Johnson 1990), introduced species occur in the following order: *Cochlicella acuta*, *Cernuella virgata*, and *Candidula intersecta*. It is probable that such introductions occurred initially as a result of coastal trade, and that the last two species later spread inland and flourished, often in habitats created by human agency.

4.8.10 Insects

The potential of insects, particularly beetles, in studies of the ecological history of the coastal zone is amply demonstrated by work on the peats at the inner margins of coastal wetlands on the Somerset Levels (Girling 1984) and Thorne Moors (Buckland 1979), and similarly the insects from the Brigg Raft (Buckland 1981). Given this potential, it is surprising that only two major studies seem to have been published of insects from organic deposits exposed in the intertidal area. The midden and overlying submerged forest at Westward Ho!, Devon (Girling and Robinson 1987), had faunas indicating fen woodland environment with pools of water. The second major study was from mineralogenic sediments underlying Ferriby boat 2, dated *c* 1800 cal BC, and underlying fen peats (Buckland *et al* 1990). Insects complemented plant macrofossils and pollen in showing that the boat had been deposited in estuarine conditions in the open mudflats of the lower foreshore. Insect evidence would be expected to survive in most waterlogged contexts in the intertidal zone, and beetles are sometimes mentioned in early accounts. Until recently work in this field has been limited because there has been only a very small number of trained specialists, but this is now increasing and there is clear potential for expanded research on intertidal organics.

4.8.11 Soils and micromorphology

Cliff exposures provide many instances of buried soils, particularly below and within blown sand and colluvial sequences. Radiocarbon dating of such soils is possible using charcoal or humus fractions. The potential of coastal exposures for work on soil history is shown by the loess-derived soil at Pegwell Bay, Kent (Weir *et al* 1971). Micromorphological investigation of both buried soils and dune stabilisation phases at Brean Down proved very profitable, both in terms of work on soil history and in the elucidation of microsequences of human activity areas (Macphail 1990, eg fig 130), thus complementing, at a much smaller scale, data from three-dimensional artefact recording. Former soils in the intertidal area at the Stumble and Purfleet, Essex, have been analysed micromorphologically, but here interpretation was limited by diagenic changes consequent upon brackish water inundation (Macphail in press). Many other buried soils in coastal locations would repay examination, for instance the Harlyn Bay cliff exposure (Whimster 1977) or the apparent land surface associated with the intertidal Yelland stone row (Fig 27 and Rogers 1946).

4.9 Erosion

Virtually the whole of the archaeological resource in the intertidal zone and cliff exposures is self-evidently subject to erosion. What is the timescale of the threat? Peat ledges in the intertidal zone end in low cliffs which are subject to undermining and collapse. The rate of erosion will vary greatly according to local factors, the periodicity of sediment cover, etc. Erosion of up to 310mm a year has been recorded at Goldcliff in the Welsh Severn Estuary (Bell 1993a, 88). At this site, peat ledges which had remained virtually unchanged over at least two years suddenly underwent catastrophic erosion during 1994, involving cracking and the peeling-off of great plates of peat 10m or more across, which took with them archaeological structures (Bell 1994). Air photographic archives offer special potential for detecting and mapping intertidal peat exposures and monitoring larger-scale changes over the timescale of available cover, perhaps up to 40–60 years.

Relatively unconsolidated Quaternary sediments in coastal cliff exposures are also very vulnerable to the effects of erosion. At Brean Down, for instance, comparison of archaeological surveys in 1955 and 1985 shows average erosion rates of 0.30m a year (Bell 1990). At Skipsea-Withow Mere the rate is 1.2m per year and the coast retreated 225m between 1825 and 1984 (Gilbertson 1984). The monitoring of intertidal exposures of a palaeosol at the Stumble, Essex has recorded erosion rates of 10–20mm per year from the surface (Murphy and Wilkinson 1991).

The number of sites where erosion has been quantified is very small and the timescale of monitoring has often been insufficient to permit long-term extrapolation. During regular monitoring of key sites the replanning of certain peat edges and levelling of surfaces would help to improve knowledge of erosion rates; this also needs to be related to information on wave power supply at specific locations (J R L Allen pers comm). Sites which would be suitable for erosion monitoring include those where we already have the advantage of some baseline data as a result of previous archaeological work, eg Westward Ho!, Ferriby, and the Essex sites. Many of the erosion processes are, however, highly episodic and so subject to the vagaries of chaos that the future trajectory of an exposure, and the vulnerability of the archaeological resource which it contains, may well be impossible to predict.

4.10 Conclusions and recommendations

Knowledge of the environmental archaeological potential of the coastal zone owes much to the observations of nineteenth-century antiquarians and archaeologists who were fascinated by submerged forests. The broad picture of distribution that they provided is augmented by recent field and analytical work, which has been restricted to a limited number of areas.

What is needed now is field assessment of sites that earlier records and recent observations suggest have special potential. Field assessment needs to be carried out jointly by archaeologists and palaeoenvironmentalists, as in Essex where an effective field methodology has been developed (Murphy and Wilkinson 1991, 11). Monitoring is necessary, both on a regular annual basis, as recommended for key exposures on Scilly (Ratcliffe and Sharpe 1991), and following major storm events. Assessment is inevitably hampered because some sites are only episodically exposed by storms. This makes it desirable to draw on a network of local observers who can monitor key sites, using the expertise of county archaeologists, contracting units, and museums, and amateurs with good local knowledge. What can be achieved by long-term non-professional monitoring is demonstrated by Ted Wright's discoveries over the last 58 years at Ferriby (Wright 1990).

The outcrops which can be used as a basis for plotting new finds and monitoring erosion have been planned in only a few intertidal exposures. Small-scale plans exist for Westward Ho! (Balaam *et al* 1987b, fig 2), Stolford and Bridgwater Bay (Kidson and Heyworth 1976), the Chapel Point and Ingoldmells foreshores in Lincolnshire (Swinnerton 1931), and Par Beach, Crab's Ledge, and Porth Mellon on Scilly (Ratcliffe and Sharpe 1991, figs 9–10; Ratcliffe 1993, figs 15, 17–8). The increasing availability of Electronic Distance Measurers (EDMs) and the increasing accuracy of Global Positioning Systems (GPSs) and supporting software should help to make the monitoring of erosion of intertidal exposures more feasible.

The episodic nature of exposure in coastal areas and the uneven distribution in space and time of environmentally aware observers mean that we should not restrict attention only to those areas that have been productive in the past. Among the most important recent discoveries are areas which hardly figure in the antiquarian literature, eg Wootton Quarr, Isle of Wight, and the Gwent Levels, Wales. Other areas, such as East Sussex, which do figure in the antiquarian and geological literature, do not seem to have been the subject of much recent scientific study.

For the more important of the sites identified, the next stage of assessment would be cleaning and non-destructive drawing and recording of what is at present undergoing erosion. Experience shows that this relatively low-cost exercise can be highly productive, as it was in the initial stages of the Brean Down project (Bell 1990, 6). Recent assessments of Scillonian coastal sites provide a model for wider application (Ratcliffe and Sharpe 1991; Ratcliffe 1993; Ratcliffe and Straker 1996). As part of these investigations strategic sampling was carried out to assess the potential for preservation of palaeoenvironmental evidence.

Beyond the assessment stage, decisions on larger-scale excavation and sampling depend on the importance of presently exposed evidence, and assessment of erosion risk (see above).

5 Survey and recording in the intertidal zone

by H J Tyson, M G Fulford, and S Crutchley

5.1 Introduction

This chapter provides a general overview of the development and characteristics of survey in the coastal and intertidal zones, as a framework for the discussion of the archaeology in the following chapters. Following a review of where survey has been carried out in England (5.2), the contexts in which it has been undertaken are analysed (5.3). The methodology and problems of survey in the coastal environment are highlighted (5.4) and the impact of these on costs is outlined (5.5). Finally, a summary of the present state of survey, and of the appropriateness and effectiveness of different types of survey, is presented (5.6). Because interest in the coast is relatively recent, this chapter draws heavily on surveys in progress, both at the fieldwork and the post-excavation and report writing stages, and the authors are grateful for the access they have had to interim reports.

Although interest in archaeology on the coast has been evident from the eighteenth century (eg William Borlase, 1753; 1758), it would be fair to say that survey and recording in the English coastal and intertidal zone is a relatively minor and recent aspect of archaeological research. Until the 1980s the scope of research in the coastal and intertidal zone was largely confined to single 'sites' or themes related to particular stretches of the coastline. Discoveries were made by chance, rather than through any systematic assessment of the archaeological potential of the coastline. The extensive publication of finds in conjunction with an assessment of the stratigraphic sequence of the intertidal site at Meols at the end of the Wirral peninsula in Cheshire (Hume 1863) serves as an example of the single-site approach. More wide-ranging research is exemplified by the work of Warren on the prehistoric land surfaces exposed off the Essex coast (Warren *et al* 1936). Here, too, the stratigraphic or geological context of artefacts and structures was a major concern. Thomas's investigation into the development of the Isles of Scilly (1985) is more recent, and conceived at the beginning of the 'modern' phase of research into coastal archaeology. The recognition of 'drowned' archaeology between the larger islands provided one of the main sources of evidence for tracing the evolution of the individual islands up to the present day. From the early 1980s up to the present we see the increasing development of both short-term commissioned surveys and longer-term research programmes.

The subject matter of this chapter embraces both intertidal and coastal surveys. The principal concern of the latter has been the monitoring of the erosion of cliffs and shorelines which are at, or just beyond, the extreme upper limit of the tidal range. Altogether, those surveys that have taken place have covered only a small proportion (less than 10%) of the estimated 3229km of coast and tidal inlets in England with direct frontage to the sea. However, if we take the length of England's coastline (8520km) arising from the Joint Nature Conservation Committee's definition, which includes estuaries, inlets, and rivers to the point of normal tidal limit, the amount surveyed represents considerably less than 5% of the whole (PPG 20, DoE 1992a, Annex 1). Nevertheless, the surveys illustrate growing awareness of the threat to the coastal archaeological resource from natural and man-made sources. These threats include rising sea-level coupled with increased erosion, as well as threats from development pressure and coastal traffic (see above, Chapter 2, and below, Chapter 8). Past research and casual discoveries were influential in shaping the pattern of intertidal research from the 1980s to the present, but recent surveys have also been undertaken where no previous work has been recorded. In these cases fresh discoveries and development-led threats have provided the impetus. A consideration of the aims and achievements of survey in the coastal zone will be followed by an appraisal of the methods and techniques which have been developed in this particular context.

5.2 The location of coastal and intertidal survey

The earliest commissioned large-scale coastal and intertidal survey to take place on the English coast was arguably the Hullbridge Project in Essex (1982–7) (Wilkinson and Murphy 1982–88; 1995; Murphy and Wilkinson 1982; Murphy nd). It covered some 200km of the heavily indented Essex coastline from the Thames at Purfleet to the south bank of the Stour (Fig 35). Survey initially focused on the Crouch Estuary (1982–3), but was then extended to include the Blackwater Estuary and the Clacton area (1984–5), the Roach and north bank of the Thames in Essex (1986), and the Stour and Colne Estuaries, as well as the Dovercourt area (1987). More recently, since 1992, there has been a continuing and expanding programme of reconnaissance of the Essex coast as part of the RCHME's regional programme, for example off Mersea Island and Bradwell-on-Sea (Crump and Wallis 1992, 38–42). The Hullbridge survey has become a model for later projects such as the Lindsey Coastal survey, which was conducted in 1989–90 and covered 20.5km of the Lincolnshire coast (Brookes *et al* 1990).

Fig 35 The location of surveys in the intertidal zone in England

Concerns about coastal erosion have led several local authorities to consider the management of their coastal archaeological resource. For example, in 1989 English Heritage instigated the Isles of Scilly Coastal Management Plan, carried out by the Cornwall Archaeological Unit. A rolling programme of fieldwork began in 1989 and a report on the results of environmental sampling is under way. Erosion caused by storms was the main impetus for a programme of coastal monitoring in October 1990, which covered 51km of the islands' coastlines in 10 days, discovering 41 new sites and monitoring 83 known ones (Ratcliffe and Sharpe 1991). This project did not include the entire coastline of Scilly but selected stretches of coastline already known for their potential. Those areas that were omitted from the survey altogether contained less than a dozen recorded archaeological sites. A rapid overall survey initially identified the most vulnerable and important sites so that subsequent fieldwork could be directed at them. Detailed yearly monitoring was suggested for 19 coastal and intertidal sites, and others were recommended for 5-yearly monitoring (Ratcliffe 1993, 40–2).

Northumberland County Council has also produced a coastal management plan which classifies sites in terms of their archaeological potential and the degree of risk of loss by erosion. The plan was developed from a rapid survey of 70 miles of coast by the Glasgow University Archaeological Unit and funded by English Heritage (Northumberland County Council 1994). Systematic survey of the intertidal zone fell outside the scope of this project. Further south, the North-East Maritime Archaeology Survey took place along 43 miles of coast covering the area from high water mark to the 12 mile limit, which represents 600 square miles of sea bed (Buglass 1994, 7). This survey included the coasts of Durham, Cleveland, and North Yorkshire and was completed in September 1994 by Cleveland County Archaeology Section with funding from the RCHME as part of the recording programme associated with the compilation of the maritime record of the NMR. The principal aim of this survey was to enhance the record of wrecks on the sea-bed, although some information about archaeology on the foreshore was also recorded.

There have also been recent surveys in the Solent. The Wootton Quarr Survey on the north coast of the Isle of Wight occupied several seasons between September 1989 and July 1994. It covered 6km of coastline and the corresponding related intertidal zone, and 12km^2 of hinterland; it also extended 3km offshore from the coast. It is particularly significant because of the range of information obtained from the intertidal and subtidal zones. The survey revealed some 157 intertidal sites and structures among which those of Neolithic, Bronze Age, Roman, Saxon, and medieval date are the best represented (Tomalin 1991; 1995; Tomalin *et al* 1994) (Fig 36). On the opposite shore of the Solent, the Langstone Harbour project in Hampshire took place over two weeks in August and September 1993 and again in August 1994. It was funded by Hampshire County Council, the Hampshire and Wight Trust for Maritime Archaeology, and the Department of National Heritage (Allen, M *et al* 1993; 1994).

In the Severn Estuary a large number of individual intertidal surveys and excavations have taken place on both the English and Welsh sides of the Estuary. Since the early 1980s to the present the Postgraduate Research Institute of Sedimentology and the Department of Archaeology of the University of Reading have carried out wide-ranging reconnaissance of the Estuary, to gain a clearer understanding of the Holocene sequence and certain aspects of the archaeological resource in the intertidal zone (eg Allen 1987; Allen and Rae 1987; Allen and Fulford 1987). More detailed surveys and assessments (see Fig 37) of particular sites and localities, particularly palaeochannels, have also been undertaken (eg Allen and Fulford 1986; Allen and Fulford 1992; 1993; 1996; Allen and Rippon forthcoming; Fulford *et al* 1992; 1995). In addition more site-oriented fieldwork has taken place on the Gwent coast under the auspices of the Severn Estuary Levels Research Committee in response to new discoveries of single sites or complexes of sites (eg Green 1989; Whittle 1989; Bell 1992; 1993a, 1993b; 1995).

A rapid, largely desktop, multi-period survey of the estuary took place in 1989 in advance of the proposed Severn Tidal Barrage and under the auspices of the newly formed Severn Estuary Levels Research Committee (Severn Estuary Levels Research Committee 1988). This covered 193km of English coastline from Beachley Point near Chepstow up-river to Gloucester, and then down-river to Hinkley Point on the Somerset coast. It involved very little fieldwork. Survey in 1991 in advance of the Second Severn Crossing, however, concentrated on specific areas to be affected by the bridge and involved limited, but more detailed, survey with a substantial field component. This included an area of 50ha of the intertidal zone on the Welsh side of the crossing, which was studied by a team of four to five people. Among other discoveries it produced important structural evidence of the medieval fishing industry on the Severn (Godbold and Turner 1993; 1994).

Richard McDonnell, funded by the RCHME, has also been undertaking research in Bridgwater Bay in Somerset. One of the objectives of this rapid assessment of the archaeological potential of the Bay was to test the recommendations outlined in *Foreshore archaeology: data standards for recording archaeological material in the intertidal zone* (Milne and Goodburn 1993). The Bridgwater Bay survey took place during 1993 and 1994 and covered 36km^2 from Hinkley Point to the wreck of the *Nornen* on the southern end of Berrow Flats (McDonnell 1993; 1995).

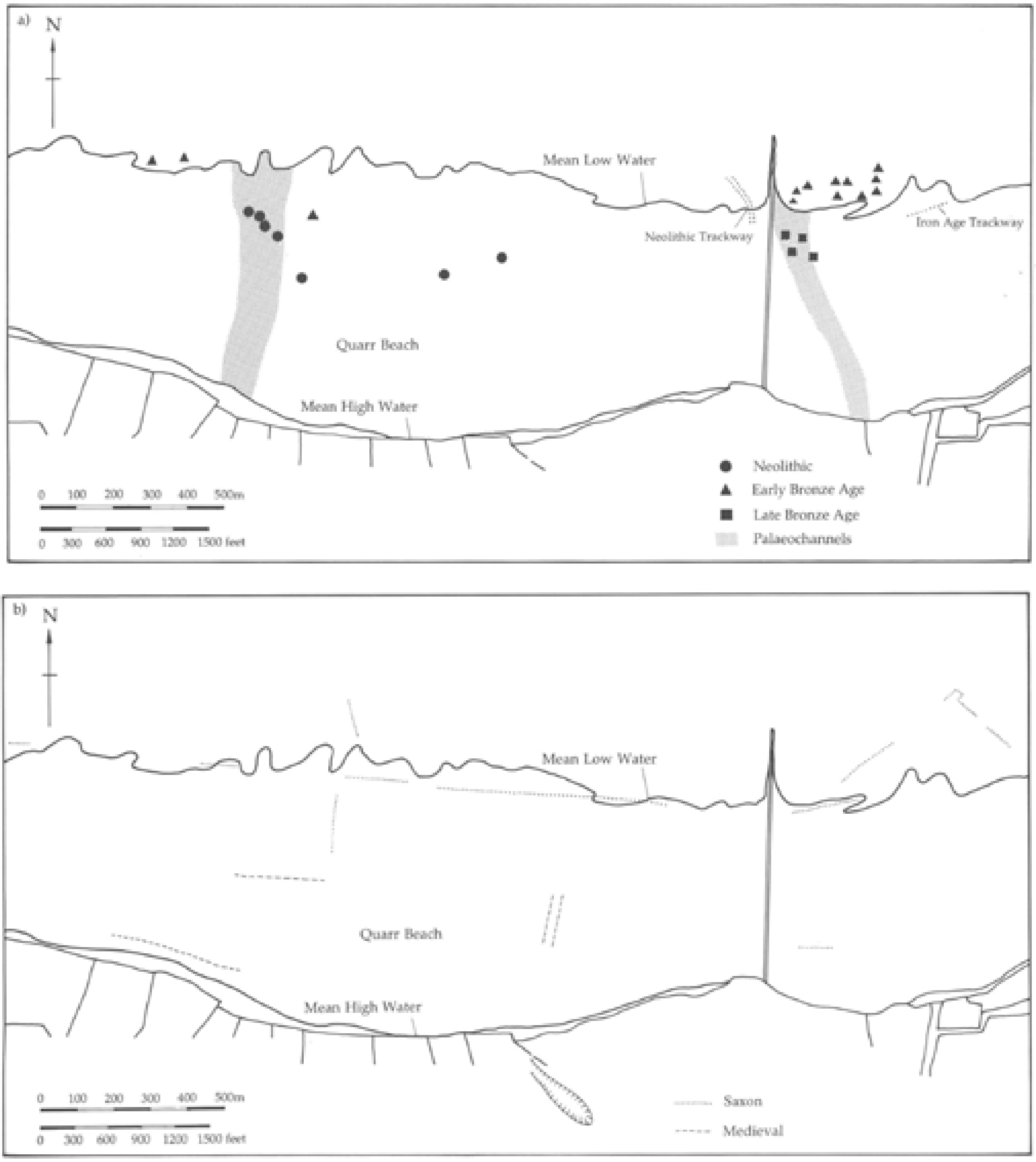


Fig 36 Wootton Quarr, Isle of Wight. (a) The distribution of prehistoric timber structures (Neolithic and Bronze Age) in the surveyed area; (b) The distribution of Saxon and later medieval timber structures in the surveyed area

Coastal survey is also taking place as part of the Humber Wetlands Project which began in 1994 (Van de Noort and Davies 1993). To date, fieldwork, including coastal survey and limited excavation at Withow Gap, Skipsea, has been completed in Holderness (Fenwick *et al* 1995; Head *et al* 1995; Humber Wetlands Survey 1994–5). Intertidal survey does not play a major part in this programme, but continued monitoring at North Ferriby has produced additional important results (Fenwick 1995).

Survey is also currently taking place in Kent in the parish of Seasalter on the north coast between Whitstable and Faversham under the auspices of the Kent Oyster Coast Environmental Survey Project

(Wren and Harrison 1995). The preliminary results of the 1995 season point to the potential of the intertidal zone for all periods from the Palaeolithic to the modern.

These surveys illustrate the growing awareness of the need for proper archaeological investigation in the intertidal and coastal zone. They have been instigated for a number of reasons and have used a variety of survey techniques, some of which have been adapted to the special conditions experienced in the intertidal zone. These and other issues relating to intertidal survey are explained in greater detail below.

5.3 The context of intertidal and coastal survey

5.3.1 Natural processes: rising sea-level and erosion

The visible erosion of archaeological deposits from coastal and intertidal contexts has provided the principal justification for the initiation of field projects. The extent to which absolute and/or relative rise in sea-level has contributed to this process is uncertain (see above, Chapter 2), but it is of special relevance in the south of England where crustal subsidence has been greatest since the last Ice Age.

Much archaeological research has been, and continues to be, reactive to new discoveries or the accelerated erosion of known sites. However, during the last decade projects have developed whose explicit objectives have included consideration of the contribution of archaeology towards the understanding of sea-level change and coastal processes. Thus the research carried out by the University of Reading in the Severn Estuary has addressed a number of interrelated themes which bear on these issues. First, a 'standard' stratigraphic sequence has been obtained for the alluvial Holocene sediments of the Estuary as a whole; the characterisation and dating of this sequence has also provided a wider context for the archaeology of the intertidal and coastal zone. This has been of great importance in distinguishing, in a geologically dynamic area, between primary and secondary contexts for archaeological material in early modern and modern sediments. Second, estuary-wide survey of historic material in the intertidal zone, particularly Romano-British settlement debris, has led both to a clearer understanding of the nature of the sites exposed, and to a general appreciation of the extent, and to some degree timing, of shoreline retreat (Allen and Fulford 1987). This has been followed by more closely focused survey of individual sites where it has been possible to gain a clearer understanding of both the context and the nature of the site (Allen and Fulford 1992). In turn, and in relation to the

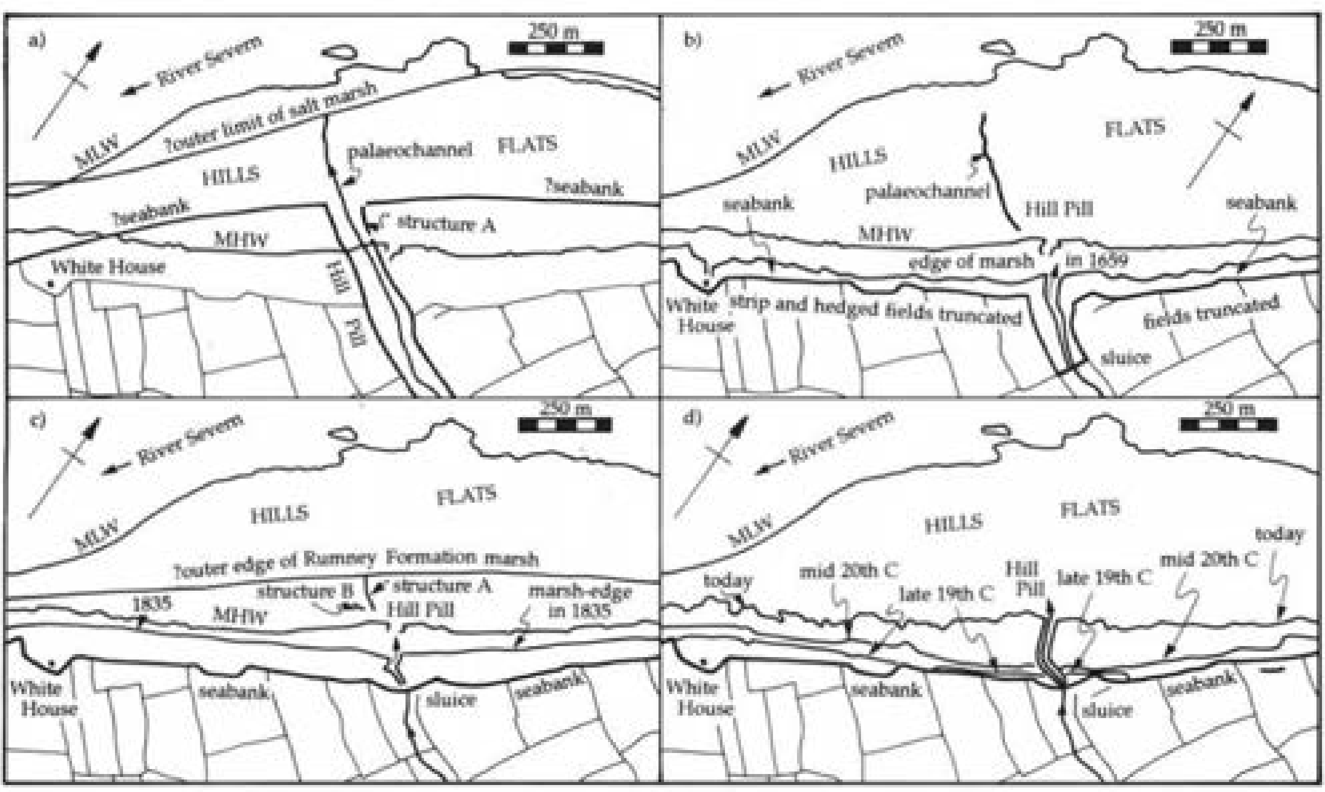


Fig 37 Summary of coastal change at Hills Flats (Glos) over the last two millennia: a) Romano-British to earlier medieval times; b) The mid seventeenth century; c) The early nineteenth century; d) Accretionary phases represented by the Awre Formation (inception late nineteenth century) and Northwick formation (inception mid twentieth century)

configuration of documented and existing sea defences and field patterns, further insight has been gained on coastal retreat and shoreline oscillation in specific locations (Allen and Fulford 1993; 1996). The study of palaeochannels, a common focus of human activity, has been found to be particularly rewarding in gaining a more detailed comprehension of shoreline movement. Gradually a sea– and landscape archaeology of the Severn Estuary and its alluvial wetlands over the last two millennia is beginning to emerge, in the context of a greater appreciation of sea-level and erosional processes.

Similarly, although the initial impetus was development-led, by 1992 a clear set of wide-ranging research aims had been developed for the Wootton Quarr Survey undertaken by the Isle of Wight Archaeological Unit on behalf of English Heritage (Fig 36). The two principal objectives were to provide:

- an overview of the archaeological potential and sea-level chronology of the intertidal wetlands and the submerged landscape of the Solent. This will provide a unifying theme for the other objectives and will culminate in a conceptual framework which can be applied to the coastal archaeological resource of the whole Solent estuarine system and its environs.

- a detailed investigation of the Wootton Quarr coastline chronology

From these principal objectives stemmed a number of subsidiary aims:

- an understanding of Mesolithic and later subsistence strategies developed within the coastal and ria (drowned valley) zone and now largely contained within the intertidal area

- an understanding of the significance of the ria mouth archaeology and the upper and lower valley sediments as indices of human activity and environmental change within the hinterland. This is defined as the catchment area between the river mouth and the head of the river corridor.

- an understanding of the post-inundation Roman and medieval maritime communities at Wootton Quarr including the onshore and offshore ceramic evidence for port of trade activities

- the development of survey and recording techniques, threat-assessment methodologies, and management options for the archaeology of the intertidal zone (Tomalin *et al* 1994, 1)

Although destructive of the archaeology, erosion has assisted the recognition of the early prehistoric landscapes in areas such as the Isles of Scilly and Essex. However, it is largely the rate and scale of erosion, coupled with a long history of past discoveries, which has set the agenda for survey in these areas. In the Isles of Scilly, submerged archaeological sites were first identified by William Borlase, who visited the islands in the 1750s and noted field walls running from the North Hill of Samson under the sea towards Tresco (Borlase 1753; Ratcliffe 1989, 24). This gave rise to theories about the existence of a drowned landscape between the islands, and of another between the Isles of Scilly and mainland Cornwall, known as 'Lyonesse' (Crawford 1927) (Fig 38).

This was explored further in Charles Thomas's *Exploration of a drowned landscape* (1985), which reviewed the archaeological and place-name evidence to demonstrate the post-glacial rise in sea-level (Figs 89–90). It was estimated that sea-level had been rising at a rate of approximately 2.4mm a year since 1900 (Thomas 1985, 21). As a result of work by Crawford, and more recently by Thomas, a programme of coastal monitoring was initiated by English Heritage, who sponsored the Cornwall Archaeological Unit to publish *The archaeology of Scilly* (Ratcliffe 1989). This laid out the priorities for the future of archaeology in the Isles; these included the regular monitoring of the cliff face and beach deposits that were known to exist, and the execution of further fieldwork to identify and record new sites (Ratcliffe 1989, 95).

Intertidal fieldwork had early origins in Essex, where, in 1911, Reader found a Neolithic floor exposed at low-water on the south bank of the river Crouch near the village of Hullbridge (Reader 1911). By the 1930s, further research (Warren *et al* 1936) had identified other exposures of the 'Lyonesse' land surface at a number of locations including Walton-on-the-Naze, Stone Point, and the Clacton area. The old land surface was found sealed under marsh clays and estuarine silts representing periods of Holocene transgression, and bands of lower and upper peats representing regression. The erosion and removal of these overlying layers has revealed important Mesolithic and further Neolithic occupation sites.

The recognition of the potential of the foreshore for archaeological discovery, and the threat posed to this by erosion, led to a programme of survey in Essex stretching from June 1982 to June 1987 (Wilkinson and Murphy 1982–88; 1995). An initial reconnaissance of each chosen survey area was undertaken, in which preliminary artefact collections were made and sites and contexts were plotted on 1:10,000 maps. This was followed by the full recording of sites, submerged forests, wooden structures and exposed sections, and collection of environmental samples. More detailed contextual work was carried out by using augers to plot buried land surfaces and subsurface topography, and by levelling to determine the height of individual sites in relation to OD. Even at this level of survey most sites were allocated little more than one tide (3–5 hours)

Fig 38 Submerged field walls, Appletree Bay, Tresco, Isles of Scilly. The parallel boulder walls in the foreground are the remains of a prehistoric field system; the circles and irregular shapes in the background are natural arrangements of boulders and seaweed (Cornwall Archaeological Unit)

and, with the exception of one site (the Stumble), the most comprehensive investigation of any site took less than a week of low tides (Wilkinson and Murphy 1995, 3). The Hullbridge Survey has set the pace for later surveys to follow, advocating the need for 'guerrilla' tactics, ie rapid reconnaissance between the tides, snatching pieces of information before removal by erosion or concealment by mobile sediments.

Following the findings of the Hullbridge project, a pilot survey of the Lincolnshire coast was undertaken in 1989. The Lindsey Coastal Survey assessed the state of previously identified areas of post-glacial deposits with archaeological potential (Brookes *et al* 1990). The work in Essex had already identified the quality of archaeology on the east coast and it was hoped that the Lindsey survey would provide a better picture of a rapidly eroding coastline between Fiskney and Tetney. The area selected for survey was chosen on the basis of potential for discovery and threat from erosion. Previous intertidal discoveries had included Iron Age and Roman salt-working at Ingoldmells Point (Warren 1932).

Further north on the east coast, a survey was completed in September 1994 of the mainly cliffed coastline from Seaham Harbour in Durham to Whitby in North Yorkshire as part of the North-east Maritime Archaeology Survey (Buglass 1994). Erosion is occurring at an average rate of 50mm a year in such places as Robin Hood's Bay (G Marshall pers comm). This stretch of the coast is particularly rich in post-medieval industrial remains in the form of harbours, trackways, and buildings on the cliff edge and on the foreshore (Figs 39–40). Erosion is therefore removing a varied and important post-medieval industrial heritage which has only recently been recognised. Further north in Northumberland, erosion is removing parts of the coastline while accretion is covering other areas (Northumberland County Council 1994). The lack of information on the rate of erosion and the effects it has on archaeology prompted the need for the coastal management plan and coastal monitoring, with emphasis on the effect of erosion at the shoreline rather than systematic survey in the intertidal zone.

5.3.2 Development threats

Whereas the Hullbridge, Lindsey, and Isles of Scilly surveys developed out of a long history of previous research, fieldwork in advance of development has significantly broadened our understanding of the archaeological potential of the coastal and intertidal zone. Although a number of chance finds had instigated a series of archaeological interventions on the Gwent coast of the Severn Estuary, development pressure led to an attempt to create an estuary-wide overview of the archaeological resource in the intertidal zone. In January 1988, the Severn Tidal Power Group proposed a tidal barrage across the Severn from Brean Down to Lavernock Point on the Welsh shore, and a survey of both sides of the estuary was commissioned by the Severn Estuary Levels Research Committee. The rapid six-month assessment was carried out on the English side by Richard McDonnell and Vanessa Straker working with the planning departments of Somerset, Avon, and Gloucestershire. This survey largely drew on information contained in local records (Severn Estuary Levels Research Committee 1988). Since the barrage scheme has not advanced further, no further estuary-wide evaluation of the archaeological resource has taken place.

A more localised development in the Severn Estuary is the Second Severn Crossing, where a preliminary survey was carried out as part of the Environmental Statement accompanying the Severn Bridges Bill, which was put to Parliament in 1990. The crossing lies between the Gwent coast near Caldicot, and Severn Beach and New Passage on the Avon shore. The preliminary evaluation on the English side of the estuary by the Glamorgan-Gwent Archaeological Trust (GGAT) took place over a nine-week period in June to August 1991 (Lawler *et al* 1992, 1). The project aimed to survey both the dry land and intertidal areas affected by the construction, but as the dry land sites were often too deeply buried beneath alluvium for thorough investigation, the sites on the foreshore assumed greater importance. The Welsh side of the estuary produced a considerable amount of information, including finds of a Palaeolithic handaxe, Romano-British pottery, hurdle work, and the remains of fish traps (Godbold and Turner 1994), but the evaluation of the English approaches to the crossing found very little intertidal data. On the English side the crossing is at English Stones, a rock platform with tidal channels and pools which have been used for fishing up to the present day. However, only two structures were found, both possible post-medieval fish traps. The Holocene silts and clays found in the intertidal zone on the Welsh side of the estuary were mostly absent on the English side, thus reducing the chances of finding archaeological sites (Lawler *et al* 1992, 35). This was the first systematic survey of a limited area of the intertidal zone to have been undertaken in the Severn Estuary, and it drew attention for the first time to the potential for understanding the development of fishing in the estuary.

Following the evaluation stage, rescue archaeological investigation was carried out on the Welsh side of

Fig 39 The alum industry at Hummersea Banks, Yorkshire; remains of brick-fronted furnaces suspected to be a range of boiling pans belonging to the alum house (The National Trust)

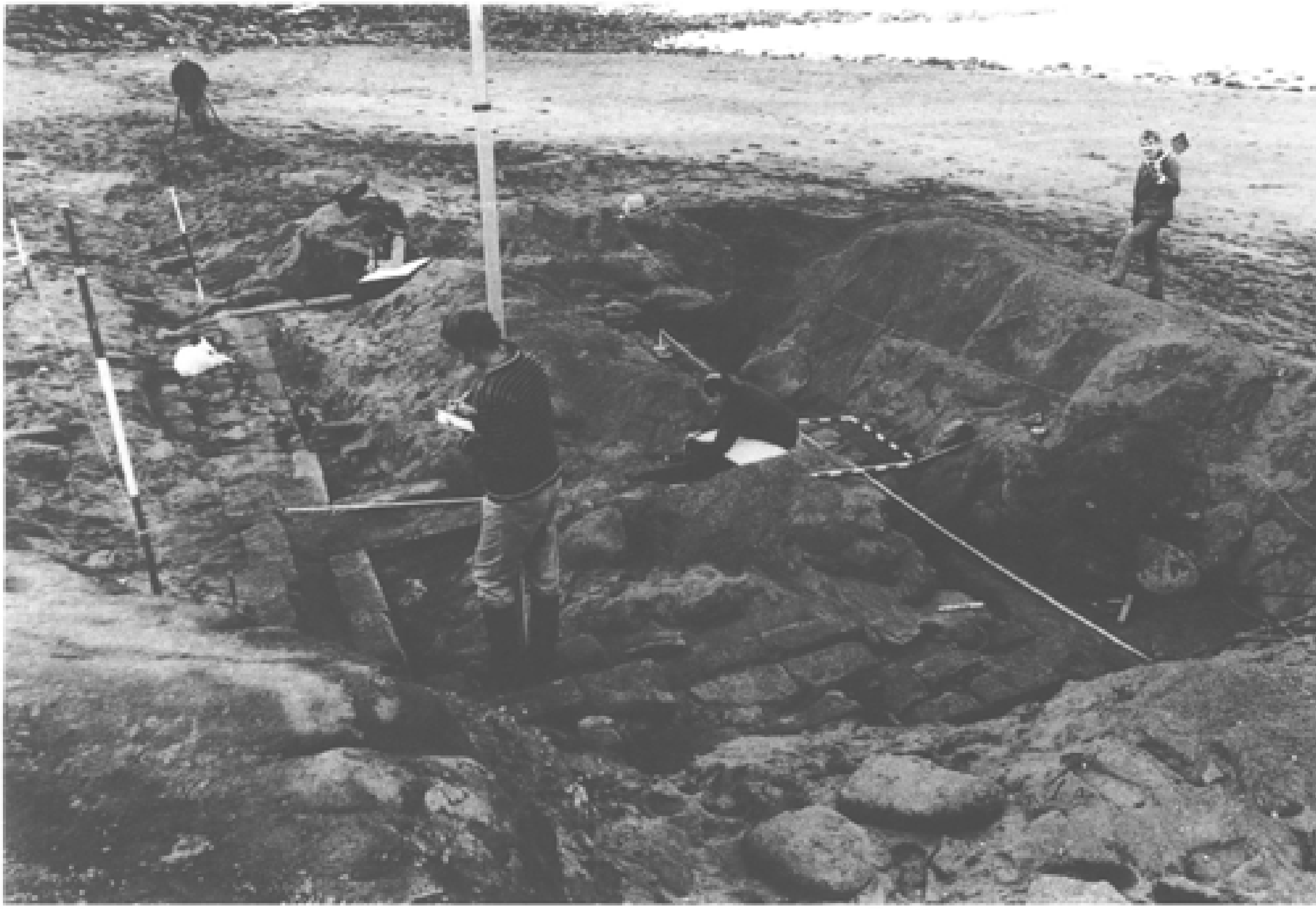


Fig 40 The alum industry at Saltwick, Yorkshire; remains of tank No. 1 belonging to the former Saltwick alum house. View of the south wall (left) and the east compartment of the tank in the foreground. The north wall lies below the planning frame (The National Trust)

the Severn by Cadw for the Welsh Office Highways Directorate. The results of the project were published in the *Annual Report of the Severn Estuary Levels Research Committee* and the *Second Severn Crossing, archaeological response phase 1. The intertidal zone in Wales, final report* (Godbold and Turner 1993). The Trust for Wessex Archaeology carried out the work on the English side. However, by the time the Trust was authorised to start work, building had already begun in the intertidal zone, and further archaeological work was confined to the dry land zone.

In the Isle of Wight the main impetus for the initial survey at Wootton Creek was the disturbance caused to the foreshore by ships' wash. However, the potential of the site had already been recognised in 1981 when Roman and medieval finds were observed in the intertidal zone. More finds emerged by the autumn of 1984, including a scatter of Roman bronze coins found by metal detectorists. It was the threat from the ferries that prompted a systematic survey of the east side of the mouth of the Creek (the East Shore Zone), which was later extended along the Quarr and Binstead Beaches. The survey has since become a research-based project to enhance the SMR while aiming at a better understanding of the development of the later Holocene landscape and environment of the north shore of the Isle of Wight (5.1, 5.3.3). It is the first systematic multi-period survey to have been undertaken in the Solent, and the results have, *inter alia*, drawn attention to the rich array of prehistoric timber arrangements (?fishing structures) surviving from the Neolithic onwards. A preliminary assessment of the results of the survey between 1989 and 1994 was produced in a draft report submitted to English Heritage (Tomalin *et al* 1994).

Another development-led survey was carried out in Whitewall Creek in Kent. Situated opposite the historic Chatham Docks, the creek was littered with nineteenth- and twentieth-century barge hulks which were threatened by the road scheme for the Medway Tunnel. The fieldwork was conducted in 1992, when the remains of over 40 vessels, including spritsail barges, swimhead barges and lighters, a heavy lifting barge, concrete lighters used in the D-Day landings, and three World War II wooden mine-sweepers were recorded (Milne *et al* forthcoming). The threat of destruction meant that the consultants for the project had only a few days in which to design and implement a rapid recording and photographic survey of the vessels. The survey took place between 20 August and 6

September 1992, by which time the contractors had begun clearing the hulks from the site. Kent County Council funded the project. The Archaeological Unit of the County Council, with funding from the RCHME, subsequently compiled a list of barges and hulks in the rest of Kent on the evidence of aerial photography as part of the recording programme associated with the compilation of the maritime records held by the NMR(see below). This is the first survey to have attempted a systematic survey of early modern and modern craft in the intertidal zone.

Other post-medieval vessel remains are also threatened by human interference. In 1969, the famous eighteenth-century wreck of the *Amsterdam* off Bulverhithe between Hastings and Bexhill was 'salvaged' by treasure hunters using a mechanical digger. The many valuable finds from the wreck were treated as commercial salvage and few were conserved. The wreck was investigated by divers and archaeologists in 1984 and it was found by geophysical survey that two-thirds of it survived under the sand (Marsden 1987, 26). The level of preservation, the richness of the artefacts, and the documented history of the *Amsterdam* have ensured its protection by legislation, but other wrecks are less fortunate.

5.3.3 Data enhancement and research

The need to enhance our understanding of the intertidal zone and to enrich the NMR and county SMRs in order to achieve better management of the archaeological resource is often advanced as a principal aim of intertidal surveys. The examples cited here complement those projects whose research objectives have already been discussed above in 5.3.1–2, where SMR enhancement is implicit.

The main aims of the maritime survey of north-east England involved the identification of sources of data, and the provision of new and enhanced records for the NMR Maritime, the SMRs of Cleveland, Durham, and North Yorkshire, and for the North Yorkshire Moors Archaeologist. Another aim was to raise public awareness of maritime archaeology in the north-east, with the intention of increasing the chances of identifying new sites.

The Langstone Harbour Archaeological Survey Project falls best into this category. The project is a long-term, multidisciplinary survey and research project using a range of archaeological and other techniques over several seasons of fieldwork (Allen, M *et al* 1994, 1). The archaeological aims of the project are:

- to provide a full database of known archaeological sites in Langstone Harbour, and to map the known resource chronologically
- to record the real and predicted biases in the database
- to assess the potential for the development of predictive models for the position and potential for future recovery of archaeological data for each period
- to provide a methodological statement for the future study and management of intertidal archaeological resources (Allen, M *et al* 1994, 1).

Research was also aimed at testing methods of survey such as Global Positioning Systems (GPS).

The survey of Bridgwater Bay commissioned by the RCHME (see above) was also designed to enhance the NMR. This resulted in the doubling of sites known previously from documentary sources with the recording of 38 new sites and areas. The latter included two fishing grounds, with many individual fish weirs and fish weir ranks which comprised the majority of the individual new records (McDonnell 1995).

5.4 Methods of survey

5.4.1 Characteristics and problems of coastal and intertidal survey

Although the methods of survey differ very little from land-based techniques, several adjustments must be made to take account of the particular conditions experienced in the intertidal zone, which often hinder fieldwork. Survey methods used must be both as rapid and as accurate as possible, to overcome the limited amount of time available between tides. The area exposed will vary between Spring and Neap tides, and the amount of time available for study will diminish the further seawards and the deeper into the intertidal zone the survey progresses. Thus structures which are only exposed at the lowest limits of Spring tides will be accessible for only a very few days and hours each year. Conversely, more time will be available for archaeology in the upper reaches of the tidal range. Conditions will vary from day to day, week to week, and season to season, and will therefore influence working practice, but irrespective of tidal regime, continuous working in the intertidal zone is not possible.

In Essex it has been found that the best time of year to undertake survey is midsummer, when there are longer hours of daylight and low tides (Murphy and Wilkinson 1991, 10). In the Severn Estuary this situation is reversed because there is generally less sediment on the foreshore during the winter than during the summer, and therefore greater viability of the potential archaeology; however, researchers face the problem of having fewer daylight hours, and therefore reduced working time, during the winter months, in addition to often cold and wet conditions.

The Welsh side of the Second Severn Crossing was surveyed between mid-August and mid-November. In the summer months, tides allowed two visits a day over two periods of four to five days each month. This allowed a six-and-a-half-hour working day (Godbold and Turner 1993, 6). However, as the daylight hours shortened, only one visit a day was possible, and on the occasions when the tides were high, or winds blew from the south-west, working time was shortened to as little as two hours or even none at all (Godbold and Turner 1993, 6). Similar difficulties with weather and tidal conditions constrained the survey of Bridgwater Bay (McDonnell 1995, 14–19). It is, therefore, essential to take account of both the climatic and tidal factors when planning a survey project.

One major difficulty in surveying and excavating in the intertidal zone is the condition of the foreshore. The accretion of soft, muddy sediments is a particularly acute problem in estuarine environments, and shifting sand and shingle present difficulties on open coasts. Unless it is possible to erect caissons, each tide will reintroduce sediments to areas that have been cleaned; any detailed planning and excavation will therefore inevitably take longer than on land. In Langstone Harbour, mud is accreting on the western shore and 'proved difficult to work in with team members sinking over their wellies at every step' (Allen, M *et al* 1994, 2). Despite the archaeological potential, further survey of this area was subsequently abandoned. Similarly, in the Lindsey Survey, a considerable stretch of the coastline between Mablethorpe and Humberston was smothered by recent sediment, and its archaeological potential, already indicated by earlier work, could not be assessed (Brookes *et al* 1990). In the Isles of Scilly, fieldwork tended to take place in the spring and summer to monitor the effects of winter storms on cliff-face and beach sites. As the Isles do not have any river estuaries producing large amounts of mobile sediment in the water, the problem of thick, sticky mud is not experienced. Instead, constantly moving sand and shingle temporarily cover archaeological deposits. In the Severn Estuary, as noted above, it has been the experience that the winter months, when stormy conditions which remove mud or prevent its deposition tend to prevail, have provided the cleanest conditions for archaeological work. Although mobile deposits of mud were reduced during the course of the winter survey of Bridgwater Bay, there was limited clearance in the mid and lower tidal ranges (McDonnell 1995, 16). Such problems highlight the need to monitor foreshores and the intertidal zone on an opportunistic basis, generally after storms, because these are likely to remove sediments and shingle to reveal new sites. Indeed, without prior assessment of conditions, any general or rigid programme of survey in the intertidal zone is liable to prove fruitless.

In order to make a coastal survey cost- and time-effective it is important to ensure that fieldworkers can be employed elsewhere during the hours when access to the intertidal zone is impossible. In this context it may be appropriate to combine coastal with off-coast activities. Gaps in fieldwork in Essex allowed workers on the Hullbridge Project to undertake post-survey work and artefact analysis (Murphy and Wilkinson 1991, 10). An original aspect of the Wootton Quarr project is that fieldworkers were also employed on a survey examining the colluvial history of chalk combes in the hinterland of the coastal survey. In 28 days of survey, 43% of the time was spent on intertidal survey and it was estimated that a full survey of this scope could not be undertaken in less than 18 months if it were to take advantage of all the opportunities offered by tidal conditions. An estimated 20% of the time was taken up by analysis of intertidal field data, and 22% was taken up with the hinterland survey (D Tomalin pers comm). For the proposed 88-week extension to the Isles of Scilly monitoring programme, fieldwork is to be spread over six years. Twenty-four weeks of the project time are to be spent in the field, with 48 weeks spent on post-excavation and writing the annual report, and 2 weeks per year set aside for preparation (Cornwall Archaeological Unit 1994, 11). An extra period of survey is planned to take place between September and October, when the maximum area of foreshore is exposed at low Spring tides.

The nature of the coast is such that access points for vehicles are limited. There is no choice but to reach sites in the intertidal zone on foot, and large amounts of equipment cannot be carried easily. In the Wootton survey, on the Welsh side of the Second Severn Crossing, and at the Stumble in the Blackwater Estuary in Essex, large wire cages have been used to store equipment in the intertidal zone on a long-term basis. For the Second Severn Crossing, one equipment cage was set up initially, but in order to complete the project three others had to be set up to store shovels, hoes, and ranging rods where they were needed along the foreshore (Godbold and Turner 1993, 5). Other pieces of equipment such as buckets and hoses were secured on site with ropes and were left with the planning frames (made from reinforcing mesh) to be covered by the tides. However, the more delicate equipment such as cameras, tripods, pumps, and batteries had to be carried daily to the sites (Godbold and Turner 1993, 6). Such arrangements for the storage of heavy equipment are vulnerable to sudden storm; the possibility of total loss has to be foreseen. In some cases fieldwork is only possible with the aid of a boat for reasons of both access and safety. In the Isles of Scilly access by boat is, of course, a necessity. At the Stumble, Essex, the use of a small boat was essential for transporting soil samples, which could be loaded into the boat at low tide and floated ashore on the flood tide (Murphy and Wilkinson 1991, 12). In the future greater thought needs to be given to alternatives such as light sledges or small hovercraft, in order to overcome the logistical difficulty of transporting equipment, finds, and environmental samples in the intertidal zone.

Special safety conditions apply in working in the intertidal zone. In Bridgwater Bay, assessment of Gore Sand and Stert Flats took place between June and July 1993 and the winter of 1993–4. This survey required the use of a boat because of the encircling effect of the river Parrett and the channel between Fenning and Stert islands. The flooding tide flows in, not from the seaward side of the flats, but from the landward side, in a way which is potentially hazardous to fieldworkers (McDonnell 1993, 46). It is therefore essential to establish local tide and current conditions before undertaking any survey. Given these conditions it is also essential that fieldworkers should operate at least in pairs. The use of mobile phones and/or two-way radios is also essential, as is a prismatic compass to give direction in case of poor weather conditions and fog. McDonnell usefully lists the safety equipment used during the survey of Bridgwater Bay, and outlines safety procedures (McDonnell 1995, 13–14).

Access and fieldwork are also restricted by the ownership of the intertidal area. The Langstone Harbour Project took place in an area designated as an RSPB reserve and fieldwork was therefore restricted to a ten-day period between the breeding season and flocking prior to migration (Allen, M *et al* 1993, 1). The area is also designated as an SSSI, and care had to be taken not to disturb wildlife. Restrictions on coastal surveys for safety and security reasons may obtain in areas owned by the Ministry of Defence.

However, there is one form of survey which poses no problems of access relating to ownership of land or physical accessibility, because the surveyor need never set foot on the area being surveyed. Aerial photographic survey allows access to otherwise inaccessible areas and reduces the need for working in what can be an extremely unpleasant and often hazardous environment. Nevertheless, it is not without its own difficulties. One major problem is that the small-scale nature of much of the archaeological record means that it will not easily be picked up from photographs above a certain scale. Other obstacles will be discussed in greater depth below (5.4.3).

The problem of accurately locating sites applies to both ground-based and aerial reconnaissance. Where sites are located near the sea-wall, it is possible to tie in the position and the level of the site with an EDM. However, if a site is located near low-water mark on an extensive intertidal flat, it is less easy to fix its position. To a certain extent this can be achieved using aerial photography, providing that the site is large enough to be visible and that the coastline can also be seen on the photograph. Sites in Bridgwater Bay have been located using prismatic compasses and landmarks on the coast, but although the prismatic compass is very portable, it is not necessarily the most accurate method of survey. Another approach to the problem of location is to use GPS (see below).

The archaeological resource in the intertidal zone is in a similar condition to a partly completed excavation, and recording it presents its own distinctive problems. Major features, such as prehistoric houses and trackways, or alignments of timbers related to fishing, are exposed and thus vulnerable to continuing erosion. In order to begin to understand all these elements, dating is an essential requisite for planning. A higher proportion of surveys in the intertidal zone than on dry land have to be prepared to meet the costs of dendrochronological and radiocarbon dating if their efforts are to be maximised.

Dating

Although the use of dendrochronology is preferable wherever possible because of its accuracy, it should be noted that even on wet, intertidal sites, the majority of timbers and structures are not datable by this technique. Three major coastal projects have been have been dated through English Heritage's Ancient Monuments Laboratory in the last decade (A Bayliss, pers comm):

Hullbridge, Essex		
	^{14}C	*c* 30% again of total cost of survey
	dendrochronology	negligible cost (timbers unsuitable)
Isles of Scilly		
	^{14}C	*c* 13% again of total cost of survey
	dendrochronology	none
Wootton Quarr		
	^{14}C	*c* 10% again of total cost of survey
	dendrochronology	*c* 5% again of total cost of survey

The relative cost of radiocarbon dating has come down slightly since the completion of the Hullbridge dating programme (1982–9), so a realistic estimate for the cost of the scientific dating required by these projects is 10–25% again of total cost. For intertidal survey a larger percentage of dating is required at an earlier stage in the project than would be the case in dry land surveys, in order to guide the fieldwork strategy and post-excavation assessment. For Wootton Quarr some 35% of radiocarbon samples were submitted before the analysis phase (on average this figure is only 10-15% for all archaeological projects).

Artefacts

More conventionally, and in line with field survey on land, it is essential to characterise the scatters of artefacts which are a major component of the archaeological resource in the intertidal zone. Just as a palaeoenvironmental specialist would be an essential member of a team surveying submerged forests or peat ledges, so, too, would an appropriate specialist be required to gain full value from a survey embracing ship and boat remains.

5.4.2 Pre-fieldwork research

5.4.2.1 Written and oral sources and museum collections

Most projects have researched the existing archaeological literature for the area of a proposed survey, and sometimes the historical literature as well. This has drawn heavily on the county SMRs, as well as other published sources, museum collections, and individuals with local knowledge and experience. In the case of the Severn Tidal Barrage assessment, 118 sites were identified on the English side of the estuary. Of these, 42 had already been recorded in the SMR, but additional documentary research, reviews of museum collections, and interviews with individuals increased this number to 115. Only 3 sites were discovered through fieldwork and, owing to lack of time, only 58 sites in total were visited in the field.

The North-east Maritime Archaeology Survey has identified nearly 2000 records relating to coastal archaeology. Many references to sites include accounts of vessel sinkings and reports of fishing nets snagging, but without further research these can only be considered potential wreck sites. Information has been recovered from museum, library, and other documentary-based research as well as by contact with local diving clubs, fishermen, and knowledgeable individuals. It required a considerable amount of time to establish and maintain these contacts. Thus, the estimated breakdown of project time suggests that 26% of the time was spent on documentary research, 8% on public relations, 9% on beach walking, 23% on administration, 12% on lectures and courses, and 22% on personal contacts (Buglass 1994, 23).

Any research which draws on previously published information or other documentary or oral sources can only be as good as those sources. This survey has suggested that the records as currently summarised in county SMRs are often inaccurate because of wrong attributions or identifications. This is probably a particularly serious problem with prehistoric flintwork (see below). Even relatively recent work, such as Bradley and Hooper's survey of Langstone Harbour (1975), can be overtaken by new developments. Although most of the pottery recovered in the 1960s was originally interpreted as Iron Age, Bradley (below, Chapter 7) now considers much of it to be of Bronze Age date. Many 'Neolithic' flints have also now been attributed to the Bronze Age, suggesting that there was considerable activity across the coastal plain at that time (Allen, M *et al* 1994, 3). The earlier work of Roe (1968; 1981) on the Palaeolithic, and Wymer (1977) on the Mesolithic, which includes coastal sites, is also being reviewed by the Southern River Valleys Palaeolithic Project sponsored by English Heritage and carried out by the Trust for Wessex Archaeology.

5.4.2.2 Geological and sedimentological context

Gaining an understanding of geological context and local sedimentary regimes has proved of inestimable value in the Severn Estuary. Three major contributions can be summarised here. Firstly, the establishment of a 'standard', estuary-wide, Holocene alluvial stratigraphy and its chronology has allowed vital distinctions to be drawn between material in primary settings and material reworked into secondary contexts (Allen 1987; Allen and Rae 1987). Secondly, understanding the relationship between episodes of accretion and erosion has been helpful in determining shoreline oscillation over the last two millennia (idem; Allen and Fulford 1992). Thirdly, the assessment of elevation differences between active saltmarshes and land surfaces identified either in the intertidal zone or behind the sea-bank has been essential in determining the date of those land surfaces (eg Allen and Fulford 1990a, b).

5.4.2.3 Aerial photography

The role of aerial survey will be discussed in detail below, but it is important to stress that the study of existing photographs, even if they were not taken for archaeological or historical purposes, is an essential prerequisite in the assessment of context prior to ground survey.

5.4.3. Aerial photographic survey

Aerial photographic survey is not a single process, but an umbrella term for a number of different activities which can be broken down into three categories. Each of these has so far been used in only a very small number of cases in the intertidal zone.

5.4.3.1 Large area/small scale survey

The first category is large area/small scale survey. The obvious examples are the RCHME's National Mapping Programme (NMP) surveys in Essex and Lincolnshire (and, to a certain extent, Kent), with Cornwall and the East Thames Corridor survey (forthcoming).

Fig 41 Kilnsea, Humberside, three miles north of Spurn Head on the North Sea coast. The photograph illustrates dramatically the effect of coastal erosion both on the modern caravan park and on the circular WW II gun platforms, one of which has already been cut in half (centre/middle). NMR 12364/49. (RCHME © Crown copyright)

The working method for the NMP is to examine all available photographs, interpret the sites, and transcribe them onto overlays to the Ordnance Survey 1:10,000 base maps (henceforth quarter sheets). In many cases manual transcription is acceptably accurate, but where there are unusually complicated sites or problems with positioning computer rectification is employed. So far only two NMP projects have covered any significant area of the coast. In the case of the Lincolnshire survey, a total of 13 quarter sheet maps were examined, covering approximately 55km of coastline. The survey examined the defined intertidal zone between mean low-water (MLW) and mean high-water (MHW), but also extended above this zone up to the sea defence walls. The areas covered included beaches, sand dunes and saltmarsh. Only photography held in the collections of the NMR was consulted, and no oblique cover was available. The cover was almost exclusively black and white, with an average scale of 1:10,000. The dates ranged from RAF cover as early as 1943 to Ordnance Survey cover from 1978. The total number of frames examined was not recorded, but from the sheets where a record was kept there were on average 8–10 frames per kilometre of coastline. The state of tide varied, but there was never visibility through the water.

A total of 18 sites were recorded in the 55km Lincolnshire coastal stretch, of which 2 were salt workings, 8 military sites (pillboxes, slit trenches, batteries etc), 3 modern features, and 5 of unknown date and function. The salt workings had been recorded previously, but the other sites were new. As well as the five sites of unknown date and function, several other possible features, generally linear banks and circles, were noted but not recorded, as they were thought to be possibly natural. Of these features, only the two salt working sites and one pillbox came from the intertidal zone.

In the case of the Essex survey, only eight sheets of the coastal zone have so far been completed, but they are producing much more positive results (Strachan 1995). The coastal survey started on the north side of the Thames Estuary and has proceeded eastwards around the coast. Photography held by the NMR, Cambridge University Committee for Aerial Photography (CUCAP), and Essex County Council (ECC) was consulted. The ECC material includes the results of the targeted reconnaissance programme. It is planned to consult the Environment Agency Anglian region, who are known to have tide-specific coverage of the coast.

The first sheets in the Estuary west of Canvey Island produced only two groups of oyster pits, but the results have improved as the survey has progressed eastwards. The project staff are currently working in the area around Foulness Island where one quarter sheet alone has produced 12 groups of oyster pits, 4 former harbours, 3 rectilinear enclosures on the salt-marsh, and 2 former sea-walls. There were no previous SMR records for any of these features, although some appear on the 1st edition OS maps. The project staff consider it likely that the number of sites will continue to increase as they pass into the main areas of the rivers Crouch and Blackwater.

A form of aerial photographic survey was used for the Kent Coastal Management Strategy and the survey of the North Kent Marshes. Kent County Council employed Alison Gale to look at aerial photography taken for the county between 1961 and 1990 as part of a joint project (above, 5.3.2) with the RCHME, funded as part of the recording programme associated with the compilation of the maritime record of the NMR. Over 250 vessel sites were identified, but it must be stressed that the photographs were examined only for vessel sites and were not used to record all sites, as would be the normal practice of the RCHME.

5.4.3.2 Small area/large-scale survey: survey as a locational aid

The second category of aerial survey involves small area/large-scale survey. The only examples noted so far are the Isle of Wight survey by David Motkin of the Isle of Wight County Council and the Langstone Harbour Project, undertaken by the Trust for Wessex Archaeology. These are not specifically archaeological aerial photographic surveys in the true sense, as they did not record the archaeology from the aerial photographs, but merely created a stable base tied in to the National Grid within which a standard terrestrial survey was carried out. There seems to be no good reason, however, why the methodology developed for these surveys should not be used in aerial photogrammetric surveys, and it may be helpful to record it here.

In the Isle of Wight, a series of 22 markers consisting of 2ft (*c* 0.6m) square plywood sheets painted with black and white triangles were laid out on the beach as the tide went out, secured in place through a hole in the centre. These markers were then surveyed using a Total Station Theodolite. They were arranged in three groups of six at the beginning, middle, and end of the proposed sortie run, with additional markers spaced out in between. Cambridge University Committee for Aerial Photography (CUCAP) then flew over the site taking a series of stereo photographs from which they provided 1:4000 film diapositives to University of Portsmouth Photogrammetric Department. In turn the latter produced a digital terrain model (DTM) on a 5m grid with altimetric accuracy of 0.2m. From this David Motkin was able to construct contour plots of the area

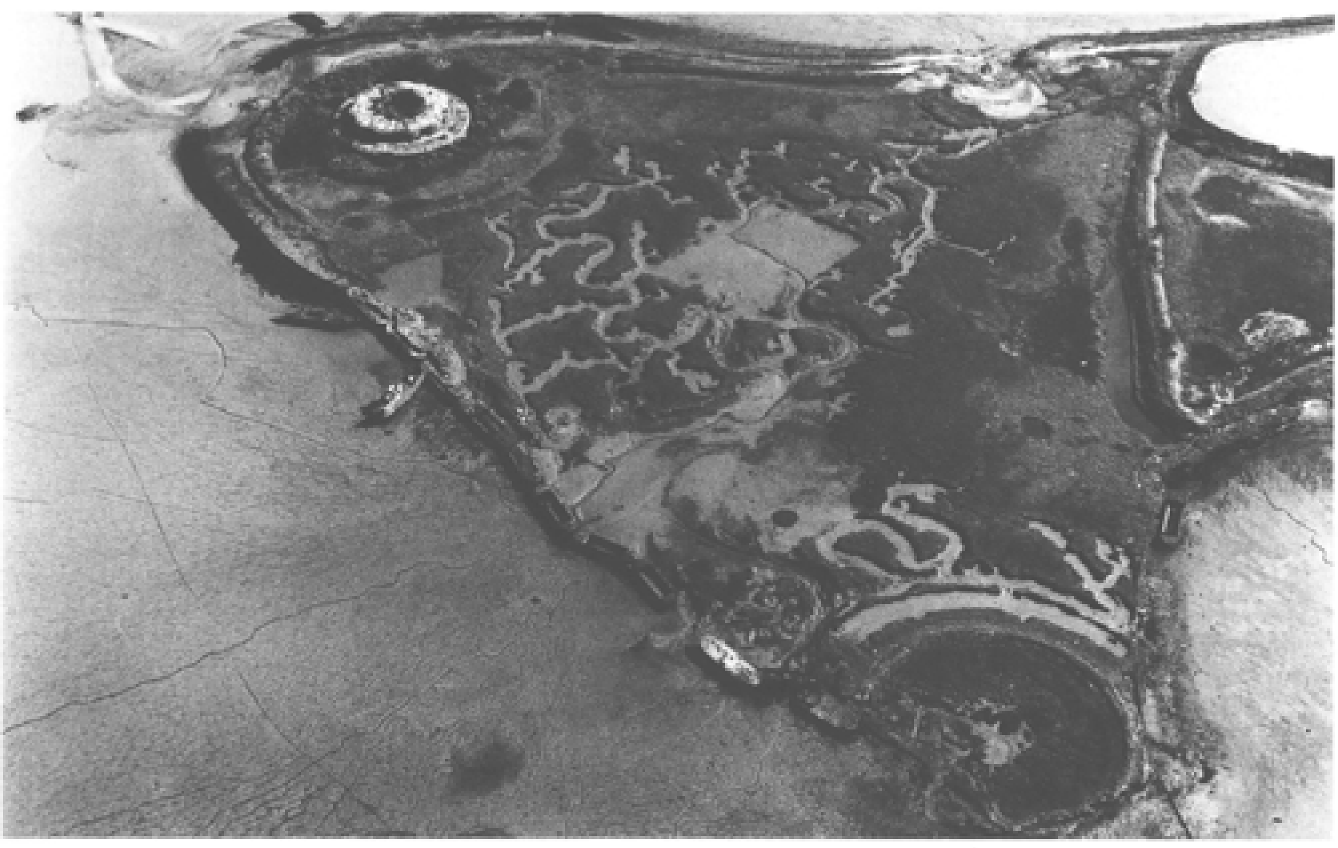


Fig 42 Hoo Fort on the river Medway, Kent, with sea defences constructed from barge hulks. TQ 7970/16 (RCHME © Crown copyright)

Fig 43 Barge hulks on Funton Creek, river Medway, Kent TQ 8969/4 (RCHME © Crown copyright)

at 0.2m intervals, which allowed him to set the archaeology, which had already been surveyed using conventional methods, in a topographical context. Although the University of Portsmouth was able to produce the DTM and plot features, not many hitherto unrecorded features emerged.

The Langstone Harbour Project used the same basic methodology but went a stage further by using a high-precision differential Global Positioning System (GPS) to check the accuracy of survey and tie it into the OS National Grid. The project used an aerial survey undertaken by the University of Cambridge in July 1992 at very low tide using a specialist metric camera. Colour photographs were taken at a scale of 1:5000 to allow accurate mapping to a planimetric scale of around 1:500 when plotted in the Leica DSR 14 analytical photogrammetric plotter (Allen, M *et al* 1994, 12). The output from the plotter was digital, and could therefore be used to create a GIS map. Before the photographs could be used for mapping, a network was constructed of very accurately surveyed points visible in the photographs. The Langstone Harbour Project is the only intertidal project where extensive use has been made of Global Positioning Systems (GPS). This was only possible through the time and equipment donated by the Department of Geology at the University of Portsmouth. The accuracy of GPS depends on the type of GPS receiving equipment. Although it is possible to use relatively cheap receiving equipment to locate sites within an accuracy of 100m, more expensive systems of the order of £25,000–£50,000 per set are required to obtain accuracy within 5mm.

A fixed position was taken on an Ordnance Survey Triangulation Pillar at Fort Purbrook, so that subsequent results could be fitted into the National Grid. A control network was formed from a 20m grid of spot heights from the whole harbour, and a 10m grid from North Binness Island (Allen, M *et al* 1994, 12). A roving receiver was used to establish control and record individual points, and outline more extensive features. The GPS was used in conjunction with the Total Station Survey of the auger holes, survey grids, and recorded cliff sections. The resulting data could then be fed into the GIS which, together with the archaeological data, was used to create terrain modelling of archaeological distributions and to determine landform development and erosion/deposition sequences (Allen, M *et al* 1994, 1). However, as with the Isle of Wight Survey, most of the archaeology was recorded on the ground using conventional recording techniques.

5.4.3.3 Aerial reconnaissance

The third category of survey is aerial reconnaissance. This type of survey has been carried out in Lancashire and Cumbria by Adrian Olivier, and in the Essex region by Steven Wallis at Essex County Council. In Cumbria, a survey was undertaken as part of the

Fig 44 Fish traps in Whitstable Bay, Kent TR 0865/5 (RCHME © Crown copyright)

RCHME programme of funding regional reconnaissance in conjunction with English Heritage's North-west Wetlands Survey. A single flight was made by Lancaster University Archaeological Unit in 1992 to examine the coastal area. The flight included parts of the Cumbrian coast from Barrow to Silloth and parts of Morecambe Bay. A number of sites were recorded, including fish traps, wrecks, and some more modern coastal features, but no follow-up work has yet assessed the significance of these results.

In Essex, the survey came about as a result of the ever-growing number of finds in the area over a period of years, which suggested that there was a good chance that there was more to be discovered. Part of the RCHME's regional reconnaissance programme examined large areas of otherwise largely inaccessible mudflats, particularly at extreme low water mark. Working from known sites as a means of familiarising themselves with the types of features they might find, Paul Gilman and later Steven Wallis and Dave Strachan flew large sections of the Essex coast, concentrating on the areas around the Blackwater estuary. These few flights in 1992–3 doubled the number of known sites within the intertidal zone in Essex. In addition, more information was gained about a number of the previously recorded but poorly understood sites.

The sites identified from the aerial survey include the Essex 'kiddles' found off Mersea Island and Bradwell on Sea in 1992 (Crump and Wallis 1992, 38–42). These are extensive stake structures thought to have been used as fish traps, which lie up to 1km from the shore and are inaccessible on foot. English Heritage funded a survey of stake structures in the Blackwater Estuary to obtain an accurate plan of the stakes and dendrochronological dates. The plotting of thousands of posts from the ground was impossible, but the resolution on aerial photos was inadequate for the identification of individual timbers from the air. Although the photographs located the site, a GPS using US Department of Defence satellites was therefore used for the plotting of individual posts on some of the alignments (see below). However, this method requires that at least four satellites be located. Staff from the Department of Land Surveying, University of East London, provided the expertise for the survey, and although the first attempt to locate four satellites was unsuccessful the second attempt managed to locate some individual posts on some of the alignments. Conventional planning was also used on selected stretches, and it has been possible to determine the extent and alignment of the structures. Other regions of England with extensive intertidal areas could undoubtedly benefit from the use of aerial survey integrated with GPS. Most GPS survey-processing software will have an almanac feature showing the configuration of the satellites over time, thus allowing fieldwork to be undertaken during periods of good satellite visibility and configuration. This is particularly useful in overcoming the limitations imposed by tidal restrictions.

Several of the coastal surveys have used existing aerial photographic evidence to identify archaeology, but have not carried out specific aerial surveys. In the north-east of England the usefulness of aerial surveys was limited. It was found that many of the coastal photographs had been taken at high tide or with cliff shadow obscuring the foreshore (Buglass 1994, 15). A recommendation was therefore made for future survey flights to coincide with low tides and good lighting conditions. Locally available 26in square vertical aerial photographs have been found to show industrial remains on the coast, and even some of the rutways cut into the foreshore are visible. Photographs of the tidal river Esk have shown that abandoned vessels lie on the mudflats and therefore merit further investigation (Buglass 1994, 15). Recently an air photographic transcription was produced by the Aerial Survey Section of the RCHME for the industrial remains at Boulby, in advance of ground survey (S Crutchley pers comm).

Aerial photography has also been used to create maps of intertidal zones. In the Second Severn Crossing project, aerial photographs were used for plotting natural drainage channels in the intertidal zone. The coverage of the Welsh side of the Severn Estuary has been used to good effect in identifying natural palaeochannels, Romano-British drainage ditches, and even the former lines of sea defences on the foreshore. Although the initial observations about the potential of the site at Rumney Great Wharf, Gwent, were made on the ground, it was only possible to understand the reclamation history of the landscape, and to map the drainage channels, by using aerial photographs (J R L Allen pers comm; Allen and Fulford 1986). As the palaeochannels have been proved to be the most likely location for past human activity, it is possible to use the location of these to target conventional survey. Another system of palaeochannels was also visible from aerial photographs taken in the early 1970s by the Ordnance Survey at Oldbury Flats (Gloucestershire). As well as relict drainage patterns which suggest that the old marsh edge was some distance from the present estuary bank, polygonal ice-wedge casts of periglacial origin are visible on the foreshore (Allen and Fulford 1992, 87).

Although extremely useful in providing a context and possible focus for archaeological survey in the intertidal zone, there are several drawbacks to the use of aerial photography, both in terms of reconnaissance and interpretation of existing material. For reconnaissance in the intertidal zone the state of the tide is the critical factor, and although near-vertical photography may allow a certain degree of penetration through the water, the larger the exposed land surface the better. By their very nature mudflats have a very shallow slope and a tidal depth of 300–500mm may move the tide line 20–30m up the beach. A second important factor in all photography is lighting conditions, which are poor at dawn and dusk, exactly when tidal conditions are at their best. The combination of tidal and lighting constraints restricts the time available for photography, and in addition there is a high risk of reflected glare off the water when the sun is at a very low angle in the sky around dawn and dusk.

Another vital factor in all aerial survey is the state of the weather. The lowest tides in the year coincide with the equinoxes, when there is also a risk of severe weather, particularly in the spring. Even when there is relatively good weather inland, there is always the possibility of coastal fog. Weather can also affect the tide itself, as strong winds can create surges, substantially adding to or subtracting from the height of the astronomical tide. There are also human factors involved in survey, including the need to find a pilot and photographer willing to make early starts, and many airfields do not open sufficiently early in the morning.

In spite of all these difficulties there is no doubt that continuing regular reconnaissance within the intertidal zone is a very rapid and cost-effective way of discovering and monitoring sites.

A different set of problems is encountered in locating the position of the photograph and interpreting what it shows. As far as new photography from current reconnaissance is concerned, local knowledge is important in the air. Two photographs need to be taken of each site, one for detail and one for context. The latter may need to be quite oblique, preferably with reference points on the coast. The intertidal zone is generally quite a narrow band, and the high-water mark is often visible as a line of driftwood. The position of photography could be fixed at the time of taking the photographs by using GPS on a circuit directly over the site.

With older photography, positioning and interpretation can be more of a problem. A sample survey of current holdings indicates that the vast majority of specialist photography held by the NMR is unsuitable for work in the intertidal zone. The bulk of photography of the coast carried no record of the state of the tide. A large proportion does not show the coastal strip in a usable form, and where sites are visible there is a general lack of detail, making it difficult to locate them accurately on the ground. This is much less of a problem with vertical photographs, where there is little height or scale distortion, but locational accuracy may still need to be resolved.

Photogrammetric plotting could be used for more detailed surveys. So far this seems to have been used purely as a means of tying in terrestrial survey, and not for interpreting and recording the archaeology. There seems to be no reason why, in areas where the archaeology is sufficiently visible, the tactics employed for the Isle of Wight and Langstone Harbour surveys should not be employed.

5.4.4. Ground- and line-walking

Although other methods of survey have their place, ground- and line-walking is perhaps the most fundamental technique in surveying the intertidal zone. Not only does it offer a practical means of covering large areas of coastline, it is essential for the investigation of observations made in the air or from other documented references. It can be carried out at varying levels of detail. It was the essential first stage of reconnaissance in the Hullbridge Project, which covered some 200km of the Essex coastline (Wilkinson and Murphy 1995, 3). In the North-east Maritime Archaeology Survey, 43 miles of coast were rapidly walked by the project officer John Buglass with the help of John Owen, a specialist on the ironstone industry in the area and a member of the Cleveland Industrial Archaeology Group. Beach walks were carried out between Saltburn and Runswick Bay to determine the extent and complexity of the industrial remains (Buglass 1994, 14).

In the North-east Maritime Archaeology Survey this local knowledge was essential in identifying sites and areas of potential as well as for monitoring the tides. Another example of the way in which local knowledge derived from unsystematic survey can lead to important discoveries is the Saxon stake-structure at Collins Creek in Essex, which was reported to the County Archaeology Section by a local boat owner, Ron Hall, in 1991. This led to an English Heritage-funded survey in 1992 which attempted to define the extent, nature, and date of the complex, and involved conventional planning, GPS, and aerial surveys (Clarke 1993, 209).

Local knowledge has also been essential in identifying sites in the Severn Estuary. The vigilance of Derek Upton, the Magor Marsh Nature Reserve Warden, has led to numerous foreshore discoveries of great importance along the Welsh (Gwent) coast, and particularly off the Caldicot Level. A key feature of this survey is that it is repetitive, with the same stretches of shore being visited again and again under different conditions. As the Warden is locally based and has a keen interest in the archaeology of the area, he is ideally placed to go out into the intertidal zone following storms to find new exposures and sites. As a result, a number of nationally significant prehistoric sites have been further investigated by detailed survey and total excavation. Repeated visits over more than half a century also account for the succession of discoveries of boats at North Ferriby (Wright 1990). Generally, environments which are liable to be smothered by muddy sediments should be revisited repeatedly; the archaeology can only be assessed when the beach conditions are good.

The observations made by Derek Upton were valuable in planning the project on the Welsh side of the Second Severn Crossing. Following the preliminary survey, controlled fieldwalking was undertaken in the east of the area that would be affected by the bridge-works (Godbold and Turner 1993, 5). A 100m grid was set up of the whole area by using electronic distance measurement from a base line on the shore, and a smaller area was chosen for fieldwalking on an area of gravel bank between the north-east end of the Bar and Sudbrook Point (Godbold and Turner 1993, 6). Fieldwalking took place in the first ten days of the project, and the foreshore was studied in 25m squares. In total, 73 squares were studied in detail, with 18 others partially searched. This revealed an extra 100 timber posts and 3 concentrations of wood; recorded artefacts included worked stone, a Levallois flake-blade and a handaxe, Romano-British, medieval and post-medieval pottery, and animal bone (Godbold and Turner 1993, 7). Although the methodology is not described in detail, the Wootton Quarr survey seems to have involved the systematic recording of wooden features and artefacts over a clearly defined survey area (Tomalin *et al* 1994, 5–6).

Rapid ground-walking is a cost-effective way of gaining an overall picture of a coastline. For example, much of the coast of the Isles of Scilly was walked in order to determine the effects of erosion on cliff-face and beach sites. In Northumberland, the Glasgow University Archaeology Research Division walked 70 miles of coast (but not the intertidal zone) in order to assess the archaeological potential and erosional risk of each area (Northumberland County Council 1994, 6). In the first season of fieldwork in Langstone Harbour, the main theme of the survey was a rapid walk-over to identify sites of importance, and locate artefacts. The nature and extent of areas of archaeological exposure were recorded, and a representative sample of artefacts was collected (Allen, M *et al* 1994, 3). Where concentrations were found, collection units of 1m² were used and a small number of exposed features were sampled by excavation whilst the rest were left (Allen, M *et al* 1994, 3). The north shore of the harbour and South Binness island were surveyed in this way and the eastern and southern foreshores were walked more thoroughly (Allen, M *et al* 1994, 4). For the Lindsey Coastal Survey, the beach was walked two hours on either side of low tide, each sector being walked twice, once in each direction. Although with this type of survey it is often only possible to undertake low-level, rapid recording of features (as in Lincolnshire), it nevertheless provides a helpful starting point for future research.

5.4.5 Detailed survey: recording methods

Once areas of potential have been identified from fieldwalking, selective detailed survey can be carried out. In Langstone Harbour, seven areas were selected for detailed survey and recording, with four detailed assessment surveys on the foreshores of North Binness, South Binness, and Long Islands. Several areas were selected for total artefact collection on a one metre square grid, and these areas were then surveyed in three dimensions. In the Isles of Scilly several areas were also chosen for more detailed survey. These included cliff-face sites which were sketch-plotted onto 1:2500 maps and photographed; artefacts were collected from cliff faces and their positions were recorded by photography, and cliff sections were drawn at 1:20 while the cliff edges were planned at 1:100. The most important sites on the islands were identified and recommended for annual monitoring, for example the intertidal peat deposits which are being eroded at every tide. Other sites were recommended for monitoring every five years. Important cliff-face sites were also identified, and this allowed fieldwork to be focused in subsequent years. Fieldworkers also took with them the previous year's section drawings for comparative purposes so that the amount of erosion could be assessed. Excavation was actively discouraged, and partial excavation occurred at only one site.

The intertidal field recording of the Wootton Quarr project was carried out principally using a Total Station Theodolite which was downloaded after each session to a Computer Aided Design (CAD) package. The beach was surveyed in stretches of 500m with local stations provided by a grid of steel pins driven into the bedrock gravels and clays at intervals of 20m. Over 2800 individual timbers were surveyed and recorded by measuring height above sediment level, cross-section dimensions, inclination, and magnetic bearing. Selected timbers were recovered for dating purposes, and a further sample of ten stakes from three alignments was removed for woodland technology analysis. These were drawn, photographed, and fully recorded. During the early stages of the project a number of recumbent trees, large branches, and root systems were noted in the peats and organic silts close to the extreme low-water mark. These were surveyed and recorded, and larger examples were sampled for dendrochronological dating. More than 13,000 artefacts were recovered. Individual positions or (for example in the case of flint) the centre of localised scatters were recorded. Simple photogrammetry was also used to record some structures such as wattlework, when the tide left insufficient time for drawing by hand. An extensive programme of hand-augering was also carried out in order to explore the stratigraphy of the enclosing sediments, including the location and extent of palaeochannels. The gouge auger (20mm x 1m) reached a maximum depth of 6m. A mechanical auger was used to obtain samples from the Fishbourne palaeochannel.

5.4.6. Small-scale surveys

It is difficult to make a clear distinction between small-scale survey and excavation, since inevitably the recording of structures in the intertidal zone involves at least the removal of superficial sediments, if not the more detailed examination of context by the careful cleaning of significant exposures and removal of environmental samples. Small-scale surveys to address individual problems have been found to be effective in a number of areas. Indeed, the highly successful Hullbridge Survey is perhaps best characterised as a composite of a large number of individual, small-scale surveys (above, 5.2; Wilkinson and Murphy 1995).

In the Severn Estuary, small-scale survey has been deployed in a number of ways. Firstly, it has been used as means of developing our understanding of shoreline movement over the last two millennia by focusing on the evidence of palaeochannels. At Hill, Glos, an EDM survey of the palaeochannel of Hill Pill recorded the base geology and surface sediments in detail, as well as the remains of a man-made structure to provide a context for it. Repeated detailed survey of the channel and its immediate environment recovered artefacts and identified a wooden structure to provide dating evidence for it and adjacent features. The analysis of the heavy metal content of sediments from early modern features was also a valuable aid to establishing a chronology. The study of existing aerial photography was essential for the mapping process, and historic map and other documentary sources provided crucial evidence for recent historical developments (Allen and Fulford 1993; 1995).

Secondly, repeated survey involving both the planning of structures and some limited excavation over a 1.5km stretch of coastline at Goldcliff, Gwent, has provided a detailed picture of the development of settlement and landscape on the peat shelf from the Mesolithic to the Iron Age (Fig 45). With at least seven individual post-built structures and associated trackways, the Iron Age is particularly well represented (Bell 1992; 1993a; 1993b; 1994) (Fig 37).

Thirdly, detailed surveys of localities with intertidal strews of cultural material have led to a better understanding of their character and context. At Oldbury, repeated visits allowed the identification and dating of a series of sediments which are releasing Romano-British cultural material onto the foreshore. These included both primary and secondary contexts. The range of material collected, and the study of the taphonomy and distribution of different categories of finds, allowed new conclusions to be drawn about the date and nature of the original settlement. A further aspect of this survey was a study of the intertidal zone in relation to the developing early modern and modern sea-bank and field systems. As with Hill, this drew on a range of aerial photographic, map, and other documentary sources, and led to the development of hypotheses about shoreline retreat (Allen and Fulford 1992).

Fourthly, on the opposite side of the Severn Estuary at Woolaston, Glos, survey in 1989–90

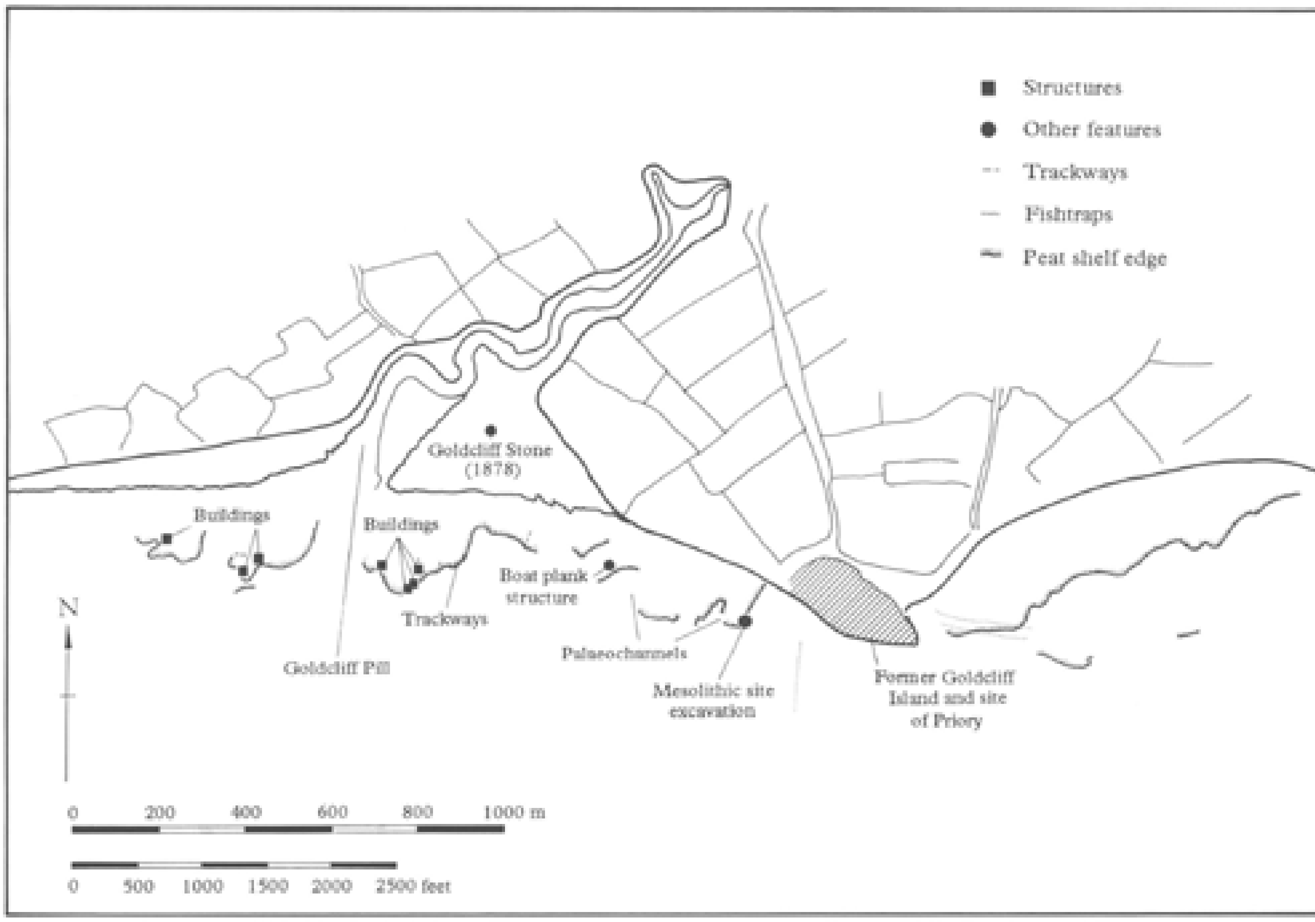


Fig 45 Severn Estuary: Goldcliff, Caldicot Level (Wales). Location of Iron Age buildings and other archaeological evidence recorded on the peat shelf in the intertidal zone west of Goldcliff Island

focused on the remains of a single structure. A timber and stone quay-like structure in the intertidal zone at the edge of an active pill (the local name for a tidal creek) was planned at 1:20 and photographed. The timbers were sampled for dendrochronological dating, and the stone was characterised lithologically. The structure was dated to the twelfth and thirteenth centuries, and a contextual study suggested that erosion had isolated it from the shore by the seventeenth or eighteenth century (Fulford *et al* 1992).

A good example of the blurred distinction between small-scale survey and excavation is afforded by the survey and limited excavation of a Neolithic settlement and contemporary land surface at the Stumble in the Blackwater Estuary. The site, near Osea Island, was first investigated in 1986 by Essex County Council Archaeology Section as part of the Hullbridge Survey. The area excavated from 1986/87 was 146m², and involved trowelling of the surface in lanes, and the triangulation of all finds (Wilkinson and Murphy, 1988b, 5.3). One trowelling pass was made with windscreen squeegees to clean the site so that a ground plan of the soilmarks and features could be obtained. Some 3500 sherds of pottery and struck flints were recorded from one area, illustrating the potential complexity of intertidal sites. Soil samples were also taken on a 1 x 1m grid from the palaeosol exposed on the site, and these produced a quantity of carbonised cereals and hazel nuts (Murphy 1988, 22). The samples had to be taken by dinghy to Osea Island to be dried and wet-sieved later in the year. Evidence of several wooden structures was found in an area which is now thought to have been dry land when the sea-level lay at approximately 9ft (2.7m) below present OD, in the third millennium BC. In 1988 the survey included surface collection from three selected areas, one of which was excavated to reveal an Early Neolithic posthole, pit, and gully complex. An area of 70m² was exposed and evidence for one or more buildings was found. A burnt flint mound of possible Neolithic date was also partially excavated. Surface finds were plotted in two dimensions using triangulation and a prismatic compass from a surveyed baseline, and from ranging rods positioned on the corners of the main excavation areas. In some of the areas surface collection on a 1 x 1m grid was used (Wilkinson and Murphy 1988b, 100). This enabled the fieldworkers to determine which areas produced the densest scatters of pottery and flint, which were sometimes obscured beneath deposits of modern estuarine clay. An auger survey at 1:500 to the west of the site revealed a complex of silted creeks along which several Iron Age structures had been constructed (Wainwright 1989, 27).

The foreshore of the river Thames has been surveyed in a number of sample areas by Gustav Milne and students at the Institute of Archaeology of University College, London, on a small-scale basis. The Thames Foreshore Project has been undertaken through the dissertation programme at the Institute. As part of this, Richard Hill has surveyed a 400m length of the Bermondsey foreshore which has revealed prehistoric features with burnt flints, pottery and other artefacts, bone, and seeds (G Milne pers comm). Jon Binns is also recording substantial remains of nineteenth-century barge repair sites. The reports of these surveys had not been published at the time of writing. In 1995, English Heritage funded a pilot study of selected areas of the Thames foreshore for the Thames Archaeological Survey; this was coordinated by Mike Webber at the Museum of London, with local archaeological societies and student groups. It showed that stratified multi-period sequences, deposits, and structures representing a variety of riverside and foreshore activities exist on the foreshore, and has confirmed their archaeological and palaeoecological potential. It is clear that these sites are under constant threat of erosion by the river, and are under pressure from proposed developments. The pilot study is being followed up by a three-year survey of the Thames foreshore from Teddington to Greenwich beginning in 1996, funded by the Environment Agency with contributions from the Bridge House Estates Trust Fund, English Heritage, University College, London, the Museum of London, and the Museum of London Archaeology Service. Students and volunteers from local archaeological societies will carry out the survey, coordinated by professional survey officers. A pilot study of the Thames foreshore downstream from Greenwich to the Greater London boundary is being undertaken at the same time, and this will be supported by an environmental pilot study to evaluate the potential of alluvial and peat deposits on the foreshore. The results will be incorporated into the Greater London Sites and Monuments Record, with a view to the development of a management strategy (M Webber pers comm). Further details of the progress of the project can be obtained from Mike Webber at the Museum of London, or from Ellen Barnes at English Heritage.

The Nautical Archaeology Society has also been involved in surveying barge hulks in the intertidal zone of the Medway at Whitewall Creek on behalf of Kent County Council (see above). Colin McKewan undertook an initial survey in 1991 with the help of students on the Nautical Archaeology Society training course. An EDM was used to plot the general positions of the vessels. As a result of the threat of immediate destruction posed by the road works for the Medway tunnel, the archaeology unit of Kent County Council became involved and a further survey was commissioned in 1992 with a team of 2–9 people working over 57 person days. Much of the recording involved volunteers working under the direction of consultants. On the first day of survey, all the vessels were examined and a list of the most important ones was drawn up so that detailed recording could be directed; it was not possible to record everything in the time available. The selected craft were rapidly planned at 1:100, followed by more detailed excavation and planning at 1:20 or 1:10. The hulks were also photographed in black and white and colour. The record of the site is described as being 'rushed and incomplete' but it focused on 'what were considered to be the more significant structural attributes in the vessels' (Milne *et al* forthcoming). Thus, factors such as bow and stern shape and side and bottom planking were recorded, as well as repairs, methods of waterproofing, and evidence for rudders. As the vessels had been partially demolished and robbed for materials in 1981, it was easier to see the structure of the boats.

Because of lack of experience in recording intertidal craft, the information from Whitewall Creek was recovered in an *ad hoc* fashion. Nevertheless, an enormous amount of information was recorded and the survey formed the basis for a report by Milne and Goodburn in 1993 on recording standards in the intertidal zone, which is to be published by the RCHME in 1997. These recommendations were put into practice by students from the Institute of Archaeology on the remaining hulks at Whitewall Creek (Milne *et al* forthcoming).

Small-scale survey has also taken place on the open coast, for example along the Sussex coast between Seaford and Eastbourne, an area known as the Seven Sisters Voluntary Marine Conservation Area. This has revealed several intertidal wreck sites, in addition to the more famous ones such as the *Amsterdam* and the *Anne*, with many more in the marine zone. Fieldwork was carried out by Philip Robertson with the help of 12 volunteers between June and July 1993. Work was timed to coincide with low water spring tides, which allowed two-and-a-half to three hours' work on site (Robertson 1993, 67). Four wreck sites were surveyed using guidelines set out by the Nautical Archaeology Society. Plans were drawn at 1:100 and were supplemented by photography. In the case of the survey of the *Coonatto*, a system of 'trilateration' was used, with a web of datum points scattered over the site. The same system was used in the survey of the *USHLA* and *UB.121* (a World War I German submarine), although the wide scattering of the site meant that it had to be surveyed in two stages (Robertson 1993, 68). In another survey, this time of a flat-bottomed barge, offsets were taken from a tape measure stretched between three datum points (Robertson 1993, 68). A systematic shore-walk was also undertaken of the whole intertidal zone. This form of small-scale survey illustrates the ability of a small team of volunteer fieldworkers to collect a large amount of information in a selected area and demonstrates the potential for survival of remains in the intertidal zone on a coast which is in places rocky and inaccessible.

5.4.7. Geophysical survey

Geophysical survey has rarely been used in the intertidal zone, but it has been deployed to determine the inland extent of sites eroding on the coast. At one important site on the Isles of Scilly, Porth Killier on St Agnes, survey in 1989 showed that a high rate of erosion was threatening this multiperiod cliff-face site. Although resistivity and magnetometer surveys were deployed to determine the surviving extent of the site, in this case none of the geophysical anomalies detected on the land behind the cliff face conclusively represented archaeological stratigraphy or clearly defined building remains (Ratcliffe and Parks 1989, 11). Although the method is not necessarily a reliable way of determining the extent of cliff-top sites, it could be helpful in determining how far features exposed on the foreshore continued onto dry land.

The technology of acoustic and seismic survey has developed rapidly in recent years and is now extensively deployed in commercial, hydrographic, and scientific marine survey. This equipment has also been used for archaeological prospection in subtidal areas. Side-scan sonar produces an oblique topographic image of the surface of the sea-bed. The introduction of digital data capture has increased options for post-processing and enhancement of images. Sub-bottom profilers are designed to resolve sub-surface detail, and off the Isle of Wight this equipment has revealed the mouths of palaeochannels on the sea-bed at -6m to -10m OD which match up with drainage channels on land (Tomalin *et al* 1994, 42). It is hoped that the inner seas of the Isles of Scilly can be surveyed using these techniques to gather data on submerged archaeology. The Department of Oceanography, University of Southampton, is currently undertaking research into the use of acoustic survey techniques for archaeological prospection. A pilot study to explore the use of acoustic survey in the development and validation of the maritime records of the NMR is also under way as a collaborative exercise between the RCHME, the University of Southampton, and the Nautical Archaeology Society Diver Training Scheme.

Magnetometers have been used extensively in the UK and elsewhere for area survey targeted primarily at wreck material. This equipment can reveal surface and sub-surface wreck deposits with ferrous content. As currently deployed, towed magnetometers may have less potential for description of other features, although the application of this technology to the detection of a wide range of archaeological features in subtidal areas is at a relatively early stage. Magnetometers have been used successfully to investigate suspected wreck deposits buried in the

Fig 46 Proton magnetometer survey in 1969 of the Amsterdam *at Hastings, East Sussex (P Marsden)*

Fig 47 Sampling with a powered percussion auger on Par Beach, St Martin's, Isles of Scilly (Cornwall Archaeological Unit)

intertidal zone. For example, a proton magnetometer survey was carried out on the East Sussex coast in 1969 on the wreck of the *Amsterdam*, in which concentrations of iron, still in the hold of the ship, were detected in the bow and the stern, possibly ballast or shot for the guns (Fig 46). A magnetometer survey was also carried out on the wreck of the *Anne* in the autumn of 1994 and this picked up iron objects below the sand, suggesting that the wreck extended beyond the remains visible on the surface (P Marsden pers comm). Problems occur with geophysical surveys when more than one wreck is found on a site. For example, the *Resolution*, a 70-gun Restoration warship known to have been wrecked off Eastbourne in 1703, has not been found. One possible explanation is that the wreck of the *Barnhill* (1940), which is exposed at low tide, masks that of the *Resolution*.

5.4.8 Augering

Another method of surveying buried remains in the intertidal zone is augering. This technique was widely used in the Hullbridge Survey to plot buried land surfaces and subsurface topography (Wilkinson and Murphy 1995, 3). Augering was also used across Langstone Harbour on eight different transects at dry land and marine locations. In the two main transects, augering was carried out at 50m intervals for shore sites and at 100m intervals for underwater sites, recording 101 auger holes in total. A 20mm diameter gouge auger with a 1m-long sample chamber was used, and samples were taken to chalky or gravel deposits up to a depth of 3.5m (Allen, M *et al* 1993; 1994).

In the 1991 season of fieldwork in the Isles of Scilly, an attempt was made to construct a plan of the extent of the peat buried under the sand at Par Beach, St Martins (Fig 47). Wet sand and shingle made the use of a Jarrat hand-auger impossible and a power percussion auger was therefore used, although this, too, was limited to areas where peat was covered by grit and sand, rather than shingle (Ratcliffe 1993, 85). Five cores were drilled, each a metre long, and two of the columns were found to contain more than one band of peat. Problems with the powered auger included the need to transport it by tractor across the soft sand, and cross-contamination between the layers, which made dating difficult. The results of the palaeoenvironmental analysis are to be published by the Cornwall Archaeological Unit in a separate interim report.

Auger surveys have also been conducted in the Isle of Wight using a 20mm x 1m gouge auger to its maximum depth at Fishbourne, Wootton Quarr, and Binstead. From these surveys it was possible to trace palaeochannels and other sediments beneath the beach. Environmental samples were taken from the Fishbourne palaeochannel using a mechanical auger (Tomalin *et al* 1994, 6). The combination of the auger data with those obtained from the marine zone using a sub-bottom profiler has led to a greater understanding of the buried landscape on the north shore of the Isle of Wight.

5.4.9 Subtidal survey

Although subtidal survey is beyond the scope of this review, its potential as an extension of intertidal survey needs to be considered here. The possibilities of mapping the sea-bed using geophysical techniques (as at Wootton Quarr) have been described above (5.4.7). In addition, it will sometimes be desirable to recover material from the sea-bed in order to understand the nature and scope of the intertidal resource. The difficulties of recovering satisfactory information cannot be underestimated, particularly in contexts where visibility under water is poor and where no solid structures survive. However, the Wootton Quarr survey has been relatively successful in tracing Neolithic trackways for short distances underwater leading from the intertidal zone (Tomalin 1995). Very careful regard must be given to the benefits or disadvantages of subtidal work as an extension of intertidal survey before it is undertaken. It may be of benefit when basic information on the location and character of archaeological material will help to define the location and extent of lost settlements or structures of Roman and later date. For this, a scheme of systematic sampling of sea-bed sediments will have to be prepared. Although this approach may provide information of considerable value for understanding settlement movement and loss over the last two millennia, it may not be helpful in recovering useful, but potentially more fragile, information for earlier, prehistoric periods.

5.4.10 Excavation

We have already noted (5.4.6) that there is no clear distinction between survey and excavation in the intertidal zone. Apart from the excavation described above at the Neolithic site at the Stumble, Essex (Fig 48), there has been almost no excavation in the intertidal zone in England. In Wales, however, following the discovery of nationally significant prehistoric sites off the Gwent coast in the Severn Estuary, there have been several excavations which have included the total excavation of timber structures combined with extensive environmental sampling (Bell 1992; 1993a, 1993b; 1994). Clearly, if fragile but well preserved sites are identified in the intertidal zone, excavation may be the only option available before their destruction by erosion or other agencies. This was the case at North Hill in the Isles of Scilly, where a prehistoric hut circle was on the verge of destruction by erosion and was recommended for excavation in 1989 in advance of damaging storms. Test pitting was also used at Par Beach on St Mary's in 1989 to determine the extent of the buried peat deposits on the beach and inland, with the aim of developing a clearer understanding of the environmental history of the Isles. It was also suggested that test pits should be dug alongside the field walls exposed on the beach, to determine the relationship between the wall and the peat (Ratcliffe and Sharpe 1991, 32).

Fig 48 The Hullbridge Survey, Essex: the Stumble, river Blackwater, in the course of excavation (Essex County Council)

Excavation requires greater resources than other techniques of investigation, and 'it is necessary to be sure that an excavation will yield information not otherwise obtainable through survey and sampling' (Murphy and Wilkinson 1991, 11). Thus, excavation technology has to be kept simple and affordable to justify the study of intertidal areas. The length of time a site is exposed also determines whether it merits excavation. A site which is accessible for less than two hours between tides is obviously less suitable for excavation than one which is accessible for four hours (Murphy and Wilkinson 1991, 11).

Special technical problems are associated with excavation in the intertidal zone. During the excavation of the Stumble, Essex, the site was kept dry by a system of drainage channels and dams made from metal lawn-edging around the site (Murphy and Wilkinson 1991, 12). An electric pump powered by a car battery was used to empty the sump into which the water ran, but the site had to be drained with buckets and sponges after every tide. Walkways were constructed from rolls of fencing posts, and plywood boards were laid down over the area to prevent damage to the site (Murphy and Wilkinson 1991, 12). Similar methods were used in the sample excavations carried out on the Welsh side of the Second Severn Crossing. Here, box sections and small trenches were dug to retrieve wood samples and even whole structures, as well as to investigate the stratigraphic sequence (Godbold and Turner 1993, 5). As at the Stumble, the trenches were often filled with water and it was necessary to use an electric bilge pump powered by a portable car battery. The car battery was found to be too heavy to move easily and the excavators switched to a lighter, motorbike battery, but this gave only two to three hours of working time (Godbold and Turner 1993, 6).

5.5 Funding

The costs of intertidal survey differ from those of survey on land. Restricted access due to tidal conditions will present an additional cost if there is no alternative activity for the team, but can be overcome by diversifying the project and incorporating a land-based component, as was the case with Wootton Quarr. Equally, the team can be occupied in writing, drawing, and research on certain categories of finds when conditions prevent survey. The larger the team the more difficult it is to manage a diversified project unless all the members have clearly defined dual roles. Depending on the nature of the survey to be undertaken, specialists may be required, in addition to a skilled surveyor. In the surveys discussed in this chapter there have been roles for geologists and sedimentologists, palaeoenvironmentalists, industrial archaeologists, and ship and boat specialists. Commissioned aerial survey in areas where no work has been done before may prove to be invaluable.

Consideration must also be given to changing shore conditions, which can reveal and obscure the archaeology. With both large- and small-scale survey, it may be necessary to budget for extra time to revisit sites. In any case it will be necessary to note areas where conditions were not suitable for survey. In the case of the detailed survey of a site which is partly obscured by each tide, extra time will have to be allowed for cleaning each day. This is also true for excavation, where extra time will also be needed to bale or pump out trenches. Pumps which are not easily portable may not be practical. The expense of constructing caissons or coffer dams may be feasible in shallow waters, to allow for round-the-clock excavation of clearly defined sites such as boats and ships and these, too, will require continuous pumping.

Most fieldwork in the intertidal zone has to be conducted at some distance from a vehicle, introducing an additional time factor which will be extended if all the equipment has to be taken on and off site each day. The removal of bulky and heavy items such as large timbers and soil samples may be extremely difficult, particularly over soft sediments, and alternative means of transportation such as sledges, or floating finds and equipment to shore, or even small hovercraft, may need to be considered.

In addition to the extra expense of fieldwork, it has to be recognised that post-excavation costs will be higher than for land-based field survey. Although the procedures for collection and analysis of artefacts such as flint and pottery are similar, the environmental aspect of intertidal work needs extra consideration. It may be possible in future to develop dated typologies of arrangements of timbers in the intertidal zone, but such a typology does not yet exist. In the meanwhile, there is little point in merely mapping a structure which is under threat in the intertidal zone without establishing its date. Survey budgets must allow for both dendrochronological and radiocarbon dating, and numerous dates may be required. As we have seen (5.4), the cost of dating programmes may amount to between 10 and 25% or more again of the entire project budget. Costs will also be high for the study of peats and submerged forests, which require specialist environmentalists and considerable resources for study in the laboratory.

Finally, there are the short- and long-term costs of the conservation and storage of waterlogged wood removed from site for study or display. The desirability of removing timbers from site for long-term curation, as opposed to detailed study and recording *in situ*, needs to be carefully weighed.

5.6 Conclusions

Systematic survey in the coastal and intertidal zones is a relatively recent development in British archaeology, beginning in the early 1980s, when concerns about the impact of coastal erosion, rising sea-level, and coastal developments began to emerge in the archaeological community. Two distinct strands of survey have emerged:

- rapid survey of the eroding shoreline (eg Isles of Scilly; Northumberland Coastal Survey)

- survey of the intertidal zone in its widest sense (Hullbridge, Wootton Quarr, Severn Estuary)

Surveys have tended to concentrate in areas where potential was known as a result of fieldwork in the past or from casual finds in the nineteenth century, but development-led survey has begun to shift the emphasis and reveal the potential of hitherto unexplored areas such as the Solent and the Severn Estuary. This is now complemented by surveys specifically commissioned to enhance the NMR and SMRs (eg Bridgwater Bay, Langstone Harbour). Apart from one or two exceptional finds such as the Ferriby boats in the Humber Estuary, efforts have been concentrated on the east coast in Essex and Lincolnshire, on the south coast in the Solent, and in the south-west in the Isles of Scilly and the Severn Estuary. Rapid survey in the north-east has revealed the potential of that coastline for industrial archaeology.

Aerial photography

In considering the usefulness and effectiveness of aerial photographic cover in the intertidal zone, it must be remembered that it has two separate and distinct applications: reconnaissance and site discovery on the one hand, and mapping and interpretation using all available photography on the other.

Looking first at reconnaissance, and the examples of Cumbria and more specifically Essex (5.4.3.3), there seems to be no question that targeted reconnaissance is a worthwhile and effective means of site discovery. The restrictions imposed by the conditions necessary for successful photography in the intertidal zone mean that targeted reconnaissance in estuaries will probably be the most productive option. In many cases smaller features may not be revealed, but general alignments can be observed, alerting the relevant bodies to the potential of such sites.

Interpretation and mapping can be subdivided into two distinct areas, large- and small-scale survey. One important factor affects both. From the assessment of known photography it is clear that much of the specifically archaeological photography of the coastal region is unsuitable as far as sites in the intertidal zone are concerned (see Appendix 1). However, it is also clear that a large amount of cover which has not previously been consulted could be most useful. Specialist bodies with an interest in the coast commission small-scale photography of the intertidal zone at very low tide for their own purposes, and these photographs have obvious archaeological potential. Coverage of the Severn Estuary and the Blackwater Estuary held by the Hydrographic Department of the Admiralty, and of the Whitstable Bay area in Kent held by the National Rivers Authority (NRA; now part of the Environment Agency), clearly showed features such as timber alignments and possible fish traps. The archaeology section of Essex County Council carried out an assessment of the usefulness of the NRA holdings for NMP in Essex and recommended their consultation by other NMP projects with intertidal areas. Early RAF photography, although often at a small scale and of poor quality, sometimes shows sites associated with the intertidal zone which have since been destroyed. This is particularly true with regard to industrial features, ranging from salterns through fishing-related sites to coastal mining.

The experience of NMP in Lincolnshire and Essex suggests a number of points:

- the photography needs to be at least 1:10,000, preferably larger, to allow proper assessment

- further training in distinguishing natural from man-made features is required

- manual plotting from verticals is quite accurate, as there is little or no height distortion and control on the coast is generally sufficient

- the potential for salt workings and military sites seems promising, but for more ancient archaeological features is still unclear. Certainly it is unlikely that small features such as timber post alignments will be visible on small-scale (ie 1:10,000) photography.

Because this is a new area of research, a large number of previously unknown sites will be discovered, many of which will not have been recognised from the air before. The correct interpretation of these sites may take some time. Sites are liable to vary in the different areas of the coast, with some appearing only in specific regions. The most obvious site-types liable to be picked up from aerial photographs are as follows:

- *wrecks* will range from barges and small vessels in dried-up creeks and marsh areas to potentially larger craft in deeper water which may already have been recorded by the NMR

- *kiddles and traps* may appear complete or as remnant timber alignments. These will be visible under the water on some photographs.

- *saltings*: many are already marked on OS maps, but in only a very cursory manner, and aerial photographs will allow a more accurate record to be made. In some cases these may extend well beyond mean high-water level, but the nature of NMP means that there is no conflict in recording.

- *oyster beds*, like kiddles and fish traps, may be of different dates reaching backwards from the present
- *sea defences/land reclamation sites* are large features, particularly susceptible to identification from aerial photography
- *military remains*: the obvious concentration will be of World War I and World War II remains, many of which are visible on the RAF/USAAF cover from the 1940s
- *submerged field systems*: the extent of this type of feature is currently unknown. Generally poor water penetration by aerial photography suggests that there may be little chance of recovering such features, but there are suggestions of potential sites in north Kent.
- *trackways, platforms, etc*: the scale of such features makes it unlikely that these will be picked up from existing photography, but the potential for targeted reconnaissance could be quite high

As a result, where any area is threatened or where a conventional ground survey is to be undertaken, all known relevant photographs should be consulted first for any information they might yield.

As far as wider area coverage and the potential for a research programme are concerned, the way forward appears to lie with the NMP (see Appendix 1). Air photographs take no account of such arbitrary boundaries as those between land and sea, and photographs taken of the coast may well show features inland, irrelevant to those who commissioned the flight but of interest to archaeologists. It therefore makes sense to include the intertidal zone as part of any area or County survey, where all the photography will be viewed as a matter of course.

The recommended approach for aerial survey in the intertidal zone would therefore be to map whole areas to NMP standards, and to integrate future reconnaissance programmes with the results of that mapping.

Ground-based survey

It is rare for any ground-based survey to have taken a comprehensive view of the archaeological resource in the intertidal zone. The east coast surveys in the intertidal zone (Hullbridge and Lindsey) have focused on the prehistoric evidence, and the scope of the North-east Maritime Archaeology Survey, in so far as it was concerned with the intertidal zone, has concentrated on a rapid survey of industrial archaeology to enhance the NMR. In the case of all the above projects, whatever their scope, it would be a mistake to believe that conditions would have permitted comprehensive survey; past experience from the Severn and North Ferriby indicates the value of repeated visits. Indeed, this can be regarded as an essential aspect of intertidal survey.

Early modern and modern hulks provided the focus for the Medway (Whitewall Creek) survey, which was undertaken under rescue conditions. Similarly, research on the Sussex coast has concentrated on the record of post-medieval and modern wrecks. The most comprehensive survey in terms both of chronological range (Mesolithic/Neolithic to post-medieval) and environmental scope so far undertaken is that in the Solent at Wootton Quarr. In the Severn Estuary there has been a considerable difference in approach between the English and Welsh coasts. On the latter, a number of excavations and surveys have been undertaken to tackle specific and localised issues. Important discoveries of individual prehistoric and Roman sites have been addressed by site-specific surveys and excavations, and development has led to more comprehensive surveys of the intertidal zone, limited to the threatened areas (Second Severn Crossing). On the English side there has been no comprehensive survey or excavation. Instead there has been detailed examination of certain Roman and medieval sites and of contexts such as palaeochannels, where geoarchaeological survey has been informative about coastal change. Multi-period survey in the Isles of Scilly has concentrated on the impact of erosion on the shoreline, rather than on the potential of the archaeological resource in the intertidal zone. The rapid survey of the Northumberland coast has followed a similar remit. Some areas, such as the Humber Estuary and the north-west, have seen almost no modern survey.

There is no doubt that survey in the intertidal zone presents challenges not encountered in land-based survey. The fact that the tidal regime will necessitate careful management of time is perhaps the most distinctive attribute of intertidal survey. To this must be added the problems of the variable visibility of the archaeological resource, particularly in the potentially archaeology-rich intertidal zone of the major estuaries. The contribution of amateurs prepared to walk the intertidal zone after storms and at periods of extreme low-water cannot be underestimated. Unless good conditions can be relied on, a concentrated period of survey in one area may be of extremely limited value. The need to be sensitive to ground conditions is particularly acute for fragile prehistoric and early historic sites. All this calls for the utmost flexibility in the timing of survey to maximise results. In the case of the more robust remains of historic wharves or hulks, these can probably be surveyed in less satisfactory conditions.

The visibility of the archaeological resource in the form of exposed structures of wood or stone, or strews of artefacts, also serves to give intertidal survey a distinctive character. Although the study of artefact collections is a recognised facet of fieldwalking on land, the need to date wooden features and structures by dendrochronology or radiocarbon determinations is a feature of intertidal survey. Given that all archaeology is vulnerable in this context, there is a need both to record features and to date them, for there is no guarantee of the long-term survival of any but the most robust archaeology in the intertidal zone. It is inevitable that the discovery of well preserved prehistoric or early historic archaeological remains will lead to the requirement for very detailed survey and/or excavation, as has been the case with prehistoric sites on the Gwent coast in Wales. Even without excavation, survey in the intertidal zone is liable to be more expensive than its land-based equivalent because of the nature of the archaeological record. If areas are identified as worth a concentration of survey effort over a restricted time-period, it is essential to link the intertidal aspect with a land-based and preferably related coastal project in order to maximise resources.

Although surveys in the coastal and intertidal zone have been undertaken for a variety of reasons which are usually reflected in their outcome, all have demonstrated the rich potential of the archaeological resource in the intertidal zone. Estuaries, particularly of the major rivers, have revealed their promise for prehistoric and early historic archaeology, but the North-east Maritime Archaeology Survey and the Medway (Whitewall Creek) Survey point up our ignorance of the later historic development of our coastline. A common theme in all the work carried out to date is how little consideration has been given to the way coastal zone archaeology can inform us about our changing relationship with the sea and the exploitation of its resources.

As the results of projects like Hullbridge, the Second Severn Crossing, and Wootton Quarr reveal, in order to be effective survey in the intertidal zone has to characterise the archaeological resource by planning and dating structures and artefact scatters, while at the same time taking full account of geological and environmental context and potential. The surveys which have been most effective in deepening our understanding of the archaeological resource as a whole have undoubtedly been those with comparatively limited objectives, whether geographical or thematic (such as Goldcliff or the Stumble); the least effective have been the rapid surveys which have necessarily drawn attention to the most obvious features, usually post-medieval or modern. However, rapid ground-survey combined with an assessment of the existing aerial photographic record has proved very efficient as a means of appraising the post-medieval and modern resource (Bridgwater Bay, Whitewall Creek). Indeed the aerial photographic record alone has been particularly informative in the survey of hulks and barges in Kent, and in the context of the National Mapping Programme in Essex.

It is clear that there is a continuing role for rapid survey for the future, to monitor erosion of known archaeological sites, to assess areas where few or no records currently exist, and to prepare the ground for detailed survey programmes of the coastal and intertidal zones. At the same time the contributions of projects like Hullbridge, the Second Severn Crossing, and Wootton Quarr powerfully demonstrate the contributions that intensive surveys of the intertidal zone have to make.

6 The archaeological resource: chronological overview

by J R L Allen, R J Bradley, M G Fulford, S J Mithen, S J Rippon, and H J Tyson

6.1 Introduction

The purpose of this chapter is to provide a review of the archaeology which has been recorded from the intertidal zone around the coast of England. It is based on the records of the National Monuments Record (NMR) of the RCHME, all the relevant county Sites and Monuments Records (SMRs), and on reports received of recent or continuing fieldwork. Apart from those stretches of coastline of which individual contributors have a personal knowledge, it is based on published records and therefore reflects the strengths and weaknesses of the observations and records of amateurs and professionals over the last 150 years. As we have seen in Chapter 5, systematic surveys of the coastal and intertidal zone have been undertaken only within the last two decades and few of these have been published in a final form.

Although every attempt has been made to marry the archaeological information with knowledge of the character of the coast from which individual finds have been recorded, this has not been possible at a detailed level. Thus the context of most intertidal finds is not adequately reported and cannot be ascertained with any precision without fresh fieldwork. This even applies at the level of distinguishing in the record between finds eroded from cliffs and those which have been released from sediments further down the tidal range. Uncertainty of context has major implications for the assessment of potential; a site may have completely eroded from a cliff, or finds may be continuing to emerge from an already exposed context in the intertidal zone. In general, finds from shores with high cliffs tend to be derived from above and are, therefore, essentially terrestrial, while those from estuaries are frequently associated with sediments within the tidal range.

In addition to the problem of defining location, there is a difficulty with the identification of many finds, a high proportion of which were reported in an age when the understanding of artefact chronologies was in its infancy. Thus, as we shall see, there are many problems with the identification and dating of prehistoric flint, just as there are with prehistoric and historic pottery. Furthermore, since many of the early reports derive from unsystematic collection and survey, it is difficult to judge the 'completeness' of the record. Where sites have been surveyed within the last decade, it is possible to gain an insight from the more recent record into what might not have been observed previously at comparable sites elsewhere.

Given the nature of the documentary evidence available, it is not surprising that contributors to this section have expressed reservations about how much the existing record can contribute to knowledge and understanding of coast-specific activities and settlement. In the majority of cases it is not possible to discern from the recorded evidence any characteristics which might not otherwise be expected from a terrestrial site. This reflects a previous lack of concern for the systematic investigation of man's relationship with the sea in the coastal zone. One corollary of this is that contributors to this chapter have found it difficult to write at length on coastal themes, such as the archaeology of fishing and oyster cultivation, boats, and building. By the same token it is difficult to infer much from the present record about the history of coastal retreat, which has been the principal agent behind the creation of the present record.

A number of general weaknesses and deficiencies in the NMR and county SMRs were identified in *Recording England's past* (RCHME 1993a), but the need to enhance the record for 'maritime sites in the offshore and intertidal zones' was highlighted as a priority (ibid, 50). This review of the archaeological resource in the intertidal zone has therefore drawn attention to some of the problems and limitations of the record which are peculiar to this context. A sharper focus on such issues is an essential prerequisite in defining priorities in the enhancement of the maritime and intertidal record.

To reiterate the nature of the evidence on which this survey is based, the emphasis in the existing record is on prehistoric and Romano-British sites and finds; there is comparatively little from the Anglo-Saxon period onwards. This should not be regarded as an accurate indicator of the archaeology that actually survives in the intertidal zone, merely as a reflection of past interests and knowledge. The question of deficiencies will be touched on here, but returned to in more detail in the concluding chapter. At the same time, there are certain issues relating to the archaeology of the coastal zone which are too large to be adequately treated here; in particular the themes of coastal defence, and of major ports and docks, are beyond the scope of this report.

6.2 Earlier prehistory: the Palaeolithic and Mesolithic periods

6.2.1 Introduction

The Palaeolithic and Mesolithic continue to be relatively neglected archaeological periods, even though recent excavations are demonstrating that England contains some of the most important early prehistoric sites in Europe. In the light of the long duration of these periods, the first occupation occurring at *c* 500,000 years bp and the Mesolithic finishing at *c* 3800 cal BC, a systematic survey of the coastal archaeology of England might initially be expected to produce a wealth of data dating to these periods. The catalogue, however, provides rather sparse records of Palaeolithic and Mesolithic sites in the coastal zone, and before assessing this evidence we must consider the major influences on the recovery of data from these periods, and its identification as either Palaeolithic or Mesolithic.

6.2.2 The nature of the evidence

6.2.2.1 The significance of global climatic change and its influence on coastal evolution

The Palaeolithic and Mesolithic archaeology of the coastal zone is of a rather different nature from that of later periods, owing to the very substantial changes in the nature of the coastline since the early Holocene. The evolution of the coastline is an ongoing process, and understanding the change in sea-level, coastal topography, and environments is essential for the interpretation of sites all periods. When dealing with later prehistoric and historic archaeology our concern is principally with the local processes of coastal evolution. These include variation in tidal patterns, frequency of storms, and anthropogenic activity, which affect restricted parts of the coastline. Few generalisations can be made regarding the relationship between coastal evolution and the archaeological record of any one of these periods as a whole.

In contrast, when considering early prehistory, the nature of the record is dictated by global fluctuations in sea-level which have occurred during the Pleistocene (see above, Chapter 2). These have derived from an interaction between eustatic and isostatic factors, and ultimately relate to global changes in climate. Such changes are most evident from the oxygen isotope record from marine sediments, which indicates at least eight major glacial/interglacial cycles since the start of the Middle Pleistocene, along with numerous stadials and interstadials (eg Shackleton and Opdyke 1973). The recent results from the analysis of ice cores indicate that there have also been many short-term 'flickers' in climate (eg Taylor *et al* 1993), the implications of which for sea-level change remain to be explored. The very marked climatic warming at 10,000 BP resulted in a substantial increase in the volume of ocean water. As isostatic processes were of less significance than eustatic processes in southern Britain, the consequence has been an overall rise in sea-level resulting not only in the loss of Palaeolithic and early Mesolithic shorelines, but of whole coastal regions. Moreover, this has actually created the coastline of southern England, since until *c* 7500 cal BC (8500 BP) the country remained joined to the continent to form the most north-westerly peninsula of the Eurasian landmass (Fig 49). In addition to creating the English Channel, the late Pleistocene/early Holocene rise of sea-level created the Irish Sea and the southernmost part of the North Sea. It is also clear that the relative rise in sea-level has not been uniform around the whole of the English coastline, owing to a wide range of regional and local factors.

As a result, although we can be confident that the later prehistoric and historic sites which are currently in coastal locations were also in contemporary coastal environments, or at least coastal regions, this is simply not the case for early prehistoric sites.

For sites of the early Holocene and Late Pleistocene our knowledge of recent climatic change and eustatic processes may enable us to infer the relative location of their contemporary shoreline. This will frequently tell us that the sites were some distance inland. For instance, the Upper Palaeolithic site at Hengistbury Head (*c* 12,500 BP) is today found on a cliff edge, but when occupied it would have been an inland site, probably selected for the exploitation of terrestrial game (Barton 1992). The ridge currently occupied by the site would have overlooked a wide valley, which is now submerged by the Solent. Even the Mesolithic site at Hengistbury is likely to have been well inland when it was occupied, since in 10,000 BP the coastline was 20km south of its present position, and the separation of the Isle of Wight from the mainland is likely to have occurred only *c* 6000 years ago.

As we move further back into the Palaeolithic, our understanding of the location of the coastline becomes extremely limited, owing to the complexity of coastal evolutionary processes and the extent of climatic change. This problem is compounded by our inability to date many Palaeolithic artefacts, as will be discussed below. For instance, the famous Golf Course site at Clacton is today no more than a few hundred metres from the current North Sea coast, and the palaeolandscape setting of this site remains unclear (Singer *et al* 1973). Climatic changes during the Pleistocene not only influenced overall sea-level, but also the location of major estuaries and hence intertidal zones. The course of the Thames, for example, has changed substantially during the Pleistocene (Gibbard 1994).

In sum, we simply lack the coastal zone for much of early prehistory. The archaeological sites in contemporary coastal contexts derive from a wide range of palaeoenvironmental contexts, the majority of which were essentially terrestrial in nature.

The converse of this is also true: we have archaeological sites in Britain which when occupied were coastal, indeed intertidal, in character, although

Fig 49 Reconstructed coastline of north-west Europe c 10,500 BP

today they are found inland. The most important of these are the finds of Acheulian handaxes on top of the Slindon Sands in west Sussex, marking the 100ft (30m) raised beach of a Middle Pleistocene sea-level. The most important of these sites is Boxgrove, Sussex (Roberts 1986; Bowen and Sykes 1994), most probably dating between 524,000 and 478,000 years ago (oxygen isotope stage 13). Boxgrove is renowned for its well preserved *in situ* activity floor where animals were butchered and artefacts manufactured. It is without doubt one of the most important Palaeolithic sites in Europe. The remains here indicate that early humans were gathering flint nodules from the base of a cliff. Numerous artefacts have been found on what would have been a beach context, but whether the inhabitants were exploiting marine resources remains a moot point.

This again serves to differentiate the early prehistoric archaeology of the coastal zone from that of later periods. When, for instance, we assess sites of the Roman period in current coastal locations, we should obtain direct information concerning the nature of the coastal exploitation of that period. The assessment of Palaeolithic and Mesolithic sites currently found in coastal contexts will not provide this sort of information (Fig 50).

Fig 50 The distribution of Palaeolithic, Mesolithic, and Neolithic finds in England's intertidal zone (see also Figs 51–2)

6.2.2.2 The problem of dating

The difficulty of assessing the early prehistoric archaeology of the coastal zone is further compounded by our limited ability to date artefacts. Many catalogue entries are single lithic artefacts, and the criteria used by the SMR, NMR or other archives/reports for classifying these as either Mesolithic or Palaeolithic are often unclear. During the last decade it has become evident that chronological trends in lithic technology and typology are far more complex than had previously been thought, and indeed for much of the earlier Palaeolithic may simply be absent. Consequently, although the handaxes from Charmouth and Swanage in Dorset may be confidently placed at a date between 500,000 and 125,000 BP, it is uncertain precisely where in this period they may lie. Even at Boxgrove, one of the most intensively studied Palaeolithic sites, where a suite of dating methods has been applied, the date of occupation of the order of 100,000 years is still in dispute, with some Quaternary scientists dating it an entire ice age younger (ie stage 11) than others are prepared to accept (Bowen and Sykes 1994).

Consequently, even when there are adequate artefactual descriptions of the finds from coastal contexts, we may still be unable to place them within any discrete archaeological period. The most frequent problem, however, is of inadequate descriptions, using imprecise terms such as 'stone axe', without any explanation of why the object is being attributed to the Palaeolithic or Mesolithic. For instance the 'flint core' from Humberside (SMR no. 1893) is attributed to the Palaeolithic, and a 'flint arrowhead' at Brow in the Isles of Scilly (PRN 7304.01) is attributed to the Mesolithic. One suspects that artefacts are being attributed to these periods as the default.

An exception to this problem of dating may arise with certain artefact types which have well defined chronological bounds. For instance, the large tanged point from Stone Point near Walton on the Naze (Essex) and the shouldered point from Shoeburyness (Essex) can both be attributed to the late glacial period. The recent dating programme on late glacial settlement in Britain suggests that we can be confident in attributing such finds to a rather narrow window of probably less than 1000 years between 12,800 and 12,100 BP, falling within the late glacial interstadial. A major caveat, however, is that there appears to be a significant plateau in the calibration curve at this period. The tight clustering of radiocarbon dates that has emerged during the last few years may reflect the existence of this plateau, rather than the settlement chronology.

6.2.3 Interpretation of the evidence

6.2.3.1 The Early Palaeolithic

This period is principally represented by a few finds of handaxes and artefacts thought to be of an early Palaeolithic date in eroding gravel deposits exposed in cliff sections. As such they are in redeposited contexts, and even if they have moved only short distances the original occupation sites are unlikely to have been coastal. As secondary finds lacking associated material, a study of these is unlikely to contribute further information concerning the English Lower Palaeolithic. However, it is important that the source and character of these finds are clearly documented, and this is partly being done by the Southern Rivers Palaeolithic Project (directed by John Wymer, funded by English Heritage). The most intriguing of the Early Palaeolithic findspots is at Doniford, Somerset, where it is claimed that Acheulian artefacts have been found associated with the remains of mammoths (SMR no. 34189).

6.2.3.2 The Upper Palaeolithic

There appear to be only two Early Upper Palaeolithic (EUP) findspots (ie between 40–20,000 BP) in the English coastal zone. The most important of these is Kent's Cavern, also renowned for its Early Palaeolithic archaeology (Campbell 1977). This site has provided one of the earliest modern humans from Western Europe and illustrates the importance of coastal caves in Britain for preserving traces of early prehistory; the Paviland Cave in south Wales, and Kirkhead Cave in Morecambe Bay, also contain important Upper Palaeolithic material (Jacobi 1980b). The second important EUP site is at Bramford Road, Ipswich, although this may not be officially classified as a coastal site, since it constitutes a set of artefacts, including diagnostic unifacial leaf points, acquired by dredging below the water table in a gravel pit.

Following the break in human settlement in Britain caused by climatic deterioration, reoccupation during the late glacial occurs from 13,000 (radiocarbon) years ago. The coastal site of Hengistbury Head is an extremely important settlement of this period. Its well preserved knapping floors permit the refitting of artefacts, and consequently a detailed understanding of late glacial technology. It is the only site of this period in Britain to have been excavated on a relatively large scale and using modern methods, and is one of a small sample of open sites; the majority of the later Upper Palaeolithic settlement derives from inland caves. The only other substantial Late Upper Palaeolithic coastal site is Titchwell on the coast of Norfolk (Barton 1992, 183–87). Artefacts from Titchwell, including end scrapers, burins, and backed knives, have been collected from a 2–3km stretch of beach which is exposed at low tide. They apparently derive from a late Devensian clay deposit which is overlain by a series of Holocene peats. The base of these has given a date of *c* 8000 cal BC, providing a *terminus ante quem* for the site, which may be substantially earlier.

Neither of these sites informs us about coastal occupation during the late Upper Palaeolithic. We can only speculate that the coastal zone is likely to have been an important source of resources during this period, and that a significant element of the archaeological record has been lost by the rise in sea-level. Carbon isotope analysis of Upper Palaeolithic human skeletal remains from England, such as from Gough's Cave, would provide an indication of the relative importance of marine and terrestrial foods in the diet, and this appears to be the only feasible approach to addressing the role of coastal settlement during this period.

6.2.3.3 The Mesolithic

The English Mesolithic, *c* 10,000 BP–3800 cal BC, is conventionally divided into two periods, the earlier Mesolithic characterised by broad blade microliths and the later Mesolithic, beginning at *c* 7500 cal BC, by narrow blade or geometric microliths. By the time of the later Mesolithic the coastline was approaching its current position and for the first time in British prehistory we can explore the character of coastal settlement (see above, Chapter 4, for environmental considerations). A major problem, however, is the lack of adequate information on lithic finds to enable sites to be attributed either to the earlier or to the later Mesolithic. Indeed, in many cases it remains unclear why the artefacts are attributed to the Mesolithic at all.

These Mesolithic finds derive from a wide variety of contexts, ranging from clifftops to caves and intertidal deposits associated with submerged forests. These are likely to relate to a wide range of site types within Mesolithic settlement systems, and the systematic comparison of assemblages from such a range of coastal contexts would be useful. The fact that so many of the references are to finds and site descriptions made more than 30 years ago reflects the limited amount of work on both the Mesolithic and coastal archaeology.

Numerous sites appear to have considerable potential for addressing questions about the Mesolithic, and urgently require evaluation and study because of ongoing processes of erosion. The most important are those which are claimed to involve an association between Mesolithic artefacts and submerged forests, providing the opportunity for integrated archaeological and palaeoenvironmental studies, such as at Porlock Weir in Somerset. Perhaps the most interesting are the submerged forests from the Hartlepool area (Trechmann 1936), from which early Mesolithic artefacts have been recovered in apparently good stratigraphic contexts and in association with considerable palaeoenvironmental evidence. Other submerged forests, such as at Daymer Bay in Cornwall, from which there are no reports of archaeological remains, may also provide important palaeoenvironmental information. Of equivalent importance are sites which appear to have good preservation of organic artefacts and faunal remains associated with lithics, such as Harkstead and Stutton in south Suffolk.

Apart from the submerged forests and coastal peats of the north-east (such as in the Holderness area), two areas of coastline appear to be particularly rich in Mesolithic artefacts. The first of these is Essex (Fig 51), for which the SMR describes a relatively high number of findspots in the coastal zone (cf Wilkinson and Murphy 1995). Some of these are from submerged contexts (eg Warren *et al* 1936), although the presence of later prehistoric artefacts may make the identification of Mesolithic (and Palaeolithic) artefacts difficult from lithic debris alone (above, Chapter 5; this chapter, below). The coastal region of the Solent and the south-west (Fig 52) also stands out as having a particularly high number of Mesolithic artefact scatters, some of which appear to be rich in retouched artefacts (Wymer 1977). It is unclear whether this reflects a true pattern of site distribution or a relatively higher rate of discovery and reporting than in other regions.

6.3 Later prehistory: the Neolithic, Bronze, and Iron Ages

6.3.1 Introduction

This section considers the potential importance of the intertidal zone, but it is not, and cannot be, a prehistory of that area. Given the quality of the data, its main aim is to define the kinds of information we shall require if we are to achieve that objective, rather than to attempt a full synthesis (Fig 53).

It is essential to begin by defining our terms. The intertidal zone is a feature of the contemporary landscape, and its archaeology has no particular unity. It occurs in at least three distinct types of situation, each of which has a very different significance for the writing of prehistory. Firstly, there are those discoveries that highlight the importance of the intertidal zone at different times in the past. These are areas of the ancient coastal margin which happen to survive in what are rather similar environments today. They have the potential to illuminate a number of activities in the prehistoric landscape that are too little understood, but it does not follow that the ancient shoreline need correspond to the modern coast at all, and similar evidence may be preserved in inland areas. This may happen because of changes in sea-levels or result from a campaign of reclamation. The consequences of these developments can vary considerably. Often they result in alterations to the water table, so that the archaeological remains lose their organic component. In other instances, however, the level of preservation may be significantly higher, and where this happens what were originally coastal sites may be preserved in areas of wetland well inside the present shoreline. The

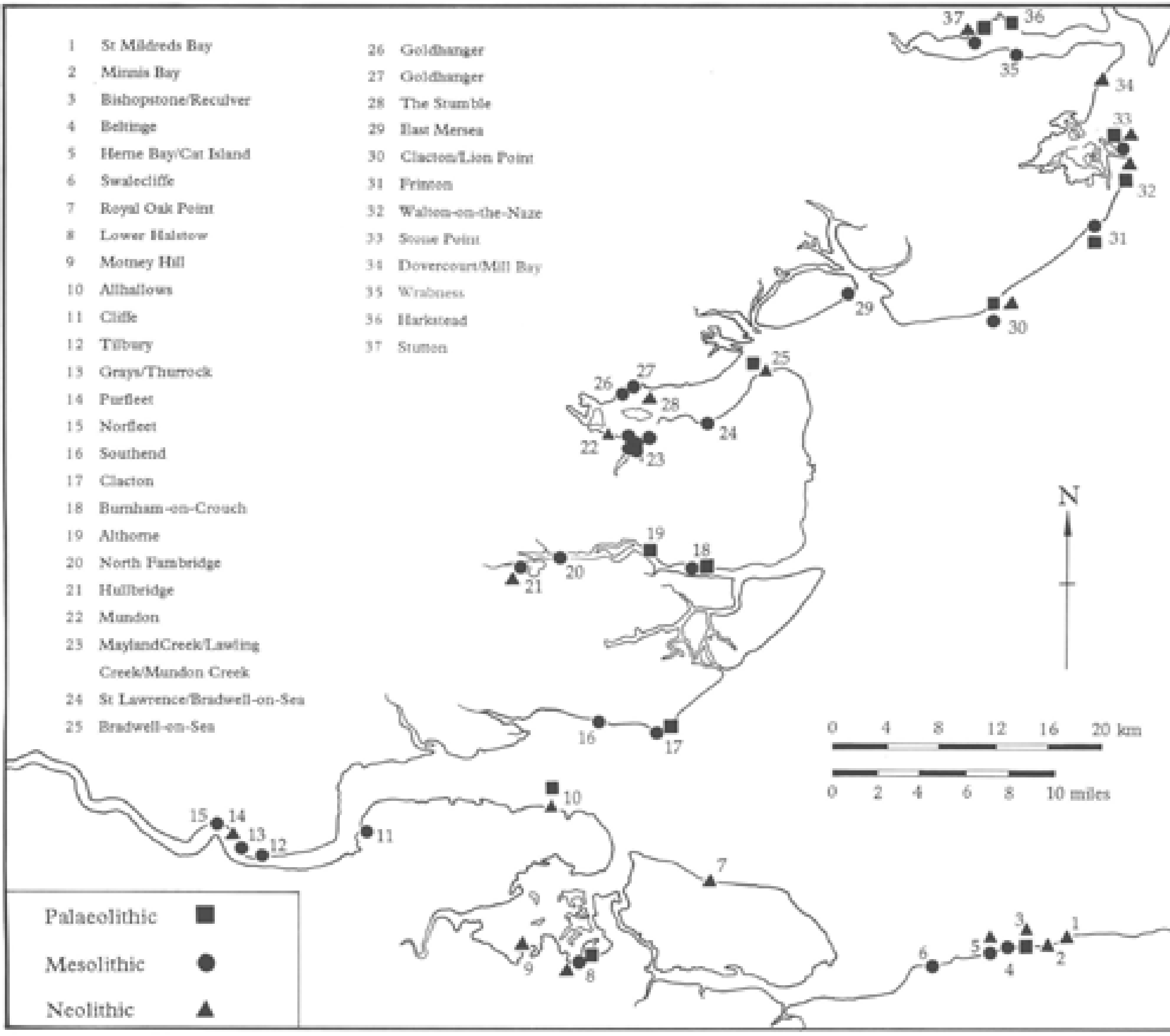


Fig 51 The distribution of Palaeolithic, Mesolithic, and Neolithic finds in the intertidal zone of Essex and north Kent

abundant evidence for Iron Age salt extraction revealed by the Fenland Survey presents a good example of this process (Coles and Hall 1994, chapter 6). For the purposes of this chapter, however, we are concerned only with those sites close to the ancient coastline that are situated in the intertidal zone today. Their management may pose special problems, but a coherent programme of research would examine this material collectively.

Secondly, there are old land surfaces preserved in the intertidal zone which were originally located some distance from the sea. They have little or nothing to tell us about the ancient uses of the coastline, and so their management and investigation must be justified in terms of academic priorities that are the same as those for landscapes further inland. Their claim to attention results from their later history. Sometimes intact land surfaces have been protected from the disturbance caused by farming or later occupation, with the result that structural features and environmental evidence survive unusually, so that, for example, excavation on the Neolithic occupation site of the Stumble in Essex has been more informative than most settlement excavations on dry land (Murphy 1988) (Fig 54). This does not mean that the site itself was in any way unusual, however. It may seem perverse to suggest that somewhere which was so difficult to investigate can be treated as a type-site, but it is entirely logical to do so.

The last category includes all those dry land sites that are exposed to coastal erosion today. These generally have the lowest archaeological potential, for in many cases they had little to do with prehistoric uses of the shoreline, and often their preservation is no better than that of other sites. The main advantage of this group is that they can be easy to find. For example, the line of a receding cliff need not be any more significant than the course taken by a modern road or a pipeline, but it does provide an opportunity for working out the

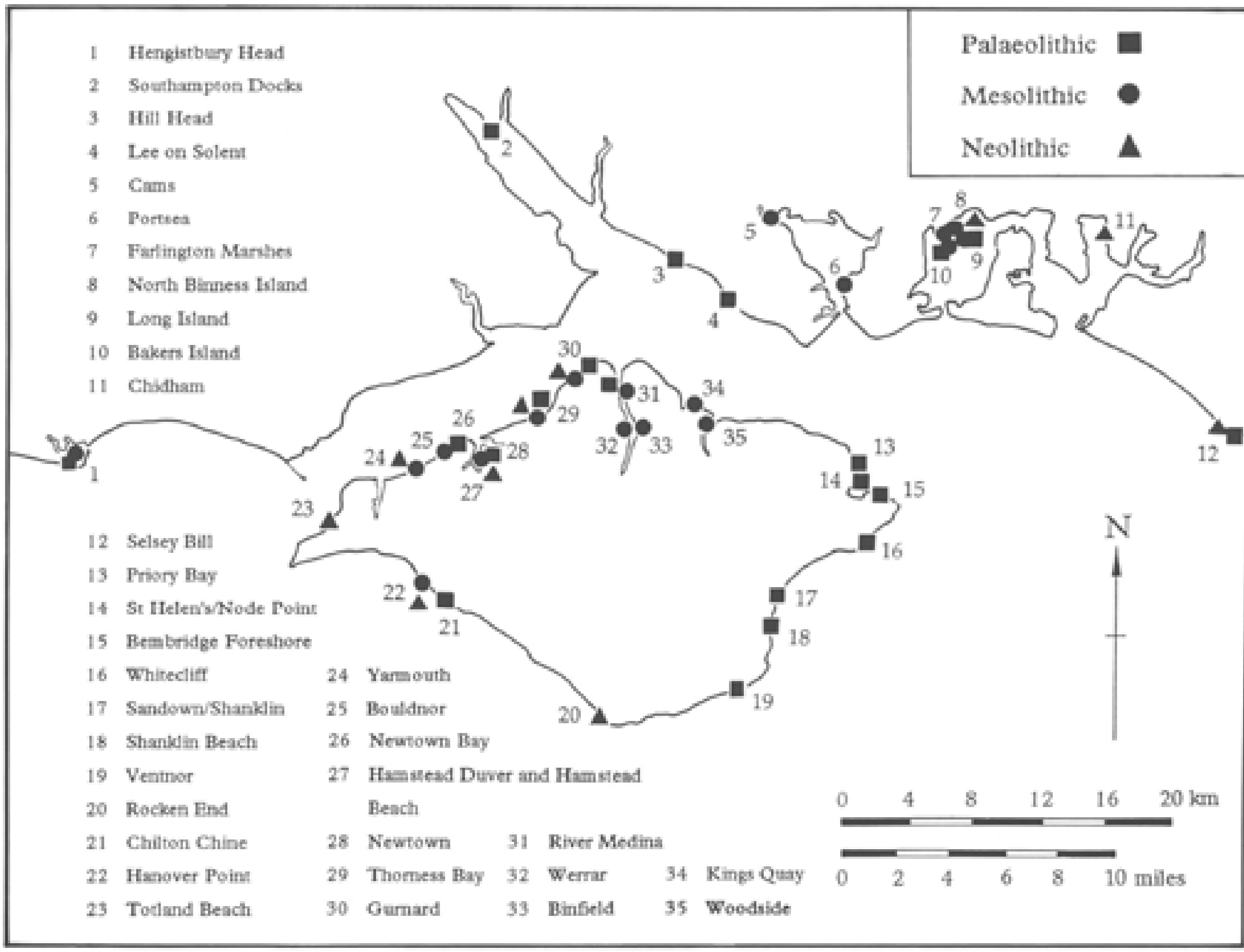


Fig 52 The distribution of Palaeolithic, Mesolithic, and Neolithic finds in the intertidal zone of the Solent: Hampshire and the Isle of Wight

intensity of prehistoric activity in areas whose archaeology is otherwise obscured.

Unfortunately, it is rarely possible to distinguish between these different situations on the basis of the information held in SMRs. With the exception of a few carefully conducted surveys, the pattern of discovery has been entirely haphazard and the quality of the record is very poor. The case of Minnis Bay in Kent illustrates this problem (Worsfold 1943). First published in a national journal, this is a classic prehistoric site in the intertidal zone. It comprised a large artefact assemblage, including pottery and a metal hoard, a variety of subsoil features associated with plant remains, and a series of waterlogged wooden structures. But all was not what it seemed. Although these features were exposed by coastal erosion, there is no evidence that the prehistoric features were ever located on the Late Bronze Age shoreline. The pits did not contain any waterlogged deposits and the environmental evidence suggested that the settlement was originally situated in dry grassland, and was only later invaded by the sea. Champion has argued that the wooden structures discovered at Minnis Bay are entirely secondary to the other features on the site, and belong to a relatively recent period when the evidence of prehistoric settlement was already being washed away (1980, 231–3). They probably come from fish weirs. Shorn of its preserved woodwork, Minnis Bay becomes a badly damaged example of a class of Late Bronze Age settlement frequently encountered on dry land where excavation can be undertaken much more easily.

At least in this case we know where the site was located, how it was found, and how it can be dated. This information is rarely available, because so few finds in the intertidal zone have been recorded to a satisfactory standard. There is also the problem of bias. Even when properly organised surveys are conducted, their results may be incomplete. For example, a recent survey of the shoreline of Chichester Harbour found numerous concentrations of worked flint and pottery, but no evidence of prehistoric salt production (Cartright 1984). Not long before, significant amounts of briquetage had been found in exactly the same area

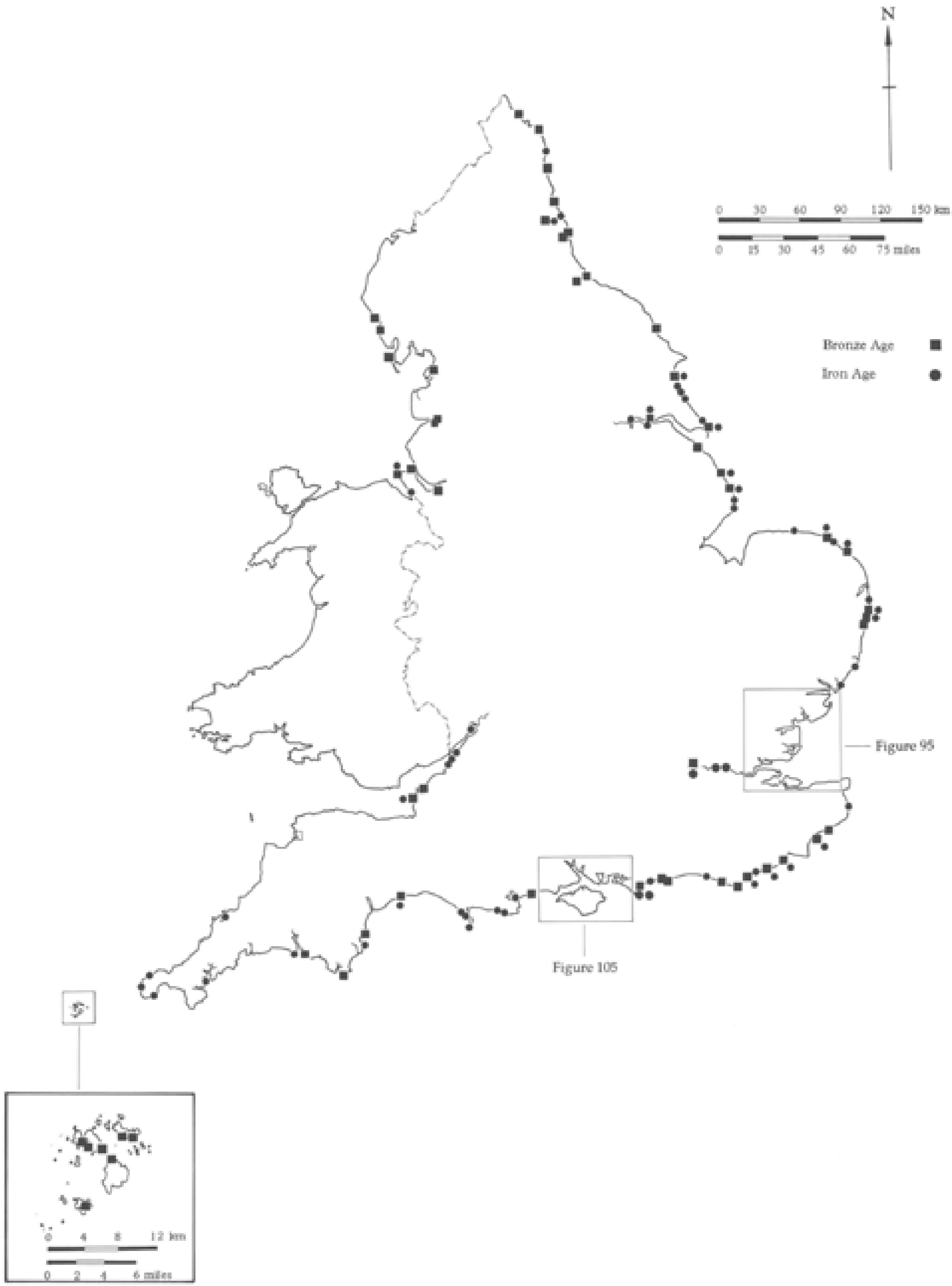


Fig 53 The distribution of Bronze Age and Iron Age finds in England's intertidal zone (see also Figs 95 and 105)

Fig 54 The Stumble, river Blackwater, Essex: excavation of a Neolithic settlement on a former dryland surface (Essex County Council)

(Bradley 1975). Nearby, in Portsmouth and Langstone Harbours, large quantities of worked flint had been collected, but in this case there were few records of pottery (Draper 1968). Often the available accounts are difficult to use, but in some cases it is possible to infer the source of the confusion. For example, in Hampshire 'Clactonian' artefacts are recorded from the same areas as Later Bronze Age pottery. This takes on a new significance when we realise that the expedient flint industries of later prehistory had not been characterised at the time when these finds were identified; in fact, the 'Palaeolithic' flintwork was probably contemporary with the pottery. There are other difficulties in translating the identifications of artefacts made at different times in the past. Thus there are salt-production sites in Dorset for which the same pottery has been dated anywhere between the Late Bronze Age and the Late Iron Age (Farrar 1975). The precise contexts of such finds are recorded so rarely that they are no help in assessing this information.

This lack of precision has serious consequences for the use of the available records. All too often it is assumed that because a site was found on the modern shoreline it must always have occupied a similar situation in the past, and this influences its interpretation. Thus finds of preserved hurdles are all too easily identified as prehistoric traps or fish weirs, when similar finds on wetland sites away from the coast would be interpreted as platforms or as lengths of trackway (Fig 55). Areas of burning are claimed as the remains of prehistoric salt production, when there is little or no evidence that they were created in a saline environment. Indeed, in central southern England there are several burnt mounds which are truncated by coastal erosion. These are almost invariably found in association with streams and have been interpreted as cooking sites where large quantities of fresh water were brought to the boil. Similarly, the flint industries collected from the intertidal zone can all too easily be interpreted in terms of a specialised adaptation to the conditions on the shoreline (Drewett *et al* 1988, 46). Such interpretations are rarely supported by any environmental evidence.

It will not be easy to correct all the errors that have crept into the records, especially where these draw uncritically on accounts published many years ago. In the discussion that follows, an attempt has been made to reconcile the terminologies that are used in county SMRs with an outline chronology that has some relevance for the issues investigated by modern archaeology. Where it is possible to do so, the evidence has been assigned to one of seven broad phases (Figs 50–3):

Earlier and Later Neolithic
Early, Middle and Late Bronze Age
Early Iron Age and Middle Iron Age

The Late Iron Age material is treated with the Roman evidence below. The one exception is the discussion of the salt industry, which treats the prehistoric and Roman material together.

It is not surprising that such difficulties of recognition and interpretation of the record have arisen, for it is never easy to undertake disciplined fieldwork in the intertidal zone, and the insubstantial remains of prehistoric activities are more difficult to recognise than the traces of later occupation. Often the finds that have been recorded result from casual collection. If Roman coins are over-represented here, so too are worked flints and metal artefacts. Briquetage was often overlooked until recently, and there are surprisingly few references to other kinds of pottery. The records also refer to numerous finds of wood, but most fieldworkers lacked the experience to identify the less obvious traces of human workmanship. Still fewer had enough experience to recognise the characteristic signs of ancient woodland management.

In some ways the best of the early observers were those with a major interest in geology. Among the most discerning was Hazzledine Warren. By contrast, the least useful records are the work of collectors who were more interested in obtaining good specimens than they were in the contexts from which these came. On the other hand, their sheer persistence means that the records extend over a period of time which few fieldwork projects can sustain. They help us to define the basic requirements for a worthwhile record of the intertidal zone.

There is an obvious need for such persistence, and what distinguishes the quality of the records from a few restricted areas is the length of time over which individual sites have been visited. Pride of place undoubtedly goes to the Humber Estuary, where the remains of five prehistoric boats and a range of associated artefacts have been recorded through a concerted programme of visits extending over more than half a century (Wright 1990; Wright and Switsur 1993) (Figs 56–8). The constant process of erosion, burial, and fresh exposure means that few if any sites can be investigated definitively during a short period of fieldwork. The discoveries at North Ferriby are of European significance, and there is no reason to suppose that the archaeology of this site is anywhere near exhaustion. The same point can be made about the estuaries of the Essex coastline, which first came to prominence in the archaeological literature over half a century ago. Some of the sites recorded at that time certainly have been lost, but a careful campaign of fieldwork showed very clearly that fresh material was still coming to light (Wilkinson and Murphy 1986; 1995). Those working in the Severn Estuary have had the same experience. Persistence, regular monitoring of the shoreline, and thorough examination of those

Fig 55 The Stumble, river Blackwater, Essex: Iron Age hurdle 'bridge' before excavation (Essex County Council)

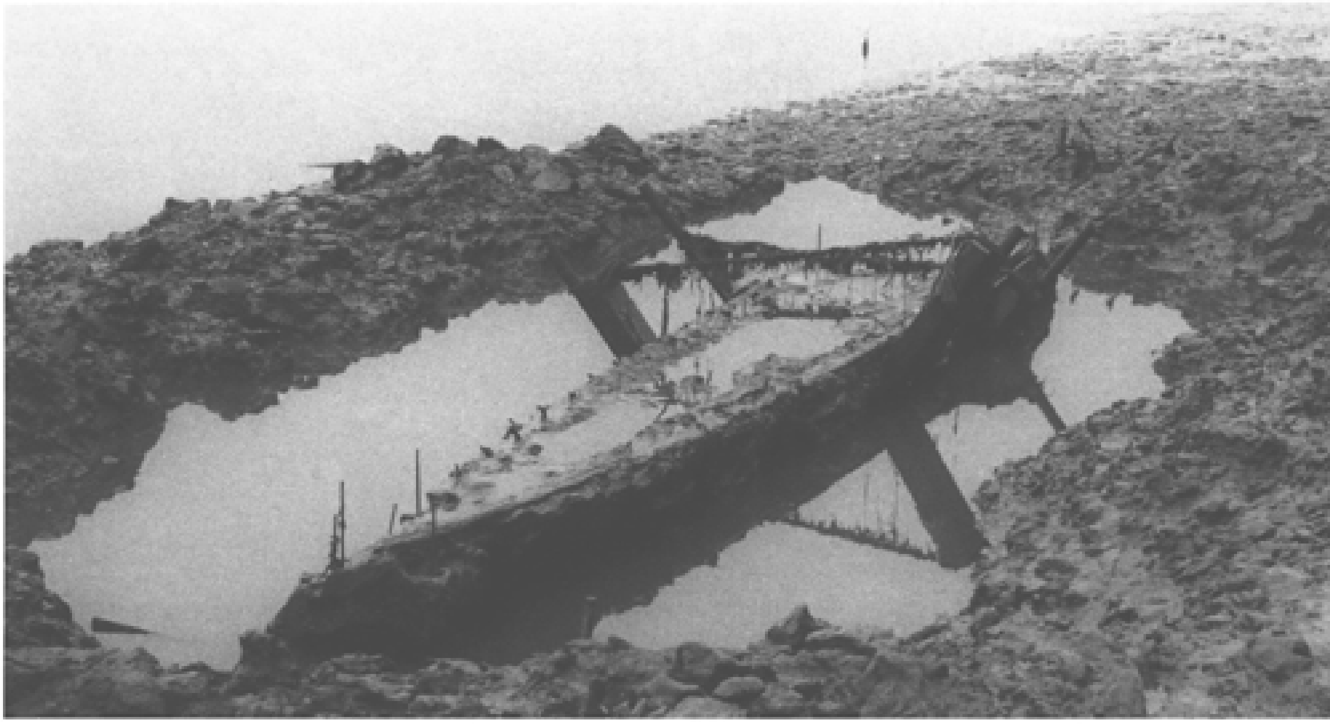


Fig 56 North Ferriby: excavation of the Bronze Age boat in 1963 (National Maritime Museum, Greenwich)

areas affected by storms have almost inevitably produced outstanding results. A single season of fieldwork, however sophisticated its methodology, would not have achieved so much.

At the same time, such survey is still essential, but its main contribution may not be in revealing new finds (and still less in discovering a comprehensive sample of the archaeology), but in establishing the chronological and environmental contexts to which these discoveries belong. Without careful fieldwork whose principal objective is to establish the basic sequence of events in relation to the changing environment on the shoreline, very few finds will realise their full potential. This has been one of the strengths of work in Holderness, Essex, south Hampshire, the Severn Estuary, and Merseyside, and the basic approach can only be compared with that taken in surveys of English wetlands like the Fenland or the Somerset Levels. Without such information it will never be possible to understand the prehistory of the intertidal zone. The ambiguities highlighted in the opening section of this paper cannot be resolved by any other means.

These comments have two implications. Any attempt to draw together the archaeological material from the intertidal zone will be based to a very large extent on the material from a few, possibly unrepresentative areas where local archaeologists have been able to monitor the finds from the shoreline over a long period, a period that may be measured not in weeks but in decades. At the same time, a few discoveries that are properly tied to their environmental contexts are worth far more than an abundance of

Fig 57 The Canewdon paddle (Bronze Age) in situ, *as excavated (Hullbridge Survey, river Crouch site 56) (Essex County Council)*

Fig 58 The distribution of boat finds in England's intertidal zone

archaeological material whose exact context is unknown. The information currently available exists in two dimensions, when it is the third dimension (its stratigraphic context) that holds the key to its interpretation. For that reason the summaries which follow lean heavily on the work that has been carried out by a small number of systematic surveys (see below, Chapter 7).

6.3.2 The intertidal zone in the past

6.3.2.1 Boats and boatworking

Like radiocarbon dates, the records of prehistoric finds from the intertidal zone need to be subjected to quality control, and when we do this many of the claims for specialised uses of the shoreline prove to be quite unsupported. There are, however, some cases in which its archaeological potential is already clear.

The first field is what Wright (1990) describes by the useful term 'boatworking'. This includes much more than the accidental discovery of sunken or abandoned vessels, for it also refers to their building, maintenance, and repair, and to the facilities associated with these processes. Log boats have been found in inland and coastal waters for more than a hundred years, but there are now a number of important discoveries of more substantial vessels of Bronze Age and Iron Age date. Large parts of these boats can be discovered, as happened at North Ferriby (ibid) and Dover (Parfitt and Fenwick 1993), or smaller pieces of reused timber may be found (Figs 56–9). A good example is a recent discovery on the Welsh shore of the Severn Estuary at Goldcliff (Bell 1993a, b). The most useful information is forthcoming when these finds are associated with other artefacts or features. At North Ferriby, for example, it seems as if the Bronze Age boats were beached on the sides of a shallow inlet. In the same area were the remains of a timber structure which could have provided a platform on which a damaged boat could be supported, a trestle that might have held a series of timbers while such a boat was being dismantled, and a causeway giving access to the lower foreshore where these vessels were beached. There was also an area of chippings resulting from an episode of woodworking. In the same area were finds of artefacts

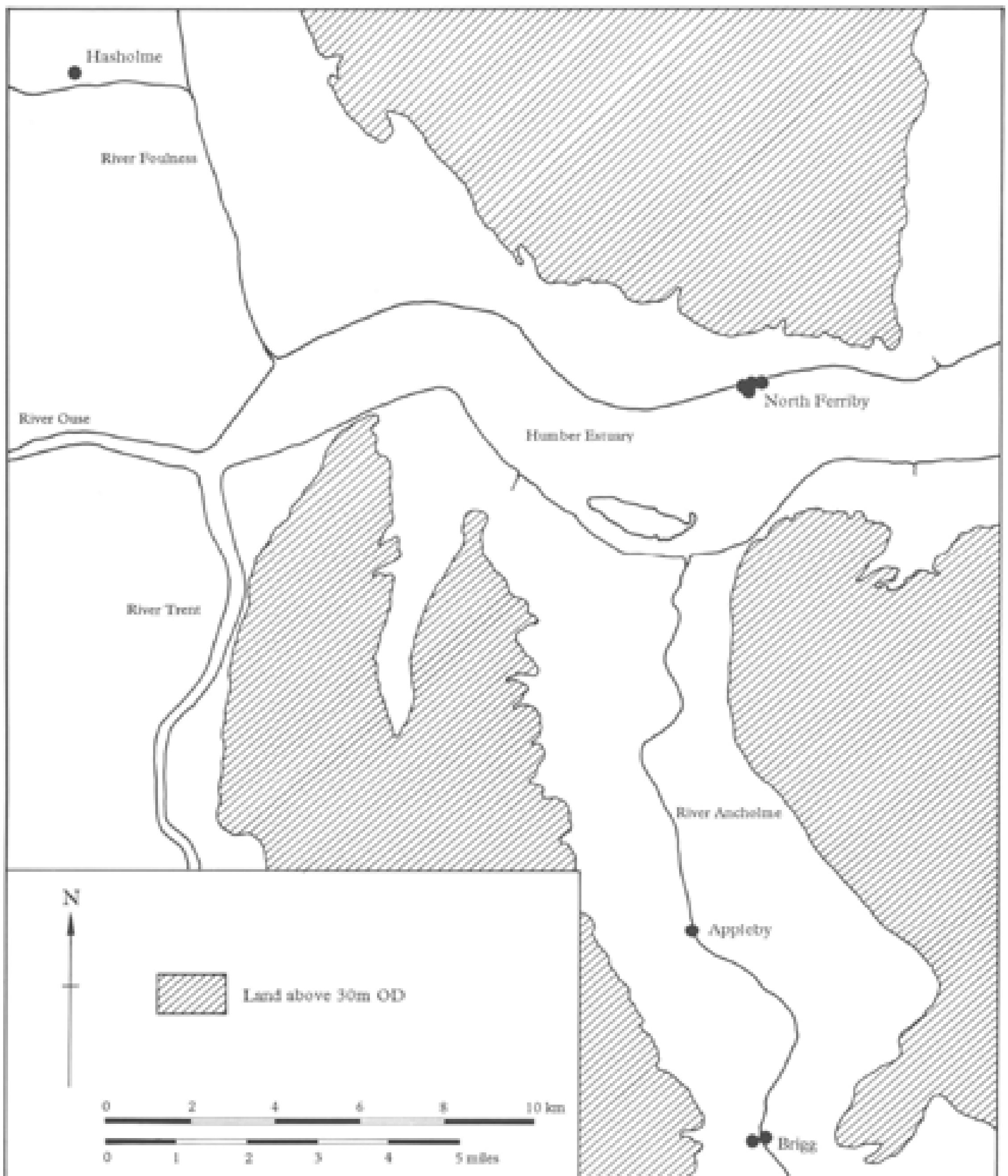


Fig 59 Prehistoric boat finds in the Humber Estuary

most probably associated with the making and repairing of boats, including a wooden patch, parts of a capstan, a length of cord, and a tool for stitching. There were also three paddles, the latest of which was found in early 1995 (Fenwick 1995). There have been finds of similar material elsewhere on the North Sea coast, notably a wooden cleat found off the modern shoreline at Hartlepool (Fenwick 1993).

Such discoveries need systematic investigation, for there are other elements that we might well expect to find in these locations. There might have been jetties and boatsheds, and somewhere there should also have been stockpiles of timber. Such material would have enormous potential, for it might be dated by dendrochronology and could also shed light on the way in which timber supplies were managed. Equally, study of the wood offers the prospect of localising its source, whether within Britain or overseas. At the same time, we need to know far more about the functions of the ancient boats whose remains have been discovered in the intertidal zone. Were they designed for passenger transport? The Ferriby boats may well have provided a ferry service across the Humber Estuary. Were they used mainly for riverine transport or were they sea-going vessels? And which types were used in each case?

6.3.2.2 Exploitation of marine resources

In fact, we know very little about the wider range of activities undertaken on the prehistoric shoreline (see above, Chapter 4). Although it seems possible that the larger boats were engaged in fishing expeditions, there is little to indicate the importance of marine resources after the Mesolithic period. Indeed, there seems to be an automatic assumption that all shell middens are of Mesolithic origin and must be the work of hunter-gatherers, although in areas of isostatic uplift, particularly in Scotland, their creation continues at least as late as the Iron Age. There are indications of a similar pattern in the Isles of Scilly (Thomas 1985). We know even less about other aspects of marine exploitation. Wright (1990) has suggested that the Ferriby boats might have been used in deep-sea fishing, but intensive exploitation of marine resources could have resulted in the creation of storage buildings, processing areas, and drying racks on the shoreline. None has so far been discovered. Indeed, there has been little attempt to look for fish bones in excavated deposits on dry land sites, and virtually no attention has been paid to the archaeological potential of bone chemistry as a source of information on this question.

In the historical period the processing of fish could be undertaken alongside other activities, the most important of which is the pasturing of livestock. Such practices were so common that when small wooden structures were encountered on the North Sea coastline in the early years of this century they were almost automatically assumed to be the temporary shelters created during these activities. Martin Bell's work at Goldcliff (Figs 45, 60) on the Welsh side of the Severn Estuary, extends this pattern back at least as far as the Middle Iron Age (Bell 1993a, b), and similar work in the same region has resulted in the discovery of insubstantial wooden buildings dating from the Middle Bronze Age (Whittle 1989). At Goldcliff there was a further complication, because the buildings took a form which is unknown on inland sites. They had probably been occupied over short periods, perhaps seasonally, and had been located very near to the coastal margin. There were many animal footprints in the vicinity, although Bell emphasises that another interpretation of these buildings connects them with fishing and wildfowling. Nearby there were a number of trackways. Similar trackways or wooden platforms have been observed on English sites in the intertidal zone, most recently at Wootton Quarr from the Neolithic (Fig 36), and suggest that such activities may have been of considerable importance throughout the prehistoric period. If so, they would provide the coastal counterpart of the evidence so effectively investigated in areas like the Somerset Levels (Coles and Coles 1986). In most cases it still remains to show that these structures were located in a marine environment. They may have been situated some way from the coast, in low-lying areas which were only later invaded by the sea.

Having said this, it would be wrong to suppose that all the wooden structures preserved in the intertidal zone have to be interpreted in terms of practical activities. A wooden platform of Late Bronze Age date discovered in the Essex coastal survey was apparently associated with a series of human skulls (P Murphy pers comm). Similarly, the poorly recorded 'lake dwellings' of Holderness have produced very few finds, but among those that are recorded are items of Bronze Age metalwork and further discoveries of human skulls (Smith 1911). Again it is helpful to compare this evidence with the finds from inland sites, for on a more impressive scale they would seem to be matched by finds from Clifton on the river Trent (Phillips 1941) and by recent discoveries at Flag Fen (Pryor 1992).

6.3.2.3 Salt

There is less ambiguity in the case of salt production (Fig 61). The clearest evidence for this process is a distinctive kind of extremely porous pottery known as briquetage (Morris 1985 and 1994). This is very widely distributed on the coastline, but it is also found at inland brine springs in the West Midlands during the Iron Age. Unfortunately this distinctive material was used in both the production and distribution of salt, so that briquetage sherds may be found on inland sites simply because salt cakes were distributed inside their moulds. For this reason, it is essential to establish that

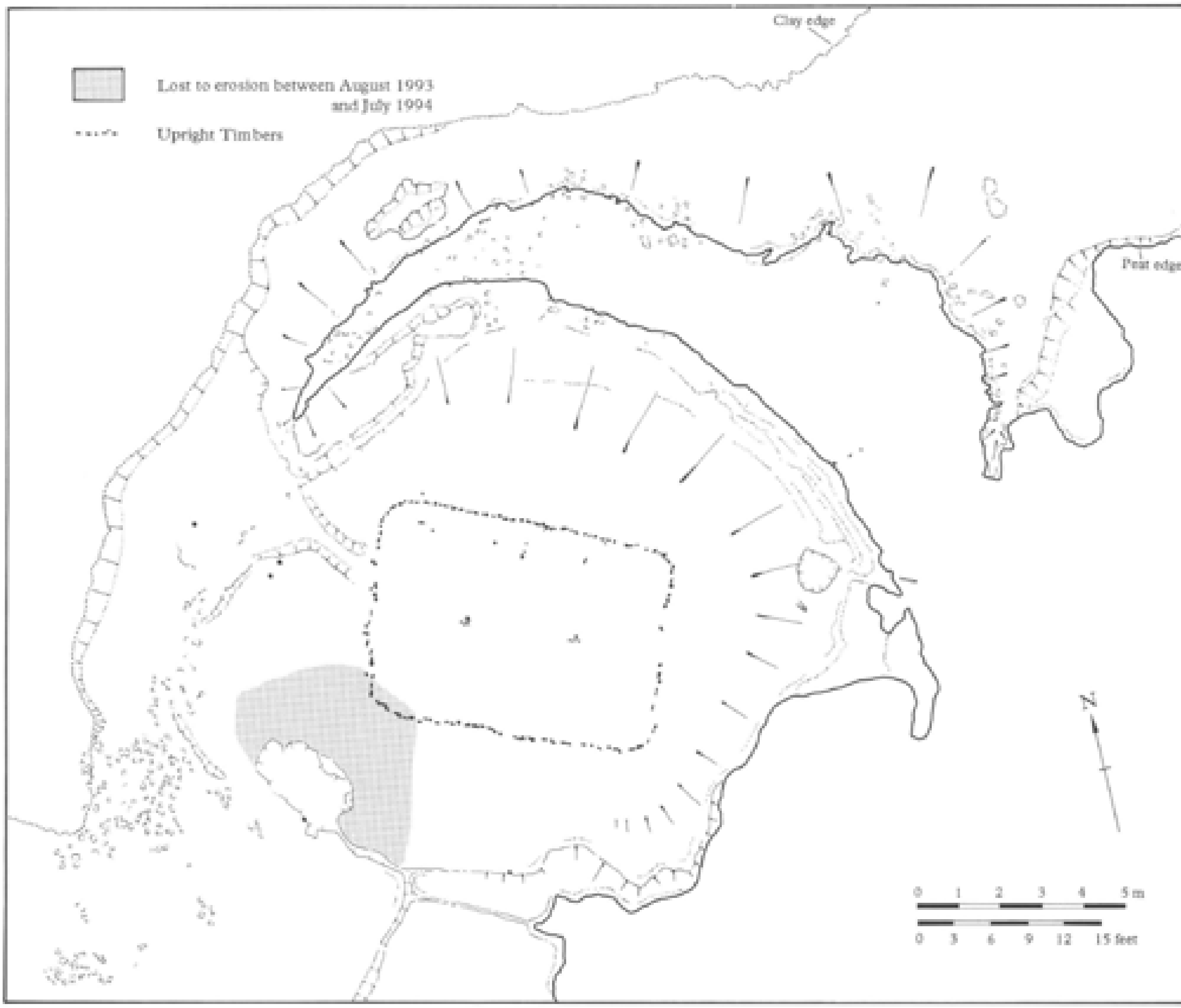


Fig 60 Severn Estuary: Goldcliff, Caldicot Level (Wales): plan of Iron Age building 6

particular finds of briquetage were involved in the production process. There are two ways of doing this. In many cases this material is directly associated with structural features, including flues, hearths, ovens, and settling tanks. In this case scientific analysis has confirmed that briquetage vessels had once contained salt (Fawn *et al* 1990, chapter 3). The other approach is to identify the distinctive features of those sherds of briquetage that are found well away from the coast, since these must have been employed in the distribution of the finished product. The briquetage sherds from Iron Age contexts at Danebury, for example, are thinner than most of those found on the shoreline. The latter were probably involved in earlier stages of production (Bradley 1992).

There is something of an imbalance in our knowledge of coastal salt production. Finds of briquetage from inland sites suggest that salt was being made using this material from at least the Middle Bronze Age, yet apart from a hearth recorded during the Essex coastal survey (Wilkinson and Murphy 1986; 1995) (Fig 62) there is little evidence from the shoreline before the Late Bronze Age/Early Iron Age, and most of the dated material extends from the Middle Iron Age to the second century AD, with a few local industries carrying on as late at the fourth century (Bradley 1992). To a large extent these problems are a product of archaeological visibility. The only prehistoric salt-production sites that can be recognised as field monuments are the Essex Red Hills. Although they have been discussed in a recent monograph (Fawn *et al* 1990), it is regrettable that the most informative excavations on these sites are almost 80 years old now. Other salt-production sites can only be identified by the discovery of subsoil features or by concentrations of burnt material containing briquetage on the shoreline. The nature of these features needs to be determined by large-scale excavation.

There is a further problem that prehistorians and Romanists share. They can identify coastal salt-

Fig 61 The distribution of salt-production sites in England's intertidal zone (see also Figs 99 and 107)

production sites only where they are associated with briquetage, but the use of this material for evaporating pans and moulds is merely one way of extracting salt from sea water. From the Middle Bronze Age to the Early Iron Age there are records of briquetage vessels found at inland sites which appear to have been cut in half, presumably in order to create a two-piece mould; the same also happens with some of the domestic pottery on these sites. Salt cakes could have been formed inside both kinds of vessel (Bradley 1992). In the Late Iron Age we encounter a further problem, for there are many salt production sites on the Dorset coast but few finds of briquetage from inland sites (Morris 1994). It seems likely that pottery and salt were made in the same area around Poole Harbour, and quite possible that this was another case in which the salt was being transported inside 'domestic' pots.

At the other end of the sequence there is the problem raised by the disappearance of briquetage during the Roman period. This change seems first to have happened near major towns, and did not occur until later in the more remote areas of the countryside (Bradley 1992). It is unlikely that inland sources took over the role of coastal sites, and it could be suggested

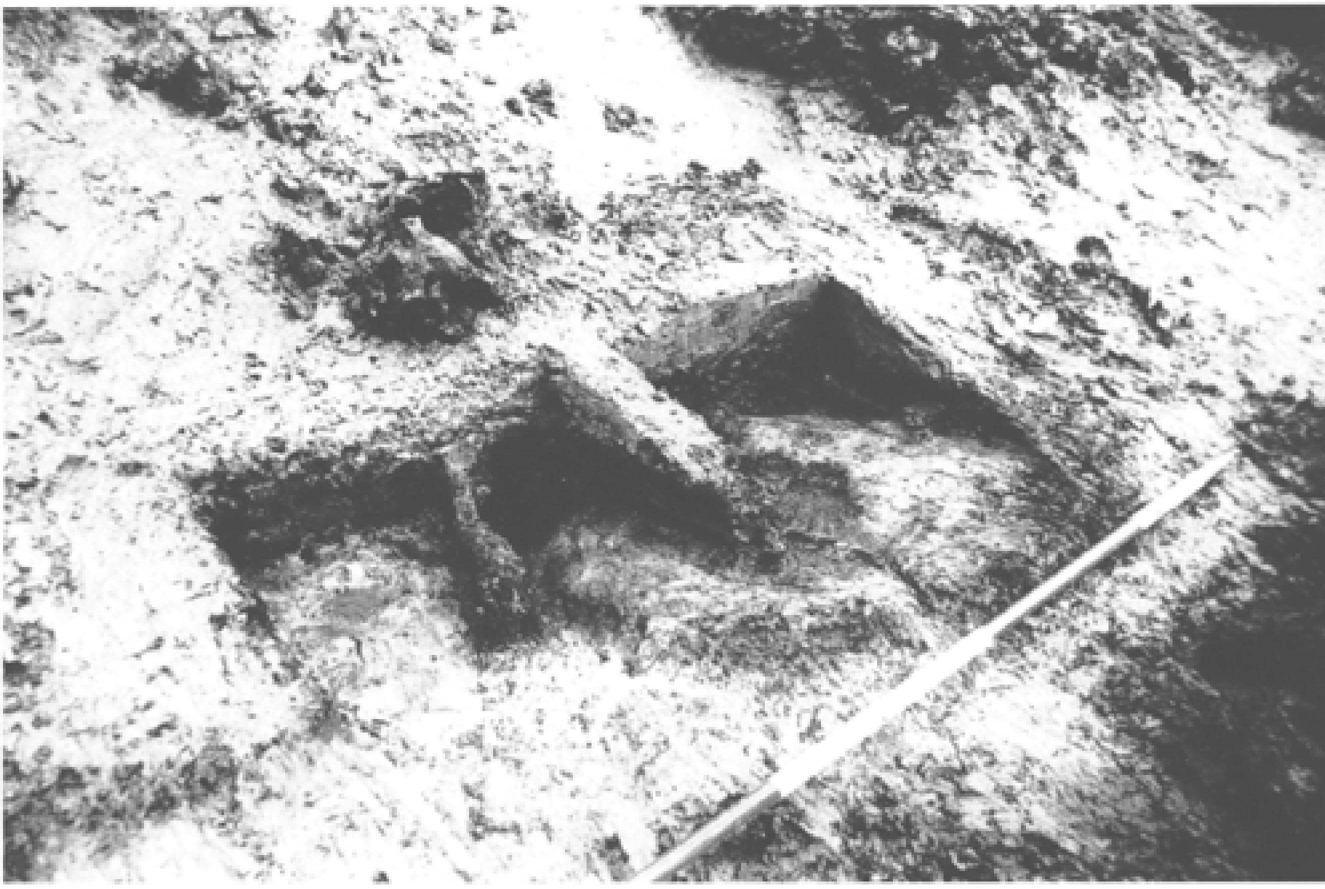


Fig 62 Late Bronze Age salt evaporation hearth at Fenn Creek (Hullbridge Survey river Crouch site 2) (Essex County Council)

that where there was a significant market for salt the industry was reorganised, with the use of metal vats for heating brine. Without the distinctive ceramics associated with older sites, the industry became archaeologically invisible. It must be a major priority to find and investigate the salt-production sites of later periods.

The evidence from Late Iron Age Dorset raises the further possibility that salt production took place alongside other small-scale industries, especially potting. For practical reasons both industries would have been working seasonally, and there seems no compelling reason why this link might not have been established during still earlier periods. Once again this is a question that requires fuller investigation.

6.3.3 The importance of old land surfaces

Not all the *in situ* deposits encountered in the intertidal zone would have been located in coastal areas in the past, but in certain cases they still represent an archaeological resource of considerable significance. This is particularly true in two situations. The first is where land surfaces have been protected from later human activity, with the result that their archaeology is especially well preserved (see above, Chapter 4). In such cases the investigation and management of these areas are linked to an academic agenda that treats them as part of dry land archaeology. In this instance their claims are based entirely on their exceptional preservation. The second case is closely related. This is where land surfaces preserve exceptionally detailed evidence of the ancient environment, and in this case they may reveal features that simply cannot be investigated in any other area. These exposures are not necessarily 'sites' in the conventional sense. Rather, their main contributions are to broader studies of the ancient lowland landscape.

The latter case is easily defined, for it refers to those environments which preserve direct evidence of their former tree cover and/or their original animal population. The so-called submerged forests are especially important here. Their dates vary considerably, but the very fact that substantial tree boles still survive makes them peculiarly susceptible to precise dating through dendrochronology. Careful survey could shed considerable light on the composition of ancient woodlands, and on the density and character of the tree cover. These are topics that would normally have to be addressed by palynology, with all the taphonomic problems caused by the differential production and dispersal of pollen. Where the material is well preserved, it should be possible to look for evidence of deliberate woodland management of the types that have been suggested from studies of inland sites. In addition, there are occasional reports of axe marks on some of the trees found in the intertidal zone. In certain cases artefacts have also been found in these areas (see below). These reports need careful investigation to ascertain whether such finds belong to the same period as the remains of ancient woodland.

A second case of great potential significance is where the silts of the intertidal zone preserve the tracks of prehistoric humans and animals. Again, this need not be related directly to the archaeology of individual sites, but this evidence could instead shed considerable light on the nature of these environments and the range of resources they were capable of sustaining. Unfortunately more interest has been shown in the human footprints than in the tracks left by animals, and this underemphasises the potential importance of these areas. The human footprints tell us little more than that people were present in these places, an observation that could just as well be based on the evidence of artefacts. We have yet to realise the true significance of the animal tracks. Like pollen analysis, the study of faunal remains is complicated by the many distortions that intervene before we can use a collection of bones to reconstruct the animal population. A major priority must be the discovery, dating, recording, and analysis of footprints in the intertidal zone. Ideally it should be carried out where organic material is preserved and where the prints left by humans and animals are associated with recognisable artefacts. Such cases are unlikely to be common, but they could occur in any period of prehistory. The all-important evidence will not be recognised unless it is specifically sought.

At a more general level, prehistoric land surfaces will be most informative where they can shed light on issues that have not been resolved by conventional excavations on dry land. It is specially important to investigate the character of prehistoric settlement during phases in which the evidence from inland areas is of poor quality, and this is particularly true in the Neolithic and Early Bronze Age. It is far from certain whether occupation at this time was necessarily organised into 'sites'. It is debatable how far structural remains have been destroyed by agriculture or even by natural processes, and the survival of stratified animal bones and plant remains is so limited that it is difficult to work out the nature of the prehistoric economy. What is needed are extensive exposures of land surfaces of these periods, sealed from later disturbance before they had undergone significant attrition. The only situations in which similar evidence might be anticipated on dry land would be beneath deposits of hillwash or alluvium, both of them contexts in which it is difficult to predict the pattern of discovery or to investigate a large area.

Suitable areas for this kind of investigation have been known since the work of Hazzledine Warren on the Essex coastline half a century ago (Warren *et al* 1936). In recent years this has been followed by a remarkably productive programme of coastal survey, including the excavation of the Stumble, which has provided the most comprehensive group of Earlier Neolithic plant remains of any domestic site in England (Murphy 1988). The Late Neolithic and Beaker occupation sites of the same region are among the best known in the country, but these have been destroyed or damaged since their original discovery. It is most important to locate similar contexts in other parts of the intertidal zone.

Similar deposits survive from later phases of prehistory, but these are much more frequent. That is not to say that the intertidal zone lacks any importance, because later prehistoric research has focused so sharply on the evidence of 'sites' (usually enclosed settlements) that we still know very little about the wider range of activities taking place in the landscape. One problem is posed by the interpretation of hoards, a striking number of which come from the coast. Although this might be no more than a reflection of the intensity of archaeological activity in this area, the fact that some of these hoards have an idiosyncratic composition suggests that the pattern may be real. In the coastal hoards of the Middle and Late Bronze Ages objects which might have circulated quite separately from one another seem to have been brought together as scrap, and in some cases this includes material of continental origin. It seems quite possible that these finds mark not only locations in which metalwork was produced, but also a neutral area on the edge of the contemporary landscape where transactions between strangers might have taken place (Bradley 1990, chapter 3). In the light of comparable evidence from the early medieval period in northern Europe, we should be especially careful to see whether these finds were accompanied by other types of feature. Where parts of the Bronze Age shoreline still survive, these might even include facilities for mooring boats.

The other place in which the later prehistoric landscape of the intertidal zone assumes a special importance is in the Isles of Scilly, where as a result of changes in sea-level field systems extend from dry land into open water (Thomas 1985). Their survival is quite remarkable and they have been well studied in recent years, but we have yet to establish their chronology with any confidence. They are clearly associated with a series of Middle Bronze Age settlements, some of which were excavated before their destruction by coastal erosion, but there have been claims that the fields themselves originated during the Neolithic period, at about the same time as the megalithic tombs of the Isles of Scilly. Paradoxically, the only large-scale excavation on one of these field systems suggested an Iron Age origin (Evans 1984). Unless we attempt to date them much more accurately, they will remain an isolated curiosity, cut off from the main currents of British prehistory.

Lastly, it has been mentioned above that some of the major settlements of the Isles of Scilly had been recorded in advance of coastal erosion. This is a widespread threat, and one which can only be addressed by directed survey of the kind that has been promoted so successfully in northern and western Scotland (Batey 1984). Until that has happened, it is impossible to suggest a way forward. One result of the Scottish work does, however, show that this approach can be unusually productive. Where dune deposits contain deep and well preserved stratigraphic sequences the accumulation of blown sand can be as useful as alluviation in protecting ancient land surfaces. Martin Bell's exemplary work at Brean Down emphasises the archaeological potential of such environments (Bell 1990), but we know far less about them in England, and this imbalance needs to be redressed. The remarkable prehistoric settlements at Gwithian in Cornwall remain largely unpublished (Thomas 1958), but, like those at Brean Down, they may provide some foretaste of the high quality of the archaeological material which might be buried by coastal dunes. The question is only tangentially related to the present project, but it needs to be considered in depth. Here the Scottish experience could be most informative.

6.4 The Roman period

6.4.1 Introduction

There are more than 280 references to finds of Roman date from the intertidal zone in the county SMRs and NMR. A significant proportion of these have also produced evidence of late Iron Age activity, and this is considered here rather than in the preceding section on later prehistory. Only salt-making of late Iron Age/early Roman date has been reviewed separately (above, 6.3.2.3). As Figure 63 shows, Roman discoveries are most numerous around the east coast to the south of Flamborough Head and the south coast to the east of the river Exe, with particular clusters in the Thames Estuary along both the Essex and the Kent coasts, and in the Solent area. A fairly even distribution of finds extends along the open East Anglian coast with some concentrations in Norfolk, and then northwards into Lincolnshire and Humberside. Thereafter the incidence of finds up the east coast declines steeply, a reflection both of the more rugged nature of the coastline and of the relative paucity of Roman material culture on native settlements in the non-urbanised area/military zone of the north and beyond the frontier in Northumberland. In general, findspots tend to focus in estuarine contexts, and this is also the case on the western seaboard, with the most numerous incidence in the Severn Estuary and, to a lesser extent, around the Wirral. Finds elsewhere around the western shores of England, both in the south-west and the north-west, are rare. Once again this is partly a reflection of the nature of the coastline, which includes accretionary shores in Cumbria, and the lack of Romanised settlement apart from military installations in both areas. Overriding all these factors, however, is the extremely limited extent of systematic survey in all areas of England's coastline.

6.4.2 The nature of the evidence

For the most part, therefore, our record consists of casual finds, the systematic survey and recording of specific Romano-British sites being the exception. To a very great extent this reflects an apparent invisibility of obvious structures, so that the emphasis is on artefacts, of which coins form the most prominent category. In some cases the latter can clearly be identified as belonging to hoards, but for the most part they represent single losses, or collections accumulated over a number of years. In fewer cases other materials such as pottery have been noted in association or in the same general location, or sometimes in isolation. In the latter case the association is generally with other evidence of fired clay indicative of salt-making (briquetage) or pottery manufacture.

Close dating of material other than coins is not always possible; in the case of late Iron Age and early Roman pottery, particularly the pottery from the south-east which is often termed 'Belgic', it can be difficult to distinguish between sherds of pre- and post-(Claudian) conquest date. Establishing start and end dates without further re-examination of the collection in question is very problematic. In any case it is clear that many sites that begin in the mid or late first century BC run on into the late first or second century AD, or sometimes later. In this context it is appropriate to consider these sites together, rather than to create an artificial distinction between (late) Iron Age and Roman. In this survey the break between Roman and Saxon is clearer; Roman sites in the intertidal zone that are recorded as having produced Anglo-Saxon material are the exception (below, 6.5.3.2, and Chapter 7.4.2). Aside from chronological issues, it has to be recognised that some early identifications are suspect. One example is of the New Forest pottery reported from the Minnis Bay group of sites in north-east Kent (Powell-Cotton 1939, 191–203). Given our present understanding of this industry and its competitors, the material in question is likely to be Oxfordshire ware.

Coin finds attributed to the intertidal zone present a problem, particularly those reported since the advent of metal detectors. One perception is that the association of finds with the beach or intertidal zone does not raise issues of rights and ownership in the same way that it does for terrestrial finds. An example of a doubtful findspot is the report of a hoard of Iron Age coins from the beach at Pevensey (Haselgrove 1987, 310).

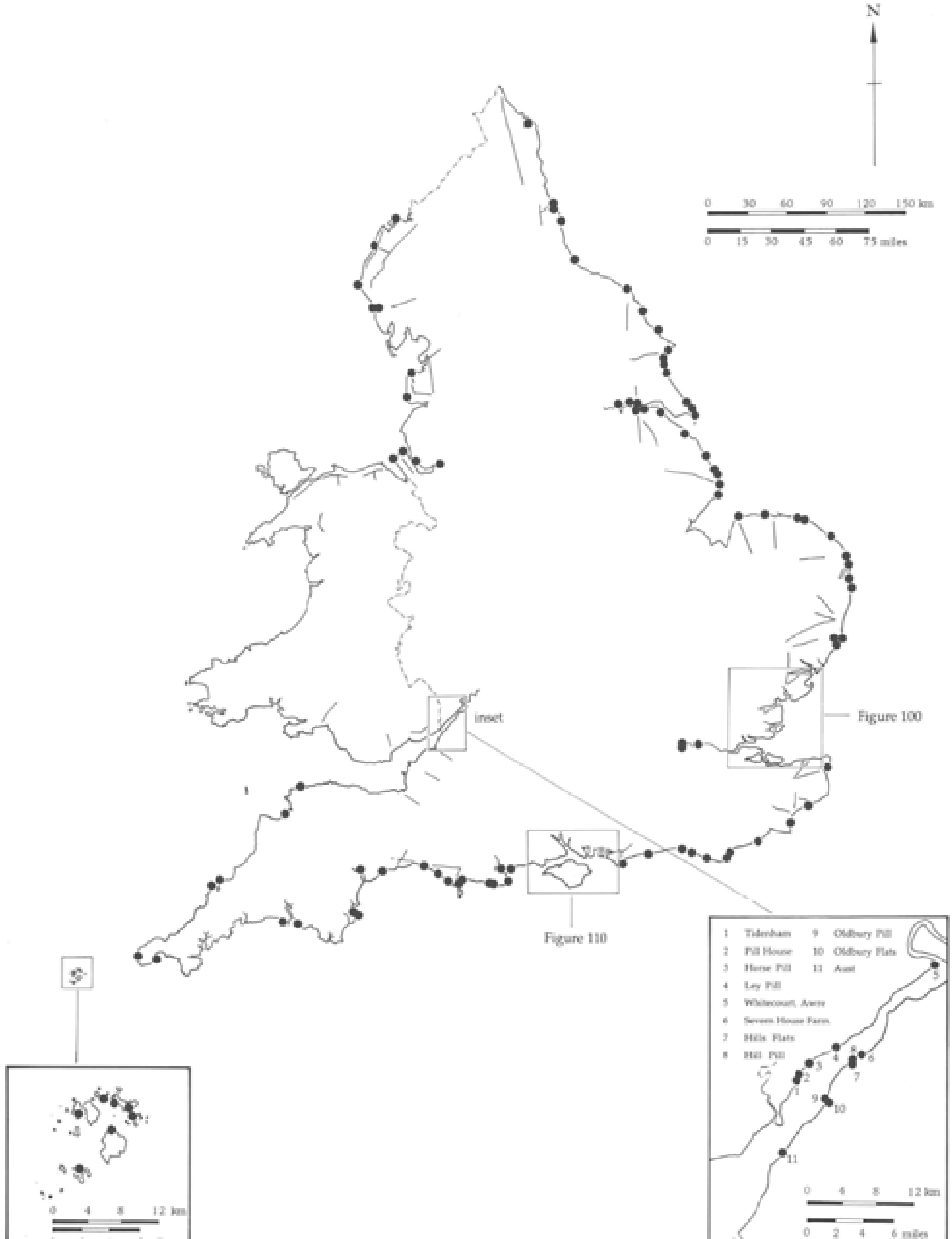


Fig 63 The distribution of Roman finds in England's intertidal zone. Roman roads heading towards coastal locations are also indicated (see also Figs 100 and 110)

Although the precise location is not recorded, we have to be alert to the possibility that this beach deposit is of post-Roman date. Equally, the chances of items in a hoard remaining together in a context which is subject to constant reworking seem remote. Although greater reliance can be placed on recent finds that can be related to sites identified from the earlier, pre-metal-detecting era, it has to be recognised that it is often convenient to attribute finds to already known sites as well as to the relatively 'neutral' area of the intertidal zone.

The need for a more thorough survey of these intertidal finds to establish their context and the full range of material culture is critical. Even with relatively recent collections of intertidal material, unconscious selectivity is evident. Large pottery assemblages, for example, were collected from Severnside sites at Oldbury and Hills Flats in Avon and Gloucestershire (Copeland 1981; Green and Solley 1980), but the abundant and very visible raw materials and residues of iron-working, which we can now see as a very important component of Romano-British settlement of the upper Severn Estuary, were entirely overlooked (Allen and Fulford 1987). Not only is there evidence of selectivity in what has been recorded among the surviving artefacts, but also little or no account has been taken of context and its relationship to the wider geological and sedimentological sequence (cf Allen and Fulford 1986; 1992). It is essential to understand both the formation processes of Holocene sediments, and how different materials behave in a marine context exposed to varying regimes of wind, wave, and tide.

6.4.3 The Roman coastline

Although oyster shells are a commonplace find (if rarely quantified) on terrestrial sites in Roman Britain, and are regarded as one of the cultural indicators of Romanisation, scant attention has been paid to their exploitation and likely areas of origin (cf Winder 1993). With the growing use of wet-sieving techniques, fish remains are becoming increasingly common finds, especially from the later Roman periods. Evidence of relatively intensive exploitation, perhaps to make varieties of fish sauce, has emerged from cities like London and York (Hartley and Fitts 1988, 104; Milne 1985, 87–95). Yet there is no context in the coastal zone in which to place inshore and offshore fishing or the harvesting of oysters. Indeed, no survey has ever been undertaken to locate the coastline of England in the Roman period (cf Jones and Mattingly 1990, 7–15). There has, however, been some consideration of Iron Age and Roman salt-making (de Brisay and Evans 1975), and survey and recording has been undertaken along certain stretches of the modern coast (ibid, Bradley 1975). The evidence for Roman harbours has been assessed and reviewed (Cleere 1978; Fryer 1973), and the most conspicuous conclusion was that there is almost no evidence for the physical remains of these installations, even in those locations where some form of harbour structure may reasonably be believed to have existed. To date the best evidence for the organisation of a Roman harbour comes from London, where excavations over the last 30 years have revealed much of successive waterfronts on both sides of the river (Brigham 1990; Milne 1985). The excellent preservation of these timber quays is largely due to their having been replaced by successor structures which have pushed the waterfront further out into the river; they are no longer in the intertidal zone. The same is also true of other finds of quay structures, such as at Chester (Fryer 1973, 246–7, fig 2) and Caerleon (Boon 1978). Although major military installations on or close to the modern coastline, such as the Saxon Shore forts, have attracted a good deal of attention as far as their date and function(s) are concerned, excavation has been concentrated on the fort interiors, and to a lesser extent on the dependent *vici*, but not on their marine context (Johnson 1976; Johnston 1977). There is no doubt that cross-channel and coastal relations were of critical importance in the history of Roman Britain; the exploits of the *Classis Britannica* on the one hand, and the testimony of the volume of imported consumer goods such as amphorae and sigillata from terrestrial sites on the other, provide excellent examples of such links. What is lacking, however, is any sense of the character, frequency or scale of ports and wharves around the coasts of Britannia, or of the incidence of settlements which depended on the sea, whether by fishing and the cultivation/harvesting of oysters or other marine mollusca, or through salt- or pottery-making. The rich finds from the midden deposit from Leigh Beck, Essex attest that there are important advances to be made in this area (Wilkinson and Murphy 1995). Nevertheless, one of the principal reasons for this enormous gap in our knowledge is our almost complete ignorance about the Roman coastline and its settlement.

The most important agency of discovery in the intertidal zone has been erosion, often in the wake of severe storms, or stormy periods. This in itself militates against the survival of structures rather than their associated finds, and thus makes it difficult to ascertain the nature of the original settlements that are exposed and how they might have related to the Roman shoreline. In the majority of cases, particularly on open as opposed to estuarine coastlines, current evidence is insufficient to establish whether the settlement in question originally occupied a coastal or former estuarine location. A key indicator here has been the presence of evidence relating to salt-making. This is the only category of cultural evidence which allows us to infer the site's original proximity to saline waters.

The nature of discoveries along the eastern seaboard in particular makes it abundantly clear that there has been substantial shoreline retreat. This is reinforced not only by the documentary evidence for the loss of later, medieval settlements from the same coastlines, but also by the knowledge that massive Roman masonry structures have been either severely eroded by the sea or all but destroyed. The Roman forts at Bradwell on the Essex coast and at Reculver on the north coast of Kent offer examples of the former, and Walton Castle, near Felixstowe, Suffolk, illustrates the latter. Here, antiquarian accounts from the seventeenth and eighteenth centuries record some surviving masonry of a structure generally regarded as typical of a late Roman Saxon Shore fort, but there is no record of any surviving fabric today (Johnson 1976) (see below, Chapter 7.4.2; 7.6.2).

Walton could be regarded as an isolated case and not symptomatic of a widespread loss of the Roman coastline. It is very tempting to assume this, given that other fortresses assigned to the same system and explicitly described in the ancient sources as on the shore (*in litore Saxonico*) do survive intact to a greater or lesser extent. Such surviving monuments can also be associated with the names in the written sources with some degree of confidence: for example, Branodunum – Brancaster; Regulbis – Reculver; Dubris – Dover; Lemanis – Lympne, etc. However, on the south-east and south coasts, these sites are located some way inland within extensive estuarine and marine creek systems, most conspicuously where there has been substantial coastal accretion: the late Roman fortresses at Lympne on the inner margins of Romney Marsh, Pevensey similarly located on the margins of Pevensey Haven, and Portchester at the head of the still open Portsmouth Harbour. Between the Thames and the Wash, only Burgh Castle now survives some way inland; all the remaining installations are on or close to the present shore. The clear inference to be drawn from the location of the survivors of these most visible of monuments is that the preferential siting was within sheltered estuaries and creek systems. Thus the locations of Walton Castle as far as it is known, or of Bradwell and Reculver, do not necessarily coincide with the ancient coastline, but probably lie at the head of an estuary or network of creeks.

Furthermore, we also have the place-name evidence of the Antonine Itinerary and the Peutinger Table for the walled town of Sitomagus located somewhere between Venta Icenorum (Caistor-by-Norwich) and Combretovium (identified with Coddenham, Suffolk). Although Rivet and Smith have suggested a location near Yoxford (1979, 456), others have suggested Dunwich on the coast (Johnson 1976). The medieval town has now all but disappeared, but some Roman material has been recovered from the site. Further documentary evidence for the erosion of the East Anglian coastline is indicated by the absence of any evidence for the projection which Ptolemy locates to the south of the Yare (Gariannus) (Rivet and Smith 1979, 138).

It is not unreasonable to conclude from the East Anglian evidence, as well as the projection backwards of the medieval losses on Humberside, that we have lost not only the Roman coastline, but also an unknown, but considerable, extent of the former mainland between Flamborough Head and Dungeness. Besides known sites or locations inferred from place-name evidence, there is another source of indirect evidence for coastal loss. From Bridlington southwards to north-east Kent the Ordnance Survey Map of Roman Britain indicates a series of routes heading towards the coast, but with no known settlement where they end or peter out (Fig 63). Given the direction of these routes and their proximity to the modern coastline, up to the last point at which their course can be traced, it is reasonable to infer that a point on the coast was their original destination.

Estimating coastal loss up the major east coast estuaries such as the Humber and the Thames is difficult in the absence of any systematic survey with this object in mind. The loss at Reculver is testimony to the situation in the outer estuary of the Thames; so too do the exposures of pottery and salt-making industries on the Upchurch marshes of north Kent and across the estuary among the Essex Red Hills. Although documentation is lacking, it is reasonable to assume that the degree of loss declines with distance up the tidal estuaries. Indeed, at Roman London, as we have seen, we have abundant evidence for the building out of the natural shoreline into the river by reclamation. What we do not know from the Essex Red Hills is how representative the surviving sites are of the original Iron Age and Roman salt-making industry. Considering the evidence for salt-making sites located among the creeks and rivers of the Wash, and now remote from the modern coast among the reclaimed Fenland, we cannot now relate the surviving Red Hills sites to their contemporary creek systems and associated open coastline.

Westwards of Dungeness we can be a little more confident of the survival of the Roman coastline where the shoreline has accreted to form Romney Marsh and Pevensey Haven (but this assumes no erosional phase before the period of accretion). Erosional processes do not seem to have been so severe along the south coast. Finds from the intertidal zone from the Solent and its associated harbours, as well as from Selsey Bill (West Sussex) (Pitts 1979, 63–83), confirm some loss of the coastline, but a lack of clear markers does not allow us to generalise about the degree of attrition. West of the Solent there is little evidence of Roman activity except around Poole Harbour where erosion has revealed evidence of Iron Age and Roman pottery- and salt-making activities around the fringes of the harbour. Terrestrial finds from Hamworthy indicate the presence of a major supply port for the Roman invasion from AD 43 (Smith 1958).

The Isles of Scilly offer evidence of the effect of both erosion and relative sea-level rise and Thomas (1985, 186) has argued that the islands still formed a largely discrete single landmass in the Roman period. Field boundaries which can be traced below the low-water mark and burials eroded at the water's edge are pointers to the extent of the land that has been submerged. The enigmatic settlement on the small island of Nornour with its rich collection of Roman metalwork offers the most graphic testimony to the advance of the sea on the eastern side of the islands, and its impact on Roman-period archaeology (Butcher 1978; Thomas 1985, 163–4; Fulford 1989).

The Severn Estuary faces the full force of the Atlantic and westerly winds and it is not surprising that evidence for Roman settlement and for field systems is plentiful in the intertidal zone. In some areas, particularly along the north shore, the extent of loss is substantial, with a retreat of the shore of over 500m. Eroded sites have been identified as far up the estuary as Awre, within about seven miles of Gloucester (Allen and Fulford 1987, 247–9).

The evidence from the north-west is slight, with very little material recovered from the intertidal zone. This is partly a reflection of the lack of systematic survey and partly of the extent to which coastal accretion has obscured older coastlines and former eroded sites. The evidence from part of the system of fortifications along the north Cumbrian coast, in particular, indicates that there has been major coastal change. It has been predicted that the site of milefort 2 lies some 400m out in the Solway, and at Beckfoot remains of a fort have been found partly eroded, but now buried beneath dunes (Bellhouse 1962; 1989). Equally, between the latter and Morecambe, it is argued that at least one milefort and three turrets have been lost through erosion. The system of mileforts and turrets appears to have extended south of Maryport, but how far is uncertain (Potter 1979, 321). Continuation as far as Moresby seems highly probable, but whether the evidence has been destroyed by erosion, or still remains to be discovered on dry land, has to be established.

The question whether any of the forts situated along the Cumbrian coast originally had ports attached to them is distinct from the issue of the extent of the frontier system. This seems plausible, particularly in the case of Ravenglass on the estuary of the Esk (Potter 1979, 5). Coastal erosion has already damaged this site. Equally, the location of the fort at Kirkbride to the north makes little sense if it was not associated with a harbour, but in this case post-Roman reclamation may well have preserved its remains. Ptolemy lists a 'harbour of the Setantii' which is tentatively located near Fleetwood (Rivet and Smith 1979, 135), to which a Roman road from the port at Kirkham points. The present-day port is at the head of the estuary of the Wyre. Just to the south, at the head of the estuary of the Ribble, another likely location for a port, is the fort and military supply base of Walton-le-Dale. The site of Meols at the head of the Wirral is comparable to the postulated port at Fleetwood. Here firm evidence of settlement in the form of late Iron Age and Roman material has been eroded from the cliffs, providing the likely destination for the course of a Roman road that has been traced leading towards Meols from the legionary fortress at Chester (Harris and Thacker 1987, 219). Assuming the former was originally a port, it would have complemented the one which served the legionary fortress for which there is firmer evidence (Waddelove and Waddelove 1990). The importance of this site is indicated by the quantity of finds; some 3000 were reported as early as the mid-nineteenth century (Hume 1863). The discovery of some 20 lead ingots from the Mersey at Runcorn, first recorded by Camden, may point to the existence of a further port there (Harris and Thacker 1987, 109; RIB 2404.33, 36). However, the proximity of Wilderspool on the one hand, and Chester on the other, would suggest that these latter finds probably represent part of a lost cargo.

Altogether, the evidence from England's modern coastline shows little evidence for the survival of the late Iron Age and Roman coast. Only on stretches of the hard-cliffed coasts and in the upper reaches of the estuaries is there a possibility of a closer approximation between the ancient and modern coastlines. The character of the former, however, particularly where high, is likely to limit the range of coast-specific occupation. One good indicator of the proximity of the Roman coastline is the survival of signalling towers, albeit in several cases severely eroded, as on the Yorkshire coast between Huntcliff and Filey, north of Flamborough Head. The nugatory remains of the latter have been the subject of recent excavation. Comparable evidence is to be found on the Cumbrian coast, where gaps in a more complex system of towers and mileforts also point to loss. Elsewhere such evidence is rare; the lighthouses above Dover (Amos and Wheeler 1929), and the signalling towers of Old Burrow and Martinhoe perched high above the north Devon coast, are the best known examples (Fox and Ravenhill 1965, 253–8).

We have already alluded to the possible importance of the ancient havens which now form Romney Marsh and the Pevensey Levels in modelling the original location of other east coast installations in relation to the open coast. A further potential of these areas, as with other reclaimed wetlands of which the Fenland is by far the most important, is of preserving the Iron Age and Roman shore and the settlements which developed on them. More limited opportunities for recovering evidence of the Roman coastline occur in areas of estuarine reclamation in the north-west. There is no certainty in any of these cases that erosional phases have not destroyed this evidence before accretion and reclamation took place. Nevertheless, and notwithstanding the practical difficulties of location, these areas offer the best remaining opportunity in England over the longer-term to understand the nature of Iron Age and Roman settlement in relation to deep estuaries and embayments as opposed to the open coast.

6.4.4 Interpretation of the record

It is assumed that, for the most part, findspots are indicative of a former settlement. The exceptions to this are coin hoards and industrial sites, where salt or pottery was manufactured, and where the settlement focus may have been some distance from the production site. The problems in general of coin finds which have been reported since the beginning of the age of metal detecting are discussed above; all, whether hoards or single finds, have to be considered critically. Although it may seem a large assumption that single categories of finds, if they are represented by a few coins or sherds (the two most common types of Romano-British material in the record), could represent the remains of a settlement, recent experience shows that unsystematic collections often relate to the knowledge, experience, and interest of the collector who has concentrated his search on one type of artefact. Subsequent systematic survey and collection, where there is an appreciation of the possible range of material culture to be found, has tended to increase both the range of artefacts and the number of finds (see above), and thereby to confirm the initial hypothesis that a settlement was indicated. Since we do not understand what happens to material once it is released into the sea, further investigation of single finds could well prove rewarding. At the same time, it has to be recognised that results will depend on the extent of the loss, the size of the original settlement, and the length of time the material has been dispersed in the intertidal zone (see above).

As far as the present record is concerned, none of the reported finds/sites (apart from the salt-making sites) provides information which is helpful in determining that site's relationship with the coast and the sea. None of the material is clearly coast-specific, but this is very much a reflection of the nature of the record, where the emphasis in the past has been on the collection of artefacts rather than on environmental material. For the latter, which is seldom independently dated, context is essential for it to be of use.

6.5 The Saxon, medieval, and post-medieval periods

6.5.1 Introduction

This section will review the wide range of intertidal archaeology, spread very unevenly around England's coast, from the post-Roman periods. Notable areas include the north-east, which is particularly rich in post-medieval industrial remains relating to extractive industries on the cliff tops. Lincolnshire and East Anglia have suffered considerable erosion and, not surprisingly, deserted settlements dominate the archaeological record, many of which may not originally have been situated on the coast. Essex, the Thames Estuary and the Bristol Channel/Severn Estuary are particularly rich in well preserved wooden structures, many of which are concerned with fishing. The south-west possibly has the widest range of sites, many related to the exploitation of marine resources, such as sea-fishing.

The following discussion follows a thematic approach. Firstly, it will consider the position of the coastline during this period. Secondly, the nature of the evidence and, in particular, the quality of SMRs, is summarised both regionally and chronologically. This material will then be discussed thematically, starting with coastally specific activities such as trade and communications, natural resource exploitation such as fishing, and extractive industries such as salt production. Other evidence will then be considered, including the effects of coastal erosion, which has caused many originally terrestrial sites to appear in the intertidal or even maritime zone (cf Chapter 3).

6.5.2 Position of the post-Roman coastline

It is often not clear whether most sites of the prehistoric and Roman periods in the intertidal zone were coast-specific (above, this chapter). By the medieval period this situation has started to change, and for the first time we have a substantial number of sites directly related to coastal exploitation. Notable examples include the hard rocky coasts of the south-west. However, that is not to say that the shoreline has been static everywhere. Certain parts of England's coast have suffered severe erosion, and elsewhere the gradual accumulation of saltmarshes has left the medieval shore stranded inland.

Detailed regional studies, for example in the Severn Estuary, have revealed a series of erosional/depositional cycles (eg Allen and Rae 1987). These episodes are closely tied to climatic variations, and in particular to periods of increased storminess. One of the most dramatic episodes of documented climatic decline and resulting coastal change started in the late thirteenth century and continued through to the early post-medieval period (Bailey 1991; Owen 1986; Rippon 1994a). These were critical centuries in the evolution of our present coastline. Along the south and east coast numerous settlements, mills, and coastal defences were abandoned during this time owing to flooding and erosion. Beaches and coastal barriers were also on the move, as demonstrated, for example, by the stranding inland of former ports such as Pevensey and New Winchelsea. A combination of documentary, cartographic, and archaeological research could be extremely informative concerning the extent of coastal change in these areas. For example, a study in Lincolnshire suggests that the coast has retreated up to a mile since the medieval period (Owen 1986, 61). In such areas, the modern cliff line cuts an arbitrary line through what has always been a 'dry land' landscape.

Elsewhere, particularly in sheltered estuaries, accretion has been the dominant process and the medieval shoreline is now some way inland; Fenland and the Sussex marshes are particularly good examples. Here, early coastlines and the associated evidence of human exploitation are likely to be well preserved but stranded inland.

6.5.3 The nature of the evidence

This is not the place to consider where to draw the boundaries between the terms 'Saxon', 'medieval', and 'post-medieval', or indeed their overall validity. Suffice it to say that the start of the period covered in this review is marked by a distinct change in material culture. Following most of the SMRs, the dates of 1066 and *c* 1500 are taken to subdivide the period into medieval and post-medieval. However, it is worth pointing out that in terms of coastal evolution, the date of *c* 1500 falls in the middle of a major period of change.

The county SMRs and NMR record just 32 intertidal Saxon sites, with 169 medieval and 427 post-medieval (Figs 64–9). Intertidal evidence for these periods comes in a variety of forms. In all of this, a critical distinction must always be made between sites and structures that originally related to the exploitation of the coast/intertidal zone, and those that are now located there only because of erosion.

The first group of sites are those which were originally situated in the intertidal zone, such as fish weirs. Though there is usually some damage from erosion, the preservation of waterlogged timber can be excellent.

The second category of evidence covers sites and structures that were designed to lie on the very edge of the intertidal zone, such as sea-walls, quays, salterns, pleasure piers, and certain military defences. Where these sites still occupy their original situation in relation to the coast, they have the greatest landscape integrity.

A third category covers those sites that originally lay on dry land. When such sites are subsequently eroded, stratified deposits are seen in a cliff and/or the intertidal shelf. These sites may have been involved in exploiting resources of the coastline, for example as fishing villages, though many were typical agricultural villages originally set back from the coast. The eroded nature of these sites makes them inherently of less value than an intact inland site, though this might be compensated for by the excellent preservation of organic artefacts and palaeoenvironmental evidence in waterlogged deposits in the intertidal zone.

A fourth category of intertidal archaeology covers simple isolated finds of pottery or coins. They may indicate *in situ* deposits actively undergoing erosion, and as such may be of value in locating sites. Alternatively, they may be all that remains of a totally eroded site, or even be objects washed overboard from a ship or wreck.

Finally, there are sites that, though documented as being in the area of the present coastline, no longer survive or are yet to be located. A common problem with such SMR entries is that it is often unclear whether anything survives today in the archaeological record. Indeed, there is a general unevenness in the SMRs and NMR in the treatment of sites known only from documentary sources, as opposed to those for which there is extant material evidence.

6.5.3.1 The nature of the evidence: spatial patterns

Since the database collected for this project was derived from three main sources (SMRs, the NMR, and literature search), the information available for this review is not so much a summary of what is in the intertidal zone, but of what different people have recorded in different areas. This will be apparent in all periods, but is particularly important in the medieval and post-medieval periods, when there appears to be a considerable element of subjectivity in what is included in the county SMRs. A particularly good example is the inclusion of ports, quays, and wharves. The records for Devon and Cornwall include a huge number, no doubt because they are such an integral part of the region's cultural heritage (Fig 70). These features are noted with much less frequency elsewhere, even in areas such as Essex and Humberside with a strong maritime/fishing tradition.

The Isles of Scilly have a long history of survey, resulting in an abundance of known sites, including settlements, harbours, extractive industries, and defensive sites. The south-west (Cornwall and Devon) also has a very rich coastal archaeology for this period, particularly around the many drowned valleys and estuaries. Sites include numerous quays/harbours, defensive structures, and stone/tin quarries. The very solid geology means that the coastline has changed relatively little, and the high density of relatively undamaged sites makes this area a very important historic landscape.

To the east and north of Minehead, the high rocky cliffs of the south-west peninsula give way to the mainly low-lying alluvial coastline of the Severn Estuary (Avon, Gloucestershire, and Somerset). Here, the present coastline was largely fashioned by man through the reclamation of coastal saltmarshes, with several important stretches of sand dunes. The Roman and early medieval sea defences were lost to erosion in the late medieval period, and the present line of sea-walls generally dates to around the fifteenth century.

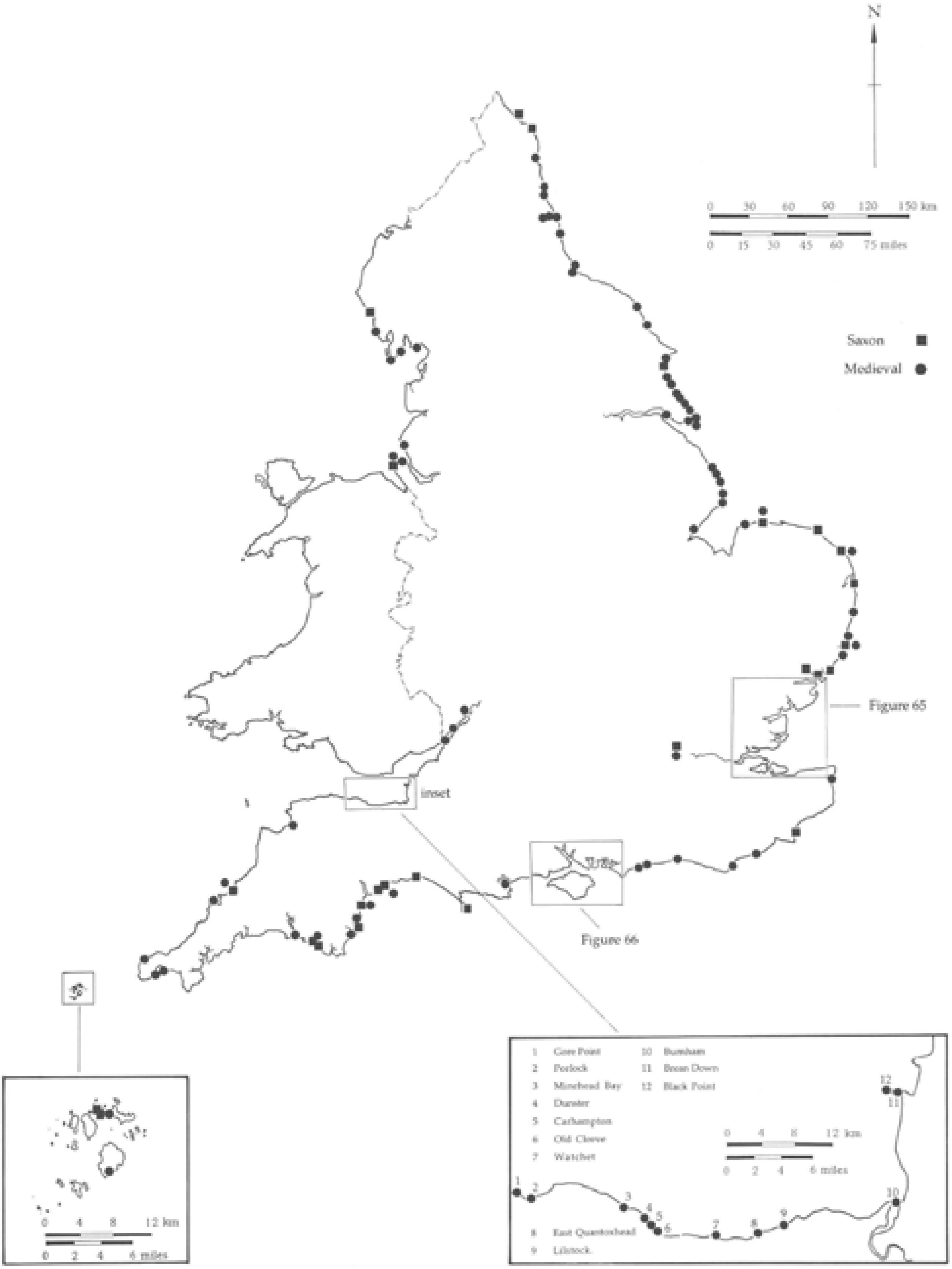


Fig 64 The distribution of Saxon and medieval finds in England's intertidal zone (see also Figs 65–6)

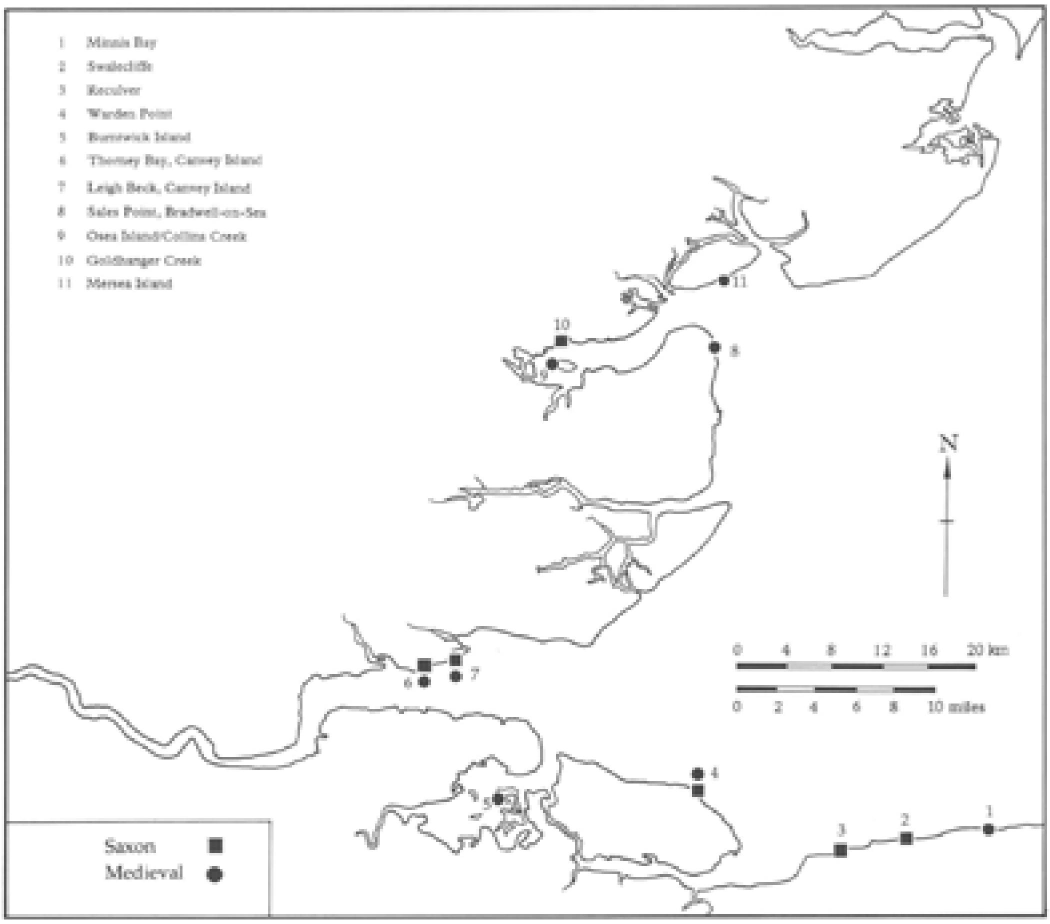


Fig 65 The distribution of Saxon and medieval finds in the intertidal zone of Essex and Kent

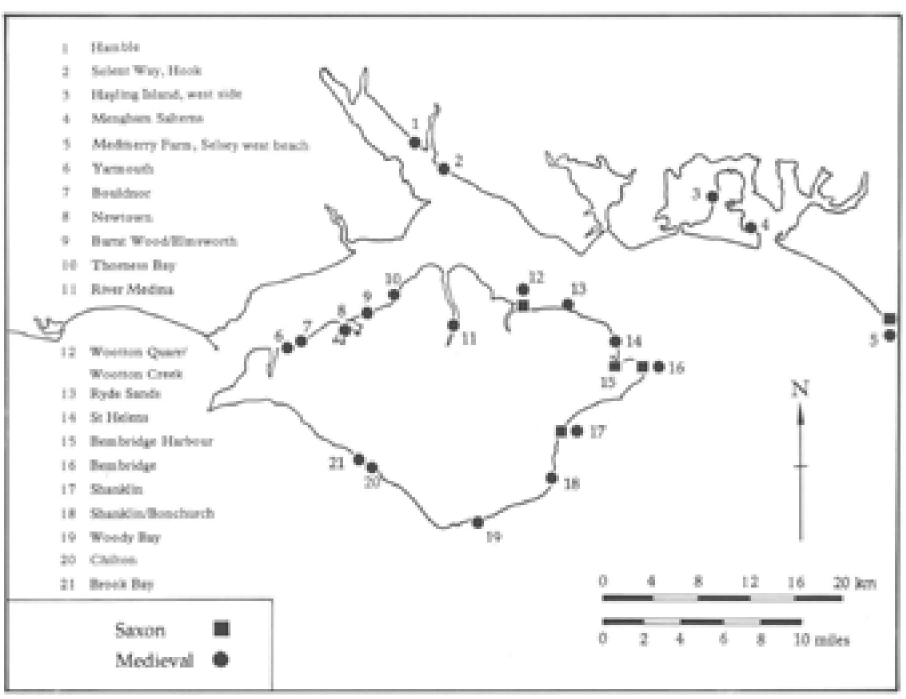


Fig 66 The distribution of Saxon and medieval finds in the intertidal zone of the Solent: Hampshire and the Isle of Wight

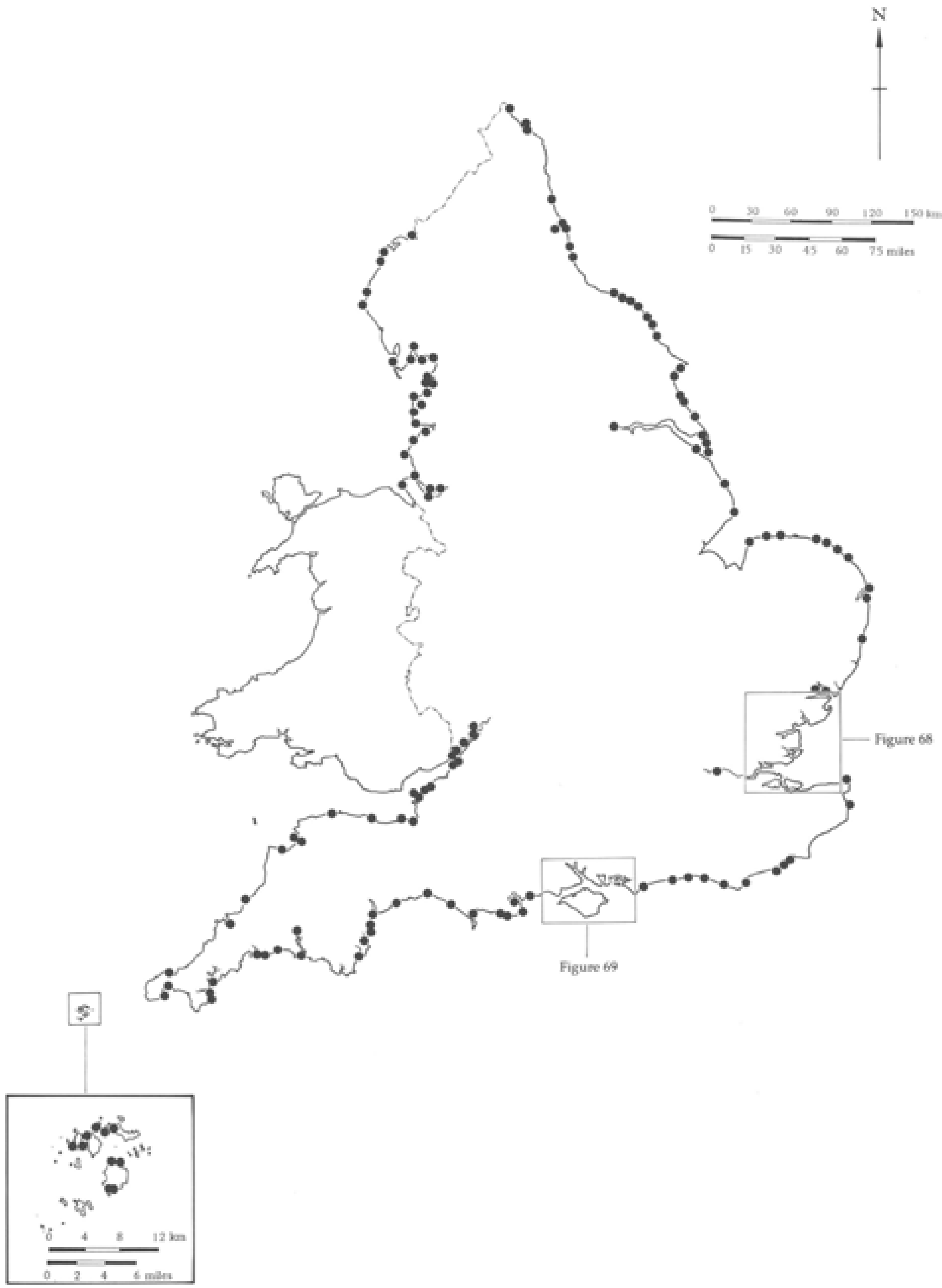


Fig 67 The distribution of post-medieval sites in England's intertidal zone (see also Figs 68-9)

Fig 68 The distribution of post-medieval finds in the intertidal zone of Essex and Kent

This retreat, along with the very considerable tidal range of the Severn Estuary, results in a huge intertidal zone rich in archaeology, notably that relating to the fishing industry and communications.

The south coast (Dorset, Hampshire, Sussex, and the Isle of Wight) is a mixture of soft rocky shorelines that have suffered considerable erosion, and sheltered estuaries where there has been much deposition. Along the stretches of open coast there appears to be relatively little intertidal evidence for the post-Roman period, though a number of eroded cliff-top sites are known. Several villages are documented as having been destroyed in Sussex, and little appears to survive of them today.

Around the south-east and East Anglia (Kent, Essex, Suffolk, and Norfolk) there is once again a mixture of eroding and depositional coastlines with numerous small estuaries providing sheltered harbours. Detailed survey of the Essex coast has found a wide range of sites, notably several complexes of fish traps. A number of important eroded sites are found along this coast, particularly in Suffolk, including the Saxon shore fort, possible Saxon monastery, and medieval castle at Walton near Felixstowe. A notable omission from the existing record appears to be that of the numerous documented harbours and quays. A good example is Leigh-on-Sea, which had five bordars 'by the sea' in Domesday, probably indicating a small fishing settlement (Darby 1971, 245). Leigh became an important fishing port in the medieval period, and remains so today, yet it has seen no archaeological work and does not appear on the Essex SMR; the documentary references alone would probably have been sufficient to gain it an entry in the Cornish SMR.

The central section of England's east coast (Lincolnshire and Humberside) is dominated by eroding soft cliffs and the great estuaries of the Wash and Humber. The apparent lack of intertidal archaeology from the Wash must to a certain extent be the result of a lack of fieldwork, though it should be remembered that this stretch of coast has a long history of accretion and reclamation; the Saxon and medieval intertidal zones are now extensively buried under more recent landclaims.

The north-east coast of England (Yorkshire, Durham, and Northumbria) has a predominantly rocky coastline, eroding at a fairly gradual pace. This is a medieval landscape dominated by castles, religious houses, and small harbours, typified by Whitby. In the post-medieval period, extractive industries dominate, and as with the south-west, there is a distinctively coastal historic/cultural landscape.

The north-west (Cumbria, Lancashire, Merseyside, Cheshire) has produced relatively little archaeological data for this period; there are numerous documented small ports and harbours, though the extent to which

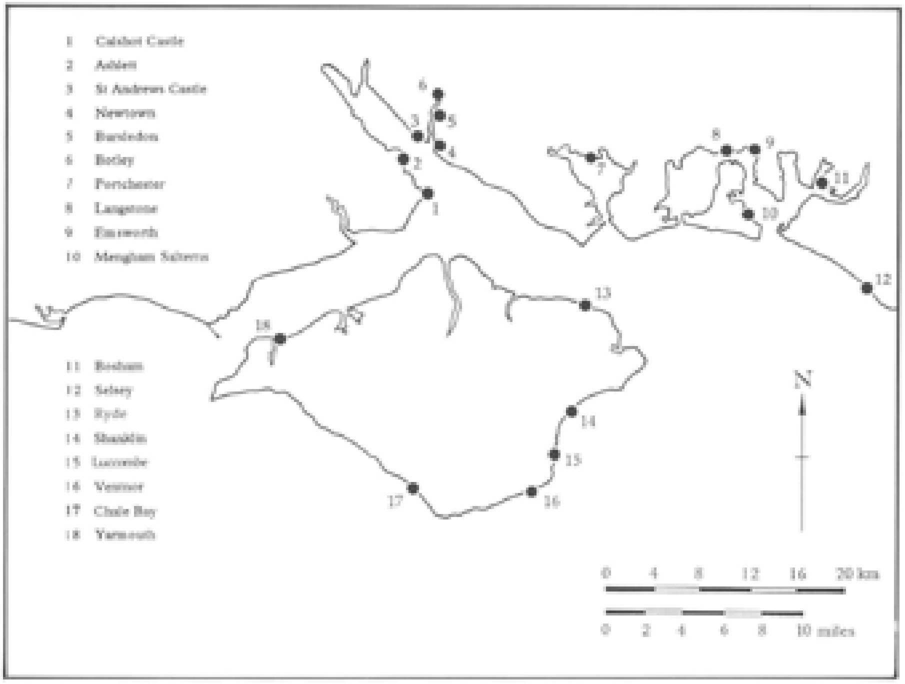


Fig 69 The distribution of post-medieval finds in the intertidal zone of the Solent: Hampshire and the Isle of Wight

medieval structures survive is not always clear. A potentially important site is Meols on the Wirral, where an extensive early medieval and medieval settlement has been eroded away (Hume 1863).

6.5.3.2 The nature of the evidence: chronological patterns

There is a considerable scarcity of evidence relating to the Saxon coast, which is largely due to a lack of distinctive and durable material culture. There appears to be little continuity between the Roman and Saxon periods, though as with all generalisations there are exceptions (eg Canvey Island in Essex: Mackley and Faulkner 1994; Rodwell 1976b). A scatter of unstratified finds of Saxon pottery and coins may result from eroded settlements, although as with Roman coins our distribution maps may reflect the activities of irresponsible metal detector users. Several early medieval sites have been recorded around the Isles of Scilly, such as a complex, well preserved, but badly eroding settlement at East Porth on Samson (Ratcliffe and Sharpe 1991, 177; Thomas 1985, 186). Some of the most important evidence comes from Essex, such as an eroding settlement off Canvey Island that may represent a small trading station (Archibald 1991; Rippon 1996b), and several timber structures have been scientifically dated to this period, including the Mersea Causeway (Crummy *et al* 1982), fishing structures and a coastal revetment in the Blackwater Estuary, and an enigmatic setting of timbers in the estuary of the Colne (Clarke 1993; Wilkinson and Murphy 1995). The importance of obtaining scientific dates on wooden structures is also demonstrated on the Welsh side of the Severn Estuary, where fishing structures which, on typological grounds, could have been post-medieval, have been dated to the pre-Norman period (Godbold and Turner 1993; 1994).

For the medieval period, a critical distinction is that between settlements, harbours, mills, and salterns which are documented, and those for which archaeological evidence exists. Several SMRs contain abundant references to documented sites, although in many cases it is not clear whether anything survives. Once such documented sites, and unstratified chance finds, are removed from the catalogue of sites, evidence for the medieval period is actually quite limited. Intertidal remains of a number of settlements are known, and while features such as wells may contain important waterlogged assemblages, erosion means that such sites may not provide as much data as a well preserved upland site. The same is true of former coast-specific sites such as salterns; the best preserved examples worthy of attention are those which have become landlocked, such as in the Pevensey Levels (East Sussex), Bicker Haven, and Wainfleet St Mary (Lincolnshire) (McAvoy 1994).

Not surprisingly, the amount of data increases rapidly for the post-medieval period (Figs 67–9). The proportion of Britain's coast that is now essentially the same as it was in the post-medieval period is quite high, and as a result, we have far more coast-specific sites. Particularly important are extractive industries in the south-west and north-east of England, fortifications along the whole south and east coast, piers and jetties, wrecks, and fishing structures. However, it must also be stressed that many extant post-medieval intertidal sites are not included in SMRs, and greater guidance and uniformity are required (cf *Recording England's past*, RCHME 1993a).

Fig 70 The distribution of ports and wharves in England's intertidal zone

6.5.4 Coast-specific sites

6.5.4.1 Sea defence

Introduction

Large parts of England's coastline have been created through the reclamation of formerly intertidal saltmarshes by the construction of a sea-wall. This process began in England in the Roman period and in many places has severely constrained the extent of the intertidal zone, with little active saltmarsh now remaining. Typically progressive in character, landclaim generates a characteristic landscape, for example that of the Fens or the Severn Levels, capable when properly drained of sustaining most kinds of farming.

Though vital to the wellbeing of many low-lying communities, the historical value of sea-walls has been greatly undervalued by archaeologists, and they rarely appear in SMRs. Some work has been carried out around the Severn Estuary (Allen and Fulford 1990a, b; Allen and Rippon 1994) and in Essex (Wilkinson and Murphy 1995), and a survey has recently been undertaken on Romney Marsh (M Gardner pers comm).

Documentary evidence on the date and location of sea-banks is with rare exceptions limited to the post-medieval period. One example is Biggar Bank on Walney Island off the Cumbrian coast, constructed from beach boulders by the monks of Furness Abbey in the thirteenth century; further reference is made to its maintenance in the sixteenth century and so the surviving structure probably represents an amalgam of medieval and post-medieval work (Rollinson 1964, 133). The repeated remodelling of fields means that the surviving field evidence, which should always be evaluated, is subtle and difficult to read (Allen 1993). Outfall works and sea-banks are vital, if inconspicuous, monuments in coastal wetland landscapes and there is great merit in properly recording, dating and conserving them.

The surviving historic sea-walls are under threat from a wide range of quarters, including agricultural 'improvement', managed retreat, and demolition by the Environment Agency in order to provide spoil for new sea defences. There is an urgent need for the surviving structures to be appraised.

Although accretion has been the predominant process along these coastlines, there have been important periods of erosion, causing sea-walls to retreat. In very rare cases, traces of field systems can be seen in the intertidal zone (eg the Gwent Levels: Fulford *et al* 1994), and several examples are known of intertidal wooden structures that appear to be the remains of former coastal revetments. At Wootton Quarr (Isle of Wight), rows of stakes up to 600m long have radiocarbon dates ranging from the seventh to tenth centuries (D Tomalin pers comm). At Collins Creek on the northern side of the Blackwater Estuary in Essex, there are similar structures, also dated to the Saxon period (Clarke 1993).

The development and character of sea defences

The pattern of progressive landclaim on a tidal marsh (Allen 1993) depends mainly on the size and shape of the marsh and on the strength of any tendency to build further outward into the intertidal zone (Fig 71). Nucleated claim, found early in the Humber wetlands (Sheppard 1966; Berridge and Pattison 1994), sees the construction of a continuous defence with no roots in high ground (Fig 71a). Prograding reclamation is well represented in the Tees Estuary (Davidson *et al* 1991), the Fens (Doody and Barnett 1987), the Essex marshes, the Severn Levels (Allen 1986; Allen and Fulford 1990a), and the Ribble Estuary (Fig 71b). A type of prograding landclaim leading to forms resembling nucleated reclamation is known from the larger meanders on the rivers Parrett and Axe in the Somerset Levels (Williams 1970; Aston and Iles 1986). The detailed appearance of landclaims on the lateral pattern depends on whether the affected marsh is long and relatively straight or partly enclosed in an embayment or behind a coastal barrier (Fig 71c, d). Each new defence after the first has only one root in an upland area. This style is represented in the Dee Estuary (Taylor and Parker 1993) and in several places in the Severn Estuary (Allen and Fulford 1987, 1990a, 1990b; Allen 1993). It is perhaps best seen in saltmarsh reclamations on the European mainland (Briquet 1930; Verger 1968; Flemming and Davis 1994; Oost and De Boer 1994).

The possibility that a sea-bank has been repositioned over a portion of its length some time after its original construction should never be overlooked. One common modification is set-back in the face of coastal erosion, the withdrawal of part of a defence to a more landward position, as occurred in several places on the Severn Levels (Allen and Fulford 1986, 1993; Allen 1993; Allen and Rippon 1995) and at Rumney Great Wharf more than once (Allen 1990a) (Fig 72). Allen and Rippon (1995) recognised a second common modification, leading to small gains of land but more specifically to a substantial shortening of the defences. On several of the rivers and streams crossing the Somerset and Severn Levels, the outfall works – flap valves, sluice gates or tidal doors generally set in stone structures – have been moved progressively further seaward, apparently in response to increasing demands for costly maintenance of the sea-banks due to rising sea-levels, but coincidentally facilitated by developments in engineering practice and materials. In places on the Severn Levels the defences have been shortened by as much as 2km or so; on the Somerset Levels, there were shortenings of up to 7km.

The Severn Estuary – a case study

No English wetland region has yet seen a comprehensive study of its history of landclaim on a combined documentary and field basis, though a model now exists for the Gwent Levels of south Wales (Rippon

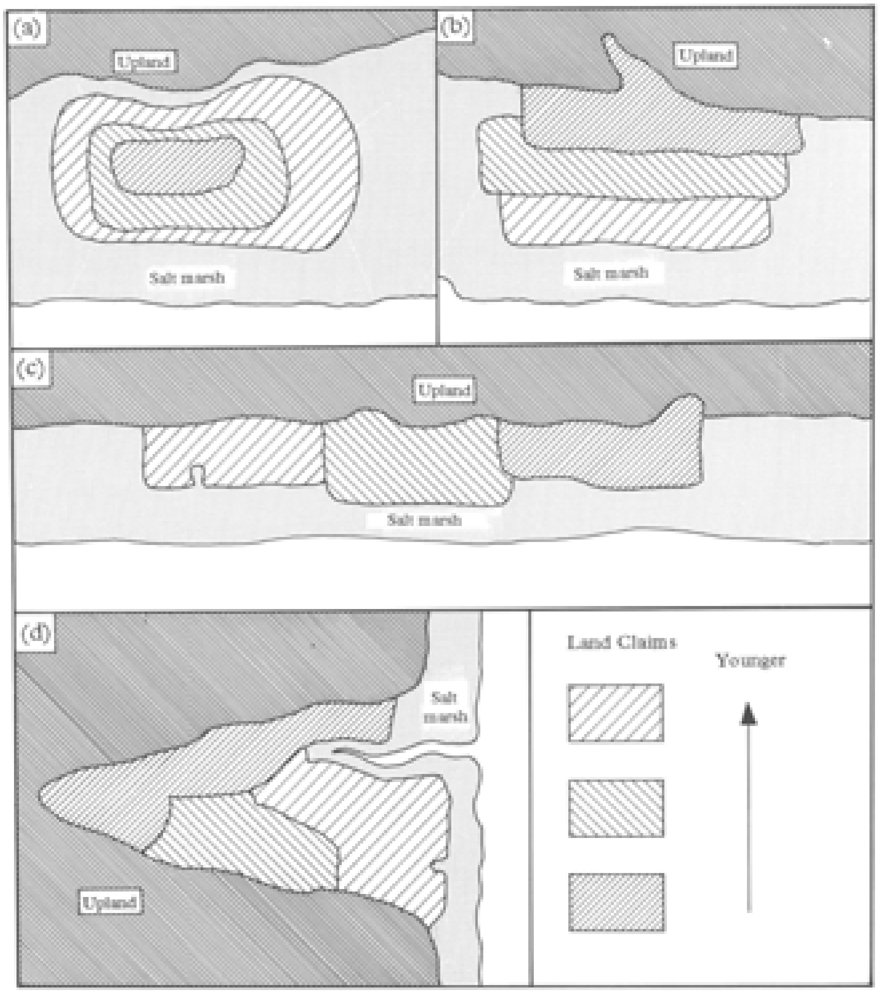


Fig 71 Models of progressive landclaim on a tidal marsh

1996a). The resource-level and potential of such regions, however, remains for the present high, as may be judged from the combined results of a number of local studies recently completed on the Severn Levels. Much of this reclaimed wetland region lies on both banks of the Severn Estuary, in the counties of Gloucestershire, Avon, and Somerset.

The largest outcrops of reclaimed wetland lie on the left bank of the estuary downstream from Gloucester. In Elmore parish, Allen and Fulford (1990b) recognised two Romano-British reclamations and a modern one. The surviving monuments are a large and, in some parts, stone-faced sea-bank (Great Wall) from the earliest reclamation, and a short length of the defence from the second claim. Two Romano-British landclaims and a medieval one were detected in the northern part of Longney parish to the south (Allen and Fulford 1990a), part of the earliest defence remaining in the landscape as a hedge-topped bank. A complex outcrop of alluvium extending from the southern part of Longney into the parishes of Moreton Valence, Whitminster, and Fretherne contained two large Romano-British landclaims and a substantial early modern one (Allen and Fulford 1990a). The sea-banks defining these reclamations can be traced as ramps or sustained differences of elevation through the fields, but survive in anything like their original form, as a low rounded bank, at only one place. The preservation of sea-banks is much better in the parishes of Arlingham and southern Fretherne, where four Romano-British, one early modern, and several modern landclaims were mapped (Allen 1990b; Allen and Fulford 1990a). The defence surrounding the largest of the Romano-British reclamations can be traced as a substantial earth bank for some hundreds of metres through the fields to the north of the Old Passage Inn. Just to the south, in the parishes of Frampton-on-Severn and Slimbridge, lies an outcrop of alluvium rich in large landclaims (Allen 1986). The oldest, lying south-east of the Gloucester and Berkeley Canal, is not younger than medieval and could prove to be Romano-British. West of where the canal now occupies the course of the river Cam there occurs an elongated, probably early medieval reclamation with intact sea defences, and to the west again a documented reclamation of 1335-6, commissioned by Thomas Berkeley III. The defences surrounding the latter's landclaim survive in full and are particularly bold earth banks (Fig 73), rivalling in scale sea-banks constructed along the Severn Estuary in recent years. Further large reclamations were added by the mid eighteenth and late nineteenth centuries, with the eighteenth-century defence persisting in many places as a low, tortuous earth bank along the edge of an abandoned tidal slough (Fig 74).

The extensive alluvial outcrop of the Vale of Berkeley further south on the left bank was taken in during the Roman period (Allen and Fulford 1987). Early modern set-back (Allen 1992a; Allen and Fulford 1992, 1993a, 1996), combined with a vigorous programme of defence upgrading, has ensured that little or nothing of the original sea-banks remains in this area, except along such places as Berkeley Pill (Fig 75). What has survived, however, are rare examples of some of the earlier outfall works. On the lower reaches of Hill Pill modest stone-built sluices of the early seventeenth and mid eighteenth centuries can still be inspected in the coastal landscape (Allen and Rippon 1995).

There are much smaller outcrops of estuarine alluvium on the right bank of the upper Severn Estuary. From the parish of Westbury-on-Severn, Allen and Fulford (1990a) described five reclamations: one Romano-British, two medieval, one early modern, and a modern example. Short lengths of the Romano-British and medieval earthen sea-banks survive here and there on the edges of the fields. Many can be inspected in the parishes of Lydney and Aylburton (Allen 1993), and in date appear to represent Romano-British, medieval, and early modern activities. A long portion of the possibly Romano-British defence has clearly been set back across the medieval fields.

The reclaimed alluvium of the Somerset Levels bordering the inner Bristol Channel is comparable in area to that of the Severn Levels upstream (Rippon 1994a, b). Although engineered coastal defences have generally speaking been less necessary here, because of the presence along the shore of protecting belts of sand or gravel beaches capped by wind-blown sand dunes, sea-banks can be found in the North Somerset Levels in the parishes of Kingston Seymour and Wick. The earliest intakes here could be Romano-British (Allen 1990c), judging from the presence of a substantial villa and the numerous near-surface finds recorded by Lilly and Usher (1972). The defending structures are bold earth banks which can be traced for considerable distances through the coastal fields. To seaward of them lie substantial landclaims, apparently of early modern date.

In the main Somerset Levels the most conspicuous engineered flood defences are along the banks of the tidal rivers. Progressive landclaim has been demonstrated in Bleadon parish on the river Axe (Williams 1970; Aston and Iles 1986) and at Pawlett on the river

Fig 72 Cowhill Warth on the south bank of Oldbury Pill, Gloucestershire (area approximately 600 x 400m). The main sea-bank has been set back across the ridge-and-furrow contained in the hedged fields

Fig 73 Slimbridge, Gloucestershire: well preserved sea-bank of Thomas Berkeley III's saltmarsh reclamation of 1335–6 (J R L Allen)

Parrett to the south (Williams 1970). Despite considerable remodelling of the agricultural landscape in both parishes, long portions of the later sea-banks have so far survived, one series in Bleadon having been modified to support a track. Also in Bleadon, a fine, early nineteenth-century outfall of well dressed mortared Old Red Sandstone can be seen where a tributary crosses the defence to join the Axe due west of the village.

6.5.4.2 Ports and quays: sea fishing, trade, and communications

Until the advent of the railways, transportation was often easier by water than over land, and as a result navigable rivers and the seas were major communications routes for people and goods. The study of ports and harbours is therefore vital to our understanding of the changing patterns of both internal and overseas trade (Fig 70). As we have already observed, survey of the major ports and docks, which have already received a certain amount of attention, is beyond the scope of this report. In contrast, however, despite the growth of waterfront archaeology, there has been very little attention devoted to minor ports and harbours.

Middle Saxon emporia and their trading contacts with northern Europe have received considerable attention (eg Hodges and Hobley 1988), along with a number of sites around the south-west coast involved in exchange with the Mediterranean world (Thomas 1988; 1990). Most work has been carried out on the large emporia of eastern and southern England, but there is evidence for a lower tier of smaller entrepots, such as Canvey Island (Archibald 1991; Rippon 1996b) and Barking Abbey, also in Essex, where a wide range of imported material suggests contact with the continent (Redknap 1992). The distribution of early monastic sites in Essex and Kent shows a marked coastal bias (Brooks 1989; Rippon 1996b), and some at least may have been associated with trade or exchange; for example, around 50 sceattas have been recovered from Reculver (Rigold and Metcalf 1978).

Emporia along the west coast have received very little attention, though a number have undergone significant erosion and appear in the intertidal zone. Apart from the famous example at Tintagel, the distribution of fifth- to seventh-century imported pottery suggests a number of other entrepots (Thomas 1988; 1990). Five eighth- to ninth-century coins and other post-Roman finds from Meols, on the Wirral, indicate a high-status settlement in the area, possibly a small trading port, since the Saxon coins found there did not circulate freely in north-west England (Bu'Lock 1960; Dolley 1961; Thacker 1987).

Fig 74 Slimbridge, Gloucestershire: eighteenth-century sea-bank surviving as a well preserved earth bank following the tortuous course of an abandoned tidal slough (J R L Allen)

Fig 75 Berkeley Pill, Gloucestershire: surviving sea-bank of pre-modern and, possibly, Romano-British age (J R L Allen)

Fig 76 Plan of the medieval quay at Woolaston Grange (Gloucestershire) (Tintern Abbey)

Fig 77 Saltwick Bay, Yorkshire: remains of seventeenth/eighteenth-century harbour enclosing the former alum house at NZ 917109 (The National Trust)

Little is known about the facilities at Saxon emporia, since excavation has focused upon the settlements themselves rather than the waterfronts. Simple hards are likely to have predominated, with timber waterfronts appearing from the later Saxon period, perhaps reflecting the growth in trade from the tenth century.

From the late Saxon period, a series of coastal ports developed. Large-scale excavations in a number of major ports have traced their development through to the present day (eg Clarke 1984, 181-92, fig 88; Good *et al* 1991; Milne and Hobley 1981). However, there has been a marked bias towards the major east coast ports, with very little work on the far greater number of small ports involved primarily in local trade; exceptions include Hartlepool, whose fishing industry appears to have been closely tied to Durham and its ecclesiastical bodies (Daniels 1991). The continued role of monasteries in medieval trade is poorly understood, though the occurrence of French imports amongst the late Saxon pottery from the 'haven' at Wootton on the Isle of Wight, close to the abbey at Quarr, is suggestive of trade contacts (Tomalin *et al* 1994, 137).

In addition to public facilities, there are probably an equal if not even greater number of private harbours, such as Tintern Abbey's quay at Woolaston in Gloucestershire (Fulford *et al* 1992) (Fig 76). The latter survey draws attention to how much remains to be done to develop our understanding of the growth of English ports, whose general history and archaeology have been set out by Jackson (1983) (Figs 77-8).

Shipbuilding, ship repairing and ship breaking have received even less attention, despite their importance to our maritime heritage (cf Banbury 1971; Holland 1971; 1985). One recent initiative has been the establishment of the British Shipbuilding History Project by the National Maritime Museum and the Universities of Glasgow and Newcastle-upon-Tyne.

With the growth of population mobility in the later post-medieval period ferries became increasingly popular. Major estuaries such as the Severn, which was once a major access route for north-south trade, were now a hindrance to east-west travel, and a series of ferry terminals was established (eg New Passage to Sudbrook and Beachley: Avon SMR 3578; Newnham to Arlingham: Gloucs SMR 6333). However, there has been very little archaeological survey to determine what survives of these often well documented structures.

There is an abundance of wrecks around the English coast, particularly in the major estuaries, and these are the subject of separate survey by NMR Maritime. They are important not only for the vessels themselves, but also for the closely dated assemblages that they might contain. Most survive below low-water mark, but there are examples in the intertidal zone. Medieval vessels are rare, though not unknown. At Buss Creek, west of Southwold in Suffolk, fragments of probably two vessels were dredged up; one timber yielded a calibrated radiocarbon date of 970–1155 (Martin *et al* 1992, 389). On the Welsh side of the Severn Estuary, at Magor Pill, a boat has recently been discovered embedded in the sediments of a silted-up river course, and dated to the twelfth century through dendrochronology (Allen and Rippon 1994; Nayling forthcoming).

However, the majority of wrecks appear to be post-medieval. Most attention has been devoted to the major seagoing vessels, such as the Dutch East Indiaman *Amsterdam* which sank in 1749 (Marsden 1985) (Fig 46). However, there is also a wide range of important river-going barges, such as the late eighteenth/nineteenth-century vessel recorded off Mersea Island (Dean 1985). Many of our estuaries have the abandoned shells of barges, which were once such an important part of the distributive system upon which maritime trade relied (eg Preston 1977, 58; and cf Whitewall Creek Survey, above, 5.3.2; Figs 42–3, 79).

In certain estuaries, islands could be reached at low tide. Causeways are found all around the coast, but can rarely be dated. A pipe trench along the Mersea Causeway in Essex gave a unique opportunity to record a long section (Crummy *et al* 1982). Wooden piles from the structure gave a dendrochronological date of the late seventh century.

Fig 78 Ravenscar, Yorkshire: presumed sockets (0.45 x 0.45m) for mooring posts of the seventeenth-century dock (The National Trust)

Fig 79 Wreck, Birling Links, Northumberland (Northumberland County Council)

Fig 80 Distribution of fish weirs in England's intertidal zone

Around 3000–5000 piles were probably used, suggesting that the island, and the estuary in which it lies, must have had resources of sufficient merit to warrant such great expenditure both in terms of timber and manpower. A monastery is first recorded on Mersea *c* 1000, though the date of its foundation is unknown; the date is intriguing, however, because the East Saxon king Sebbi, who ruled Essex from *c* 665–695, was said by Bede to 'devote himself to religious exercises, frequent prayer, and acts of mercy, and preferred a retired monastic life' (Crummy *et al* 1982, 86).

6.5.4.3 Intertidal fishing structures

The intertidal zone (and major rivers) have long seen the use of fixed fishing structures, broadly termed weirs. These were 'a barrier erected across a fish route in the sea or a river to deflect the fish into an opening where they can be caught in a net or wicker basket' (Salisbury 1991, 76). The barriers are usually of timber (usually wattle hurdles) or stone, and occur in pairs, forming a large V-shaped structure. They are most common in muddy estuaries with wide intertidal zones and clear directional flow of the tide (Fig 80).

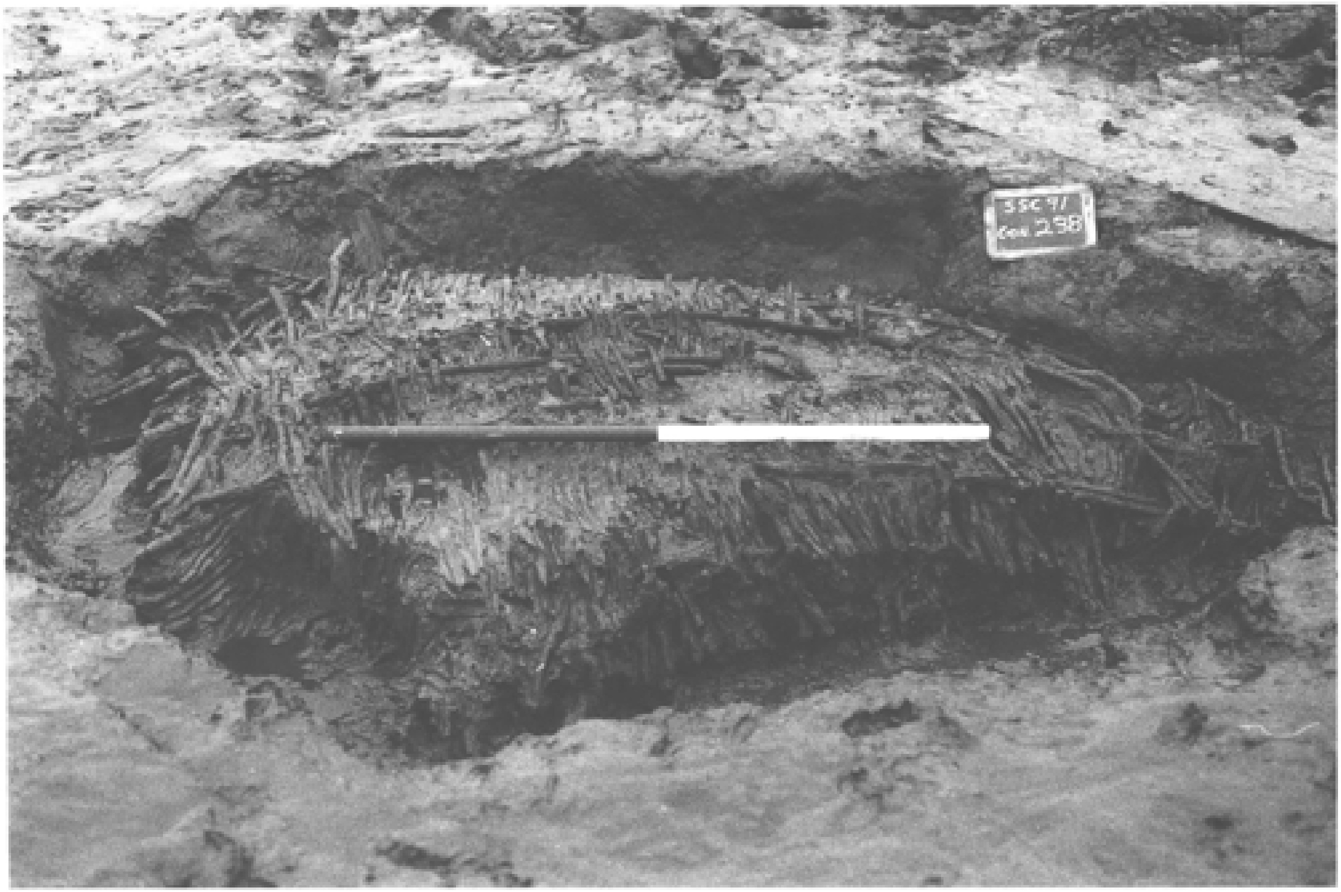


Fig 81 Fish trap of hazel of eleventh/twelfth-century AD date from the area of the former outfall of the river Nedern/Troggy, Caldicot off the Gwent coast (Severn Estuary) (S Godbold and R C Turner)

The existing SMR/NMR record suggests that the Severn Estuary/north Devon has the most abundant evidence (eg Godbold and Turner 1993; 1994; McDonnell 1993), and recent work in Essex has revealed some important Saxon structures (Clarke 1993; Crump and Wallis 1992). Other examples are known off the north-west and north-east coasts, and such was the ubiquity of the documented fishing industry that many more no doubt await discovery. The more open rocky coasts with very narrow intertidal shelves were not conducive to this type of fishing; for example, the Cornwall SMR contains just one reference to a fish weir (Tolverine: SMR 18907).

Some regional and chronological variation is evident in the nature of these structures, though no systematic collation of the evidence is yet available. Interestingly, artefact analysis relating to fishing tackle has also started to detect regional variations in fishing methods, determined by variables including the nature of rivers/estuaries and the varieties of fish species present (Steane and Foreman 1991).

In the Severn Estuary, the most ancient method involved rows of large conical wicker baskets, known as putts, placed to the rear of V-shaped arrangements of woven panels several metres long (eg Godbold and Turner 1993; 1994; Green 1992; Stuckey and Evans 1988) (Fig 81). In Somerset, these structures appear to have been called 'weirs', though upstream in Shropshire the term 'kidell' was used (Bond 1988, 87). Much larger stone versions of this type of fish weir survive at a number of places along the west Somerset/north Devon coast (McDonnell 1980, 134) (Fig 82). These massive structures can be several hundred metres long, and are similar in scale to wooden structures in Essex known as kiddles (Clarke 1993; Crump and Wallis 1992) (Fig 44). Woven panels hundreds of metres long fed to a single large basket. Calibrated radiocarbon dates of AD 640–75 and AD 882–957 have been obtained for such structures at Collins Creek (Clarke 1993), to the south of Tolleshunt D'Arcy on the northern side of the Blackwater Estuary (Fig 83), and similar structures are known at Sales Point off Bradwell (on the southern side of the Blackwater Estuary) and Foulness Island (on the northern side of the Thames Estuary; Crump and Wallis 1992). All these structures lie very low down in the intertidal zone, and air photography has played a major part in their discovery. The Essex Domesday contains several references to fisheries, with a notable cluster in the Blackwater; the Collins Creek and Sales Point sites may be associated with monastic sites with Domesday fisheries at Mersea and Bradwell respectively. Early Christian teaching encouraged the consumption of fish, though the 'no meat' rule declined from the late twelfth century (Bond 1988, 69). Not surprisingly, monasteries became major proprietors of fisheries, especially in coastal waters. For example, in the late eleventh/early twelfth century Bath Abbey had 104 fish weirs at its estate at Tidenham in the Severn Estuary (Bond 1988, 75).

In the post-medieval period a new tradition appears in the Severn, involving smaller baskets, known as putchers, stacked several rows high in wooden frames up to 200m long; this method of fishing still survives in places around the Estuary (Green 1992).

The construction of saltwater fishponds or 'lucks' is well documented on the Isle of Wight, and one is recorded at Wootton in 1304, later leased by Quarr Abbey (Tomalin 1991, 44); this may have been used for oysters. Elsewhere, very little appears to be known about oyster 'farming'. An enclosed lagoon probably for this purpose has been identified at Wootton Haven; the site is undated but may be associated with a hurdle structure radiocarbon dated to AD 690–1020 (1140±70 BP; GU-5053) (Tomalin 1991, 43). Such features need to be distinguished from the ponds linked with tidal mills which may be defined by substantial walls and associated sluices (Fig 84). Lesser features are represented by arrangements of square holes, known locally as 'hullies', such as those which have been cut into rocky foreshore at Seaton Carew in Hartlepool Bay. They were for keeping shellfish, and show that fixed structures related to fishing are not entirely restricted to the lowland muddy estuaries.

Very little work has been carried out on the settlements from which these fisheries were exploited. Indeed, we have relatively little archaeological evidence at all about the resources which coastal settlements were exploiting. Documentary research in Devon has revealed a specialised class of seasonal settlement exploiting coastal resources such as sea birds, fish and shellfish (Fox and Kissock 1993, 5). However, no archaeological work appears to have been carried out on such sites. It is also not known whether similar patterns of seasonal exploitation existed elsewhere.

Many coastal saltmarshes were subject to seasonal grazing, particularly for sheep (eg Lincolnshire: Owen 1993). On the Essex marshes, a series of temporary shepherds' huts are known from their 'wick' place-names and occasional finds of medieval material from reused Roman earthwork mounds (Darby 1971, 241–3; Round 1903, 369–74; Sealey forthcoming). As little excavation has been carried out, we cannot say whether any of these sites were involved in exploiting intertidal resources.

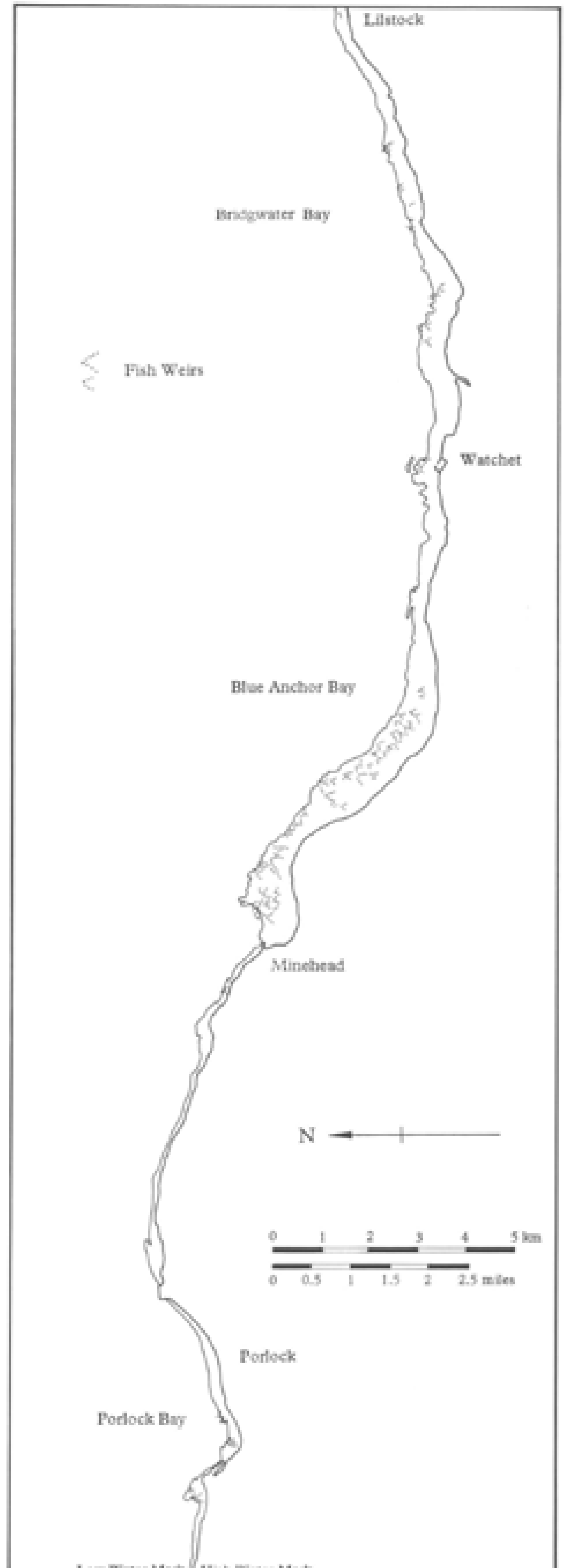
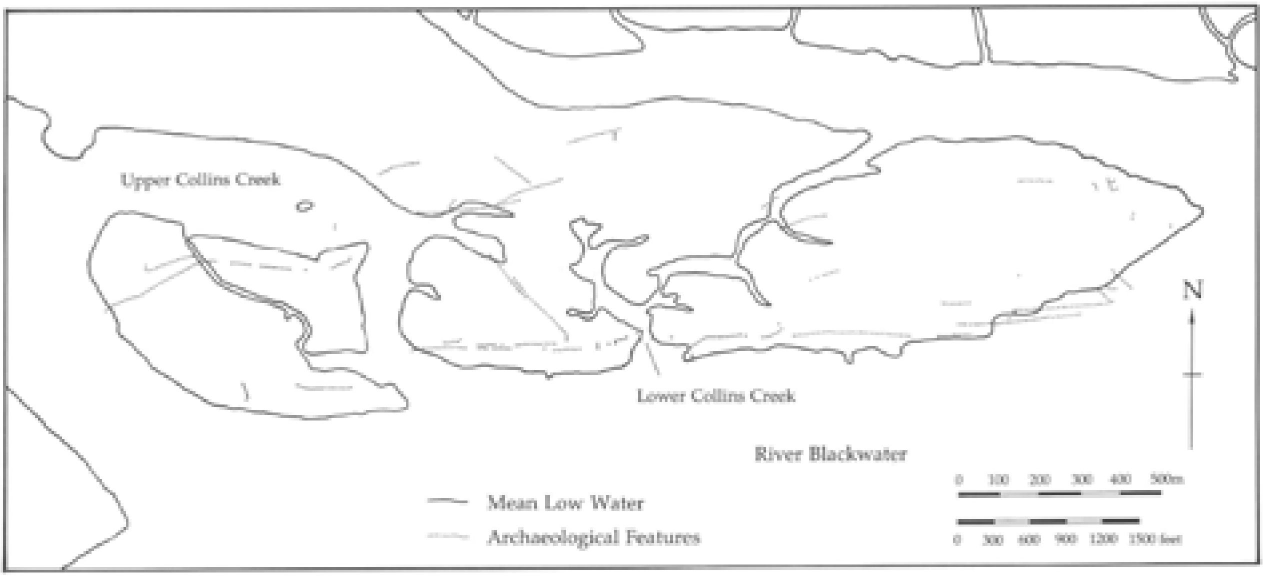


Fig 82 Location of fish weirs between Lilstock and Porlock, Somerset (see Fig 80 for location)



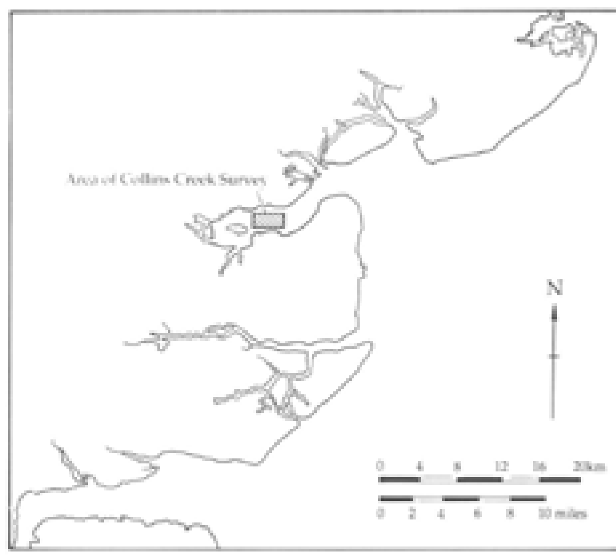


Fig 83 Fish weirs (kiddles) at Collins Creek, Blackwater Estuary, Essex

6.5.4.4 Salt production

Salt was vital for preserving meat, fish, and dairy produce, and the evaporation of sea water to produce salt is known from the Bronze Age (above, this chapter and Chapter 7). The industry is documented from the eighth century AD, when Saxon kings granted monastic houses land to develop salt-workings and cut peat for fuel (Keen 1989, 134). The most common method involved collecting beach sand in a trough, draining out the brine and then boiling off the water in lead or ceramic pans (Crossley 1990, 222; Keen 1989, 142; Taylor 1975). Alternatively, water could be collected in troughs at high tide. Therefore, a salt works consisted of an area of foreshore, a boiling house, and a waste heap for discarded pans and other burnt debris.

Domesday gives an impression of the distribution of eleventh-century salt production, which occurred all along the coast between Lincolnshire and Cornwall (Darby 1977, figs 89–90). However, the Domesday folios clearly suffer from omissions; for example, there are no salterns listed at 'Salcombe' in Devon or 'Salcot' in Essex, despite both place-names being derived from 'salt' (Darby 1971, 246; Darby 1977, 265).

The presence of a salt industry in these lowland areas reflected the value placed upon the coast. In areas such the Severn Estuary, saltmarshes were reclaimed from the late Saxon period; land was valued for agriculture, which was clearly incompatible with salt production requiring direct tidal access. In this area there were therefore no Domesday and few medieval salterns. By contrast, in parts of Lincolnshire, East Anglia, Essex, and Sussex, the coastal Levels comprised tidally inundated saltmarshes, and salterns were abundant into the medieval period, until pressure grew to convert these areas into agricultural land.

By the sixteenth century, coastal salt production had become largely confined to northern England and Scotland (Crossley 1990, 222; Owen 1984, 46), though commercial salt works were still to be found in the north Kent marshes (Preston 1977, 31). Competition from the inland sources in Cheshire meant that the coastal industry disappeared at the end of the eighteenth century (Taylor 1975, 19).

Documented salterns are therefore found all around the English coast, both the low-lying coasts of southern Britain and the higher rocky cliffs of northern Britain, where they were closely associated with the mining of coal to provided fuel (eg Pilbin 1935). However, few salterns appear to survive, at least along the present coastline. In fact, the best preserved examples are likely to be in areas which have been stranded inland by saltmarsh accretion and reclamation, such as Bicker Haven and Wainfleet St Mary in Lincolnshire (Healey 1975, 36; McAvoy 1994),

Fig 84 Remains of ?eighteenth-century sluice and mill-pond wall, Bembridge Harbour, Isle of Wight (M G Fulford)

South Grimsby on Humberside (Rudkin 1975, 37), and Harty Marshes, Isle of Sheppey, Kent (RCHME 1994b).

6.5.4.5 Other extractive industries

The digging of peat from inland bogs is well documented, and many salterns are associated with the right of 'turbary' (peat cutting) (eg Taylor 1975, 17). A number of such turbaries have recently been discovered in the intertidal submerged forest off Romney Marsh (J Eddison pers comm). These examples appear to have been cut in a contemporary landscape inland of a beach barrier. However, there seems no reason why intertidal peat deposits would not have been dug for peat elsewhere, though in most places evidence is likely to have been long since eroded away. There is certainly some evidence for the use of timber from submerged forests, such as Meols on the Wirral, where axe marks have been noted on tree stumps, and local tradition records the use of these timbers in several local buildings (Ellison 1967, 27; Morton 1891, 237–8).

Seaweed was an important resource in a number of communities around the country. In the Isles of Scilly, it was used as animal fodder and manure. As well as being a type of seaweed, 'kelp' was the name given to the burnt residue used in soap- and glass-making (Gill 1975, 89; Grigson 1956, 374). Archaeologically, the main traces are the roughly built circular stone pits used for burning. In 1822, there were said to have been 40–50 kelp kilns on Scilly.

Gravel was needed in vessels as ballast, and the intertidal zone provided one source. At Great Yarmouth in Norfolk, the right of digging gravel for ballast dates back to the thirteenth century (Tooke 1984). The industry continued into the post-medieval period, and in 1602 the 'Ballast Quay' was constructed. This well documented structure still survives, and yet it is not recorded in either the SMR or NMR, a striking example of how important post-medieval structures are missing from these databases (cf *Recording England's past* (RCHME 1993a)). Gravel extraction off the Devon coast in the early part of this century ruined the natural beach, allowing storms to partially destroy the village of Hallsands (Worth 1904, 302–46; 1923, 131–47).

Certain rocky coastal cliffs contain important minerals, and another extractive industry found along various coasts (though not inherently coastal, as the same minerals can be found inland) is quarrying. A fine example is Corbyn Head in Devon, where quarrying for millstones is documented from the twelfth century; circular cut marks can still be seen in the cliff (NMR SX.96 SW 16/44762). Evidence of stone quarrying has recently been discovered on the Isles of Scilly (Bathinghouse SMR 7676; Green Bay SMR 7704), and on the beach at Wootton Quarr, from where Bembridge limestone was exported to the mainland (Tomalin *et al* 1994, 140–4). Finds include an unfinished mortar roughout (Tomalin *et al* 1994, 143) and recently a whole stone quern has been found offshore at Ryde Middle Bank (Tomalin pers comm). Bembridge stone may also have been used as tempering in late Saxon pottery (Tomalin 1991, 41). Quarr has added importance, because the nearby Victorian quay at Binstead may have a medieval predecessor used for exporting the stone. Along with a fishery, tile kiln, and a possible small port or quay (Tomalin *et al* 1994, 137–8, 150–2), the medieval stone trade may have been controlled by Quarr Abbey on the nearby cliff top. However, more extensive outcrops occur in the intertidal zone eastwards to Bembridge itself (Fig 85). Concentrations of associated sites such as those at Quarr have a high group value.

The Cornish tin industry is a very well known example of a coastal extractive industry, of which abundant remains survive both on the cliff tops and in the intertidal zone. For example, mining at the Wherry tin mine in Mounts Bay began in the early eighteenth century on a rocky intertidal outcrop. The works lay *c* 220m from the shore and were abandoned in 1792 after a ship collided with a landing stage (Hawkins 1818, 136–7) (Fig 86).

Fig 85 Possible quarry for the extraction of Bembridge Limestone at Nodes Point, St Helens, Isle of Wight (M G Fulford)

In north-east England alum, coal, iron, and jet were mined from the cliffs from prehistory onwards. Mine shafts and quarry cuttings do survive, many of which can be documented to the post-medieval period (Marshall 1990; Owen 1981; Pybus 1983; Robinson 1962). The extent to which medieval or earlier workings survive is not clear. In the post-medieval period, workings shifted away from the cliff faces to inland coalfields, but many mines were still located close to the coast for ease of transport. Many coal and ironstone harbours survive, as well as cliff-top workings and processing sites, such as the calcining kilns at Runswick Bay in County Durham (recently surveyed by the National Trust). Rutways, cut into the

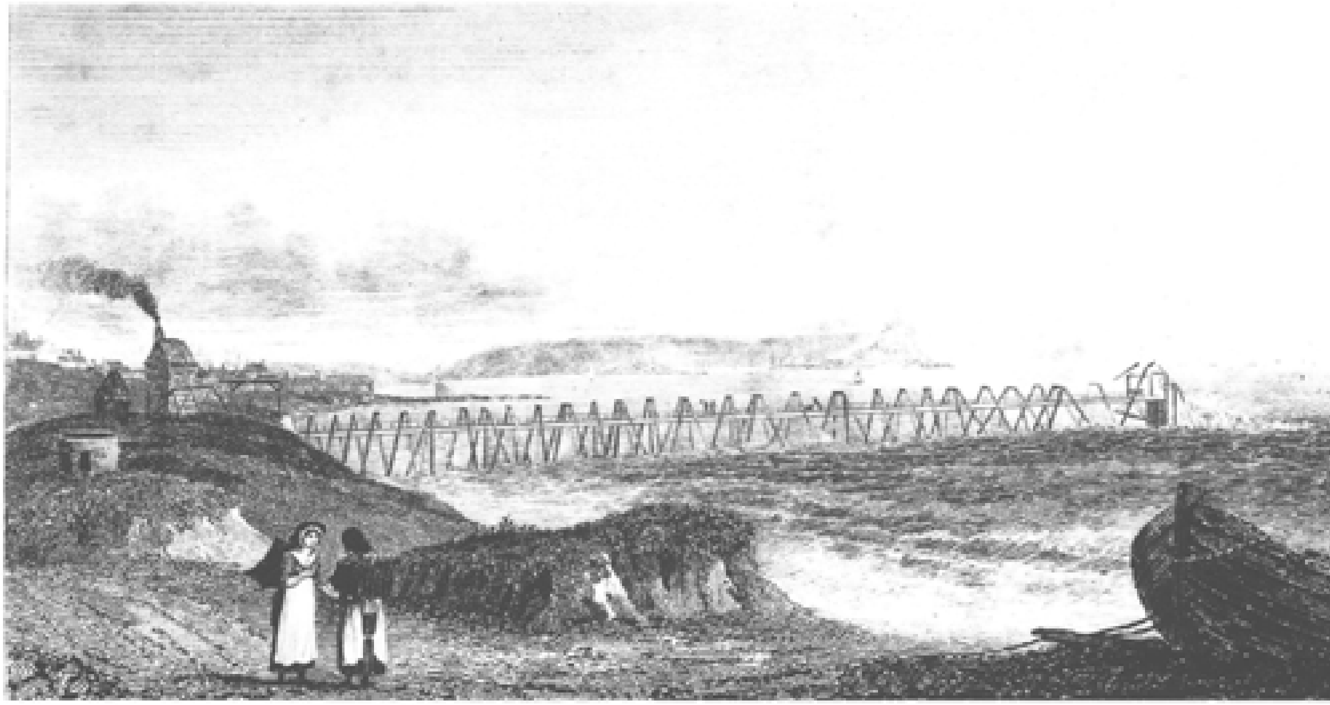


*Fig 86 Wherry tin mine, Mounts Bay, Cornwall (*Trans Royal Geol Soc Cornwall, *Vol 1 (1818), pl 1)*

Fig 87 Ravenscar alum works, Yorkshire: rutway (1.2m gauge) used for guiding carts to the mid-nineteenth-century dock below the alum house (The National Trust)

Fig 88 Saltwick, Yorkshire: remains of circular tank No. 2 (diam: c 7m) forming part of the alum house (The National Trust)

foreshore to allow carts to transport materials to the cliff face, survive at a number of locations including Runswick Bay and Ravenscar (Marshall 1990) and elsewhere (eg Owen 1981; 1991) (Fig 87). Another very well preserved cliff-top site is the alum works at Ravenscar in North Yorkshire (Pybus 1983) (cf Saltwick, North Yorkshire, Fig 88). Clearly, parts of the coast of north-east England represent an important historic/industrial landscape forming an integral part of the cultural heritage of the region. What is also clear from the recent RCHME/National Trust surveys is that this landscape is rapidly eroding.

Certain lowland areas also have industrial landscapes along their coasts. In northern Kent, for example, the nineteenth century saw a rapid expansion of the cement and brick industries, concentrating around the Medway (Preston 1977). These industries, along with shipbuilding, trade, and related engineering, made this estuary the major industrial area in Kent from *c* 1850. This was in addition to the long tradition of fishing in the Thames Estuary (Preston 1977, 17). Numerous barge yards and small ports/wharves were to be found along the coast, though little fieldwork appears to have been done on any of these remains.

6.5.4.6 Military defence

Discussion of defensive structures in the coastal zone is beyond the scope of this review.

6.5.4.7 Religious houses

There is a long tradition of religious houses being located on remote coastlines. At Brean Down in Somerset, a Romano-Celtic temple may have been reoccupied in the post-Roman period; certainly, a small cemetery was established nearby which has recently suffered erosion (Bell 1990). In the Saxon period, there is a marked tendency for early monasteries to be located by the coast (see above). Many of the Roman Saxon shore forts have evidence of Middle Saxon churches; Rigold (1977, 70) argues that this was because of the symbolic appeal of these 'starkest of Roman monuments'. In the medieval period, small chapels (eg Chapel Jane on Gurnard's Head, Cornwall: Johnson and Rose 1990) and great monastic houses (eg Whitby) were similarly located on the coast. Indeed, at Dunwich, Suffolk, little survives of the Franciscan friary recently surveyed by the RCHME (1993b). Many monasteries were closely

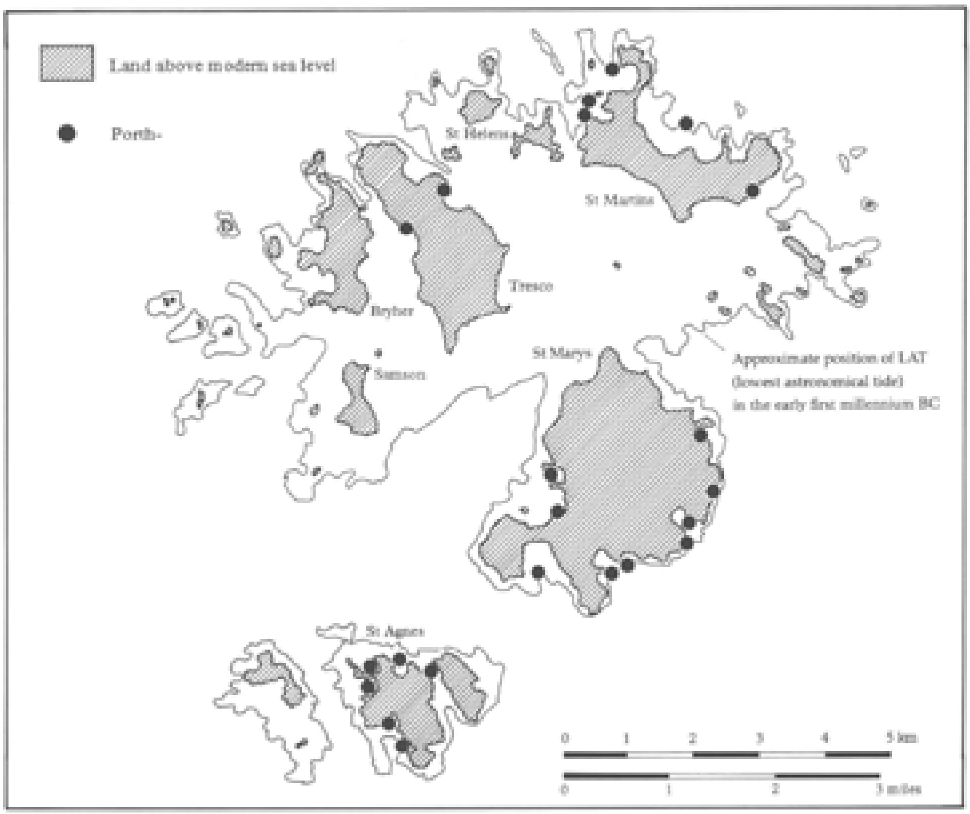


Fig 89 Place-names and the drowning of Scilly: the earlier, Porth- names tend to be found around the outer shores of the islands

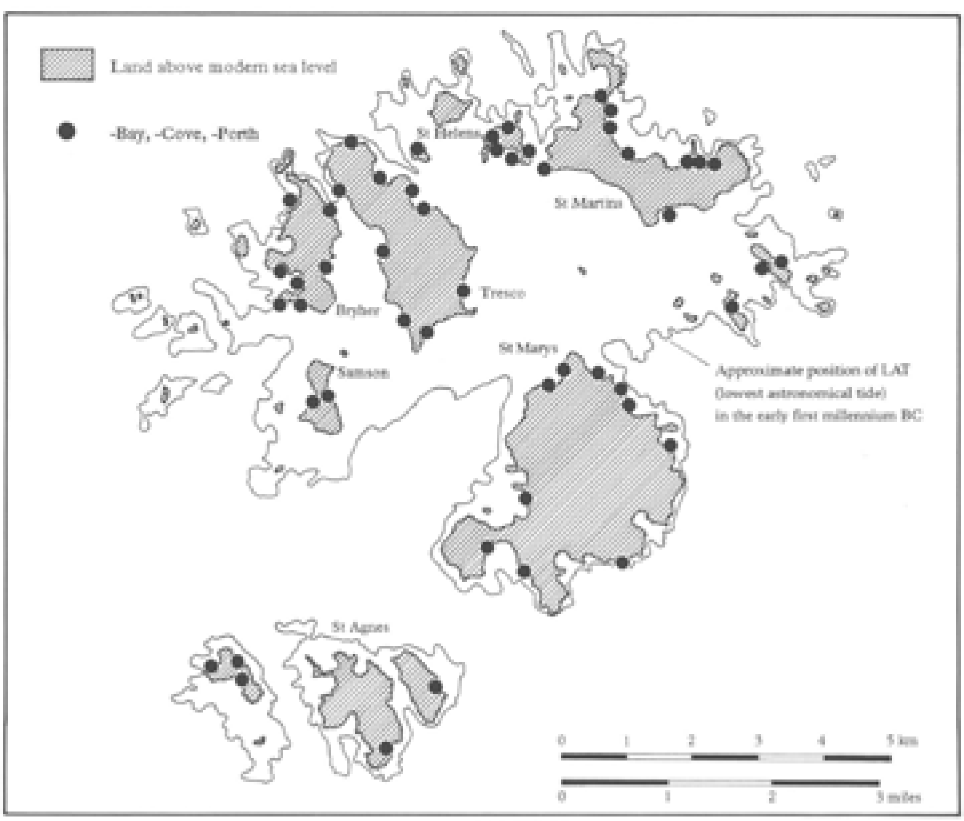


Fig 90 Place-names and the drowning of Scilly: later placenames of -Bay, -Cove, -Porth, which are found along the inner shores after the drowning of the low-lying land and the emergence of the islands

Fig 91 Distribution of lost medieval settlements around the coast of England

involved with exploiting marine resources, and others were involved in foreign trade (eg Barking, Bradwell, and Quarr; see above). Many monasteries grazed large flocks of sheep on coastal saltmarshes (Owen 1993).

In these areas, the groups of individual 'sites', such as fishing structures, quays, and industrial workings, need to be studied as coherent groups, reflecting the aggressive policies of these monastic landowners to the exploitation of resources.

6.5.5 Coastal settlements

We have remarkably little archaeological evidence from settlements that were originally coast-specific to reflect the patterns of exploitation of marine resources. At present, we must rely upon the evidence that reached major towns through trade. Because of coastal erosion, many such coastal sites will have been lost, though some will now appear in the intertidal zone, or are now landlocked because of the silting of former tidal rivers or saltmarsh accretion.

Fig 92 St Helens, Isle of Wight: remains of thirteenth-century church tower reused as a seamark in the eighteenth century. World War II pillbox to right (M G Fulford)

The English coast has been retreating since the last Ice Age, with major changes still occurring in the medieval and post-medieval periods. In certain areas, such as the Isles of Scilly, the sea appears to have flooded low-lying areas during the post-Roman period. Thomas suggests that the Isles of Scilly did not become separate islands until the late seventh or eighth century (Thomas 1985, 187) (Figs 89–90). Certainly there are a number of currently intertidal sites that appear to represent a flooded, formerly dry land, landscape of the post-Roman period. For example, at East Porth on Tean a circular structure is associated with pottery of the fifth/sixth century. At East Porth on Samson, two sequential buildings have been excavated, that last dated to the seventh or eighth centuries (Thomas 1985, 186); this site is currently threatened with erosion (Ratcliffe and Sharpe 1991, 77).

However, it appears that around most of England the most dramatic coastal retreat took place from the thirteenth century. There are abundant references in documentary sources to previously coastal settlements, harbours, mills, and even castles having been abandoned and eroded by the sea. The main period of loss appears to have been between the late thirteenth and sixteenth centuries (cf Willson 1902) (Figs 91–2).

These sites are often included in SMRs on the basis of documentary research; it is rarely stated whether there are any surviving cliff-top remains or evidence for the site in the intertidal zone. The latter is obviously unlikely along coasts with cliffs more than a couple of metres high. The greatest number of sites is along the Holderness coast (Sheppard 1912), though searches through the county SMRs have revealed a scatter of sites along the Lincolnshire, East Anglia, Kent, Sussex, Lancashire, and Cumbria coasts.

Where it is made explicit, little if anything appears to survive of most documented eroded settlements. For example, a large part of the medieval town of Dunwich in Suffolk has been eroded away, and survives only as an extensive intertidal strew of material and a few fragments of *in situ* brickwork, interpreted at the time of discovery as part of a kiln (Anon 1952, 110), but more likely to be a well.

One remarkable site is Shipden, near Cromer in Norfolk. Though not strictly intertidal, as it is now permanently submerged, the remains include footings of the church, several houses, and a street. The site lies around half a mile from the coast and disappeared between the late thirteenth and mid-fifteenth century (Trett 1982).

Stratified remains of medieval settlements in the intertidal zone are rare, though several examples occur in Suffolk, including Covehithe (SMR 01311), where three well preserved wells were discovered. At Eccles in Norfolk, ten wells have been recorded, with waterlogged finds including leather shoes (Pestall 1993). A middle Saxon settlement at Medmerry Farm, West Sussex, also illustrates the importance of these now intertidal settlements, as wooden structures with very well preserved clay floors and associated middens were observed (White 1934).

7 The archaeological resource: regional review

by R J Bradley, M G Fulford, and H J Tyson

7.1 Introduction

In the introduction to the last chapter it was observed that much of what is currently documented from the coastal and intertidal zone concerns the prehistoric and Romano-British periods. Records for the earliest prehistoric periods and for the medieval and post-medieval period do exist, as the previous chapter demonstrates, but the obvious imbalance in the record prejudices the systematic regional review that the later prehistoric and Roman material warrants.

The purpose of this chapter, therefore, is to give a more detailed impression of the archaeological record for the later prehistoric and Roman period from around the coast of England than was possible in the chapter concerned with the period-by-period review. The sources for this chapter are the same as for Chapter 6, but this review is derived from a series of substantial, county-by-county syntheses which form the principal archive of this study. A regional survey of this kind will give a clearer indication of major gaps in even the most basic knowledge of the coast, as well as indicating areas where past finds reveal a potential for investigation in the future.

7.2 The Tweed to Flamborough Head

7.2.1 Prehistory

This is one length of coastline which has been investigated recently. The Northumberland coast has been subjected to a rapid survey (Northumberland County Council 1994), and so has the shoreline between Seaham and Whitby (Buglass 1994).

In the light of the comments made earlier in Chapters 4 and 6, two particular topics are important here. First, there are numerous reports of areas of submerged forest which would repay careful investigation. These chiefly concern finds from Cresswell, Hauxley, Seaburn, Hartlepool Bay, Hornsea, Owthorpe, and Easington (Trechman 1936; 1947; Smith and Francis 1967). Although some artefacts have been reported from these areas, there is very little to indicate whether this relationship is significant. At Hartlepool, however, flints, animal bones, and wooden stakes do come from recent fieldwork in the intertidal zone, and what may have been a Neolithic or Early Bronze Age fish trap has been recovered from stratified deposits on Seaton Carew beach (Annis 1994). Such finds suggest that this is an area of special significance.

Second, the coast of north Northumberland is an area in which prehistoric finds are regularly recorded in eroding sand dunes (Northumberland County Council 1994). These are mainly Early Bronze Age burials, although a Beaker occupation site has been found at Ross Links (Brewis and Buckley 1928). Another area which is suffering from serious erosion is Flamborough Head, where recent fieldwork has investigated a series of Neolithic flint industries on the cliff edge (T Durden pers comm). These were probably the sites where raw material collected on the beaches was tested and shaped before it was taken inland. The industry was directed towards the production of elaborate artefacts such as discoidal knives and transverse arrowheads.

7.2.2 Roman

With the exception of distinct structures, such as Roman military installations, there are difficulties in distinguishing between the pre-Roman and the Roman Iron Age in the north-east. Equally, there is no clear distinction to be made between the nature of native settlement north and south of the Hadrian's Wall frontier (Jobey 1982).

Although there are no recorded finds of Roman Iron Age date in the intertidal zone north of the Tyne, the closeness to the shore of sites such as the burials between Beadnell and Seahouses (Tait and Jobey 1971) or the native settlement at Tynemouth Priory (Jobey 1967) has to be considered. The extent to which proximity to the sea may have influenced the character of these sites, or any others, has yet to be established. It is also not known whether any site has been subject to coastal erosion.

The Tyne clearly provided an important access route for troops and supplies to the northern frontier. The evidence is strong but indirect, since to date no certain structural evidence of any Roman waterfront has been discovered. The involvement of units from the *Classis Britannica* in the building of Hadrian's Wall, and the dredging from the bed of the Tyne of an inscription recording the arrival of troop reinforcements from Germany (RIB 1322), point to the existence of port facilities on the north bank at Newcastle (Pons Aelius) itself, or at Wallsend (Cleere 1978, 37). Equally, the decision to make the fort at South Shields on the south bank at the mouth of the Tyne a major supply base for the Severan campaigns of the early third century suggests that sea-based supply was paramount then (Land 1974, 4). The existence of port facilities on the Tyne is further inferred on the basis of artefacts with distinctive east coast distributions which reach Hadrian's Wall.

These would include certain well known coarse pottery types manufactured in the south-east, such as Colchester mortaria and Thames Estuary BB2 (Hartley 1973; Williams 1977).

The most important context for finds at South Shields is Herd Sand, where at least 25 coins were recorded between 1891 and 1980, and particularly between 1908 and 1915 (Blair 1907–8, 1909–10, 1911–12, 1915–16). There seems no reason to doubt this provenance. The coins range in date from Nero (54–68) to Gordian III (238–244) and Victorinus (268–70) (Salway 1981, 747); all but the last two are of first- and second-century date. The only other recorded find is a bronze patera with an inscribed dedication to Apollo. The north sands at South Shields have also produced a bronze patera and remains of undated timbers (Bosanquet and Richmond 1936). A more doubtful findspot is the Trow Rocks off South Shields from which Roman coins have been discovered (Blair 1903–4, 1905–6), since this location has been a dumping ground for material dredged from the Tyne.

The late Roman signal stations of Huntcliffe, Goldsborough, Ravenscar, Scarborough, and Filey are a celebrated cliff-top feature of the north-east coast, but almost all trace of Filey has now been lost to the sea, and part of the signal station at Scarborough has been eroded, the remainder perching precariously at the edge of the cliff. Fortunately what remains of Filey has recently been the subject of excavation (Ottaway 1994; 1995). In comparison with the cliff top, few finds have been reported from the intertidal zone between the Tyne and south of Flamborough Head. The industrialisation and expansion of port facilities at Sunderland and at Middlesborough and Stockton-on-Tees in the nineteenth century may account for the lack of reported finds from the estuaries of the Wear and Tees, where evidence of coastal settlement, and use as ports or landing places, might otherwise be expected. Such potential is indicated by the discovery of a midden producing samian and later Roman coarse pottery on the shore at Hartlepool (Trechmann 1936, 168). Given the size of Tees Bay, which includes the lower, non-industrialised stretch of the estuary of the Tees, the lack of finds there is surprising. South of the Tees a cluster of finds from around the mouth of the Esk at Whitby also suggests potential.

7.3 Flamborough Head to the Wash

7.3.1 Prehistory

There are reports of areas of submerged forest from this part of the coastline. Besides Cleethorpes, Humberside, the main locations are between Mablethorpe and Skegness, Lincolnshire, with the most important exposures between Sutton-on-Sea and Ingoldmells. In no case are there convincing cultural associations of prehistoric date (Pennick 1987; Van de Noort and Davies 1993).

There is evidence for substantial timber structures in the Humber wetlands, and these fall within the aegis of a project currently in progress (Van de Noort and Davies 1993). They apparently consist of substantial wooden platforms associated with human remains and artefacts including bronze metalwork (Smith 1911). Among them is the Barmston 'crannog' which was excavated and published in the 1960s (Varley 1968). Recent work as part of the Humber Wetlands Project at a site of Neolithic date at Withow Gap, Skipsea (Holderness), where erosion had exposed many tree trunks and smaller branches, found no evidence of human activity. On the contrary, teeth marks on ten timbers suggested that beavers may have played a significant role in the creation of timber 'structures' (McAvoy 1995).

Another major area is the Humber Estuary itself, and particularly the important complex at North Ferriby which has already been referred to in Chapters 4 and 6 (Wright 1990). Some dedicated survey work has already been organised in this area, and work at Melton, 1.5km west of Ferriby, has revealed a whole series of timber features, some of which are of prehistoric origin (Crowther 1987).

The other major group of intertidal sites is at Ingoldmells in Lincolnshire, where there is evidence of Iron Age salt production (Swinnerton 1932). This included a number of structural features, mainly ovens and hearths, as well as what may have been a series of small wooden buildings whose clay floors were raised above the level of the surrounding area. The description of these features published in the 1930s (Warren 1932) makes them sound remarkably like the Middle Iron Age structures on the inland site of Mere West (Orme *et al* 1981).

7.3.2 Roman

Recorded erosion of the coastline south of Flamborough Head since the medieval period has been extensive. Although late Iron Age and Roman material has been recorded from, or close to, the present shore as far south as Kilnsea (Loughlin and Miller 1979, 52; Sheppard 1907, 55), just short of Spurn Head, no detailed excavation or survey has been undertaken from which the possible relationship with the Roman coast might be inferred. It is likely that Bridlington Bay can be identified with the Gulf of the Gabrantovices regarded by Ptolemy as suitable for a harbour (Rivet and Smith 1979, 137–8). This hypothesis is supported by the incidence of Roman coin finds, with some Greek as well as late Iron Age gold staters, from this area and down the coast as far as Barmston and Ulrome (Loughlin and Miller 1979, 80) where there is evidence of late Iron Age and Roman settlements. Additional Iron Age and Roman coins, including a hoard of mid third-century AD bronze denominations from the cliff at Hollym, are recorded from several locations along the coast to the south as far as Easington and Kilnsea on Spurn, where a major concentration of finds of late Iron Age and Roman date is recorded (Loughlin and Miller 1979, 52–4). These include Iron Age and Roman coins, a range of metalwork finds among which is noted a bronze figure of Mercury, querns, and pottery apparently derived from a number of different midden-type contexts in some of which oysters were particularly numerous. The finds range in date down to the late Roman period.

The Humber provided a major route into the north-east of England from the late Iron Age onwards, and major settlements of that date have been identified and partly explored at Redcliff west of North Ferriby, and at South Ferriby on the opposite bank. Redcliff has produced evidence of settlement, as well as a rich range of coins and Gallo-Belgic and other pottery imports of pre-Claudian date, whereas metalwork alone, including a large number of inscribed and uninscribed Iron Age coins, has been recorded from the eroded site at South Ferriby (Crowther *et al* 1990; May 1992).

The use of the Humber continued to develop in the Roman period, with some shift in the location of the major settlements and ports. Like the other legionary fortresses in Britain, York, the base of Legio VI, was strategically located on a navigable river with access to the open sea. A range of evidence suggests that a major port developed on the Ouse, one of the Humber tributaries, to serve the fortress and, later, the colonia. However, Brough (vicus Petuariensis) on the north bank of the Humber to the west of North Ferriby emerged as the major port on the lower estuary opposite Old Winteringham. It also controlled the river crossing on the strategically important route between Lincoln and York. The site on the south bank has been suggested as the possible location of a Claudio-Neronian fort or supply base, although the earliest evidence from Brough is of early Flavian date (Whitwell 1988). The Roman harbour is believed to lie to the west of the walled area of Brough, but it has not been investigated. The number of lead pigs recorded from the vicinity suggests that Brough played a major part in the export of lead. At Faxfleet on the north shore opposite the mouth of the Trent, settlement evidence has been recorded, including possible wharf facilities, both in the intertidal zone and on higher ground (Loughlin and Miller 1979, 39–40). Traces of structures, as well as brooches, pottery of Iron Age and Roman date, wooden objects, and possible kiln furniture, have been recovered from the foreshore. A lead pig from the Derbyshire lead fields was also found close by. Just as with the late Iron Age, less is known about the southern shores of the estuary. Occasional finds have been recorded from South Ferriby, including a small hoard of fourth-century silver coins (Sheppard 1910, 33). Other concentrations of casual finds occur at East Halton Skitter (Whitwell 1988, 63–4) and Grimsby, where pottery and coins of first- to fourth-century date have been recorded (SMR nos 1188, 1191, 1200).

Scatters of Romano-British pottery and coins from dates up to the fourth century have been found at several sites along the Lincolnshire coast at such locations as Mablethorpe (SMR no. 41437), where a hoard of first- to fourth-century date was also recovered, Anderby, and Skegness (SMR nos 41609, 41687). However, the principal location for late Iron Age and Roman finds is Ingoldmells, where a substantial settlement existed. A ditch which produced a range of third-century pottery, animal bones, and some leather was recorded on the south side of Ingoldmells Point early in this century (Warren 1932, 254). This settlement seems to have succeeded an extensive salt-making industry with its origins in the early Iron Age, but there is no evidence that the production of salt continued through from the latest Iron Age/earliest Roman period until the late Roman period at this site. Swinnerton seemed confident that there was discontinuity (1932). Timber structures of unknown (but probable Iron Age) date have also been observed off Ingoldmells. Only at Chapel St Leonards to the north is there evidence of Iron Age and Roman salt-making. There are no records of finds between Skegness and the north Norfolk coast.

7.4 East Anglia

7.4.1 Prehistory

In addition to records of the survival of submerged forest between Hunstanton and Holme-next-the-Sea, there are scattered artefacts of most phases from the foreshores of Norfolk and Suffolk, but most of these seem to come from areas which are prone to cliff falls. There is a concentration of Neolithic axes from the coastline of north Norfolk, and other finds of flint artefacts from the shore of north Suffolk. There are also records of Neolithic artefacts from alluvial deposits at the mouths of the rivers Orwell and Deben. At present there is nothing to suggest a focus for future research in Norfolk and Suffolk.

The situation is very different in the outer Thames Estuary. The Essex coast was one of the first areas in which the intertidal zone was examined in any detail, and recent survey has set a new standard for such studies (Wilkinson and Murphy 1986; 1995). Some 200km of the Essex coastline have now been examined in the field. As the results of this work are already published or in press, they can be summarised very briefly here. It is clear that this is a region which would repay still more research (Figs 93–5).

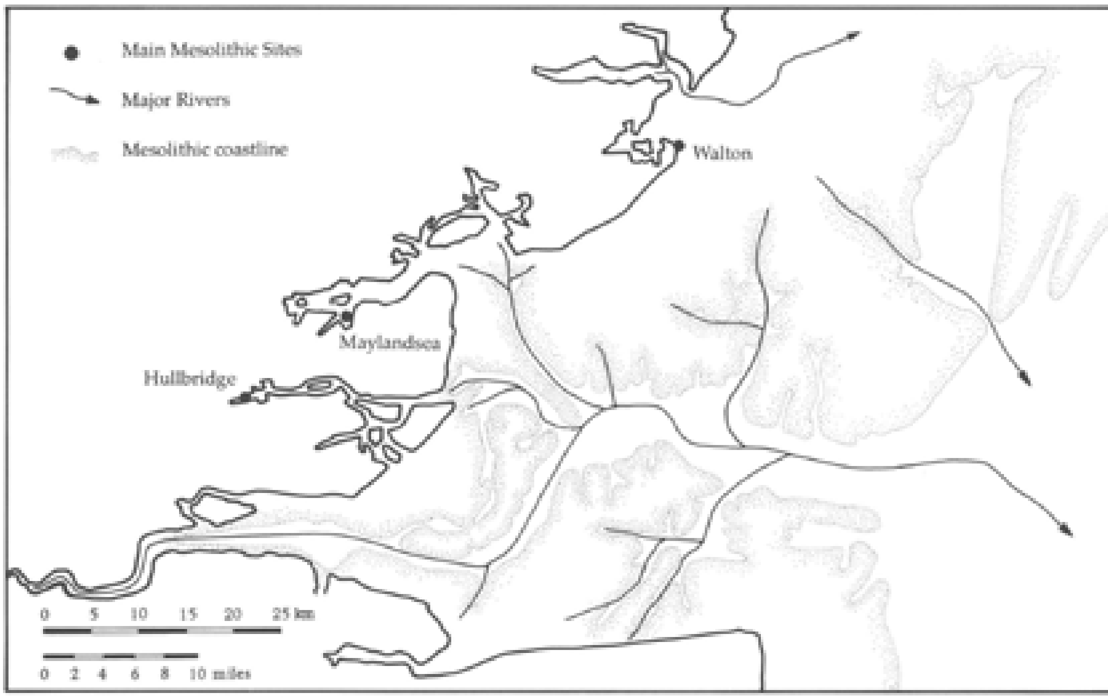


Fig 93 Essex: reconstruction of the Mesolithic coastline between c 8500–7500 cal BC (after Wilkinson and Murphy 1995, fig 126)

The evidence takes four main forms: further areas of submerged forest; wooden structures preserved in the intertidal zone; buried land surfaces associated with well preserved occupation sites; and the distinctive traces left by salt production.

The submerged forests have been known since the last century, and in some cases they seem to have been associated with finds of flint artefacts (Wilkinson *et al* 1983; Wilkinson and Murphy 1986; 1988b; 1995). The main occurrences are at Hullbridge, Woodham Ferrers, North Fambridge, Stow Maries, and Purfleet. There are also a number of preserved wooden structures, which seem to have survived mainly along the tidal rivers and estuaries rather than the open coast. These include lines of stakes, timber platforms, trackways, and a possible fish trap, as well as the ephemeral circular shelters recognised by many workers from Warren to the present day (Warren *et al* 1936). Not all of these finds can be dated precisely, but the available radiocarbon dates focus on the Later Bronze Age and Iron Age (Fig 96).

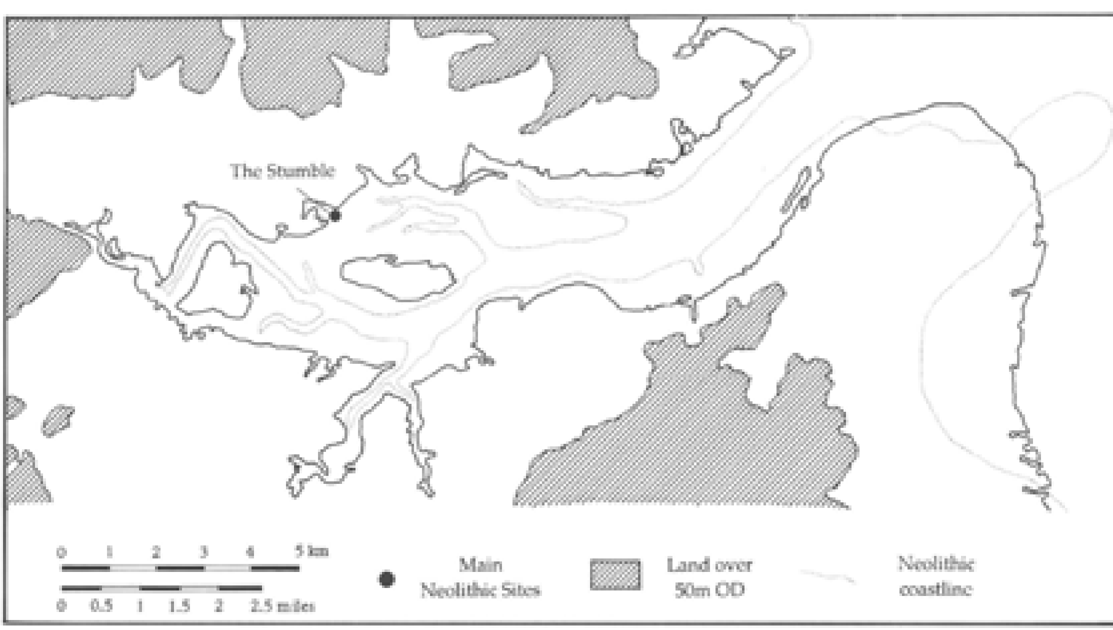


Fig 94 Essex: reconstruction of the Neolithic archaeology and palaeogeography of the Blackwater Estuary (after Wilkinson and Murphy 1995, fig 128)

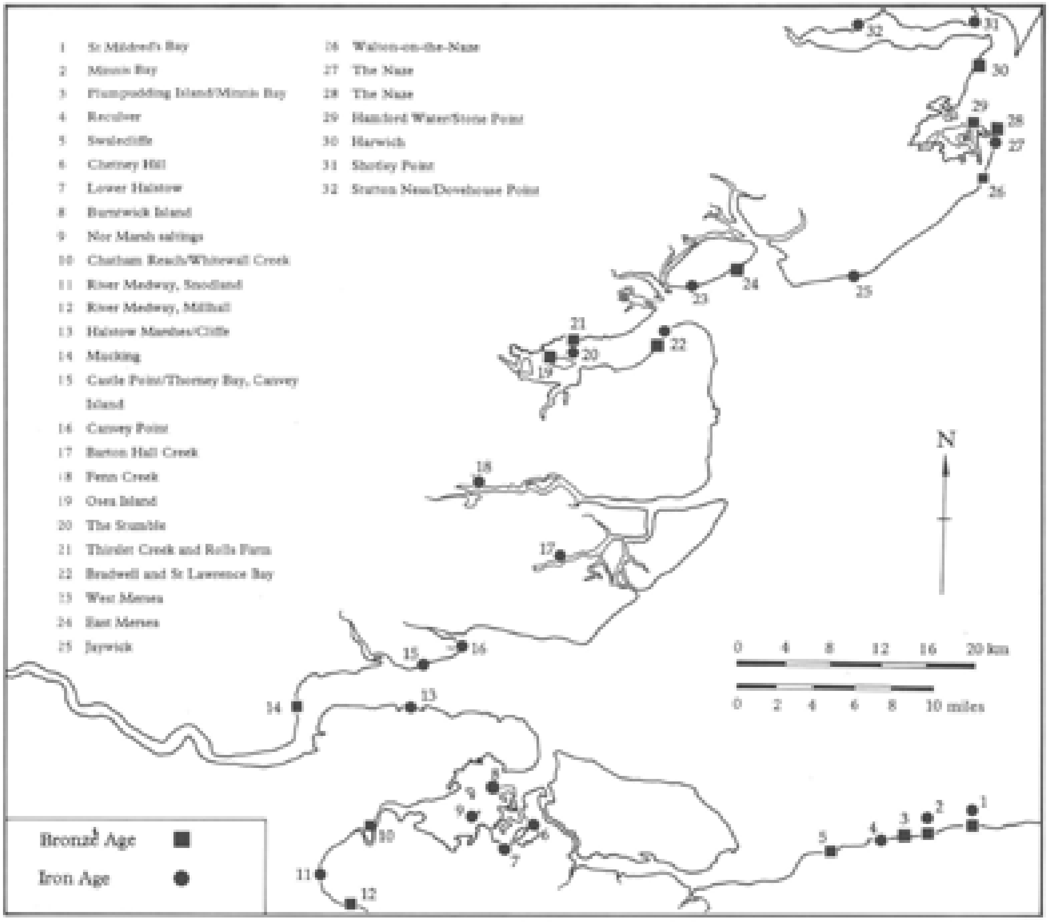


Fig 95 Distribution of Bronze Age and Iron Age sites in the intertidal zone of Essex and north Kent

By contrast, the finds of earlier material relate to surfaces that were originally dry land (Wilkinson and Murphy 1986). The most important of these are the earlier Neolithic site at the Stumble, which has now been excavated, and the remarkable series of Late Neolithic and Beaker land surfaces and pits found between the Stour and the Blackwater (Warren *et al* 1936). These include the important group of Grooved Ware pits at Clacton, and the finds of pottery and flintwork which Warren associated with the 'Lyonesse' surface (ibid). It is unfortunate that most of these sites no longer survive. If similar deposits are recognised in the future, their systematic investigation will be of real importance.

7.4.2 Roman

The majority of finds from the Norfolk coast consist of late Iron Age and Roman coins. The most important source is the beach at Weybourne on the north coast, where a hoard of Gallo-Belgic E staters was found in 1940, presumably eroded from the cliffs (Norfolk SMR no. 6264). Other single finds of staters including Gallo-Belgic D and E have also been recorded, the distribution extending eastwards towards Sheringham (Norfolk SMR no. 6265). Deposition of coins in this locality continued until at least the end of the second century. Finds include a gold *aureus* of Nero (Norfolk

Fig 96 Hullbridge Survey: river Crouch site 29 (context 68). Remains of a Bronze Age wooden platform (copyright Essex County Council)

SMR 6276) and second-century bronzes, the latest of Septimius Severus (AD 193–4) (Norfolk SMR no. 20476). There is one record of a fourth-century coin from Sheringham, and other fourth-century coins are reported from Runton Gap, Eccles, and Caister-on-Sea.

A context for Caister is provided by the mid to late Roman fortified site now situated within 1km of the shore. Extensive excavations were carried out in the 1960s; the additional find of a complete pottery vessel in the intertidal zone is not surprising, but draws attention to our ignorance of the wider context of the site and the possibility of extramural settlement and cemeteries. A similar situation prevails with the coastal aspect of the Roman fort at Brancaster (Branodunum), where post-Roman shoreline movement has created a barrier between the fort and the sea. Pottery (BB2) has been reported from a channel leading to Brancaster Harbour (Norfolk SMR no. 14058). Other evidence of settlement, but without a broader context, is recorded from Winterton Ness, where pre-Flavian pottery, briquetage, and animal bone were found eroding from an old land surface (Clarke 1939, 103). Elsewhere, reported finds consist of small collections of sherds (Sea Palling) (Norfolk SMR nos 8360 and 8361), or single finds of sherds (Thornham and Holkham SMR nos 15343 and 11468).

A similar pattern of evidence prevails in Suffolk, with the emphasis on stray finds of coins and pottery. A major collection of Iron Age coins, including a gold stater, Icenian silver, and some bronze, has been reported from the beach south of Lowestoft at Covehithe, with an isolated Icenian silver from Benacre Beach just to the north. This is also the location where two Roman 'wells' were reported exposed in the cliff face in the late nineteenth century. These contained large quantities of Roman pottery and animal bone, as well as wood from the lower sections (Fox 1911, 303–4). No context is known, however, for the large quantities of late Roman coins reported from the shore between Aldeburgh and Orford.

Other reports of 'wells' exposed in the cliff face have been made from Easton Bavents and Felixstowe, where there is evidence of a first- to fourth-century settlement (Grubbe 1891, 305). The latter is also the location of the Roman fort at Walton Castle, now completely lost to the sea (above, 6.4.3). Part of the fort is shown surviving on the cliff edge in 1613, but by 1766 the remaining masonry is depicted as lying on the beach (Fox 1911, 303–4) (Figs 97–8). No survey has been made of what remains of this site, now more than 200m out to sea, but evidence of a probable extramural cemetery has emerged from the cliff, where two inhumations with grave goods (bronze armlets) have been reported.

Other substantial Roman structures have been reported from the cliffs north of Lowestoft at Dinah's Gap, Caister, and Corton. At Dinah's Gap, the remains of walling were reported, along with coins and midden debris; at Corton, where fourth-century coins have also been recorded, the timber and masonry foundations of a structure 25 yards square were found (Morris 1949, 100). Interpretation of these buildings must remain uncertain, although it has been suggested that they were signal stations. To the south, at Dunwich, a few recent finds of Roman material from excavated contexts can be set alongside a series of chance finds of coins, metalwork, and pottery from the beach in the eighteenth and nineteenth centuries. As suggested above (Chapter 6), this may be the site of Sitomagus (Fox 1911, 304).

The estuaries of the Blyth, the Alde, and, probably, the Stour have produced evidence of salt-making. In the case of the Alde this originates in the Iron Age, and the same may be true of the other rivers (Suffolk SMR no. 02412 and 02569). In addition to probable salt-making debris, Stutton on the Stour has produced a hoard of second- and third-century *sestertii* (Scott 1984, 18, Suffolk SMR no. 09776).

The incidence of salt-making sites increases dramatically along the heavily indented Essex coastline and up the tidal estuaries, with a concentration of some 300 find sites (the Essex Red Hills) between the river Colne and Canvey Island (Fawn *et al* 1990, 6) (Fig 99). The majority of these sites appear to date from the period between the mid first century BC and the later first century AD, but with some evidence of continuity into the second/early third century AD. Although the presence of settling and evaporation tanks indicates the proximity of tidal waters, the precise relationship between the location of the Red Hills sites and the contemporaneous shoreline is unclear. The distribution pattern suggests that estuarine locations were favoured, and the discovery of sites on the Dengie peninsula up to 5km inland of the present coastline indicates the complexities of establishing the configuration of estuaries and shoreline in the late Iron Age/early Roman period (Fawn *et al* 1990, 5). Although there is a recent survey of this evidence (ibid), the sites on the modern coastline are being destroyed by erosion, while some of those located on reclaimed farmland are being damaged by the plough or threatened by development (RCHME 1994a). There is a case for their active management and, if necessary, for renewed excavation.

Although the evidence of salt-making is easy to recognise in this period, that of associated settlements has been harder to discover and no modern excavation of such a site has taken place (Fig 100). The potential for the discovery of settlements in the intertidal zone is signalled by finds from Canvey Island. Twenty-seven complete pottery vessels of first- to early third-century date were recovered from Canvey Point in 1925, and further material of early Roman date has been found subsequently (Faulkner 1994, 7). Evidence of domestic occupation including pottery of first- to fourth-century date in association with salt-making debris is also reported on the eastern side of Canvey Island at Leigh Beck. Fieldwork carried out between 1937 and

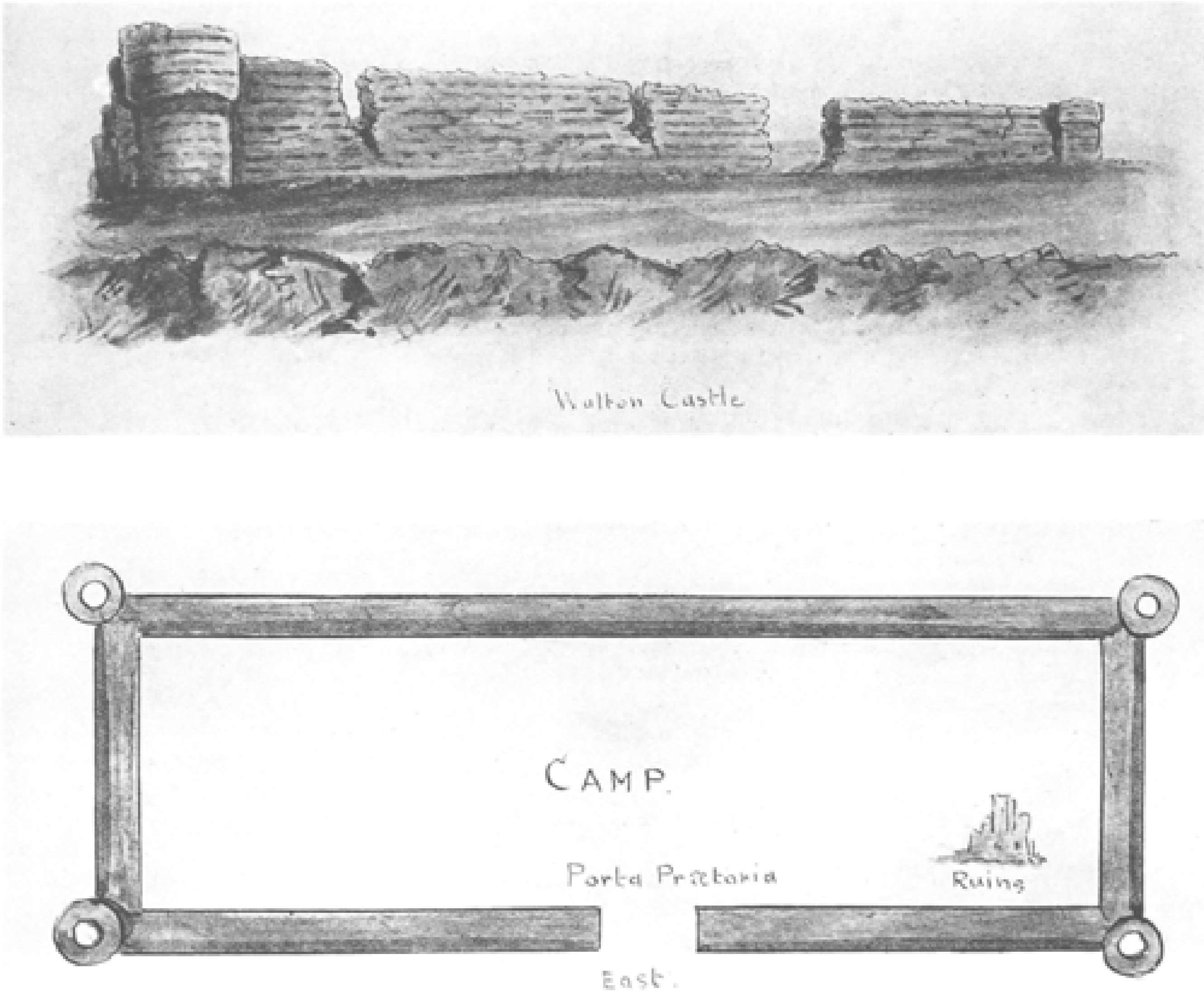


Fig 97 Walton Castle, Suffolk: ground plan and ruins (from a drawing made in 1623) (VCH Suffolk I *(1911), 288–89)*

Fig 98 Walton Castle, Suffolk: ruins (from a drawing made in 1700) (VCH Suffolk I *(1911), 288–89)*

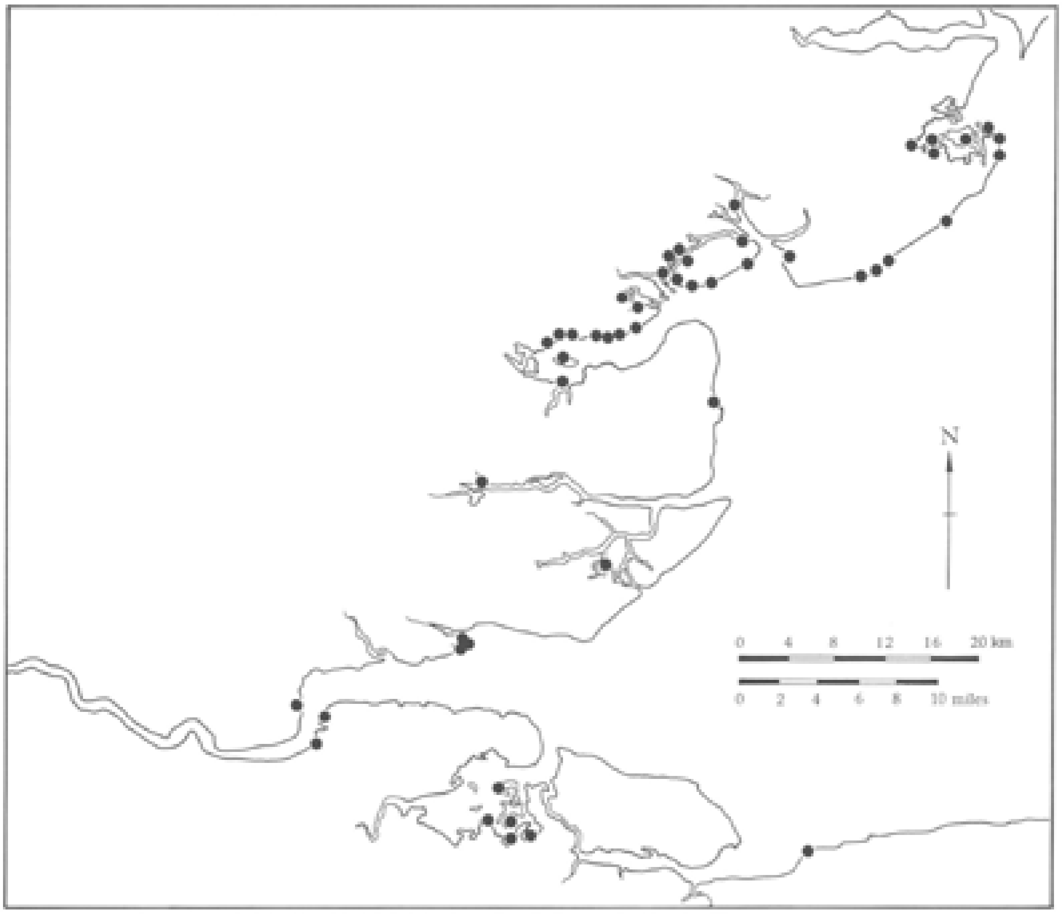


Fig 99 Distribution of salt-making sites in Essex and north Kent

1941 at this site has been followed up by excavation of Red Hill deposits in 1993 (Faulkner 1994). Midden deposits at Leigh Beck were sampled as part of the Hullbridge Project and produced abundant remains of fish and shellfish. This important environmental information indicates the potential for further investigation and characterisation of the exploitation of marine resources on the Essex coast (Wilkinson and Murphy 1995).

Attention has already been drawn in Chapter 6 to the importance of the late Roman fort at Bradwell-on-Sea (Fig 101) and to our ignorance of the setting of the late Roman shore forts in general. Recent work at Bradwell as part of the Hullbridge Project has provided valuable new information about the environs of the fort (Wilkinson and Murphy 1995).

An important aspect of the Leigh Beck site is the evidence of probable continuity into the Anglo-Saxon period, and this also applies to the range of Roman, Anglo-Saxon, and medieval material recovered from the intertidal zone at Thorney Bay (also on Canvey Island), where salt-making of late Iron Age/early Roman date is again in evidence (Thompson 1982, 677; Rodwell 1976b, 265). Information is lacking on the context of this probable domestic material, as with the Roman and medieval pottery recovered from Benfleet Creek during the construction of a bridge in 1971 (Rodwell 1976a, 259).

7.5 The upper Thames Estuary

7.5.1 Roman

The evidence for salt-making westwards of Canvey Island (Essex) in the late Iron Age and Roman period is non-existent (as is the case with the upper estuary of the Severn), but evidence for general settlement is substantial (Fig 100). A considerable quantity of occupation material was recovered in the late nineteenth century during the construction of both the Albert Dock at Plaistow and East Ham and the Tilbury Docks, at depths of between two and three metres below the present ground surface (Francis 1932, 152; Spurrell 1885, 275). Further finds of Roman burials and pottery have been noted along the foreshore for up to two miles east of Tilbury Fort. More importantly, at East Tilbury three circular wooden huts (internal diameters of 3.5 to 6m) and the remains of a fourth have been reported, and evidence of a possible trackway was also noted (Fig 102). These remains have been dated to the Romano-British period on the basis of their association with pottery of first- and second-century date (RCHME 1923, 39; Francis 1932, 152). Further east, Roman finds are also reported at Stanford-le-Hope (NMR TQ78SW9/417014). No Roman finds have been recorded from the intertidal zone along the comparable stretch of the south bank between Southwark and Gravesend, where a few coins have been noted from the foreshore.

7.6 Kent

7.6.1 Prehistory

Kent, like Essex, is another area of considerable potential, but its archaeology remains too little known. There are a number of finds of Neolithic material from the Kent Marshes and from the coast between Reculver and Whitstable, and there is earlier Neolithic pottery from what seems to have been an old land surface at Minnis Bay on the Isle of Thanet (Macpherson-Grant 1969, 249). Further concentrations of Neolithic artefacts are recorded from the marshes on the southern shore of the Medway. Most of the Bronze Age material is metalwork, and only a limited proportion of this may have been associated with occupation sites. These finds fall into three categories. First, there are discoveries of intact objects, mainly weapons, from the estuaries of the major rivers. These date from the later Bronze Age and may be considered as part of a wider phenomenon, involving the deposition of fine objects in rivers and other watery locations (Bradley 1990, chapter 3). They have no real relevance to the archaeology of the intertidal zone. A second group of finds consists of broken fragments of metal, which would normally be interpreted as hoards. These have a markedly coastal distribution and, like examples in Essex and Sussex, they could result from the production and exchange of bronze artefacts at the edge of the settled landscape (ibid). The evidence for a possible Bronze Age wreck in Dover Harbour, evidenced by a scatter of bronze objects on the sea-bed, emphasises the importance of coastal traffic (Muckelroy 1981). Lastly, there are a few sites where what seem to be metalworking residues have been discovered on the shoreline, together with evidence of contemporary settlement. These appear to have been dry land sites, only later invaded by the sea. Minnis Bay is the best known example (Worsfold 1943), but there may be others on the Isle of Thanet.

7.6.2 Roman

The evidence from the Kent coast can be divided into two. East of Gravesend, the estuaries of the Medway and the Swale, including the Isle of Sheppey, form a coherent area with large expanses of estuarine alluvium and tidal saltmarsh (referred to hereafter as the North Kent Marshes). This can be distinguished from the rest of the largely chalk-dominated north and east coast of Kent.

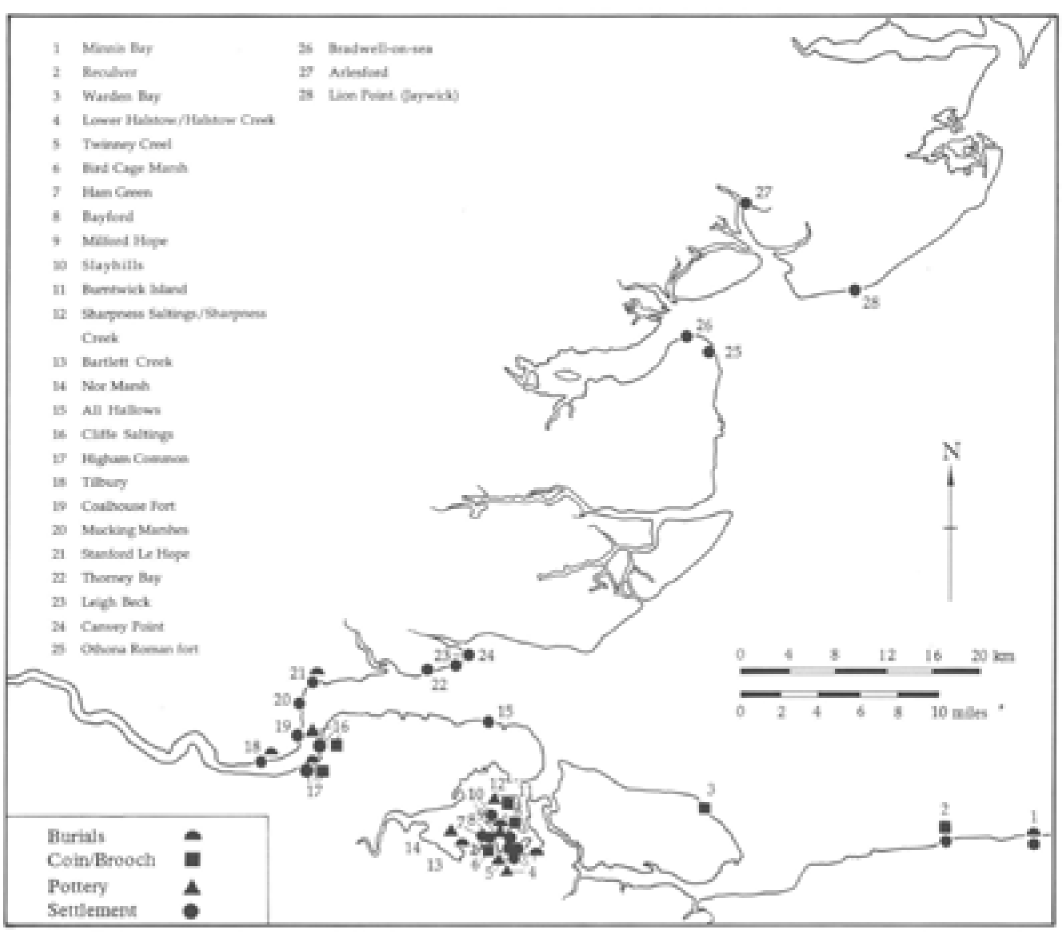


Fig 100 Distribution of Roman sites and finds in the intertidal zone of Essex and north Kent

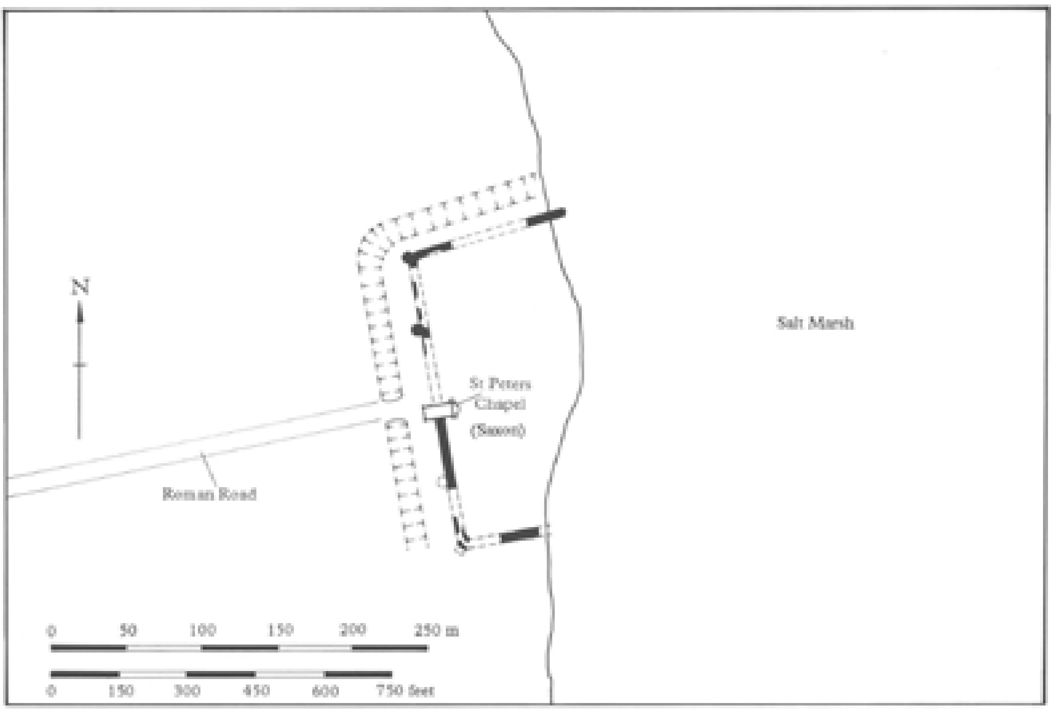


Fig 101 The late Roman fort at Bradwell-on-Sea, Essex

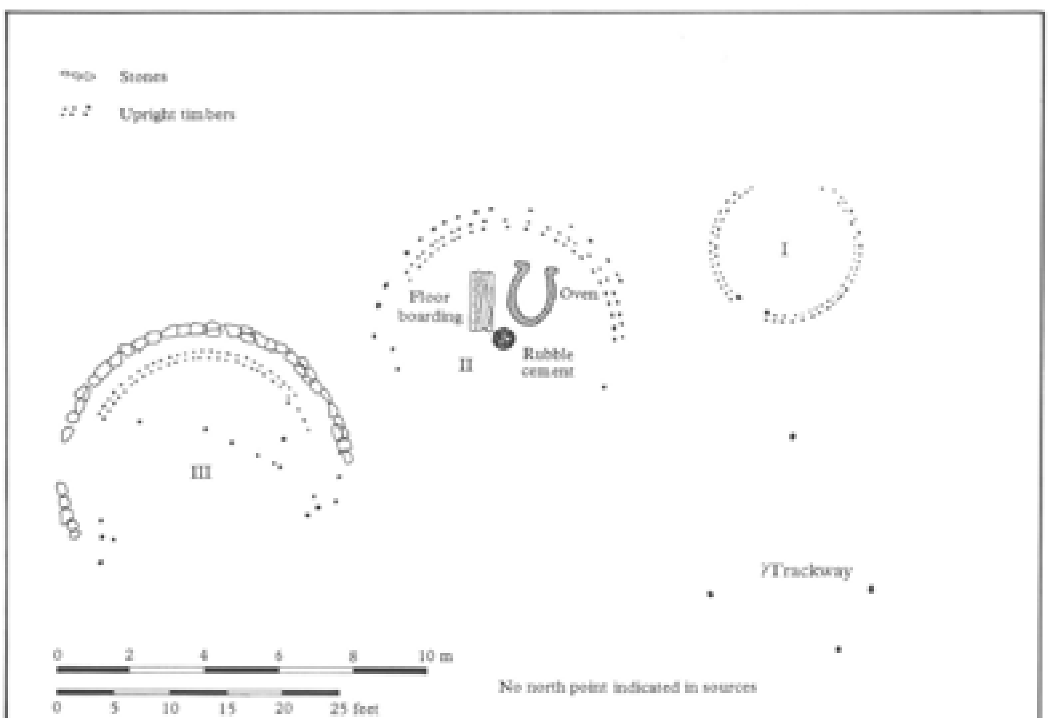


Fig 102 Early Roman circular structures in the intertidal zone at Tilbury, Essex

Unlike the opposite shore of the outer Thames Estuary, where evidence of salt-making alone is conspicuous in the archaeological record, the North Kent Marshes have produced abundant evidence for both salt-making (also attested on Romney Marsh to the south, below) and pottery manufacture, in several instances at the same locations (Figs 99, 103). Although mounds comparable to the Essex Red Hills have not been reported from Kent, the distinctive debris of salt-making is common to both sides of the estuary. Although there has been investigation by fieldwork, very little has been published (Miles 1975). It is important that the available evidence be brought together and compared with the large quantity of material which is now available from the Essex bank of the Thames. There is no certain pre-Roman salt-making from north Kent; the earliest material is of latest Iron Age/earliest Roman date, with evidence of production continuing through the second and into the third century AD. This runs parallel with the date range of pottery production which includes Upchurch Ware and Black-burnished Ware (BB2) (Monaghan 1987). Both, but particularly the latter, were traded up the east coast as far as the Antonine frontier. There is little evidence for the continuation of either industry after the early to mid third century.

Although the emphasis of past work has been on the identification and recovery of evidence relating to salt- and pottery-making, there is a wider range of settlement evidence which serves to distinguish the archaeological record of the North Kent Marshes from that of the Essex coast (Fig 100). Among the earliest datable finds are several Iron Age coins which have mostly come from two locations, Chetney Hill and Burntwick Island. The Roman record includes a notable number of burials, both single and multiple, comprising both human cremations and dog inhumations (Slayhills). This is complemented by other forms of evidence, such as building materials, a range of domestic pottery, and metalwork, particularly coins, for example from Bayford, Ham Green, Lower

Fig 103 Distribution of pottery production sites in England's intertidal zone

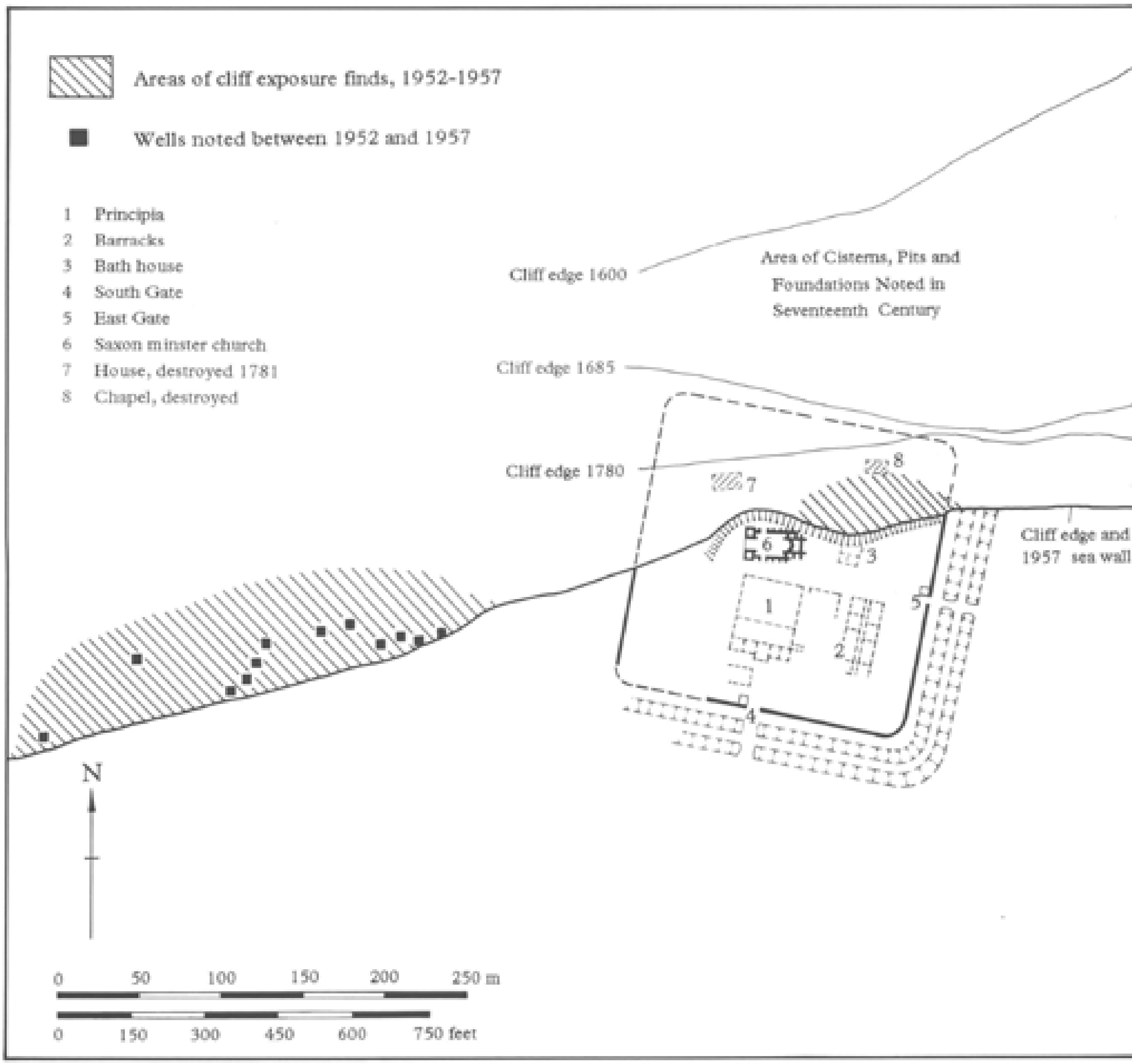


Fig 104 The Roman fort at Reculver, Kent, showing extent of shoreline retreat since c 1600

Halstow, and the Slayhills area. In addition two notable hoards have been recovered: one of about 500 bronze coins of first- to third-century date (Warden Bay, Isle of Sheppey), and a second of jewellery and bronze and silver coins of first- and second-century date (Slayhills). A number of first- to third-century coins, but not necessarily from a hoard, have also been recovered from Burntwick Island. With the exception of a possible Christian artefact from the latter site, and a 'probable *follis* of Diocletian', there are no certain fourth-century finds from the marshes. In conclusion, it cannot be emphasised too strongly that there has been no systematic attempt to understand the range of industrial sites from the North Kent Marshes in their settlement context, and very little publication. It is important that fresh work is initiated.

No other stretch of the Kent coastline rivals the North Kent Marshes for the richness of its archaeological record, but there are a number of other important, but ill-understood sites, particularly along the rest of the north coast, which has clearly been subject to considerable erosion. About half of the Roman fort at Reculver has been lost to the sea, and a number of pits and probable wells have been recorded in the intertidal zone, or in the eroding cliff face (Philp 1957) (Fig 104). Although the majority are of second- to early third-century date, some remained open into the fourth century, and a stamped silver ingot (EXOFFI ISATIS) is of this date (RIB 2402.8). The importance of this site is not, however, necessarily confined to the fort; finds of earlier date include some six Iron Age gold coins. Further eastwards at Minnis Bay, better known for its evidence of prehistoric settlement (see above, Chapter 6), finds of Roman pottery suggest continuation of occupation into the fourth century, and at least one fourth-century inhumation has been reported slightly to the west of the main concentration of finds. The same longevity of occupation may also be true of the St Mildred's Bay site, where 'Belgic' and Romano-British pottery have been reported. Other finds of late Iron Age pottery at Westgate (Fisher 1938, 147), and of a possible, but not securely dated, late Iron Age/Roman chalk quarry at Birchington on Thanet point to the potential of the north Kent coast.

Much less evidence has been recorded from the Channel coasts of Kent, where finds have mainly eroded from the cliffs; an example of this is the collection of building material and other objects from Pegwell Bay. One important discovery has been a quern production site exploiting the local Folkestone Beds Sandstone at East Wear Bay, Folkestone, where over 60 examples have been collected from the foreshore (Keller 1988, 59). Although limited excavation of a context with manufacturing debris produced only first century AD pottery, the association of some 20 querns with the site of the Roman villa excavated in 1924–5 suggests a longer period of production. Salt-making is inferred at Dymchurch on Romney Marsh from finds made in the mid nineteenth century during construction of the sea-wall (Ward 1922, 207). These included an extensive range of Roman finds among which were quantities of probable briquetage, as well as pottery, a range of stone artefacts, metalwork, glass, and animal and human bones. More recent investigations have failed to relocate this site.

7.7 The south coast: Romney Marsh to Selsey Bill

7.7.1 Prehistory

In contrast to Kent, we know very little about the archaeology of this stretch of coastline. There are the usual reports of submerged forests (Osborne White 1928), in this case between Hooe Level and Rye, and there is a single radiocarbon date from one such deposit near Hastings which suggests a context in the earlier Neolithic period. There is also a vague report of an antler artefact and several bronze implements from a similar deposit at Little Galley Hill (ibid, 79).

Finds of briquetage have been recorded from the Pevensey Levels, and from settlement sites close to the shoreline at Bishopstone and Shoreham, but so far there has been no evidence of *in situ* salt-production sites (Bradley 1992).

The only distinctive feature of this area is the large number of bronze hoards revealed by coastal erosion, either in cliff falls or within the intertidal zone. Virtually nothing is known about their original contexts, but compared with finds from other areas they occur so often that any new discoveries should be investigated systematically.

Otherwise the main characteristic of this particular length of coastline is the large number of prehistoric sites being destroyed by cliff falls. This is a problem which has mainly affected Iron Age occupation sites, including several hillforts in East Sussex and open settlements on Selsey Bill.

7.7.2 Roman

Very few finds are recorded from the intertidal zone between Romney Marsh and Selsey Bill, and most of these are coins. Iron Age gold staters have been reported from the beaches at Cliff End, Fairlight, Hastings, Eastbourne, and Brighton, and a multiple find of silver coins has been recorded from Pevensey (Rudling 1984, 217; Haselgrove 1987, 306–10). The Hastings coins were found in the nineteenth century. At Eastbourne and Hastings there have also been complementary finds of Roman date: amphora sherds from the former, and coins, including a gold *solidus* of Theodosius, from the latter (Eddison and Green 1988, 178). A further Roman find, a gold medallion of Antonia, was reported from the beach at Seaford.

Selsey Bill is subject to considerable erosion and has been a rich source of finds, particularly high-value coins of Iron Age date. For this reason in particular, it has been proposed as the nucleus of a major late Iron Age *oppidum* (Aldsworth 1987, 41–3). The coins include a possible hoard of 31 British, Gallo-Belgic, and other continental issues from Bognor beach at the northern end of the promontory, and some 255 Gallo-Belgic and British coins from the beach close to Medmerry Farm (Haselgrove 1987, 291–95). Iron Age pottery was also found at the latter. Six Iron Age 'floors' are recorded from the southern end of Selsey Bill, and a further four were reported as destroyed in 1945. Other finds, including a small hoard of some 22 coins reported in 1986, cannot be closely located.

These Iron Age finds can be set alongside numerous others of Roman date from Selsey Bill. Pottery is the most abundant artefact from a number of localities, of which at least four have produced concentrations of material in midden-like contexts. Coin finds on the other hand are comparatively rare and are almost entirely of first- to third-century date. One cremation burial is recorded, but the only recorded structure is a drystone well, which is reported to be of Roman date (NMR no. SZ89SE29/462428). The report by divers of a 'quarry' at the Mixon shoal, some 1.25 miles south of the lifeboat station and well beyond the intertidal zone (NMR no. SZ89SE14/462386), is of considerable significance for the possible extent of erosion of the Bill since the Roman period. Although this reef might have been exploited intertidally, further investigation is needed to determine its nature.

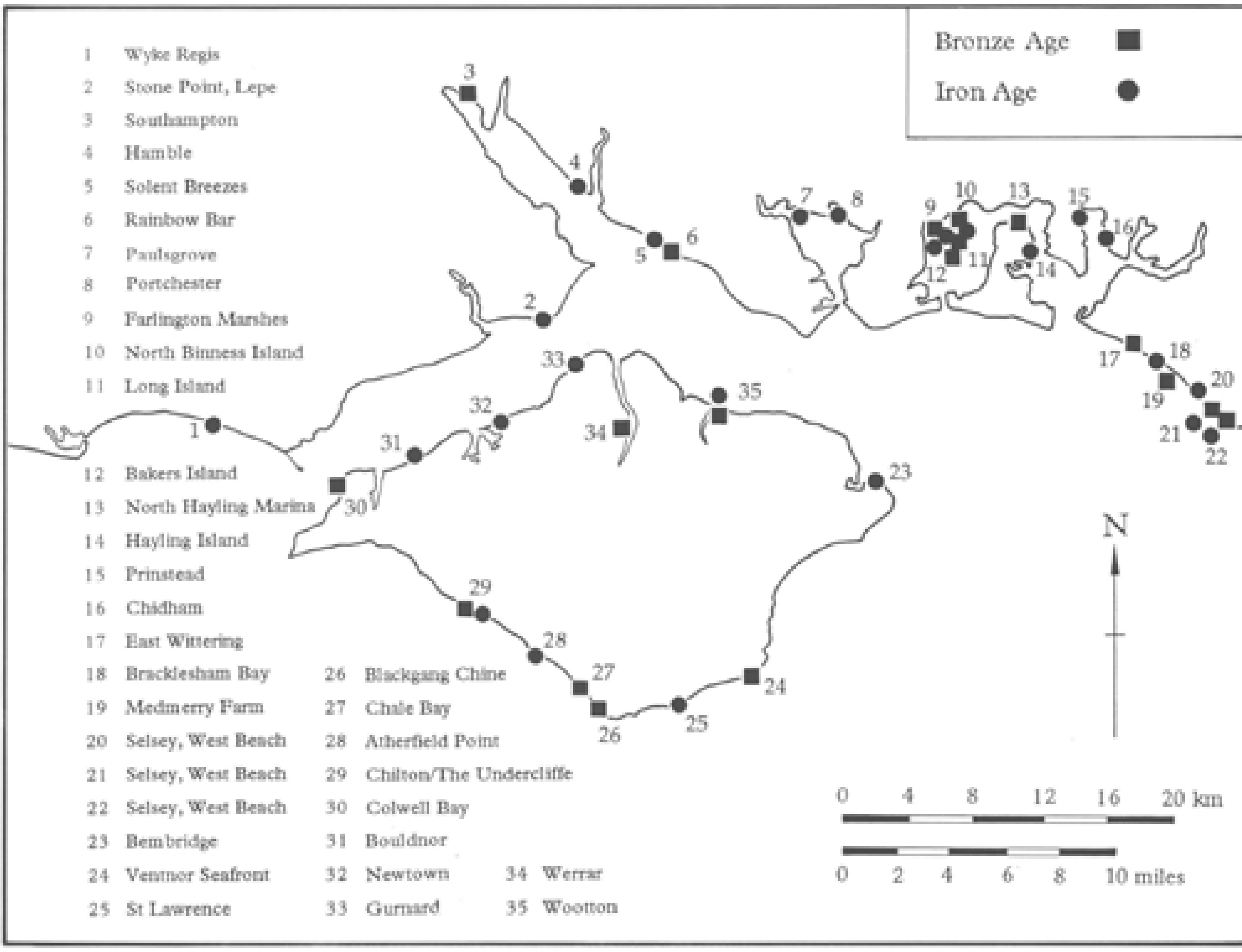


Fig 105 The distribution of Bronze Age and Iron Age sites and finds in the intertidal zone of the Solent (Hampshire and the Isle of Wight)

7.8 The Solent

7.8.1 Prehistory

By comparison with Kent and Sussex, this area has been quite well served. The harbours on the Hampshire/Sussex border have been examined by field survey since the 1960s (Draper 1968; Bradley and Hooper 1975; Cartwright 1984) and at present the archaeology of Langstone Harbour is being investigated in greater detail (Allen, M *et al* 1993). The same applies to the intertidal zone on the northern shore of the Isle of Wight, where the Wootton Quarr intertidal survey has produced important results of all periods (above, Chapter 5) (Fig 105).

This research, particularly in Hampshire and West Sussex, has revealed a large amount of worked and burnt flint. Although at one time it appeared that a substantial proportion of this material was Neolithic (Bradley and Hooper 1975), it now seems that much of it belongs to the Middle and Late Bronze Ages and may have been associated with areas of settlement which were originally situated on dry land (Allen, M *et al* 1993). However, lithic scatters of latest Mesolithic/earliest Neolithic date and characterised by finds of flint picks have been recorded from Wootton Quarr. Here, too, have been found the only certain Neolithic timber structures: five trackways of a lateral corduroy of rods or wands and occasional vertical pegs, two brushwood trackways with occasional anchoring pegs, one of which was radiocarbon dated to 3040–2629 cal BC (GU-5340; 4270±70 BP), and three further trackway or platform sites. Two other trackways have been found at Newtown on the north-west coast of the island. A number of small rectangular post-settings for fish traps, each 1–1.5 by 2–3m, located around the present intertidal mouths of the Quarr and Binstead streams may be attributed to the early Bronze Age (Tomalin 1995) (Figs 36, 106). Otherwise, earlier claims for extensive occupation during this period must be viewed with caution. This revision would account for the rarity of Neolithic pottery and for the large number of later Bronze Age sherds and metal finds in the intertidal zone. It probably forms part of a much wider pattern of settlement extending across the coastal plain. Later Bronze Age flint industries usually contain a high proportion of scrapers. With the recognition of these assemblages, it is no longer necessary to postulate a specialised pattern of activity in this area. Wooden structures of Late Bronze Age date have been recorded in the course of the Wootton Quarr survey. A group of five of these, comprising long, symmetrical settings of upright posts some 2m apart and ranged over a length of 3–5m, were recorded clustered together at Binstead Hard (Tomalin 1995) (Figs 36, 106).

The other major feature of this region is the identification of some 30 sites with evidence of briquetage (Bradley 1975; 1992) (Fig 107). Their chronology extends from the Middle Iron Age to the mid first century AD, but in most cases this material is found scattered over the modern beach. At Chidham in Chichester Harbour, however, two sites were excavated before their destruction by coastal erosion, and these produced the badly damaged remains of a settling tank and a possible reservoir, as well as traces of flues and a hearth (Figs 108–9). A rather similar flue has been excavated on the cliff near to Titchfield Haven (Hughes 1973), and there is another Iron Age saltern at Hook on the shore of Southampton Water (Fox 1937). On the Isle of Wight evidence of salt-making is recorded from Newtown and Wootton Quarr.

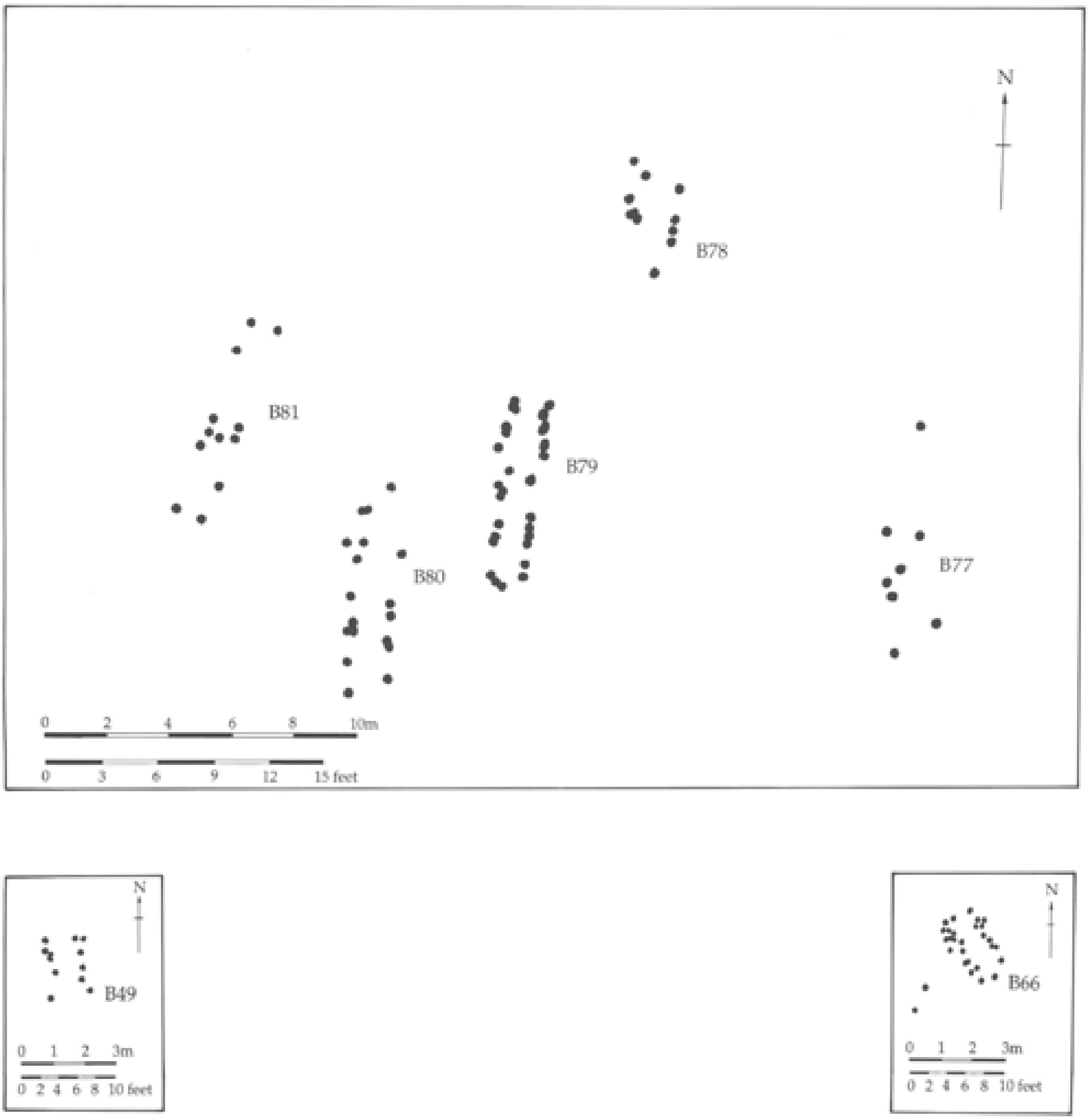


Fig 106 Wootton Quarr, Isle of Wight: wooden structures of early Bronze Age (B 49, B 66) and of late Bronze Age date (B 77–81)

Fig 107 The distribution of late Iron Age and Roman salt-making sites in the Solent (West Sussex, Hampshire, and the Isle of Wight)

7.8.2 Roman

Comparatively few finds or sites of late Iron Age and Roman date have been reported from the Solent (Fig 110), although several major sites lie close to the shore. In particular we should draw attention to the following: the *civitas* capital at Chichester, close to the head of one of the tidal creeks which forms part of Chichester harbour; the late Roman fort at Portchester at the head of Portsmouth Harbour to the west; and the late Roman fort, or walled town, at Bitterne, at the head of Southampton Water. Close to Chichester lies the Roman palace at Fishbourne, right at the head of a navigable creek. Although this site is interpreted as originating in a Claudian supply base, little, apart from likely location, is known of the associated wharf facilities which probably also served the later buildings, enabling construction materials to be delivered straight to the site. Equally, nothing is known of any wharf facilities associated with either Portchester or Bitterne. However, the possibility of locating relatively minor landing sites ('port of trade activities') is suggested by the discovery of pottery scatters of first- to fourth-century date with a high ratio of non-local wares, in the intertidal zone at Fishbourne, Isle of Wight (Tomalin *et al* 1994, 23–4). This material is interpreted thus, rather than as settlement debris, despite the presence of other finds including coins, worked bone, leatherwork, basketry, and ropework. The theoretical and methodological issues which might allow us to distinguish between an interpretation which emphasises trading, rather than other settlement aspects, remain to be addressed.

The remains of one other broadly classifiable building type, a villa, have been identified eroding from a cliff-top site into the intertidal zone at Gurnard, Isle of Wight (SMR nos. 20339, 20338) (Fig 111). Apart from a wide range of finds and building materials, a double-post alignment was recorded in the nineteenth century as extending some '140 yards in a north westerly direction from the beach' (Motkin 1991). Whether this structure survives, and whether it is of Roman date, remains to be determined (Motkin 1991, 425). Potentially, it offers the possibility of gaining some insight into the relationship between a villa and the marine environment. A complex but poorly understood timber and brushwood structure of Roman date has also been recorded in the course of the Wootton Quarr survey (Tomalin *et al* 1994, 24). The remains of settlement sites of late Iron Age and Roman date have been destroyed by erosion of the cliff face around the south coast of the island (Basford 1980, 29).

In addition to salt-making, discussed in 7.8.1, above, the Wootton Quarr survey has produced evidence of stone-quarrying in the intertidal zone. Quarr is the location of outcrops of Bembridge Limestone, which was used for building both on the island and on the mainland, and its use is best known at the Flavian palace of Fishbourne and the late Roman fort at Portchester. Quarries are evident just inland at Quarr and Binstead (Westmore *et al* 1994, 140), but possible evidence of exploitation in the present (and past) intertidal zone remains to be explored. A discrete strew of first- and second-century pottery was recorded close to an outcrop of Bembridge Limestone offshore at Binstead (Westmore *et al* 1994, 141). Extensive outcrops in a similar intertidal location remain to be investigated at St Helens and Bembridge itself. The third type of industry represented in the intertidal zone in the Solent is tile-making at Dell Quay on Chichester Harbour, close to the Fishbourne palace site (SMR no. 0626).

Although few finds have been made along the northern shores of the Solent and its associated inlets, a number of discoveries from the Isle of Wight demonstrate the potential of the area. Iron Age and Roman

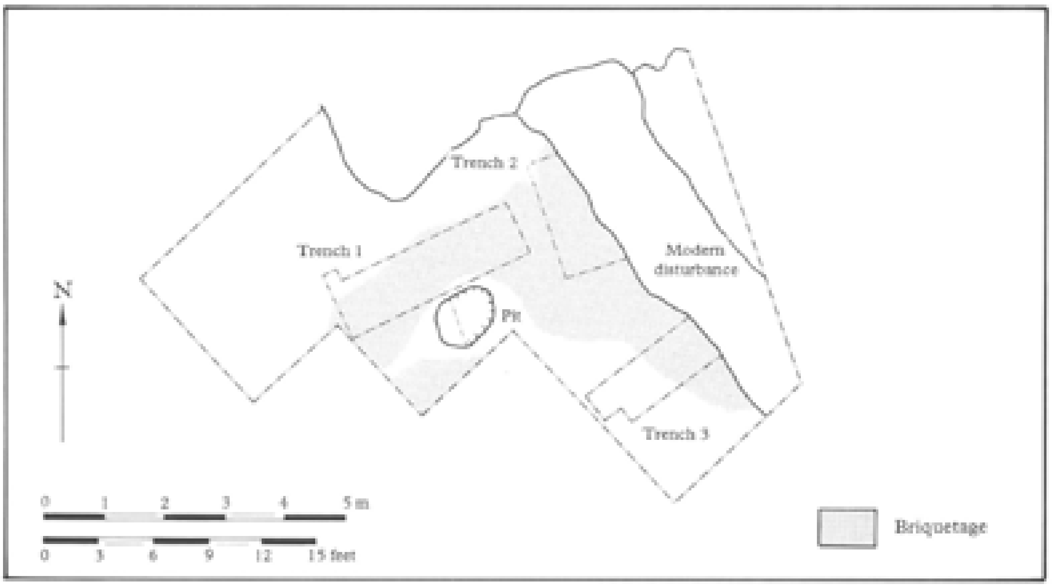


Fig 108 Late Iron Age and early Roman salt-making site at Chidham, West Sussex, Site A

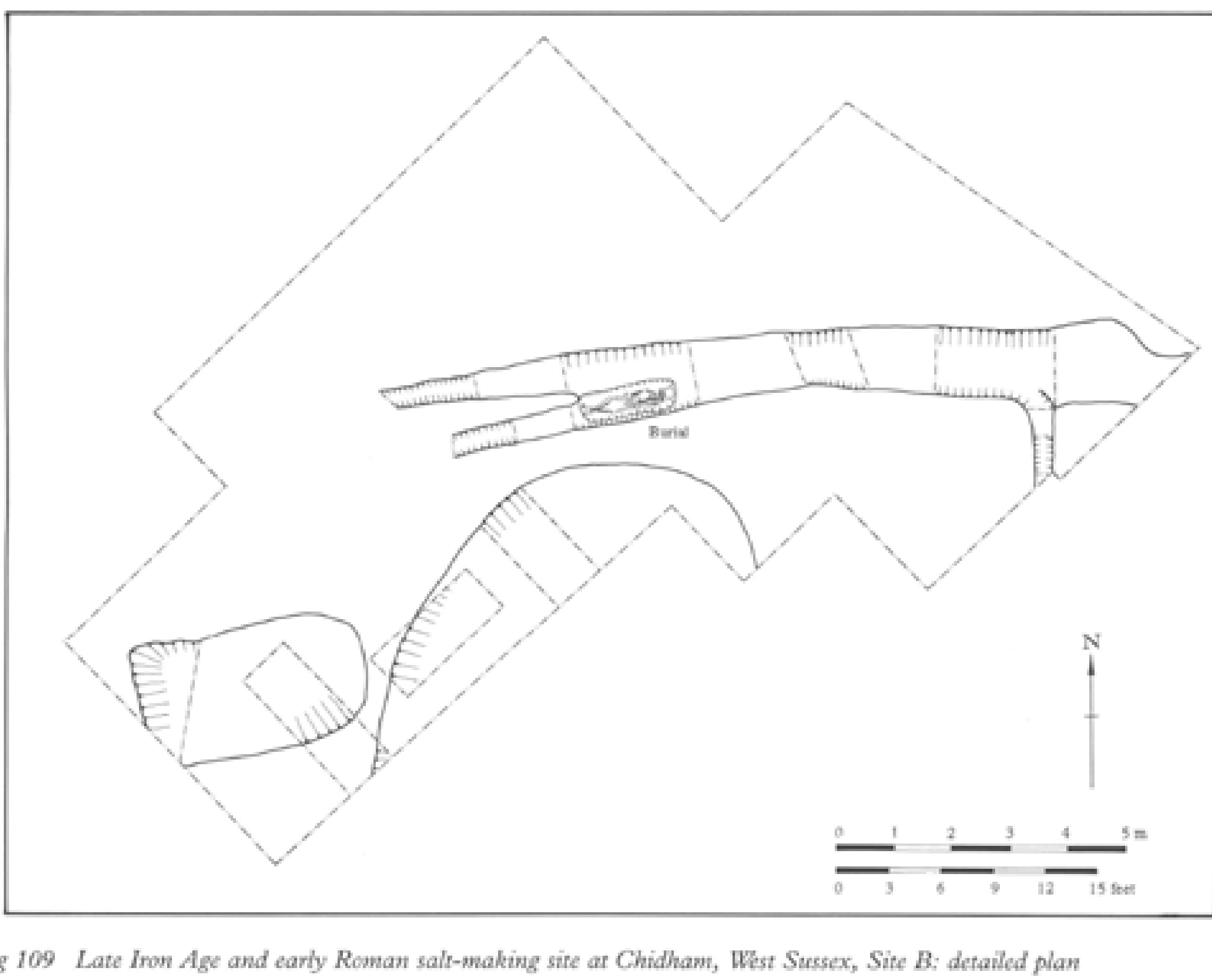


Fig 109 Late Iron Age and early Roman salt-making site at Chidham, West Sussex, Site B: detailed plan

coin finds have been made on the north-west shore at Newtown, including a hoard of Greek and Roman coins found in 1845 (SMR no. 20303); at Gurnard, where a hoard of counterfeit lead-tin *denarii* of Lucius Verus and the two Faustinas has been recently reported; and at Bembridge to the east, where a possible hoard of late first- and second-century bronzes is recorded, as well as an Iron Age gold stater (SMR no. 20326). Iron Age and Roman coin finds from the south coast, notably at Chale and St Lawrence, are probably to be associated with the remains of eroding settlements noted above (SMR nos. 20298, 20306).

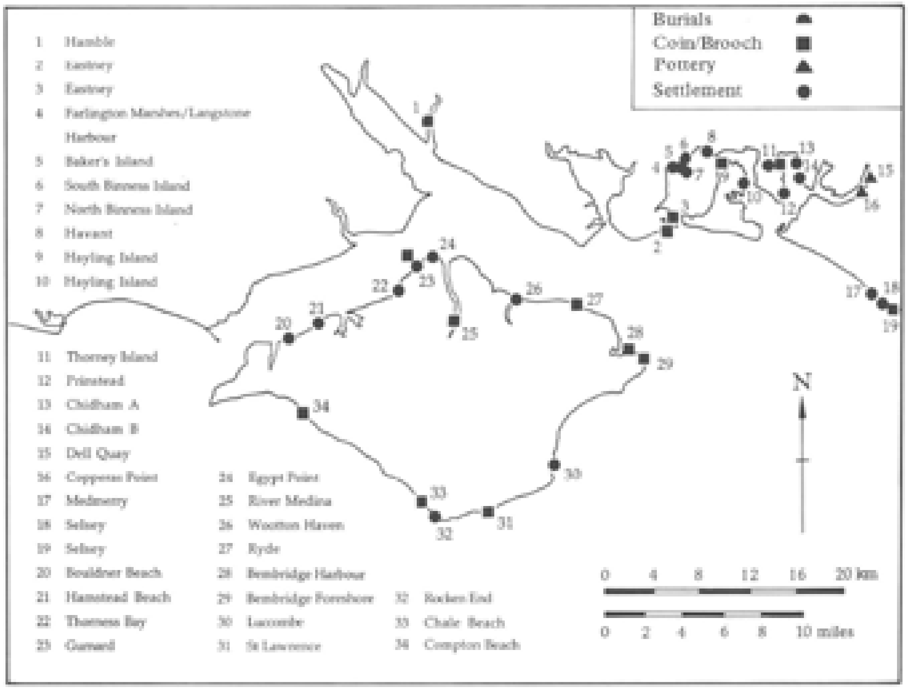


Fig 110 Distribution of Roman sites and finds in the intertidal zone of the Solent (Hampshire and the Isle of Wight)

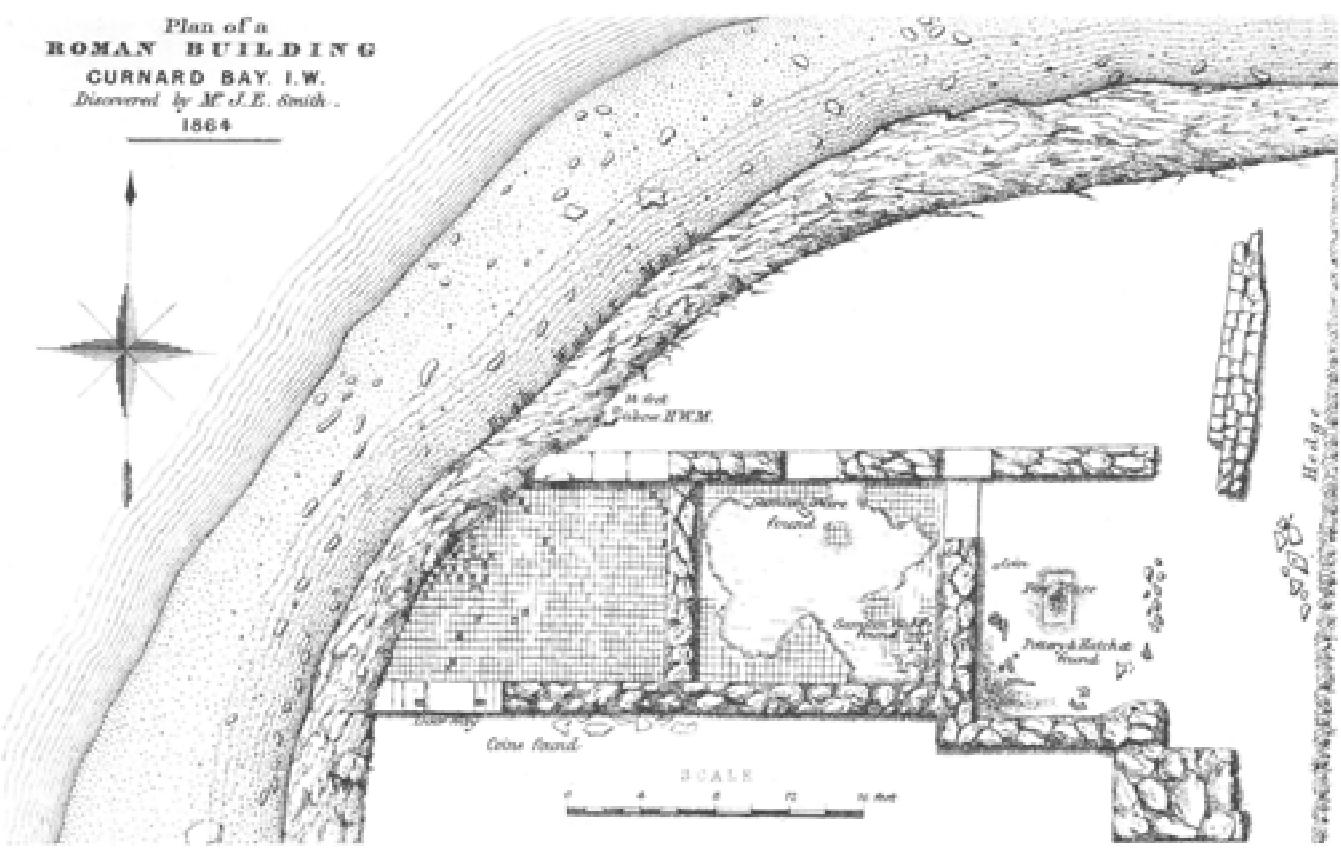


Fig 111 Gurnard Bay, Isle of Wight: plan of a Roman building (JBAA 22 (1866), pl 21)

7.9 The south coast west of the Needles to Land's End

7.9.1 Prehistory

Evidence for Iron Age and Roman salt production in Dorset is similar to that reported in 7.8.1 above, and occurs in several areas of the county, in particular Poole Harbour where large quantities of briquetage have been found on and close to the shoreline (Farrar 1975; Sunter and Woodward 1987). Most of this material is of Late Iron Age and early Roman date and needs to be considered alongside the important material discussed in Chapter 6. There is further evidence for coastal salt production from cliff-top sites in Purbeck, some of them threatened by coastal erosion (ibid), and also from the marshy area inside Chesil Beach, where there is structural evidence for Iron Age ovens (Bailey 1962). In Purbeck it seems as if salt-working took place as part of a wider pattern of activity extending to the production of shale ornaments (Sunter and Woodward 1987, 44–124). There is clearly a need for further research in this field.

There is little evidence from the south of Devon and Cornwall, but this is because so much of the coastline is defined by hard rocks. Here the main threat to the archaeology is occasioned by cliff falls, and the main sites to be affected are the generally undated flint scatters found overlooking the sea, and the coastal promontory forts or cliff castles dated to the Iron Age.

A few sites stand out from this general pattern. There was a Late Bronze Age midden on the northern shore of the isthmus connecting Mountbatten to the mainland (Cunliffe 1988), and there may also have been a metalworking site on Preston Sands in Torbay. This included preserved hearths, tin slag, and a number of posts, but its date is not securely established (Pidgeon 1885)

Lastly, there are reports of submerged forests near Fowey, Looe, Falmouth, and Porthleven, but none of these were found together with artefacts.

7.9.2 Roman

The harbour and settlement at Hengistbury Head were important in cross-channel trade from the late Iron Age, and the peninsula has suffered considerable erosion of its archaeological resource (Cunliffe 1987). However, the most important focus of activity west of the Isle of Wight is Poole Harbour, around whose shores there was a major pottery industry from the late Iron Age to the late Roman period. As with north Kent, salt-making appears to have been an important parallel industry although as yet there is comparatively little evidence for it (7.9.1). The working of Kimmeridge Shale to make a range of bracelets, armlets, and other artefacts was also carried out at a number of sites (Cox 1988). These activities form part of a wider range of industries on the Isle of Purbeck, of which the extraction of stone and Purbeck 'marble' is well known (Sunter and Woodward 1987; above, 7.9.1). Extraction, however, is not recorded as part of the archaeology of the intertidal zone. Among the settlements which border the harbour, special mention must be made of Hamworthy, which seems to have served as a landing place or port from the earliest years of the Roman conquest (Smith 1958). The importance of the site is demonstrated by the Roman road whose course from Badbury Rings is focused on the settlement.

West of Poole Harbour, the only significant settlement on the south coast was the legionary fortress and later town at Exeter. This may have been served by a port at Topsham at the confluence of the rivers Clyst and Exe where significant finds of first- to fourth-century date have been made (NMR no. SX98NE10/447819). Otherwise the significance of finds in the intertidal zone has to be assessed on their merits; there are no terrestrial sites to provide a context. A number of coins of first- to fourth-century date, as well as other finds, occur at Sidmouth, some possibly originating from the reuse of the Early Iron Age hillfort at High Peak (Taylor 1944, 22–3). Further to the south-west, the hillfort at Berry Head on the south side of Tor Bay provides a certain context for a large number of Roman coins (NMR no. SX95NW10/447506). Three pewter flagons were found in Tor Bay in the nineteenth century, at Goodrington Sands, Paignton (SMR no. 021), and a range of coins of first- to third-century date has been reported from Torquay itself (NMR no. SX96SW5/447596). Close to Plymouth a number of Roman coins have been found in Heybrook Bay, Wembury (NMR no. SX44NE). These, like the pewter from Paignton, may have originated from hoards or shipwrecks. A similar explanation may account for a group of radiate coins recorded from Whitsand Bay to the west of the Tamar in Cornwall.

7.10 The Isles of Scilly

7.10.1 Prehistory

The Isles of Scilly are perhaps the best example anywhere in Britain of an area whose archaeology bears the mark of a rising sea-level, and this area has been well researched. There are detailed surveys of the field systems which extend across the intertidal zone and into open water, there have been a number of important and productive excavations of settlements whose remains are threatened by coastal erosion, and there is now a concerted programme of monitoring the effects of damage to these sites (Ratcliffe and Sharpe 1991). The existing information about both sea-levels and changing settlement patterns in the Scilly Isles has been synthesised in a book with the evocative title *Explorations of a drowned landscape* (Thomas 1985).

Fig 112 Crab's Ledge, Tresco, Isles of Scilly: example of a prehistoric boulder wall (© Cornwall Archaeological Unit)

The available information is plentiful and, thanks to Thomas's careful study, relatively well known today. But certain problems remain and these should influence any additional measures that are taken to manage and interpret the coastal archaeology of this area. There are two major problems, and these arise because it is so difficult to articulate the surface finds from the shoreline with the structural remains of settlements and fields which extend inland from the coast. The problem with the portable artefacts is that they are so poorly dated. Although it is tempting to emphasise the high numbers of flint scrapers from the Scilly Isles, these may simply be multi-purpose tools made from small pieces of raw material. Their resemblance to dated industries in other parts of the country may be quite fortuitous. The second problem is also chronological. At present most attention has been devoted to planning the remarkable series of field walls on the islands, but their dating is very uncertain and may never be resolved if research is confined to the most damaged fractions in the intertidal zone (Figs 112–4). At one extreme there have been claims that these were integrally linked to megalithic tombs; at the opposite end of the sequence they seem to be closely bound into the pattern of later Bronze Age, Iron Age and Roman settlement. If their interpretation is to be refined, it may be necessary to work on the well preserved sections found on dry land.

A further characteristic of the Isles of Scilly is the prospect of relating the archaeological remains to well dated layers of peat. In time these should provide vital evidence of the chronology and character of settlement, but that work is still in progress (Ratcliffe 1993; above, Chapter 4). When it is brought to a successful conclusion it could provide a model for similar studies in other regions.

7.10.2 Roman

Coastal erosion has been the most important agent in revealing evidence of Roman-period occupation of the islands. Cist burials are the most commonly recognised category of evidence. The most important discoveries have been made on Nornour in the Eastern Isles where subsequent excavation revealed evidence of 11 or more circular, stone-built huts among which was found a large assemblage of Roman artefacts (Fig 115). These included a quantity of first- to fourth-century coins and hundreds of bronze objects, particularly brooches of first- and second-century date. The unusual nature of this assemblage has led to its being interpreted as, on the one hand, a votive deposit, and, on the other, the remains of a shipwreck cargo (above, Chapter 6; Fulford 1989) (Figs 116–7).

Fig 113 Par Beach, St Martin's, Isles of Scilly: possible stone row (© Cornwall Archaeological Unit)

Otherwise, evidence of settlement, as opposed to burial, is rare. Erosion has revealed a Romano-British site on the north-west shore of Tean (SMR No. 711.0), with evidence of continuity into the early medieval period (Thomas 1985, 183). The Roman aspect is provided by a limpet midden of first- to fourth-century date which has provided valuable insights into the settlement economy: evidence has been documented of cereal cultivation, stock raising, the exploitation of marine resources such as shellfish and fish, and the hunting of wild animals and birds (Ratcliffe 1993, 64). On St Agnes a prehistoric and Romano-British settlement comprising hut circles and limpet middens has been reported from the cliff at Porth Killier (Ratcliffe and Parkes 1989; Ratcliffe 1993). As noted above in Chapter 4, these midden deposits deserve further investigation for the information that they can provide on the exploitation of marine resources.

Indirect evidence of settlement is provided by the burial record. A second site on the island of Tean is indicated by the discovery of a Porthcressa-type cist, possibly of first-century date, on the south coast (Thomas 1985, 183). Similar types of burial have been noted from Green Bay, Bryher, where Romano-British sherds have also been found intertidally between the latter location and Cliff Fields on Tresco, and from the north coast of St Mary's, where groups, or cemeteries, of Porthcressa-type cist burials have been recorded between Halangy Point and Bar Point. Another cist burial is recorded as eroding from the south coast of St Martin's (Ratcliffe and Parkes 1990, 12).

Fig 114 Porth Cressa, St Mary's, Isles of Scilly: remains of a mid to late Bronze Age hut circle exposed in the cliff face (© Cornwall Archaeological Unit)

Fig 115 Nornour, Eastern Isles, Isles of Scilly: remains of the excavated prehistoric settlement and Romano-British shrine on Nornour looking out over what would have been a cultivated plain when the site was in use, but is now part of the shallow lagoon between Scilly's present islands (© Cornwall Archaeological Unit)

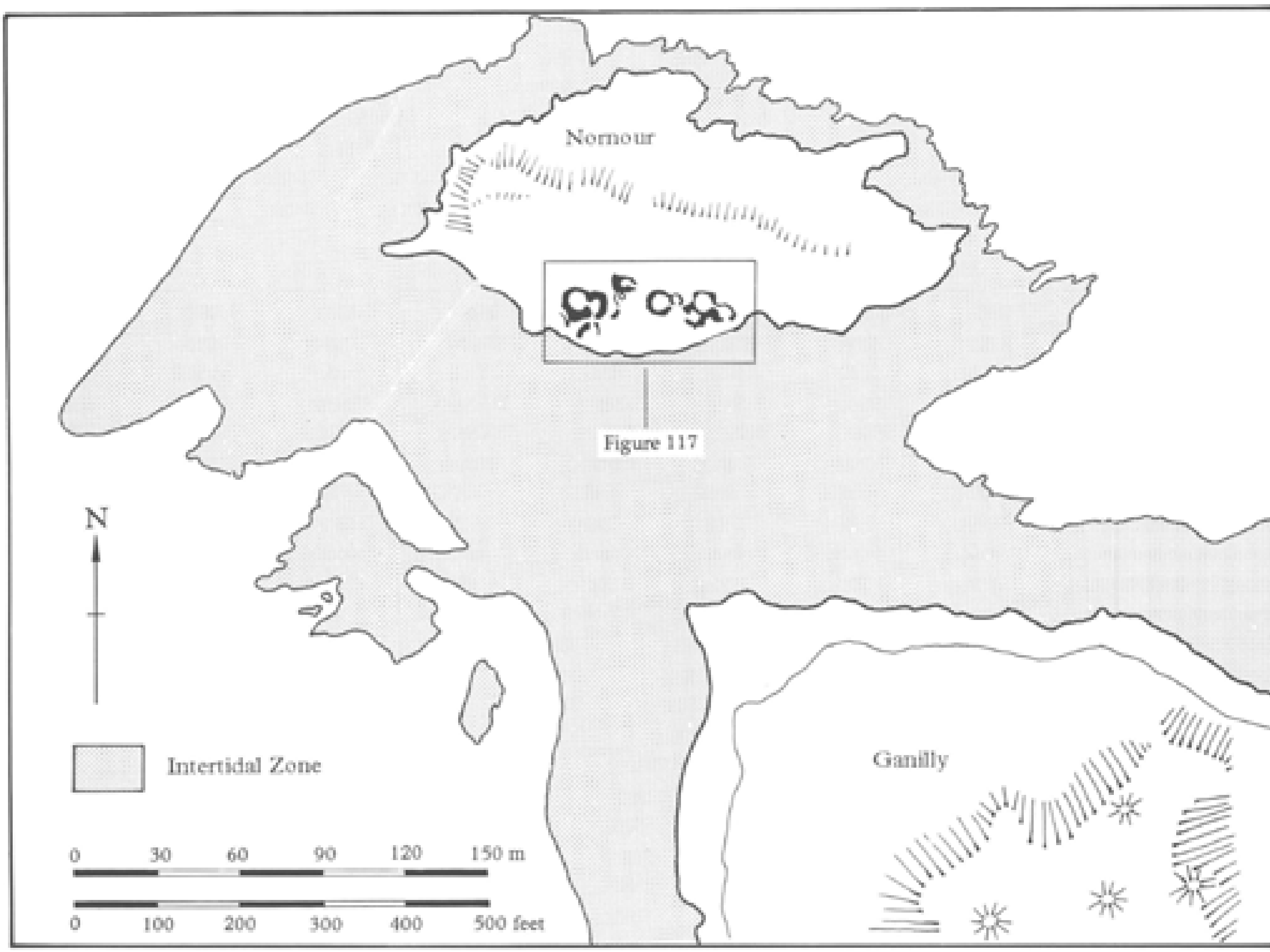


Fig 116 Nornour, Eastern Isles, Isles of Scilly

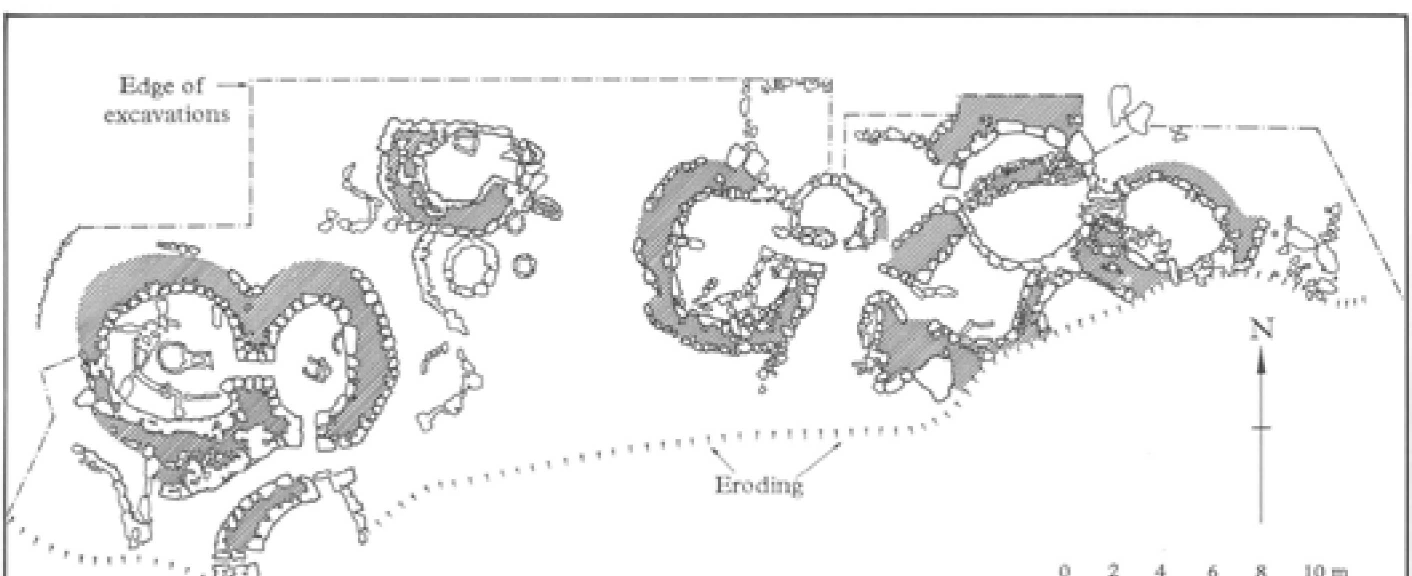


Fig 117 Nornour, Isles of Scilly: plan of prehistoric and Roman structures

7.11 The south-west coast – Land's End to Avonmouth

7.11.1 Prehistory

Very little is known about the prehistory of this enormous area, although there is yet another submerged forest near St Ives (Cornwall) and two more at Porlock (Godwin Austin 1865) and Minehead (Somerset) (Dennison 1985), both of which seem to have been associated with prehistoric flintwork of uncertain age. There are also finds of Neolithic axes from the foreshore at Oldbury (Avon) and Hills Flats (Avon/Gloucestershire) (Allen 1990d), as well as further flint artefacts from the shingle at Blackstone rocks (Avon) (Isles 1982). In 1983 investigation at Westward Ho! revealed three lines of wooden stakes driven into a layer of peat on the foreshore which yielded a radiocarbon date in the earlier Neolithic period (Balaam *et al* 1987b, 183). The potential of this part of the coastline is emphasised by the south bank of the Taw (Rogers 1946, 124) (above, Chapter 4). Otherwise the main evidence that settlements were established close to the sea comes from sites buried in blown sand at Gwithian and Brean Down (Thomas 1958; Bell 1990) (above, Chapter 4). These provide detailed evidence for earlier and later Bronze Age settlement of a quality which is almost unmatched in south-west England. Both sites must have been permanently occupied. There is evidence for salt production at Brean Down and there are indications that other features might have existed in the intertidal zone beneath this site, although it has not been possible to investigate these so far. The inland finds from the Somerset Levels (Coles and Coles 1986) may give some indication of the kinds of structures associated with the use of more marginal environments.

The shortness of this section emphasises the point that too little work has been carried out in this area. The increase in findspots, mainly of later date, resulting from archaeological work associated with the Severn Bridge only reinforces this point.

7.11.2 Roman

Very few finds have been made in the intertidal zone between Land's End and the mouth of the Avon. In Cornwall the most important location of Roman activity is at the mouth of the Camel at Padstow, where numerous finds of pottery, including sigillata, glass, and bronze artefacts were discovered among the dunes in the mid nineteenth century (Trollope 1860). Just to the west, at Trevone Bay, several inhumations in coffins associated with Roman pottery and a bronze fibula were found eroding out of a sandbank on the shore (ibid).

Between the Camel and the Avon, finds of Roman date are rare. Some of the wooden structures at Westward Ho! at the mouth of the Taw–Torridge estuary, possibly to be associated with fishing, have yielded radiocarbon dates of Roman age. The only example of settlement, however, is reported from the Doniford river east of Watchet, Somerset (Wedlake 1955). There, second- to fourth-century coins, pottery, and building materials are recorded as eroding from the cliff face at the mouth of the river. On the tidal reaches of the Avon are the remains of the settlement of Abonae, believed to have been a port linking across the Severn Estuary to the south coast of Wales (Bennett 1985). Little is known about the nature of this settlement, which originated in the Claudian period, least of all of evidence for quays or wharves or any other structure which might survive in the intertidal zone.

7.12 The Severn Estuary: Avonmouth to Gloucester

7.12.1 Prehistory

See previous section.

7.12.2 Roman

Several extensive strews of cultural material have been reported from the upper estuary of the Severn. The resurveying of known sites in the intertidal zone, as well as the re-examination of existing collections of artefacts associated with them, has transformed our understanding of these sites. In addition, recent estuary-wide reconnaissance has provided a geological and sedimentological framework for them, so that for material eroding from alluvial contexts which could have formed over one of a number of periods, it is possible to distinguish between the potentially primary and the secondary contexts into which the material has been transposed. Equally, excavation and survey to landward of intertidal strews have radically improved our understanding of certain sites that were known mostly by their pottery. In addition to the pottery, which dates predominantly from the second to the fourth century, resurvey has identified substantial assemblages of iron-making slag, which, like the pottery, is common to all sites (Allen and Fulford 1987). The finer residues, consistent with forging, have been found in association with certain primary contexts and a smaller number of sites. The ores, where they occur, have proved to derive from the Forest of Dean. Slags apart, only limited numbers of non-ceramic objects have been found from any site. In the case of the settlement at Oldbury Flats, Avon, it was possible to identify one of the sources from which material was being released as a silted palaeochannel, and this led to a more wide-ranging characterisation of the landscape context of the site as a whole (Allen and Fulford 1992). The importance of the drainage streams or pills as potential foci of settlement is also emphasised by the site at Hills Flats (Avon/Glos).

7.13 The north-west: the Dee to the Solway

7.13.1 Prehistory

This final section of the coastline contains three points of interest: further areas of submerged forest whose chronology remains to be resolved, areas of soft silts in the intertidal zone in which human footprints are preserved, and a series of Neolithic and Early Bronze Age occupation sites with occasional evidence of organic preservation. There are also reports of log boats from the coastline of north-west England, but these finds remain undated.

The submerged forests are widely distributed, but lack any clear association with archaeological material (Boyd Dawkins 1884). The principal examples have been noted to the south of the Ribble, on the coast of the Wirral peninsula, and along the shores of the Mersey and the Dee. Those close to Leasowe Lighthouse included trees that may possibly have been felled with an axe (Morton 1891, 237). Further areas of submerged forest were noted at the mouth of the river Alt in Lancashire (Reade 1878), and close to Drigg and St Bees in Cumbria (Kendall 1881). They also occur off the coast between Fleetwood and Blackpool, and at Cardurnock Flats in the Solway (Boyd Dawkins 1884).

Recent survey has shed considerable light on the intertidal zone in Merseyside, where human, animal, and bird footprints, tentatively dated to the Neolithic or Early Bronze Age period, have been identified at Formby. The footprints comprise red deer, roe deer, aurochs, crane, unshod horses, and one canine. To date, 104 human footprint trails have been recorded, of which 75 were sufficiently well defined to enable approximate stature and full gait characteristics to be calculated. Children predominated, followed by adult women, and then men whose trails are often associated with red deer tracks. The occurrence of butchered animal bone in the same stratigraphic horizons supports the suggestion that they were engaged in hunting (Cowell *et al* Roberts 1993; Gonzalez *et al* in press). There also appear to have been circular wooden buildings on the beach at Meols, but their date is uncertain (Cox 1894, 44).

Further to the north there is considerable evidence for earlier prehistoric occupation on the coast. A whole series of settlements, ranging in date from the earlier Neolithic to the Bronze Age, have been discovered on Walney Island (Cross 1950) and more have been found through cliff erosion at Drigg in Cumbria. Here the main finds were hearths and worked flint, but in one case they included what may have been a wooden platform (Cherry 1982). This produced radiocarbon dates in the later Neolithic. There is a concentration of stone axes in the same area. The important Mesolithic sites on this section of coastline were investigated by the Eskmeals Project (Bonsall *et al* 1989). It may be worth examining the later occupation of this area in detail.

7.13.2 Roman

The most important find-site in the north-west is Meols at the end of the Wirral peninsula. The earliest finds reported from this site include late third-century Carthaginian silver coins and a number of British and Gaulish Iron Age coins, but the most numerous are of Roman date (Harris and Thacker 1987, 104). These cluster in the intertidal zone to the east of Dove Point, and include a number of brooches which range in date from the mid first to the early third century AD. The date of the coins extends from the mid first to the late fourth century. In addition pins, beads, spindle whorls, iron tools, and other implements have been reported. No pottery of certain Roman date is identified. Medieval finds are, perhaps, more numerous than Roman, but with some artefact types such as fish hooks there are no clear distinctions between Roman and medieval examples. Much of this material was published by Hume (1863), who claims to have discovered evidence of several successive land surfaces, the Roman finds being principally associated with a submerged forest (1863, 22). There are also reports of clay floors and stone bases for posts, but these are undated (Thompson 1965, 99). The potential importance of this settlement is indicated by the presence of a Roman road whose course is known for most of the length of the Wirral (Harris and Thacker 1987, 219). Further Roman finds including pottery of third- to fourth-century date are reported from Hilbre Island off the north-west tip of the Wirral (Thompson 1965, 102).

Although the legionary fortress of Chester was clearly in part served by sea and the Dee, the remains of wharves are now buried under reclaimed land, and are relatively remote from the tidal river (Harris and Thacker 1987, 178; Waddelove and Waddelove 1990, 261). The Mersey, too, may have provided access to a port which served the works depôt at Wilderspool. Some twenty lead pigs of late first-century date were found in the sixteenth century on the foreshore at Runcorn (Petch 1987, 234; RIB 2404. 33).

North of the Mersey very few finds are reported from the intertidal zone. The discovery of a Roman pottery vessel from a sandbank north of Fleetwood suggests that further investigation might be useful there, for, like the Wirral, a Roman road points towards the head of the Wyre peninsula. North of Morecambe Bay some Roman material has been reported from Drigg near Ravenglass, perhaps from the dunes (SMR 04430). At Ravenglass itself, erosion of the site prompted excavation in the 1970s (Potter 1979). Elsewhere up the Cumbrian coast Bellhouse (1989) has predicted the location of towers and milefortlets in what is now a coastal or intertidal location, but no evidence has yet been recovered to confirm the existence of these postulated sites.

8 Managing England's coastal heritage

by T Champion, A Firth, and D O'Regan

8.1 Introduction

Virtually all coastal activities are managed and regulated to some extent by public authorities, through central government, through its agencies, or through local government (for a recent overview, see Department of the Environment 1993). This management structure is very complex and fragmented, and each organisation or agency is responsible for its own specific sector or sectors of interest, either nationally or locally. Within this complex structure, the weight attached to the archaeological value of the environment in the general issues of coastal management has varied very greatly; few agencies have the archaeological resource as their primary responsibility. The aims of this chapter are therefore to describe the major threats to the archaeology of the coastal zone, to identify the principal methods of conserving the coast, to set out the principal mechanisms through which the coastal zone is managed, and to identify those agencies and procedures that are most significant for the protection of the archaeological heritage (Fig 118).

Fig 118 Scarborough, North Yorks: the fourth-century AD Roman signal station occupies a spectacular setting close to a popular seaside resort and has been severely damaged by erosion; there are many considerations involved in managing such a site, including coastal defence, transport, tourism, agriculture, public and private property interests and ecology, as well as the archaeological value of the monument (copyright English Heritage/Skyscan)

The first part of the chapter discusses in detail the nature of the activities and processes that occur on the coast and the mechanisms through which they have an impact on the archaeological resource. These descriptions should be understood as a preliminary statement. There has been little research on the physical and chemical mechanisms through which the human and natural processes discussed here lead to the alteration of archaeological sites and a consequent loss of information, in contrast to such terrestrial studies as the destruction of sites in the plough zone (Haselgrove *et al* 1985; Schofield 1991). Nor has there been much research into detailed management strategies for the preservation of coastal sites, unlike those in wetlands (Coles 1995). It has also proved almost impossible to collect meaningful quantitative data for the impact of human activities or natural processes on the archaeology of the coastal zone, and much of the discussion has therefore necessarily been couched in qualitative terms.

Coastal management, and in particular the management of coastal archaeology, can be approached in two ways: first, according to the activities which may have an impact on the coast and its archaeology, and which require management; and second, according to the institutions (including laws, procedures, and organisations) through which such management takes place. The growth of coastal management has to some extent been a response to previous activity, but is also shaped by existing institutions, some of which may have arisen to deal with other activities. For the purposes of this chapter we have reviewed approaches to the conservation of the coast, and then adopted a framework based on management 'regimes' which draws together the activities and the institutions. The framework seeks to reflect actual practice as closely as possible, complete with quirks and irrationalities. Some institutions and activities fit uneasily within the regimes proposed, but in general the regimes presented are a useful way into a complex situation.

As will be shown in detail below, many of the activities that pose a threat to the archaeology of the coastal zone are already regulated by a variety of systems for permissions and licences, some of which require detailed archaeological assessment in advance. In some cases the regulatory mechanisms are those familiar to archaeologists in the management of the terrestrial resource, extended to their outermost seaward limits; in other cases they are procedures specific to the coastal or offshore zones. The weight attached to the archaeological evidence, and the methods for assessing it, vary considerably.

Coastal activities and processes vary greatly from one region to another, and the discussion of the regimes will be followed by a description of four regional case studies to illustrate the range of management problems and solutions in more detail.

This chapter is concerned only with the situation in England, but many of the problems identified are shared with other parts of the United Kingdom and other countries in north-western Europe, which have a broadly similar archaeological record and are exposed to a broadly similar set of human and natural impacts.

8.2 Activities, impacts, and effects

The coastal zone is the location for a wide range of human activities and natural processes. These can often be very intensive, and have major consequences for the archaeological resource. Human activities can also interact with natural processes in a very complex manner, compounding their effects. One major difference between the assessment of such effects in the coastal zone and in terrestrial archaeology is the scale of time, and even more of space, over which they operate; whereas most activities on dry land have a comparatively immediate and localised effect, in the coastal zone the results can be long-delayed and in comparatively distant locations.

In order to discuss the significance of human activities and natural processes on the archaeological resource of the coastal zone, the following concepts can be used:

- *impact* is defined as the mechanism by which an activity or process produces a measurable change in a characteristic or property of an archaeological site or its environment

- *effect* is defined as the change in a characteristic or property of an archaeological site or its environment brought about by the impact of an activity or process. It is important to distinguish the physical properties of impacts on archaeological sites from effects on the archaeological values embodied in those sites (Wildesen 1982). An effect is a matter of professional archaeological judgement about a measurable change in a characteristic or property of an archaeological site, as it relates to the archaeological values of that site. Thus the concept of an effect implies a threshold beyond which an activity may be said to have produced a significant alteration of the archaeological material.

8.2.1 Describing impacts and effects

An impact may be direct if it is caused by an activity which is immediately related to its effect in time and space, or indirect if the effect is separated from the initial agent in time or space. For example, construction of a sea-wall may have the direct impact of excavating archaeological material, while the result of the construction of the wall on wave energy may have an indirect impact by promoting erosion of the sea-bed in the adjacent area.

An impact may be regarded as either adverse or not adverse. An adverse impact is one that has a detrimental effect on the integrity of the site, for example by eroding site components. Some impacts will not have an adverse effect on archaeological material and may thus be neutral, and others may even be beneficial to a site. For example, deposition of material on top of a site may compact it, but may also protect it from erosion or weathering.

Impacts may be immediate, or delayed in time, or remote in location. Immediate impacts produce an effect on the archaeological resource in some direct and immediate way, such as the loss of an archaeological site through excavation for construction. Other processes or activities may be equally significant for archaeology even if they produce no immediate physical impact; the effects may be felt at some geographically distant location, for instance when construction of sea defences alters patterns of erosion and sediment deposition along an entire stretch of coast, or the impact may be delayed in time, for example when the cumulative effects of changes in tidal currents as a result of construction activity bring about significant erosion only after a considerable lapse of time.

Impacts and their effects may also be instantaneous or long-term. Many natural processes such as erosion and deposition are continuous, and their impact on archaeology needs to be assessed on an appropriately long-term basis; the effects may be broadly uniform, for example in the superimposition of new deposits on an accreting coast, or may be highly variable, for instance where coastal erosion is characterised by intermittent episodes of cliff fall. Many human activities, on the other hand, will result in brief episodes of archaeological impact, such as the loss of sites through construction, but others, such as maritime transport or some forms of coastal recreation, are more or less continuous and will have long-term effects, especially where they serve to accelerate or intensify natural processes.

The fact that some of these archaeological impacts may not be immediate and instantaneous, but may be delayed, remote or long-term, makes prediction of their precise nature very difficult. This is in contrast to the position on dry land, where more of the threats derive from human activities whose impacts tend to be immediate and instantaneous. The more complex situation of coastal archaeology, and the greater difficulties of predicting the nature of archaeological impacts, need to be explicitly recognised.

8.2.2 The nature of impacts and effects

Although there are many different activities and processes that affect coastal archaeology, it is possible to group their impacts and effects under a number of general headings:

- *removal*, where part or all of a site is physically removed, for example by erosion, dredging or excavation for construction. The effect on the archaeological evidence is irretrievable destruction of the site, or that part of it affected, and loss of the information contained in it; some elements, such as stone tools, may physically survive, but they will be separated from the matrix of the site, and may be damaged, or redeposited in another location.

- *disturbance*, where the physical structure of all or part of a site and its contents is altered, without any part of it being actually removed, for example by such activities as trawling, oyster dredging or pipelaying. The archaeological value of the site as a source of information will be seriously reduced through the disturbance of its stratigraphy, damage to structures, damage to and relocation of artefacts, disruption of internal associations, and exposure of new material to weathering or erosion.

- *intrusion*, in which a portion of the site is affected by the presence of extraneous matter, for example by piling or root growth, but none of it is actually removed. The effects on the archaeology may include distortion or disruption of the stratigraphy, damage to artefacts, or alteration of the environmental conditions for preservation.

- *exposure*, in which the protective layers at the top of, or above, a site are removed, exposing archaeological material to a new physical environment, for example through the erosion of superficial deposits mantling the archaeological remains. The effects, apart from the possible removal and loss of upper layers of the site which cause the exposure, include the increased risk of further loss through erosion and weathering or human activities such as vandalism, and of accelerated decay of organic material through alteration of the previous anaerobic conditions of survival.

- *burial*, the opposite of exposure, in which, too, a new environment is created for the archaeological evidence, for example through changes in the pattern of sediment deposition or the dumping of dredging spoil. The deposition of new covering layers may be beneficial in providing protection from destructive forces, but may also have negative effects. Archaeological sites and the objects they contain may suffer compaction or distortion through the mechanical effects of the superimposition of new layers, or the physical changes may produce environmental changes, such as desiccation; in the long term, such depositions may have other effects, such as changes in fauna and flora, or new opportunities for potentially destructive human activities. Access to the site will also be impeded.

- *alterations* to the chemical and biological conditions of a site, which may involve no physical changes, for example through pollution or changes to the water table. The consequences of such changes are little understood, but they may affect the conditions for long-term preservation; for example, survival of organic remains may be threatened by desiccation or the influx of new species of insect.

- *change of setting*, where there are alterations to the area surrounding a site, whether the site itself is affected or not. The archaeological consequences are not so much to the value of the site itself, but to the potential for its exploitation, whether by the public or by archaeologists. Encroachment of unsuitable development on a monument's setting, thus reducing the possibilities for its appropriate appreciation, is a problem familiar in dry land archaeology. In addition, changes in the coastal zone may reduce access to sites by leaving them surrounded by marsh or isolated on offshore islands, or in more extreme cases totally inundated by rising sea-levels.

8.2.3 Sources of impact

There are many sources of impact on archaeological material at the coast. These include natural processes, human activities, and combinations of the two. Natural processes such as erosion and accretion, in combination with the rise and fall of land and sea-level, are responsible for the current shape and nature of the coast and continue to alter its form. Natural processes also include biological and chemical processes; flora and fauna contribute to the changing nature of the coast through root growth and burrowing, and chemical reactions influence and alter the physical make-up of the land and the sea bed. Human activities such as construction, fishing, and dredging are undertaken both on land and at sea and may have an impact on archaeological material. Natural processes and human activities may interact to create sources of impact. On the one hand, natural processes may be moderated by human activities; for example, construction of coastal defences may decrease erosion (Fig 119). On the other hand, human activities may accelerate natural processes; for example, quarrying of beach material may

Fig 119 Tynemouth Priory, Tyne and Wear: coastal erosion has necessitated the construction of massive defences to protect the monument

promote coastal erosion. The effects of such interactions may be complex: coastal defence structures which significantly reduce erosion in one section of coast may also reduce water supply to the area behind the defences, thus altering a physical environment suitable for the survival of organic archaeological material, or may induce erosion on other stretches of coast because of reduced sediment supplies for maintaining beaches.

Natural processes are active all along the coast, forming a complex interactive system involving land and water; waves, currents, and wind are continually altering the form of the coast. Some areas of coast are eroding, and such erosion supplies sediments to accreting areas of coast. Other sections of coast are relatively neutral, experiencing very little change through erosion or accretion. Sea-level rise and the relative movement of land have contributed to past changes in coastal form and continue to influence the physical form of the coast. Longer-term predictions for the effect of changing sea-level on coastal processes and the consequent impacts on archaeology have been discussed in detail in Chapter 2.

Human activities also play a significant role in creating landforms and modifying the operation of geomorphological processes. There are very few spheres of human activity which do not, even indirectly, have an impact on the natural environment, and this is particularly true of the coastal zone (Goudie 1993). The most important types of human activity and the mechanisms for managing them are described in detail below (8.4), but the impacts and effects of some of the more common activities are shown in Table 5.

8.3 Managing coastal conservation

Institutionalised approaches to conservation in England have been dominated by a concentration on the subject of the conservation, so that the laws and organisations used in the conservation of archaeology differ from those for the management of the countryside, ecology, and the built heritage. Although this permits specialisation and application of management mechanisms to precise needs, conservation by subject tends to be divisive. Institutional means have been developed to overcome such divisions, but their effectiveness may be limited. It is now increasingly recognised that specific conservation aims are most likely to be achieved by comprehensive and integrated management of all activity within a relevant zone. Conservation efforts directed to rural areas, such as the Countryside Stewardship initiative and the Environmentally Sensitive Areas scheme, are in fact forms of such conservation by zone. The recognition of the advantages of such a zonal approach, particularly for the coast, has led to the emergence of the concept of Coastal Zone Management (CZM).

A special feature of the coast is the fact that very considerable areas of land and lengths of coast are owned or managed by several large organisations, such as the Ministry of Defence, the National Trust, the Environment Agency and recently privatised utilities such as the water and electricity companies. Whether in pursuit of a statutory obligation or not, these bodies tend to adopt a uniform and integrated policy of conservation of all subjects together, in so far as they impinge upon their own properties and functions. The growth of an approach to the conservation of the coast based on zone, or the policies of large organisations, offers an opportunity for the effective integration of provision for conservation of the cultural heritage into a wider framework.

8.3.1 Archaeology

Archaeological policy is the responsibility of the Heritage Division of the Department of National Heritage (DNH). The Planning Inspectorate of the Department of the Environment (DOE) also has an interest, and the Department of Transport is responsible through the Receiver of Wreck within the Coastguard Agency for reporting and disposing of historic wreck.

The legal basis for site protection is contained in the Ancient Monuments and Archaeological Areas Act 1979, which provides for the protection of ancient monuments through the process of designation known as scheduling. The schedule currently includes many coastal sites, some of which are in the intertidal zone. Section 53 of the Act contains special provision for designation of monuments in territorial waters, though this has not yet been used. Section 61(7)(c) of the Act provides for vessels to be scheduled, and could be used to protect underwater shipwrecks.

The Protection of Wrecks Act 1973 provides for the designation of restricted areas which are thought to contain the wrecks of vessels of archaeological, historical or artistic importance. A small number of areas have been designated; most are the sites of shipwrecks of post-medieval date, and the majority are on the south and south-west coasts of England.

Extensive use is made of planning mechanisms, notably statutory plans and development control, to protect sites and wider areas. Guidance on such matters is set out in PPG 16, *Archaeology and planning* (DOE 1990b), which states that archaeology is a material consideration, and that where remains of national importance exist, there is a presumption in favour of their preservation. PPG 15, *Planning and the historic environment*, also provides guidance on the protection of the historic landscape, and deals briefly with the question of sustainability (DOE 1994c). PPG 20 on coastal planning makes specific reference to the historic landscapes associated with the coast,

Table 5 Mechanisms of human-induced erosion in coastal zones (after Goudie 1993)

HUMAN-INDUCED EROSION ZONES	EFFECTS
Removal of beach aggregates	Loss of sand from frontal dunes and beach ridges
Construction of groynes, breakwaters, jetties and other structures	Downdrift erosion
Construction of offshore breakwaters	Reduction of littoral drift
Construction of sea-walls, revetments	Wave reflection and accelerated sediment movement
Deforestation	Removal of sand by wind: sand drift
Fires	Migrating dunes and sand drift after destruction of vegetation
Grazing sheep and cattle	Initiation of blow-outs and transgressive dunes: sand drift
Off-road recreation vehicles	Triggering mechanism for sand drift attendant upon removal of vegetation cover
Reclamation schemes	Changes in coastal configuration and interruption of natural processes, often causing new patterns of sediment transport
Recreation	Accelerated deterioration, and destruction, of vegetation on dunal areas, promoting erosion by wind and wave action

and notes that the coastal zone has a rich cultural heritage (DOE 1992a: paragraph 2.8). Though the jurisdiction of planning authorities extends only to the shoreline, it is recognised that onshore developments may have effects beyond that limit, and that these should be taken into account (see paragraph 8.4.3, below).

Archaeological policies are implemented by English Heritage, in exercise of its functions and duties under the National Heritage Act 1983, which limits its authority to England; that is, to the area above MLW (Mean Low-Water). New legislation would be needed to extend English Heritage's jurisdiction into territorial waters, for instance to deal with any Scheduled Monuments which might be designated there, with protected wrecks, or with underwater archaeology more generally. Responsibility for protected wrecks is exercised directly by the Department of National Heritage.

The Royal Commission on the Historical Monuments of England is the lead agency for the recording of sites. Its Royal Warrant, reissued in 1992, affirms its responsibility for monuments and constructions in or under the sea-bed in UK territorial waters. As well as compilation of the National Monuments Record (NMR), these responsibilities include identification, survey, and interpretation, and the Commission has established a Maritime Team within the NMR to carry them out.

Local authorities play a significant part through their role as planning authorities; they prepare development plans and implement development control procedures. They may also prepare strategies specifically aimed at the management of archaeology (eg Northumberland County Council 1994). For the most part they are responsible for the maintenance of local Sites and Monuments Records, though the extent to which coastal and offshore sites have been incorporated varies greatly.

The Joint Nautical Archaeology Policy Committee (a non-statutory committee representing a wide range of interests and acting as a pressure group) has also produced a *Code of practice for sea-bed developers.*

8.3.2 Countryside

Countryside conservation is the responsibility of the Countryside and Wildlife Division of the Department of the Environment, and the Countryside Commission is the lead agency. The statutory framework is set out in the National Parks and Access to the Countryside Act 1949, the Countryside Act 1968, and the Environment Act 1995. The Exmoor, North York Moors, and Lake District National Parks include stretches of coast, as does the New Forest. Of the designated Areas of Outstanding Natural Beauty (AONBs), a total of 17 include stretches of the coast; these coincide in some cases with Heritage Coasts (see below). Detailed policies with respect to the coast are contained in National Park and AONB management plans, and the Countryside Commission provides central guidance (Countryside Commission 1992a; 1992b). Conservation of coastal countryside often features in local authority statutory and management plans;

PPG 20 includes guidance on policies to conserve the beauty and amenity of the coast (DOE 1992a). Although it is unlikely that such policies will generate major conflicts with archaeological interests, complete concurrence cannot be assumed.

Designation as a Heritage Coast is specifically aimed at the protection of the coast zone. It is a non-statutory designation, but its objectives have been endorsed by the Government. Heritage Coasts are defined by local authorities in consultation with the Countryside Commission. The designation now applies to 30 areas in England, comprising 1027km of the coast, more than one third of the total (Heritage Coast Forum 1993a). Although non-statutory, most of the designated areas fall within areas subject to statutory protection: 2 fall wholly or partly within National Parks, 24 wholly or partly within AONBs, and only 4 are outside such areas. In addition, many Heritage Coasts are also in part protected as SSSIs or National Nature Reserves.

The policy objectives of the designation recognise the need to conserve, protect, and enhance the natural beauty of the coasts, including their heritage features of architectural, historical, and archaeological interest. These objectives, which are to be achieved by strict enforcement of the planning process, have been endorsed by the Secretary of State for the Environment, and are included in PPG 20 (DOE 1992a: paragraphs 1.16–17 and 4.15). It is proposed that management plans should be adopted for all Heritage Coasts by the year 2000. Designation is frequently the occasion for cooperative activity between many public and voluntary bodies; communication between the many bodies concerned was encouraged by the Heritage Coast Forum, succeeded in 1995 by the Coastal Heritage Network (CoastNET).

8.3.3 Ecology

The Countryside and Wildlife Division of the Department of the Environment is also responsible for ecological conservation. English Nature is the lead agency, with a Maritime Team comprising the Marine Task Force, the Estuaries Initiative, and the Coastal Initiative (English Nature 1994). In addition, the Joint Nature Conservation Committee (JNCC) plays a significant role in promoting and disseminating basic research and dealing with matters that have a United Kingdom or international dimension. JNCC includes a Coastal Conservation Branch, a Marine Conservation Branch, and the Marine Nature Conservation Review (Joint Nature Conservation Council Review Group 1993). The Royal Society for the Protection of Birds (RSPB) and the Royal Society for Nature Conservation (RSNC) – the Wildlife Trusts – are significant non-governmental organisations responsible for the management of nature reserves. RSPB and the Marine Conservation Society (MCS) played a major role in stimulating recent interest in coastal and marine management (Gubbay 1990; RSPB 1990; 1993a). In addition to private and local nature reserves there is an extensive range of ecology designations, including National Nature Reserves (NNRs), voluntary and statutory Marine Nature Reserves (VMNRs/MNRs), Sites of Special Scientific Interest (SSSIs), Special Areas of Conservation (SACs, under the Habitats and Species Directive), Special Protection Areas (SPAs, under the Birds Directive), and Ramsar sites protected, especially as waterfowl habitats, under the international Convention on Wetlands of International Importance. This was signed at Ramsar and is known as the Ramsar Convention; sites are called Ramsar sites. English Nature has published a strategy that links these designations through a three-tier approach covering a) the wider sea; b) sensitive marine areas; and c) areas of special interest (English Nature 1993b). As with countryside conservation, complete concurrence between ecological and archaeological interests should not be assumed.

8.3.4 Proprietary interests

Land above mean high-water is presumed to belong to the owner of the adjoining land, but any encroachment on Crown foreshore is held to be a public nuisance, as it may interfere with the right of navigation (Howarth 1992: 43). The character of land ownership above the high-water mark is the same as for non-coastal land. The land covered by the flow and re-flow of the sea, including the foreshore and the beds of navigable rivers, tidal estuaries, and other 'arms of the sea' is, unless proven otherwise, owned by the Crown. Exceptions occur where the Crown has sold or granted ownership to another person, or where some other stronger title can be demonstrated. Ownership of land below mean low-water (ie the sea-bed) out to the limits of the territorial sea is presumed to lie in the Crown, though it appears that the legal basis of Crown ownership of the sea bed is weaker than with respect to the foreshore (Gibson 1977; 1980; 1993; Howarth 1992; Pickering 1993). The Continental Shelf Act 1964 vested in the Crown any rights exercised by the United Kingdom with respect to the sea bed, subsoil, and their natural resources outside territorial waters. These limited rights do not amount to ownership of the sea bed of the continental shelf, nor of archaeological material that may be found there, and they are subject to international law.

Responsibility for managing Crown foreshore was transferred to the Crown Estate by the Coast Protection Act 1949. Approximately half of the foreshore vests in the Crown and is managed by the Crown Estate. The overall holding was diminished by historical grants of foreshore by the sovereign, and by the sale of foreshore by the Crown Estate and its predecessors. Crown ownership of the foreshore and sea-bed is occasionally challenged in relation to specific areas and historic rights. The presumptive nature of the Crown's claim is such that the onus is on the claimant to produce evidence that will overturn the Crown's rights. The Duchies of Cornwall and Lancaster hold foreshore on the basis of a similar presumption. The Duchy of Lancaster's ownership of foreshore extends between mean high- and mean low-water marks intermittently along the coast. The Duchy of Cornwall has a presumptive right to all foreshore around Cornwall, plus interests in Devon and Scilly, but some areas were sold piecemeal in the last century.

Other significant coastal landowners with interests in foreshore include the Ministry of Defence, the Church of England, a number of private estates, and the National Trust. The National Trust is a particularly important coastal landowner as a result of Enterprise Neptune, a special campaign introduced 25 years ago that has led to the acquisition of over 850km of coastline in England, Wales, and Northern Ireland, including a great deal of coast with high heritage value (National Trust 1993).

Both the Crown Estate and the Duchy of Cornwall use leases and licences to generate income from their coastal interests, rather than selling foreshore or sea-bed outright. Leases are drawn up for regulatory purposes (local and port authorities), for conservation (National Trust, RSPB, English Nature), amenity (local authorities, private companies), and mooring (fairway committees). There are about 2000 foreshore leases affecting Crown Estate sea-bed and approximately 100 leases covering foreshore owned by the Duchy of Cornwall. Leases are tailored to specific circumstances, though they usually include common clauses, for example covering environmental matters, nuisance, trespass, and consent for works. Licences are issued for aggregate extraction, bridges, cables, pipelines, and shellfish.

8.3.5 Local authorities

It is important to recognise that the interest of local authorities in coastal management is not limited to the planning process. Their extensive interests are increasingly being set out in coastal plans and strategies (eg Hampshire County Council 1991; Northumberland County Council 1994). Local authorities also host and support many of the forums involved in coastal management, and are ultimately responsible for implementing policies formulated by other organisations. Local authorities are empowered to introduce by-laws relating to public health and recreation. The Government is committed to a review of by-law-making powers to assess their adequacy for existing needs, especially in relation to environmental protection (DOE/Welsh Office 1993a).

The Association of County Councils (ACC), the Association of District Councils (ADC), and the Association of Metropolitan Authorities (AMA) set up the National Coast and Estuaries Advisory Group (NCEAG) to advise central and local government on coastal policies and strategies, to develop partnerships between various sectors, to gather information and to promote best practice (NCEAG 1993; King and Bridge 1994). Local authority associations such as ACC, ADC, AMA and the Association of County Planning Officers also have members who advise on coastal matters through their committee structures, and the Association of Chief Technical Officers has a specific coastal management committee.

Local authority jurisdiction extends, at a minimum, to the mean low-water mark. However, the boundary should not be confused with the baselines from which the territorial sea is measured as their statutory foundations are entirely separate. Local authority jurisdiction often extends across areas of coastal water and the Local Government Commission can recommend further boundary changes below the high-water mark.

8.3.6 Coastal zone management

The concept of Coastal Zone Management (CZM) has emerged in response to the very fragmented nature of management structures, documented in more detail below, and to the growing perception of the need for a more integrated approach. It represents an 'ideal type', a model to be aspired to and a target against which achievement can be measured, rather than a formally organised or statutorily required procedure. Many coastal initiatives have arisen recently in attempts to introduce a greater degree of coordination into the varied approaches to specific threats and the procedures of established organisations. CZM is now a very rapidly growing area of activity; in as much as it attempts to systematise a broad range of interests, CZM may serve as a focus through which archaeological interests can be given greater prominence and coordinated with a wide range of other policies and activities.

The recent upsurge of interest in CZM is conveniently dated to the deliberations of the House of Commons Environment Committee in 1992 (House of Commons Environment Committee 1992a; 1992b; also 1994). However, the sources of the upsurge really lie in several different quarters, including pressure from interest groups such as the RSPB and the Marine Conservation Society, initiatives by a number of local authorities, and reinvigoration of the Heritage Coast programme (see Firth 1995). The Government has responded on several occasions with a number of initiatives (DOE 1992b; 1994b;

DOE/Welsh Office 1993a; 1993b), which have amounted to rather less than the House of Commons Environment Committee demanded. The changes that have occurred are nonetheless significant. The near-exponential growth in coastal initiatives from a wide range of authorities and forums may be an unintended consequence of the Government's refusal to be drawn into the development of a comprehensive strategy.

The Countryside Division of the Department of the Environment is responsible for coastal policy generally and for responding to the House of Commons Environment Committee report. DOE also provides the secretariat to the Government's internal Inter-Departmental Group and to the Coastal Forum, which is intended to facilitate exchanges between central and local government and conservation, commercial, and recreational bodies (DOE 1995).

Key elements of CZM have been to provide the organisation and opportunity for the varied interests to meet, to promote the dissemination of information and guidance, and to produce integrated plans. The preparation of plans has included Coastal Management Plans, Shoreline Management Plans, Heritage Coast Management Plans, Catchment Management Plans and Estuary Management Plans. The National Coasts and Estuaries Advisory Group has put together an overview of plans and initiatives (King and Bridge 1994), and there is an expanding literature of guidance and comment (Countryside Commission 1992a; 1992b; DOE 1992a; DOE/Welsh Office 1993b; Earll 1994; English Nature 1993a; NRA 1993a). There is an extensive range of forums from local pressure groups through committees involved in plan preparation to regional, national, European, and international groups, many of which produce documentation and sponsor conferences. Preparation of information products, directories, databases, and GIS is a further characteristic of CZM.

8.3.7 Information technology

The special nature of coastal management, particularly the need to integrate large quantities of spatial and numerical information as a basis for decision-making, would seem to be an ideal opportunity for the application of information technology (IT). A survey of the current use of such technology among organisations with an interest in coastal management produced a very disappointing response rate. The initial impression of a comparatively low level of IT exploitation may, therefore, be in need of upward revision. It should also be remembered that this a very fast-developing field, in terms both of technology and number of participants, and there is little doubt that the position will change greatly in the near future.

Use of IT has concentrated on electronic databases and geographical information systems (GIS). Fewer than 25% of organisations responding used either technology, and fewer than half of those using databases also used GIS. The National Monuments Record and local Sites and Monuments Records are maintained on databases; some local authority SMRs make use of GIS, and requirements for GIS implementation at a national level are being reviewed. GIS is more likely to be used by large national organisations such as the British Geological Survey, English Nature, the Environment Agency or the RSPB. In such cases, however, the archaeological information recorded is unlikely to extend beyond Scheduled Ancient Monuments.

Some information products are available. The United Kingdom Digital Marine Atlas (UKDMAP), produced by the British Oceanographic Data Centre, represents a concentrated source of information on the marine and coastal environment of the British Isles. The North Sea Map Database (TheMAP) incorporates a range of information on the North Sea, from pipelines and cables to water quality monitoring sites. Both of these include information on the location of protected wreck sites. In general, however, although information about the land and the sea has been gathered, mapped, and disseminated, the line of the coast itself has been largely ignored (Bartlett 1994).

8.3.8 Delimitation and mapping

The baseline from which the territorial sea is measured is generally the low-water mark, but in many places it extends across bays, estuaries, and harbour works. The position of the baseline is calculated by the Ministry of Defence and updated repeatedly to account for changes in coastal morphology. The baseline is used for a number of seaward measurements, including 3nm (nautical miles) and 6nm limits as well as the 12nm limit of the territorial sea. The limits of the continental shelf, on the other hand, are set out as a series of lines between points. The relevance of these boundaries to archaeologists is discussed further in the conclusions to this chapter.

There are difficulties in establishing an adequate map base for the intertidal zone. The paper products of the Ordnance Survey and the Hydrographic Office represent the coast in different ways, and present problems of reconciliation. These problems seem likely to affect archaeological survey and recording. A pilot scheme has been undertaken for coastal zone maps that draw upon OS maps (above low-water mark) and Admiralty Charts (below high-water mark). The British Geological Survey (BGS) is involved in surveying, collating, and mapping earth science information through its Coastal Geology Group, Engineering Geology and Geophysics Group, and the Marine Geology and Operations Group.

8.4 Management regimes

8.4.1 Access, recreation, and tourism

Recreation at the coast is an increasingly important and varied element of leisure activity, whether for tourists or for local residents. Tourism is one of England's most important industries. In Britain as a whole it is worth £30 billion per annum and employs 1.5 million people, providing jobs for 6% of the labour force. It accounts for 3.4% of the GDP and 5.3% of total consumer spending, with day visitors spending £9 billion (British Tourist Authority 1992). In England in 1993 domestic trips by UK tourists numbered 73 million, and 46% of these were to seaside destinations (English Tourist Board 1994).

With the rise in available leisure time and the active promotion of the tourist industry in recent years, pressure for access to the coast has grown, and much public policy is directed towards the provision of increased access. There is a public right to cross the foreshore to navigate or fish in tidal waters, but although bathing and recreation may be tolerated by landowners, there is no public right to do so (Pickering 1993).

The coast is attractive for quiet recreation and for more energetic pursuits; Table 6 gives figures for active participation in some common forms of coastal recreation.

There is no coordinated policy for the public presentation and interpretation of the coastal zone, but a number of conservation bodies with coastal interests provide information, interpretive facilities, and education services that develop links with schools and the wider community. In addition, some of the privatised utilities, such as the water companies, have education programmes. There are several museums with explicitly maritime themes, and more with maritime-related collections. The North of England Museums Service has prepared a report on the care and development of its maritime collections (Gale 1992).

Threats

The growth of the leisure industry requires development to provide appropriate facilities for access, accommodation and recreation. The effects of tourism on the archaeological remains derive partly from such development, and partly from the activities of tourists (Fig 120). Construction and maintenance of access routes such as roads and footpaths, of car parks and hotels, and of specialised shore-based facilities may have a damaging impact on archaeological remains, resulting in the physical removal or disturbance of sites.

Leisure activities themselves have varied impacts on archaeology. Land-based activities such as walking, riding, cycling, biking or off-road vehicles will all create increased erosion, threatening archaeological remains through exposure, disturbance or removal. Attempts to manage them through the provision of defined areas such as marked footpaths may have a mitigating effect, but the attraction of many of these activities is the free use of open country. Many of the most attractive locations are also the most vulnerable, such as sand dunes, and these are also likely to be archaeologically important.

At the other extreme, some activities will have little or no impact. Swimming, surfing or windsurfing will have little effect beyond human pressure on the foreshore. Jet-skiing and the use of powerboats, by themselves or for water-skiing, will generate wash which may be dissipated in open water, but could cause erosion in more confined locations. Diving of itself may be archaeologically harmless, but provides the opportunity for interference with archaeologically important remains. A general consequence of access to the coast is the increased risk of vandalism; this would include purposeful damage to a site with the aim of collecting artefacts, malicious or thoughtless defacing of sites, and indiscriminate indulgence in damaging activities (Lyneis *et al* 1980).

Regime

Statutory rules governing rights of way, footpaths, bridleways and byways are found principally in the Highways Act 1980 and the Wildlife and Countryside Act 1981. Important provisions on long-distance routes (notably National Trails, many of which have substantial coastal stretches) and access to open country (which includes the foreshore) are set out in the National Parks and Access to the Countryside Act 1949 and the Countryside Act 1968. A number of other statutes include procedures and duties to encourage access, as do schemes such as Environmentally Sensitive Areas and Countryside Stewardship. The Environment Agency and various privatised utilities have statutory duties to promote access to, and use of, the coast.

The Countryside Division of the Department of the Environment is responsible for policy on public access, and the Countryside Commission is the lead agency. Many coastal access initiatives are implemented by local and National Park authorities through their own policies

Table 6 Regular participant numbers in sports activities in Great Britain (Heritage Coast Forum/Sports Council 1993)

Windsurfing	500,000
Yachting	400,000
Sub-aqua diving	60–70,000
Surfing	10,000
Hang-gliding	6000
Jet skiing	5000
Land yachting	2500
Microlight flying	2200

or through arrangements for Heritage Coasts. Details can be drawn from statutory plans, coastal strategies, and management plans, as well as central guidance provided by the Countryside Commission (1989; 1990; 1992c; 1993; Countryside Commission/Department of the Environment 1992). The National Trust also has a notable role in the provision of facilities for informal recreation.

Tourism is the responsibility of the Tourism Division of the Department of National Heritage. The English Tourist Board (ETB) is concerned with developing English tourism, and provides support services for the 11 Regional Tourist Boards. ETB has sponsored some coastal projects, notably the English Seaside Campaign, and it has supported seaside resorts through Local Authority Initiative programmes (English Tourist Board 1994). A number of the Regional Tourist Boards have published strategies, in consultation with public and private sector partners, that contain policies relevant to the coast which have implications for development, and for education and access relating to coastal heritage.

The British Association of Tourism Officers has a membership of Local Authority Tourism Officers, and aims to encourage the development of tourist facilities in the UK. The membership of the British Resorts Association includes local authorities and a number of

Fig 120 Dymchurch, Kent: development related to seaside recreation and tourism has encroached on the setting of a Martello tower constructed as part of England's defence system (copyright English Heritage/Skyscan)

Fig 121 Hastings, East Sussex: engineering solutions to coastal erosion; to supplement earlier wooden groynes, more recent constructions include a boulder barrier at the top of the beach (foreground) and a low-shore barrier (middle right); the coffer dam surrounding the Amsterdam *can also be seen (centre) (Photo Jonathan Adams)*

regional Tourist Boards. It seeks to promote and represent the interests of member resorts and all UK inland and seaside resorts.

Recreation is regulated by local and harbour authority by-laws and by self-regulation by recreational groups. Many statutory plans and management plans include policies that affect recreational activities and the infrastructure that they require. There is a large number of recreational groups which represent the interests of participants and maintain a degree of control over their activities through information, guidance, and codes of practice. The British Marine Industries Federation is a trade organisation representing over 1300 companies involved in boating and water-based leisure activity.

The construction of facilities for access to the coast is regulated by development control procedures. PPG 20 on coastal planning states that public access to both developed and undeveloped coast should be a basic principle unless impractical or demonstrably damaging (DOE 1992a, paragraph 3.9), but also emphasises the importance of the archaeology of the coastal zone and reiterates the policies of PPG 16 (DOE 1992b, paragraph 2.8).

8.4.2 Coastal defence

Coastal defence involves two distinct types of activity, coast protection and sea defence. Coast protection prevents the erosion of coastal land by the sea, and sea defence protects the land against flooding by the sea through the overtopping of watercourses and sea-banks. In England coastal defence has been undertaken for many centuries, and indeed some early coastal defence systems are themselves the focus of historical and archaeological interest. There is a range of practical defence techniques, from sea walls, earth banks and breakwaters, to beach recharge, barrages, and dune building. Archaeological remains can be affected by construction and maintenance operations, as well as by the indirect impact of the defences.

A survey of coastal protection by the Ministry of Agriculture, Food and Fisheries (1994c) indicated that 1018km out of a total coastal length of 3763km were protected, 860km by artificial works and 158km by natural defences such as cliffs. Over 40% of the artificial defences were in need of moderate or significant repair work. A total of 135km of coast was also described as suffering significant erosion.

A survey of sea defences by NRA showed a total length of 2214km defended. Of this, 18% were classified as in need of moderate or significant work (NRA nd).

Threats

Techniques of coastal defence may be divided into the categories of 'hard' and 'soft' engineering (see in particular Clayton 1993; Davidson *et al* 1991). Hard engineering structures are designed to oppose natural forces and include structures such as breakwaters, sea-walls, groynes, and flood embankments (Fig 121). These types of structures have been successful in protecting the coast but may bring unintentional side-effects. First, such structures may interrupt natural sediment transport along the coast. Interruption of this natural system may result in altered processes for a considerable distance. A second problem is 'coastal squeeze', which describes the reduction in the width of the intertidal zone between high- and low-water marks and in the number and diversity of habitats in this zone. Many activities, including coastal defence, reduce the area of the intertidal zone; land reclamation has long-term implications for the habitats through the alteration of sediment transport and tidal currents, and dredging deepens and widens offshore channels for shipping, removing subtidal and intertidal areas. The result of 'coastal squeeze' has been a significant decline in the area of intertidal habitat.

The best form of coast protection is a good beach, which provides protection from erosion by absorbing wave energy. 'Soft engineering' attempts to work with the natural systems to provide protection for coastal communities, and includes the techniques of beach recharge, stable bays, managed retreat, and cliff management.

A range of coastal defence structures is present along the coast, with varying implications for archaeological material (MAFF 1993b).

Offshore techniques

Artificially constructed offshore barriers are effective in reducing wave energy on shorelines. Direct impact on archaeological sites may result from disturbance or compaction of the sea floor in construction. However, on the landward side, accretion of sediments will bury archaeological materials and protect them from erosion. The indirect effects of sediment build-up can reduce upper shore and cliff erosion, reducing sediment input on adjacent shorelines and thus resulting in accelerated erosion, which may expose, disturb or remove archaeological material.

Stable bays reduce shoreline erosion and supra-tidal flooding by trapping sediment and lengthening the coastline, thus reducing wave energy per unit of shore. The technique involves constructing hard points along the coast which trap sediments and extend the shoreline. Such constructions may reduce deposition of sediments downshore, resulting in increased erosion of adjacent shorelines and possible exposure of archaeological material.

Tidal or storm surge barriers are built at the mouth of a river to restrict storm tides and prevent flooding upriver. Such tidal barriers are present on the Hull, the Tees, and the Thames. The impact of barriers on archaeological materials may vary. Barriers have the effect of lowering the high-water mark, which results in the encroachment of terrestrial plant species and drying-out of wetland areas. The resulting desiccation of 'wet' sites may result in the loss of archaeological information over time. Moreover, barriers can result in a rise in mean sea-level on the seaward side, and in wave refraction, leading to increased intertidal erosion and possibly local scour and removal of sediments, exposing archaeological material.

Low shore techniques

Groynes act as barriers to longshore drift on the exposed beaches, collecting sediments to maintain beach levels. However, by reducing sediment supplies, they promote downdrift erosion (that is, erosion further down the coast in the direction of the longshore drift), which may expose hitherto buried archaeological sites. Further, they may promote offshore sand loss, exposing submerged sites to erosion. Onshore sites may benefit by increased deposition of sediments, protecting them from mechanical processes.

Beach recharge or nourishment is a 'soft' approach and involves importing material to maintain beach profiles. Material is dredged from the sea and fed onto the beach. Archaeological sites may be exposed, disturbed or removed in collecting source material from the sea. The large volumes of water used in hydraulic pumping can have serious scouring effects which may expose archaeological material. The use of heavy machinery may compact archaeological material. Placement of coarser material than was previously present may reduce aeolian processes, starving adjacent dune systems and leading to exposure and long-term extraction and destruction of archaeological material. Deposition of material on the beach may bury archaeological remains, providing protection from mechanical processes.

The planting of *Spartina anglica* has also been employed as a natural sea defence. As Doody *et al* (1991) describe, this species rapidly colonises mudflats, acting as a sediment trap and extending vegetation seaward, creating a succession of grazing marsh. Archaeological sites may be distorted through intrusion of roots into deposits, and also through desiccation. Benefits include reduced erosion of archaeological material. The spread of *Spartina* is currently being controlled because of its detrimental effect on ecological diversity.

Upper shore techniques

Sea walls are designed to withstand wave attack during storms, and involve deep foundations and massive construction. They are generally located in urban areas and built on top of beaches. Archaeological deposits on the landward side of the wall will be disturbed by construction. Moreover, sea walls reflect wave energy, which can scour deep pits forward of the wall. This also lowers the beach level, moving sand further off the beach and exposing more sand to the risk of permanent removal by tidal- and wave-induced currents. This process not only destabilises the wall in the long term but will expose archaeological deposits in the intertidal and offshore areas through scour. Deposits located behind the wall will benefit from protection from natural processes.

Revetments are designed to reduce cliff erosion. They are placed on the upper position of the beach and are designed to reduce wave energy and thus reduce (not halt) cliff erosion. Construction may intrude on, expose, disturb or remove archaeological sites. In addition, such structures may cause wave reflection and reduction of sediment on the lower beach, exposing intertidal material. Over the long term, offshore erosion may completely destroy sites. Landward sites may benefit from protection against exposure due to mechanical weathering.

Flood embankments are employed as sea defence and have a major modifying effect on the environment, which in turn may have an impact on archaeological material. Prevention of saline flooding and deposition on the protected areas leads to increased desiccation and oxidation of soils, and consequently to lowering of the protected land surface elevations. This may alter archaeological material through desiccation and deterioration of certain classes of fragile archaeological material, especially organic material. Moreover, flood embankments are often constructed over existing saltmarsh and estuarine channels, thus forcing the tidal discharge along the base of the embankment, creating erosion and increasing wave run-up on the defence structure. Such increased erosion may expose archaeological material forward of the wall (see also the discussion of managed retreat below). Finally, earth embankments on the upper shore prevent the shoreline as a whole from responding to sea level rise. This produces 'coastal squeeze' where the shore profile becomes progressively narrower, resulting in the loss of mudflat and saltmarsh and any constituent archaeological material. Moreover, the traditional method of constructing and repairing flood embankments is to excavate material from the landward or seaward side of the bank, which may disturb archaeological material.

Cliff strengthening involves reducing the stress on the cliff face and preventing mass failure and slumping. It is a form of 'soft' engineering. Techniques for strengthening the cliff face include piling techniques in conjunction with some form of toe protection and revetments (the 'toe' is the bottom front edge of a cliff), and the reduction of face angles and cliff height. Drainage systems are installed in soft rock cliffs to reduce water pressure and erosion and slumping. Piling, reducing cliff angle and the introduction of drainage systems may have an impact on archaeological resources, through intrusion, disturbance or removal. Archaeological material may also benefit from reduction of erosion of the cliff.

Dunes provide a natural form of sea defence and three dune-building options, all 'soft' engineering approaches, may be employed: the construction of artificial dunes, the restoration of degraded dune systems, and the management of a healthy dune system. Most techniques for building dunes involve interrupting the wind flow and increasing the deposition of sand. Badly eroded dunes may need to be reformed using earthmoving equipment and subsequently stabilised by fences or planting. Stabilisation of dune systems will benefit archaeological material by protection from erosion. The restructuring of eroded dune systems may have an impact on archaeological material contained in those systems. Artificial dune-building can cause deterioration of the intertidal system by over-abstracting sand from the beach and locking it up in the dune with the addition of vegetation. The result is a shoreline whose ability to absorb wave energy is decreased, possibly exposing archaeological material on the beach and intertidal areas.

Managed retreat is a 'soft' approach to coast protection and involves stepping back from the present shore defence location and allowing the shore to develop the wider profiles which it would adopt under a natural regime. There are a number of possible impacts for archaeological material. First, the reinstated wave and tidal action may expose areas to erosion in the long term as a result of the construction of a secondary defence. An undisturbed saltmarsh consists of mudflats followed by saltmarsh, which grades into fenlands and eventually into dry land. A complete saltmarsh absorbs all tidal and wave energy over the entire area of the saltmarsh. The construction of a secondary defence at the back of a saltmarsh means that the marsh is incomplete and as a result does not fully absorb and dissipate wave and tidal energy. The energy reaches the wall and is reflected back into the saltmarsh, producing erosion. Second, the original line of sea defence or coast protection may be of archaeological interest. For example, reclamation in the Wash has been undertaken since Roman times, and many defences and much of the reclaimed land contain archaeological information (see Clarke 1973 on King's Lynn). Third, the const ruction of the secondary defence may have an impact on archaeological material.

The benefits of managed retreat include the resubmergence of deposits which were formerly periodically wet, providing an enhanced environment for preservation of fragile, organic material, and increased deposition of material on the surface of sites, providing protection against mechanical weathering.

Regime

MAFF's Flood and Coastal Defence Division has overall responsibility for coast protection and flood defence in England and provides a substantial proportion of the funding. However, MAFF does not have an immediate regulatory role, nor does it have powers to carry out coastal defence work itself. MAFF input to coastal defence makes use of several approaches, including statutory functions and obligations, strategic guidance, sponsored research, and conditional funding – notably through the MAFF Memorandum relating to Scheme Approvals and Grant under the Coast Protection Act 1949, and the series of MAFF Grant Memoranda for flood defence schemes. MAFF encourages the preparation of Shoreline Management Plans as strategic support for proposals (MAFF 1989; 1993a; 1993b; 1994c; MAFF/Welsh Office 1993).

The Coast Protection Act 1949 (CPA) provides the legal framework of coast protection, and the powers and duties of coast protection authorities (the council of each maritime district) are set out in Part I. Coast protection authorities are responsible for 1191km of defence elements, and other authorities and private owners (including Railtrack and MoD, for example) are responsible for 496.5km of defence elements. Section 18 of the CPA 1949 enables coast protection authorities to prohibit excavation or removal of materials from the seashore, which includes the sea bed to 3nm. Thirty-nine authorities have made such orders covering part or all of their coastline. Recently, coast protection authorities have banded together in 14 regional groups – linked in turn via the Coastal Defence Group Forum, supported by MAFF – to improve coordination. Coast protection works are subject to environmental assessment procedures (DOE 1994a).

The legal framework for flood defence and land drainage is set out in the Water Resources Act 1991 and the Land Drainage Act 1991. The Environment Agency takes a lead role through the Regional and Local Flood Defence Committees and through its functions and duties in respect of main rivers. Altogether, the Environment Agency is responsible for 1438km of sea defence elements. Internal Drainage Boards (IDB) are responsible for flood defence on watercourses that are not main rivers, and there are 50 IDBs around the English Coast. Local authorities and private owners also have responsibilities for flood defence, maintaining 427km and 350km of sea defence elements respectively (NRA 1993b; nd). Improvement and maintenance of flood defence works are permitted development, though major improvement works may be subject to environmental assessment under the Land Drainage Improvement Works (Assessment of Environmental Effects) Regulations 1988. New works do not count as permitted development and require planning permission, and may warrant environmental assessment under Schedule 2 of the Town and Country Planning (Assessment of Environmental Effects) Regulations 1988.

Planning mechanisms are being used to protect lives and property exposed to danger from erosion and flooding. PPG 14 (DOE 1990a) encourages coastal authorities to introduce a presumption against development in areas of coastal landslides or rapid coastal erosion, and notes that some of the features that cause or result from instability may be of archaeological interest. Circular 30/92 (DOE/MAFF/Welsh Office 1992) requires planning authorities to take flood risk surveys into account when preparing structure and local plans, and to consult the Environment Agency with respect to developments in certain areas (such as coastal floodplains) and of certain types before granting planning permission.

Reclamation of land from the sea is a Schedule 2 project under the Town and Country Planning (Assessment of Environmental Effects) Regulations 1988. Consequently, significant reclamation projects within local authority planning jurisdiction might be expected to involve environmental assessment. Reclamation may be carried out under other statutory powers, notably Harbour Acts. Reclamation projects are likely to require licences under the Food and Environment Protection Act (1985) (see below, 8.4.15) and navigational consents under Section 34 of the Coast Protection Act 1949 (see below, 8.4.10).

8.4.3 Development

Many of the other management regimes described here involve a measure of construction activity that comes under the heading of development. This is treated separately here because of the legal provision for the control of development, which represents one of the most important threats to the archaeology of the coastal zone. The coast is often favoured as a location for major industrial developments, as well as residential and recreational uses. Some industries, notably shipbuilding and repair, must be close to the water, but for others the attraction is the ready availability of flat land, bulk transport facilities, and water.

Threats

The threats to coastal archaeology from development activities are for the most part similar in type to the threats to archaeology elsewhere: removal and disturbance of archaeological remains, modification of historic landscapes, and encroachment on the settings of standing monuments and historic buildings. There is, however, a much higher risk of indirect effects, for instance through the alteration of patterns of erosion and accretion; of delayed effects, where the impacts take some time to have a significant cumulative effect on the resource; and of remote effects, where the impacts produce changes at locations some distance along the coast or seaward from the development.

Regime

Development is controlled through the planning process. Local planning authorities are generally responsible for development policies and their implementation, through statutory planning and development control. In some cases, standing conferences of local planning authorities have been influential in formulating policies on coastal development (eg SERPLAN 1993). The DOE provides guidance to local planning authorities through Regional Planning Guidance (RPG), Planning Policy Guidance (PPG), and circulars. The most relevant guidance is contained in PPG 15, *Planning and the historic environment*; PPG 16, *Archaeology and planning*; and PPG 20, *Coastal planning*. PPG 20 encourages local authorities to collect data on 'the scale and pace of coastal change', and this could have important implications for future planning.

Special regimes apply to areas covered by Development Corporations, and the Merseyside, London Docklands, Teesside, and Tyne and Wear Development Corporations have powers relevant to coastal development. In addition, the DOE has a Thames Gateway Task Force which is responsible for the Thames Gateway area (Thames Gateway Task Force 1994).

Notwithstanding the judgement in Argyll and Bute District Council *v* Secretary of State for Scotland 1976 (Session Cases 248), that planning jurisdiction extends only to developments above low-water mark, irrespective of the overall jurisdiction of the local authority, the Department of the Environment has been advised that the planning system does cover areas below low-water mark within local authority boundaries (see English Nature 1993a: 69 note 8). One of the key recommendations of the House of Commons Environment Committee was that landward and seaward planning control should be harmonised as far as the 12 mile limit. The Government, however, rejected any extension of planning jurisdiction in favour of existing sectoral (industry/process) consents. PPG 20 does note that local planning authorities should recognise that onshore development can often have an impact offshore. In sum, archaeology is a material consideration to the limit of local authority jurisdiction, including areas of land covered by water in estuaries, river mouths and bays. Beyond this jurisdiction, and beyond the low-water mark generally, archaeologists should be mindful of the offshore effects of development onshore.

Major industrial developments are complex undertakings and will often require consent under many of the other regimes described separately in this chapter. They may be required to fulfil the demands of the Town and Country Planning (Assessment of Environmental Effects) Regulations 1988, thereby requiring consideration of the cultural heritage. Schedule 1 projects, such as crude oil refineries, non-nuclear power stations above 300 MW, iron and steel works, and integrated chemical installations, require environmental assessment in every case and are often found at the coast. Schedule 2 covers a considerable range of industrial projects which may require environmental assessment if they are likely to have significant effects on the environment by virtue of factors such as their nature, size or location. Department of the Environment Circular 15/88 includes indicative criteria which set the threshold above which a Schedule 2 project will be considered to require environmental assessment (see DOE/Welsh Office 1989). The language is far from prescriptive, but it suggests that environmental assessment may be required for manufacturing plants covering more than 20-30ha or plants involving significant emissions. There appears to be no specific provision with respect to industrial projects located at the coast. Major industrial developments will often be subject to Integrated Pollution Control (IPC), which is enforced by the Environment Agency.

8.4.4 Electricity

The electricity industry falls into two main areas, generation and supply, both of which can affect the coastal zone. The generating industry is split between National Power, PowerGen (5 major coastal installations) and Nuclear Electric (12 major coastal installations). The supply side is split between the National Grid Company, which maintains the super grid, and the regional electricity companies, which run smaller distribution cables. The super grid rarely impinges upon the coast, the main exception being the link with France which comes ashore at Folkestone. However, the smaller cables often run across rivers, estuaries, and stretches of sea-bed. Works associated with electricity supply frequently involve intervention in archaeology; for example, *Lighting up the past in Scilly* (Ratcliffe 1991a) documents archaeological work carried out in association with South Western Electricity in a coastal environment.

Threats

Generating stations and their associated fuel supply facilities (gas pipelines, coal quays) and discharge outlets often occupy extensive coastal sites, and can also involve offshore interests, especially gas production. The threats they pose are similar to those of other development work (see above, 8.4.3) and pipeline construction (see below, 8.4.11).

A more serious threat would arise from proposals for the construction of tidal barrages for electricity generation, for example across Bridgwater Bay. Construction operations would have the immediate effect of removing or disturbing archaeological remains. The long-term effects caused by the alteration to tidal currents, water levels, and erosion and accretion systems, and possible indirect consequences through the promotion of leisure activities in the bays, would be geographically very extensive and potentially very serious for archaeology.

The supply side may also pose threats through the installation and maintenance of cables below ground, on the foreshore, and on the sea bed. They may be buried at depths of up to 1m, and may disturb or expose archaeological remains. Supply lines above ground may also have an archaeological impact where support structures may cause damage or disturbance.

Regime

Responsibility for electricity lies with the directors of the private undertakers and the Secretary of State (Department of Trade and Industry), as set out in the Electricity Act 1989. Undertakers who wish to build generating stations of 10 megawatts capacity or more, to install electric lines above and below ground, and to carry out other works connected with the transmission or supply of electricity have duties towards sites, buildings, and objects of architectural, historic or archaeological interest. Moreover, they must consult English Heritage in the course of preparing statements concerning the performance of such duties. In addition, consents are required for high-capacity generating stations and installation of certain overhead cables. These consents are subject to environmental assessment regulations.

8.4.5 Fishing

Fishing is one of the oldest and most important activities in the coastal zone. Structures and objects related to fishing, especially weirs and traps, are an important component of the archaeology of the intertidal zone. Fishing includes finfishing and shellfishing for both recreational and commercial purposes, and employs a range of different methods to harvest fish from both the water column and the sea floor. Commercial fishing represents the most intensive use which is made of UK waters (Tait 1981). Recreational fishing is generally carried out by individuals on shore or on boats, with rod and reel. Bait-digging and shellfishing are undertaken commercially, with large dredgers employed to harvest shellfish, but it is also carried out recreationally. Demersal (or near-bottom) fishing focuses on species living close to the sea floor such as cod, haddock, saithe, hake, plaice and sole. It employs a trawl or seine, and is the fishing technique which has the greatest impact on archaeological sites. Current policy is largely aimed at the promotion of the fishing industry and the conservation of fish stocks rather than consideration of its environmental consequences.

The equipment used in fishing has a long history and is very varied (Davis 1958). There has been some research on its impact on archaeological remains (Ferrari 1994), and on its effect on the natural environment (de Groot 1984; Fowler 1989).

Threats

There are several types of trawl or seine. The beam trawl is a tapering bag of netting towed over the sea bed with the mouth of the bag held open by a beam which in turn is held off the sea floor by runners. The upper leading edge of the bag is connected to a head rope and fastened to the beam. The under part of the bag, which drags along the bottom, is attached to a longer ground rope. As the trawl is towed, the ground rope trails behind the headrope so that fish disturbed by the groundrope are already enclosed under the upper part of the net. The size of the beam trawl varies and can be up to 15m in length. There are many variations on this basic design, for example the otter trawl, which is larger than the beam trawl, and the Spanish trawl, which is towed by two vessels and can be employed in depths of up to 600m.

Beam trawls have been used for several hundred years and were the principal method of demersal fishing in the days of sail. With the introduction of steam-driven boats capable of towing heavier nets, the beam trawl was superseded by the larger, more easily handled, and more efficient otter nets. Modern commercial fisheries use them less frequently but they are still operated by small boats in inshore waters for which the modern otter nets are too large.

In recent years there has been an increase in the use of beam trawls made more effective by the introduction of 'tickler chains' in front of the groundrope. These chains plough up the bottom in front of them so that the fish buried in the sediment cannot let the net ride over them. Electrified ticklers are also used, so that the fish jump out of the sand. These electrified chains, being lighter, do less damage to the bottom.

Shellfish, lugworms, and ragworms are collected commercially through the use of suction dredgers and recreationally through the use of hand-held shovels. Increasing mechanisation of the industry with the introduction of suction dredgers has increased the size of the invertebrates collected, resulting in an increased depth of disturbance of the substrate (RSPB 1993b).

Trawling the sea bed exposes, disturbs, and removes archaeological material, often bringing pieces to the surface in the nets (Figs 122–3). Areas of sea bed, at depths ranging from tens of metres to 600m, may be disturbed as a result of fishing techniques. Movement of nets through the substrate will disturb archaeological material, altering deposits by scattering material and disturbing the context of the site. Moreover, deposits may also be altered through exposure and subsequent disintegration of material. Mechanical bait-digging and shellfish collection disturb the substrate and may have an impact on archaeological material. Non-commercial bait-digging in the intertidal zone may also disturb or remove archaeological remains.

Fig 122 Hurst Castle, Hampshire: the sixteenth-century castle is part of the coastal defences built by Henry VIII; the spit joining the castle to the mainland is occasionally breached by the sea during storms, flooding the adjoining coast and isolating the castle; a buried land surface extends below the sea, from which archaeological material has been recovered by local fishermen (copyright English Heritage)

Regime

Fishing is subject to extensive control by European Union policies and regulations. Within England the Fisheries Division of MAFF has overall responsibility for policy and implementation in this area, though its work is supplemented considerably by the Sea Fisheries Committees (SFCs). There are 11 SFCs in England, generally attached to one or more county councils. MAFF regulates fisheries through a range of stock conservation measures that are enforced by sea fishery officers, generally belonging to the Sea Fish Inspectorate. The SFCs may also appoint fishery officers to enforce by-laws within their district. Sea fishery districts extend from high-water mark, or a line across river mouths, estuaries, etc, to 6nm. The Environment Agency has a number of fisheries functions throughout England out to 6nm from the baselines. It can introduce regulations and by-laws, and acquire dams, weirs, and fixed engines (fish traps). MAFF can make grants to encourage fish farming, and can exempt fish farmers from certain aspects of conservation legislation. Marine salmon farms are subject to environmental assessment, which is invoked upon application for consent to the Crown Estate Commissioners (CEC). The CEC must inform adjacent planning authorities, DOE, the Countryside Commission, English Nature, and relevant water authorities that an environmental statement has been requested, and then inform those agencies of their decision and any conditions applied. Shell fisheries can be established upon application to MAFF on any portion of the shore or sea bed out to 6nm from the baselines.

8.4.6 Harbours

Port and harbour developments are essential for maritime trade, providing facilities for freight, fishing, and passenger services. As Doody *et al* (1993) describe, port developments have assumed a greater importance in recent years as trade with other European Community countries increases. The size of these ports varies, with some servicing international trade, such as Southampton, London, Teesside, and Tyneside, while others cater for domestic trade, such as Boston, Wisbech, and Langstone. There are about 60 major ports in England, and many smaller ones.

Most ports are located in deep bays, estuaries, and rivers, taking advantage of favourable locations which have often been the focus of human activity for a very long time, as the discovery of a Bronze Age boat at Dover has illustrated (Fig 124; Parfitt and Fenwick 1993). Many ports are themselves historic towns with important medieval and older archaeological remains.

A more recent trend has been the rise of recreational boating, and the provision of marinas, many of which have been located near existing harbours. A survey of marina provision in southern England (Sidaway 1991) identified 81 marinas, 15 marina villages, and 186 moorings existing in April 1990 between Norfolk and Cornwall; Essex and Hampshire had the highest number of installations.

Threats

Ports pose an archaeological threat through their construction and maintenance, and also act as a magnet to attract other potentially damaging developments.

Construction work onshore might include warehouses, loading docks, and slipways. Offshore activities include the building of quays, wharves, and docks. All these activities could affect archaeological remains by removing and disturbing them, or by altering sediment regimes to promote erosion.

Routine operation of harbours also presents possible effects. The impact of ship movement is discussed below (see 8.4.10). Maintenance dredging of navigation channels is also essential, and could cause loss, disturbance or exposure of sea bed remains. Water storage barrages may be employed in harbours to maintain water levels for mooring of ships; in addition to their construction, they have a potential impact through alteration of sea-levels and erosion regimes, and opportunities for the promotion of leisure activities.

Ports are often the centre for significant associated development, such as road and rail facilities essential to the running of the port, and industrial expansion.

Regime

The Ports Division of the Department of Transport deals with most aspects of harbours, though some exceptions are noted below. Harbours are generally regulated by local enactments which are numerous and, in some instances, of considerable antiquity. A series of general enactments have set out the overall framework within which local harbour acts are introduced and implemented, notably the Harbour, Docks and Pier Clauses Act 1847, and the Harbours Act 1964. It is, however, essential to return to the local acts to deal with matters of detail. In formulating or considering any proposals, harbour authorities have an environmental duty to have regard to the desirability of maintaining the availability to the public of any facility for visiting or inspecting any building, site or object of archaeological, architectural or historic interest.

Harbour works may be subject to a number of consent procedures, notwithstanding the statutory powers of each harbour authority. The principal consent

Fig 123 The Solent, Hampshire: archaeological artefacts recovered during fishing from the buried land surface off the coast of south-west Hampshire (Photo Gary Momber)

Fig 124 Dover, Kent: excavation of a Bronze Age boat discovered in road building, but originally lying in a tidal creek of the river Dour (copyright English Heritage)

procedure, based upon harbour revision orders, is set out in the Harbours Act 1964. If a harbour revision order is obtained then the proposal is exempt from the requirement for Section 34 consent under the Coast Protection Act 1949. It is quite likely, however, that a FEPA licence (see below, 8.4.15) will be required for the deposit of building materials in the sea. A further licence may be required if the foreshore and bed of a harbour fall within the seashore (including sea bed) covered by an order under Section 18 of the Coast Protection Act 1949 (see above, 8.4.2). Many of the constructions associated with harbour works are subject to the Transport and Works order-making procedure, but the procedure does not apply if the same purpose can be achieved through a harbour revision order (see below, 8.4.10). If the harbour authority is within a county then any works which constitute development may be subject to planning controls, including statutory plan policies. However, development which is authorised by a local or private Act, or by a harbour revision or empowerment order, is permitted development under Part II of the General Development Order. Environmental assessment may be required through the harbour revision order procedure (Harbours Act 1964). In addition, harbours may have their own policies on development, set out in management plans.

Associated British Ports (ABP) is a subsidiary of Associated British Ports Holdings Limited, which took over the management of harbours previously vested in the British Transport Docks Board (ie nationalised ports). Specific local acts are required to empower ABP to carry out works or other significant changes at its ports. The Port of London has its own suite of arrangements. MAFF has an interest in small harbours used principally by the fishing industry and can provide financial support for fisheries infrastructure at any harbour. Dockyard ports are harbours in the vicinity of naval installations and are subject to the Dockyard Ports Regulation Act 1865, which provides for specific regulations and for the appointment of Queen's Harbour Masters.

The British Ports Association is the principal industry group, with over 50 member ports in England.

8.4.7 Marine safety and emergencies

Marine emergencies include shipping accidents such as groundings and sinkings, and oil and chemical spills. Shipwrecks form an important part of the archaeological record of the coastal zone, but modern incidents may have an effect on that resource.

Threats

Shipwrecks on rocky shores may have little direct effect on archaeological remains, but groundings on low-lying coasts may have an impact where archaeological remains are preserved in the intertidal or subtidal zones; however, there is little evidence for the extent of such threats. Such incidents are impossible to predict, and beyond the scope of regulations.

Marine pollution, whether from shipwrecks or other causes, may be a more serious problem. The oil or chemical spilled may cause direct or indirect damage to archaeological material. Such substances may, in the long term, chemically alter the preservational environment. However, the short-term and long-term effects of chemicals on archaeological deposits and their contexts are unknown.

For archaeological purposes the clean-up of marine emergencies along the coast may have an impact on archaeological material. Clean-up involves the physical removal of oil and chemicals from the shore, having a direct impact on archaeological material. Techniques employed to remove material include shovelling of contaminated soil and sand, the use of high-pressure hoses and detergent to wash the affected areas, and specially designed suction machines to remove oil from mud flats and beaches. Reclaimed oil must be stored, and often a pit is dug at the back of the affected area in which to collect oil for later removal. Thus, the effect of cleaning operations on archaeological deposits may include destruction, removal, disturbance or exposure.

Regime

Responsibility for marine safety is divided between the Department of Transport and its agencies and the Health and Safety Executive, an agency responsible to the Department of Employment. The DOT agencies are organised as the Marine Emergencies Organisation and the Coastguard. The Health and Safety Executive is principally responsible for health and safety in coastal workplaces and offshore installations (but not ships), including matters relating to diving archaeologists. Companies have significant responsibilities as employers and operators, and employees have individual responsibilities, under the Health and Safety at Work Act 1974.

The Marine Pollution Control Unit (MPCU), within the Coastguard Agency (see Coastguard 1994), heads pollution control efforts at sea. It also maintains a national contingency plan and provides advice and assistance to local and port authorities, who have primary responsibility for cleaning up pollutants that come ashore. MPCU has facilities for establishing Joint Response Centres to coordinate onshore operations; it also commissions research on controlling and cleaning up spills, and runs regular exercises with local and port authority staff. Local authorities, some port authorities, and oil companies have prepared contingency plans which are drawn on, together with advice from Government Departments and conservation agencies, in the event of a major incident; it is desirable that such contingency plans should include details of coastal heritage that might be adversely affected either by contamination or by clean-up operations.

8.4.8 Military activity

The 'Defence Estate' of the Ministry of Defence includes a significant amount of coastal land. Some installations, such as naval bases and military ports, must obviously be situated on the coast, and for others, such as bombing and artillery ranges, the coast provides a suitable extent of open and remote land. Most coastal land in military use is in fact used for weapon firing and bombing ranges (Ministry of Defence nd). The MOD currently owns 58 coastal locations, covering 238km of coast.

Threats

The impact of military activity on archaeological sites is linked to the level of use of those sites. Activities include construction and maintenance of buildings, harbours, and associated facilities, as well as routine service operations, especially the training of personnel using machines. Military land may also be used for agriculture and woodland, and in some areas there is public access.

Direct impacts are a product of construction, and operations such as use of tracked vehicles, trench digging, and explosions. All of these activities can bring about the removal, disturbance or exposure of archaeological remains, and artillery and bombing ranges could also have a significant impact on the intertidal and subtidal zones. A special problem identified by the Ministry of Defence (Ministry of Defence nd) is the disposal of litter, rubble, spoil, and military equipment. The excavation of pits to dispose of rubbish may result in intrusion into, and extraction and exposure of archaeological material. Where military land is used for non-military purposes, such as agriculture or woodland, these activities will have their own impact (see below, 8.4.12).

Regime

The MOD estate is administered by the Defence Lands Service, which has a conservation office (DLS Conservation). In addition, each property where conservation is an issue has a Conservation Group; there are over 200 such groups in the UK. The groups are chaired by the Head of Establishment and include representatives from the base, including Estate Managers, plus representatives from English Nature and a wide range of conservation bodies. The Conservation Groups also serve as interest groups for voluntary activities by military personnel. A Conservation Dossier, based on a layout recommended by DLS Conservation, is produced for each property, and this is then used to generate sensitivity maps for Conservation Management Plans. The MOD pursues general policies with respect to archaeology and does not make special reference to the coast. The MOD is in the process of developing a SMR for all sites and findspots on MOD land in order to trigger consultation with county archaeologists.

Land held by the MOD is subject to 'safeguarding', whereby MOD arranges for the Department of the Environment to issue directions to local planning authorities under Section 14 of the Town and Country Planning Act 1988. The directions include a map and covering letter specifying areas where certain types of development should not receive planning permission without formal consultation with MOD. The priority is to maintain operational integrity rather than to protect the coast.

The MOD has additional powers to make use of land for exercises and manoeuvres. Section 6 of the Land Powers (Defence) Act 1958 grants the power to require use of land for limited training purposes, including cliff assault exercises. Section 1 of the Manoeuvres Act 1958 provides powers to authorise execution of manoeuvres; drafts of manoeuvres orders are to be sent to local and other authorities. Section 6(4) of the Land Powers (Defence) Act 1958 states that nothing is to authorise any person to injure or deface any Scheduled Monument. Similarly, Section 2(3) of the Manoeuvres Act 1958 provides that the officer directing the manoeuvres shall take care that there is no interference with earthworks, ruins or other remains of antiquarian interest.

Section 14 of the Military Lands Act 1892 provides that the Secretary of State may make by-laws concerning the use of land held for military purposes in order to secure the safety of the public. Section 2 of the Military Lands Act 1900 makes provision for by-laws relating to the coast and sea. Any such by-law may not injure any public right (any right of navigation, anchoring, grounding, fishing, bathing, walking or recreation) unless made with the consent of the DTI, which can consent to such a by-law if it is 'reasonable'. Section 7 of the Land Powers (Defence) Act 1958 extends the power to make by-laws over sea areas that do not abut military lands.

8.4.9 Minerals

Mineral resources may occur in solid, liquid, and gaseous forms and all can be found in deposits beneath the seas. Such minerals include:

- oil and gas
- sand, gravel, and rock
- silica, and heavy mineral sands for their mineral or element content (eg tin)
- phosphates and carbonates for use as fertilisers
- metals

Sources of minerals along the coast are located on land, beach, and under inshore and offshore waters. Exploitation of offshore minerals began spasmodically several hundred years ago, but it was not until this century that significant operations began. Mineral extraction operates at many levels: oil and gas extraction in the North Sea, land-based coal extraction, large and small rock quarrying and gravel pits, removal of sand and aggregates from beaches, and offshore dredging for marine aggregates.

Commercially, minerals are a very important resource. Aggregates (sand and gravel) are essential for the construction industry, and with increased pressure on terrestrial sources of aggregates, more attention is being paid to possible maritime sources. There are approximately 80 aggregate abstraction licences. In England and Wales marine aggregates form 18% of the total aggregate production; in the south-east of England the figure rises to 30% of total production (British Marine Aggregate Producers Association 1993, 271).

Oil and gas are discussed in more detail in paragraph 8.4.11 below.

Threats

Terrestrial mining of minerals may be undertaken through deep shaft mining or open-faced mining. Mines can often extend over several kilometres under the land and ocean floor, but their direct effect on archaeological remains may be minimal. Associated activities, such as waste dumping, could have a significant effect on the promotion or prevention of erosion.

Recently coastal super-quarries have been proposed which would provide enormous quantities of rock material for construction. Their effects would include total loss of archaeological remains in the terrestrial area affected, and significant modification of historic landscapes; in addition, the scale of coastal alteration could be sufficient to cause indirect effects elsewhere along the coast.

Offshore marine aggregates are dredged by a number of methods, from the dipper, backhoe, and cutter suction dredgers to the most common form of dredger, the bucket dredger, all of which cut into the sea-bed and extract aggregate materials. Other dredger types, such as the suction dredger, suck m aterial from the surface of the sea bed.

Mineral extraction has consequences for areas affected directly or indirectly by the result of the dredging (Bray 1979). Terrestrial mineral extraction may result in subsidence of adjacent areas, which may distort archaeological sites. Extraction may indirectly increase local erosion of the area and may lower local water levels (Carter 1988). Increased erosion may expose archaeological material and lowering of local water tables may desiccate 'wet' archaeological sites.

Marine aggregate dredging may have a direct impact on coastal and submerged sites through possible subsidence of submerged structures, change in local scour and water flow patterns, and alteration of soil characteristics (Bray 1979). Subsidence of structures and changes in scour patterns may expose submerged archaeological material. Continual removal of coarse or fine materials from the sea bed will alter the nature of the soil and the preservational environment of the sediments. Indirect results of dredging include the possible movement of material seaward due to removal of offshore deposits, changes in wave refraction patterns due to changes in sea bed contours with associated shifts in consequent erosion or deposition of material, and the dredged area acting as a sink to impede longshore drift and cause erosion on the downdrift side (Bray 1979). Archaeological material may suffer impacts through exposure, a product of movement of material offshore, and increased mechanical weathering. Similarly, changes in wave refraction and subsequent erosion and deposition patterns may expose and bury archaeological material along the coast. Downdrift erosion resulting from sediment sinks may expose archaeological material.

An important consideration in the removal of offshore minerals is the area's role in coast protection. Offshore features such as sandbanks, bars or beaches often act as natural coast protection structures, preventing erosion of the adjacent coast. An example of the consequences of beach aggregate removal comes from the village of Hallsands, Devon. In 1887, 660,000 tons of beach material were removed for the construction of the dockyards at Plymouth, lowering the shore level by 4m. With no natural replenishing source of shingle, cliff erosion began and resulted in a loss of 6m between 1907 and 1957, destroying the village (Goudie 1993). Similar events on a smaller scale will destroy archaeological sites.

Regime

Dredging for marine aggregates for the construction industry and for coastal defence work is managed through licences issued by the Crown Estate. Currently, licensing is subject to the Government View Procedure, coordinated by the Minerals Planning Division of the Department of the Environment; a licence for extraction will not be issued unless all the various interested Departments view the proposal favourably. The licensing procedure includes an assessment by the environmental consultants H R Wallingford, designed to determine the likely effects of the proposal, including risks such as coastal erosion. There is general dissatisfaction with the procedure, and consultation papers were circulated to seek opinions on alternatives (DOE/Welsh Office 1994). In November 1995 the Government announced that it was proposing to introduce a new statutory system, drawing on the procedures of the Town and Country Planning Acts (DOE/Welsh Office 1995). Similar non-statutory procedures will be introduced as an interim measure. Marine dredging of minerals and quarrying of aggregates from superquarries will also have implications for coastal heritage in harbour areas where new wharfage and navigation channels are required.

The Sea-sand (Devon and Cornwall) Act 1609 states that it is lawful for all persons resident and dwelling in Devon and Cornwall to fetch and take sea-sand at all places under the full sea-mark for the bettering of their land, and for the increase of corn and tillage. The Act also recognises the rights of boat operators to land and transport sea-sand. Elsewhere, local authorities may have acquired powers under Section 18 of the Coast Protection Act 1949 to prohibit extraction of materials from the fore- and seashore (see 8.4.2).

British Coal has had an appreciable interest in mining at the coast, particularly in north-east England. The relevant mines have now closed and are being disposed of. Mine closure has ended coastal tipping of colliery waste which has, in turn, prompted a resumption of erosion on cliffs that were protected by 'black beaches'. In addition, mine pumps have been switched off, raising the danger of flooding and overspill by heavily contaminated water. Pollution from disused mines (including metalliferous ore mines) is high on the Environment Agency agenda, not least because of the Wheal Jane disaster when ten million gallons of heavily contaminated water escaped to the sea from disused tin workings after a plug failed. Treatment works to deal with contaminated minewater may involve extensive capital works (NRA 1994b).

8.4.10 Navigation

Maritime transport for commercial or recreational purposes in inshore waters is one of the most important activities of the coastal zone, and there is a general right of navigation in tidal waters. Public policy is aimed at promoting and facilitating the right of navigation, regulating activities that might impede it rather than considering its environmental consequences.

Threats

The direct archaeological effects of navigation derive from the erosion caused by the wash generated by vessels. This can cause exposure, erosion, and loss of archaeological remains, especially in confined areas such as estuaries, where the wash energy cannot easily be dissipated (Fig 125).

Indirect effects arise from the provision of facilities for navigation, such as harbours and marinas (see above, 8.4.1 and 8.4.6).

Regime

Navigation in tidal waters, and associated activity such as anchoring, is a public right. Moorings, however, can only be installed with the permission of the landowner; the Crown Estate and the Duchy of Cornwall lease large areas of sea-bed in estuaries and bays for this purpose (Crown Estate nd). Trinity House Lighthouse Service is responsible for managing and coordinating the provision of aids to navigation to the mariner, and for removing any danger to general navigation caused by wrecks (THLS 1994). As navigation is a public right, regulation and improvement of navigable waters requires statutory authority. Consequently there are very many local navigation and conservancy acts applicable to the coast.

Section 34 of the Coast Protection Act 1949 sets out restrictions on operations which may be detrimental to navigation, but provides a consent mechanism for such operations. Written consent must be obtained from the Ports Division of the Department of Transport before any person (with certain exceptions) can carry out the following actions if they are likely to

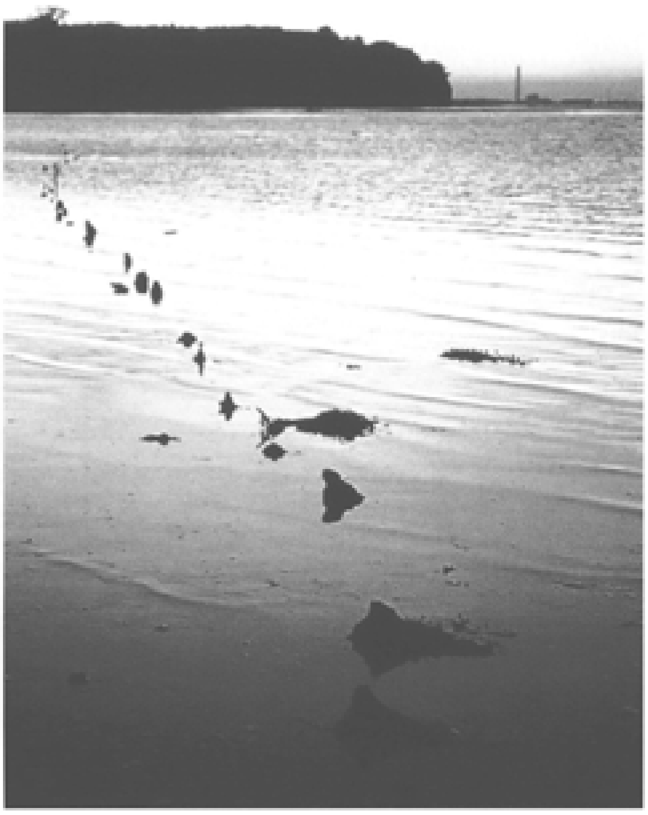


Fig 125 Wootton Haven, Isle of Wight: the natural processes of erosion threatening the prehistoric remains exposed in the intertidal zone are exaggerated by the wash created by large ferries (Copyright Isle of Wight Council)

result in obstruction or danger to navigation, or if the intended use of the works will result in similar obstruction:

a) construct, alter or improve any works below MHWS (mean high-water level of spring tides)

b) deposit any object or materials below MHWS

c) remove any object or any materials below MLWS (mean low-water level of spring tides)

Section 34 consents apply to the seashore, which includes the sea bed within the seaward limits of the territorial sea with the exception of the bed and shores of certain rivers. Section 4 of the Continental Shelf Act 1964 extended consent requirements for a) and c) to works throughout the continental shelf. On receiving an application, DOT may publish the details of the proposal and procedure for objections, and may require a local inquiry to be held. Conditions may be placed on the consent if it is granted. It is worth noting the general exception in Section 47 of the Coast Protection Act 1949, which provides that nothing in the Act or in any order made under it shall authorise or require any person to carry out any work or do anything in contravention of the Ancient Monuments and Archaeological Areas Act 1979.

The Transport and Works order-making procedure may apply to works which interfere with rights of navigation in waters within or adjacent to England and Wales, up to the seaward limits of the territorial sea. Specific details are set out in the Transport and Works (Description of Works Interfering with Navigation) Order, which lists the following works:

barrages
bridges
cables
land reclamation
navigational aids
offshore installations
piers
pipelines
tunnels
utilities structures

Further details of the order-making procedure are set out below in paragraph 8.4.14.

The Environment Agency has functions as a navigation authority and conservancy authority which were transferred to the NRA through the Water Act 1989 or Water Resources Act 1991. The British Waterways Board is generally responsible for managing inland navigation routes, but these include some tidal areas. Other relevant bodies include the Inland Waterways Association, which promotes commercial and recreational navigation, and the Waterway Recovery Group, a voluntary organisation committed to reclaiming derelict routes. Cooperation with such organisations may be necessary to safeguard coastal heritage in the estuaries that link inland navigation routes to the sea.

8.4.11 Oil and gas

Offshore oil and gas exploration and production are among the fastest-growing areas of expansion in maritime industry. This growth has direct impacts on the coast, as well as stimulating much onshore development.

Threats

These activities have potential consequences for archaeology in three areas: offshore installations, terrestrial or coastal developments, and pipelines connecting these two.

The effects of offshore installations could be limited in extent, but could amount to removal or disturbance of archaeological deposits on the sea bed through the fixing of the legs and anchor ropes of drilling rigs and other platforms. Operational activities, whether for exploration or production, can produce drilling waste, which is sometimes dumped on the sea bed, and archaeological remains could be affected.

Onshore activities frequently demand extensive construction, resulting in the potential removal, loss, exposure, and disturbance of archaeological remains.

Pipelines are generally laid on the sea bed in deeper water, sometimes covered by a protective layer of rock. These operations could result in the compaction or disturbance of archaeological remains. In shallower waters, and across the foreshore, pipelines are generally buried, and such construction works would involve the removal, disturbance or exposure of any archaeological remains. There are currently 12 landing points for offshore oil and gas.

Regime

The Mineral Workings (Offshore Installations) Act 1971 applies to specified activities which depend on the use of an installation which is maintained in the water or on the foreshore. The specified activities include exploitation or exploration of mineral resources, storage of gas, conveyance of things by pipes, and provision of accommodation. The 1971 Act applies to the shore or bed of 'controlled waters', which comprise tidal waters to the limits of territorial waters, waters in areas designated under the Continental Shelf Act 1964, and inland waters specified by statutory instrument.

The licences used to regulate oil and gas activity are issued by the Department of Trade and Industry (DTI). Licences are distinguished by the environment to which they apply and the type of activity that they permit. A distinction is made between seaward and landward areas, but the lines used to define these areas coincide only approximately with the coast, so an offshore project may be 'landward' and a land-based project may be 'seaward'. Licensees are granted exclusive licence and liberty to search for, bore for and get petroleum, according to whether the licence is for exploration, appraisal or development and production. A licence is contractual, and there is no further consent procedure as such. However, DTI sets out base conditions for applicants, which may include environmental constraints, when each round of licensing is announced (eg DTI 1994), and the licences themselves include conditions based on model clauses set out in regulations which cover work plans, consents, interference with navigation or fishing and so on. The principal industry organisation is the UK Offshore Operators Association, which has published general and specific environmental guidelines (UKOOA 1991; 1994).

The two principal acts applicable to pipelines at the coast are the Pipe-lines Act 1962 and the Petroleum and Submarine Pipe-lines Act 1975. Cross-country pipelines (>10 miles in length) cannot be constructed without the consent of the Minister in the form of a 'pipe-line construction authorisation'. Local pipelines (<10 miles in length) do not require consent, but the Minister must be given advanced notice of the intention to execute pipeline works (Pipe-lines Act 1962). Authorisations for cross-country pipelines and diversions cannot be granted unless the Secretary of State has taken environmental information into consideration (Electricity and Pipe-line Works (Assessment of Environmental Effects) Regulations 1990). Under Section 43 of the Pipe-lines Act 1962, the Minister and the person formulating proposals for pipeline works are expected to have regard to the desirability of protecting buildings and other objects of architectural or historic interest, and they must take into account any effect which the proposals would have on any such buildings or objects. They must have particular regard to the desirability of ensuring that things constructed in the course of the execution of the proposed works are kept below ground. Controlled pipelines (in, under or over the territorial sea and continental shelf) may not be constructed or used without written authorisation from the Secretary of State. There is no provision for environmental assessment of proposals for controlled pipelines, though *Development below low water* states that the environmental impact of pipelines linked to oil and gas development is included in environmental assessment of the whole development (DOE 1993c: see paragraph 5.9.4)

8.4.12 Rural development

Most of the land immediately above high water is rural, and subject to the same pressures as countryside further from the coast. Much of it has a high cultural value for aesthetic, historic, and environmental reasons, but it can often be very vulnerable.

Threats

Agricultural activities may remove, disturb or expose archaeological sites through ploughing and other operations. Associated activities such as the drainage of wetlands may desiccate archaeological sites. The planting of woodlands may cause damage as a result of the penetration of archaeological sites by tree roots, and may result in desiccation on wet sites. Other potential impacts may be caused by clearance, planting, felling, and removal.

Regime

The rural coastline is managed by several initiatives. Environmentally Sensitive Areas are designated parts of the countryside where landscape, wildlife, and historic features of national importance have been created by traditional farming methods. The ESA scheme is intended to support farmers who continue to use traditional methods by way of ten-year management agreements (MAFF 1994a). Several of the ESAs are specifically coastal or have substantial coastal components for which payments can be made. The ESA Division of MAFF is responsible for administering the scheme.

Countryside Stewardship is an initiative of the Countryside Commission undertaken in collaboration with English Nature and English Heritage. The coast is one of the types of landscape which may be subject to Countryside Stewardship agreements in respect of coastal fringe or cliff top pasture, saltmarshes, coastal grazing marshes, coastal heaths, sand dunes, and shingle grasslands. Protection of archaeological sites in coastal grasslands is also cited, and some of the prioritised historic landscapes may be located at the coast. Payments are available for specific coastal environments, notably sand dunes and saltmarsh, and other payments relating to the management of grassland, moorland, lowland heath, field margins, and access are also relevant (Countryside Commission 1994).

The Rural Development Commission was established by statute and is sponsored by the Department of the Environment (Rural Development Division). It advises the Government on economic and social matters that affect people living in rural areas, defined as areas of England that lie outside towns with a population of more than 10,000. Rural Development Areas are areas that have special social and economic problems, and are defined according to census and unemployment data; they cover much of the coast, and a number of towns on or close to the coast have been included on exceptional grounds (Rural Development Commission 1994). RDAs receive assistance through Rural Development Programmes and are Priority Areas for the Rural Development Commission. Notwithstanding the large amount of coastline within rural areas, the Rural Development Division of DOE and the RDC itself do not appear to pursue any specifically coastal policies. However, RDC is involved in some coastal initiatives, and some of the projects and programmes encouraged by RDC result in capital works or other impacts on the coast.

8.4.13 Telecommunications

Modern telecommunications systems still require the use of submarine cables in addition to satellites. British Telecommunications plc is the principal body laying and operating submarine telecommunications cables around the UK; it currently has 27 cables in use. Cable and Wireless (Mercury) also operates a few cables out of the UK. In addition, some cables run through UK waters without coming ashore in the UK. A considerable number of cables from states bordering the North Sea run along the English Channel to the Atlantic.

Threats

Archaeological impacts may arise from preliminary survey work, laying and maintenance of cable, and removal of disused cables. Preparatory investigation may involve intrusive survey of the sea bed, disturbing and exposing archaeological deposits, though also providing detailed knowledge of sea bed conditions. Cable technology moves very fast, and although cables are manufactured with a life-expectancy of 25 years they are regularly upgraded; all BT cables will soon be converted to fibre optic. Laying the cables involves burying them where they cross the foreshore and in shallow waters, potentially destroying archaeological remains. In deeper water submersible ploughs, running on tracks or skis and towed by surface vessels, are used for trenching, laying cable, and subsequent inspections, and the use of such machinery could damage sites on the sea bed.

Trawling and anchoring regularly, though infrequently, cause breaks in cables. Maintenance work could also disturb underlying archaeological remains.

Disused cables are retrieved, though in one case Cable and Wireless were asked by the National Trust to leave a cable because of its heritage value. Recovery operations would certainly disturb archaeological sites on the line of cable.

Regime

The International Cable Protection Committee promotes the safeguarding of submarine telecommunications cables against human and natural hazards. The committee also serves as a forum for the exchange of technical and legal information.

Section 11 of the Telecommunications Act 1984 gives operators the right, for statutory purposes, to execute works on any tidal water or lands for, or in connection with, the installation, maintenance, adjustment, repair or alteration of telecommunication apparatus. 'Tidal water or lands' includes any estuary or branch of the sea, the shore below mean high water springs, and the bed of any tidal water. Operators have an equal right to keep apparatus installed on, under or over tidal water or land, and to enter any tidal water or land to inspect such apparatus. The operator must submit a plan of the proposed works to the Secretary of State for approval before executing any works with respect to tidal water. The Secretary of State must decide whether to approve the plan, with or without modification, as soon as reasonably practicable, after consulting authorities with functions relating to the tidal waters or land in question. Agreement must be reached with the Crown Estate and Duchies if the work is to involve land in which the Crown has an interest. The Secretary of State must be satisfied that people with proprietary interests in the waters or land will be adequately compensated for any loss or damage arising from the works. Environmental assessment is not required for submarine telecommunication cables.

Fig 126 Whitewall Creek, Kent: jumbled mass of timbers derived from the post-medieval hulks disturbed in construction of a road bridge (Photo Jonathan Adams)

8.4.14 Transport

Threats

Construction of communication routes at or to the coast frequently involves major engineering projects, such as the building of roads in difficult or unstable coastal environments, or of bridges across river estuaries (Fig 126). New projects may be necessitated not only by increased traffic to the coast, but also by the changing configuration of the coastline, rising sea-levels, or coastal defence initiatives such as managed retreat.

The direct impact of such projects, as on dry land, will be through the removal or disturbance of archaeological remains in the areas of the coast and foreshore affected by the route, and by associated construction operations. In addition, construction may also have indirect effects as a result of alterations to existing patterns of drainage, water flow in rivers, or tidal currents, thus creating the possibility of removal or exposure of sites through erosion.

Regime

The Transport and Works order-making procedure was introduced to reduce the need for private and hybrid bills when engaging in significant construction work. The procedure is administered by the Transport Works Processing Unit of the Department of Transport (DOT). The types of work for which an order may be sought are set out in the Transport and Works Act 1992. Applications for orders must include an environmental statement, unless a waiver has been agreed in advance, and a statement of views from relevant local authorities. The applicant must also notify English Nature and the Countryside Commission, the Department of National Heritage if the work may affect an area restricted under the Protection of Wrecks Act 1973, and English Heritage and the RCHME if the work may affect a Scheduled Monument. Copies of the application and supporting documents (including the Environmental Statement) must be sent to relevant local authorities, to DNH in the case of a restricted area, and to English Heritage and the RCHME in the case of a Scheduled Monument or any other archaeological site.

The DOT is the highway authority for trunk roads and special roads (such as motorways). The county council is generally the highway authority for all other roads within their area. Complications arise for bridges carrying roads for which the DOT is not the highway authority and where the bridge approaches are in different counties. In such cases one authority becomes the highway authority for the whole bridge, either by agreement between the councils or by determination by the Minister. Both the DOT and local highway authorities may construct new highways and may provide and maintain new road ferries. Section 105A of the Highways Act 1980 requires that the DOT must determine whether the project falls within the scope of the Environmental Assessment Directive when considering the construction of a new highway or the improvement of an existing highway. If the project falls within Annex I (eg special roads) or Annex II the Secretary of State must publish an environmental statement. The threshold conditions which a road must cross to qualify for environmental assessment under Annex II are set out in the indicative criteria of Department of the Environment Circular 15/88, namely major road improvements over 10km in length, or over 1km in length through a National Park, or within 100m of a SSSI, national nature reserve or a conservation area.

The framework for managing railways is set out in the Railways Act 1993, which places an environmental duty on the Secretary of State and on the Rail Regulator. Railway lines are owned and operated by Railtrack through regional zones. Railtrack's Technical Support Unit maintains a national database of coastal track surveys. Lines for long-distance railway traffic are Annex I projects under 85/337/EEC for which environmental assessment is mandatory.

In England, major airports are not usually associated with the coast, but the availability of flat land, and the ability to reclaim land, give coastal locations certain advantages. There have in the past been proposals for an airport in the Thames Estuary, and there are plans for building an airport on the Severn Levels in Wales. Aerodromes with a basic runway length of 2100m or more are Annex I projects under 85/337/EEC, for which environmental assessment is mandatory.

8.4.15 Water quality and quantity

Water supply is for the most part a matter for inland areas, but there are particular concerns at the coast for the discharge of water and sewage, and the maintenance of water quality.

Threats

Discharge of foul water involves the construction of sewers, sewage processing installations and outfalls, and disposal at sea. Land-based processing installations often have a coastal location. Construction of sewage treatment facilities and outfalls may impact on archaeological materials on land and at sea in two ways; through the effects of onshore construction, similar to those of other development projects, and through the laying of offshore outfalls, as with other pipelines (see above, paragraph 8.4.11).

Four types of material have been dumped at sea: sewage sludge, dredge spoil, and solid and liquid industrial waste. The dumping of industrial liquid waste ceased in 1992 and dumping of sewage sludge will stop in 1998. The greatest amount of material dumped is dredge spoil (Davidson *et al* 1991) and there are a large number of licensed sites for its disposal. Most of this spoil results from excavations for the construction of docks, harbours, marinas and their access channels, and from other activities such as maintenance dredging. Disposal at sea of rubbish and dredge spoil may bury, compact, and distort submerged archaeological material.

Where dumping takes place close to shore, the material dumped may also affect patterns of coastal erosion and accretion. The cessation of dumping coastal mine waste in north-east England, which maintained beach levels, has led to loss of beach material (Carter 1988). Archaeological deposits along the coast are subsequently exposed and damaged or destroyed by increased erosion.

The effect of water quality (pollution) on archaeological resources may be a factor for the preservation of terrestrial, intertidal, and submerged archaeological sites. Pollution alters the chemical composition of water (groundwater and seawater) and soil. However, very little research has been carried out on water pollution and its effect on archaeological sites.

Regime

Water falls within the responsibilities of the Water Quality Division and the Water Resources and Marine Division of the Department of the Environment. The Environment Agency has functions in respect of water resources by virtue of Part II of the Water Resources Act 1991 and the Environment Act 1995. The Authority is obliged to take all such action that it considers necessary or expedient to conserve, redistribute, augment, and secure proper use of water resources (NRA 1993d). The Environment Agency also has functions with respect to water pollution by virtue of Part III of the Water Resources Act 1991 and the Environment Act 1995. Part III makes provision for water quality objectives, pollution offences (including discharges), precautions against pollution including water protection zones and nitrate sensitive areas, and codes of good agricultural practice (NRA 1993c). The provisions of Part III apply to 'controlled waters', which include ground waters (waters contained in underground strata), inland freshwaters (relevant lakes, ponds, rivers, and water courses to the freshwater limit), coastal waters (highest tide/freshwater limit to baseline, plus waters of any adjacent enclosed dock), and relevant territorial waters (baselines to 3nm). In all its operations, the Environment Agency has a statutory obligation towards the environment.

Water services are supplied to consumers by water and sewage undertakers, established under the Water Industry Act 1991. They are responsible for the extensive capital works introduced to comply with UK and European water quality standards, notably the Bathing Water Directive and the Urban Wastewater Treatment Directive. The undertakers have similar environmental duties to the Environment Agency under the Water Resources Act 1991.

A licence from MAFF is needed under Part II of the Food and Environment Protection Act 1985 (FEPA) for the deposit of substances or articles, or scuttling of vessels, in the sea or under the sea bed of territorial waters and the continental shelf. Certain deposits are exempt from the provisions of FEPA as a result of the Deposits in the Sea (Exemptions) Order 1985. MAFF must include in a licence such provisions as appear necessary or expedient to protect the marine environment, the living resources it supports, and human health, and to prevent interference with legitimate uses of the sea. MAFF may include in a licence such other provisions as it considers appropriate. MAFF may require the applicant to supply such information and permit such examinations and tests as may be necessary or expedient to decide whether a licence should be issued, and what provisions the licence, if issued, should contain.

8.5 Regional case studies

Natural processes and human activities vary greatly around the coast, and national policies need to be sensitive to local conditions. In order to illustrate this variability, and to examine some of the approaches to the management of coastal archaeology that have been developed, four areas of coast with varying configurations of physical geography and human usage were studied in more detail; Bridgwater Bay, Merseyside, the Wash and North Norfolk, and Cleveland and North Yorkshire. More details of the current state of archaeological knowledge of these areas can be found in the relevant sections of Chapters 6 and 7 above.

8.5.1 Bridgwater Bay

Bridgwater Bay lies on the south-west coast of England, on the southern side of the Severn Estuary. It forms the estuary of the river Parrett, with its northern limit marked by Brean Down and its western by Hinkley Point. It is characterised by estuarine conditions, with a broad area of sand and mudflats exposed at low tide. The coastline is formed by low cliffs, sand beaches, and sand dunes. At the southern side near Stolford there are areas containing stratified layers of peat. The Bay is generally subject to accretion; there is sand and shingle drift eastward into the bay, and the mud deposits are accumulating. However, there is also erosion along the cliffs at Hinkley Point, and dune erosion near Brean (Motyka and Brampton 1993). Storm surges at high spring tides can produce overtopping at Brean, and at the low-lying coast east of Hinkley Point.

The bay lies entirely within one county, Somerset, and within two districts, Sedgemoor and West Somerset. There are no major areas of residential or commercial development on the bay. The main focus of settlement is the town of Bridgwater, which lies inland on the river Parrett. At the south-western corner of the bay is the Hinkley Point nuclear power installation, and the area around it is managed as a nature reserve. The bay is important for its landscape and natural environment, especially for its bird life. It has been designated as a National Nature Reserve and a Ramsar site, and there are also two SSSIs on the coast, at Brean Down and Berrow Dunes.

Archaeology

The archaeological potential of the bay has been assessed by a rapid survey of the central and southern parts of the intertidal zone by the RCHME, which has confirmed the presence of a considerable quantity of remains, especially of structures related to fishing. The potential of the coastal zone is less well documented, apart from the excavations at Brean Down. The peat layers on the southern side of the bay, presumably the seaward extension of the deposits explored in the Somerset Levels, are likely to contain an important record of human impact on the environment.

Threats

The bay is generally an area of accretion, but there are localised pockets of erosion, which have led to the construction of sea defences, especially on the sandy eastern coast. Continued erosion poses a potential threat to the archaeological remains, and active erosion of the peat layers on the south coast has been observed. The stability of the remains recorded in the intertidal zone cannot be certainly established without monitoring over a longer period. The effects of future climate change are unlikely to produce significant changes in sea-level, but localised changes to wave and current patterns may be more important.

The coast of the bay is largely undeveloped. Port and harbour facilities are inland, at and near Bridgwater, which has been the focus for the development of associated industrial activity. Marina development has also taken place inland at Bridgwater. The effects of these activities on the coast are relatively slight; dredging to maintain the navigable channel has an impact, but it is limited in extent.

The major threat at the coast lies in tourism and recreation, which are economically important activities especially on the east coast. Beach recreation is intensive from Berrow to Brean, and the exposed sandflats are used for sand-yachting, horse-riding, and off-road vehicles. These activities put considerable pressure on the environment above the high-water mark and in the intertidal zone.

A tidal barrage across the bay has been suggested for tidal regulation, increased leisure use, and electricity generation. Its effects on the archaeological remains would need careful assessment.

Management

The Somerset Structure Plan Alteration No. 2 (Somerset County Council 1993) has no specific policy relating to the coastal zone as a whole, though the importance of the coast is recognised in several individual policies. It has designated Special Landscape Areas, some of which are located on the coast (including Bridgwater Bay, Brean Down, and Berrow Dunes) where development will be limited. Policies for development include restricting development to existing developed areas; similarly, tourism policies call for the enhancement of existing facilities but will not normally agree to new developments along stretches of undeveloped coast. Facilities for recreation will be enhanced, and access to coastal locations improved, but with regard to the landscape quality and the nature of the coast. Archaeology is included in the County Structure Plan with policies following the guidance of PPG 16, but there is no specific mention of coastal archaeology. The coastal district councils of West Somerset and Sedgemoor are currently developing their local plans; Sedgemoor has established an officers' coastal study group.

The dominant theme of management in the bay is nature conservation and the Management Plans for the nature reserve and SSSIs focus on flora and fauna located there.

There are also initiatives to place Bridgwater Bay in a wider planning context. The Severn Estuary Conservation Group addresses estuary-wide issues that may affect all areas of the estuary, such as water quality, development, and pollution. The Group publishes a newsletter, *The Severn Estuary Newsletter*, which highlights notable issues in the estuary such as aggregate dredging and other threats to nature conservation. The Somerset and South Avon Coastal Defence Group is currently planning a Shoreline Management Plan for the Somerset and South Avon coast.

Conclusions

The Bridgwater Bay area is typical of a considerable proportion of the English coastline. It is relatively undeveloped, and the major human threat comes from tourism and recreation. There is a high level of environmental awareness and active management for conservation, but archaeology does not figure prominently in the perception of the environmental values of the coastal zone. Current threats to the archaeological remains may not appear severe, but the nature of the archaeology has only recently been appreciated and there is no baseline and no series of observations from which to estimate the long-term stability of the resource.

Management plans for the most part do not recognise the coast as a zone requiring special consideration, but there are now initiatives in place which are seeking to coordinate coastal issues, especially at a scale larger than the individual district.

8.5.2 Merseyside

The Merseyside study area defined here includes the Mersey Estuary itself, and the adjacent coasts where it widens out into the open sea of Liverpool Bay. It stretches from the north Wirral coast to Warrington at the base of the estuary, and on the north side past Liverpool to Southport in Sefton. It is divided into an inner and an outer zone by the narrows between Liverpool and Birkenhead.

The natural processes of the area are dominated by the tidal currents of Liverpool Bay. Erosion is present along the open exposed coast, with some pockets of accretion resulting from redistribution of sediments from the estuary. The inner estuary experiences slower tidal flows, and sand and mud are deposited to form banks which are exposed at low tide. Within this section, the low-water channel shifts between the northern and southern banks, continually eroding and reworking the sediments, and preventing the growth and consolidation of intertidal banks.

The open coast beyond the narrows comprises mainly sand beaches and sand dunes. To the north of the estuary the Sefton coast has few concentrated settlements, and is characterised by disused agricultural land. The open coast in the north Wirral to the south of the estuary has a balance of settlement and undeveloped areas. The open coast is characterised by increasing tourism and recreational activities, and the growing importance of nature conservation. The inner estuary is dominated by tidal currents with sand and mud foreshore and beaches, and areas of marshland. Industry and commerce once flourished, especially along the northern shore, but have declined in recent years. Current initiatives have focused on attracting industry and commerce, and stimulating economic growth. There are also extensive areas of open land within the inner zone.

There are 2 National Nature Reserves, 1 Ramsar site, 3 local nature reserves, and 27 SSSIs in the area.

Archaeology

The most obvious features of the cultural heritage of Merseyside are the remains of its post-medieval maritime economy, including ports and harbours, warehouses, canals, and associated industrial development. There are several museums and other heritage attractions in the area with specifically maritime themes. Other archaeological periods are less well documented, though the observation of prehistoric footprints and stratified layers of peat off the Sefton coast suggests that there are considerable remains awaiting investigation in the intertidal zone.

Threats

There are pockets of active erosion in the area, especially on the open coast. Within the inner estuary the effects of the constant reworking of the sediments on any underlying archaeological deposits is not clear.

The major human threats affect two zones. Within the inner estuary the pressure for regeneration of the economy is likely to lead to redevelopment of the industrial areas, with potential impact through construction and its indirect impacts. On the open coast, the major pressure is from recreation and tourism, which are also seen as important factors in the economic future of the area.

There has been offshore exploration for oil and gas in Liverpool Bay, and substantial resources have been located which are now beginning to be exploited commercially.

Management

The main communication network for issues affecting the entire estuary is provided by the Mersey Estuary Project Group, which initiated the Mersey Estuary Management Plan. The plan contains policies for such themes as access, recreation, and tourism. It identifies landscape and townscape (LT) as areas of special concern, where its objective is 'to protect and enhance the quality of the built environment and areas of open coast adjoining the estuary'. Its policies include the following:

LT1 Partner organisations should seek to protect and enhance the quality of the built environment adjoining the estuary. Where new development is acceptable in locational terms, the form and scale of development which would be visible from viewpoints along the waterfront and from the river should respect the special character of the estuary.

LT2 Wherever possible partner organisations should seek to retain the estuary's waterfront heritage, including existing docks and water spaces and historic buildings and features, with opportunities for enhancement and appropriate reuse being promoted especially where these will help regeneration.

LT4 Subject to the natural dynamics of the estuary, partner organisations should seek to retain and enhance the remaining areas of natural shoreline and open land adjoining the estuary and its tributaries. Sites of geological, geomorphological or nature conservation interest, or which form an existing or potential natural sea defence, should be protected from development.

LT5 The character of the open coast and adjacent areas should be preserved and opportunities for landscape enhancement, creative nature conservation, and informal recreation should be promoted.

It should be noted that, although the built heritage is acknowledged, there is no mention of other archaeological remains.

Three of the local planning authorities have specifically identified the coastal zone as an area demanding special attention. Liverpool City Council defines a Mersey Coastal Zone in which special policies for development have been proposed. Sefton Borough Council has identified a Coastal Planning Zone within the Borough Structure Plan, in which the objective is 'wise' use of the Zone as a whole, including physiographic conditions and natural resources. Wirral Borough Council defines a coastal zone, and, within this zone, proposals for development will have to satisfy additional development control criteria, relating in particular to the preservation and enhancement of the character of the coast.

Sefton Borough Council, in conjunction with the Countryside Commission, initiated the Sefton Coast Management Scheme in 1978 (see Jones *et al* 1993). The project closely models the Heritage Coast style of management and employs a Project Officer to encourage a corporate approach between landowners and agencies, adopting a coordinating approach to coast-wide strategies. Key issues for conservation and land management include specific reference to archaeology.

Conclusions

The Mersey Estuary comprises two very different types of zone, one characterised by previous industrial development where future threats are likely to be from redevelopment, the other by open countryside where recreation and tourism combine with natural processes to pose the main threat. There is a high awareness of the need for environmental conservation, but the extent and importance of the archaeological part of the cultural heritage have not been fully documented. Nevertheless, there are management initiatives which would make possible the incorporation of archaeological objectives. The Mersey Estuary Management Plan is an integrated and zonal approach to CZM, but does not at the moment explicitly affirm the importance of archaeology. On a smaller scale, some of the planning authorities have adopted a specialised approach to the control of development along the coast, and the Sefton Coast Management Scheme is an interesting example of the integrated consideration of coastal issues. All these projects would facilitate the consideration of archaeological concerns in an appropriate framework.

8.5.3 The Wash and the north Norfolk coast

This study area lies on the east coast of England, and includes the coastline from Gibraltar Point at the northern limit of the Wash, around the sides of the Wash itself and eastward along the Norfolk coast to Sheringham.

The coast of the Wash comprises low-lying land reclaimed from the sea, fronted by saltmarshes, and defended by multiple banks. Accretion is occurring widely, with siltation by current-borne sediments enhanced by alluvial deposits discharged by rivers. Saltmarsh colonisation is in progress, particularly on the west and south margins of the Wash.

To the east of the Wash the coast is formed of sand dunes and mudflats, with low chalk cliffs at Hunstanton. Further east still, the coast is highly varied. The barrier island of Scolt Head and the shingle spit of Blakeney Point protect much of the coast and have generated a varied environment of intertidal flats, saltmarshes and sand dunes. The coast here is generally accreting, with sediment derived from the erosion of the low sand and clay cliffs around Weybourne and Sheringham to the east.

The coast is largely undeveloped. There are ports at Boston and King's Lynn on the Wash, and smaller quays along the Norfolk coast. Other settlements are mostly small. There is little industrial development away from these sites, and the dominant coastal activities are tourism and recreation; the whole area, and in particular the eastern Wash and the Norfolk coast, is the location for a wide range of beach and aquatic recreation.

The area lies in two counties, Lincolnshire and Norfolk, and seven districts. There are many designated areas for nature conservation. The North Norfolk coast is an AONB and a Heritage Coast.

Archaeology

The coastline of the Wash is a product of the most recent phases in a long sequence of land reclamation starting in the Roman period, and has little archaeological significance. The areas of archaeological interest related to human occupation of the coastline of the Wash, and its history of reclamation, now lie inland behind the defences.

Archaeological material has been found sporadically along the Norfolk coast, but much of it has been derived from the erosion of originally terrestrial sites on top of the low cliffs.

Threats

Because of the extent of accretion and reclamation, the threats to the archaeology of the past coastline of the Wash are now terrestrial rather than marine; agriculture, development, and drainage are the main threats to the archaeology of such a wetland environment (Coles 1995). A coastal threat would occur only if long-term sea-level rise exceeded current defences and was not matched by adequate improvement and heightening, or if a deliberate policy of managed retreat was adopted. Current predictions suggest that such a rise is unlikely, at least before the latter part of the next century.

The most critical threat on the Norfolk coast is the erosion of the low cliffs near Sheringham; elsewhere, despite localised pockets of erosion, the general pattern of accretion tends to protect the archaeological remains. Long-term sea-level rise will accelerate the process of erosion, but its detailed effects elsewhere are not so clear.

The main impact of human activity is through tourism and recreation. The development of tourist-related facilities and the pressure of visitor numbers will cause erosion and loss of the archaeological record.

Management

Management responses have been developed at the level of county and district authorities, through multi-agency forums, and through integrated approaches to specific zones.

Lincolnshire County Council has adopted an alteration to the structure plan which has policies specifically for the coast, for protecting the conservation value and tourism value of the area. King's Lynn and West Norfolk District Council identifies the coastal zone in the local plan and defines it as extending seaward and landward of the coastline; its limits have been determined on the basis of the geographical extent of natural coastal processes and human activities. It extends seaward to the low-water mark and the landward extent is plotted on the proposals map. Specific policies have been developed for this zone.

At a larger scale, the Wash Estuary Strategy is being developed by the County Councils of Norfolk and Lincolnshire and others to provide a forum for discussion of issues in the Wash and to produce a strategy for the management of the Wash Estuary. The objectives of the strategy are to provide a framework in which the distinctive landscapes and archaeological and historic features, among others, are safeguarded.

The Norfolk Coast Project provides the major network for communication for the area of the North Norfolk AONB between coastal landowners, conservation groups, and local and national agencies. It thus has interests that extend inland away from the coast, but it has taken over the management of the overlapping Heritage Coast. The Project is a partnership between individuals, local authorities, statutory agencies, conservation organisations, industry, and other interested groups (Norfolk Coast Project 1994), and acts to highlight issues and disseminate information to interested bodies, and to coordinate management approaches at the coast. It is consulted by the Wash Strategy Working Group. The priority of the project is visitor management and it provides a coordinating role in developing a common approach to coast-wide visitor management issues. The objectives of the project are:

- to conserve and enhance the natural beauty of the Norfolk coast
- to facilitate and enhance the public's enjoyment, understanding, and appreciation of the area
- to promote sustainable forms of social and economic development that in themselves conserve and enhance the area's natural beauty

To manage this area a Visitor Management Strategy has been developed, which aims to complement statutory planning documents such as the Structure and Local Plans of the County and District Councils and other policy documents. The Norfolk County Archaeological Section is represented on the Norfolk Coast Project and has contributed to the Visitor Management Strategy.

The Project has drafted specific policies for archaeology:

A1 continue to use the planning process to avoid damage to archaeological sites from visitor-related development

A2 ensure that archaeological sites vulnerable to visitor pressure are adequately monitored, with follow-up action where needed

A3 develop interpretation to raise visitor awareness and enjoyment of the AONB's archaeology

A4 promote responsible use of metal detectors and encourage the reporting of all archaeological finds

A5 encourage those participating in sub-aqua to liaise with Norfolk Landscape Archaeology over any discoveries of wrecks or finds

Conclusions

Although this stretch of coast is mostly low-lying, the threats to archaeology are highly variable, depending on the local details of the historic development of the coast, the provision of coast defences, the current pattern of erosion and accretion, and the nature of the local economy. Management responses have developed at several levels; there is explicit recognition of the special needs of the coast, and archaeological interests are represented in management groups in a way which has enabled the development of appropriate policies.

8.5.4 Cleveland and North Yorkshire

This area is on the north-east coast of England and extends from Hartlepool in the north to Bridlington in the south. At the northern limit the coast is low-lying around Hartlepool and the Tees Estuary with sand dunes and intertidal peat deposits. The mouth of the Tees itself has mostly been reclaimed for port and industrial purposes. This area is subject to some erosion, with southward drift and accretion at the mouth of the Tees.

Further south, from Saltburn to Bridlington, the coast is mostly formed by cliffs of clay and shale, with chalk at Flamborough Head. There are several small bays. The whole of this coast is subject to erosion, with no significant accretion.

There is extensive urban and industrial development in the north at Hartlepool and the Tees, with smaller towns such as Whitby and Scarborough to the south. Otherwise the coast is predominantly rural, with tourism representing an important element of the local economy.

The area lies in two counties, North Yorkshire and Cleveland, and six districts. The North Yorks Moors National Park extends to the coast here, and there are two designated Heritage Coasts, North Yorkshire and Cleveland, and Flamborough Head, as well as several SSSIs.

Archaeology

The northern part of this area formed part of a detailed survey of coastal archaeology undertaken by Cleveland Archaeology Section, in collaboration with Durham County Council, North Yorkshire County Council, North Yorks Moors National Park and the RCHME; over 2000 sites were identified (Buglass 1994). Further south, the predominantly cliffed coast means that coastal remains are limited to the small bays, though terrestrial archaeological sites occur on the clifftops.

Threats

The threats in this region are sharply divided. In the northern region the low-lying coasts are exposed to some erosion, but the potential impacts of urban regeneration are much more important; the decline of traditional heavy industry has produced considerable pressure to redevelop. Further south cliff erosion poses the major threat.

In 1991 a licence to explore for hydrocarbons was issued for a block adjacent to Bridlington Bay and Flamborough Head. An environmental statement was prepared, which included the submerged archaeological remains in the area.

Management

The management needs of the environment have been recognised in several different ways, though coastal archaeology is incorporated to a variable extent.

Policies for archaeology have been included in structure and local plans and Heritage Coast management plans, but there are no policies specifically for coastal archaeology. Humberside County Council and some of the district councils identify the coast as a zone for special policies, but again there are no policies specifically for archaeology. Cleveland County Council and the four district authorities have combined to produce a draft of a Cleveland Coastal Zone Management Strategy.

The Industry and Nature Conservation Association (INCA), a joint initiative by industry, local authorities, and English Nature, consists of a small expert team with experience in both industry and conservation, a Board representing local business and conservation interests, and a broader-based steering group providing policy direction. The overall aim of INCA is to ensure that industry and nature exist and grow in harmony so that the public may benefit from prosperity in an improving environment. It has undertaken a fundamental review of the state of the environment on Teesside and will be coordinating a Tees Estuary Management Plan.

Conclusions

This area illustrates very clearly the different types of human and natural threats, and the different types of landscape and archaeological resource exposed to them. It also emphasises the need for consideration of the detailed local conditions before the effects of long-term and large-scale processes can be properly estimated.

8.6 Conclusions: problematic issues in managing England's coastal heritage

8.6.1 Complexity

A striking feature of coastal management in England is the complex blend of organisations which may be involved in any given issue. Each section of the coast may involve activities by central government and agencies, local authorities at county and district levels, harbour authorities, development corporations, committees and forums, private companies, industry groups and professional associations, and an extensive range of non-governmental organisations. The lead organisation in each case may be a proponent or an arbiter, may represent a broad public or a narrow interest, and may have acquired its role through expertise or historical accident. In many respects, mastering the institutional dynamics of coastal management in respect of a particular issue or area will be the key to managing England's coastal heritage successfully.

Local complexity also occurs in statutes and policy documents. Statutes with general application may include schedules which contain details of local relevance, or refer to secondary legislation such as regulations and orders that are set out in statutory instruments. In addition there is an extensive range of local acts applicable to harbours, navigable waterways, and major constructions. Tiers of statutory plans and other planning documents are frequently overlain by many different management plans, strategies, and initiatives which overlap both functionally and geographically. Consequently, the particular statutes or documents which contain powers or policies impinging on coastal heritage, and the work of archaeologists, will be different from one stretch of coast to another.

Although coastal management is split between many organisations, there are certain key players in central government (notably MAFF, DOE and DOT) and among the national agencies (ie English Nature, the Countryside Commission, and the Environment Agency). However, the precise involvement of these organisations is far from straightforward. First, although one organisation may be responsible ultimately for a number of regimes, the offices that are involved within those organisations may be quite separate (see Table 7). Second, the geographical structures of national organisations also vary considerably, some being highly centralised whereas others operate through a diffuse regional structure. Third, the degree of integration across functional and geographical divisions also varies from one organisation to another.

There is no single model for coastal management around England, because the issues, initiatives, principal bodies, frameworks, and procedures vary from one stretch of coast to the next. Guidance on managing England's coastal heritage can be offered only in broad terms, because the details of implementation can vary so markedly. Examples of best practice can be identified and publicised, but further application of such examples must be sensitive to local circumstances. Complexity can be 'managed', however, by addressing local circumstances explicitly. An appraisal that identifies the local, national, European, and international webs that enfold coastal management in a particular area will form the surest base for effective archaeological strategies.

8.6.2 Boundaries

Archaeologists must become familiar with the many boundaries that cut across the coastal zone, and with the status of the segments so divided. Each of the regimes discussed above cuts the coast according to a different principle with a different purpose. In addition to jurisdictional boundaries, there are ownership boundaries and special area designations. The limits of each will have to be sought separately. Archaeologists must also have an awareness of the boundaries that cut the sea horizontally; boundaries tend to address the sea's surface, the water column or the sea bed, but rarely all three. Such complexity has appreciable implications for introducing a consistent and comprehensive archaeological input to the consent procedures concerned. The continuing complexity of boundaries seems unlikely to change, especially given the Government's reluctance to extend local planning authority jurisdiction.

8.6.3 Curatorial responsibility: central versus local

The discussion above has emphasised the involvement of both national and local agencies in the management of the coast. For archaeological concerns on dry land the planning system exercised by local planning authorities plays a critical role in archaeological preservation, through development plans and development control procedures. District and county authorities have consequently emerged as a prime focus for archaeological expertise and management information. The archaeology of the supratidal and intertidal zones can also benefit from such protection in so far as any threats to it fall within the definition of development; local authorities are also heavily involved in the rapidly growing field of integrated coastal zone management. But there are also some key issues where the lead responsibility lies with centrally organised national bodies, such as coastal protection, flood defence or some harbour works. In these cases there is a risk of a disjunction between the lead agency and those with curatorial responsibility for archaeology.

This problem becomes particularly acute in the subtidal zone beyond the limits of planning authority jurisdiction, where the sectoral approach to permissions is adopted. The 'central versus local' question was a key issue in the deliberations of the House of Commons Environment Committee, and in the Government's responses. Although the Environment Committee, drawing on a strong body of opinion, favoured the extension of local authority control over the coast, the Government rejected the option in favour of the central, sectoral approach. This preference suggests that consent procedures will focus on views and information provided by the central archaeological agencies.

However, archaeology is managed on a quite different basis. Although English Heritage is a statutory consultee in respect of some procedures, its role is usually limited to works which impinge upon Scheduled Monuments, and the real focus of curatorial advice lies with the archaeological officers of local authorities. Although this is not a problem as far as the Town and Country Planning process is concerned, it presents a dilemma for consents determined centrally. On the one hand, English Heritage may have to develop a role at the coast which runs contrary to its policy for land archaeology, and for which additional resources will be required, and on the other hand, central government offices may start to contact local authority archaeologists directly. Whereas local authorities have a clear interest in sectoral proposals that are close to the shore, they have a less obvious interest in matters out on the continental shelf, even though proposals pass through the same procedure. Diminishing interest with distance from the shore will also be reflected in local authorities' ability to give a considered response to proposals, and in the share of resources that they can commit.

8.6.4 Coastal environments

The coast is a demanding environment; steep cliffs, sharp rocks, and soft muddy shores fringe waters which move capriciously over hidden shoals under the impetus of weather and tide. Coastal management is similarly demanding, and has to be navigated skilfully to make the trip successful. Charts and pilots are essential and there is plenty of advice available, but none of it can tell archaeologists where they want to get to. Archaeologists should be aware of coastal management, but their aims and objectives have to be established beforehand lest they be swept away on a flood tide of paper. There is currently a high level of awareness of archaeology among non-archaeological coastal managers, and a sympathetic response to its needs, but the archaeological profession needs to respond with clear priorities and well supported arguments.

Carefully directed archaeology can make a significant contribution to coastal management, not only in terms of data about coastal change and the presence or absence of settlements, or in providing an additional attraction for tourism, but in answering questions about what is it like to be human on the edge of the sea. It is, after all, the human dimension of the coast – life, livelihood, and environmental responsibility – which has motivated recent efforts to improve coastal management. Archaeologists could try to bring their perspectives about how previous generations dealt with the sea to bear on contemporary issues, not as models for action, but as general illumination. Arguably (and without relying on precarious cross-cultural comparisons) the people involved in all of the regimes listed above will face some problems and pleasures which were familiar to people who lived and worked on the same coasts in earlier times. Such common concerns can be emphasised in discussing the relevance of archaeology at the coast, and the need for broad participation in the management of coastal heritage.

Although the basis for introducing archaeological research into management must respect local circumstances, the landscape assessments highlighted in PPG 20 offer an approach that has general relevance. Landscape perspectives on peoples' engagement with their coastal environments could raise questions which are directly relevant to preservation, to the enjoyment and knowledge of the public, and to the enhanced appreciation of the coast by people who live and work there. In short, a clear research agenda is fundamental to managing England's coastal heritage, and to coastal management as a whole.

Table 7 Responsibilities of central government offices

DEPARTMENT	DIVISION	IMPLEMENTING PROCEDURE OR ORGANISATION
Department of Transport	Ports Division	Section 34 consents; harbour revision orders; harbour by-laws etc
	Costguard Agency	Receiver of Wreck; Marine Pollution Control Unit
	Railways I Directorate	Railtrack; Office of the Rail Regulator
	Urban and General Directorate	Transport and Works Processing Unit
	Highways, Safety and Traffic	Bridges and crossings
Ministry of Agriculture, Fisheries and Food	Flood and Coastal Defence Division	Grant memoranda; strategic guidance
	Fisheries Division I– IV	Shellfish; fishfarming; harbour grants; conservation measures; vessel licensing etc
	Marine Environment Protection Division	FEPA licensing
	ESA Division	Environmentally Sensitive Areas
Department of the Environment	Countryside Division	Countryside Commission; Coastal Policy Branch
	European and Migratory Wildlife Division	English Nature
	Planning Divisions	Statutory plan and development control policy; PPGs, RPGs etc; Planning Inspectorate
	Minerals Planning Division	Coordination of Government view
	Water Sponsorship and Navigation Division	National Environment Agency; inland navigation
	Water Quality Division	Water quality directives; discharges of water; water quality objectives
	Environment Protection Group	Her Majesty's Inspectorate of Pollution
	Water Resources and Marine Division	Coordination of marine environmental policy
	Rural Development Division	Rural Development Commission
Department of Trade and Industry	Electricity Division	Generating stations and facilities
		Transmission cables
	Oil and Gas Division	Landward and seaward licensing
	Telecommunications and Posts Division	Consents for telecommunications cables
Ministry of Defence	Territorial Waters Office	Baselines, delimination
	Defence Lands Service	MoD property; conservation
	Hydrographic Office	Survey and charts
Department of National Heritage	Heritage Division	English Heritage; RCHME; maritime archaeology
	Tourism Division	English Tourist Board; Regional tourist boards
	Sport and Recreation Division	Sports Coucil
Cabinet Office	Office of Science and Technology	NERC laboratories and institutions
Department of Employment	Health and Safety Executive	Offshore Safety; Health and Safety at Work

9 Potential and priorities

by M G Fulford and T Champion

9.1 Introduction

The study of the archaeology of the intertidal zone has drawn heavily on the NMR, county SMRs, and evaluation of the published record. The strength of this record is that it has provided us with the basis of a national overview of the archaeological resource, but it contains two fundamental weaknesses. Firstly, the majority of the records for both the prehistoric and the historic periods contain data of poor quality; a major problem here is the failure to identify closely the context of finds, so that it is often difficult to distinguish between those from in situ contexts in the intertidal zone and those from, for example, eroding cliffs. Equally, a great many records fall far short of what is now expected in terms of identification, a problem which is particularly critical for the prehistoric period. Conceptually, too, the interpretive framework can be seen as an extension of that applied to land-based archaeology, with little consideration of what might be related to specific coastal or marine activities and installations such as fishing, boat-building, wharfage, etc. The well preserved coastal site surveyed at Tollesbury Wick Marsh, Essex, provides a good example of a site whose date and function are unknown (RCHME 1995) (Fig 127). Secondly, and much more seriously, there is the concentration of records in the prehistoric (Mesolithic to Iron Age) and Roman periods. Medieval and post-medieval records are scarce enough not to warrant the regional treatment given to prehistoric and Roman finds in Chapter 7. Thus, in the absence of entire categories of coastal monuments and sites such as flood and sea defences, or seaside and harbour architecture, and of coastal industries such as fishing, ship-building, and leisure, there is insufficient data with which to begin to characterise England's coastal heritage. As we have seen, Cornwall is the only county to draw systematic attention to its small ports and harbours in its SMR. Indeed, it was a general concern about the coastal and intertidal record which led to the initiation of this review (cf RCHME 1993a).

Our study has, however, significantly benefited from the results, usually of an interim nature, of a number of current or recent surveys of the intertidal zone which have drawn attention to its archaeological potential. The special value of these surveys in combination is that it has been possible to gain a much clearer insight into the range of archaeological sites and monuments in the intertidal zone, particularly those related to marine or coast-specific activities. Evidence of structures related to fishing, for example, appears for

Fig 127 Tollesbury Wick Marsh, Essex: a) Earthwork survey of coastal site of unknown date and function (RCHME 1995, fig 6); b) Interpretation of a) (RCHME 1995, fig 8)

the first time in surveys undertaken since the 1980s. Taken individually, it is striking how variable, whether implicitly or explicitly, the scope of each survey has been. Thus the North-east Maritime Archaeology Survey has concentrated on the industrial archaeology of the early modern and modern periods, whereas there is very little in the Hullbridge Survey which post-dates the late Iron Age/early Roman period. The Whitewall Creek Survey was explicitly concerned with the recording of barges and hulks. On the other hand, the Wootton Quarr survey has taken a more holistic view, with the archaeological record embracing the Mesolithic/Neolithic to the early modern period. The overwhelming emphasis of all this recent work has been on the intertidal zone, where the threat has been perceived to be the greatest, but little attempt has been made to understand how development pressures, for example, are affecting the archaeological and architectural resource immediately inside the sea wall, or at those points on the coastline where the present land surface is eroding.

In assessing the state of the archaeological resource for each period, contributors have drawn attention to the dichotomy between evidence for coast-specific activities and for terrestrial settlement adventitiously exposed in the intertidal zone. Although it is clear that the greater part of the record from the later medieval period onwards does indeed relate to coast-specific settlement or activities, some uncertainty surrounds the status of earlier material. Since our ignorance of the extent of shoreline retreat from the Mesolithic onwards is a recurring theme, it is perhaps unwise to assume that settlement evidence of prehistoric, Roman or early medieval date revealed in the intertidal zone derives from terrestrial rather than shoreline settlement, until a clearer understanding of nature and context has been obtained. Indeed, our uncertainty about such a fundamental issue as the relationship between settlement evidence exposed in the intertidal zone and its contemporaneous coastline draws attention to the urgent need to try to advance comprehension in these matters.

The remainder of this chapter will be concerned with four themes; firstly with indicating the academic issues where there is the greatest urgency to take survey forward, secondly with a methodology for prioritising for risk, thirdly with a strategy for management of the coastal zone, and fourthly and finally with the development of a strategy for survey.

9.2 Period-by-period review

9.2.1 Prehistory

The Palaeolithic

Finds of Palaeolithic date are rare in the intertidal and coastal zone and no site has yet been able to inform us about coastal occupation. The overall importance of Early Upper Palaeolithic occupation sites such as Kent's Cavern (Devon) and Kirkhead Cave (Cumbria) cannot be overstated, but the greatest potential lies with the Late Upper Palaeolithic sites such as Hengistbury Head (Dorset) and Titchwell (Norfolk). The Devensian deposits which have produced end scrapers, burins, and backed knives require further exploration. The potential of the archaeological resource for the Palaeolithic is also being explored by the English Heritage-sponsored Southern Rivers Project.

The Mesolithic and later prehistory: the submerged forests and peats

General

Although a significant number of the submerged forests date to *c* 3800 cal BC, exposures of the forests and the peats typically range in date between *c* 4900 cal BC and *c* 1200 cal BC. Submerged forests contain a potentially very rich resource of artefactual, structural, and environmental evidence relevant to a number of issues. Although comparable evidence can be found inland, for example in wetlands such as the Somerset Levels and the Fenland, these are prone to desiccation resulting from drainage schemes and to widespread destruction from peat extraction and agriculture. The greatest incidence of this type of resource is in the Fenland itself, and in major river estuaries such as the Humber, Severn, and Thames. Altogether, there is an unquantified resource in an unknown state of preservation sealed beneath post-Flandrian alluvium bordering those estuaries. The depth of this alluvium is such that it is generally beyond the resources of modern archaeology to investigate it satisfactorily or to monitor it during the course of development. In the intertidal zone this evidence is exposed from time to time without the necessity for deep excavation, but it is undergoing erosion at rates which are as yet unquantified.

A further dimension of the peats and submerged forests is that they become more coast-specific after the main phase of post-Flandrian sea-level rise. Whereas it is not always easy to establish the relationship of Mesolithic or other early prehistoric peats and submerged forests with their associated coasts, this becomes a little more evident in later prehistory.

Submerged forests and peats can contain a rich resource of biological evidence relevant to issues of extinction and introduction, and thus the interaction between people and plant and animal communities. In the west of Britain, where acid soils mean that animal bones are often only preserved on coastal prehistoric sites, finds of aurochs' bones and of other wild, sometimes extinct, animals are numerous.

At the outset there is much to commend a national base-line survey of the peats and 'submerged forests' of England. The resource has never been systematically mapped or quantified, nor has its potential been assessed against a standard set of agreed criteria to determine priorities for further study. A second level of study would involve the preparation of base maps of individual selected exposures which would provide a framework both for the monitoring of erosion and for the recording of new discoveries. Some priority areas for assessment are listed below and identified in figure 129.

Hunter gatherer/agricultural transition
Significant numbers of submerged forests date to around *c* 3800 cal BC and have the potential for addressing the problem of the hunter-gatherer/agricultural transition. Many of them have produced lithics and charcoal. Environmental investigation of key sites needs to be carried out in order to establish whether the charcoal is the result of natural fires, local hearths or more widespread manipulation of coastal environments by Mesolithic communities, as has been documented in the very different context of some British uplands. The extent of this evidence, and of late Mesolithic coastal activity, requires evaluation. The preservation of biological evidence on these sites makes them particularly promising in the context of evaluating people/environment relationships at the time of the transition to agriculture. The environmental evidence would contribute to evaluation of the following issues:

- were there sedentary late Mesolithic communities in selected coastal contexts? were they manipulating their environment, and to what end?
- to what extent is there evidence of continuity or change in natural or manipulated environments *c* 3800 cal BC?
- is there evidence of significant natural environmental change during this period?

Later prehistory
An important aspect of the period between the Early Neolithic and the Iron Age is the possibility of recovering well preserved structural evidence associated with contemporary land surfaces from the intertidal zone. The evidence from the Stumble (Essex) indicates the potential that a drowned 'dry land' landscape not otherwise disturbed by subsequent cultivation offers for understanding Neolithic exploitation and settlement. Similar potential exists for the Mesolithic along the Essex coast. For understanding structures, settlement, and exploitation of Bronze and Iron Age date in a 'wetland' and coastal environment, both the Hullbridge Survey of the Essex coast and the recent work at Goldcliff (South Wales) in the Severn Estuary demonstrate considerable potential. Although Goldcliff appears to represent a specialised settlement exploiting an estuarine environment, the Stumble has produced little indication of a coastal or marine aspect. Nevertheless, because of the preservation of the associated land surface, it is an important contribution to our evidence for a period where little of comparable quality survives from 'terrestrial' sites.

For later prehistory and the historic period there is some evidence for episodes of particularly marked environmental change which may relate to climatic episodes. From the literature, the Iron Age appears to have been a period of particularly dramatic change in coastal environments when peats were buried by estuarine clays. It is important to establish whether these changes are reliably dated, and the extent to which they are synchronous from region to region.

The clear incisions made when ditch systems have been cut through peat surfaces into the underlying alluvium have proved remarkably susceptible to discovery by aerial and also ground-based survey. Information about the existence and extent of ditch systems which have drained alluvial wetlands is crucially important to our understanding of their exploitation in the historic period, and perhaps also in later prehistory. It would be reasonable to search for this evidence at all locations where alluvial wetlands have been subject to erosion.

9.2.2 Roman

Despite the ubiquity of artefacts of Roman date in the intertidal zone, there is little that can be written about the nature of coastal settlement, its interrelationship with the sea, and the exploitation of marine resources. To give one example, although oysters are a distinctive attribute of settlement inland, the evidence for their cultivation is non-existent, and there is no means of gauging its impact on coastal settlements. Was the practice relatively localised, or spread widely along the coasts? The study of the fish and shellfish remains from the midden at Leigh Beck on Canvey Island, Essex, indicates the potential for the identification and characterisation of comparable sites around the coast.

Salt is even less visible as a product, although distinctive traces of its production can be found at numerous locations of late Iron Age and Roman date along the east and south-east coasts. We know surprisingly little about the context of salt production and its relationship with settlement; more problematic still is the apparent decline in evidence for salt manufacture after the second century AD. Is there a real decline, with production perhaps concentrating outside Britain, or is it that methods of production changed so that the process becomes less visible archaeologically? Metal vats, for example, may have replaced ceramic containers and the use of flues and kiln-like structures. The relationship between salt production and potting, which is particularly well attested on the north Kent coast as well as around Poole Harbour, Dorset, also remains to be explored.

Traded artefacts, both continental in origin like terra sigillata, or Romano-British such as Colchester mortaria or Dorset BB1, show the importance of cross-channel and coastal trade, but the frequency and character of ports are unknown. Although evidence of harbour works has emerged at London and at some major military sites such as the legionary fortresses, there is a distinct lack of information from other, particularly civilian, settlements. Even at some of the best known Roman coastal installations such as the late Roman Saxon Shore forts there is a dearth of evidence. It is, therefore, critically important to determine the extent to which coastal traffic and trade lay outside the control or influence of the army, as well as to characterise the military contribution. In this context it is important to establish whether the type of port or wharfage facility constructed in civilian settings differed from those with a military association. At the same time, the degree to which trade and supply was channelled and controlled through London needs to be assessed, and the difference in the scale of provision of port facilities at different locations may prove to be a critical indicator. The question of the importance of individual coastal locations is particularly tantalising in those situations where they are linked to the hinterland by known roads, especially in East Anglia or the Wirral, where Roman roads have been traced to the coast, but without any evidence so far recorded of terminus settlements on the shore. Much has been destroyed by coastal erosion, as the intertidal finds make clear, but the extent of this loss has yet to be defined.

Superficially, much of the evidence of Romano-British date from the intertidal zone appears to have a distinctive character, but this requires much better characterisation, in the context of an assessment of the role of the sea for navigation and of the extent of marine exploitation for the production of food resources, salt, and consumer goods such as pottery. One outstanding aspect of the record so far is its apparent selectiveness: many sites are known only as collections of coins which do not seem to represent dispersed hoards, and others are known only as pottery scatters. On the face of it, there seems to be a clear difference between Essex findspots, which are largely represented as salt-making sites without much other settlement evidence, and those from north Kent, which may include evidence of settlement, pottery, and salt-making. However, such differences may be more apparent than real.

In addition to exploring the evidence relating to maritime activities, it should also be recalled that the intertidal zone has provided important evidence about the exploitation of alluvial wetlands in the Roman period. The potential for discovering other ditch systems comparable to those discovered off the Wentlooge Level in South Wales, etched into the surface of peat exposures, remains to be explored elsewhere around the shores of England.

9.2.3 Post-Roman: Saxon and medieval

The most striking aspect of the record for post-Roman archaeology in the intertidal zone is its apparent rarity. In most other respects, the need to understand the nature of coastal settlement and its relationship with the sea is comparable to that identified for the Roman period. In this case, given the relative scarcity of Anglo-Saxon material culture in comparison with the Roman period, the problem of advancing our understanding is much more acute. It is perhaps not surprising that so little of this date has been recognised in the intertidal zone. However, the fact that multi-period sites, such as that at Canvey Island, Essex, have been identified, serves to highlight the potential of the archaeological resource for this period in the context of systematic survey. The problem is even more acute in the western half of Britain in the fifth to the eleventh centuries because of the overall lack of material culture that can be assigned to this period. This adds urgency to the need to identify and date threatened timber structures such as wharves or quay structures, revetments, and structures related to fishing and salt production. These may prove to be our most helpful indicators of coastal activities, including the character of coastal and overseas traffic and trade for the period.

Our difficulties are, of course, compounded by the abundance of evidence from documentary sources for the loss of settlement, particularly around the eastern and southern shores of England, between the late thirteenth and the sixteenth century, which has presumably destroyed much of the record of earlier settlement. Despite the scale of destruction implied by the written sources, the material record is almost non-existent. Thus we have no clear idea of the scale of individual settlement loss, nor of the nature of the remedial action taken and the rate and character of replacement settlement on the coast. As with the selectivity of the record for earlier periods which we have noted above, the absence of evidence may simply reflect the fact that it has not been sought. Until we have a clearer picture of the evidence for medieval coastal settlement, it will not be possible to address the range of issues which have been identified for earlier periods. In addition, the medieval period presents us with the distinctive challenge of attempting to understand the transformations and readjustments of settlement and the wider coastal landscape in the wake of coastal retreat (Chapter 3). As with the Roman period, there is considerable potential for exploring the extent of medieval field and drainage systems in estuarine wetlands, where they can be identified cutting peat surfaces exposed in the intertidal zone.

9.2.4 Post-medieval

Compared with the rate of coastal erosion implied by our sources for the high medieval period, there has been comparative stability from the late sixteenth/ seventeenth century onwards, albeit assisted by a continuing investment in coastal defence schemes. However, despite the greater chances of preservation, comparatively little has been recorded from the post-medieval period in the intertidal zone. So rich is the survival of evidence from this period that it has proved easier to tackle aspects of it in a thematic way.

Although the brief of this survey excludes military remains and the dock and other installations of our major ports, there nevertheless remain considerable areas of ignorance in matters which were of critical concern for the development of Britain as a major trading, imperial, and industrial nation. The potential for advancing our understanding of nationally important aspects of the latter, such as the alum, coal, ironstone, and jet industries, which all exploited coastal and intertidal resources, has been amply demonstrated by the findings of the North-east Maritime Archaeology Survey. Of these, the alum industry is perhaps the most important nationally, and there is a need for systematic survey of each site. Such survey should include study of the clifftop and foreshore topography as well as the evidence for the quarries themselves, to develop the work of Gary Marshall and others. So far the approach has been piecemeal with selected survey at varying levels of detail in Cleveland and North Yorkshire.

Some of the most telling gaps in our knowledge of coastal activities in the post-medieval period relate to shipbuilding and the development of the smaller ports and harbours. Although little is known about the development of the latter, their potential is implicit in their listing in the Cornwall SMR, the implication being that the subject has been overlooked elsewhere and that it deserves a wider, national treatment. The same is surely true of the shipbuilding, ship-repairing, and ship-breaking industries, of which little now survives in a functioning state. Some research is being carried out on the shipbuilding industry of the Beaulieu River in the New Forest, while the Wootton Quarr survey on the Isle of Wight noted evidence that could be related to shipbuilding at Fishbourne in the sixteenth and seventeenth centuries. Perhaps the best way forward with evidence of this period is to endeavour to characterise sample stretches of the coastline on a regional basis, in conjunction with research on the relevant documentary sources.

9.3 Thematic issues

9.3.1 Environmental potential

The principal environmental potential of the intertidal zone has been discussed above in its prehistoric context. The contribution of the submerged forests and peats cannot be overstated, but it is inappropriate to study them without also seeking to understand the contemporary populations who exploited them and settled among them.

9.3.2 Dendrochronology

The 'submerged forests' have major dendrochronological potential, demonstrated by the successful dating of some sites (eg Stolford (Somerset) and Woolaston (Glos) in the dating of the 'Sweet Track'). Difficulties with dating bog oaks on some intertidal sites could be due to local hydrological factors, methodological problems, or simply the fact that only small numbers of samples have been attempted. Nevertheless, we cannot overemphasise the importance of the long tree-ring reference sequences from these sites for the dating of much less substantial assemblages of prehistoric wet wood from inland sites. Potentially, the assemblages of wet wood could prove an outstanding archive of reference material for other researchers, providing, for example, known age samples for radiocarbon laboratories. Equally, the further potential of the 'submerged forests' for developing chronologies for species other than oak, and for contributing to the progress being made with pine, beech, and elm, needs to be explored.

Dendrochronology has a particularly important role to play in the investigation of the timescales of coastal environmental change. Refined chronologies are relevant to the extent of Holocene sea-level fluctuation, the impact of stochastic events on coastal environments (for example, storm surge), and the extent to which changes are synchronous or otherwise from region to region.

Archaeologically, dendrochronology is of special significance because it will help to evaluate environmental change on timescales which are more relevant to issues of human environmental perception and knowledge than chronologies derived from radiocarbon and prehistoric artefacts can be. Indeed, the tree-rings themselves are a major source of environmental evidence, notably for the information they provide on climatic behaviour.

9.3.3 Coastline change

The most abundant archaeological record from the intertidal zone is for the Roman period. While this in itself is evidence of widespread shoreline retreat, there is accumulating evidence for a period of particularly dramatic coastal change and sand dune inundation at the start of the Little Ice Age, with a special emphasis on the period of the late thirteenth to sixteenth centuries. This perception is related to a combination of documentary, cartographic, and archaeological research which points to the destruction of settlement and the setback of sea defences in, or a little before, this period. One corollary of this research is that it is beginning to provide us with some insight into the formation of the present coastline from the later medieval period onwards. However, there is nothing with which to assess the location of earlier shorelines, nor the nature and extent of associated coastal retreat or accretion. The recovery of Neolithic and later fishing structures in the present intertidal zone may point to the possibility that, in general, retreat since *c* 3800 cal BC has not been as substantial as some authorities have conjectured. At the same time there is clear evidence of significant regional variation, which needs to be assessed.

Dating the retreat is a major concern; here it will be helpful to have the evidence of multi-period sites such as Canvey Island in Essex and Minnis Bay in Kent in order to gauge when loss was taking place. If a clearer understanding can be obtained of the chronology of the more significant episodes of coastal erosion, it will be of enormous value in understanding the archaeology of earlier settlements destroyed in the process. Were later prehistoric and Roman sites destroyed by erosion at about the same time as the medieval settlements, or has there been an almost continuous process of attrition? Moreover, given the volume of documented settlement losses from the late thirteenth century onwards, there is a strong argument for looking more closely at the evidence for this in the context of the present and more recently documented coastline and settlements. In Chapter 3 Allen has set out models for settlement behaviour in the face of erosion and setback in the context of retreating upland and lowland coasts as well as in the case of the advancing lowland coast. The medieval period provides an ideal context for the study of settlement transformations during a major phase of shoreline retreat. One approach to developing this theme is to consider a regional programme of survey which examines the origin of settlements and field patterns which currently occupy the shoreline, in conjunction with the evidence from the intertidal and subtidal zones. Did any of the sites already exist in 'terrestrial' form before erosional processes exposed them on the present coast to make them coastal settlements? How did setback of the coast affect them?

9.3.4 Coastal and flood defence

The construction of flood defences, especially on wetlands, is a prerequisite of settlement, and little survives of the English coastal wetlands that has not been defended and reclaimed. Sea-banks represent an important monument to man's continuing relationship with the sea. Although defences of this kind date back to the Roman period, only a few of those currently in use have produced evidence to show that they predate the sixteenth century. Although there is a powerful case for assessing the surviving evidence as a class of monument in its own right, a better understanding can only be obtained in the context of a regional study. The regional approach advocated for the study of shoreline change is surely appropriate here. In order to understand the significance of individual sea-banks it will be necessary to review them as part of the wider history of reclamation and sea defence, as has been attempted in parts of the Severn Estuary. This has demonstrated how, in turn, it can inform our assessment of the significance of the archaeology in the intertidal zone. Those regions which for the most part comprise former estuarine wetlands with complex histories of sea and flood defence deserve urgent study in order to provide a contextual significance for the surviving individual earthworks. This prioritises areas such as the alluvium of the Humber basin, the Wash, the outer Thames Estuary in Essex and Kent, Romney Marsh, and the Severn. In their totality, sea and flood defences represent a class of monument that deserves urgent appraisal.

9.3.5 Coastal settlement and the maritime cultural landscape

As we have seen in the period-by-period review, apart from major settlements like the principal ports, which have seen continuity since their establishment in the Roman or post-Roman period, the archaeological record contains remarkably little evidence of coastal settlement and the information that this category of site might provide on the changing exploitation of intertidal and marine resources. Equally, almost no evidence has been reported which would allow us to analyse the developing relationship between settlements, the coast, and marine resources for any period, whether prehistoric, Roman, Saxon or medieval. Our understanding of the last period, for example, is almost totally confined to a perspective which is dependent on documentary sources. It cannot be emphasised too strongly that it is not necessarily a question of absence of evidence, but of the absence of systematic investigations designed to collect the evidence with which to address these issues. We are still a very long way from developing an understanding of what Westerdahl (1992) has characterised as the 'maritime cultural landscape'.

For the prehistoric period, the weight of evidence is concentrated on poorly dated and poorly identified flint assemblages and on the highly visible detritus of the salt industry, with very limited consideration of the existence and nature of the associated settlements. However, Goldcliff (South Wales) illustrates the considerable potential here for the Iron Age. For our understanding of man/sea relations in the Roman period we have the evidence of traded artefacts across Britain, and of large-scale urban excavations of ports like London and, to a much lesser extent, York. However, we are otherwise dependent on the investigations of coastal forts such as South Shields, Brancaster, Reculver, Richborough, Dover, Portchester, etc, which for the most part predate the era of environmental archaeology. The context in which most of this research took place was in the advancement of our understanding of the military and political history of Roman Britain. Any detailed understanding of the maritime aspect of this history, let alone of non-military and/or smaller settlements, is almost non-existent. The discovery of a site like the Leigh Beck (Essex) midden illustrates the potential for the further investigation of this theme.

However, the present study has drawn attention to a large number of findspots, mostly of pottery and coins, in the intertidal zone which are the remains of settlements, themselves perhaps transposed or diminished, on the modern coastline. Such records form the bulk of what is known from the intertidal zone for the Roman period. Only further research will inform us how far these were both physically related to the coastline of the period, and dependent on trade and/or the exploitation of marine resources. Interestingly, in those areas where the recovery of briquetage and pottery wasters is conspicuous in the record, such as on either side of the Thames Estuary, there is a corresponding lack of reports of settlement evidence. This simply emphasises our ignorance of the possible seasonality and settlement context of these industries.

Evidence of coastal settlement from the Saxon period as a whole is almost non-existent, although a few intertidal sites with late Roman evidence have also produced early Saxon material. Rare scatters of Saxon sceattas in the intertidal zone provide the only other category of evidence for the eighth century, and these could be further investigated for other categories of associated material. Although it is possible to target for further investigation those sites that have produced settlement evidence of this period, it is otherwise difficult to develop a 'stand alone' strategy for coastal settlement of this period.

As in the Roman period, excavation and documentary research in the medieval and post-medieval periods have had an urban focus, concentrating on the major port cities like London, York, Southampton, and Bristol. Less work has been done on smaller ports such as Hartlepool, Hull, or Plymouth. Before the advent of routine and systematic environmental sampling, the aspect of the life of these ports which commanded most attention was that of trade as reflected in the evidence of ceramics and other artefacts. However, as with the Roman period, almost no work has been carried out on smaller coastal communities. Among the major issues here are whether and what evidence survives of the coastal villages recorded in Humberside, Lincolnshire, and East Anglia as having been damaged or destroyed by storms between the late thirteenth and sixteenth centuries. Secondly, there is the need to gain a clearer understanding of the response to coastal setback by examining the evidence for the origins and development of existing settlements on the coast and their associated landscapes.

9.3.6 Early ports, quays, and wharves

Only one county (Cornwall) drew systematic attention to the possible antiquity of its harbours, and this, to a large extent, depended on the evidence of documentary sources. The surviving remains have not been subjected to systematic study and analysis. Elsewhere, perhaps because of a perception of their modernity, wharf and port structures are not listed in SMRs. Within the intertidal zone, records of quay and wharf remains are very limited and generally occur in contexts where there is no working harbour facility today, as is the case with the medieval quay at Woolaston, Gloucestershire. Since the sites of known ports, wharves, and harbours can be readily identified for assessment, as has been the case with the recent survey of Hummersea in Cleveland, further research is thus most effectively directed towards the record for the post-medieval period; evidence of structures of earlier periods is more likely to be the product of chance discovery. It is inevitable that surveys of quays and wharves will require study of their associated harbour-furniture and standing buildings, in order to gain an understanding of the context of their development.

9.3.7 The fishing industry

Recent surveys have drawn attention to a wide array of post-settings in the intertidal zone. These range from linear arrangements (eg kiddles in Essex and Kent), often several hundred metres in length, to V-shaped structures (fish weirs), hurdles, and to individual fish baskets. Although the number of sites investigated is limited, it is significant that all recent surveys have revealed evidence of fishing structures, some of them as early as the Neolithic, others dating to all periods up to recent times. Aerial survey is rapidly adding to our knowledge of the incidence of shellfish cultivation, with the identification of features such as oyster pits and oyster beds. Abundant references to fishing in medieval and post-medieval documentary sources have not been tested against the archaeological record, and the development of onshore structures related to offshore fishing, such as sheds for the curing and drying of fish, has scarcely been considered at all. Dendrochronology and radiocarbon dating are critical in the assessment of these structures. Although clear proof of function is not always evident, parallels with early modern or modern structures are convincing.

9.3.8 Salt-making

Although salt-making is not confined to the open coast, but is recorded far inland on the edges of tidal creeks in areas like the Somerset Levels and the Fenland, the greatest concentration of evidence occurs around the coasts of Essex and north Kent. Lesser numbers of sites are recorded in Lincolnshire, the Solent and its harbours, and Poole Harbour in Dorset. Much of the evidence comes in the form of briquetage; few extensive excavations have been undertaken. Although the majority of archaeological sites date from the late Iron Age through to the second or early third century AD, there is both earlier, prehistoric evidence from the Bronze Age, as well as substantial numbers of documentary records from the medieval and early modern period with no archaeological correlation. There is, thus, an urgent need to develop a methodology for investigating the character of the salt-making industry, for all those periods and/or regions in which its technology did not depend on processes which produce abundant waste in the form of briquetage. Aerial survey has a special role to play in developing the existing map-based record of saltings from the medieval and early modern periods.

9.3.9 Pottery-making

Pottery-making of Romano-British date is attested from intertidal finds along the north Kent coast (Upchurch pottery) and from Poole Harbour, Dorset (BB1), in association with briquetage. Coastal pottery production does not seem to have been a significant feature of either the prehistoric or the medieval and later periods. As with salt, our understanding is focused on the very visible evidence of the pottery and its production, and not on the possible remains of associated settlement and other industries.

9.3.10 Quarrying

Quarrying in the intertidal zone is certainly attested on a significant scale from the Roman period onwards, although some exploitation of coastal outcrops of rock such as Kimmeridge Shale and Whitby jet is instanced earlier. Important Roman examples which have not been systematically studied from this perspective include the jet industry of Whitby (North Yorkshire), Kimmeridge Shale (Dorset), and Bembridge Limestone (Isle of Wight). The last certainly remains important through the Saxon and medieval periods. The extraction of ironstone and alum is a distinct feature of the early modern period in North Yorkshire, and abundant evidence, mostly the subject of rapid assessment with some detailed survey, survives in the intertidal zone. In this case there is also evidence of the processing, transport, and harbour facilities.

9.3.11 Ships, boats, and craft

Chance finds are continuing to increase our knowledge of early boats and craft, though these finds are by no means confined to the intertidal zone. Discoveries in the context of former wetlands such as the Graveney Boat (Kent), the Hasholme Boat from Humberside, or the Barlands Farm vessel from Gwent provide examples. With a few exceptions of known vessels of Roman and medieval date which have been subjected to limited study, further systematic survey has to be confined to developing the record for the early modern period, since hulks and wrecks of that date survive in some quantity. The recent Whitewall Creek (Medway) survey indicates a good deal of survival of vessels of eighteenth-century and later date, but there is no understanding of the overall extent of the resource. A pilot survey in the north-west indicates the potential for further work in the Mersey as well as the rivers Douglas and Weaver.

9.3.12 Shipbuilding

Shipbuilding, ship-repairing, and ship-breaking were major British industries, but no systematic appraisal has been made of what survives on shore and in the intertidal zone. There is a reasonable expectation of good survival from the early modern and modern periods and there is clearly scope for an approach integrated with the British Shipbuilding History Project, which is being coordinated by the National Maritime Museum and the Universities of Glasgow and Newcastle-upon-Tyne.

9.4 Prioritisation for risk

The previous sections have touched on the need to combine an estimate of the archaeological importance of sites with a prioritisation in terms of the risk to which they are exposed. Such a dual system of evaluation is critical to the effective allocation of resources of time, personnel, and finance, and needs to take account of likely changes in the foreseeable future.

Simple versions of such an approach have been suggested before (see also Chapter 2 above). The survey of coastal archaeology in Northumberland (Northumberland County Council 1994, 11) assigned sites to low, medium or high categories on each of two scales, archaeological potential and risk of active erosion; a site scoring two 'high' grades could be regarded as particularly sensitive.

The method used by the Humber Wetlands survey (Van de Noort and Davies 1993) similarly scored sites for potential and threat, but adopted a more explicitly quantitative approach. The index for the preservation potential of a site was scored according to water level, land use and known archaeology and palaeoecology, and a single score system was adopted for threats. The scoring system was as follows:

Preservation potential (P)

3 High preservation potential of archaeological and palaeoecological material
2 Moderate preservation potential of archaeological and/or palaeoecological material
1 Limited preservation potential of archaeological and/or palaeoecological material
0 Poor preservation potential of archaeological and/or palaeoecological material

Threat (T)

3 Threat of destruction or degradation of most (>75%) of the archaeological and palaeoecological resource
2 Threat of destruction or degradation of a large part (50-75%) of the archaeological and palaeoecological resource
1 Threat of destruction or degradation of a limited part (<50%) of the archaeological and palaeoecological resource
0 Absence of threats of destruction or degradation

The preservation/threat Index (I) was then determined using

$$I = \frac{P+T}{6}$$

Index range: 0-1 (1 = site with very important archaeological potential and under severe threat; 0 = a site of limited archaeological importance, with no apparent threats to its status)

For example, at Easington Beach on the Holderness coast a pilot study identified the main threat to the archaeological resource as coastal erosion, with an Index = 0.7 (preservation potential 2/3; threat 2/3).

Although this scheme was developed primarily for non-coastal sites, it shows one way in which the threats to England's coastal heritage, including the effects of sea-level rise, might be assessed using a semi-quantitative scale.

It is doubtful whether such an approach could yet be implemented on anything other than the most basic level in many parts of the coast, because of the current lack of information at an appropriate scale. Indeed, the identification of specific sites and recommendations for further research made below are based on potential archaeological importance unmodified by an estimate of perceived threat, since the information necessary for such a procedure is not yet available.

Any refinement of such a scheme of evaluation would require more precise documentation of the archaeological resource of the coastal, intertidal, and subtidal zones than currently exists. It would also require information about natural coastal processes and their small-scale effects; archaeological sites are mostly of a fairly restricted spatial extent, whereas information about coastal processes is typically at a larger scale, and as yet too gross for detailed estimation of the likely impact on the sites. We also have too little quantified information about the nature of human impacts, and in particular only a very weakly developed understanding of the processes that lead to the destruction of sites and the loss of information. Further research in all these areas, both in methodology and in the provision of substantive information, is required if management decisions are to be robust and sustainable.

There is a specific problem with the estimation of risk in the medium- to long-term future. Such an approach to evaluation and prioritisation must have due regard to the changing nature of the threats over time, particularly those derived from natural processes. Chapter 2 described the estimated magnitude and general effects of the net changes in sea-level to be expected over the next century, and this will undoubtedly be the major cause of change in impact on archaeology through time. In considering the impact of sea-level change on archaeological priorities, a clear distinction needs to be drawn between different components of the archaeological resource, dependent on their location and on the nature of the coast.

All parts of the UK coast will experience a rise in net sea level during the next century, although the rate of rise will vary through time and over space. Even in northern England, at sites close to the former centre of ice-loading, the rate of sea-level rise expected towards the end of the next century will be greater than 4mm per year, which is faster than that recorded in southern England in the recent past.

Estimating the impact of future sea-level rise on archaeological material in the subtidal and intertidal zones is difficult, because many local processes controlling rates of sedimentation and site exposure will influence local impacts.

9.4.1 The subtidal zone

Archaeological sites in the subtidal zone will for the most part not be affected by sea-level change, and will remain exposed to the same threats as currently affect sites on and below the sea bed.

9.4.2 The intertidal zone

For sites currently located in the intertidal zone, the anticipated rise in sea-level over the next century could potentially result in increased protection, as they move from an intertidal to a subtidal environment. The impact of this change will be greatest in areas of low tidal range, where the projected rise in sea-level amounts to a high percentage of the existing tidal range. For sites higher in the intertidal zone, a rise in sea level will increase water depth and, depending on the rate of sedimentation, possibly increase site protection; however, the increased protection would limit or prevent access to such sites. Furthermore, where a rise in sea-level is accompanied by a steepening of the beach profile and an increase in site exposure, erosion by wave and current action is likely to increase.

The greatest rise in sea-level is expected in sites in southern England, where much coastal archaeological material is currently located in the intertidal zone. Here future sea-level rise will increase inundation periods, but if erosion accompanies sea-level rise, significant damage to intertidal sites is to be expected. Importantly, the impact of sea-level rise in this region may be less severe than the effects of lateral changes in shoreline position which may accompany such a rise. Already many of the coastal lowlands of southern England lie several metres below sea defences, and if these are abandoned or breached and not repaired then sites previously isolated from the sea will experience inundation and possible erosion. A simple relationship between sea-level rise and coastal inundation does not exist.

In northern England, sites which have experienced crustal uplift during the Holocene, and thus have been isolated from marine influence, may once again be brought into the upper intertidal zone. In low energy settings where a plentiful sediment supply exists, sediment accretion may increase protection of these sites and erosion will pose no significant threat. Indeed, increased sediment mantling will encourage site preservation, as would elevated groundwater levels. The possible impact of changes in salinity and pH of coastal aquifers on archaeological sites and their contents is, however, poorly understood.

9.4.3 The supratidal coastal zone

Much of England's low-lying coastline is already protected by extensive sea defences; this is especially true for the major estuaries, but also for other areas such as the Somerset Levels and the East Anglian Fenlands. For areas such as these, artificial defences may be sufficient to withstand the level of sea-level rise predicted by the end of the next century, assuming that necessary maintenance and capital works programmes are successfully implemented. In this case, the archaeological sites now protected behind these defences will suffer no change in the threats to which they are exposed arising from sea-level change, but they may of course be subject to other changing terrestrial influences. Areas with important archaeological evidence for human settlement and exploitation of the coast in the past, such as the Fenlands, may therefore not be exposed to additional threats from this source.

Coasts comprised of hard rock may suffer little additional impact, but some of the most obvious, and occasionally spectacular, effects of rising sea-levels will be felt on coastlines made up of comparatively soft rock or unconsolidated deposits, where these are not additionally reinforced. In particular, increased erosion can be expected on parts of the coastline of north-east England, East Anglia, and along the Tertiary deposits of the Thames Estuary and the Hampshire-Dorset basin. In these cases, the archaeological effects will need careful evaluation. At several places in the discussion in this report, attention has been drawn to the distinction between coast-specific archaeological sites, and those that are now situated at the coast because of shoreline change. Where accelerated erosion is likely to occur, the coastlines have already retreated by various amounts in the past, and the archaeology is predominantly terrestrial. There may in some cases be some evidence for past human response to sea-level change and erosion, and this is a historical theme worthy of serious investigation, but in other cases the archaeological sites may be the evidence for past human societies that had little or no interaction with the coast. In these cases they need to be evaluated in the different framework of terrestrial archaeology, alongside other sites and areas that may be subject to other terrestrial threats, rather than in a context of coastal archaeology alone.

9.5 Developing a strategy for management

The discussion of the archaeological potential of the coastal zone in this chapter so far has been based primarily on academic concerns and priorities for the exploration of the archaeological remains of the coastal zone in order to further our understanding of the past. However, a management plan for England's coastal archaeology would also include other objectives, such as preservation and public awareness, appreciation, and enjoyment of this heritage, and perhaps access where appropriate. Much of the archaeological evidence reviewed in earlier chapters is derived from human activities related to the exploitation of the resources of the sea and the coast for a wide variety of purposes which forms an important part of our past. England takes considerable pride in its maritime history, and the archaeological evidence deserves equal attention. The coastal zone contains a wealth of information and visible evidence for our past, which could be used far more extensively for public education and enjoyment. Access is inevitably a difficult question, particularly on safety grounds, but may be possible in certain cases.

These objectives, however, depend on the survival of the archaeological evidence of the coastal zone, or at least the most significant parts of it. Management for preservation is therefore a fundamental necessity, since the archaeological resource is finite and irreplaceable, and currently under threat. On dry land the major threat to the survival of the archaeological evidence is human activity such as development, agriculture, and forestry; natural processes such as erosion or changes in the water table act at a comparatively slow rate, when not accelerated by human interference. In the coastal zone, however, the dynamic environment ensures a much more rapid and active role for natural processes; human activities are still a major threat to the survival of coastal archaeology, but the balance between human and natural threats is very different from that affecting the terrestrial resource. Natural processes are diminishing the coastal archaeological resource both quantitatively and qualitatively, and active management is therefore needed if the potential for academic and other purposes outlined above is to be realised.

There are three very important characteristics of the coastal zone which have been described in previous chapters and which are fundamental to the development of an appropriate management strategy. The first is the nature and extent of the archaeological resource. The second is the very fragmented nature of the existing structure of responsibilities for coastal zone management. The third is the very varied nature of the threats to the archaeology, both now and in the foreseeable future.

The archaeological remains surviving in the coastal zone, as described in earlier chapters, can be regarded as a seamless resource extending from dry land past the coastline to the subtidal zone and even the continental shelf. The essential unity of this resource as evidence for past human activity makes it desirable that, as far as possible, it should be managed in an integrated way.

Secondly, the structure of coastal zone management as described in Chapter 8 is characterised above all else by its enormous fragmentation and diversity. There are different statutory regimes in force for different parts of the broad coastal zone. There are many different organisations involved, at a variety of levels from national to local. Some have an existing obligation to consider archaeology, some do not. A management strategy, if it is to be effective, must therefore recognise the nature and complexity of the existing structures and seek to respond to them in suitable ways. The archaeological response will therefore inevitably be a varied and multiple one, operating at many levels and through many channels.

Thirdly, the varied nature of the threats to the archaeology has been described in Chapters 2 and 8, the former dealing mainly with the effect of rising sea-level and the latter with other threats. Any realistic management response to these threats must be based on three areas of knowledge:

- the extent and importance of the resource
- the nature of the processes and threats affecting it
- the mechanisms through which these processes and threats actually modify the evidence

In all of these areas, the better our knowledge, the more soundly based will be the response. The gaps in our knowledge of the extent and importance of the resource and the priorities for remedying them have been described above, but the two other areas of information also deserve attention.

The general nature of the threats affecting coastal archaeology is well known, but their extent and regional variability are less well documented. The main exceptions to this are some of the physical processes of coastal change, especially erosion and accretion. At the broad level of approach to the coastal zone as a historic landscape, our understanding of the general nature of coastal processes is sufficient to allow an assessment of their likely impact on areas of archaeological potential; much less information is available, however, about the nature and variability of these processes at the very small scale appropriate to individual archaeological sites. Sea-level change has also been the focus of extensive research in recent years. The likely extent of this change, and the likely regional variations, have been discussed earlier in this chapter and in Chapter 2.

The nature of human activities is less well understood, except in the most general terms. Little quantitative information has been collected concerning the intensity and regional variation of the human activities that threaten coastal archaeology. Figures for the increase in tourist pressure, for example, are only a very approximate guide to increased threat, since it is not easy to translate them into activities which will adversely affect the archaeological resource; much will depend on the precise nature of tourist-related activities and of the relevant coast and its archaeological potential. There is clearly a need to gather information about human activity at the coast in a form and at a scale appropriate to archaeological needs.

Our understanding of how these natural processes and human activities work to alter the archaeological resource is still very rudimentary. A conceptual scheme has been suggested in Chapter 8; the scheme itself is in need of refinement through practical application, and the mechanisms through which the impacts take effect also need further research. These impacts, both natural and derived from human activity, operate through a complex series of physical, chemical, and biological processes. Some of the physical processes, especially those which also operate in the terrestrial context, such as the mechanical damage to sites through erosion or construction, may be partly understood, although the conditions of the intertidal and subtidal zones may be specific to those environments. Other physical processes, such as wave-induced erosion or the impact of shingle deposition, are unique to the coastal context, and their effect on archaeological sites and objects is much less well understood.

There is even more uncertainty surrounding the effects of chemical and biological processes, which again are unique to the coastal environment. It would be easy to assume that their effects were principally on archaeological objects, especially those made from organic materials, rather than on the structure of sites, but even that assumption may be unwise, since little is known, for instance, about the physical changes which may follow biological changes such as the establishment of new plant species.

There are thus major areas of uncertainty about the archaeological resource and the threats to its survival, and improvements in management decision-taking can only be made as we continue to improve the quality of our information. Further research is needed in all these areas to improve the standard of information available.

Decision-making is inevitably concerned with the establishment of priorities, and consideration will also need to be given to the appropriate methods of agreeing on concepts of importance and value. This is not just a question of values and importance within archaeology, for archaeology will increasingly be set alongside other factors. To a much greater extent than on dry land, coastal archaeology is influenced by other considerations. Coastal sites are affected by a wider range of natural processes and human activities, and over a much greater spatial scale. The coastal environment is such that knock-on effects may be felt a long way from the source. Archaeological considerations will therefore be only part of a very complex set of factors, and archaeologists must be prepared to debate the importance of their interests in potential conflict with others. On land, these conflicts are most often between archaeology and development, but on the coast they may well involve a conflict of environmental values, where decisions may not be so easy. The archaeological profession will need to become more flexible in its outlook and to engage in new areas of debate.

9.5.1 Recommendations

The key to the development of an effective management strategy for coastal archaeology is the reconciliation of the need for an integrated approach to the preservation of the archaeological remains with the very fragmented nature of the institutional and statutory framework currently in existence. In comparison with the maritime position, terrestrial archaeology is managed through a much more unified system. The planning system, and in particular the principles and procedures contained in PPG 16, regulate the balance between archaeology and development and cover many of the most serious threats to terrestrial archaeological remains.

Although it remains Government policy not to extend the planning system to territorial waters below low-water mark, it would be highly desirable to put in place a set of arrangements analogous to the planning system, which would enable comparable principles and procedures to be enforced. Such principles include the recognition of archaeology as a material consideration in the preparation of strategic plans and the granting of specific permissions, and the presumption in favour of physical preservation in situ of remains of national importance, and the procedures include consultation and advice, and the assessment and evaluation of the archaeological resource where appropriate. There are recognised roles for national agencies such as English Heritage and the RCHME, and also for local authorities.

The creation of a broadly analogous system for archaeology in the intertidal and subtidal zones poses a variety of problems, which have varied implications for legislation, resources, and administrative procedures. As discussed in Chapter 8, there is a non-conformity in the geographical extent of the statutory powers of the various agencies concerned. In particular, the statutory remit of English Heritage needs to be extended to embrace the territorial waters, to allow it to play its proper role in giving specialist advice, and to consider grant-aiding appropriate projects.

One of the most important factors in improving the quality of management decisions is the availability of good information about the nature of the archaeological resource, and there is therefore a critical role to be played by the RCHME as the lead agency for national survey and recording, and the coastal local authorities as the curators of existing SMRs. These roles need to be recognised, but it is also essential that the records are maintained at a level adequate for appropriate advice and information to be supplied in respect of coastal and intertidal as well as terrestrial archaeology. The nature of the known archaeology has been described in Chapters 6 and 7, and some areas where the archaeological potential is now well recognised and which merit further survey are set out below. In many other areas, however, the archaeological potential has not been clarified; some such areas may also merit further survey at an appropriate scale, but until then the state of our knowledge of the extent of the archaeological remains preserved at the coast would suggest that it would be a wise precaution to assume that such remains might be present.

In addition to further research on the nature and extent of the preserved archaeological remains, there is a need for further investigation of the impact of natural processes and human activities on the resource which could address questions of the physical, chemical, and biological effects of such impacts, and the methodology of assessment and prioritisation, as well as the geographical variability of the impacts around the coast.

The fragmented nature of the maritime management regimes creates special problems for the replication of an analogous system for consultation and advice. There is a clear need to establish the importance of archaeological concerns in the preparation of strategic plans and the granting of licences and permissions, and the acceptance of the procedures of assessment and evaluation where appropriate. In the short term, the main priority could lie with the integration of archaeology into Coastal Zone Management plans.

This project has been concerned primarily with the archaeological remains of the intertidal zone, though attention has from time to time been extended to the subtidal archaeology. The nature of the archaeological remains in the subtidal zone, extending to the continental shelf and even beyond territorial waters, and the wide-ranging effects of human activities and natural processes, make it essential that adequate provision is made for the proper consideration of archaeological matters beyond territorial waters, and that further research should be directed to the problems of managing subtidal archaeological remains.

A set of detailed proposals to implement these general recommendations were submitted to English Heritage and the RCHME by the University of Southampton at the end of this project, and those proposals form the basis of the joint policy statement which is included at the beginning of this report.

9.6 Developing a strategy for survey

In developing a strategy for survey in the coastal and intertidal zones, it is necessary to consider the potential of both aerial and ground-based approaches in a national context before assessing how they can be deployed to best effect on a regional basis.

9.6.1 Undertaking survey in the coastal zone

In our review of survey in Chapter 5, we noted the selective strategy, both implicit and explicit, employed by past projects. 'Comprehensive', multi-period surveys of the intertidal zone remain the exception, but where they have been undertaken, as in the Solent at Wootton Quarr, they have produced an impressive array of evidence that can be related to many of the periods and/or themes outlined above (this chapter). However, even where the evaluation of the archaeology has been at its most thorough, still greater clarity can be achieved by developing in parallel an understanding of the geological context, as has been achieved in the Severn Estuary (above, Chapter 5). Other surveys have sought to tackle particular problems by, for example, focusing on the prehistoric land surfaces of the Essex coast, surveying the industrial archaeology of the Cleveland and North Yorkshire coasts, or recording eighteenth-century and later hulks and other craft. Assessment of erosion of cliffs and shorelines at the upper limit of the intertidal zone has been confined to limited areas such as the Isles of Scilly and Northumberland. In Wales, however, a rapid survey has now been undertaken of the entire coastline. No survey has sought to take an integrated view of the archaeological resource in the intertidal and subtidal zone and its relation to the development of existing terrestrial settlement and coastal landscapes. However, the Wootton Quarr project represents a significant departure in the development of a holistic coastal survey, one of its objectives being an understanding of the significance of valley sediments as indices of human activity and environmental change as far as the head of the Fishbourne river valley.

9.6.2 Preliminary observations

The results of surveys are clearly closely correlated with their aims, which may include enhancement of the NMR and the SMR, addressing the needs of coastal management plans, rescue in advance of development, research, and so on. Perhaps the most effective surveys in terms of their contribution to knowledge have been those which have been most focused in their research design, whether this has meant a concentration of effort on a limited geographical area or on a particular theme or category of monument. Rapid and extensive survey on the ground as a means of assessing the whole intertidal resource has proved to be ineffective, but as a means for appraising the post-medieval and modern record this approach has proved extremely valuable. However, any proposal for survey has to begin with an assessment of the existing NMR/SMR record, including the aerial photography and the documentary evidence from the medieval period onwards. Such 'desk-top' assessments should form an essential component of any Estuary or Coastal Management Plan. The scope of such reviews should include consideration of the geological context, and of the hinterland and subtidal resource, as well as the intertidal resource.

Beyond this initial stage of assessment, it is necessary to consider a variety of approaches depending on the aims and scope of the proposed survey (Table 8). If 'total' survey of a specific stretch of coastline is envisaged (eg Wootton Quarr), it may be necessary to embrace most or all of the categories outlined below. On the other hand there are many situations (cf Whitewall Creek) where such a holistic approach is inappropriate. This stage of survey both embraces Level 3 of the RCHME's draft guidance on recording archaeological sites and monuments in *Foreshore archaeology* (Milne and Goodburn 1993; also Milne *et al* forthcoming), and goes beyond them in the nature and complexity of what needs to be recorded in order to gain an adequate understanding of the archaeological resource. As we have seen in Chapter 5, a distinctive feature of survey in the intertidal zone which cannot be underestimated is the crucial importance of repeated visits, linked to winter storm conditions, to localities with high potential, particularly for the prehistoric, Roman, and medieval periods.

Table 8 Strategies for survey: a schematic approach

PRELIMINARY (DESKTOP) SURVEY		SETTING UP SURVEY IN THE FIELD	
Research:		i) Assess unpublished museum collections	
i) NMR/County/District SMR	a) Monitoring of recorded archaeology	ii) Assess (and, if necessary, re-assess) conditions of shore to define study areas	
ii) aerial photography →**rapid reconnaissance** (national and county collection, see Appendix 1)	b) Liaise with local groups and agencies to undertake prospective/ opportunistic investigation	iii) Consult specialists on geological context, palaeoenvironmental potential, dating requirement (dendro and ^{14}C), period and 'theme' specialists	→**costed research design**
iii) documentary sources (including cartography)		iv) Develop survey methodology	
iv) geological background		v) Consider commissioning new aerial photography vi) Develop research design for hinterland survey integrated with intertidal	

9.6.3 Survey methodologies

What underlies the methodologies outlined below is the visibility or completeness of the archaeological resource. Through the historic period towards the present, the visible archaeological resource increasingly represents the totality of what survives in relation to coastal environments and exploitation. However, as we move from the historic periods back through the Roman and prehistoric, we find that the resource increasingly represents only a fraction of the past, that the relationship between the terrestrial and the marine becomes increasingly obscure, and that more techniques and sources, such as scientific dating and palaeoecology, are required to inform our understanding. Thus we might compare the evidence of sea defences, harbour works and wharves, shipbuilding and ship repair facilities, and the abandoned hulks from stabilised shores of nineteenth- and twentieth-century date, with the areas of peat and land surfaces of prehistoric date exposed in the intertidal zone. Along the major estuaries such evidence represents a very small percentage of surfaces which have been either destroyed by erosion or buried by metres of alluvium which form the reclaimed wetlands of these environments.

Surveying the post-medieval and early modern periods

At this stage it may be helpful to describe three possible approaches to coastal survey, each with a different level of complexity. The least problematic in terms of methodological requirements, but the most challenging in terms of the variety and volume of the evidence is survey within the post-medieval/early modern period, where the archaeology is largely visible and the documentary record is rich (cf Milne and Goodburn 1993; Milne *et al* forthcoming). It may be appropriate to consider the monuments and remains of this period using a category-by-category approach, for example the survey of particular classes of industrial archaeology such as the alum industry, or collections of abandoned ships and boats. Equally, there may be a need to take a broader view and characterise coastal landscapes in their entirety. Here an understanding of geological context and landscape development may be appropriate, particularly in relation to medieval and post-medieval land-claim and setback. We have also drawn attention to the importance of harbour 'landscapes', particularly in the case of the lesser ports and harbours of England. So, too, with the recording of industrial remains such as shipbuilding and the range of industries highlighted on the north-east coast, there is a need to take a landward as well as a seaward perspective. Although the drawing together of relevant documentary sources may require a considerable commitment, this category of survey requires little or no specialist dating or environmental service. Depending on the precise aims, the scope of such survey might range into the hinterland as well as the subtidal zone.

Surveying the late prehistoric to medieval periods

A second approach to survey embraces the late Iron Age/Roman and medieval periods, where the archaeology is less visible and there is little or no documentary record. It will be necessary to acquire the necessary specialist knowledge for understanding artefact assemblages in the intertidal zone, as well as to deploy resources on dendrochronological and radiocarbon dating, and, to a varying degree, on environmentalists. An understanding of the geological context, and also of sea-level movements, particularly in relation to the Holocene, is essential. Although one possibility will be to confine survey within the intertidal zone, there is much to favour a research strategy which embraces the immediate coastal hinterland and the subtidal zone. Carefully targeted areas should embrace both Roman and medieval evidence and offer the prospect of understanding issues such as shoreline retreat and the ensuing settlement readjustment, as well as patterns of land reclamation and sea/flood defence. In this approach to survey it may prove necessary to explore the potential of the subtidal resource in order to locate and map the extent of individual sites so as to gain as full an understanding as possible of Roman and medieval settlement loss and shoreline retreat. In addressing the wider issue of the relationship of settlement to the marine environment, it is likely that any one project will embrace a number of the specific thematic issues.

Surveying the earlier prehistoric periods

With the prehistoric period we are concerned with the third approach to survey which, for the most part, may deal only with evidence in the intertidal zone. It is perhaps the most complex period in terms of the resources and expertise required. Here, the intertidal zone may offer the only insight into landscapes largely destroyed by erosion, deeply buried by alluvium, or, in the case of the Isles of Scilly, submerged beneath the sea. In this situation it is essential to have specialised knowledge for the interpretation of artefact assemblages, and adequate resources for dendrochronological and conventional radiocarbon dating. At present there does not seem to be an effective alternative to using conventional methods of radiocarbon dating, which may account for between about 10 and 25 per cent again of the entire costs of a typical project. Equally, the environmental contribution is almost certainly likely to be more demanding of resources than for later periods. The assessment of peats and submerged forests, which are likely to have provided the context for a large number of intertidal finds, will form a critical component of any research strategy (above, this chapter). An understanding of the geological context, particularly in relation to Holocene sea-level movements and landscape development, remains crucial. Although there may be evidence for extending the scope of survey into the subtidal zone, this should not be contemplated unless it is clear that the quality of information recovered justifies the proposed expenditure of resource. On the other hand, a further relevant approach might also embrace survey in the hinterland, particularly where comprehension of the intertidal resource depends on an understanding of the hinterland component. In many cases, such as estuarine wetlands where prehistoric horizons are blanketed by metres of alluvium, it may not be practical in the short term to consider the immediate hinterland of the coastal zone. However, there are exceptions, and as we shall see below for the Isles of Scilly, study in the intertidal and subtidal zone of what were once terrestrial field systems cannot be divorced from study of their surviving counterparts on land. In developing combined intertidal and hinterland research designs, careful thought needs to be given to the way in which one will inform the other.

The issues surrounding the interpretation of the prehistoric period invite the consideration of a development of the above approach solely for the investigation of the resource in the intertidal zone; one which is concerned primarily with the submerged forests and peats, and settlements or other human activity associated with them. This site-specific approach is typical of that directed towards the discoveries made in the intertidal zone off the Gwent coast of south Wales. In addition to the evidence that careful survey of peat ledges and submerged forests may provide about human communities in a marginal environment, this resource has considerable potential for informing us about plant and animal introductions and extinctions. Experience suggests that the scale and complexity of the archaeological resource, and its variable visibility in the intertidal zone, mean that research is likely to be quite focused.

Thus we can trace a range of general approaches to survey in the intertidal and coastal zone. At one end of the chronological spectrum is the diverse and extensive post-medieval to modern resource, which demands the highest skills of recording and comprehension of context from documentary sources, and at the other end there is a more limited (but as yet largely undefined) resource which requires considerable investment for contextual, dating, environmental, and other specialist purposes.

In setting out the approaches outlined above, the intention is not to be prescriptive, but to show how the requirements of a particular survey will influence its aims and the preparation of the detailed research design. As we have seen in Chapter 5, in addition to combining most aspects of the techniques associated with terrestrial survey and excavation, survey in the intertidal zone has begun to develop a distinctive palaeoecological approach which is almost unique in the character of its association with this environment. Such survey will lead to the characterisation of 'the maritime cultural landscape' of England in the way that Westerdahl has recently argued in a Scandinavian context (1992).

9.7 National priorities: a way forward

In the first part of this chapter we have drawn attention to a wide range of period-based and thematic issues which need to be addressed in the context of the archaeology of the intertidal zone. Available resources may require a yet more focused approach, so that in determining future policy towards the archaeological resource in the intertidal zone it may be necessary to make a nationwide appraisal of the resources which are known to be the rarest. The purpose of this section is to highlight areas of fundamental concern where the resource appears to be most at risk.

9.7.1 Submerged forests and peats

In the first place we can point to the issue of the survival and degree of preservation of submerged forests and peats in the intertidal zone. Where coasts have been stabilised by hard engineering these are disappearing, in some cases rapidly. This is a good example of a scarce resource, representing a very small proportion of the original entity, where a national programme of evaluation is called for to establish priorities in recording and survey.

9.7.2 Developing a policy for local groups to undertake opportunistic survey

In developing a strategy for the assessment of the peats and submerged forests it will be advisable to identify agents who can monitor (see also below) the state of areas of known potential in different weather and tidal conditions, and advise on new discoveries over the longer term. Without Derek Upton's reports on new discoveries in the intertidal zone of the Gwent coast over a number of years, it is very doubtful whether our understanding of prehistoric settlement in that area would have advanced to the extent that it has. The effect that extremes of weather can have on the visibility of archaeology in the intertidal zone encourages the formation of a system of flexible response. Equally, to undertake any project in the intertidal zone without a full knowledge of local conditions and how these may affect the programme of work will inevitably lead to wasted resources. Thus, the unique circumstances prevailing in coastal archaeology call for the development of a specific policy which will mobilise the energies of local observers who can inform county, district, and national agencies of new discoveries and the development of site-specific threats.

How should strategic survey for SMR enhancement and academic purposes be prioritised in the future? We have drawn attention in Chapter 5 to the conditions which make coastal archaeology (where it involves survey in the intertidal zone) more expensive than equivalent survey on dry land. In this context it is more appropriate to develop a strategy which explores shoreline change and settlement transposition/transformation on dry land integrated with intertidal work, than to concentrate solely on an intertidal project. Only in the case of research on the peats and submerged forests may it be more effective to develop a programme confined to the intertidal zone, where laboratory-based research can run in tandem with the fieldwork. Otherwise the distribution of evidence of all periods around the southern and eastern shores of England is such that it should be possible to select areas to develop a polyfocal research programme which might address a number of the period and thematic issues identified above.

9.7.3 'Lowland' coast estuaries

Given the limited amount of detailed survey in the intertidal zone, few areas should be exempt from consideration for future programmes of strategic survey for establishing or enhancing the record. However, the richness of the results from the Solent and the Severn Estuary points to the potential of further work in similar environments. Despite the contribution to date of the Hullbridge survey in Essex, which has concentrated on the potential of prehistoric land surfaces preserved in the intertidal zone, there is great scope to pursue further integrated terrestrial and intertidal survey in the Essex and Kent marshes of the Thames Estuary. Indeed, the richness of the historic record from north Kent, and the range of problems which could be addressed on the basis of existing knowledge, argue that research should begin with the southern shore, and this is amply demonstrated by the preliminary results of the current Kent Oyster Coast Environmental Survey Project. While the Taw/Torridge Estuary demonstrates that smaller estuaries have considerable potential (Chapter 4), the extraordinary richness of the discoveries from the larger estuaries, and their potential for the capture of extensive archaeological landscapes before destruction by natural or human agencies, argues that priority should be given to their exploration. Although limited investigation of the Welsh coast of the Severn, the Essex coast of the outer Thames, and aspects of the Solent has pointed to their potential, very little has been done in the north to explore the potential of, say, the Mersey or the Humber, although in the past the latter has produced finds of international importance such as the Ferriby boats.

9.7.4 'Upland' coasts

While research focused on the major estuaries should form one strand of a research strategy, it is important to complement this with integrated land-based and intertidal/subtidal survey on sections of the open coast. Such survey should be concentrated on those areas where the existing SMR and documentary record is relatively rich. In addition to the enhancement of the existing record, careful choice of location will allow the testing of the documentary record of settlement destruction and abandonment in the medieval period, and the impact on existing settlements and landscape in the context of a newly defined shoreline. Such a strategy should be pursued on the east coast in Humberside, Lincolnshire, and East Anglia, where erosion continues to pose a major threat. We can anticipate that new techniques of survey will need to be developed to address these issues in the subtidal zone.

If the threat to major estuaries and the east coast defines the area where the greatest effort should be devoted to assessing and recording the archaeological resource, some resource should also be devoted to evaluating both the archaeological potential and the scale of the threat in the north-west, where the existing record is at its weakest. It would be possible to combine a rapid assessment of the resource with a development of the appropriate methodology to address some of the themes which have emerged as important for the post-medieval to modern period.

Although the careful deployment of resources to address some of the issues identified in this report should be the priority in the short-to-medium term, the potential in some areas, particularly from the post-medieval period onwards, is such that the development of methodologies which can be adopted for recording purposes by a wide range of agencies is highly desirable.

9.7.5 Monitoring

There is no doubt that the results of the monitoring (see also above) of properly recorded archaeological resources such as at Wootton Quarr, Isle of Wight, or the estuary of the Blackwater, Essex, to study rates of loss and degradation will be extremely influential in determining future survey and management strategies. It is strongly recommended that monitoring programmes continue to be built into future survey plans.

9.8 Regional priorities: a provisional assessment

In the light of national priorities, this list should be regarded as no more than indicative, serving to stimulate debate at regional level (Fig 128). This will undoubtedly draw attention to chronological and thematic issues which will profoundly influence the scope of the suggestions listed below. Four levels of priority have been identified, with three asterisks indicating the most pressing need for survey, and no asterisks the least urgent. This scheme of ranking embraces the national priorities discussed above.

The north-east (Northumberland to Humberside)**

Submerged forests and peats*: assessment of potential of localities such as Cresswell, Hauxley, Saltburn, Hartlepool Bay, Hornsea, Owthorpe, Easington, and Cleethorpes

Coastal dunes: monitor Northumberland coast

Estuaries**: multi-period assessments of the estuaries of the Tweed, the Tyne, the Tees (including Hartlepool and Tees Bays), and the Humber (***), including sea/flood defence

Settlement and shore-line loss, particularly medieval and later*: Flamborough Head, Bridlington Bay, and Holderness

Industrial archaeology: alum, coal, iron, and jet industries in the coastal zone

Lincolnshire and East Anglia**

Submerged forests and peats*: assessment of localities such as Mablethorpe to Skegness, Hunstanton to Holm-next-the-Sea

Coastal dunes: assess potential of Lincolnshire coast

Estuary**: assessment of the Wash including sea/flood defence

Settlement and shore-line loss*: assessment of Roman finds scatters and documented medieval records for Lincolnshire (Mablethorpe to Skegness); for Norfolk (eg Cromer (Shipden), Eccles); for Suffolk (eg Covehithe(*), Dunwich (**), Walton Castle (**))

Salt-making: Iron Age/Roman: Mablethorpe to Skegness, Lincolnshire; medieval salterns, Lincolnshire, north Norfolk

Thames Estuary (Essex and north Kent marshes)***

Although the execution of the Hullbridge Survey, with its emphasis on the Mesolithic to Iron Age periods, might suggest that future efforts on the Essex coast ought to be concentrated on the Roman to early modern periods, the richness of the results, often from very limited survey, suggests that further work on the early periods (Mesolithic to Iron Age) would be well justified. In the first instance the selective revisiting of certain known sites to assess rates of erosion would be very helpful. Further research may reveal a number of sites which deserve the same, or a greater, level of investment as the Stumble (Neolithic).

Late Iron Age/Roman to medieval settlement, salt- and pottery-making***: ought to be the focus of survey on the north Kent coast, where the NMR/SMR list numerous sites

Multi-period sites***: Leigh Beck, Canvey Island (Essex), and Minnis Bay (Kent) deserve further assessment

Fishing***: considerable potential from both the Essex and Kent shores

Sea/flood defence***: the evidence from Essex and north Kent needs to be assessed

Industrial archaeology***: barge- and shipbuilding (Medway), wharves and harbours on the Essex and Kent coasts

South coast: east of the Solent**

Submerged forests and peats**: assess exposures between Pevensey and Pett. The latter locality has also produced evidence of possible medieval salt-making.

Selsey Bill*: a number of sites and finds ranging in date from Iron Age to early medieval deserve to be assessed

Sea/flood defence***: the evidence from Romney Marsh and the Pevensey Levels needs to be assessed

The Solent*

Submerged forests and peats**: assessment of exposures in the western Solent

The evidence from Wootton Quarr and the Langstone Harbour survey indicates the potential of the Solent for further research. The considerable investment in research in the Solent has confirmed its high potential for future work. Consideration of further centrally funded strategic survey will need to be balanced against the requirements of other areas of high potential which have been less intensively studied. Priority in the Solent should be given to aspects of the archaeological resource in the intertidal zone, such as stone-quarrying, which are not well represented elsewhere.

South coast: west of the Solent (excluding Devon and Cornwall)

Poole Harbour: deserves multi-period assessment. In the past it has produced considerable evidence of salt- and pottery-making of Iron Age and Roman date.

The south-west (Devon and Cornwall)

Submerged forests and peats: assess numerous exposures (particularly Cornwall) with particular reference to Tor Bay, Westward Ho! and the Taw-Torridge Estuary

Coastal dunes: monitor dunes of north Cornwall

Estuaries: multi-period assessments of the Camel, Exe, Tamar and Fal

Monuments and settlements: assessment of Yelland (Taw-Torridge), Devon, with Mesolithic to Bronze Age lithic scatters and intertidal stone row

Isles of Scilly*

Drowning of the landscape*: continue to search for further physical and environmental evidence which will shed light on the evolution of the islands in their present form

Survey of field walls and associated features in the intertidal zone in association with their dry land counterparts*

Continue to monitor archaeological resource exposed in the intertidal zone

The Severn Estuary**

Outer Estuary**: submerged forests and peats: assess the resource with particular reference to Porlock, Minehead and Stolford, Somerset

Inner Estuary*: since one of the greatest concentrations of intertidal archaeology to have emerged over the last two decades lies only on the Welsh shore of the inner estuary, there is a strong argument for pursuing intensive survey on the English shores where there has been little or no investigation. An assessment of the whole intertidal resource is desirable, but with particular reference to lithic sites and peats at Hills Flats and Oldbury Flats (Glos), between Clevedon and Sand Point, Somerset, and to intertidal features at Brean Down, Somerset.

Fishing**: considerable potential indicated from the Somerset and Gloucestershire coasts

Sea/flood defences: assess the evidence from Somerset and Gloucestershire

The north-west

There is comparatively little evidence from the north-west where there is also an accretionary tendency; the following suggestions offer a preliminary insight into the possible scale of the resource.

Submerged forests and peats*: assess the evidence from localities such as Meols, Altmouth, and Formby

Coastal dunes: assess the evidence from the south Cumbrian and Lancashire coasts

Estuaries*: multi-period assessments of the Dee, Mersey, Ribble, and Wyre should take precedence over Morecambe Bay and the Solway

Settlement and shoreline loss: assess the evidence from the Wirral (eg Meols) and Lancashire coasts

Fig 128 Priorities for survey in the coastal and intertidal zone. Highest priority indicated by three asterisks

Appendix 1 The use of aerial photographs of the intertidal zone

Introduction

The existing aerial photography of the intertidal zone must be assessed to judge its usefulness for archaeological purposes. In particular, it needs to be established whether the photography shows the intertidal zone at the optimum tide when sites might be visible. An appropriate test of the usefulness of a photograph may be whether known sites are identifiable.

In comparison with terrestrial survey, aerial photography by its very nature covers a large area. Thus features recorded on a single photograph may lie in the intertidal zone itself, slightly inland, or, in the right conditions, some way out to sea. Given that there has been comparatively little intentional survey of the intertidal zone as yet, the majority of existing collections contain these general (vertical) photographs.

Survey

The study which follows addressed these issues by evaluating the range and nature of the collections of all those bodies which hold photographs of the intertidal zone, as well as their accessibility. It also examined all known aerial photographic surveys that have been carried out in the intertidal zone, the results of which are covered in Chapter 5. No attempt was made to examine or evaluate those archaeological surveys which were not based on aerial photography, but simply used the existing cover provided by aerial photographs as one source of information.

The vast majority of air photographs covering the intertidal zone have no record of the state of the tide attached to them. Some vertical cover has details of the time on the print and so it would be possible to calculate the state of the tide using an almanac, but the prints have to be viewed to obtain the information. There is no way of knowing in advance whether any given photograph will show the tide at a useful level even when the photograph in question is over an area of known archaeology.

The existing cover has been broken down into two distinct areas:

(a) photographs held by the National Monuments Record – Air Photographs (formerly the National Library of Air Photographs NLAP)

(b) photographs held by other bodies

National Monuments Record – Air Photographs

To simplify the process of searching, the country was divided into seven zones as shown below.

The total figures for all seven areas were 29,642 specialist oblique prints and 312,156 verticals.

As noted above, raw numbers of photographs are not necessarily a useful guide to their archaeological potential. An assessment was therefore made of the specialist oblique photographs recovered from the cover searches of the south-west and South coast areas (I and II) to see how useful they were for retrieving or recording sites in the intertidal zone. Of the 950 prints in Area I, only 208 showed the intertidal zone in any form whatsoever, and only 20 showed it in such a way that archaeological remains might be seen (eg at low tide). Of the 2357 photos in Area II, 464 showed the intertidal zone and 64 showed it in a usable way. In each case approximately 20% showed the intertidal zone and only 2–3% showed it usably. No actual sites were noted in Area I, but there were two or three potential sites in Area II.

The search for Area I took the best part of a day and for Area II two days. This gives a rough estimate of 1000 photographs per day for initial searches. Given its time-consuming nature, this does not seem a very cost-effective method of primary research for examining the intertidal zone.

The quantity of photography and the time taken to examine it supports the preferred option, outlined in Chapter 5, of carrying out the assessment and evaluation county by county as part of the National Mapping Programme for England (NMP), since the majority of photographs consulted showed features of archaeological interest, albeit sites not specifically related to the intertidal zone.

	Zone	Counties	Oblique Photos	Vertical Photos
I	The south-west	Avon, Gloucester and Somerset	950	19,783
II	The South coast	Dorset, Hampshire and West Sussex	2357	53,647
III	The East coast	Norfolk, Lincolnshire and Humberside	5606	42,868
IV	The north-west	The Dee to the Solway	3251	38,814
V	The north-east	Yorkshire to the Scottish Border	3419	32,959
VI	The far west	Devon and Cornwall	10,809	99,225
VII	The south-east	East Sussex to Essex	3250	24,860

All material (with the exception of certain classified items) held by the NMR is readily accessible through the NMRC, Kemble Drive, Swindon, SN2 2GZ.

Non-RCHME photographic libraries

The bodies that hold photographic cover of the intertidal zone can best be broken down into four groups:

1 *photographic libraries*; the only other national library facility is the Cambridge University Collection of Aerial Photographs (CUCAP). This consists of vertical and oblique aerial photographs of archaeological and architectural sites covering large parts of the country.

2 *private photographic survey companies*; for example Aerofilms, BKS, and OS. The size of the collections is generally very large with only a small percentage actually covering the intertidal zone. The prints are generally held by the commissioning body, either local government or a specialist contractor.

3 *specialist bodies*; for example Hydrographic Office, NRA, NERC, and Agricultural Development and Advisory Service (ADAS). Bodies such as the Hydrographic Department and the various regional branches of the National Rivers Authority commission photography of the intertidal zone at small scale, ie 1:5000 and at very low tide for their own purposes. The photographs are generally very clear and have a high archaeological potential.

4 *local authorities*; most counties hold at least one year's comprehensive county cover, normally flown by one of the large private survey firms. Other cover such as the RAF is generally duplicated by the NMR. Their archaeological usefulness is uncertain as the tidal state is unknown.

More detailed descriptions of the various collections are given below.

Conclusion

The assessment of known photography has revealed two clear points. Firstly, it appears that much of the archaeologically specific photography of the coastal region is not suitable for use with regard to sites in the intertidal zone. However, this is balanced by the second point, which is that a large amount of photography which has not previously been consulted could prove most useful. Specialist bodies with an interest in the coast such as the Hydrographic Department and the various branches of the former National Rivers Authority have been commissioning photography of the intertidal zone at a small scale, ie 1:5000, and very low tide for their own purposes for several years. Examination of the cover of the Severn Estuary and the Blackwater Estuary held by the Hydrographic Department and coverage of the Whitstable Bay area in Kent held by the NRA clearly showed known features such as timber alignments and possible fish traps (Chapter 5).

Even some non-specialist vertical cover is likely to yield useful information. Early RAF photography, although often at a small scale and of poor quality, can show sites associated with the intertidal zone which have since been destroyed. This is particularly true for industrial features, such as salterns, fishing-related sites, and coastal mining.

Any survey programme covering the intertidal zone should be coordinated with the NMP and the national reconnaissance programme for three reasons:

i) although specialist oblique archaeological photographs do not show features in the intertidal zone, they do show archaeology which needs to be recorded as part of a county or area survey

ii) the majority of vertical non-specialist photography tends to be orientated east-west. Since a large proportion of the coast runs north-south, looking only at the coast would be very time-consuming, without a definite product.

iii) it is entirely possible that all the non-specialist vertical cover will show the tide at a wholly unsuitable level, which could lead to considerable effort for very little return

It is therefore expedient to include the intertidal zone as part of a larger area survey.

The collections

1 The Cambridge University Collection of Aerial Photographs (CUCAP) is housed in Cambridge and consists of two parts, much like the NMR collection. The oblique/specialist collection covers much of the country and may include cover of the intertidal zone. In addition to the specialist oblique cover, large sections of the coast have vertical cover and sortie diagrams are available for specific regions.

The specialist oblique photography may be useful for detail in areas of saltflats and perhaps may show military sites, but in general it was not taken with intertidal archaeology in mind. The vertical cover varies depending on the reason for the flight. Some large-scale low-tidal cover commissioned by English Nature over the years has potential.

All prints are available for consultation by appointment. The collection is accessed through a card index ordered by grid reference.

2 Private photographic survey companies (BKS, Aerofilms, National Remote Sensing Centre etc) have very large collections with only a small percentage actually covering the intertidal zone. Specially commissioned

low-tide work will have been carried out for the various specialist bodies who will hold the prints to be consulted. Non-specialist flights done for planning purposes, censuses etc will be held by the relevant local government body, but will be of doubtful use owing to the unpredictable nature of the tide.

Note: although all known companies were contacted not all replied.

Aerofilms

The commissioning bodies hold the prints. They hold hundreds of runs of photography. They have an open access library, but this is only for films.

BKS

The commissioning bodies hold the prints. They have a library accessible by appointment but this is only for films. Copies of prints are available for purchase.

Cartographical Services Ltd

The commissioning bodies hold the prints. They have an open access library but this is only for films. Copies of prints are available for purchase. The sortie listings provide some potential contract contacts.

Clyde Surveys

The commissioning bodies hold the prints. They have a library accessible by appointment but this is only for films. Copies of prints are available for purchase. The sortie listings provide some potential contract contacts.

National Remote Sensing Centre (Incorporating Geonex) (NRSC)

The NRSC holds cover of between 80–85% of the English coastline at scales of 1:10,000 and 1:25,000, with certain small areas at 1:5000. The state of the tide is unknown.

They will perform a cover search for a given area and return details of their holdings in 24–48 hours. The commissioning bodies hold the prints, but NRSC has a library of films which can be consulted by appointment.

Ordnance Survey

The OS has massive holdings of films and its prints are most easily accessible through other bodies such as the NMR.

The OS holdings can be broken down into two sorts. It holds cover of the entire coast flown at mean low water (MLW) for tidal mapping, but at a scale of 1:20,000. It also has massive holdings of films at other larger scales, which may well cover the intertidal zone, but the tidal state of these is unknown.

3 The specialist bodies have a varied range of interests and consequently a variety of holdings.

Hydrographic Department

They have flown sorties for over 20 years for the purpose of updating oceanographic charts. Small areas were flown piecemeal as charts needed updating. Although they are generally in small patches the Hydrographic Department's holdings cover most of the coastline of England.

Sorties are flown exclusively at low or ebb tide and the quality is extremely high. There is very little glare, and clear water penetration is available a surprising distance from the shore. The scales range from 1:4000–1:25,000, but the majority are around 1:10,000–1:12,000. When two areas known to contain archaeological sites were viewed, several features were clearly discernible, and this suggests that in other previously unmapped areas any features which are present should be visible.

Visiting is difficult, although all prints are theoretically available for viewing by appointment. The indexing system plots sorties on overlays to a small-scale map base, which in turn refers to individual runs on larger-scale bases.

National Rivers Authority – Southern Region

Note: the National Rivers Authority has now been succeeded by the National Environmental Agency.

They have flown an annual survey since 1973 for low spring tide. Cover extends from Kent to Hampshire including the Isle of Wight. Approximately 3000 prints are produced per year.

Sorties are flown at low tide at the same period each year. The photographs are exceptionally clear owing to the use of a stabilised and forward-compensated camera base. There is no reflected glare and water penetration is quite high. The scale is at 1:5000 with an altitude of 2500ft. The potential for finding new archaeological sites from these photographs is very high.

Their indexing system is very clear and easy to use. The same runs are flown each year and they have one overall cover sheet showing the location of the various cross-sections, and the general areas of the sorties. For each year they then have a series of flight traces on OS 1:50,000 base maps showing the sortie runs and the approximate photo centres. The prints themselves are stored in boxes by area, separated into runs. All prints are available for viewing by appointment.

National Rivers Authority – Anglian Region

They have flown an annual survey since 1991 for low spring tide. Cover extends from the Humber to the Thames, including the Essex estuaries in 1993. As part of a rolling five-year programme they expand to cover wider stretches of mudflats or indeed fly inland up some of the major river systems.

Sorties are flown at low tide at the same period each year. The photographs are exceptionally clear due to the use of a stabilised and forward-compensated camera base. There is little reflected glare, but water penetration is very poor, probably as a result of sediment. The scale is at 1:5000 with an altitude of 2500ft. The potential for finding new archaeological sites from these photographs is very high.

Their indexing system is the same as that used by Southern Region. All prints are available for viewing by appointment.

Natural Environment Research Council

Air photographs back up a digital thematic mapper and cover small areas scattered around the country. In 1994 they carried out a project called Land-Ocean Interaction Study (LOIS) looking at the intertidal zone from Berwick to the Wash.

It was possible to view only a small selection of their photography, which happened to be in their central offices ready for dispersal to the regions. These were at *c* 1:10,000 scale and were very crisp and clear. There was more evidence of glare than with the Hydrographic Department's photography, but clear water penetration was still quite good. A number of linear features apparently consisting of posts running out across the channels were visible. On consultation of the OS 6 inch maps these were recorded as 'Old piles', but nonetheless showed the possibilities of recovering more ancient features of a similar scale. Their holdings would probably be worth consulting on an area-by-area basis, if only for the fact that they fly at low tide.

Their index consists of sorties drawn onto the OS 1:50,000 base maps. The accessibility of their material is uncertain as the prints are sent out to those areas actually carrying out the research.

English Nature

They hold a substantial collection of prints covering Sites of Special Scientific Interest (SSSIs) and National Nature Reserves (NNRs). These are supplied by private contractors, eg CUCAP, GEONEX and ADAS.

Their headquarters hold a manual catalogue indexed alphabetically by site on a county by county basis. The actual prints are held in numerous regional offices with only some duplicates at their Peterborough headquarters.

Their index may be useful as a guide to the commissioned bodies for specific areas. A very large proportion was flown by CUCAP and may be more easily retrievable than checking the CUCAP indexes.

Agricultural Advisory and Development Service (ADAS)

They hold a large number of films, some of which cover the coastal zone, but for which the tidal state is unknown. They have also flown a number of specifically low-tide sorties over the years. Most recently they flew the NRA Anglian Region surveys of their area in 1991–3. In previous years they have flown contractual work such as the Essex salt marshes at 1:5000 for English Nature in 1988, and regions from Sunderland to Newbiggin, North Norfolk, and the Wash at 1:10000 for their own internal use.

The prints for those flights carried out on contract are now held by the contracting bodies. It is possible that during reorganisation the prints from those flights carried out for internal use have been lost. Copies from all films are available for purchase.

4 All levels of local government appear to have holdings of photography for their particular region. These range from the county-wide surveys carried out on a regular basis for the counties' planning departments to specialist oblique photography of selected areas of coasts and coastal towns. In the time available it has proved impossible to contact all bodies with photography of the intertidal zone, but the following give some idea of the range of material currently held.

District level

The district of Adur (Shoreham-by-Sea) holds approximately 70 oblique views of the coastline and the Adur floodplain. These are accessible for viewing and copies are available.

Borough level

Great Grimsby, Ellesmere Port, and North Tyneside all hold photographic cover, although from the description it is likely that this is duplicated at the higher county level.

County level

Most counties hold at least one year's comprehensive county cover, normally flown by one of the large private survey firms. In addition several counties hold copies of earlier photography such as RAF or in certain cases Luftwaffe cover, although this includes only the east of the country.

In most cases where there is additional specialist oblique cover this is duplicated by the NMR.

These bodies commission photography for planning or census purposes and are not generally interested in the coastal strip, so the tidal state is unknown. As a result their use purely for examining the intertidal zone is limited, but the coast could be looked at when the general cover is viewed as part of the National Mapping Programme coverage of each county.

In general, cover held by the counties is available for viewing and copies can be purchased.

County Council holdings of air photographs

Avon

County cover	1:10,000 in 1975 black and white 1:10,000 in 1991 colour by ADAS
Specialist	No mention

Cheshire

County cover	1:10,000 in 1971–3 by Aerofilms, and in 1992–3 by Geonex. 1:10,000 in 1985 by JAS (Western county only) 1:10,000 in 1991 by Geonex (Mersey Barrage)
Specialist	Largely duplicated by NMR

Cornwall

County cover	1:3000 in 1963 by Meridian (Incomplete cover) 1:10,000 in 1988 by JAS
Specialist	Largely duplicated by NMR

Devon

County cover	1:10,000 in 1962 by Huntings 1:10,000 in 1967 by BKS 1:10,000 in 1969 by Faireys 1:10,000 in 1976 by MAL (Duplicated by NMR) Additional False-colour infra-red (FCIR) cover of the north coast is held by the Exmoor National Park.
Specialist	Largely duplicated by NMR

Dorset

County cover	1:12,000 in 1972 1:10,000 in 1986 of the south-east coast
Specialist	None worth mention

Durham

County cover	1:10,000 in 1991 and 1992 by Aerofilms
Specialist	No mention

East Sussex

County cover	1:10,000 in 1982 partial cover 1:10,000 in 1987 1:10,000 in 1987–8 (post hurricane) 1:25,000 in 1991 and 1993 by Geonex Additional OS cover at various scales for small coastal areas
Specialist	No mention

Essex

County cover	1:12,000 in 1960, 1970, 1980–1, and 1990
Specialist	Largely duplicated by NMR Since 1992 intertidal zone survey flights

Gloucester

County cover	Largely duplicated by NMR except specialist small area surveys
Specialist	Largely duplicated by NMR

Hampshire

County cover	1:10,000 in 1971 and 1984–5 1:10,000 in 1992–3
Specialist	No mention

Isle of Wight

County cover	1:10,000 in 1986, 1992, and 1993
Specialist	Largely duplicated by NMR Additional low tide flights in 1989, 1992 and 1993.

Kent

County cover	1:10,560 in 1961 and 1967 1:20,000 in 1972 1:10,000 in 1985 and 1990
Specialist	No mention

Lancashire

County cover	1:10560 in 1961 by Aerofilms 1:10,000 in 1988 by Geonex
Specialist	Largely duplicated by NMR except certain urban areas

Lincolnshire

County cover	1:12,000 in 1971–2 by Huntings 1:25,000 in 1993
Specialist	Largely duplicated by NMR and CUCAP

Norfolk

County cover	CUCAP, Hunting and OS in addition to RAF.
Specialist	Mainly copied by NMR

Northumberland

County cover	1:11,000 in 1960 by BKS 1:11,000 in 1971 by BKS (SE county only) 1:2200 in 1964 by BKS (Coast–Border to Tynemouth) 1:3000 in 1960 by BKS (Berwick) 1:10,000 in 1991 by Geonex (Coast–Cheswick to Whitley Bay) Further partial surveys at various scales from 1966–77 by JAS, Fairey and Cartographic Services.
Specialist	Various including coastal cover from Seaton Sluice to Berwick.

North Yorkshire

County cover	1:10,000 in 1965 by MAL (Duplicated by NMR?)
Specialist	Probably duplicated by NMR

Somerset

County cover	1:10,000 in 1971 and 1981 1:25,000 in 1992 (with 1:10,000 enlargements)
Specialist	No mention

Suffolk

County cover	1:12,000 in 1971 1:10,000 in 1986 1:25,000 in 1991, and 1992
Specialist	No mention

West Sussex

County cover	1:12,000 in 1971 1:10,000 in 1981, 1986, and 1988 1:25,000 in 1991
Specialist	No mention

Bibliography

Abbink, A A, 1986 Structured allocation and cultural strategies, in *Gedacht over Assendelft* (ed R W Brandt, S E Van der Leeuw and M J A N Kooijam), **6**, 23–32, Amsterdam

Aharon, P, 1984 Implications of the coral reef record from New Guinea concerning the astronomical theory of ice ages, in *Milankovitch and climate: understanding the response to astronomical forcing* (ed A L Berger, J Imbrie, J Hays, G Kukla and B Saltzman), 379–89, Dordrecht

Aharon, P, and Chappell, J, 1986 Oxygen isotopes, sea-level changes and the temperature history of a coral reef environment in New Guinea over the last 10/5 years, *Palaeogeography, Palaeoclimatology, Palaeoecology*, **56**, 337–79

Akeroyd, A V, 1972 Archaeological and historical evidence for subsidence in southern Britain, *Phil Trans Roy Soc London, A*, **272**, 151–69

Aldhouse-Green, S H R, Whittle, A W R, Allen, J R L, Caseldine, A E, Cuilver, S J, Day, M H, Lundquist, J, and Upton, D, 1993 Prehistoric human footprints from the Severn Estuary at Uskmouth and Magor Pill, Gwent, Wales, *Archaeol Cambrensis*, **141**, 14–55

Aldsworth, F G, 1987 Prehistoric and Roman Selsey, *Sussex Archaeol Collect*, **125**, Lewes

Allen, J R L, 1986 A short history of salt marsh reclamation at Slimbridge Warth and neighbouring areas, Gloucestershire, *Trans Bristol Gloucestershire Archaeol Soc*, **104**, 139–55

Allen, J R L, 1987 Late Flandrian shoreline oscillations in the Severn Estuary: the Rumney formation at its type site, *Phil Trans Roy Soc London, B*, **315**, 157–84

Allen, J R L, 1990a Reclamation and sea defence in Rumney parish (Monmouthshire), *Archaeol Cambrensis*, **137**, 135–40

Allen, J R L, 1990b Late Flandrian shoreline oscillations in the Severn Estuary: change and reclamation at Arlingham, Gloucestershire, *Phil Trans Roy Soc London, A*, **330**, 315–34

Allen, J R L, 1990c The postglacial geology and geoarchaeology of the Avon wetlands, *Proc Bristol Nat Soc*, **50 (special issue)**, 28–46

Allen, J R L, 1990d Notes: three neolithic axes from the Severn Estuary, *Trans Bristol Gloucestershire Archaeol Soc*, **108**, 171–4

Allen, J R L, 1990e Constraints on measurement of sea-level movements from salt-marsh accretion rates, *J Geol Soc*, **147**, 5–7

Allen, J R L, 1990f The formation of coastal peat marshes under an upward tendency of relative sea-level, *J Geol Soc*, **147**, 743–5

Allen, J R L, 1990g Salt-marsh growth and stratification: a numerical model with special reference to the Severn Estuary, southwest Britain, *Marine Geology*, **95**, 77–96

Allen, J R L, 1990h The Severn Estuary in southwest Britain: its retreat under marine transgression, and fine-sediment regime, *Sedimentary Geology*, **66**, 13–28

Allen, J R L, 1991 Saltmarsh accretion and sea-level movement in the inner Severn Estuary: the archaeological and historical contribution, *J Geol Soc*, **148**, 485–94

Allen, J R L, 1992a A reconnaissance map of medieval alluvial ploughlands in the Vale of Berkeley, Gloucestershire and Avon, *Trans Bristol Gloucestershire Archaeol Soc*, **110**, 87–97

Allen, J R L, 1992b Strong winds and windblown trees: a palaeoclimatic indicator, *Weather*, **47**, 410–16

Allen, J R L, 1993 Muddy alluvial coasts of Britain, field criteria for shoreline position and movement in the recent past, *Proceedings of the Geologists' Association*, **104**, 241–62

Allen, J R L, and Fulford, M, 1986 The Wentlooge Level: a Romano-British saltmarsh reclamation in south-east Wales, *Britannia*, **17**, 91–117

Allen, J R L, and Fulford, M G, 1987 Romano-British settlement and industry on the wetlands of the Severn Estuary, *Antiq J*, **62**(2), 237–89

Allen, J R L, and Fulford, M, 1990a Romano-British wetland reclamations at Longney, Gloucestershire, and evidence for the early settlement of the inner Severn Estuary, *Antiq J*, **70**(2), 288–326

Allen, J R L, and Fulford, M G, 1990b Romano-British and later reclamations on the Severn salt marshes in the Elmore area, Gloucestershire, *Trans Bristol Gloucestershire Archaeol Soc*, **108**, 17–32

Allen, J R L, and Fulford, M G, 1992 Romano-British and later geoarchaeology at Oldbury Flats: reclamation and settlement on the changeable coast of the Severn Estuary, *Archaeol J*, **149**, 82–123

Allen, J R L, and Fulford, M G, 1993 The late Flandrian tidal palaeochannel at Hills Flats on the Avon-Gloucestershire border, in *Archaeology in the Severn Estuary, 1993* (ed M G Bell), Severn Estuary Levels Research Committee Ann Rep, 37–40, Lampeter

Allen, J R L, and Fulford, M G, 1996 Late Flandrian coastal change and tidal palaeochannel development at Hills Flats, Severn Estuary (SW Britain), *J Geol Soc*, **153**, 151–62

Allen, J R L, and Rae, J, 1987 Late Flandrian shoreline oscillations in the Severn Estuary: a geomorphological and stratigraphical reconnaissance, *Phil Trans Roy Soc London, B*, **315**, 185–230

Allen, J R L, and Rae, J E, 1988 Vertical saltmarsh accretion since the Roman period in the Severn estuary, southwest Britain, *Marine Geology*, **83**, 225–35

Allen, J R L, and Rippon, S, 1994 Magor Pill, Gwent: the geoarchaeology of a late Flandrian tidal palaeochannel, in *Archaeology in the Severn Estuary, 1994* (ed M G Bell), Severn Estuary Levels Research Committee Ann Rep, 41–50, University of Wales, Lampeter

Allen, J R L, and Rippon, S, 1995 The historical simplification of coastal flood defences: four case histories from the Severn Estuary Levels, *Trans Bristol Gloucestershire Archaeol Soc*, **113**, 73–88

Allen, J R L, and Rippon, S, forthcoming Iron Age to Early Modern activity at Magor Pill and palaeochannels, Gwent: an exercise in lowland coastal zone geoarchaeology, *Antiq J*, forthcoming

Allen, M J, Fontana, D, Gardiner, J, and Pearson, A, 1994 *The Langstone Harbour archaeological survey project: the assessment 1993*, Winchester

Allen, M J, Gardiner, J, Fontana, D, and Pearson, A, 1993 Archaeological assessment of Langstone Harbour, Hampshire, *Past*, **16** (Dec 1993), 1–3

Amos, C J, and Wheeler, R E M, 1929 The Saxon shore fortress at Dover, *Archaeol J*, **86**, 47–58

Annis, R, 1994 A Neolithic fishweir from Cleveland, *Past*, **17**, 7

Anon, 1952 A Dunwich relic, *Proc Suffolk Inst of Archaeol Hist*, **25**, 110–1

ApSimon, A, Donovan, D T, and Taylor, H, 1961 The stratigraphy and archaeology of the late-glacial and post-glacial deposits at Brean Down, Somerset, *Proc Univ Bristol Speleol Soc*, **9**, 67–136

Archibald, M, 1991 Lead objects with official coin types, in *Aspects of Saxon and Norman London: 2, finds and environmental evidence* (ed A G Vince), London and Middlesex Archaeol Soc spec pap, **12**, 279–360, London

Aston, M, and Iles, R, 1986 *The archaeology of Avon*, Bristol

Atkinson, D, and Houston, J, 1993 *The sand dunes of the Sefton Coast*, Liverpool

Bailey, C J, 1962 An Early Iron Age "B" hearth site indicating salt working on the north side of the Fleet at Wyke Regis, *Proc Dorset Natur Hist Archaeol Soc*, **84**, 132–35

Bailey, M, 1991 *Per imperetum maris*: natural disaster and economic decline in eastern England 1275–1350, in *Before the Black Death: studies in the crisis of the early fourteenth century* (ed B M S Campbell), 184–208, Manchester

Balaam, N D, Levitan, B, and Straker, V, 1987a *Studies in palaeoeconomy and environment in southwest England*, BAR Brit Ser, **181**, Oxford

Balaam, N D, Bell, M G, David, A E U, Levitan, B, MacPhail, R I, Robinson, M, and Scaife, R G, 1987b Prehistoric and Romano-British sites at Westward Ho! Devon: archaeology and palaeoeconomy and environment in south-west England 1983 and 1984, in Balaam *et al* 1987a, 163–264

Banbury, P, 1971 *Shipbuilders of the Thames and Medway*, Newton Abbot

Bard, E, Hamelin, B, and Fairbanks, R G, 1990 U-Th ages obtained by mass spectrometry in corals from Barbados: sea-level during the past 130,000 years, *Nature*, **346**, 456–8

Barnes, B, Edwards, B J N, Hallam, J S, and Stuart, A J, 1971 The skeleton of a late-glacial elk associated with barbed points from Poulton-le-Fylde, Lancashire, *Nature*, **232**, 488–9

Bartlett, D, 1994 *GIS and the coastal zone: past, present and future*, Cork

Barton, N, 1992 *Hengistbury Head: the later Upper Palaeolithic and early Mesolithic sites*, **2**, Oxford

Basford, H V, 1980 *The Vectis report: a survey of Isle of Wight archaeology*, Newport

Batey, C, 1984 *Caithness coastal survey*, Durham

Bell, M G, 1977 Excavations at Bishopstone, *Sussex Archaeol Collect*, **115**, 1–299

Bell, M G, 1987 The molluscs, in Balaam *et al* 1987a, 201–13

Bell, M G, 1990 *Brean Down excavations 1983–1987*, Engl Heritage Archaeol Rep, **15**, London

Bell, M G, 1992 Survey and Excavation at Goldcliff 1992, in *Archaeology in the Severn Estuary, 1992* (ed M G Bell), Severn Estuary Levels Research Committee Ann Rep, 15–30, Lampeter

Bell, M G, 1993a Field survey and excavation at Goldcliff, Gwent, 1993, in *Archaeology in the Severn Estuary, 1993* (ed M G Bell), Severn Estuary Levels Research Committee Annu Rep, 81–101, Lampeter

Bell, M G, 1993b Intertidal archaeology at Goldcliff in the Severn Estuary, in *A spirit of enquiry* (ed J Coles, V Fenwick and G Hutchinson), 9–13, Exeter

Bell, M G, 1994 Field survey and excavation at Goldcliff, Gwent 1994, in *Archaeology in the Severn Estuary, 1994* (ed M G Bell), Severn Estuary Levels Research Committee Annu Rep, 115–44, University of Wales, Lampeter

Bell, M G, and Johnson, S, 1990 Non-marine Mollusca, in Bell 1990, 246–50

Bell, M G, Brayshay, B, Cameron, N, Caseldine, A, Johnson, S, Norris-Hill, J, and Thomas, D, forthcoming a *Archaeological and palaeoenvironmental studies at Prestatyn, Clwyd*

Bell, M G, Hillam, J, and McGrail, S, forthcoming b *Intertidal archaeology at Goldcliff in the Severn Estuary*

Bellhouse, R L, 1962 Moricambe in Roman times and Roman sites along the Cumberland coast, *Cumberland & Westmorland Antiq Archaeol Soc Res Ser*, **62**, 56–72

Bellhouse, R L, 1989 *Roman sites on the Cumberland coast: a new schedule of coastal sites*, Cumberland and Westmorland Antiq Archaeol Soc Res Ser, **3**, Carlisle

Bennett, J, 1985 *Sea Mills, the Roman town of Abonae, excavation at Nazareth House in 1972*, City of Bristol Mus and Art Gallery Monogr **3**, Bristol

Berridge, N G, and Pattison, J, 1994 *Geology of the country around Grimsby and Patrington*, London

Berryman, K, 1988 Tectonic processes and their impact on the recording of relative sea level changes, in *Sea surface studies: a global view* (ed R J N Devoy), 127–61, London

Bird, E C F, 1985 *Coastline changes: a global review*, London

Blair, R, 1903–4 Exhibited, *Proc Soc Antiq Newcastle-upon-Tyne*, **3**(1), 94, 102

Blair, R, 1905–6 Miscellanea, *Proc Soc Antiq Newcastle-upon-Tyne*, **3**(2), 189

Blair, R, 1907–8 *Proc Soc Antiq Newcastle-upon-Tyne*, 3 ser, **3**

Blair, R, 1909–10 *Proc Soc Antiq Newcastle-upon-Tyne*, 3 ser, **4**, 83, 103, 124, 224, 288

Blair, R, 1911–12 *Proc Soc Antiq Newcastle-upon-Tyne*, 3 ser, **5**, 161, 188

Blair, R, 1915–16 *Proc Pre Soc Newcastle-upon-Tyne*, 3 ser, **7**, 33–4

Bloom, A L, Broecker, W S, Chappell, J M A, Matthews, R K, and Mesolella, K J, 1974 Quaternary sea-level fluctuations on a tectonic coast: new 230Th/234U dates from the Huon Peninsula, New Guinea, *Quaternary Research*, **4**, 185–205

Bond, C J, 1988 Monastic fisheries, in *Medieval fish, fisheries and fishponds in England* (ed M Aston), BAR Brit Ser, **182**, 69–112, Oxford

Bonsall, C, Sutherland, D, Tipping, R, and Cherry, J, 1989 The Eskmeals project: late Mesolithic settlement and environment in north-west England, in *The Mesolithic in Europe* (ed C Bonsall), 175–205, Edinburgh

Boon, G C, 1978 Excavations on the site of a Roman quay at Caerleon and its significance, in *Monographs and collections* (ed G C Boon), **1**, 1–24, Caerleon

Boon, G C, 1980 Caerleon and the Gwent Levels in early historic timbers, in *Archaeology and coastal change* (ed F H Thompson), Soc Antiq London Occas Pap, **1**, 24–36, London

Borlase, W, 1753 Of the great alterations which the islands of Scilly have undergone since the time of the ancients, *Phil Trans Roy Soc London*, **48**, 57–67

Borlase, W, 1758 *The natural history of Cornwall*, Oxford

Bosanquet, R C, and Richmond, I A, 1936 A Roman skillet from South Shields, *Archaeol Aeliana*, 4 ser, **13**, 139–51

Bowen, D Q, and Sykes, G A, 1994 How old is Boxgrove Man?, *Nature*, **371**, 751

Bowen, D Q, Hughes, S, Sykes, G A, and Miller, G H, 1989 Land-sea correlations in the Pleistocene based on isoleucine epimerization in non-marine molluscs, *Nature*, **340**, 49–51

Bowen, D Q, Sykes, G A, Reeves, A, Miller, G H, Andrews, J T, Brew, J S, and Hare, P G, 1985 Amino acid geochronology of raised beaches in south west Britain, *Quaternary Science Reviews*, **4**, 279–318

Boycott, A E, 1936 The habitats of fresh-water mollusca in Britain, *Journal of Animal Ecology*, **5**, 116–86

Boyd Dawkins, W, 1872 Ancient geography of the west of England, *Proc Somerset Archaeol and Nat Hist Soc*, **1**, 27–30

Boyd Dawkins, W, 1884 Lancashire and Cheshire in prehistoric times, *Trans Lancashire Cheshire Antiq Soc*, **2**, 1–7

Boyle, P J, and Mitchell, R, 1981 The microbial ecology of crustacean wood borers, in *Marine biodegradation: an interdisciplinary study* (ed J D Costlow and R C Tipper), 17–24, Maryland

Bradley, R, 1975 Salt and settlement in the Hampshire Sussex borderland, in *Salt: the study of an ancient industry* (ed K W de Brisay and K A Evans), 20–5, Colchester

Bradley, R, 1990 *The passage of arms – an archaeological analysis of prehistoric hoards and votive deposits*, Cambridge

Bradley, R, 1992 Roman salt production in Chichester Harbour: rescue excavation at Chidham, West Sussex, *Britannia*, **23**, 27–44

Bradley, R, and Hooper, B, 1975 Recent discoveries from Portsmouth and Langstone Harbours: Mesolithic and Iron Age, *Proc Hampshire Fld Club Archaeol Soc*, **30**, 17–27

Brandt, R, and van der Leeuw, S E, 1987 The Assendelver Polder of the Netherlands and a wet perspective on the European Iron Age, in *European wetlands in prehistory* (ed J M Coles and A J Lawson), 203–226, Oxford

Bray, R N, 1979 *Dredging: a handbook for engineers*, London

Brewis, P, and Buckley, F, 1928 Notes on prehistoric pottery and a bronze pin from Ross Links, Northumberland, *Archaeol Aeliana*, 4 ser, **5**, 13–25

Brigham, T, 1990 The late Roman waterfront in London, *Britannia*, **21**, 99–183

Briquet, A, 1930 *Le littoral du nord de la France et son evolution morphologique*, Paris

British Marine Aggregate Producers Association, 1993 *Aggregates from the sea: why dredge?*, London

British Tourist Authority, 1993 *Tourism statistics 1992*, London

Brookes, I P, Hunt, C O, Dorning, K J, Harding, J L, and Jones, A M, 1990 *The Lindsey coastal survey 1989–1990*, Lincoln

Brooks, N, 1989 The creation and early structure of the kingdom of Kent, in *Origins of the early Anglo-Saxon kingdoms* (ed S Bassett), 55–74, Leicester

Bu'Lock, J D, 1960 The Celtic, Saxon and Scandinavian settlement at Meols in Wirral, *Trans Hist Soc Lancashire Cheshire*, **112**, 1–28

Bu'Lock, J D, 1961 The Anglo-Saxon coins from Meols sands, *Trans Hist Soc Lancashire Cheshire*, **113**, 197–201

Buckland, P C, 1979 *Thorne Moors: a palaeoecological study of a Bronze Age site*, Birmingham

Buckland, P C, 1981 Insect remains from beneath the raft, in *The Brigg raft and her prehistoric environment* (ed S McGrail), BAR Brit Ser, **89**, 155–75, Oxford

Buckland, P C, Beal, C J, and Heal, S V C, 1990 Recent work on the archaeological and palaeoenvironmental context of the Ferriby boat, in *Humber perspectives through the ages* (ed S Ellis and D R Crowther), 131–46, Hull

Buglass, J, 1994 *Lost at sea, maritime archaeology of the north-east of England*, unpubl report, Cleveland County Archaeology Section

Butcher, S A, 1978 Cornish Archaeology, *Cornish Archaeol*, **17**, 29–112

Butler, S, 1987 Coastal change since 6000 BP and the presence of man at Kenn Moor, Avon, *Proc Somerset Archaeol Natur Hist Soc*, **131**, 1–11

Campbell, J, 1977 *The Upper Palaeolithic in Britain*, Oxford

Carter, R W G, 1988 *Coastal environments: an introduction to physical, ecological and cultural systems of coastlines*, London

Cartwright, C R, 1984 Field survey of Chichester Harbour, *Sussex Archaeol Collect*, **122**, 23–7

Caseldine, A E, 1984 The Somerset Levels, in *Environmental archaeology* (ed H C M Keeley), Department Environment Occ Pap, **6**, 66–78, London

Cavis-Brown, J, 1910 Selsey or Pagham harbour, *Sussex Archaeol Collect*, **53**, 26–31

Champion, T, 1980 Settlement and environment in later Bronze Age Kent, in *Settlement and society in the British later Bronze Age* (ed J Barrett and R Bradley), BAR Brit Ser, **83**, 223–46, Oxford

Cherry, J, 1982 Sea cliff erosion at Drigg, Cumbria: evidence of prehistoric habitation, *Trans Cumberland Westmorland Antiq Archaeol Soc*, **82**, 1–6

Churchill, D M, 1965 The displacement of deposits formed at sea-level, 6500 years ago in southern Britain, *Folia Quaternaria*, **7**, Krakow

Clark, J G D, 1952 *Prehistoric Europe: the economic basis*, London

Clarke, C P, 1993 Archaeology in Essex, 1992, *Essex Archaeol Hist*, **24**, 209

Clarke, H, 1973 The changing riverline of King's Lynn, Norfolk, in the Middle Ages, *Int J Naut Archaeol*, **2**(1), 95–106

Clarke, H, 1984 *The archaeology of medieval England*, Oxford

Clarke, J A, 1980 A numerical model of worldwide sea-level changes in a viscoelastic earth, in *Earth rheology, isostasy, eustasy* (ed N A Morner), 525–34, Chichester

Clarke, R R, 1939 The Iron Age in Norfolk and Suffolk, *Archaeol J*, **96**, 1–113

Clayton, K M, 1993 *Coastal processes and coastal management*, Northampton

Cleere, H, 1978 Roman harbours in Britain south of Hadrian's Wall, in *Roman shipping and trade: Britain and the Rhine province* (ed H Cleere and J Du Plat Taylor), CBA Res Rep, **24**, 36–40, London

Coastguard, 1994 *An Introduction to The Coastguard Agency*, Southampton

Codrington, T, 1869 The superficial deposits of south Hampshire and the Isle of Wight, *Quart J Geol Soc*, **26**, 528–48

Coles, B, 1995 *Wetland management: a survey for English Heritage*, Exeter

Coles, B, and Coles, J, 1986 *Sweet Track to Glastonbury*, London

Coles, J, and Goodburn, D (eds), 1991 *Wet site excavation and survey: proceedings of a conference at the Museum of London, October 1990*, WARP Occ Pap, **5**, Exeter

Coles, J, and Hall, D, 1994 *Fenland survey*, London

Collingwood, R G, and Wright, R P, 1965 *The Roman inscriptions of Britain*, **1**, Oxford

Collingwood, R G, and Wright, R P, 1990 *The Roman inscriptions of Britain*, **2**, Gloucester

Construction Industry Research and Information Association, 1994 *CIRIA 94 annual report: report for the year ended 31 December 1993*, London

Coope, G R, 1994 The Late glacial Coleoptera from St Bees, Cumbria, in *Cumbria: Field Guide* (eds J Boardman and J Walden), Quaternary Research Association, Cambridge

Copeland, T, 1981 Fieldwork at Hills Flats in the River Severn astride the Avon–Gloucestershire county boundary, *Bristol Avon Archaeol Res Grp Rev*, **2**, 47–57

Cornwall Archaeological Unit, 1994 Proposed five-year fieldwork programme of coastal monitoring and recording in the Isles of Scilly, unpubl project design, Cornwall Archaeological Unit

Countryside Commission, 1968 *The coasts of England and Wales: measurements of use, protection and development*, London

Countryside Commission, 1989 *Enjoying the countryside: priorities for action*, Cheltenham

Countryside Commission, 1990 *Paths, routes and trails: policies and priorities*, Cheltenham

Countryside Commission, 1992a *AONB Management Plans: advice on their format and content*, Cheltenham

Countryside Commission, 1992b *Heritage Coasts in England: policies and priorities 1992*, Cheltenham

Countryside Commission, 1992c *Out in the country: where you can go and what you can do*, Cheltenham

Countryside Commission, 1993 *Horses in the countryside: a code of practice for owners and riders*, Cheltenham

Countryside Commission, 1994 *Countryside stewardship: handbook and application form*, Cheltenham

Countryside Commission/Department of the Environment, 1992 *A guide to definitive map procedures*, rev edn, Cheltenham and Bristol

Cowell, R W, Milles, A, and Roberts, G, 1993 Prehistoric footprints on Formby Point beach, Merseyside, in *North-west Wetlands Survey Annual Report* (ed R Middleton), 43–8, Lancaster

Cox, E W, 1894 Traces of submerged lands on the coasts of Lancashire, Cheshire and North Wales, *Trans Hist Soc Lancashire Cheshire*, **110**, 42–9

Cox, P W, 1988 Excavation and survey on Furzey Island, Poole Harbour Dorset, *Proc Dorset Natur Hist Archaeol Soc*, **10**, 49–72

Coy, J, 1987 Non-domestic faunal resources in the South-west, in Balaam *et al* 1987a, 9–30

Crabtree, K, 1990 Pollen analysis of the foreshore peat, in Bell 1990, 203–5

Crawford, O G S, 1927 Lyonesse, *Antiquity*, **1**, 5–14

Cross, M, 1950 A prehistoric settlement at Walney Island, *Trans Cumberland Westmorland Antiq Archaeol Soc*, **50**, 15–9

Crossley, D, 1990 *Post-medieval archaeology in Britain*, Leicester

Crown Estate, nd *The Crown Estate and Moorings*, London

Crowther, D R, 1987 Sediments and archaeology of the Humber foreshore, in *East Yorkshire Guide* (ed S Ellis), 99–105, Quarternary Research Association, Cambridge

Crowther, D, Willis, S, and Creighton, J, 1990 The topography of Redcliff, in *Humber perspectives* (ed S Ellis and D R Crowther), Hull

Crummy, P, Hillam, J, and Crossman, C, 1982 Mersea Island: the Anglo-Saxon causeway, *Essex Archaeol Hist*, **14**, 77–86

Crump, B, and Wallis, S, 1992 Kiddles and the Foulness fishing industry, *Essex J*, **27**, 38–42

Cunliffe, B W, 1980 The evolution of Romney Marsh: a preliminary statement, in *Archaeology and coastal change* (ed F H Thompson), Soc Antiq London Occ Pap, **1**, 37–55, London

Cunliffe, B W, 1987 *Hengistbury Head, Dorset*, **1**, Oxford

Cunliffe, B W, 1988 *Mountbatten, Plymouth. A prehistoric and Roman port*, Oxford Univ Comm Archaeol Monogr, **26**, Oxford

Curwen, E, 1931 Prehistoric remains from Kingston Buci, *Sussex Archaeol Collect*, **72**, 185–217

Daniels, R, 1991 Medieval Hartlepool: evidence of and from the waterfront, in Good *et al*, 43–50

Daniels, R, 1994 North-east England, maritime archaeology record project design, unpubl report, Cleveland County Council

Darby, H C, 1971 *The Domesday geography of eastern England*, Cambridge

Darby, H C, 1977 *Domesday England*, Cambridge

Darvill, T, 1987 *Ancient monuments in the countryside: an archaeological management review*, Historic Buildings and Monuments Commission Archaeol Rep **5**, London

Darvill, T, and Wainwright, G, 1994 The Monuments At Risk Survey: an introduction, *Antiquity*, **68**, 820–4

Davidson, N C, d'A Laffoley, D, Doody, J P, Way, L S, Gordon, J, Key, R, Pienkowski, M W, Mitchell, R, and Duff, K L, 1991 *Nature conservation and estuaries in Great Britain*, Peterborough

Davis, F M, 1958 *An account of the fishing gear of England and Wales*, London

de Brisay, K W, and Evans, K A (eds), 1975 *Salt: the study of an ancient industry*, Colchester

de Groot, S J, 1984 The impact of bottom trawling on benthic fauna of the North sea, *Ocean management*, **9**, 177–90

de Rance, C E, 1877 *The superficial geology of the country adjoining the coasts of South West Lancashire*, Memoir of the Geological Survey of the United Kingdom, London

Dean, M, 1985 A boat recovered from the foreshore at West Mersea in Essex, *Int J Naut Archaeol Underwater Explor*, **14**(3), 217–26

Dennison, E, 1985 Medieval fishweirs, in Somerset Archaeology 1984–5 (ed E Dennison), *Proc Somerset Archaeol Natur Hist*, **129**, 20–2

Department of the Environment, 1990a *Planning Policy Guidance 14: development on unstable land*, London

Department of the Environment, 1990b *Planning Policy Guidance 16: archaeology and planning*, London

Department of the Environment, 1992a *Planning Policy Guidance 20: coastal planning*, London

Department of the Environment, 1992b *Coastal zone protection and planning: the Government's response to the second report from the House of Commons Select Committee on the Environment*, London

Department of the Environment, 1993 *Coastal planning and management: a review*, London

Department of the Environment, 1994a *Environmental Assessment: amendment of regulations*, London

Department of the Environment, 1994b *News release: Environment Minister announces new initiatives for the coast*, London

Department of the Environment, 1994c *Planning Policy Guidance 15: planning and the historic environment*, London

Department of the Environment, 1995 *Wavelength*, Bristol

Department of the Environment/Ministry of Agriculture Fisheries and Food/Welsh Office, 1992 *Development and flood risk*, London

Department of the Environment/Welsh Office, 1989 *Environmental Assessment: a guide to the procedures*, London

Department of the Environment/Welsh Office, 1993a *Managing the coast: a review of coastal management plans in England and Wales and the powers supporting them*, London

Department of the Environment/Welsh Office, 1993b *Development below low water mark: a review of regulation in England and Wales*, London

Department of the Environment/Welsh Office, 1994 *Consultation paper: review of licensing arrangements for minerals dredging in England and Wales*, London

Department of the Environment/Welsh Office, 1995 *Review of licensing arrangements for minerals dredging in England and Wales*, London

Department of Trade and Industry, 1994 *15th round of offshore licensing – base conditions and restrictions*, pers comm

Devoy, R J N, 1979 Flandrian sea-level changes and vegetation history of the lower Thames Estuary, *Phil Trans Roy Soc London*, B, **285**, 355–407

Devoy, R J N, 1982 Analysis of the geological evidence for Holocene sea-level movements in southern England, *Proceedings of the Geologists' Association*, **93**(1), 65–90

Dimbleby, G W, Greig, J, and Scaife, R, 1981 Vegetational history of the Isles of Scilly, in *Environmental aspects of coasts and islands* (ed D Brothwell and G W Dimbleby), BAR Int Ser, **94**, 127–44, Oxford

Directorate of Fisheries Research, 1991 *An introduction to the Directorate of Fisheries Research*, London

Directorate of Fisheries Research, 1992 *Research into fisheries and the marine environment 1989–90: report of the Director*, Lowestoft

Directorate of Fisheries Research, 1993 *Fisheries and the marine environment: policy support and research 1991–92, report of the Director*, Lowestoft

D'Olier, B, 1972 Subsidence and sea-level rise in the Thames Estuary, *Phil Trans Roy Soc London*, B, **272**, 121–30

Dolley, R H M, 1961 The Anglo-Saxon coins from Meols sands, *Trans Hist Soc Lancashire Cheshire*, **113**, 197–201

Doody, J P, 1984 *Spartina anglica in Great Britain*, (Focus on nature conservation Number 5), Attingham

Doody, J P, 1990 *Spartina* – friend or foe? A conservation viewpoint, in Spartina anglica – *a research review* (eds A J Gray and P E M Benham), ITE Publication no. **2**, 77–79, London

Doody, P, and Barnett, B, 1987 *The Wash and its environment*, Peterborough

Doody, J P, Johnston, C, and Smith, B, 1993 *Directory of the North Sea coastal margin*, Peterborough

Dorset County Council, 1994 *The Dorset coast today*, Dorchester

Dowell, M, 1994 Coastal erosion at Wootton Creek: implications for the intertidal archaeological resource, unpubl BSc thesis, University of Southampton

Draper, J C, 1968 Hampshire: survey of islands in Langstone Harbour, *Arch Newsletter*, **6**(9), 204

Draper, J (ed), 1987 *Romano-British industries in Purbeck*, Dorset Natur Hist Archaeol Soc Monogr Ser, **6**, Dorchester

Drewett, P, Rudling, D, and Gardiner, M, 1988 *The south-east to AD 1000*, Harlow

Earll, R C (ed), 1994 *Overlapping management plans: is this an issue?*, Kempley

Eddison, J (ed), 1995 *Romney Marsh: the debatable ground*, Oxford Univ Comm Archaeol Monogr, **41**, Oxford

Eddison, J, and Green, C (eds), 1988 *Romney Marsh: evolution, occupation, reclamation*, Oxford Univ Comm Archaeol Monogr, **24**, Oxford

Edwards, K J, 1988 The hunter-gatherer agricultural transition and the pollen record in the British Isles, in *The cultural landscape: past, present and future* (ed H J Birks, H H Birks, P E Kaland, and D Moe), 255–66, Cambridge

Ellis, C M, 1968 A gazetteer of water, wind and tide mills of Hampshire, *Proc Hampshire Fld Club Archaeol Soc*, **24**, 119–40

Ellison, N, 1967 *The Wirral Peninsula*, London

English Nature, 1993a *Estuary Management Plans: A co-ordinator's guide*, Peterborough

English Nature, 1993b *Conserving England's marine heritage: a strategy*, Peterborough

English Nature, 1994 *Campaign for a living coast: update 94*, Peterborough

English Tourist Board, 1994 *Annual report 1994*, London

Essex County Council, 1993 Saxon fish-traps on the Blackwater, *Essex Archaeologist*, **10**, xiii

Evans, J G, 1975 *The environment of early man in the British Isles*, London

Evans, J G, 1979 The palaeoenvironment of coastal blown-sand deposits in western and northern Britain, *Scottish Archaeol Forum*, **9**, 16–26

Evans, J G, 1984 Excavations at Bar Point, St Mary's, Isles of Scilly, 1979–80, *Cornish Studies*, **11**, 7–32

Fairbanks, R G, 1989 A 17,000 year glacio-eustatic sea-level record: influence of glacial melting rates on the Younger Dryas event and deep-ocean circulation, *Nature*, **342**, 637–42

Farrar, R A H, 1975 Prehistoric and Roman saltworking in Dorset, in de Brisay and Evans, 1975, 4–20

Faulkner, N, 1994 Summary of earlier work at Leigh Beck and other Canvey sites, *Trans Rochford Hundred Fld Archaeol Group*, **1**, 2–14

Fawn, A J, Evans, K A, McMaster, I, and Davies, G M R (eds), 1990 *The red hills of Essex: salt-making in antiquity*, Colchester

Fenwick, H, van de Noort, R, Head, R, Lillie, M, and Dinnin, M 1995 Introduction to the archaeological survey, in van de Noort and Ellis (eds), 1995 149–60

Fenwick, V, 1993 A winged cleat from Hartlepool, in *A spirit of enquiry* (ed J Coles, V Fenwick, and G Hutchinson), 49–51, Exeter

Fenwick, V, 1995 A paddle from the North Ferriby foreshore (Vale of York), in *Humber Wetlands Survey* (1994–5), 16–8

Ferrari, B, 1994 Cultural, physical and biological processes affecting the formation, stabilisation and protection of archaeological deposits in UK coastal waters, unpublished PhD thesis, University of St Andrews

Ferrari, B, and Adams, J, 1990 Biogenic modifications of marine sediments and their influence on archaeological material, *Int J Naut Archaeol Underwater Explor*, **19** (2), 139–51

Firth, A J, 1990 Managing archaeological resources underwater, Unpubl MSc thesis, London School of Economics

Firth, A, 1993 The management of archaeology underwater, in *Archaeological resource management in the UK: an introduction* (ed J Hunter and I Ralston), 65–76, Stroud

Firth, A, 1995 Archaeology and coastal zone management, in *Managing ancient monuments: an integrated approach* (eds A Q Berry and I W Brown), 155–67, Mold

Fisher, C E, 1938 Archaeology in Kent, 1938, *Archaeol Cantiana*, **50**, 147–8

Flemming, B, and Davis, R A, 1994 Holocene evolution, morphodynamics and sedimentology of the Spiekroog barrier island system (south North Sea), *Senckenbergiana Maritima*, **24**, 117–55

Folland, C K, Karl, T R, and Vinnikov, K Y A, 1990 Observed climate variations and change. In: Houghton, J T, Jenkins, G T, and Ephraums, J J (eds) *Climate change; the IPCC Scientific Assessment*, Cambridge, 195–238

Fowler, P J, and Thomas, C, 1979 Lyonesse revisited: the early walls of Scilly, *Antiquity*, **53**, 175–89

Fowler, S L, 1989 *Nature conservation implications of damage to the seabed by commercial fishing operations*, Peterborough

Fox, G E, 1911 *Romano-British Suffolk*, Victoria History of the Counties of England, London

Fox, A, and Ravenhill, W, 1965 Old Burrow and Martinhoe, *Antiquity*, **39**, 253–8

Fox, C F, 1937 Salt works at Hook, Warsash, Hants, *Proc Hampshire Fld Club Archaeol Soc*, **13**, 105–9

Fox, H S A, and Kissock, J, 1993 The Leicester AGM and conference on seasonal settlement, *Medieval Set Res Group Annu Rep*, **8**, 5–6

Francis, A G, 1932 On the subsidence of the Thames estuary since the Roman period at Southchurch, Essex, *Essex Naturalist*, 23 (1931–32), 151–70

Fryer, J, 1973 The harbour installations of Roman Britain, in *Marine archaeology: the proceedings of the 23rd symposium of the Colston Research Society at the University of Bristol* (ed D J Blackman), 261–73, London

Fulford, M G, 1989 A Roman shipwreck off Nornour, Isles of Scilly, *Britannia*, **20**, 245–9

Fulford, M G, 1990 Woolaston Pill, medieval quay excavation, in *Archaeology in the Severn Estuary, 1990* (ed M G Bell), Severn Estuary Levels Research Committee Ann Rep, 19, Lampeter

Fulford, M G, Allen, J R L, and Rippon, S J, 1994 The settlement and drainage of the Wentlooge Level, Gwent: excavation and survey at Rumney Great Wharf 1992, *Britannia*, **25**, 175–211

Fulford, M G, Rippon, S, Allen, J R L, and Hillam, J, 1992 The medieval quay at Woolaston Grange, Gloucestershire, *Trans Bristol Gloucestershire Archaeol Soc*, **110**, 101–27

Gale, A, 1992 *Catching the tide: the status and future of maritime collections in north east Museums*, Newcastle

Gamble, C, 1994 Time for Boxgrove Man, *Nature*, **369**, 275–6

Gerald of Wales (Giraldus Cambrensis), 1908 *The itinerary through Wales: description of Wales*, London

Gibbard, P L, 1994 *Pleistocene history of the lower Thames Valley*, Cambridge

Gibson, J, 1977 Foreshore: a concept built on sand, *Journal of Planning and Environmental Law*, **1977**, 762–70

Gibson, J, 1980 Coastal zone management law: a case study from the Severn Estuary and the Bristol Channel, *Journal of Planning and Environmental Law*, **1980**, 153–65

Gibson, J, 1993 Coastal zone planning law: the role of the law in management of the coastal zone in England and Wales, *Marine Policy*, **17**(2), 118–29

Gilbertson, D D, 1984 *Late Quaternary environments and man in Holderness*, BAR Brit Ser **134**, Oxford

Gilbertson, D D, and Mottershead, D N, 1975 The Quaternary deposits at Doniford, West Somerset, *Field Studies*, **4** (2), 117–29

Gill, C, 1975 *The Isles of Scilly*, Newton Abbot

Girling, M A, 1984 Investigations of a second insect assemblage from the Sweet Track, *Somerset Levels Pap*, **10**, 79–91

Girling, M A, and Robinson, M, 1987 The insect fauna, in Balaam *et al* 1987a, 239–46

Godbold, S, and Turner, R, 1992 Second Severn crossing 1991, Welsh intertidal zone, in *Archaeology in the Severn Estuary*, 1992 (ed M G Bell), Severn Estuary Levels Research Committee Annu Rep, 45–56, Lampeter

Godbold, S, and Turner, R, 1993 *Second Severn crossing: archaeological response phase 1 – the intertidal zone in Wales, final report*, Blaenavon

Godbold, S, and Turner, R C, 1994 Medieval fishtraps in the Severn Estuary, *Medieval Archaeol*, **38**, 19–54

Godwin, H, 1943 Coastal peatbeds of the British Isles and North Sea: presidential address to the British Ecological Society, *J Ecology*, **31**, 199–247

Godwin, H, 1978 *Fenland: its ancient past and uncertain future*, Cambridge

Godwin, H, and Godwin, M E, 1934 Pollen analysis of peats at Scolt Head Island, Norfolk, in *Scolt Head Island* (ed J A Steers), 64–76, Cambridge

Godwin Austen, R A C, 1865 On the submerged forest-beds of Porlock Bay, *Quart J Geol Soc*, **22**, 1–9

Gonzales, S, Huddart, D and Roberts, G, in press Holocene development of the Sefton coast: a multidisciplinary approach to understanding the archaeology, in *Proceedings of the Archaeological Sciences Conference, Liverpool 1995*, Oxford

Good, G L, Jones, R H, and Ponsford, M W (eds), 1991 *Waterfront archaeology: proceedings of the third international conference, Bristol, 1988*, CBA Res Rep, **74**, London

Goudie, A, 1993 *The human impact on the natural environment*, Oxford

Goudie, A S, and Brunsden, D, 1994 *The environment of the British isles: an atlas*, Oxford

Grant, W D, Boyer, L F, and Sanford, L P, 1982 The effects of bioturbation on the initiation of motion of intertidal sands, *Journal of Marine Research*, **40** (3), 659–77

Gray, A J, Benham, P E M, and Raybould, A F, 1990 *Spartina anglica* – the evolutionary and ecological background, in Spartina anglica – *a research review* (ed A J Gray, P E M Benham, and A F Raybould), 5–10, London

Green, C, 1992 The Severn fisheries, in *Archaeology in the Severn Estuary*, 1992 (ed M G Bell), Severn Estuary Levels Research Committee Annu Rep, 69–73, Lampeter

Green, M, and Solley, T W J, 1980 Romano-British pottery from Salmon Lodge, Oldbury on Severn, *Bristol Archaeol Research Gp Rev*, **1**, 30–34

Green, S, 1989 Some recent archaeological and faunal discoveries from the Severn Estuary Levels, *Bull Board Celtic Stud*, **36**, 187–99

Greensmith, J T, and Tooley, M J, 1982 IGCP Project 61: Sea-level movements during the last deglacial hemicycle (about 15,000 years). Final report of the UK Working Group, *Proceedings of the Geologists' Association*, **93**(1), 1–125

Greensmith, J T, and Tucker, E V, 1973 Holocene transgressions and regressions on the Essex coast outer Thames estuary, *Geologie en Mijnbouw*, **52**, 193–202

Greensmith, J T, and Tucker, E V, 1976 Major Flandrian transgressive cycles, sedimentation and palaeogeography in the coastal zone of Essex, England, *Geologie en Mijnbouw*, **55**, 133–46

Greensmith, J T, and Tucker, E V, 1980 Evidence for differential subsidence on the Essex coast, *Proceedings of the Geologists' Association*, **91**(3), 169–75

Grigson, G, 1956 A little known Isle of Scilly, *Country Life*, **119** (March 1, No. 3085), 374–5

Grinsell, L V, 1970 *The archaeology of Exmoor*, Newton Abbot

Grubbe, J E, 1891 Vestiges of Roman colonization discovered in the neighbourhood of Southwold, *Proc Suffolk Inst Archaeol Hist*, **7**, 303–10

Gubbay, S, 1990 *A future for the coast? Proposals for a UK coastal zone management plan: a report for the World Wildlife Fund for Nature from the Marine Conservation Society*, Ross-on-Wye

Gubbay, S, 1991 *A definition of the 'coastal zone' for UK coastal zone management programmes*, Ross-on-Wye

Hall, D, and Coles, J, 1994 *Fenland survey*, Engl Heritage Archaeol Rep, **1**, London

Hampshire County Council, 1991 *A strategy for Hampshire's coast*, Winchester

Harris, B E, and Thacker, A T (eds), 1987 *A history of the county of Cheshire*, **1**, Oxford

Hartley, B, and Fitts, L, 1988 *The Brigantes*, Gloucester

Hartley, K F, 1973 The marketing and distribution of mortaria, in *Current research in Romano-British coarse ware* (ed A Detsicas), CBA Res Rep, **10**, 39–51, London

Haselgrove, C, 1987 *Iron Age coinage in south-east England: the archaeological context. Part ii*, BAR, **174 (ii)**, Oxford

Haselgrove, C, Millett, M, and Smith, I (eds), 1985 *Archaeology from the ploughsoil: studies in the collection and interpretation of field survey data*, Sheffield

Hawkins, J, 1818 On submarine mines, *Trans Roy Geol Soc Cornwall*, **1**, 127–42

Hawkshaw, J C, 1871 Notes on the peat and underlying beds observed in the construction of the Albert Dock, Hull, *Quart J Geol Soc*, **27**, 237–40

Head, R, Fenwick, H, van de Noort, R, Dinnin, M, and Lillie, M, 1995 The meres and coastal survey, in van de Noort and Ellis (eds), 1995, 162–239

Heal, V, 1993 A perspective from Porlock: the maritime potential of the Exmoor coast, in *A spirit of enquiry: essays for Ted Wright* (ed J Coles, V Fenwick and G Hutchinson), 61–4, Exeter

Healey, R H, 1975 A medieval salt-making site in Bicker Haven, Lincolnshire, in de Brisay and Evans, 1995, 36

Heritage Coast Forum, 1993a *Heritage coasts in England and Wales: a gazetteer*, Manchester

Heritage Coast Forum, 1993b *Heritage coast: sport and recreation*, Manchester

Heritage Coast Forum/Sports Council, 1993 *Sport and recreation on Heritage Coasts: a study of the planning, management and sustainable development of sport and active recreation on Heritage Coasts*, Manchester and London

Heyworth, A, 1978 Submerged forests around the British Isles: their dating and relevance as indicators of post-glacial land and sea level changes, in *Dendrochronology in Europe* (ed J Fletcher), BAR Int Ser, **56**, 279–88, Oxford

Heyworth, A, and Kidson, C, 1982 Sea-level changes in southwest England and Wales, *Proceedings of the Geologists' Association*, **93**(1), 91–113

Hill, D, 1981 *An atlas of Anglo-Saxon England*, Oxford

Hillam, J, 1987 The tree-ring dating, in Millett, M, and McGrail, S, The archaeology of the Hasholme logboat, *Archaeol J*, **144**, 69–155

Hillam, J, 1993 Tree ring analysis of oak timbers from the excavations at Goldcliff, Gwent, unpublished report, English Heritage Ancient Monuments Laboratory

Hillam, J, 1994 The dating of timber from the Wootton Quarr survey, Isle of Wight, unpublished report, English Heritage Ancient Monuments Laboratory

Hillam, J, Groves, C M, Brown, D M, Baillie, M G L, Coles, J M, and Coles, B J, 1990 Dendrochronology of the English Neolithic, *Antiquity*, **64**, 210–20

Hodges, R, and Hobley, B, 1988 *The rebirth of towns in the west*, CBA Res Rep, **68**, London

Holden, E, 1966 Possible medieval salt pans at Pett Level, *Sussex Notes and Queries*, **16**, 301–04

Holland, A J, 1971 *Ships of British oak*, Newton Abbot

Holland, A J, 1985 *Buckler's Hard – a rural shipbuilding centre*, Newton Abbot

Houghton, J T, Callander, B A, and Varney, S K, 1992 *Climate change: the supplementary report to the IPCC scientific assessment*, Cambridge

Houghton, J T, Jenkins, G J, and Ephraums, J J, 1990 *Climate change: the IPCC scientific assessment*, Cambridge

House of Commons Environment Committee, 1992a *Coastal Zone Protection and Planning: report, together with the proceedings of the Committee relating to the report*, **1**, London

House of Commons Environment Committee, 1992b *Coastal zone protection and planning: minutes of evidence and appendices*, **2**, London

House of Commons Environment Committee, 1994 *Coastal zone protection and planning: minutes of evidence*, London

Howarth, W, 1992 *Wisdom's law of watercourses*, 5th edn, Crayford

Huddart, D, 1992 Coastal environmental changes and morphostratigraphy in southwest Lancashire, England, *Proceedings of the Geologists' Association*, **103**, 217–36

Hughes, M, 1973 Excavations at Brownwich Farm, Titchfield, 1971, *Rescue Archaeology in Hampshire*, **1**, 2–28

Humber Wetlands Survey 1994–5: first annual report, Humber Wetlands Project, School of Geography and Earth Resources, University of Hull

Hume, A, 1863 *Ancient Meols, some account of the antiquities found near Dove Point on the sea-coast of Cheshire*, London

Iles, R, 1982 Archaeology in Avon in 1981, *Bristol and Avon Archaeol*, **1**, 50

Jackson, G, 1983 *The history and archaeology of ports*, Tadworth

Jacobi, R M, 1980a The early Holocene settlement of Wales, in *Culture and environment in Prehistoric Wales* (ed J A Taylor), BAR Brit Ser, **76**, 131–206, Oxford

Jacobi, R M, 1980b The Upper Palaeolithic in Britain with special reference to Wales, in *Culture and environment in Prehistoric Wales* (ed J A Taylor), BAR Brit Ser, **76**, 5–99, Oxford

Jarrett, M G, 1976 *Maryport, Cumbria: a Roman fort and its garrison*, Cumberland & Westmorland Antiq Archaeol Soc Extra Ser, **22**, Kendal

Jefferies, R L, 1976 The north Norfolk coast, in *Nature in Norfolk*, Norwich

Jennings, S, and Smyth, C, 1987 Coastal sedimentation in East Sussex during the Holocene, *Progress in Oceanography*, **18**, 205–41

Jennings, S, and Smyth, C, 1990 Holocene evolution of the gravel coastline of East Sussex, *Proceedings of the Geologists' Association*, **101**(3), 213–24

Jobey, G, 1967 Excavations at Tynemouth priory and castle, *Archaeol Aeliana*, 4 ser, **45**, 33–104

Jobey, G, 1982 The settlement at Doubstead and Romano-British settlement on the coastal plain between Tyne and Forth, *Archaeol Aeliana*, 5 ser, **10**, 1–24

Johnson, N, and David, A, 1982 A Mesolithic site on Trevose Head and contemporary geography, *Cornish Archaeol*, **21**, 67–103

Johnson, N, and Rose, P, 1990 *Cornwall's archaeological heritage: from prehistory to the Tudors, 8000 BC – AD 1540*, Truro

Johnson, S, 1976 *The Roman forts of the Saxon shore*, London

Johnston, D E (ed), 1977 *The Saxon shore*, CBA Res Rep, **18**, London

Joint Nature Conservation Council Review Group, 1993 *Review group on JNCC marine and coastal projects: review papers*, Peterborough

Jones, B, and Mattingly, D, 1990 *An atlas of Roman Britain*, Oxford

Jones, C R, Houston, J A, and Bateman, D, 1993 A history of human influence on the landscape, in *The sand dunes of the Sefton coast* (ed D Atkinson and J Houston), 3–17, Liverpool

Jones, R L, and Keen, D H, 1992 *Pleistocene environments in the British Isles*, London

Keen, L, 1989 Coastal salt production in Norman England, in *Anglo-Norman studies XI: proceedings of the Battle conference 1988* (ed R Allen Brown), 133–79, Woodbridge

Keller, P T, 1988 The evidence for ancient quern production at Folkestone, *Kent Archaeol Rev*, **93**(Autumn), 59–68

Kendall, J D, 1881 Interglacial deposits of west Cumberland and north Lancashire, *Quart J Geol Soc*, **37**, 29–38

Kennard, A S, and Woodward, B B, 1901 The peat and forest bed at Westbury on Severn: IV Palaeoentology, *Proc Cotteswold Natur Fld Club*, **14**, 32–41

Kerney, M P, 1963 Late glacial deposits on the chalk of south-east England, *Phil Trans Roy Society London*, B, **246**, 203–54

Kerney, M P, 1976 Two post-glacial molluscan faunas from south-west England, *J Conchology*, **29**, 71–3

Kidson, C, and Heyworth, A, 1973 The Flandrian sea-level rise in the Bristol Channel, *Proceedings of the Ussher Society*, **2**, 565–84

Kidson, C, and Heyworth, A, 1976 The Quaternary deposits of the Somerset Levels, *Quart J Engineering Geology*, **9**, 217–35

Kidson, C, and Heyworth, A, 1978 Holocene eustatic sea level change, *Nature*, **273**, 748–50

King, G, and Bridge, L, 1994 *Directory of coastal planning and management initiatives in England*, Maidstone

Lambeck, K, 1993 Glacial rebound of the British Isles – I. Preliminary model results, *Geophysical Journal International*, **115**, 941–59

Land, D H, 1974 *The geology of the Tynemouth District*, Memoirs of the Geological Survey, new ser, London

Lawler, M, Parkhouse, J, and Straker, V, 1992 *Archaeology of the Second Severn crossing: assessment and recommendations for the English approaches*, unpublished report, Glamorgan-Gwent Archaeol Trust

Legget, D J, and Jones, A, nd *The application of GIS for flood defence in the Anglian Region: developing for the future*

Lenihan, D J, 1981 *National reservoir inundation study Volume 1. Summary (final report)*, 1, Santa Fe

Levitan, B, 1990 The vertebrate remains, in Bell 1990, 220–41

Levitan, B, and Locker, A, 1987 The vertebrate remains, in Balaam *et al* 1987a, 213–23

Lewis, M P, 1992 *The prehistory of coastal south-west Wales*, unpubl PhD thesis, St Davids University College, Lampeter

Liddle, M J, 1975 A selective review of the ecological effects of human trampling on natural ecosystems, *Biological Conservation*, **1**, 17–36

Lilly, D, and Usher, G, 1972 Romano-British sites on the north Somerset levels, *Proc Univ Bristol Speleol Soc*, **13**, 37–40

Long, A J, 1992 Coastal responses to changes in sea-level in the east Kent Fens and southeast England, UK over the last 7500 years, *Proceedings of the Geologists' Association*, **103**, 187–99

Long, A J, and Hughes, P, 1995 Evolution of the Dungeness foreland during the last 4000 years, *Marine Geology*, **124**, 253–71

Long, A J, and Innes, J B, 1993 Holocene sea-level changes and coastal sedimentation in Romney Marsh, southeast England, UK, *Proceedings of the Geologists' Association*, **104**, 223–37

Long, A J, and Innes, J B, 1995 The back-barrier and barrier depositional history of Romney Marsh, Walland Marsh and Dungeness, Kent, UK, *J Quaternary Sci*, **10**, 267–83

Long, A J, and Shennan, I, 1993 *Holocene relative sea-level and crustal movements in southeast and northeast England, UK*, Quaternary Proceedings, **3**, Cambridge

Long, A J, and Shennan, I, 1994 Sea-level changes in Washington and Oregon and the 'earthquake deformation cycle', *Journal of Coastal Research*, **10**(4), 825–38

Long, A J, and Tooley, M J, 1995 Holocene sea-level and crustal movements in Hampshire and southeast England, United Kingdom. *J Coastal Research* special issue no 17, 299–310

Loughlin, N, and Miller, K, 1979 *A survey of archaeological sites in Humberside*, Humberside Libraries and Amenities, Hull

Lovegrove, H, 1966 Possible medieval salt pans at Pett Level, Sussex, *Sussex Notes and Queries*, **16**, 253–301

Lucy, W C, 1872 The gravels of the Severn, Avon and Evenlode and their extension over the Cotteswold Hills, *Proc Cotteswold Natur Fld Club*, **5**, 71–140

Lucy, W C, 1877 The submerged forest, Holly Hazel, Sharpness, *Proc Cotteswold Natur Fld Club*, **6**, 105–25

Lyell, C, 1885 *The student's elements of geology*, London

Lyneis, M M, Weide, D L, and Warren, D, 1980 *Impacts: damage to cultural resources in the California desert*, Las Vegas

Mackley, R, and Faulkner, N, 1994 Excavation on the Leigh Beck marshes 1993, *Trans Rochford Hundred Fld Archaeol Group*, **1**, 1–56

Macphail, R, 1990 Soil history and micromorphology, in Bell 1990, 187–96

Macphail, R, 1994 Some soils of the intertidal zone of coastal Essex, *SEESOIL: J Southeast England Soils Discussion Group*

Macphail, R, in press The contribution of soil micromorphology to the understanding of archaeological sites and landscapes, *SEESOIL: J Southeast England Soils Discussion Group*

Macpherson-Grant, N, 1969 Two neolithic bowls from Birchington, Thanet, *Archaeol Cantiana*, **84**, 249–50

Marsden, P, 1985 *The wreck of the* Amsterdam, London

Marsden, P, 1987 *The historic shipwrecks of south-east England*, Norwich

Marshall, G, 1990 The Ravenscar alum works: new evidence from documentary and archaeological sources, *Trans Scarborough Archaeol Hist Soc*, **28**, 15–33

Martin, E, Pendleton, C, and Plouviez, J, 1992 Archaeology in Suffolk in 1991, *Proc Suffolk Inst Archaeol Hist*, **37**(4), 374–89

Mather, A S, and Ritchie, W, 1977 *The beaches of the highlands and islands of Scotland*, Edinburgh

Mathewson, C C, and Gonzalez, T, 1988 Protection and preservation of archaeological sites through burial, in *The engineering geology of ancient works, monuments and historical sites* (ed P G Marinos and G C Koukis), 1, 519–26, Rotterdam

May, J, 1992 Iron Age coins in Yorkshire, in *Celtic coinage: Britain and beyond, the eleventh Oxford symposium on coinage and monetary history* (ed M May), BAR Brit Ser, **222**, 93–111, Oxford

McAvoy, F, 1994 Marine salt extraction: the excavation of salterns at Wainfleet St Mary, Lincolnshire, *Medieval Archaeol*, **38**, 134–63

McAvoy, F, 1995 Excavations at the Withow Gap, Skipsea (Holderness), in *Humber Wetlands Survey (1994–5)*, 16

McDonnell, R, 1980 Somerset Archaeology 1979: tidal fish weirs, west Somerset, *Proc Somerset Archaeol Natur Hist Soc*, **124**(1979), 134–5

McDonnell, R, 1993 Preliminary archaeological assessment in Bridgwater Bay: Gore Sands and Stert Flats, in *Archaeology in the Severn Estuary, 1993* (ed M G Bell), Severn Estuary Levels Research Committee Annu Rep, 41–6, Lampeter

McDonnell, R, 1995 *Bridgwater Bay: a rapid preliminary assesment of Gore Sand and Stert Flats*, Swindon

Megaw, J V S, Thomas, A C, and Wailes, B, 1961 The Bronze Age settlement at Gwithian, Cornwall, *Proc West Cornwall Fld Club*, **5**, 200–15

Miles, A, 1975 Salt-panning in Romano-British Kent, in de Brisay and Evans 1975, 26–31, Colchester

Millett, M, and McGrail, S, 1987 The archaeology of the Hasholme logboat, *Archaeol J*, **144**, 69–155

Milne, G, 1985 *The port of Roman London*, London

Milne, G, and Goodburn, D, 1993 *Foreshore archaeology: data standards for recording archaeological material in the intertidal zone*, report prepared for RCHME

Milne, G, and Hobley, B (eds), 1981 *Waterfront archaeology in Britain and Northern Europe*, CBA Res Rep **41**, London

Milne, G, McKewan, C, and Goodburn, D, forthcoming Recording vernacular vessels in the inter-tidal zone: Whitewall Creek, 1992, *Int J Naut Archaeol Underwater Explor*

Ministry of Agriculture Fisheries and Food, 1989 *Caring for the future: flood and coastal defence*, London

Ministry of Agriculture Fisheries and Food, 1993a *Coastal defence and the environment: a strategic guide for managers and decision makers in the National Rivers Authority, Local Authorities and other bodies with coastal responsibilities*, London

Ministry of Agriculture Fisheries and Food, 1993b *Coastal defence and the environment: a guide to good practice*, London

Ministry of Agriculture Fisheries and Food, 1994a *Our living heritage*, London

Ministry of Agriculture Fisheries and Food, 1994b *Flood and coastal defence: research and development annual report 1993–94*, London

Ministry of Agriculture Fisheries and Food, 1994c *Coast protection survey of England: summary survey report*, London

Ministry of Agriculture Fisheries and Food/Scottish Office Environment Department/National Rivers Authority, 1992 *Flood and coastal defence research and development: report of the Advisory Committee*, London

Ministry of Agriculture Fisheries and Food/Welsh Office, 1993 *Strategy for flood and coastal defence in England and Wales*, London

Ministry of Defence, nd *The Ministry of Defence and conservation*, London

Moffet, L, Robinson, M A, and Straker, V, 1989 Cereals, fruits and nuts, in *The beginnings of agriculture* (ed D Williams, N Gardener, and A Milles), BAR Int Ser, **496**, 243–61, Oxford

Monaghan, J, 1987 *Upchurch and Thameside Roman pottery: a ceramic typology for northern Kent, 1st to 3rd centuries AD*, BAR Brit Ser, **173**, Oxford

Morgan, R A, 1982 Current tree-ring research in the Somerset Levels, in *Archaeological aspects of woodland ecology* (ed M G Bell and S Limbrey), BAR Int Ser, **146**, 261–77, Oxford

Morgan, R A, Litton, C D, and Salisbury, C R, 1987 Trackways and tree-trunks – dating Neolithic oaks in the British Isles, *Tree-ring Bulletin*, **47**, 61–9

Morris, A J, 1949 The Saxon shore fort at Burgh Castle, *Proc Suffolk Inst Arch*, **24**, 100–20

Morris, E L, 1985 Prehistoric salt distributions: two case studies from western Britain, *Bull Board Celtic Stud*, **32**, 336–79

Morris, E L, 1994 The organisation of salt production and distribution in Wessex, in *The Iron Age in Wessex: recent work* (ed A P Fitzpatrick and E L Morris), 14–6, Salisbury

Morton, G H, 1891 *Geology of the country around Liverpool*, London

Motkin, D L, 1991 Edwin Smith and the discovery of Roman occupation in Gurnard Bay 1864–1880, *Proc Isle Wight Natur Hist Archaeol Soc*, **10**, 139–47

Motyka, J M, and Brampton, A H, 1993 *Coastal management: mapping of littoral cells*, Wallingford

Muckelroy, K, 1981 Middle Bronze Age trade between Britain and Europe: a maritime perspective, *Proc Prehist Soc*, **47**, 275–97

Murphy, P, 1988 Carbonised Neolithic plant remains from the Stumble, an intertidal site in the Blackwater estuary, Essex, England, *Circaea, Bull Ass Envir Archaeol*, **6**, 21–38

Murphy, P, nd *The Hullbridge Survey: interim report 2*, Chelmsford

Murphy, P, and Wilkinson, T J, 1982 *The Hullbridge Survey: interim report 1*, Chelmsford

Murphy, P, and Wilkinson, T J, 1991 Survey and excavation on the tidal foreshore zone, in *Wet site excavation and survey: proceedings of a conference at the Museum of London, October 1990* (ed J M Coles and D M Goodburn), WARP Occ Pap, **5**, 10–5, Exeter

National Coasts and Estuaries Advisory Group, 1993 *Coastal planning and management: a good practice guide*, Exeter

National Rivers Authority, 1993a *Catchment management planning guidelines*, Bristol

National Rivers Authority, 1993b *National Rivers Authority flood defence strategy*, Bristol

National Rivers Authority, 1993c *National Rivers Authority water quality strategy*, Bristol

National Rivers Authority, 1993d *National Rivers Authority water resources strategy*, Bristol

National Rivers Authority, 1994a *Annual research and development review 1993*, London

National Rivers Authority, 1994b *Abandoned mines and the water environment*, London

National Rivers Authority, nd *National Rivers Authority sea defence summary*, Bristol

National Rivers Authority and Halcrow, 1991 *The future of shoreline management*

National Trust, 1993 *Coastline Special: Enterprise Neptune – saving our unspoilt coastline*, Cirencester

Natural Environment Research Council, 1994a *From shore to shelf edge: coastal marine sciences research in the Natural Environment Research Council*, Swindon

Natural Environment Research Council, 1994b *Strategy for marine science and technology 1994–2000*, Swindon

Natural Environment Research Council, nd *Coastal zone management*, Swindon

Nayling, N, 1993 Tales from the riverbank: Bronze Age palaeochannels in the alluviated Nedern Valley at Caldicot Castle Lake, Gwent, in *A spirit of enquiry: essays for Ted Wright* (ed J Coles, V Fenwick, and G Hutchinson), 72–6, Exeter

Nayling, N, forthcoming A medieval boat from Magor Pill, Gwent, in *Archaeology in the Severn Estuary, 1995* (ed M G Bell), Severn Estuary Levels Research Committee, Ann Rep, Lampeter

Norfolk Coast Project, 1994 *A visitor management strategy for the Norfolk coast*, Wells-next-the-Sea

Northumberland County Council, 1991 *Northumberland coast management plan: consultation draft*, Morpeth

Northumberland County Council, 1994 *A strategy for coastal archaeology*, Morpeth

Nyman, J A, Carloss, M, DeLaune, R D, and Patrick, W H, 1994 Erosion rather than dieback as the mechanism of marsh loss in an estuarine marsh, *Earth Surface Processes and Landforms*, **19**, 69–84

Oost, A P, and de Boer, P L, 1994 Sedimentology and development of barrier islands, ebb-tidal flats, inlets and back-barrier areas of the Dutch Wadden Sea, *Senckenbergiana Maritima*, **24**, 65–115

Ordnance Survey, 1978 *Roman Britain: north sheet*, 4 edn, Southampton

Ordnance Survey, 1991 *Roman Britain: south sheet*, 4 rev edn, Southampton

Orford, J D, Carter, R W G, and Jennings, S C, 1991 Coarse clastic barrier environments: evolution and implications for Quaternary sea level interpretation, *Quaternary International*, **9**, 87–104

Orme, B, Coles, J, Caseldine, A, and Bailey, G, 1981 Meare Village West, *Somerset Levels Papers*, **7**, 12–69

Osborne White, H J, 1928 *The geology of the country near Hastings and Dungeness*, Memoirs of the Geological Survey, London

Ottaway, P, 1994 Filey Roman signal station, *Interim*, **19** (1), 27–36

Ottaway, P, 1995 Filey Roman signal station: what happened next..., *Rescue News*, **65**, 2

Owen, A E B, 1984 Salt, sea banks and medieval settlement on the Lindsey coast, in *A prospect of Lincolnshire* (ed N Field and A White), 46–9, Lincoln

Owen, A E B, 1986 Mablethorpe St Peter's and the sea, *Lincolnshire Hist Archaeol*, **21**, 61–2

Owen, A E B, 1993 Beyond the sea bank: sheep on the Huttoft Outmarsh in the early thirteenth century, *Lincolnshire Hist Archaeol*, **28**, 39–41

Owen, J S, 1987 A transport curiosity: trackway transport on a tidal foreshore, *J Transport Hist*, 3 ser, **8** (2), 210–15

Owen, J S, 1991 An alternative form of guided transport on the Yorkshire coast, *J Trevithick Soc*, **18**, 126–32

Parfitt, K, and Fenwick, V, 1993 The rescue of Dover's Bronze Age boat, in *A spirit of enquiry* (ed J Coles, V Fenwick, and G Hutchinson), 77–80, Exeter

Parkes, C, 1990 *Archaeological fieldwork in the Isles of Scilly, March 1990: Early batteries on the Garrison St Mary's*, Truro

Pearce, D, Markandya, A, and Barbier, E, 1989 *Blueprint for a green economy*, London

Peltier, W R, 1987 Mechanisms of relative sea-level change and the geophysical responses to ice-water loading, in *Sea-surface studies: A global view* (ed R J N Devoy), 57–94, London

Pennick, N, 1987 *Lost lands and sunken cities*, London

Pestall, T, 1993 Archaeological investigations into the lost village of Eccles-next-to-the-Sea, Norfolk, *Medieval Set Res Group Annu Rep*, **8**, 17–21

Petch, D F, 1987 The Roman period, in *A history of the county of Chester* (ed Harris and Thacker), Oxford

Petch, J A, 1925 Roman Durham, *Archaeol Aeliana*, 4 ser, **1**, 29

Pethick, J, 1981 Long-term accretion rates on tidal salt marshes, *Journal of Sedimentary Petrology*, **51**, 571–77

Pethick, J, 1993 Shoreline adjustments and coastal management: physical and biological processes under accelerated sea-level rise, *Geogr J*, **159**(2), 162–8

Phillips, C W, 1941 Some recent finds from the Trent near Nottingham, *Antiq J*, **21**, 133–43

Philp, B J, 1957 Recent discoveries at Reculver 1955–57, *Archaeol Cantiana*, **71**, 167–68

Pickering, H, 1993 *Working papers in coastal zone management: property rights in the coastal zone: England and Wales*, Portsmouth

Pidgeon, D, 1885 On some recent discoveries in the submerged forest at Torbay, *Quart J Geol Soc*, **41**, 9–22

Pilbin, P, 1935 A geographical analysis of the sea-salt industry of north-east England, *Scott Geogr Mag*, 51, 22–8

Pirazzoli, P A, 1991 *World atlas of Holocene sea-level changes*, Amsterdam

Pitts, M W, 1979 A gazetteer of Roman sites and finds on the West Sussex coastal plain, *Sussex Archaeol Collect*, **117**, 63–83

Plater, A J, 1992 The late Holocene evolution of Denge Marsh, southeast England: a stratigraphic, sedimentological and micropalaeontological approach, *The Holocene*, **2**, 63–70

Plater, A J, and Long, A J, 1995 The morphology and evolution of Denge Beach and Denge Marsh, in *Romney Marsh: the debatable ground* (ed J Eddison), Oxford Univ Comm Archaeol Monogr, **41**, 8–21, Oxford

Plater, A J, and Shennan, I, 1992 Evidence of Holocene sea-level change from the Northumberland coast, eastern England, *Proceedings of the Geologists' Association*, **103**, 201–16

Polsue, J, 1974 *Lake's parochial history of the county of Cornwall*, **1&4**, Truro

Potter, T W, 1979 *Romans in north-west England, excavations at the Roman forts of Ravenglass, Watercrook and Bowness on Solway*, Cumberland & Westmorland Antiq Archaeol Soc Res Ser, **1**, Kendal

Powell-Cotton, P H G, 1939 The Beck find: prehistoric and Roman site on the foreshore at Minnis Bay, *Archaeol Cantiana*, **51**, 191–203

Preece, R, 1979 The molluscan fauna of an early post-glacial tufa at Totland, Isle of Wight, *J Conchology*, **30**, 35–42

Preece, R, 1980 The biostratigraphy and dating of a post-glacial slope deposit at Gore Cliff, near Blackgang, Isle of Wight, *J Archaeol Sci*, **7**, 255–65

Preece, R C, and Robinson, J E, 1984 Late Devensian and Flandrian environmental history of the Sancolne Valley, Lincolnshire: molluscan and ostracod evidence, *J Biogeogr*, **11**, 319–52

Preece, R C, Scourse, J D, Houghton, S D, Knudsen, K L, and Penney, D N, 1990 The Pleistocene sea-level and neotectonic history of the Eastern Solent, Southern England, *Phil Trans Roy Soc London*, B, **328**, 425–77

Preston, J M, 1977 *Industrial Medway: an historical survey – the industrial development of the lower Medway Valley with special reference to the nineteenth and early twentieth centuries*, Rochester

Price, J, Wilson, P R, Briggs, C S, and Hardman, S J (eds), 1988 *Recent research in Roman Yorkshire*, BAR Brit Ser, **193**, Oxford

Pryor, F, 1992 Current research at Flag Fen, Peterborough, *Antiquity*, **66**, 439–531

Pybus, D, 1983 The alum hole at Sandsend, *Trans Scarborough Dist Archaeol Hist Soc*, **25**, 31–5

Quelennec, R E, 1990 The CORINE coastal erosion project: identification of coastal erosion problems and data base on the littoral environment of eleven European countries, *Senckenbergiana Maritima*, **21**, 25–32

Rackham, O, 1986 *The history of the countryside*, London and Melbourne

Ratcliffe, J, 1989 *The archaeology of Scilly: an assessment of the resource and recommendations for its future*, Truro

Ratcliffe, J, 1991 *Lighting up the past in Scilly: archaeological results from the 1985 electrification project*, Truro

Ratcliffe, J, 1993 *Fieldwork in Scilly 1991 and 1992*, Truro

Ratcliffe, J, and Parkes, C, 1989 *Archaeological fieldwork in the Isles of Scilly: recording work at cliff-face sites on Samson and St Agnes*, Truro

Ratcliffe, J, and Parkes, K, 1990 *Archaeological fieldwork in the Isles of Scilly: September 1989*, Truro

Ratcliffe, J, and Sharpe, A, 1991 *Fieldwork in Scilly, Autumn 1990*, Truro

Ratcliffe, J, and Straker, V, 1996 *The early environments of Scilly*, Truro

Reade, T M, 1878 The submarine forest at Altmouth, *Quart J Geol Soc*, **34**, 447

Reader, F W, 1911 A neolithic floor in the bed of the Crouch River, and other discoveries near Rayleigh, Essex, *Essex Naturalist*, **16**, 249–66

Redknap, M, 1992 The Saxon pottery from Barking Abbey: part 2, the continental imports, *London Archaeologist*, **6**(14), 378–81

Reid, C, 1913 *Submerged forests*, Cambridge

RIB – see Collingwood and Wright, 1965; 1999

Rigold, S E, 1977 *Litus Romanum* – the Saxon shore forts as mission stations, in *The Saxon Shore* (ed D E Johnson), CBA Res Rep, **18**, 70–5, London

Rigold, S E, and Metcalf, D M, 1978 A checklist of English finds of Sceattas, *British Numis J*, **47**(1977), 31–52

Rippon, S, 1994a Medieval wetland reclamation in Somerset, in *The medieval landscape of Wessex* (eds M Aston and C Lewis), 239–53, Oxford

Rippon, S, 1994b The Roman settlement and landscape at Kenn Moor, North Somerset – interim report on survey and excavations in 1993–4, in *Archaeology in the Severn Estuary 1994* (ed M G Bell), Severn Estuary Levels Research Committee Annu Rep, 21–34, University of Wales, Lampeter

Rippon, S, 1996 *The Gwent levels: the evolution of a wetland landscape*, CBA Res Rep, **105**, York

Rippon, S, forthcoming Essex *c* 700–1066, in *The archaeology of Essex* (ed O Bedwin), Chelmsford

Rivet, A L F, and Smith, C, 1979 *The place-names of Roman Britain*, London

Roberts, M B, 1986 Excavation of the Lower Palaeolithic site at Amey's Eartham Pit, Boxgrove, West Sussex: a preliminary report, *Proc Prehist Soc*, **52**, 215–46

Robertson, P, 1993 Searching the Seven Sisters, *Sussex Archaeol Soc Newsletter*, **70**, 11

Robertson, P, 1994 The Severn Sisters voluntary marine conservation area, a maritime archaeological perspective, unpub MLitt thesis, St Andrew's

Robinson, D A, and Williams, R B G, 1983 The Sussex Coast past and present, in *Sussex: environment, landscape and society* (ed Geographical Editorial Committee: University of Sussex), 50–66, Gloucester

Robinson, D N, 1984 The buried forest of Lincolnshire, in *A prospect of Lincolnshire* (eds N Field and A White), Lincoln

Robinson, E, 1990 Ostracods, in Bell 1990, 208–10

Robinson, P C, 1962 A geological guide to the jet industry on the Yorkshire coast, *Trans Scarborough Archaeol Hist Soc*, **1**, 3–7

Rodwell, W, 1976a Roman and medieval finds from South Benfleet, archaeological notes, *Essex Archaeol Hist*, **8**, 259–63

Rodwell, W, 1976b Early Anglo-Saxon pottery from Canvey Island, archaeological notes, *Essex Archaeol Hist*, **8**, 265

Roe, D, 1968 *A gazetteer of British Lower and Middle Palaeolithic sites*, CBA Res Rep, **8**, London

Roe, D, 1981 *The Lower and Middle Palaeolithic periods in Britain*, Routledge, London

Rogers, E H, 1946 The raised beach, submerged forest and kitchen midden of Westward Ho! and the submerged stone row of Yelland, *Proc Devon Archaeol Exploration Soc*, **3**(3), 109–135

Rollinson, W, 1964 Schemes for reclamation of land from the sea in north Lancashire in the eighteenth and nineteenth centuries, *Trans Hist Soc Lancashire Cheshire*, **115**, 133

Round, J H, 1903 Introduction to the Essex Domesday, in *The Victoria County History of Essex* (eds M A Doubleday and W Page), **1**, 333–425, London

Royal Commission on the Historical Monuments of England, 1923 *An inventory of the historical monuments of Essex*, London

Royal Commission on the Historical Monuments of England, 1993a *Recording England's past: a review of national and local Sites and Monument Records in England*, London

Royal Commission on the Historical Monuments of England, 1993b *Dunwich Greyfriars: a Franciscan friary near Southwold, Suffolk. An archaeological survey by the Royal Commission on the Historical Monuments of England*, London

Royal Commission on the Historical Monuments of England, 1994a *A 'Red Hill' site at Canvey Island, Essex. An archaeological survey by the Royal Commission on the Historical Monuments of England*, Swindon

Royal Commission on the Historical Monuments of England, 1994b *Salt working mounds in the Harty Marshes, Isle of Sheppey. An archaeological survey by the Royal Commission on the Historical Monuments of England*, Swindon

Royal Commission on the Historical Monuments of England, 1995 *Coastal sites on Tollesbury Wick Marsh, Tollesbury, Essex*, Swindon

Royal Society for the Protection of Birds, 1990 *Turning the tide: a future for estuaries*, Sandy

Royal Society for the Protection of Birds, 1993a *A shore future: RSPB vision for the coast*, Sandy

Royal Society for the Protection of Birds, 1993b *Making the coast count: strategic planning and management on the north-west coast*, Sandy

Rudkin, E H, 1975 Medieval salt making in Lincolnshire, in de Brisay and Evans, 1975, 37–40, Colchester

Rudling, D, 1984 Two Gallo-Belgic gold coins from the foreshore at Eastbourne, East Sussex, *Sussex Archaeol Collect*, **122**, 217–8

Rural Development Commission, 1994 *Rural Development Areas 1994*, Salisbury

Salisbury, C R, 1991 Primitive British fishweirs, in Good *et al* 1991, 76–87, London

Salway, P, 1981 *Roman Britain*, Oxford

Schiffer, M B, 1987 *Formation processes of the archaeological record*, Albuquerque

Schofield, A J (ed), 1991 *Interpreting artefact scatters: contributions to ploughzone archaeology*, Oxford

Scott, V M, 1984 Surface finds at Stutton Suffolk, *Colchester Archaeol Group Annu Bull*, **27**, 15–18

Scourse, J D, 1991 Late Pleistocene stratigraphy and palaeobotany of the Isles of Scilly, *Phil Trans Roy Soc London*, B, 1995, **334**, 405–48

Sealey, P R, New light on the salt industry and Red Hills of prehistoric and Roman Essex, *Essex Archaeol Hist*, **26**, 65–81

SERPLAN, 1993 *Coastal planning guidelines for the south east*, London

Severn Estuary Levels Research Committee, 1988 *The archaeological potential of the Severn Estuary: an initial assessment for STPG*

Shackleton, N J, and Opdyke, N D, 1973 Oxygen isotope and palaeomagnetic stratigraphy of equatorial Pacific core, V28–238, *Quat Research*, **3**, 39–55

Shennan, I, 1982 Interpretation of Flandrian sea-level data from the Fenland, England, *Proceedings of the Geologists' Association*, **93**(1), 53–63

Shennan, I, 1986a Flandrian sea-level changes in the Fenland. I. The geographical setting and evidence of relative sea-level changes, *J Quaternary Science*, **1**, 119–54

Shennan, I, 1986b Flandrian sea-level changes in the Fenland. 2: Tendencies of sea-level movement, altitudinal changes, and local and regional factors, *J Quaternary Science*, **1**, 155–79

Shennan, I, 1987 Sea-level changes in the North Sea Region, in *Sea-level changes* (eds M J Tooley and I Shennan), 109–51, Oxford

Shennan, I, 1989 Holocene crustal movements and sea-level changes in Great Britain, *J of Quaternary Science*, **4**, 77–89

Shennan, I, 1992 Late Quaternary sea-level changes and crustal movements in Eastern England and Eastern Scotland: an assessment of models of coastal evolution, *Quaternary International*, **15/16**, 161–73

Shennan, I, 1993 Sea-level changes and the threat of coastal inundation, *Geogr J*, **159**(2), 148–56

Shennan, I, 1994a Coastal evolution, Section 2. Data synthesis: altitudinal trends, in *The Fenland Project, Number 9: Flandrian environmental change in Fenland* (ed M J Waller), E Anglian Archaeol Rep, **70**, 53–60, Cambridge

Shennan, I, 1994b Coastal evolution, Section IV. Hypothesis testing, in *The Fenland Project, Number 9: Flandrian environmental change in Fenland* (ed M J Waller), E Anglian Archaeol Rep, **70**, 81–4, Cambridge

Shennan, I, Orford, J D, and Plater, A J, 1992 IGCP Project 274: Quaternary coastal evolution: case studies, models and regional patterns, *Proceedings of the Geologists' Association*, **103**(3), 163–5

Shennan, I, Tooley, M J, Davis, M J, and Haggart, B A, 1983 Analysis and interpretation of Holocene sea-level data, *Nature*, **302**, 404–6

Sheppard, J A, 1966 *The draining of the marshlands of South Holderness and the Vale of York*, York

Sheppard, T, 1907 Notes on the more important archaeological discoveries in East Yorkshire, *East Riding Antiq Soc*, **14**, 55

Sheppard, T, 1910 A Roman urn from Lincolnshire, *Lincolnshire Notes and Queries*, **11**(2), 33–6

Sheppard, T, 1912 *The lost towns of the Yorkshire coast*, London

Shore, T W, and Elwes, J W, 1889 The new dock excavation at Southampton, *Proc Hampshire Fld Club Archaeol Soc*, **1**, 43–56

Sidaway, R, 1991 *A review of marina developments in southern England*, Sandy

Simpson, P, 1994 *The natural preservation of wooden stakes on the foreshore at quarr: an assessment of their* in situ *stability*, Unpubl MA thesis, University of Durham

Singer, R, Wymer, J J, Gladfelter, B G, and Wolff, R G, 1973 Clacton-on-Sea, Essex: report on the 1969–70 excavations, *Proc Prehist Soc*, **39**, 6–74

Smith, A G, 1958 Post-glacial deposits in south Yorkshire and north Lincolnshire, *New Phytol*, **57**, 19–49

Smith, A G, and Morgan, L A, 1989 A succession to ombrotrophic bog in the Gwent Levels and its demise: a Welsh parallel to the peats of the Somerset Levels, *New Phytol*, **112**, 145–67

Smith, D B, and Francis, E A, 1967 *Geology of the country between Durham and West Hartlepool*, Memoirs of the Geological Survey, London

Smith, G, forthcoming *Coastal erosion survey, Aberdaron Bay to Great Orme, North Wales*, London

Smith, H P, 1958 *The history of the borough and county of the town of Poole: origins and early development*, **1**, Poole

Smith, P D E S, Allen, J P, Hamlin, A, Orme, B, and Wootton, R, 1983 The investigation of a medieval shell midden in Braunton Burrows, *Proc Devon Archaeol Soc*, **41**, 75–80

Smith, R A, 1911 Lake-dwellings in Holderness, Yorkshire, *Archaeologia*, **62**, 593–610

Smith, R A, 1919 Foreign relations in the Neolithic period: presidential address, *Proc Prehist Soc East Anglia*, **3**(1), 14–32

Somerset County Council, 1993 *Somerset structure plan alteration No. 2*, Taunton

Spencer, P J, 1975 Habitat change in coastal sand dune areas: the molluscan evidence, in *The effect of man on the landscape: the highland zone* (ed J G Evans, S Limbrey, and H Cleere), CBA Res Rep, **11**, 96–103, London

Spurrell, F C J, 1885 Early sites and embankments on the margins of the Thames estuary, *Archaeol J*, **42**, 269–302

Steers, J A, 1971 The east coast floods 31 January – 1 February 1953, in *Applied coastal geomorphology* (ed J A Steers), 198–223, London

Steane, J M, and Foreman, M, 1988 Medieval fishing tackle, in *Medieval fish, fisheries and fishponds in England* (ed M Aston), BAR, **182** (i), 137–81, Oxford

Steane, J M, and Foreman, M, 1991 The archaeology of medieval fishing tackle, in *Waterfront archaeology* (eds G L Good, R H Jones and M W Ponsford), CBA Res Rep **74**, 88–101, London

Strachan, D, 1995 *Essex aerial reconnaissance: 1995 annual report*, Chelmsford

Streif, H, 1982 The occurrence and significance of peat in the Holocene deposits of the German North Sea coast, in *Proceedings of the symposium on peat lands below sea level* (ed H de Bakker and M W Van Den Berg), **30**, 31–41, Wareningen

Stuckey, K, and Evans, J, 1988 Looking for history in the mud, *Bristol Avon Archaeol*, 7, 38–40

Sunter, N, and Woodward, P, 1987 *Romano-British industries in Purbeck*, Dorchester

Swinnerton, H H, 1931 The post-glacial deposits of the Lincolnshire coasts, *Quart J Geol Soc* , **87**, 360–75

Swinnerton, H H, 1932 Prehistoric pottery sites of the Lincolnshire coast, *Antiq J*, **12**, 239–53

Swinnerton, H H, and Kent, P E, 1976 *The geology of Lincolnshire from the Humber to the Wash*, 2nd ed, Lincoln

Sykes, C M, 1938 Some flint implements from the Blackstone rocks, Clevedon, *Proc Univ Bristol Speleological Soc*, **5**, 75–9

Tait, J, and Jobey, G, 1971 Romano-British burials at Beadnell, Northumberland, *Archaeol Aeliana*, 4 ser, **49**, 53–70

Tait, R V, 1981 *Elements of marine ecology: an introductory course*, Cambridge

Taylor, K C, Lamorey, G W, Doyle, G A, Alley, R B, Grotes, P M, Mayewski, P A, White, J W C, and Barlow, L F, 1993 The 'flickering switch' of late Pleistocene climate change, *Nature*, **361**, 432–5

Taylor, M V, 1944 The Sidmouth bronze, legionary standard or tripod?, *Antiq J*, **24**, 22–6

Taylor, P M, and Parker, J G, 1993 *The coast of North Wales and Northwest England: an environmental appraisal*, London

Taylor, R, 1975 The coastal salt industry of Amounderness, *Trans Cheshire Antiq Soc*, **78**, 14–21

Thacker, A T, 1987 Anglo-Saxon Cheshire, in *A history of the County of Chester* (eds B E Harris and A T Thacker), **1**, 237–92, Oxford

Thames Gateway Task Force, 1994 *Thames Gateway Planning Framework: consultation draft*, London

Thomas, C, 1958 *Gwithian – ten year's work*, Cambourne

Thomas, C, 1985 *Exploration of a drowned landscape*, London

Thomas, C, 1988 The context of Tintagel: a new model for the diffusion of post-Roman Mediterranean imports, *Cornish Archaeol*, **27**, 7–22

Thomas, C, 1990 *Gallici Nautae de Gallarum Provinciis*: a sixth/seventh century trade with Gaul reconsidered, *Medieval Archaeol*, **34**, 1–21

Thomas, D, 1992 Nant Hall Road, Prestatyn, *Archaeol Wales*, **32**, 59

Thompson, F H, 1965 *Roman Cheshire*, Chester

Thompson, I, 1982 *Grog-tempered 'Belgic' pottery of south-eastern England*, BAR Brit Ser, 108, Oxford

Toft, L A, 1988 A study of coastal village abandonment in the Swansea Bay region, 1270–1540, *Morgannwg*, **32**, 21–37

Tomalin, D J, 1991 *Wootton Haven: an assessment of a multi-period intertidal site with an appraisal of select archaeological features on the Solent seabed*, draft report, Isle of Wight County Archaeological Unit, Newport

Tomalin, D (ed) 1995 *Wootton Haven: an assessment and updated project design for the Wootton-Quarr intertidal survey*, Isle of Wight County Council, Newport

Tomalin, D J, Loader, R A, and Westmore, I, 1994 *Review, The Wootton-Quarr survey, summary of the field assessment, draft 1, (ed D Tomalin), draft report for English Heritage*, Isle of Wight County Council Archaeological Unit, Newport

Tooke, C S, 1984 The ballast trade in the port of Great Yarmouth, *Great Yarmouth and District Archaeol Soc*, **2**(1), 13–16

Tooley, M J, 1974 Sea level changes during the last 9000 years in northwest England, *Geogr J*, **140** (1), 18–42

Tooley, M J, 1978a *Sea level changes in north-west England during the Flandrian stage*, Oxford

Tooley, M J, 1978b The history of Hartlepool Bay, *Int J Naut Archaeol Underwater Explor*, **7**, 71–87

Tooley, M J, 1980 Theories of coastal change in northwest England, in *Archaeology and coastal change* (ed F H Thompson), Soc Antiq London Occas Pap, **1**, 74–86, London

Tooley, M J, 1982a Sea-level changes in northern England, *Proceedings of the Geologists' Association*, **93**(1), 43–51

Tooley, M J, 1982b Introduction to the IGCP Project 61: Sea-level movements during the last deglacial hemicycle (about 15,000 years). Final report of the UK Working Group, *Proceedings of the Geologists' Association*, **93**(1), 3–6

Tooley, M J, 1985a Sea-level changes and coastal morphology in northwest England, in *The geomorphology of northwest England* (ed R H Johnson), 94–121, Manchester

Tooley, M J, 1985b Climate, sealevel and coastal changes, in *The climatic scene* (eds M J Tooley and G M Sheail), 206–34, London

Tooley, M J, and Jelgersma, S (eds), 1992 *Impacts of sea-level rise on European coastal lowlands*, Oxford

Tooley, M J, and Switsur, V R, 1988 Water level changes and sedimentation during the Flandrian Age in the Romney Marsh area, in *Romney Marsh: evolution, occupation, reclamation* (eds J Eddison and C Green), Oxford Univ Comm Archaeol Monogr, **24**, 53–71, Oxford

Trechmann, C T, 1936 Mesolithic flints from the submerged forest at West Hartlepool, *Proc Prehist Soc*, **2**(2), 161–68

Trechmann, C T, 1947 The submerged forest beds of the Durham coast, *Proc Yorkshire Geol Soc*, **27**

Trenhaile, A S, 1987 *The geomorphology of rock coasts*, London

Trett, P, 1982 Marine Archaeology, *Great Yarmouth and District Archaeol Soc*, **1**(4), 7–9

Trinity House Lighthouse Service, 1994 *Annual Review*, London

Trollope, E, 1860 Roman Remains in the vicinity of Padstow Cornwall, *Archaeol J*, **17**, 311–18

Turk, F, 1978 The animal remains from Nornour: a synoptic view of the finds, in Excavations at Nornour, Isles of Scilly 1969–73: the pre-Roman settlement, *Cornish Archaeol*, **17**, 99

Turner, K R, Pearce, D, and Bateman, I, 1994 *Environmental economics: an elementary introduction*, Hemel Hempstead

UK Offshore Operators Association Ltd, 1991 *Environmental guidelines*, London

UK Offshore Operators Association Ltd, 1994 *Environmental guidelines for exploration operations in near-shore and sensitive areas*, London

van de Noort, R, and Davies, P, 1993 *Wetland heritage: an archaeological assessment of the Humber Wetlands*, Hull van de Noort, R, and Ellis, S (eds), 1995 *Wetland heritage of Holderness: an archaeological survey*, Humber Wetlands Project, School of Geography and Earth Resources, University of Hull

van de Plassche, O, 1986 *Sea level research: a manual for the collection and evaluation of data*, Norwich

Vanderzee, M P, 1988 Changes in saltmarsh vegetation as an early indicator of sea-level rise, in *Greenhouse: planning for climatic change* (ed G I Pearson), 147–60, Melbourne

Varley, W, 1968 Barmston and the Holderness crannogs, *East Riding Archaeol*, **1**(1), 12–26

Verger, F, 1968 *Marais et waden du littoral français*, Paris

Waddelove, A C, and Waddelove, E, 1990 Archaeology and research into sea-level during the Roman era: towards a methodology based on highest astronomical tide, *Britannia*, **21**, 253–66

Wainwright, G (ed), 1989 *Archaeology Review, 1988–89*, London

Waller, M, 1994 *The Fenland Project, Number 9: Flandrian environmental change in Fenland*, E Anglian Archaeol Rep, **70**, Cambridge

Waller, M, Burrin, P J, and Marlow, A, 1988 Flandrian sedimentation and palaeoenvironments in Pett Level, the Brede and lower Rother valleys and Walland Marsh, in *Romney Marsh: evolution, occupation, reclamation* (ed J Eddison and C Green), Oxford Univ Comm Archaeol Monogr, **24**, 3–30, Oxford

Walsh, K, 1993 *Early medieval environment and economy: Lindisfarne – a case study*, Leicester

Ward, E M, 1922 *English coastal evolution*, London

Warren, S H, 1911a On the correlation of the prehistoric 'floor' at Hullbridge with similar beds elsewhere, *Essex Natur*, **16**, 265–82

Warren, S H, 1911b On a prehistoric interment near Walton-on-Naze, *Essex Natur*, **16**, 198–208

Warren, S H, 1932 Prehistoric timber structures associated with a briquetage site in Lincolnshire, *Antiq J*, **12**, 254–6

Warren, S H, Piggott, S, Clark, J G D, Burkitt, M C, Godwin, H, and Godwin, M E, 1936 Archaeology of the submerged land-surface of the Essex coast, *Proc Prehist Soc*, **2**(2), 178–210

Warrick, R A, 1993 Climate and sea-level change, in *Climate and sea-level change: observations, projections and implications* (eds R A Warrick, E M Barrow, and T M L Wigley), 3–21, Cambridge

Warrick, R A, Le Prevost, C, Meier, M F, Oerlemans, J, and Woodworth, P L, 1996 Changes in sea-level, in *Climate change 1995: the science of climate change* (eds J T Houghton, L G Meira Filho, B A Callander, N Harris, A Kattenberg, and K Maskell), 359–405, Cambridge

Warrick, R A, and Oerlemans, J, 1990 Sea-level rise. In: Houghton et al (eds), 1990, 257–281

Watson, R T, Rodhe, H, and Oeschger, H, and Siegenthaler, U, 1990 Greenhouse gases and aerosols. In: Houghton et al (eds), 1990, 1–40

Wedlake, A L, 1955 Traces of a Romano-British settlement, *Somerset and Devon Notes and Queries*, **27**, 30–2

Wedlake, A L, and Wedlake, D J, 1963 Palaeoliths from the Doniford gravels on the coast of west Somerset, *Proc Somerset Archaeol Natur Hist Soc*, **107**, 93–100

Weir, A H, Catt, J A, and Madgett, P A, 1971 Postglacial soil formation in the loess of Pegwell Bay, Kent, England, *Geoderma*, **5**, 131–49

West, R G, and Sparks, B W, 1960 Coastal interglacial deposits of the English Channel, *Phil Trans Royal Soc London*, B, **243**, 95–133

Westerdahl, C, 1992 The maritime cultural landscape, *Int J Naut Archaeol*, **21(1)**, 5–14

Westmore, I, Basford, F, and Tomalin, D, 1994 *An appraisal of the early sources and shipment of Bembridge limestone building stone on the Wootton-Quarr coast of the Isle of Wight, The Wootton-Quarr survey: a summary of field assessment, draft 1*, (ed) D Tomalin, draft report for English Heritage, Isle of Wight County Council Archaeological Unit, Newport

Wheeler, R E M, 1929 The Roman lighthouses at Dover, *Archaeol J*, **86**, 29–46

Whimster, R, 1977 Harlyn Bay reconsidered: the excavations of 1900–1905 in the light of recent work, *Cornish Archaeol*, **16**, 61–88

White, G M, 1934 A settlement of the South Saxons, *Antiq J*, **14**, 393–400

Whittle, A, 1989 Two later Bronze Age occupations and an Iron Age channel on the Gwent foreshore, *Bull Board Celtic Stud*, **36**, 200–23

Whitwell, B, 1988 Late Roman settlement on the Humber and Anglian beginnings, in *Recent research in Roman Yorkshire* (eds J Price, P R Wilson, C S Briggs, and S J Hardman), BAR Brit Ser, **193**, 49–78, Oxford

Wigley, T M L, 1994 Outlook becoming hazier, *Nature*, **369**, 709–10

Wigley, T M L, and Raper, S C B, 1992 Implications for climate and sea-level of revised IPCC emissions scenarios, *Nature*, **357**, 293–300

Wildesen, L E, 1982 The study of impacts on archaeological sites, in *Advances in archaeological method and theory* (ed M B Schiffer), **5**, 51–96, London

Wilkinson, T J, and Murphy, P, 1984 *The Hullbridge basin survey 1984: interim report 5*, Chelmsford

Wilkinson, T J, and Murphy, P, 1986 Archaeological survey of an intertidal zone: the submerged landscape of the Essex coast, England, *J Fld Archaeol*, **13**(2), 177–94

Wilkinson, T J, and Murphy, P, 1988a Wetland development and human activity in Essex estuaries during the Holocene transgression, in *The exploitation of wetlands* (eds P Murphy and C French), BAR Brit Ser, **186**, 213–38, Oxford

Wilkinson, T J, and Murphy, P L, 1988b *Hullbridge basin survey 1987*, interim report, **8**, Chelmsford

Wilkinson, T J, and Murphy, P L, 1995 *The archaeology of the Essex coast, Volume 1: the Hullbridge Survey*, E Anglian Archaeol Rep, **71**, Chelmsford

Wilkinson, T J, Murphy, P, and Austin, T J F, 1983 *The Hullbridge Basin survey, April–June 1983: interim report 4*, Chelmsford

Wilkinson, T J, Murphy, P, and Mason, K, 1983 *The Hullbridge Basin survey, July 1983: interim report 3*, Chelmsford

Williams, D F, 1977 The Romano-British Black-burnished industry: an essay on characterisation by heavy mineral analysis, in *Pottery and early commerce: characterisation and trade in Roman and later ceramics* (ed D P S Peacock), 163–220, London

Williams, M, 1970 *The draining of the Somerset Levels*, Cambridge

Willson, B, 1902 *Lost England. The story of our submerged coasts*, London

Wilson, D G, 1975 Plant remains from the Graveney boat and the early history of *Humulus lupulus* L. in Western Europe, *New Phytol*, **75**, 627–48

Winder, J, 1993 A study of the variation in oyster shells from archaeological sites and a discussion of oyster exploitation, unpubl PhD thesis, University of Southampton

Wood, S V, and Rome, J L, 1868 On the glacial and post-glacial structure of Lincolnshire and south-east Yorkshire, *Quart J Geol Soc*, **24**, 146–57

Worsfold, F, 1943 A report on the Late Bronze Age site excavated at Minnis Bay, Birchington, Kent, *Proc Prehist Soc*, **9**, 28–47

Worth, R H, 1904 Hallsands and Start Bay, *Trans Devonshire Assoc*, **36**, 302–346

Worth, R H, 1923 Hallsands and Start Bay, Part III, *Trans Devonshire Assoc*, **55**, 131–147

Wren, C R, and Harrison, M G, 1995 *The Kent oyster coast environmental survey project: preliminary report*

Wright, E V, 1990 *The Ferriby Boats*, London

Wright, E V, and Switsur, V R, 1993 The Ferriby 5 boat fragment, *Archaeol J*, **150**, 46–56

Wymer, J J (ed), 1977 *Gazetteer of Mesolithic sites in England and Wales*, CBA Res Rep, **20**, London

Zong, Y Q, 1993 *Flandrian sea-level changes and impacts of projected sea-level rise on the coastal lowlands of Morecambe Bay and the Thames Estuary, UK*, Unpubl PhD, University of Durham

Index

by Lesley Adkins

Where several page references are given, major ones are shown in **bold**. Figures and tables are referred to by page number in *italics*. Some entries are listed in period order, rather than alphabetical order (for example, under pottery, Roman is listed before medieval).

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Front cover
Scarborough Castle, aerial view of the remains of the Roman signal station and medieval chapels from the west.