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Coastal Archaeology and Erosion in Scotland

Ancient Monuments Group

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Conference Proceedings — Coastal Archaeology and Erosion in Scotland

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Cover: The abandoned whaling station at Bunavoneadar, Harris, Western Isles. Tom Dawson/SCAPE

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The editor and publishers wish to give thanks for the kind permission to reproduce the illustrations.

FOREWORD

Scotland's coasts are much admired for their beauty. Along them also lie some of Scotland's most spectacular buildings. These range from the ancient settlements at Skara Brae and the Knap of Howar in Orkney, both of which are over 5000 years old, to medieval castles like Tantallon in East Lothian, the great artillery fort at Fort George on the Moray Firth, and the World War coastal defences on Inchkeith in the Firth of Forth, all redolent with history.

These sites are but the most visible part of a tapestry of archaeological sites which hold the key to an important element of our past. Scotland has always had strong connections along the seaways of Northern and Western Europe. The ancient sites of the west have links with Ireland, whence, it is believed, came some of the ancestors of the Scottish kings. The North Sea, viewed from the east or west, is almost an inland sea and connections with Scandinavia, the Baltic states, Germany, Denmark and Holland have been a constantly recurring theme of the past millennium and more.

Many archaeological sites have been exposed by storms eroding the coast. Others lie just back from the present edge. In an era of rising sea levels and increased storminess, their future is as important to us as is their past. Since the 1970s Historic Scotland has funded rapid assessment surveys, and excavations of eroding settlements and burial places in many parts of Scotland, much initiated by Patrick Ashmore, as is the present campaign. That work has been driven by a mixture of research and rescue. Over the past decade, however, systematic survey has allowed a new understanding based on a 20 per cent sample of our coastline. We now know that there are perhaps as many as 12,000 sites vulnerable to coastal erosion, of which we think about 600 will be of exceptional importance.

That work on auditing the resource continues. Increasingly it is wrapped up in another strengthening trend: the involvement of local communities, and inclusive local decision making. Projects like the assessment excavations and artefact collecting at Achnahaird Sands and the survey of sites bounding Loch Hourn, both in NW Scotland, have shown how local people's initiatives can add to our understanding. Central organisations like the Council for Scottish Archaeology, and now the Scottish Coastal Archaeology and Palaeo-environment (SCAPE) Trust based at the Universities of Stirling and St Andrews, have played a vigorous supporting role for those interested in monitoring the state of coastal archaeology in their areas under the umbrella of Shorewatch. Projects in the Inner Hebrides, including both survey and monitoring, provide a model for other parts of Scotland. The current assessment survey and Shorewatch project in the Clyde estuary will provide a test of its robustness. We firmly believe that helping local coastal archaeology groups to enable themselves is an important and sustainable component of a strategy for the future.

This volume retails a wealth of experience on coastal survey in Scotland. Each of the brief reports demonstrates the particular strengths of approaches tailored to the character of the coastlines surveyed. Their results are brought together at the end in a set of recommendations. This volume thus provides a *vade mecum* for future work and a base line for local initiatives. It will also, I hope, serve as a spring-board for inclusive discussions about the best way forward in mitigating the effects of coastal erosion on Scotland's rich archaeological and built heritage.

DAVID J BREEZE
Chief Inspector of Ancient Monuments
Historic Scotland

1 ARCHAEOLOGY AND THE COASTAL EROSION ZONE

PATRICK ASHMORE

In what follows, both Historic Scotland and its recent predecessors are, for simplicity, generally referred to as HS.

Introduction and Past Work

The coast of Scotland is, at a precision appropriate to the discussion of rapid survey results, 12,000 km long (see Appendix to Chapter 22) and has some of the most remarkable archaeological remains in Britain. Historic Scotland's predecessors started protecting important buildings against erosion at least 144 years ago. In 1857, for instance, a wall was built to protect the area below St Andrews Cathedral in Fife, and foreshore protection was constructed at Lochranza Castle on Arran after a storm caused the collapse of its north-east corner (Figure 1.1). In 1886, the Commissioners of Works strengthened the sea cliff at St Andrews Castle (Figure 1.2). In the 1930s, Skara Brae and Midhowe in Orkney, and Jarlshof in Shetland, were protected by sea walls, and in the late 1940s another sea wall was built at the Broch of Gurness in Orkney (Maxwell 1990). These and other coastal defences were costly to maintain, requiring repairs after storms, but they protected important and much-visited monuments and the cost could be justified.

Figure 1.2. St Andrews Castle, Fife, with the strengthened sea cliff visible below the castle.

Local authorities have wide powers to arrange coastal protection within their areas, subject to approval by Scottish Ministers. But economic soundness is an important criterion for defences (The Scottish Office 1996, 40) and the case for preserving an archaeological site can be difficult to communicate before excavation. The situation was not much different in the 1970s, when HS was expected to have a more wide-ranging approach to archaeological sites than protection and display of monuments in its care, yet had no statutory

Figure 1.1. Lochranza Castle, Arran.

duty to deal with coastal erosion. As today, the options for dealing with eroding monuments were seen as excavation, abandonment or protection (Figure 1.3); but the cost of building sea walls – and maintaining them – was thought to be too high for defences to provide a generally satisfactory solution. The threat seemed to be worst in the Northern and Western Isles, and possibly in Caithness because those areas have been sinking relative to sea level over most of the period that people have lived in Scotland.

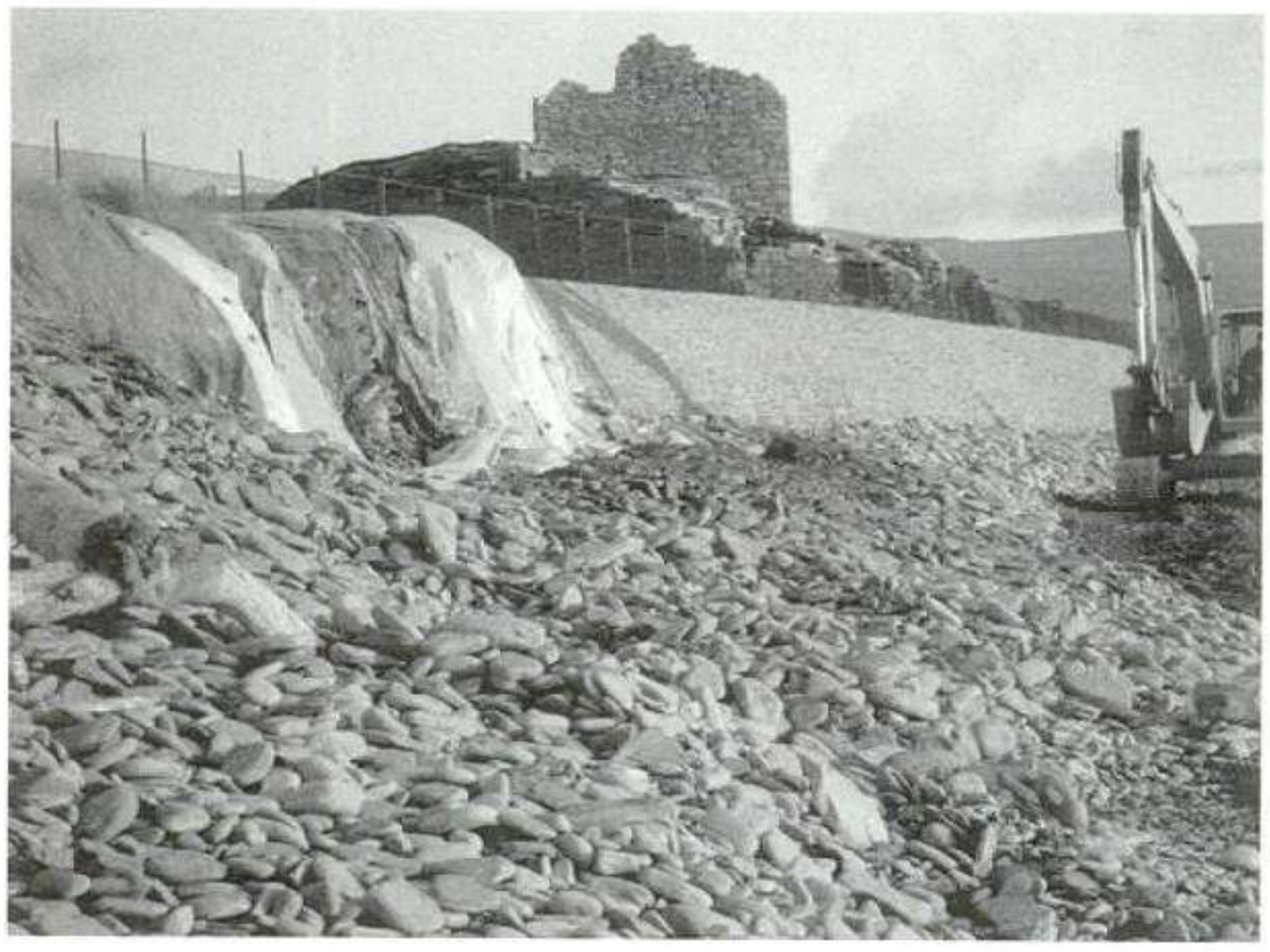

Figure 1.3. The construction of a breakwater in 1993 for the future protection of Jarlshof, Shetland.

Perhaps erroneously, the threat in Shetland and Orkney was thought to be quite well understood in the late 1970s. In 1978, to obtain more information about other areas, HS arranged surveys of parts of the coast of the Western Isles, and between 1980 and 1982 it sponsored surveys of the Caithness coast.

Area	Source	Survey Cover
Fife	Kenworthy np	small-scale
Highland (Caithness)	Mercer 1981	northern shore
Highland (Caithness)	Batey 1984	eastern shore
Western Isles (north)	Cowie np	more than half
Western Isles (south)	Shepherd np	more than half

Table 1.1. Coastal archaeological surveys supported by HS and starting between 1977 and 1994.

In the early 1980s, HS implemented a policy of assessing the importance of threatened archaeological sites, together with the nature and extent of the threat. A rolling programme of site monitoring and assessment through sampling, augering and surface inspection was undertaken in selected areas. Following the surveys, five settlement sites in the Western Isles and two in Caithness were extensively sampled. In the meantime, major coastal excavations were carried out, for instance at the Neolithic to medieval settlements at Pool, Sanday, Orkney. In all, between 1977 and 1994, HS and its predecessors carried out or sponsored excavation of 37 major sites and groups of sites.

Area, Site and Last Field Year	Excavator	Reference
CAITHNESS		
Cnoc Stanger house 1981	Mercer, R	Mercer 1996
Freswick middens 1982	Batey, C and Morris, C	Morris et al 1995
FIFE		
E Wemyss middens 1990	Duffy et al	in preparation
ORKNEY		
Birsay Bay Project 1 1981	Morris, C	Morris 1989
Birsay Bay Project 2 1983	Morris, C	Morris 1996
Birsay Bay Project 3 1983	Morris, C	in preparation
Brough of Birsay 1981	Hunter, J	Hunter 1986
Hurnip's Point chambered cairn 1991	Hunter, J	Hunter 1993
Links of Noltland settlement 1981	Clarke, D V	in preparation
Point of Cott 1985	Barber, J W	Barber 1997
Pool 1988	Hunter, J	in preparation
Scar boat burial 1991	Dalland, M	Dalland & Owen 1998
St Boniface 1990	Lowe, C	Lowe 1998
Skara Brae II 1977	Clarke, D V	
Tresness 1983	Smith, B	archive
Tuquoy 1988	Owen, O	in preparation
Warebeth 1988	Bell, B	Bell & Dickson 1989
SHETLAND		
Broch of Burland 1983	Barber, J W	Carter et al 1995
Cunningsburgh 1990	Barber, J W	
Eastshore of Virkie 1983	Barber, J W	Carter et al 1995
Kirki Geo, Fair Isle 1983	Barber, J W	Carter et al 1995
Ness of Burgie 1983	Barber, J W	Carter et al 1995
Sands of Breckon 1983	Barber, J W	Carter & Fraser 1996
Scatness 1983	Barber, J W	Carter et al 1995
W ISLES		
Balelone 1983	Barber, J W	Barber forthcoming
Baleshare 1990	Barber, J W	Barber forthcoming
Barvas 1989	Cowie, T	in preparation
Callanish Leobag 1989	Cowie, T	in preparation
Cnip 1978	Close-Brooks, J	Close Brooks 1995
Cnip 1992	Armit, I	Armit forthcoming
Dalmore 1983	Ponting, M	in preparation
Dalmore 1983	Sharples, N	in preparation
Hornish 1984	Barber, J W	Barber forthcoming
Newton Ferry 1984	Barber, J W	Barber forthcoming
Rosinish 1977	Shepherd, I A G	in preparation
South Glendale 1983	Barber, J W	Barber forthcoming
Udal RUX6 1983	Crawford, I	in preparation

Table 1.2. Coastal excavations sponsored by HS and ending between 1977 and 1994.

Meanwhile other approaches to protection were explored. In the early 1980s, soft engineering work was carried out at Links of Noltland on Westray, in Orkney (by Scottish Conservation Projects volunteers, sponsored by HS, with supervision from Scottish Natural Heritage (SNH)) to stabilise the wind-blown sand overlying partially excavated 5000-year-old buildings and field systems. The site was taken into state care to ensure its permanent protection. However, if maintenance were neglected for as little as a year, the site could return to an unstable state very rapidly. More generally, sand stabilisation did not seem to be a sound long-term answer for sites which were being eroded by the sea as well as by the wind.

In addition, HS was a partner in projects looking at the ancient environment of areas in which the coast was an important element; the fullest of these was carried out by Sheffield University in the Western Isles (Gilbertson et al 1985).

In 1994 HS published *Archaeology and the Coastal Erosion Zone: Towards a Historic Scotland Policy* (Ashmore 1994). Its broad conclusions, here rephrased to take account of further thinking, were that:

- additional systematic survey is required to understand the problem
- 300–600 excellent archaeological sites are directly threatened by coastal erosion
- over a 40-year period protection would cost about the same as excavation but would provide zero visible return
- a comprehensive excavation strategy would cost £2m or £3m a year for one or two generations

In essence, the strategy since 1994 has been to:

- take part in a Scotland-wide study of **coastal processes**
- commission **Coastal Zone Assessment Surveys** of long stretches of coastline and **Focal Studies** of particular sites and themes
- foster **local involvement** and awareness of coastal archaeology and its problems
- help to integrate heritage interests into **local authority Coastal Zone Management** plans

Coastal processes

HS needs to be sure that if it does support protection of a site by a sea wall, loss of the sediment source represented by the eroding site will not lead to erosion elsewhere; so HS, together with the Scottish Office Agriculture, Environment and Fisheries Department took part in an SNH initiative, the definition and description of coastal cells. The boundary between two cells is drawn at a point across which there is little or no longshore drift: coastal cells are lengths of the coastline within which sediments erode, drift and accumulate, but beyond which they do not travel. *Coastal Cells in Scotland* by H R Wallingford, published in 1997, and detailed area studies published in 2000, provide an important background to effective management of the coastline.

Coastal Assessment Surveys

Between 1994 and 1996, HS sponsored Dr Raymond Lamb, the Orkney Archaeologist, to assess the coastal erosion of archaeological sites in Sanday and other parts of Orkney. In 1996, HS published a specification for Coastal Zone Assessment Survey (HS *Archaeological Procedure Paper 4*). The survey prescription was intended to allow extensive survey at a reasonable cost (with an original target of keeping the net cost at £85 to £95 per kilometre of coastline, as measured by thread on a 1:50,000 map). All types of features of archaeological interest were to be included, from fossil oaks and midden layers to jetties and World War II glider traps. It included recording of data on geomorphology and point of time coastal erosion, providing a resource not duplicated elsewhere. The results were to be used to improve choices of what to do next.

HS commissioned or grant-aided 16 Coastal Zone Assessment Surveys between 1996 and 1999. On average each covered considerably more than 100 km of coastline and they provide an almost exactly 20 per cent sample of the Scottish coastline.

<table>
<tr><th>Area</th><th>Cover</th><th>Length (km)</th></tr>
<tr><td>Fife 1 (= Firth of Forth 2)</td><td>Kincardine to Fife Ness</td><td rowspan="2">193</td></tr>
<tr><td>Fife 2</td><td>Fife Ness to Newburgh</td></tr>
<tr><td>Firth of Forth 1</td><td>Dunbar to Kincardine</td><td>170</td></tr>
<tr><td>Highland 3</td><td>Ullapool to Lochinver</td><td>93</td></tr>
<tr><td>Highland 4</td><td>Kyle of Durness to Torrisdale</td><td>125</td></tr>
<tr><td>Highland 5</td><td>Inner Moray Firth</td><td>200</td></tr>
<tr><td>Orkney 1</td><td>Orkney South Isles</td><td rowspan="3">339</td></tr>
<tr><td>Orkney 2</td><td>Westray and West Mainland</td></tr>
<tr><td>Orkney 3</td><td>Sanday and North Ronaldsay.</td></tr>
<tr><td>Shetland 1</td><td>Burra and Trondra</td><td rowspan="4">630</td></tr>
<tr><td>Shetland 2</td><td>Northmavine</td></tr>
<tr><td>Shetland 3</td><td>Westside</td></tr>
<tr><td>Shetland 4</td><td>South Mainland, Lunnasting, Whalsay</td></tr>
<tr><td>Solway 1</td><td>Carrickcarlin Point to Gretna</td><td>318</td></tr>
<tr><td>Western Isles 1</td><td>Lewis</td><td>450</td></tr>
<tr><td>Western Isles 2</td><td>Barra and Vatersay (Branigan 2000)</td><td>61.7</td></tr>
</table>

Table 1.3. Coastal Zone Assessment Surveys.

The surveys listed in Table 1.3 have been copied and circulated. All but one (Branigan 2000) remain unpublished.

The cost of each survey varied from about £85 to about £135 per kilometre, averaging slightly under £120, with the cost per kilometre depending upon terrain and the number of previously unrecorded or poorly recorded sites. The surveys provide a succinct record for each coastal stretch of what was visible on the day it was visited.

Although from a national perspective this 20 per cent sample is useful, notably large geographical gaps remain, including the Ayrshires and the Clyde estuary, Argyll and the Inner Hebrides (in effect, the old Strathclyde local authority area) and the east coast excluding the Moray, Forth and Tay estuaries. From the analyses of Hansom, Lees and Dawson (this volume), it is clear that the surveys have been targeted on the areas most threatened by coastal subsidence and storminess. However, it is desirable that assessment surveys be undertaken in the Clyde estuary (in a broad sense) to identify its particular character, resources and vulnerabilities. A survey of Coll, Tiree and Islay will be managed by the Scottish Coastal Archaeology and Palaeo-Environment (SCAPE) Trust in the period 2001–3; and of parts of the Clyde Estuary in 2002-2004.

The surveys included a fairly arbitrary 50–200 m wide landward strip of ground to help provide an immediate context for those sites on the edge between sea and land. Ideally, the width of the inland survey strip should have been variable in order to satisfy wider academic aims. A general-purpose definition of an archaeological coastal zone should be a melding of models of past topographies and likely natural resources with archaeological and ethnographic data or models. The goal of covering a significant proportion of Scotland's coastline at an acceptable cost precluded such analysis.

Thorough examination of the intertidal area was not possible, yet the potential is clearly there for exciting discoveries. In Shetland and the Western Isles, for instance, where the sea level is still slowly rising, there are archaeological sites and peatlands submerged below the Low Water Mark. Large areas of land may have been exposed around the present Western and Northern Isles at the end of the last glaciation, and the North Sea plain, although probably separated from the present landmass north of the Forth by a wide sea channel, may have provided a habitat favourable for settlement. The Solway area may also have had a very different character from that of today.

The surveyors were not required to rank the sites in order of importance. Doing so would have introduced considerable problems of recognition and categorisation. It would have been hard to compare disparate site-types. Also, it would have perpetuated a site-oriented approach at odds with modern landscape approaches. Beyond that, there are philosophical and pragmatic problems in ranking archaeological sites: their interest and importance depend on what happens to be visible at the time of inspection, on the survival of related archaeological and palaeo-environmental evidence in the area, and on modern (and possibly evanescent) research interests. Instead, the surveyors were invited to write a *Summary and Recommendations* section characterising and identifying the most important aspects of the built heritage and including, where appropriate, the published views of others (HS 1996, 18).

The surveyors recorded many previously unknown sites, and the papers in this volume allow an estimate of the numbers and types of sites immediately vulnerable to coastal erosion, and better assessments of the potential for archaeological research programmes along the coastline. They provide a significantly better platform for national assessment than existed before the surveys.

Focal Studies

In addition to surveys, and often as a partner in multi-funded projects, HS has commissioned and received drafts or final reports on several Focal Studies. Focal Studies is a catch-all term for more intensive work on particular aspects of coastal archaeology. The list in Table 1.4 illustrates their variety; it is not intended to be complete.

Area	Focal Study
Fife	Shipwreck heritage of Fife
Fife	Kincardine foreshore survey
Fife	East Wemyss gasworks
Fife	Newport on Tay wreck
Fife	Crombie Point
Fife	Three Mariners
Solway	Soft sediments in the inner Solway
Solway	Dendrochronology on fossil oaks
Orkney	Eday and Stronsay: recording of six sites
Orkney	Evaluation excavations at various sites
Shetland	Evaluation excavations at various sites
W Isles	Uig, Harris, detailed study of erosion and archaeology

Table 1.4. Focal Studies: some of the more detailed studies of various aspects of coastal archaeology.

Local Involvement and Awareness

As part of a strategy to help local people to monitor their shorelines for erosion of archaeological sites, and to liaise with professional archaeological institutions, HS has been funding Shorewatch since 1998. This project is currently managed by the Council for Scottish Archaeology (CSA) and SCAPE. CSA has prepared *Shorewatch: Your Project Starter Pack* to provide guidance to local groups. The strategy has been to start small and ensure that participating groups develop a sense of ownership in the hope that the initiative will be self-sustaining The first two groups to take part were based in Fife and in Lewis. In addition, in 2000, HS grant-aided a community-based excavation project at Achnahaird Sands, a site highlighted in the coastal assessment survey of the area between Ullapool and Lochinver.

Local Authority Coastal Zone Management schemes

HS, in partnership with SNH, has also contributed financially to the Fife Shoreline Management Plan (Fife Council 1998) and to the East Lothian Shoreline Management Plan (in preparation) to ensure proper integration of the built heritage. The plans focus on coastal protection. The built heritage is a material consideration in recommendations for protection, managed retreat, or abandonment. Since the Fife plan was the first Scottish Shoreline Management Plan to follow the MAFF prescription it is hoped that plans prepared by other local authorities will use it as a model.

The Coastal Zone Assessment Surveys are described in Chapters 5–14, Focal Studies in Chapters 15–18, Shorewatch and coastal management in Chapters 19–21. They are prefaced by three papers on coastal processes, past, present and future (Chapters 2–4). The final paper, Chapter 22, is a synthesis of the statistics, conclusions and recommendations in the papers that precede it.

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(I) LATE DEVENSIAN AND HOLOCENE COASTAL PROCESSES

2 ARCHAEOLOGICAL SURVIVABILITY AND PAST COASTAL PROCESSES

JAMES D HANSOM

Introduction

Most of the 11780 km of Scottish coast (Doody 1999) remains relatively natural and undisturbed. As a result, the survivability of the archaeological record is mostly related to the effects of natural, rather than human-induced, changes in coastal position. The coastal erosion that may affect an archaeological site is driven by several factors, some of which may have been initiated as long ago as the Late Devensian and were certainly both operational and subject to large changes during the Holocene. Almost all of the factors affecting present-day coasts, including wave regime and sediment supply, have also been subject to large variations in the past. The legacy of these variations continue to exert a major control on the present coastal context including the structural setting, sea level changes, nearshore processes and, crucially, sediment availability.

Structural Setting and Sea Level Change

The coastline of Scotland is influenced by a series of overlapping geological and geomorphological gradients. The geology is dominated by hard and ancient rocks in the north and west, and by mainly softer and younger sedimentary rocks in the south and east (Mitchell 1997). Quaternary glaciation has further enhanced these geological differences by subjecting the north and west to intense glacial erosion, whereas the south and east suffered less erosion and substantial glacial deposition (Glasser 1997) and this has affected the availability of coastal sediment. Strong north-west/south-east environmental gradients also result from Scotland's location in the eastern Atlantic, and steep declines in wind and wave energy occur from the Western and Northern Isles into the relatively sheltered inner west mainland and the North Sea (Carter 1992). With some exceptions, structurally dominant, high and hard coastal landforms such as cliffs and rocky shores are more prevalent in the north and west, with most of the large-scale depositional coastal features of the Scottish coast being found in the east and south.

The effect of glaciation on sea level change has resulted in another set of west/east and north/south gradients that have affected the coast over the last 18000 years. Over much of the mid and late Holocene, differential isostatic uplift outpaced global rise in sea level and resulted in falling relative sea levels inside of a line of no change (zero-isobase) and rising relative sea levels outside (Figure 2.1). Although the area enclosed within zero-isobase contracts through time, its boundary takes an elliptical path that includes most of the Central Belt and Highlands and excludes most of the outer coast of the Northern Highlands and the Northern and Western Isles. The process is ongoing with, for example, the combined effect of isostatic submergence of the land and eustatic rise of the sea producing an estimated relative sea level rise in the Western Isles of the order of 2–4 mm per year (Angus & Elliot 1992). Other coastal processes being equal, the general coastal response to such trends is more conducive to survival of existing coastal forms and archaeology within the zone of emergence that occurs inside the line of zero-isobase and more conducive to the erosion and loss of existing coastal forms and archaeology within the zone of submergence that occurs outside zero-isobase.

Holocene Sediment Supply

A central factor influencing how coastlines actually respond to sea level change is the way in which such change interacts with sediment supply (Hansom 1999). Sediment supply over the Lateglacial and Holocene periods has been mainly controlled by the availability of glacigenic sediment from both rivers and the continental shelf and by the sense and magnitude of sea level change. Over the early part of this period, from about 13000 years BP in areas outside zero-isobase and about 10000 years BP in areas inside zero-isobase (Figure 2.2), rapidly rising sea level resulted in rapid transgression and only limited opportunity for substantial onshore sediment movement and thus shoreface modification. However, as the rate began to slow and transgression slowed, wave processes had a greatly enhanced opportunity to produce substantial sediment movement and shoreface modification and large amounts of first gravel and then sand arrived on Scottish shores (Firth *et al* 1995; Hansom 2000). Although the rate of sea level rise had generally slowed by 6500 BP, for many Scottish coasts it subsequently began to fall again at a variety of start dates and rates depending on location relative to zero-isobase. Outside zero-isobase, sea level continued to rise, albeit at a slower rate (Figure 2.2).

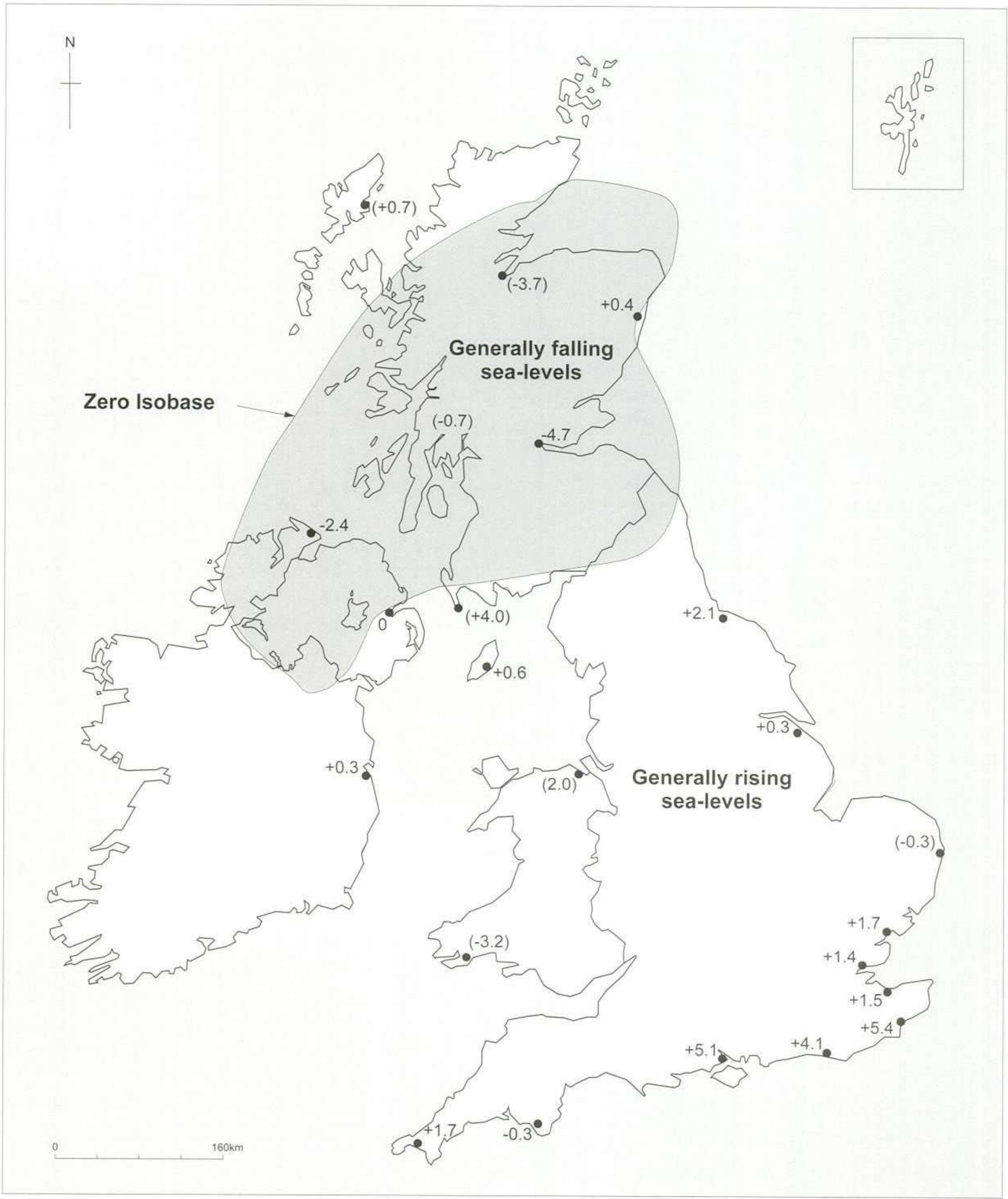

Figure 2.1. Recent sea level changes around Britain, mm per year. Modified after Carter (1988).

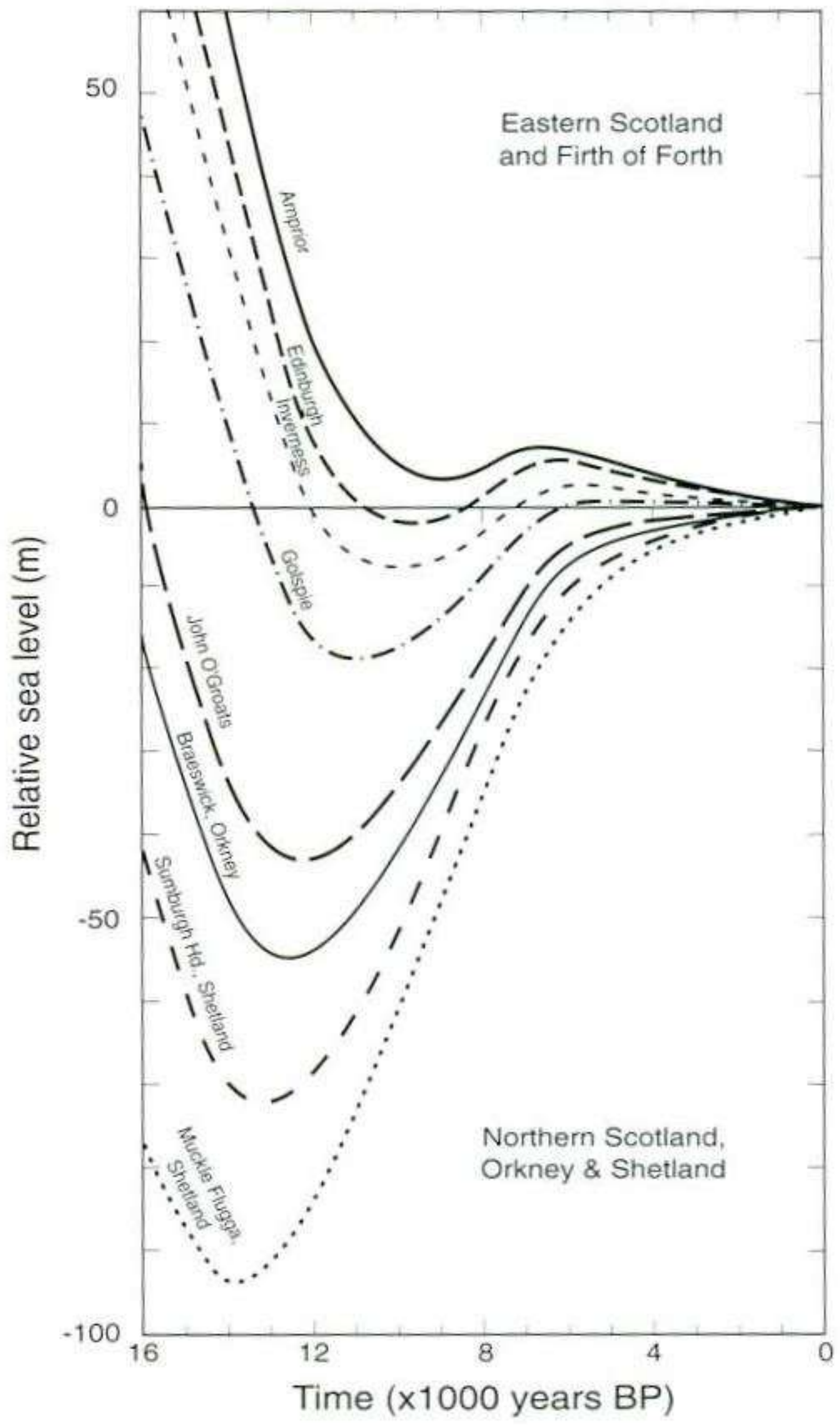

Figure 2.2. Modelled sea level curves along a transect from outside of the line of zero-isobase (Northern Scotland and Shetland) to inside of zero-isobase (Eastern Scotland and the Firth of Forth at Arnprior). Modified after Lambeck (1993).

The arrival of large amounts of sediment broadly coincided with the reduction in rates of sea level change around 6500 BP, but thereafter a change occurred in the sediment availability on many coasts (Carter 1988; 1992; Hansom 1999). Beach sediment budgets switched from one of surplus prior to about 6500 BP (when sediment was swept shorewards by waves constantly reworking new sediment sources, augmented by substantial sediment inputs from rivers) to one of deficit (when only limited amounts of sediment were available to move shorewards, contained within either an essentially static, or very slowly rising, wave zone outside of zero-isobase). During the Holocene, expanding vegetation cover also resulted in declining sediment yields from catchments, except in those areas of exceptional glacigenic supply, such as at major river exits like the Spey.

Coastal Response

The general mid-Holocene switch in coastal sediment supply from surplus to deficit led to two main responses on the coast: the adjustment of nearshore gradients and the internal reorganisation of coastal sediment supplies.

Assuming a relatively constant energy input, conditions of sediment deficit result in beach sediments being removed into deeper water in order to maintain a nearshore gradient capable of dissipating wave energy, and this encourages upper and back-beach erosion (Carter 1992). Such erosion should be most advanced in those areas subject to high energy conditions and where rising sea level exacerbates the trend (Hansom 1999). These conditions are met in the north and west of Scotland where tide-gauge evidence shows submergence (Angus & Elliot 1992) and where very few beaches have anything other than purely erosional edges (Mather & Ritchie 1977). Most machair and dune systems in Scotland are fronted by eroding sub-vertical dune faces (Figure 2.3).

Figure 2.3. Eroding beaches and dunes are common in Scotland and are often distinguished by the absence of a cordon of young dunes and the presence of steep coastal edges cut into mature dune systems.

Although the date of the switch varies between sites, the positive beach sediment budgets that fed the embryo and fore-dunes once sited seaward of the dune system were reversed by negative sediment budgets and the frontal dunes cannibalised (Hansom & Angus 2001).

Support for the above geomorphological analysis of early surplus and later decline in sediment supply comes from archaeological sites built originally within accreting coastal dunes and now found on eroding coasts. Optically stimulated luminescence dating of aeolian sands by Gilbertson *et al* (1999) indicates that the carbonate sand of the Benbecula and North Uist machairs began to arrive from offshore about 8700 radiocarbon years BP and in Barra about 6800 radiocarbon years BP. Houses at Rosinish in Benbecula show the onset of sand deposition from 5700 BP (Ritchie 1979) and Neolithic houses at Skara Brae in Orkney were occupied around 4700 BP. Such settlements were built close to or within coastal sand dunes at a time of plentiful sand supply. However, it is likely that many similarly aged sites such as Bornish and Baleshare in the Uists, Traigh Varlish in Vatersay, and Skara Brae itself were abandoned at a later date

Figure 2.4. Skara Brae in Orkney was constructed within a once healthy dune system that is now subject to frontal erosion as a result of sediment deficit exacerbated by submergence.

due to enhanced instability resulting from storms and wind-blow (Ritchie 1979; Gilbertson *et al* 1996). The relatively recent discovery of many such sites (Skara Brae was uncovered by a storm in 1850) is due to exhumation as the eroding edge of the sand dunes progressively exposes them (Figure 2.4).

Another repercussion of the decline of sediment supply over the period since 6500 BP was the reorganisation of coastal sediment into more compact coastal cells (Carter 1992). Coastal cells are budgetary units with distinct longshore boundaries within which it is possible to quantify sediment inputs and outputs. Under conditions of plentiful sediment supply, coastal sediment losses (for example to dune building) may be offset by sediment gains (for example, those that may result from the alongshore transport of sediment between sections of the coast and from sediment bypassing of headlands). However, reductions in sediment availability may often force a resultant landward migration of the shoreline and enhance the effect of headland barriers or favour the emergence of new barriers to alongshore exchanges (Figure 2.5).

After about 6500 BP, sediment reductions on the Scottish coast resulted in the emergence of coastal sediment cells which, because they were both smaller and discrete, tended to subsequently evolve by internal reorganisation of existing sediment (via erosion and deposition), rather than by the arrival of new sediment (Hansom 1999). Evidence for the development of such prota-cells is well displayed by the evolution of Culbin Sands in the Moray Firth, a beach and dune system intimately linked to the longshore supply of sand and gravel from the east. About 6500 BP, the prota-cell of Culbin included both the Spey and Findhorn catchments and westwards movement of gravels led to the construction of the spectacular emerged gravel ridges that now underlie the Kinloss/Findhorn and Culbin areas. However, the emergence of Burghead as a barrier to westerly sediment movement between 6500 and 4600 BP led to large reductions in the sediment supply to Culbin (Comber 1995). Lack of sediment from the west and ongoing westerly tracking waves in the Moray Firth then resulted in updrift erosion of existing beaches, alongshore westerly sediment transfer, and downdrift deposition. Born of a process of

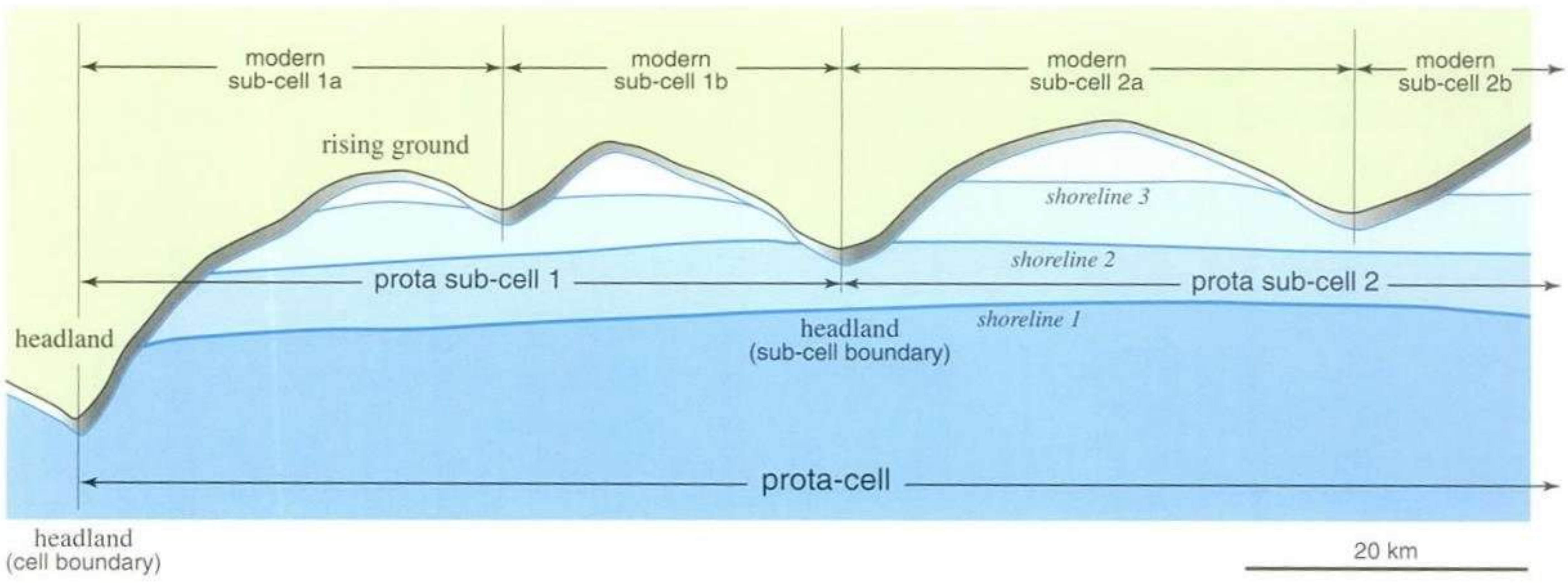

Figure 2.5. The process of coastal recession favours an increased occurrence of barriers to longshore movement of sediment.

internal reorganisation of sediment within the cell, the spectacular gravel spit of 'The Bar' is the direct descendant of earlier spits. Similar reorganisation occurred throughout Scottish coasts and led to the establishment of the series of well-organised, but sediment-deficient, coastal cells that we see today.

Archaeological Survivability

From an archaeological perspective, the survivability of evidence depends on the location of any structures or artefacts within the coastal landform itself and whether the location is close to Mean High Water Spring or not. Low altitude sites that are several hundred metres inland within sand dunes may not be immediately under threat, but a site at a similar altitude 5 m from the dune front may not survive much longer. Many known sites are presently under threat from such coastal recession, but it is certain that many more lie unknown within eroding shores. These may be destroyed before they are even recognised or before archaeological rescue work is mobilised. A good example is on the submerging shore of Sanday in the Orkney Islands where a probable Neolithic cist burial was exposed by storm erosion of the overlying sand dunes in early 2000 (Figure 2.6). Rescue work was possible on this cist but not on another close by which had been destroyed by waves. Nevertheless, the argument presented above suggests that recognisable trends exist in the coastal response to natural changes that allow some degree of prediction of the areas that contain the sites most at risk.

Where relative sea level is still falling, the potential archaeological survivability should be highest because such coastal sites are still emerging (Figure 2.1). It should also be high in areas subject to ongoing accretion such as in the inner firths, although there may be attendant problems of burial rather than destruction. However, even within such areas, the ongoing processes of internal reorganisation of coastal sediment suggest that a downdrift location of the site favours survival, whereas it may be a matter of time before erosion ensures that an updrift site disappears. Where relative sea level has been rising, the potential for archaeological survivability is more limited. Not only are sites in these areas more at risk from transgression and flooding, but they are also more likely to have been subject to sediment deficits for an extended time as a result of a history of submergence. Additionally, in Scotland many such sites, for example in the Northern and Western Isles, are exposed to a high-energy storm wave environment and so are likely to be at a more advanced stage of sediment deficiency than otherwise. Such sediment-depleted sites are the most vulnerable to any future increases in either wave heights or storminess.

Figure 2.6. A cist burial, probably dating from the Neolithic, exposed on the foreshore at Lopness, Sanday, Orkney, by storm erosion of the backing sand dune in February 2000.

The above analysis suggests that, just as in the past, the present configuration of the coast is set for radical change. Similarly, as a result of sediment deficits, beaches and sand dunes in their present form are essentially wasting assets. Although gloomy, such an interpretation is of vital importance to coastal archaeology because it indicates that geomorphological information, appropriately formulated, has the ability to identify the areas most at risk. It can therefore inform strategies aimed at targeting where archaeological effort might best be focused.

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3 CONTEMPORARY COASTAL PROCESSES IN SCOTLAND

GEORGE LEES

Introduction

The rapid rise in sea levels which accompanied the retreat of the Devensian ice-sheet led to dramatic changes in the landforms and outline of the Scottish coastline (Hansom, this volume). However, in spite of the relative climatic stability of the present interstadial period, it is quite evident that change along the coastline is not confined to millennia past but continues to this day, albeit less spectacularly.

A broad range of landforming processes affect Scotland's coastlines today. Many shorelines are eroding. Others are, in contrast, advancing seaward. In many of the firths especially, large quantities of sand and shingle drift alongshore, but, as losses of sediment downdrift are compensated for by gains from shorelines updrift, beaches remain in a state of equilibrium. Some shorelines are emerging from the sea, while others are being progressively submerged. This paper considers how and where Scotland's coastline is changing today. Though the processes of change are largely interrelated, this paper focuses on coastal erosion, not least because of the perceived threat it poses to our archaeological and built heritage.

Coastal Erosion and Change in Scotland Today

In many places around the Scottish coastline, particularly along the outer flanks of the firths, sand and gravel moves along the coastline, driven by waves in a process known as longshore drift. On any shore, this material will move one way, then another, in response to changing wind and wave directions. However, a nett or long-term drift direction is evident on many longer and straighter sections, in particular around the south shore of the Firth of Forth (E–>W), the north shore of the Firth of Forth (E–>W), the north shore of the Outer Tay (W–>E), along the Angus coastline (NE–>SW), Aberdeenshire coastline (S–>N), Moray coastline (E–>W) and the Ayrshire coastline, where both north and south drifting pathways exist on separate stretches of the coast.

Longshore drift pathways such as these are typically blocked where they meet prominent features such as headlands. The most prominent of these features allow us to split up the coastline into major units which are, in effect, independent of one another with respect to beach sediment movement. These large natural divisions are known as coastal cells. Recent research funded by Scottish Natural Heritage (SNH), Historic Scotland and the Scottish Executive has identified the distribution of these cells around the Scottish coastline (Figure 3.2) (H R Wallingford 1997). The concept of coastal cells is directly analogous to that of river catchment areas on land.

Cells can be subdivided into smaller sub-cells by features which block longshore drift under all but the most exceptional circumstances. These are also shown on Figure 3.2. In the Islands and on deeply embayed coasts such as those of the West Highlands, virtually every bay and sea loch constitutes a separate cell; for simplicity, therefore, only the principal divisions are indicated on this map.

Between 1972 and 1984, surveys based on historical maps, charts and aerial photographs were conducted of sandy beaches in 127 countries by the International Geographical Union's Commission on the Coastal Environment (Bird 1987). This Commission reported that, world-wide, over 70 per cent of beaches had retreated since initially surveyed, 20 per cent were stable, and less than 10 per cent had advanced (Figure 3.3a).

Between 1969 and 1981, the Department of Geography at Aberdeen University mapped and described all 647 sandy beaches over 100 m in length in Scotland. On completion of this study they reported that in Scotland as a whole approximately 40 per cent of beaches were eroding, 22 per cent were stable and 11 per cent were advancing; 18 per cent showed evidence of both advance and retreat, and the final 9 per cent were protected or backed by some other stable feature such as rocks (Figure 3.3b) (Ritchie & Mather 1984).

Statistics on coastal erosion were reported for each of the former local authority regions (Figures 3.4a and 3.4b) and these recorded that:

- erosion was most prevalent in Dumfries & Galloway, Shetland and the Western Isles
- erosion was least marked in Lothian & Borders, Orkney and Strathclyde (Highlands and Islands)
- prograding (advancing) beaches were most common in Strathclyde, and Tayside & Fife
- prograding (advancing) beaches were least common in Dumfries & Galloway, Grampian and Shetland

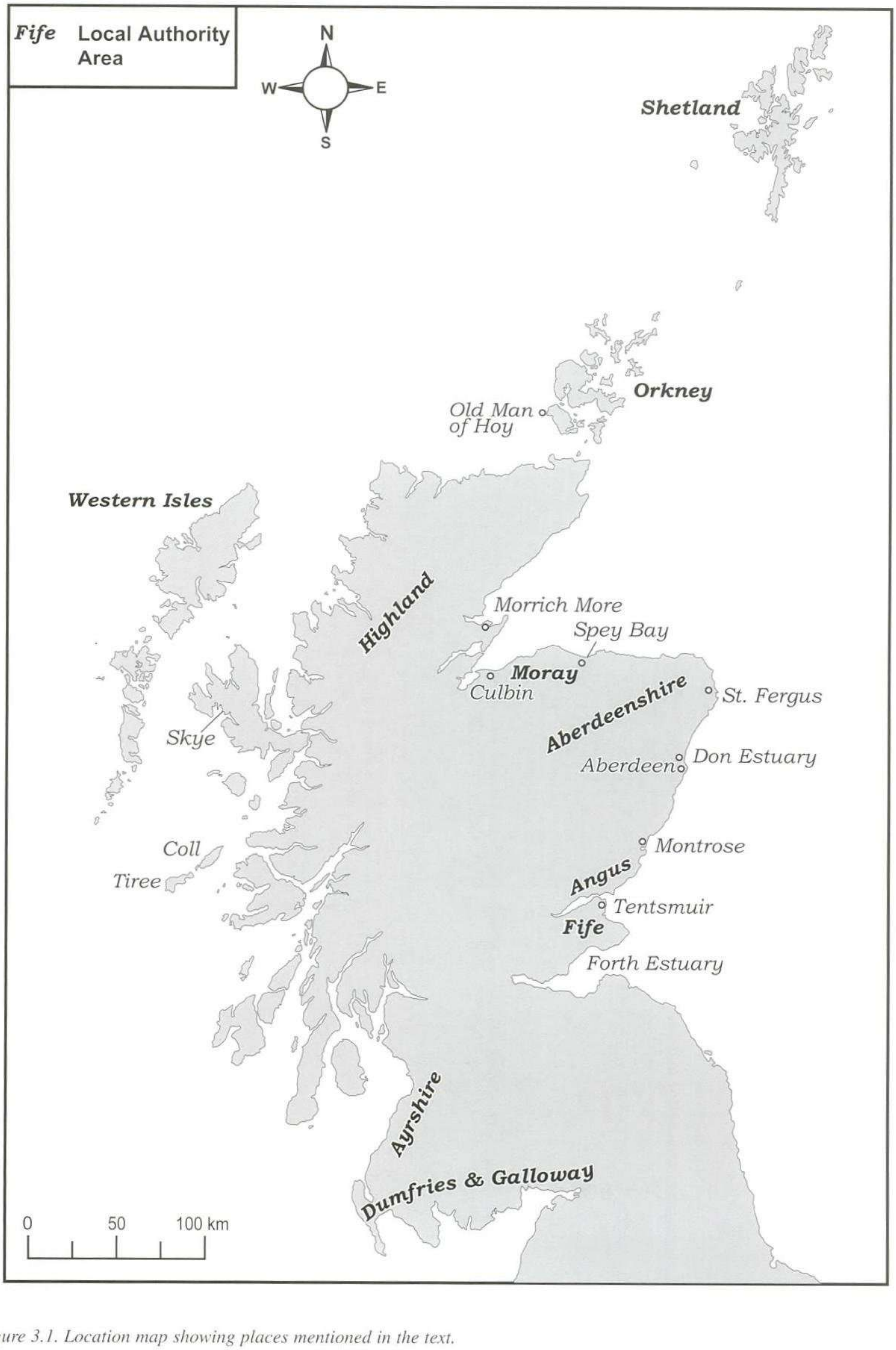

Figure 3.1. Location map showing places mentioned in the text.

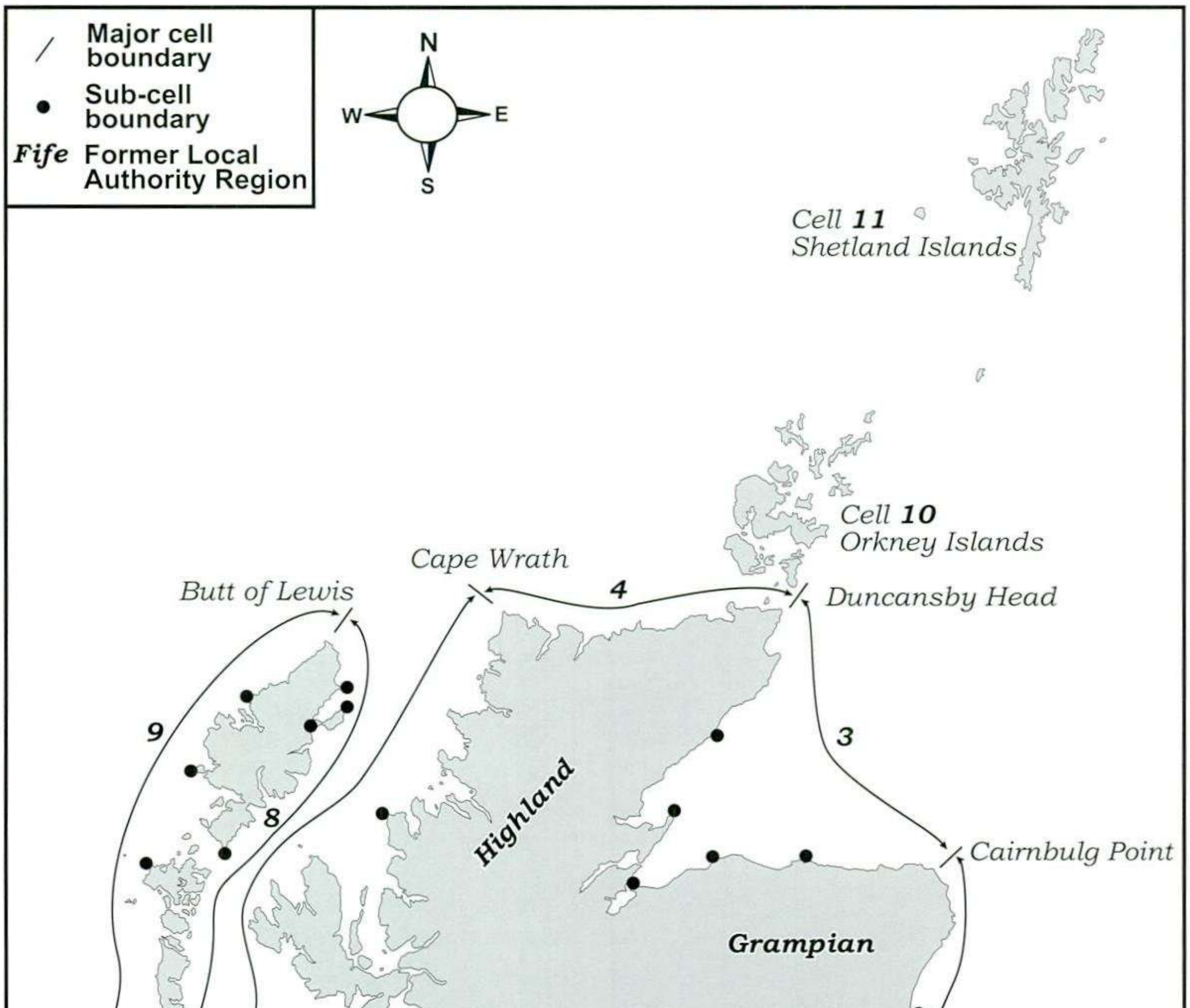

Figure 3.2. Distribution of principal coastal cells around Scotland. From: H R Wallingford (1997).

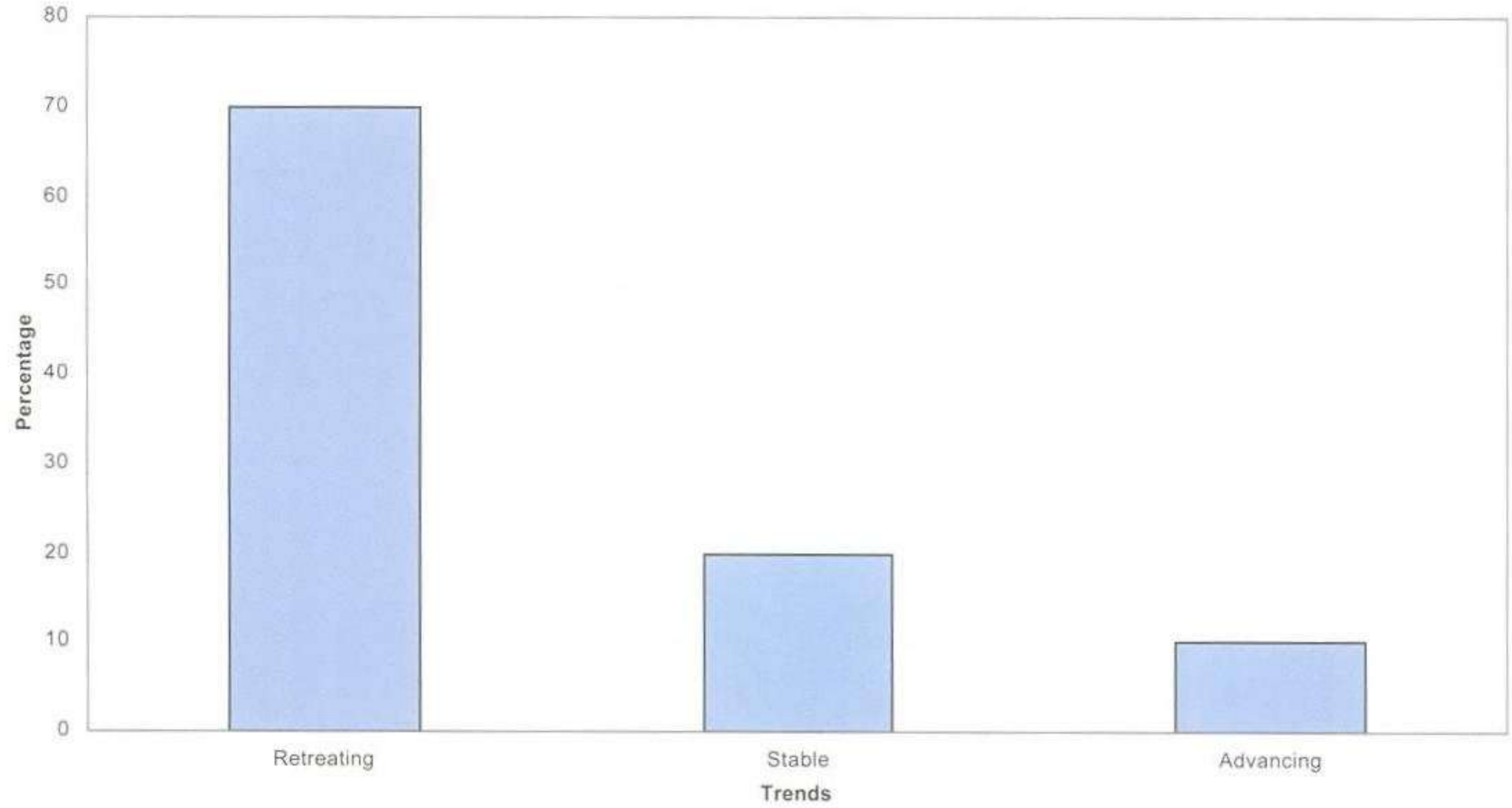

Figure 3.3a. Global trends in shoreline position, based on surveys organised by the International Geographical Union's Commission on the Coastal Environment 1972–84. Adapted from Bird (1987).

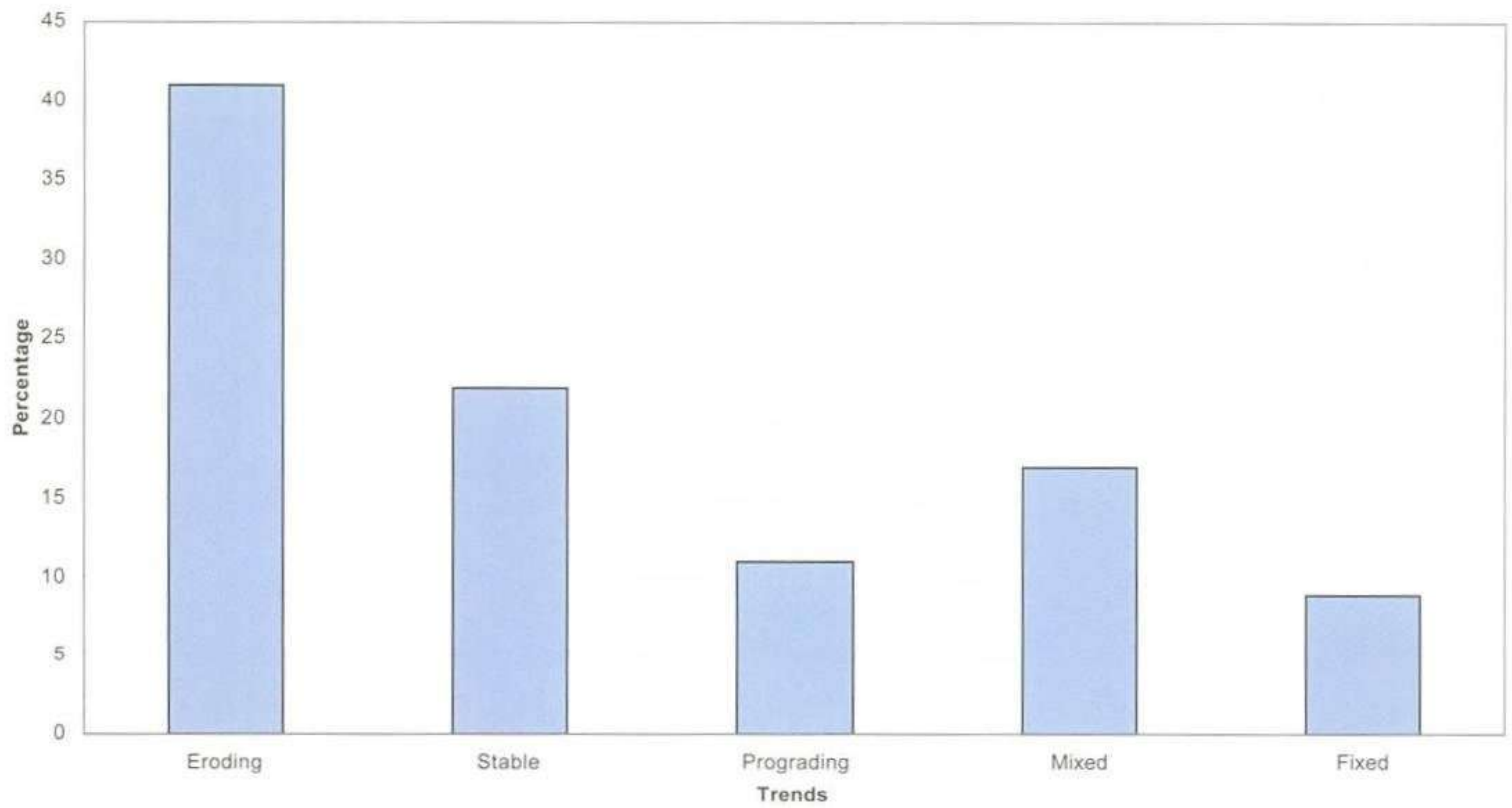

Figure 3.3b. Apparent trends on Scottish beaches, based on surveys by the Department of Geography, University of Aberdeen, 1969–81. Adapted from Ritchie & Mather (1984).

Systematic information on the actual rates of change along Scotland's coastline is lacking, but some information can be gleaned from site-specific geomorphological studies and coastal defence related surveys (Table 3.1). The figures quoted in Table 3.1 are based, in general, on comparison of historical Ordnance Survey maps and aerial photographs with those of today. The exact methods used to compare these and the accuracy of the techniques employed is variable, but the figures provide an indication of approximate rates of change. By the nature of these studies, the areas referred to tend to be among the most dynamic on the Scottish coastline so the values quoted represent extremes: most other areas of the coastline tend to be much more stable than these.

Factors Predisposing a Coastline to Erosion

It is evident from this data that coastal erosion is widespread in Scotland today and, even if less severe than in most other regions of the world, it is certainly more prevalent than coastal advance.

It is generally believed that the predominance of coastal erosion over advance is largely due to a **reduction in sand and shingle supply from the adjacent sea bed**. During, and immediately after, the last glaciation, as the ice caps melted, great drifts of sand and gravel were spread over the continental shelf, at that time dry land due to the lower relative sea level, as glacio-fluvial outwash. As sea level rose, these sediments were driven onshore by the waves until at or

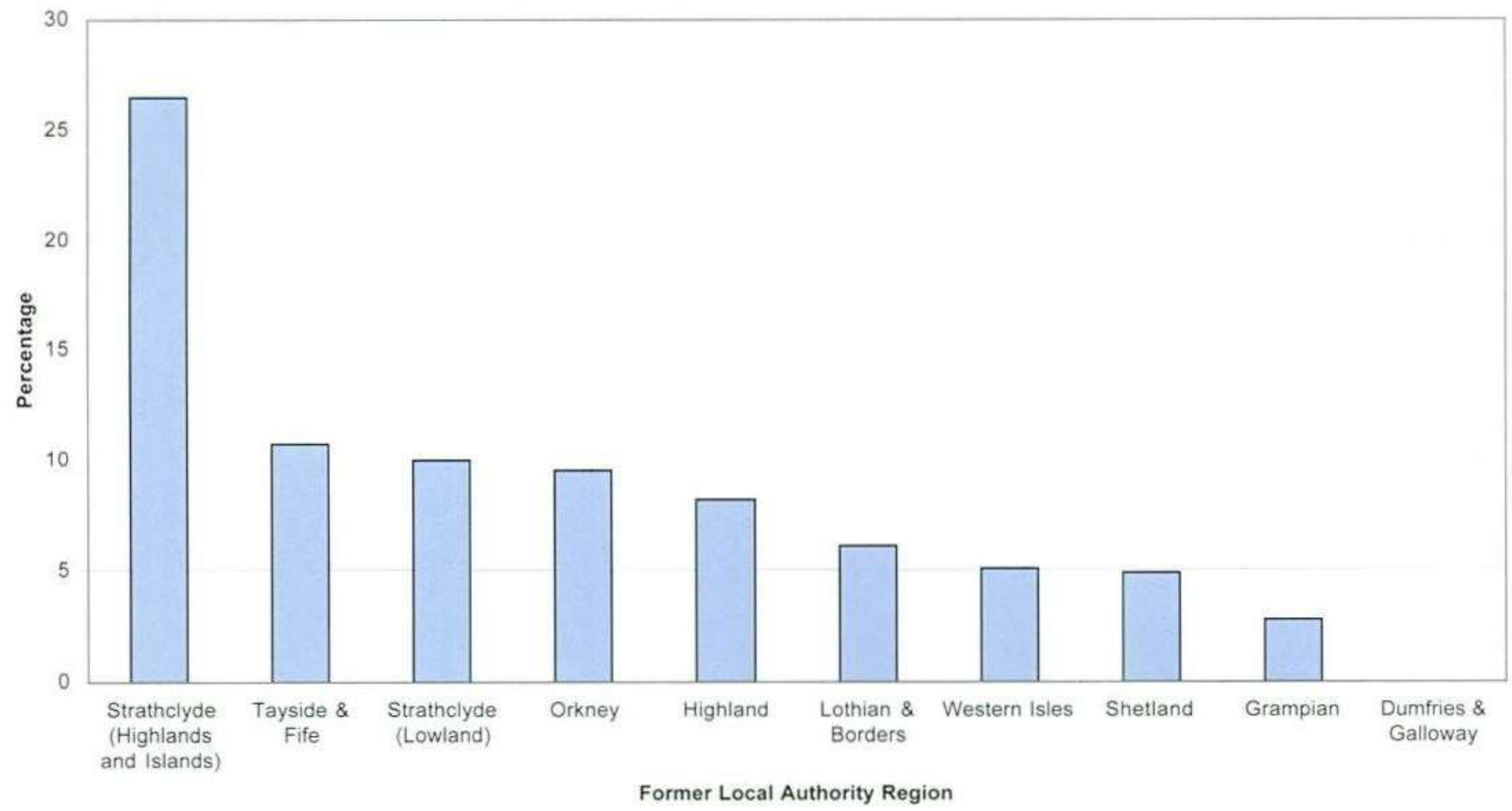

Figure 3.4a. Proportion of beaches prograding (advancing) in the former Scottish local authority regions. Adapted from Ritchie & Mather (1984).

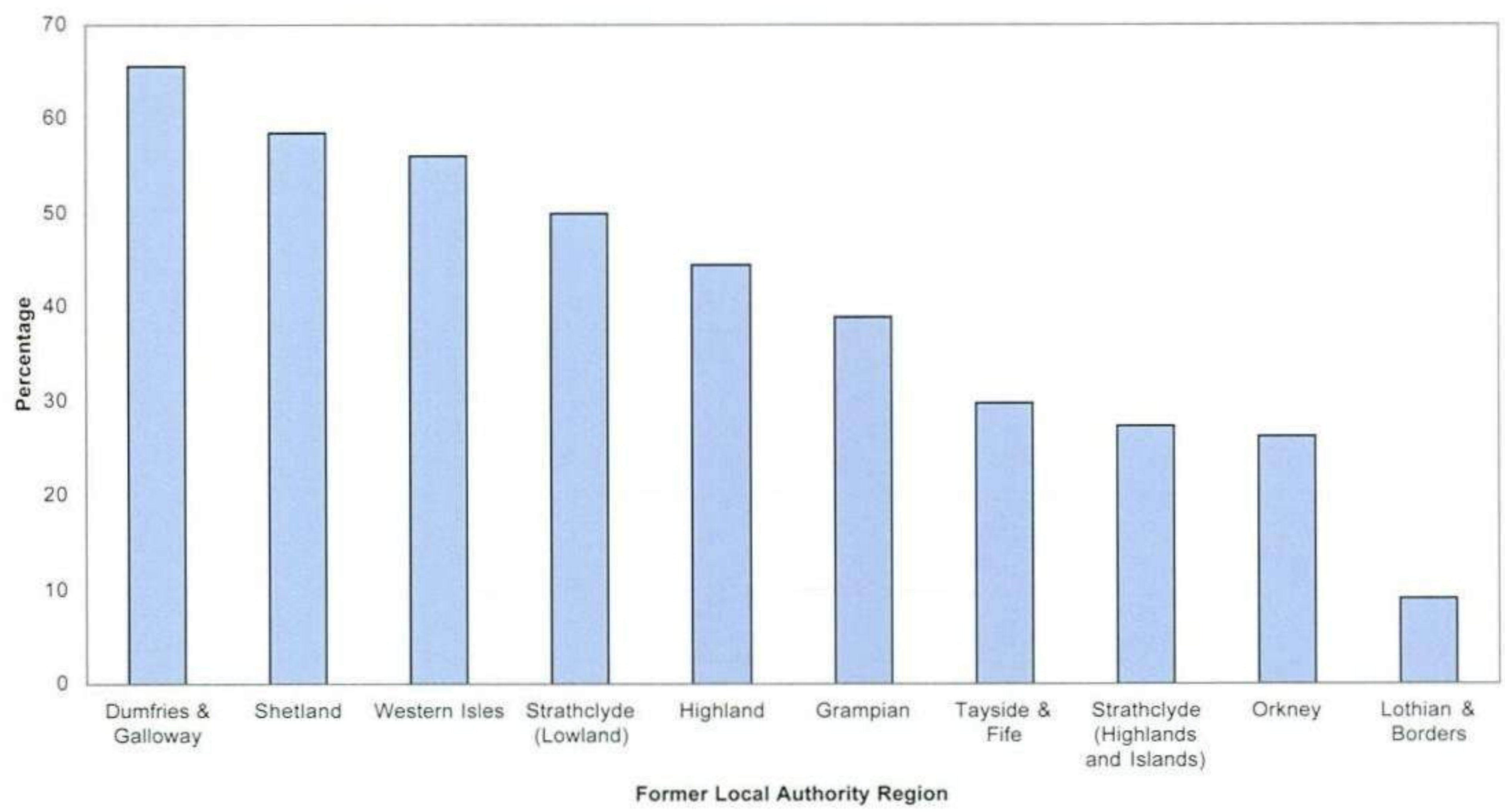

Figure 3.4b. Proportion of beaches eroding in the former Scottish local authority regions. Adapted from Ritchie & Mather (1984).

around the position of the coastline today. Around 5–6000 BP, in most areas, isostatic uplift of the Scottish land surface began to outpace the global rise in sea level, effectively lifting shorelines of the time clear of the sea. This process left behind wide areas of sandy beach which, subsequently, were reworked by onshore winds into dune fields. For a period, the beaches and dunes thus formed continued to be fed with sand and gravel from the nearshore seabed, driven shorewards by wave activity acting upon areas above storm wave base. It is now generally held, however, that most such deposits around the Scottish coastline have become 'used up' and are no longer forming a significant sediment resource for today's beaches (Ritchie & Mather 1984).

Other potential sources of new sediment for beach building, such as cliff erosion and fluvial supply from inland, nowadays bring only small volumes of new material into the coastal sediment budget and even these supplies tend to be very localised. In effect, the beach sediment we see at the coastline is generally being recycled from one shoreline to another. This lack of a sediment reservoir for beach construction goes a long way towards explaining the general prevalence of erosion in contemporary times. But there are certain other, essentially spatial, factors which can predispose a particular coastline to erosion.

First and foremost among these is the **nature of the bedrock or of the overlying sediments which are**

Location	Landform	Process	Period	Mean annual rate of change
Culbin Forest, Moray	Sand dunes	Coastal erosion	1990–92	1.1 m
Montrose Bay, Angus	Sand dunes	Coastal erosion	1965–97	0.1–2.0 m
NW Morrich More, Easter Ross, Highland	Sandy foreland	Coastal erosion	1730–1987	1.2 m
Don Estuary (north bank), Aberdeen	Estuarine shoreline	Coastal erosion	1903–73	3.1 m
Aberdeen beach	Sand beach (Mean High Water Spring/Mean Low Water Spring)	Coastal erosion	1868–1962	0.7 m/1.4 m
St Fergus, Grampian	Coastal dune ridge	Coastal erosion	1970–date	c 1 m
Kilkenneth, Tiree	Coastal dune ridge	Coastal erosion	1878–1975/1975–98	1 m/1.3 m
Bhasapoll, Tiree	Coastal dune ridge	Coastal erosion	1875–1994	0.3 m
Totamore Dunes, Feall Bay and Crossapol Bay, Coll	Coastal dune ridge	Coastal erosion	1875–1998	0.4–0.6 m
NE Morrich More, Easter Ross, Highland	Sandy foreland	Coastal advance	1730–1987	5 m
NE Morrich More, Easter Ross, Highland	Sandy foreland	Coastal advance	1907–87	7.5 m
Tentsmuir Point, Fife	Sandy foreland	Coastal advance	1812–1990	4.8 m
Buckie Lochspit, Culbin, Moray	Shingle spit	Spit extension (longshore drift)	1870–1988	8.5–94.5 m
Culbin Bar, Moray	Shingle spit	Spit extension (longshore drift)	1878–1988	5–45.7 m
Spey Bay spit, Moray	Shingle spit	Spit extension (longshore drift)	1870–1995	20–41 m

Data compiled from: Hansom & Leafe (1990); Comber *et al* (1994); Gemmell *et al* (2001); McManus & Wal (1996); Stapleton & Pethick (1996); Wright (1997); Halcrow Crouch (1998); Dawson (1999).

Table 3.1. Rates of change on the Scottish coastline (see text for details and interpretation).

exposed at the coast. Thus, where clifflines of hard igneous or metamorphic rocks, such as granite and gneiss, exist, erosion may proceed at less than 1 mm per year – to all intents and purposes indiscernible. Even the sedimentary rocks on Scotland's coastline, such as sandstone and limestone, are relatively stable under present climatic conditions, though prone to occasional rockfalls. A prime example of this was the creation of the Old Man of Hoy in Orkney at the turn of the 18th century through collapse of the arch which had previously connected it to the island of Hoy (Hansom & Evans 1996).

These relatively resistant rocks contrast markedly with most of those around the English coastline which are typically much younger and more friable than their Scottish counterparts. Indeed, it is the 'softness' of the chalk, clay and sandstone formations in the south and east of England which is primarily responsible for the prevalence of coastal erosion on these coasts.

While the rocky foundation of Scotland's coastline is fairly durable, this bedrock is often overlain at the coast by loose 'drift' sediment less resistant to wave attack and slumping. Foremost amongst these deposits are sand and gravel beaches, sand dunes and links or machair, mudflats and salt marshes. Shorelines formed in such material are inherently dynamic and may retreat (or advance) by anything from a few tens of centimetres to a few metres per year, and occasionally more. Recently, for instance, 4 m of dunes have been lost from one part of the dune system at Montrose in a single season (Halcrow Crouch 1998). Glacial tills are also commonplace on the shoreline and are equally susceptible to erosion though not, of course, growth.

The second key factor predisposing a shoreline to erosion is its **exposure to wave attack**. Wave height, and hence capacity to erode, increases with wind strength and fetch - that is the distance of sea over which the wind can blow uninterrupted by landmasses. Thus erosion is more typically witnessed on exposed shores in the north and west of Scotland. Conversely, sheltered coasts such as those of the west Highland sea lochs or estuaries, or in the lee of islands, are generally more stable.

The third factor influencing a shoreline's susceptibility to erosion is the behaviour of **relative sea level** in the area concerned. Even though sea level worldwide is gradually rising by 1–2 mm per year, most mainland areas in Scotland are also continuing to rise due to isostatic uplift of the land following removal of the ice. In general, in Scotland, this uplift is presently keeping pace with global sea level rise, except in areas most remote from the ancient ice cap, such as the Northern Isles and Western Isles, where coastlines are gradually submerging by a few millimetres per year. Naturally, coastal erosion is likely to be more widespread and severe in such areas than on shorelines still emerging from the sea.

The situation in mainland Scotland is in marked contrast to that in south-east England where compaction and subsidence of the land surface exacerbates the global rise in sea level by an additional few millimetres every year.

Causes of Coastal Erosion in Scotland Today

Based on the arguments above, the shorelines most susceptible to erosion in Scotland will tend to be those formed in soft or loose sediment, in exposed locations where sea level rise is outpacing isostatic uplift of the land, for example in Orkney, Shetland, the Western Isles, and Dumfries and Galloway. This supports the records of erosion noted by Ritchie & Mather (1984) cited earlier.

That said, erosion is clearly not confined to these areas. Moreover, the arguments presented do not explain why erosion might appear more severe in one year than another, nor the general perception that erosion is more prevalent now than in historical times. For an insight into these questions we need to consider how individual beaches behave.

On any specific shoreline, beach material – principally sand and gravel – may be lost through longshore drift to neighbouring shores or through storm activity which draws sediment offshore. Streams or rivers crossing the beach may wash material offshore, and onshore winds can blow sand inland. The removal of sand or gravel for construction, farming, bunkers on golf courses, and other human activities clearly depletes the overall resource. The continual attrition of beach sediment as it is reworked by waves further diminishes the volume of sediment on a beach, albeit slowly.

Balanced against these losses are those processes and activities which add sediment to a beach. Longshore drift feeds sand and gravel onto beaches from shorelines updrift and, under fairweather conditions, wave activity tends to drive sediment onshore, counteracting the impacts of storm activity. Streams and rivers may carry sediment to the coast from inland, though this rarely makes a significant contribution to the beach resource. Similarly, contemporary erosion of cliffs and rocky shores generates only limited volumes of new sediment for incorporation into beaches. Exceptionally, offshore winds blow sand onto beaches from deflated areas inland. Tipping of rubble and associated debris contributes small amounts of sediment to the beach resource, though often at significant cost to the amenity and environment. Lastly, biogenic activity, such as shell production, can be important locally as, for instance, on the 'Coral Beach' of Skye.

Broadly speaking, over the course of a year, sediment supplies to a beach will balance the losses from it and the beach will stay in a state of dynamic equilibrium fluctuating through a range or 'envelope' of beach profiles (Hansom 1999) but remaining, overall, in a stable condition. When, however, sediment losses start exceeding supplies year-on-year the shoreline will start to erode. Many factors may be responsible for such a change (Table 3.2) (Bird 1993).

1	Increased wave attack upon coast due to a relative **rise in sea level**
2	Increased wave attack of shore due to **more frequent, long lasting or severe storms** arising from climate change
3	Increased loss of sand or shingle due to **changes in the angle of approach of dominant waves**
4	**Reduction in sand and shingle supply from the adjacent seabed**, eg because supply has run out
5	**Reduction in sand and shingle supply from alongshore due to interception of longshore drift**, eg because of breakwater construction
6	**Reduction in sand and shingle supply to the coast from rivers**, eg due to reduced rainfall or dam construction
7	**Reduction in sand and shingle supply to the coast from eroding cliffs and foreshore outcrops**, eg due to construction of coastal defences
8	**Removal of sand and shingle from the beach by quarrying** or ad hoc extraction
9	**Construction of sea walls** causing reflection of storm waves and consequent beach lowering
10	Increased wave attack of shore due to **deepening of nearshore seabed**, eg due to dredging
11	**Intensification of wave attack due to beach lowering on an adjacent shore**
12	**Migration of beach lobes or forelands under longshore drift**, causing cycles of shoreline advance and retreat
13	Increased loss of sand inland due to **destabilisation and drifting, landward, of dunes**
14	**Reduction of sand supply to the shore from seaward drifting dunes**, eg due to overstabilisation
15	**Rise in the beach water table**, eg due to increased rainfall or local drainage modification, rendering the sand more erodable

Adapted from: Bird, E C F 1993 Submerging Coasts. The Effects of a Rising Sea Level on Coastal Environments.

Table 3.2 Principal causes of beach erosion

Bird (1987) warns against the temptation to ascribe the erosion of any one particular area to just one of these factors; invariably, a number of factors combine to cause coastal retreat. In a Scottish context, however, some are more pertinent than others in explaining why erosion may be taking place and, indeed, why it may appear more prevalent than in the past. For example, the profound influence of **reduced sediment supply from the adjacent seabed** has already been noted.

Climatic factors are particularly important too, especially given the changes to Scotland's climate predicted to arise through global warming and which may, indeed, already be taking place (Hulme & Jenkins 1998). Of these, perhaps the most obvious cause of increased erosion is increased wave attack due to a relative **rise in sea level**. It is noted above that, historically, most of the Scottish mainland has been rising more rapidly than global sea level (Smith 1997). The acceleration in sea level rise predicted to come about because of global warming (Hulme & Jenkins 1998; Dawson *et al* 2001) will, however, progressively outpace isostatic recovery across the whole of Scotland, leading to gradual submergence of up to 3 or 4 mm per year on all coastlines by about the middle of the 21st century, (Dawson *et al* 2001). Indeed, there is some evidence that this process has already started in some areas such as the Forth Estuary which, formerly, were emerging from the sea (Pethick 1999).

A further consequence of climate change, which may arise, is **increased storminess** (Dawson, this volume; Hulme & Jenkins 1998; Hill *et al* 1999). Self-evidently this trend would cause increased wave attack and erosion. Again, there is evidence that an increase in wave heights in the north-east Atlantic and North Sea has taken place in recent decades (Bacon & Carter 1991; Leggett *et al* 1996), though whether this is linked to global-warming-related climate change is uncertain.

Changes to **wind strength and direction** might also give rise to altered patterns of erosion (and sediment accumulation) as this controls wave height and direction and, consequently, the direction and magnitude of longshore drift. Over the course of time, most beaches adopt a stable 'plan shape' or orientation in response to the prevailing wind, and hence wave, direction. Changes to this average wind direction over the course of a few years, however, may cause the beach to seek a new equilibrium position in response. The beach, in effect, rotates, eroding at one end while advancing at the other. Even a slight change in the mean wind direction, therefore, can significantly alter the pattern of erosion and stability displayed along a particular shore.

Natural changes in the dominant wind direction from one year to the next may also give rise to perceived changes in the rate of erosion. For example, when a south-westerly gale blows, as is typical across Scotland, shores facing that aspect will erode. During the mid- to late-1990s there appear to have been unusually strong and prolonged south-easterly gales and, consequently, erosion of the south Fife and Angus shorelines was widely reported, whereas rates of erosion on westerly shores were unremarkable in comparison.

Apart from these trends which are, essentially, outwith human control (in the medium term at least), **human factors** can also cause erosion, particularly where these alter and, in particular, reduce the sediment input to a particular beach. Examples of such activities are many, but include sand and gravel extraction from beaches, the construction of groynes, piers or breakwaters which interrupt sediment drift, the construction of coastal defences, and, potentially, offshore or nearshore dredging.

Managing Coastal Erosion and Change

Coastal erosion and change are naturally occurring processes which affect, periodically, most soft coastlines in Scotland. These processes are essential for the creation, conservation and integrity of coastal habitats, landforms and landscapes. Where coastal assets such as buildings and monuments are threatened by erosion, management approaches that neither aggravate the erosion on adjacent shores nor damage important elements of the natural heritage should be pursued. Thus, although not the primary subject of this paper, the following points are pertinent to sound and sustainable erosion management.

Firstly, it should be recognised that **all defences impact upon natural processes and therefore should by and large be subject to an environmental assessment**. The fact that defences interfere with natural processes is self-evident since, if they were unable to reduce or prevent the process of erosion, they would not be constructed in the first place. To illustrate this point, defences may:

- reduce sediment input to the beach and hence the coastal cell, thereby potentially exacerbating erosion elsewhere
- deflect wave energy causing beach lowering or terminal scour or even failure of the defence itself
- intrude upon otherwise scenic and unspoiled landscapes

Secondly, **local authorities and other bodies with a vested interest in the coastline should consider preparing strategies for the management of coastal erosion which prioritise an area's coastal defence needs and identify means of coastal erosion management which do not impact on adjacent**

shorelines. A prime example of one such strategy is a Shoreline Management Plan (SMP) (Beech & Thornton, this volume). Shoreline Management Plans are formal but non-statutory documents 'which set out a strategy for coastal defence of a specified length of coast, taking account of natural coastal processes and human and other environmental influences and needs' (MAFF 1995). Under direction from MAFF, local authorities in England and Wales have prepared or are preparing these plans for the entire English and Welsh coastline, based on the coastal cells and sub-cells there. In Scotland, SMPs have been prepared recently by Fife Council, with the assistance of Scottish Natural Heritage and Historic Scotland, for the Fife area, and by Highland Council for part of the Inner Moray Firth. Two more are currently (2002) in preparation for the Angus and East Lothian coastlines under the direction of the Local Authorities concerned. They have considerable potential in other areas of the Scottish coastline too and provide a valuable means of balancing the preservation of our cultural heritage against the potential damage to our natural heritage which ill-conceived defences can bring about (Hansom *et al* 2000).

Conclusions

The Scottish coastline is continuing to change today in response to changes in sea level, sediment supply and climate. The dominant, but by no means exclusive, trend affecting Scotland's beaches appears to be erosion, though, because of isostatic recovery and uplift of the Scottish landmass, this is less prevalent than in most other countries. No one factor is responsible for this trend, but, of all the possible determinants influencing coastal stability, a relative lack of new sediment for beach building (linked to a diminution in supply from the nearshore seabed) appears to be the most crucial.

Changes brought about by global warming, such as sea level rise and increased storminess, will exacerbate erosion and coastal retreat in the 21st century. Managing such changes cannot continue to rely, indefinitely, on the erection of sea walls and other such coastal defences in response to actual or perceived erosion threats. Instead, more proactive approaches need to be adopted, such as the preparation of SMPs, which prioritise defence needs and provide the guidance necessary to plan future coastal development according to, rather than in spite of, the natural behaviour of the coastline.

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4 ESTIMATING THE VULNERABILITY OF SCOTLAND'S COASTLINE TO THE EFFECTS OF FUTURE CLIMATE CHANGE AND SEA LEVEL RISE

ALASTAIR G DAWSON

Introduction

According to the global warming debate, sea levels are rising and storminess is on the increase. If such predictions turn out to be true, there is reason to be fearful that in the years ahead the coastline of Scotland may be subject to considerable damage and erosion. Many archaeological treasures of Scotland's past lie at or close to sea level and, because of this, there is a pressing need to be able to estimate the degree to which Scotland's coastline is likely to be subject to considerable erosion in the future. This account attempts to address two basic questions in this regard:

- Is sea level rising around the Scottish coastline and, if so, are we able to provide realistic estimates of by how much it is likely to rise in the future?
- Is it possible to estimate whether or not storminess is likely to increase in the future. This simple question is extraordinarily complex and difficult to answer.

Estimating Sea Level Rise

In order to understand more clearly the problem of rising sea levels world-wide and, in particular, around the Scottish coastline, it is essential to understand that the reconstruction of patterns of former sea level change for any location on the surface of the earth is not only a function of the volume of water stored within the oceans at any point in time, but is also related to vertical movements of the land surface. In many areas of the world, these vertical land movements represent a legacy from the end of the last Ice Age. Ever since the time that the ice-sheets began to melt and sea level began to rise, there has been a continued redistribution of ice and water across the surface of the earth. Since land, water and ice are influenced by the earth's gravity field in different ways, it is not surprising that the changing distribution of water and ice across the surface of the earth has had complex effects.

In areas where ice-sheets formerly covered the land surface and where they have now long since disappeared, the earth's crust has been rebounding (isostatically) from the former ice loads and is continuing to do so. In Scotland, the disappearance of ice over 10000 years ago still continues to have an effect. At present in Scotland, in areas where the ice was formerly thickest (eg the western Highlands), the earth's crust is still rebounding at a rate of 1–2 mm per year. By contrast, in areas where there was little or no ice, crustal uplift at the present time is difficult to detect; indeed, in some areas the land may be sinking. By AD 2100 if the volume of water in the world's oceans were to remain constant (ie if there was no rise caused by global warming), much of the Scottish landmass would rise by c 10 cm relative to present sea level (Dawson et al 2001).

In contrast to the earth's land surface, the ocean surface responds almost instantaneously to the melting of ice on land. The immediate response to melting glaciers and ice-sheets is a rise in sea level, but due to gravitational effects acting on the ocean surface across the world, the addition of a given volume of water to the world's oceans does not result in the same rise in relative sea level everywhere. Nor are the surfaces of the world's oceans at a uniform height everywhere. The influence of gravity on ocean water corresponds to an ocean surface known as the geoidal sea surface which, when viewed from a satellite, is extremely uneven. The geoidal sea surface in the central Indian Ocean, for example, is around 150 m lower than that in the North Atlantic.

When water is added to the world's oceans from melting ice, the increase in ocean water volume leads to extremely small changes in the nature of the earth's rotation. Thus, in respect of the British Isles, recent computer modelling has suggested that such processes, on their own, may presently be contributing to a rise in relative sea level in the order of 0.4 mm per year. Thus, if the latter processes were the only processes affecting changes in relative sea level in Scotland, one might envisage annual rates of land uplift in the order of 1 mm per year and a rise in water levels in the order of 0.4 mm per year, causing a relative fall in sea level of 0.6 mm per year. However, these processes are not the only ones to be considered.

The most important factor apart from those described above is an increase in the volume of the world's oceans caused by melting of glaciers and ice-sheets. The two largest ice-sheets which presently exist in the world occur in Antarctica and Greenland. If all the ice locked up in the East Antarctic ice-sheet were to melt tomorrow, there would be an increase in ocean water volume equivalent to a rise in sea level in the order of

+60 m. This is extremely unlikely, however, since much of the ice in East Antarctica rests upon a continental landmass and is essentially frozen on to the underlying land surface and is therefore relatively stable. The ice that covers the area of West Antarctica, however, is more unstable since much of the edge of this ice-sheet terminates in the ocean. In theory, the West Antarctic ice-sheet could contribute to a rise in sea level in the order of +6 m. Considerable attention has been given to the potential hazard presented by the possible melting of the West Antarctic ice-sheet. However, present scientific opinion is that this ice-sheet is likely to remain relatively stable during the next several centuries. In the northern hemisphere, complete melting of the Greenland ice-sheet in the future would lead to a rise in sea level also in the order of +6 m. The Greenland ice-sheet, however, is similar in many respects to the East Antarctic ice-sheet, also being frozen at its base onto an underlying landmass. One might imagine that the effects of global warming might lead to the melting of ice on the surface of the Greenland and Antarctic ice-sheets, thus contributing to a rise in sea level. However, large ice-sheets such as these need not necessarily contribute to a rise in sea level as a result of global warming. Some hold the view that the volume of ice in Greenland and Antarctica is actually increasing (causing reduction in ocean volume) as a result of increased snow precipitation along the ice-sheet margins caused by increased evaporation rates from warmer ocean waters surrounding the ice-sheets (see IPCC 1996).

It is not surprising therefore, that there is a very high degree of uncertainty of the response of the Greenland and Antarctic ice-sheets to global warming. This is reflected very clearly in the relevant chapters contained within the reports written by the Intergovernmental Panel on Climate Change (IPCC). Estimates of the various factors having contributed to the rise in sea level that has taken place over the last c 100 years exhibit an uncertainty as to whether or not the Greenland and Antarctic ice-sheets have been contributing to a decrease or an increase in global ocean water volume (Table 4.1) (IPCC 1996).

Component contribution	Low	Middle	High
a) Thermal expansion (global)	2	4	7
b) Glaciers and ice caps	2	3.5	5
c) Greenland ice-sheet	-4	0	4
d) Antarctic ice-sheet	-14	0	14
e) Surface/groundwater	-5	0.5	7
Total	-19	8	37

Table 4.1. Estimated contributions to sea level rise over the last 100 years (in cm) (based on various sources). The classifications 'low', 'middle' and 'high' correspond to three scenarios of sea level change described by the IPCC (1996).

The other important sources of ice in the world are stored within small ice caps and in valley glaciers. It is well-known that there was a progressive decline during the 20th century in the volume of ice stored within glaciers and small ice caps in the world. Many hold the opinion that melting of ice from these areas as a result of rising air temperatures may go a long way towards accounting for the observed rise in sea level. There is, however, one additional process that is considered important in understanding the nature and rate of recent sea level rise. It is thought that the warming of oceans in recent decades caused by rising air temperatures may have led to a thermal expansion of the ocean water column thus leading to a rise in sea level. Not surprisingly, the IPCC predictions are that a significant amount of future sea level rise will be attributable to the effects of ocean thermal expansion caused by global warming.

The view that the world's oceans on average have been subject to a perceptible sea surface temperature rise in recent decades is widely held. Some have argued that this process of thermal expansion of ocean waters may have contributed on average c 7 cm to the rise in sea level over the last 100 years. However, it is not so clear if the North Atlantic Ocean and, in particular, the ocean waters around Scotland reflect these average conditions. Detailed investigations of observed changes in sea surface temperature for waters around the Scottish coastline as measured over the last c 120 years do not show this trend of sustained warming of surface waters (Figures 4.1–4.3). Inspection of the graphs of sea surface temperature change for January and July for the three locations described shows that the data can be interpreted in different ways. Whereas the majority of the graphs do not show any marked increase in sea surface temperatures over the last c 120 years, a different interpretation can be made if the dataset is shortened. For example, if the sea surface temperature data for the last 20 years is analysed separately, the majority of the graphs show evidence of ocean warming.

The most striking feature of all the graphs, however, is the marked interannual variability in sea surface temperature. It is also clear that the rises and falls in sea surface temperature are not synchronous between one area and another. This would appear to indicate the great complexity of ocean circulation in this part of the North Atlantic region and also how difficult it is to make generalised statements regarding whether or not the North Atlantic Ocean has been progressively warming (or cooling) during the last century. It is therefore concluded that the principal cause of rising sea levels around the Scottish coastline during the last c 100 years has principally been due to the effects of melting ice-sheets, ice caps and glaciers around the world. The gravitational effects on sea level may also

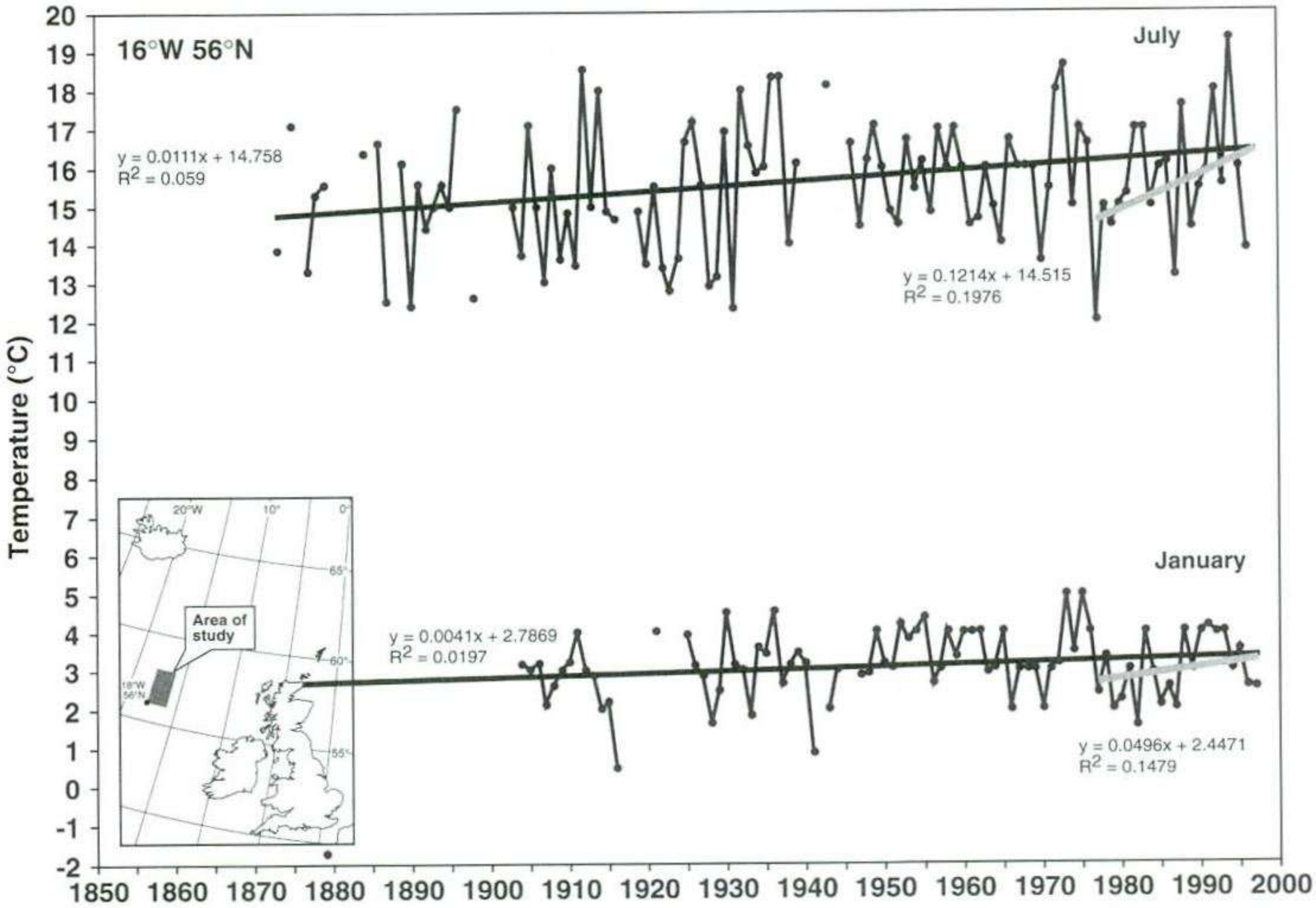

Figure 4.1. Graph showing January and July sea surface temperatures for a 2 x 2° latitude and longitude block area of the North Atlantic, the south-west corner of which is defined by 18°W and 56°N. Regression coefficients and R^2 values are also shown for 95% significance levels and calculated both for the entire time series and for the last 20 years (1977–97). Source: Comprehensive Ocean-atmosphere Data Set (COADS) database.

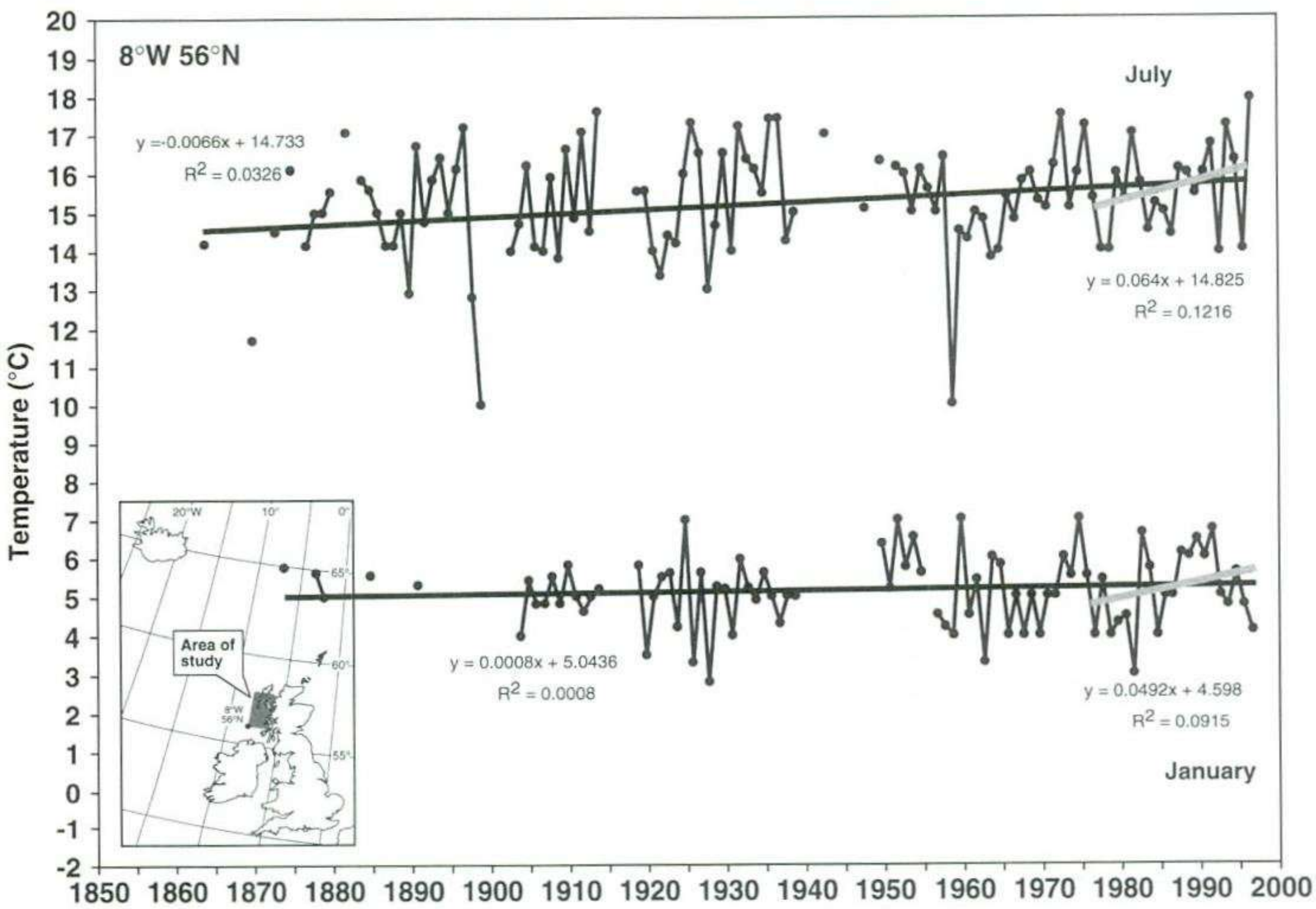

Figure 4.2. Graph showing January and July sea surface temperatures for a 2 x 2° latitude and longitude block area of the North Atlantic, the south-west corner of which is defined by 8°W and 56°N. Regression coefficients and R^2 values are also shown for 95% significance levels and calculated both for the entire time series and for the last 20 years (1977–97). Source: COADS database.

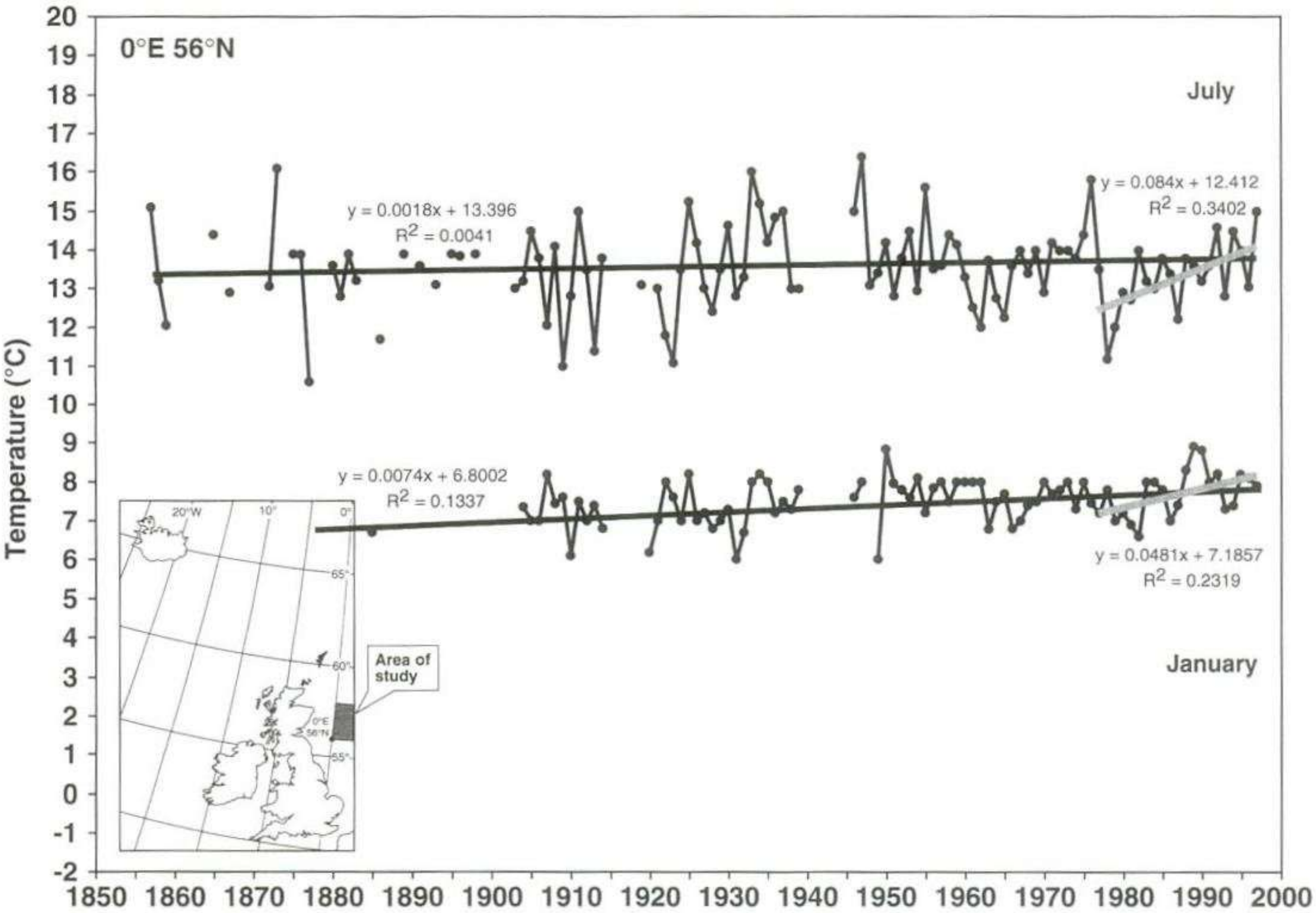

Figure 4.3. Graph showing January and July sea surface temperatures for a 2 x 2° latitude and longitude block area of the North Sea, the south-west corner of which is defined by 0°E and 56°N. Regression coefficients and R^2 values are also shown for 95% significance levels and calculated both for the entire time series and for the last 20 years (1977–97). Source: COADS database.

have been an important element contributing to the observed rise in relative sea level. In addition, much of the Scottish landmass has been rising as a result of isostatic readjustment to ice-sheet melting at the end of the last Ice Age thus creating a complex and regionally variable history of relative sea level changes. In terms of estimating future sea levels around the Scottish coastline, it is concluded here that the component of sea level rise attributable to the process of thermal expansion may be negligible.

For any location on the coastline of Scotland therefore, these various factors have combined over time to produce vertical changes in relative sea level. An attempt is made here to make use of predictions of likely future sea level rise and to combine these with information on the most likely future rebound patterns in Scotland in order to derive predictions concerning the future rise in relative sea level in Scotland. These are shown in two diagrams depicting 'best estimate' scenarios of future changes in relative sea level rise for AD 2050 and AD 2100 respectively (Figures 4.4 and 4.5). Unfortunately, absence of data for the Orkney and Shetland Isles presents difficulties in estimating future values of relative sea level rise for these areas. It is clear, however, that the effects of sea level rise and storminess change are likely to be most strongly felt in these areas. It is estimated here that these areas may experience a relative sea level rise of 16–30 cm by AD 2050 and c 30–50 cm by AD 2100.

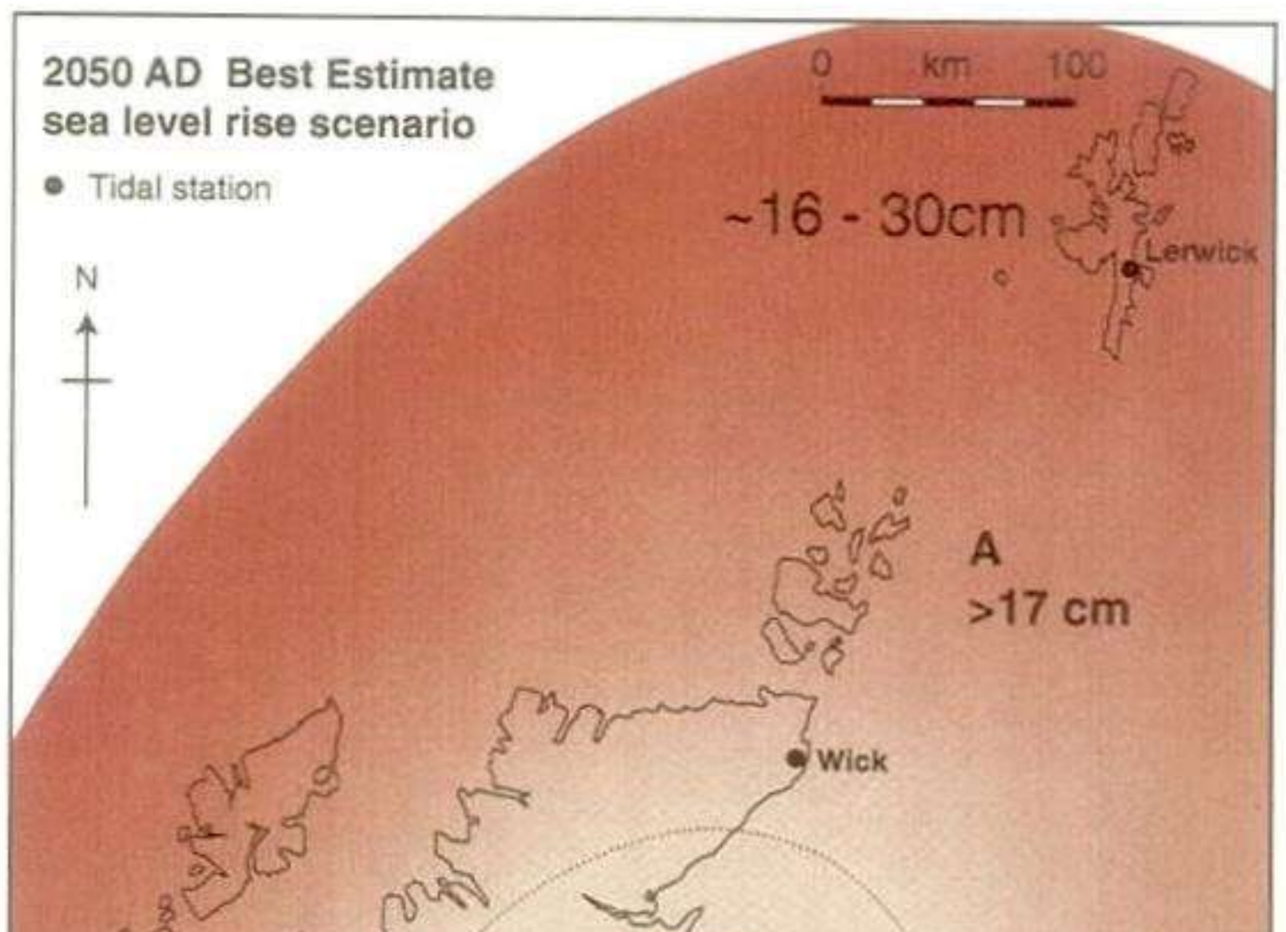

Figure 4.4. Best estimate sea level rise scenarios for 2050 AD. Note that three zones are identified and defined by the shape of the isobases of crustal uplift. Zone B is the area between the inner and outer ellipses and represents an intermediate zone between A and C where it is difficult to determine precisely the best estimate of future sea level rise (after Dawson et al 2001).

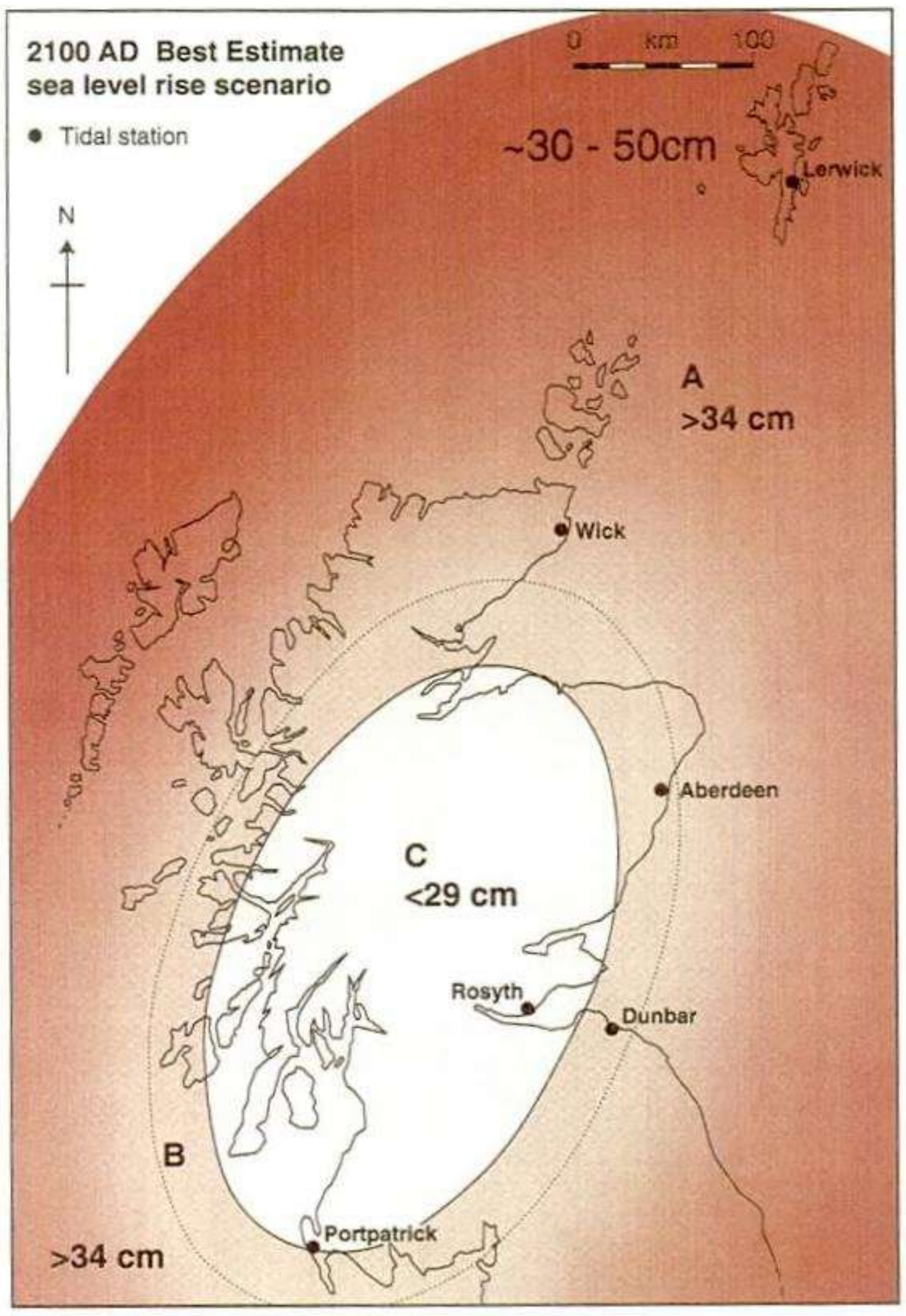

Figure 4.5. Best estimate sea level rise scenario for 2100 AD. Note that three zones are identified and defined by the shape of the isobases of crustal uplift. Zone B is the area between the inner and outer ellipses and represents an intermediate zone between A and C where it is difficult to determine precisely the best estimate of future sea level rise (after Dawson et al 2001).

Estimating Changes in Storminess

Of course, people living in coastal communities together with politicians and planners not only need to know how much sea level is likely to rise around the Scottish coastline in the future, but also if there is likely to be any change in the pattern of storminess arising from future changes in climate. Severe storms may destroy entire coastal communities in a matter of hours and it is essential to understand whether storminess in Scotland is likely to increase or decrease in the future.

In recent years, it has been recognised that historic changes in storminess in the North Atlantic region can be investigated by comparing long-term differences in air pressure between Iceland and the Azores (Figure 4.6) (Jones *et al* 1997). For example, when high pressure exists over the Azores there is usually low pressure over Iceland and, more often than not, stormy weather over Scotland. By contrast, high pressure over the North Atlantic is often associated with the southward displacement of cells of low pressure leading to unsettled weather farther south. Recently, an index of monthly air pressure differences, known as the North Atlantic Oscillation (NAO) index, has been developed. The NAO index makes use of instrumental records of air pressure from Iceland, the Azores and Gibraltar that extend back to AD 1824. The index itself ranges from approximately +6 to -6 (cf Hurrell 1995; Appenzeller *et al* 1998). In general, months when the index is strongly positive coincide with times when the Icelandic low pressure cell is well-developed and

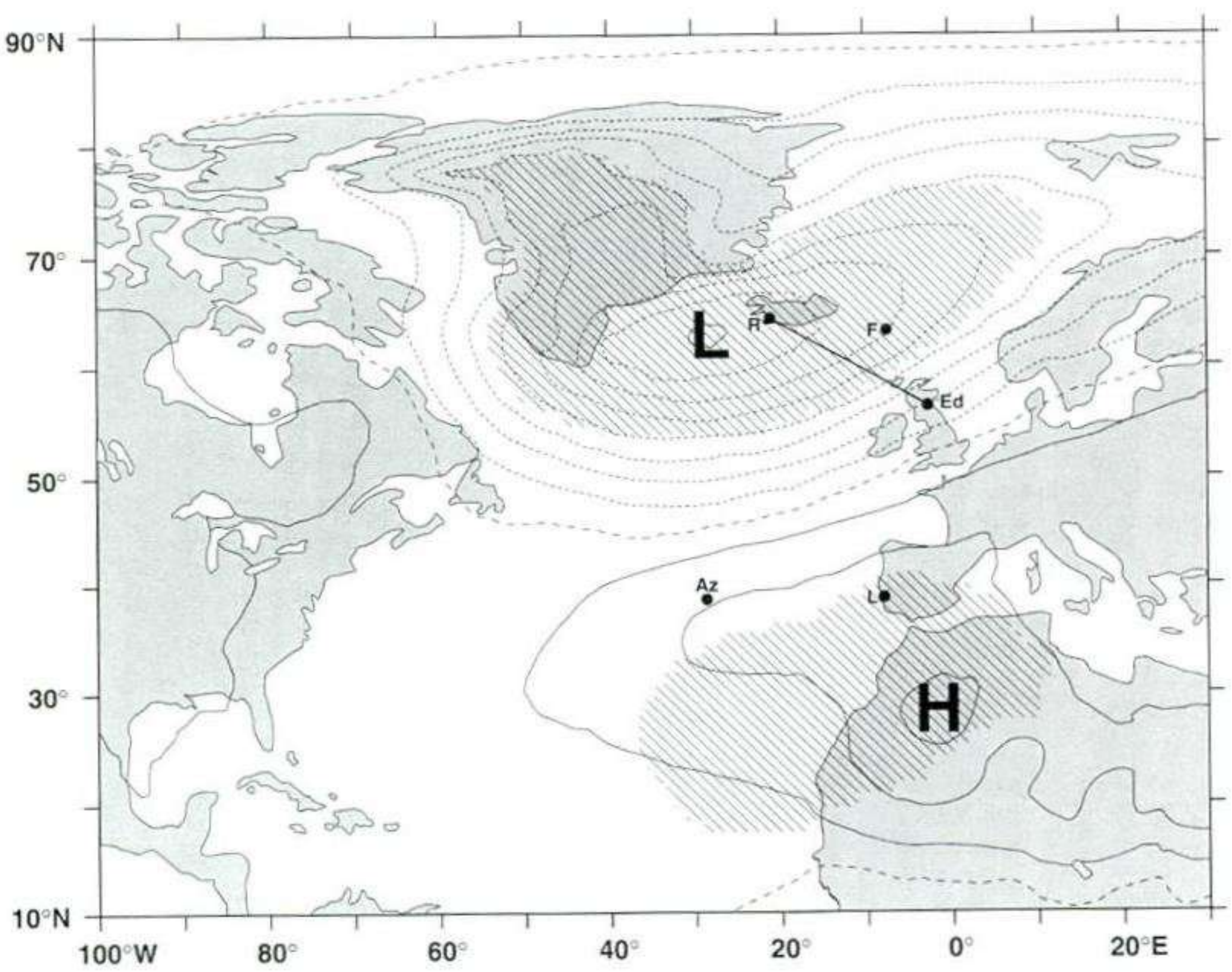

Figure 4.6. Map showing a schematic illustration of the North Atlantic Oscillation (NAO) index. The index is calculated as the monthly mean air pressure difference between Iceland and the Azores and thus represents a measure of the relative strengths of the Azores 'high' and the Icelandic 'low'. A separate NAO index has been calculated on the basis of monthly pressure differences between Iceland and Lisbon. The shaded areas represent the dominant areas across which low pressure or high pressure occurs. The asterisk refers to the ice core drill site described by Appenzeller et al (1998) and for which an NAO series has been derived.

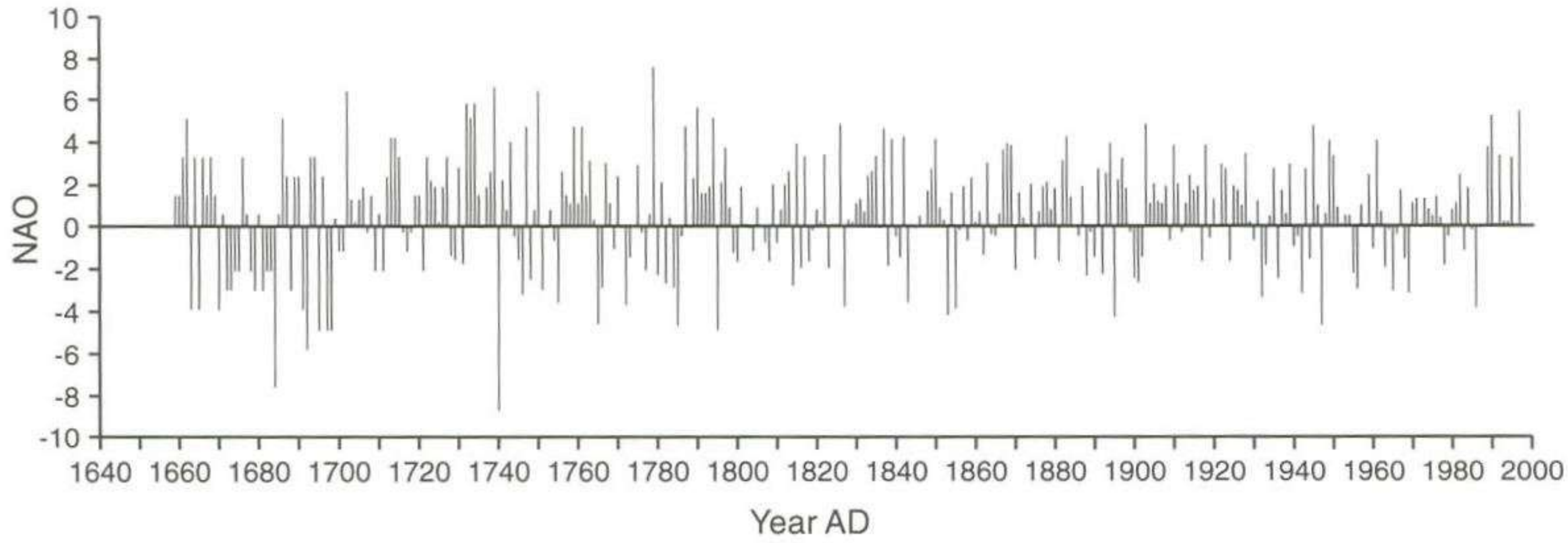

Figure 4.7. Graph showing the reconstructed North Atlantic Oscillation (NAO) index for February, 1659–1997 AD (based on Jones et al 1997).

usually correspond with times of increased storminess across Scotland. By contrast, months when the index is strongly negative generally coincide during winter with air stability and the expansion of cold polar air across Scotland and the rare occurrence of storms.

More recently, the NAO index has been extended back to the 17th century as a result of analysis of monthly records of air temperature for Edinburgh and central England. A strongly positive NAO index during winter not only coincides with the passage of cyclones across Scotland but also with higher than average winter temperatures due to the occurrence of mild south-west winds. In general terms, therefore, periods when the NAO index is strongly positive during winter correspond to stormy weather, higher than average temperatures, and higher than average winter rainfall (Figure 4.7). Changes in the NAO index may also be related to changes in sea surface temperature across the North Atlantic, although the precise relationships remain unclear (see below). It should be noted from Figure 4.7 that since c AD 1985, NAO winter values have been strongly positive and this has coincided with a marked increase in winter storminess.

The relatively simple concept of linking changes in storminess to changes in the NAO index is complicated, however, by the role of the Gulf Stream and its part in the North Atlantic Ocean heat conveyor which, via warm ocean currents, enables large quantities of heat to be pumped into the North Atlantic region (Figure 4.8). The North Atlantic Ocean conveyor functions as a result of the extremely important role played by sea ice formation in the Greenland Sea. When sea ice forms, brine is expelled into the surrounding ocean waters, causing surface water to sink. (Figure 4.9). In this way, the surface currents in the North Atlantic, of which the Gulf Stream plays a major part, are associated with the sinking of dense saline water in areas of the Greenland Sea where sea ice is formed. This dense water sinks to the floor of the ocean and is returned southwards across the floor of the North Atlantic Ocean so enabling ocean circulation to be maintained.

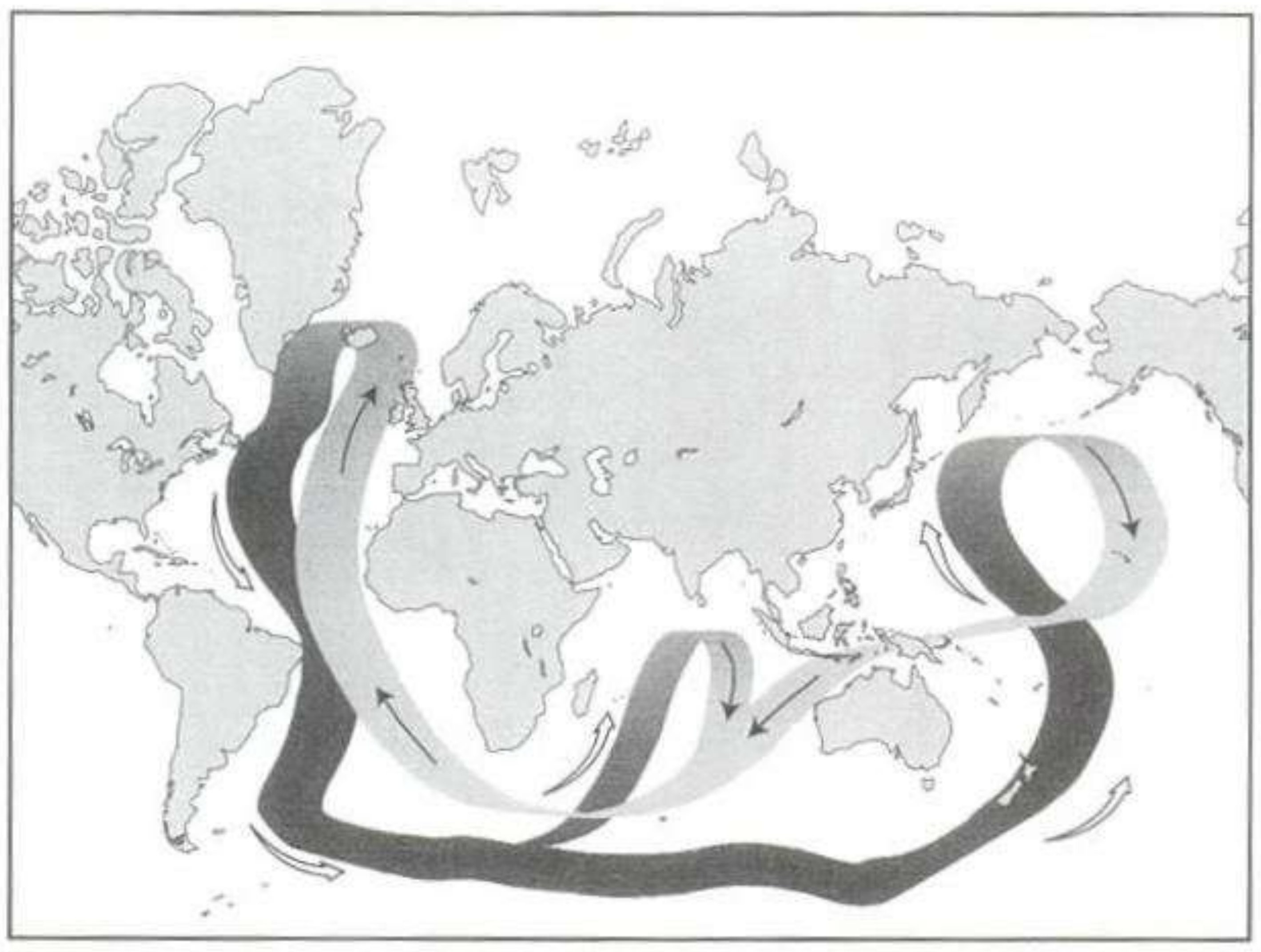

Figure 4.8. Schematic illustration of the thermohaline conveyor of the North Atlantic. The point where the surface water begins to sink generally coincides with the main area of North Atlantic Deep Water (NADW) formation.

There have been fears that global warming may lead to a shutdown of this ocean conveyor and a corresponding climatic deterioration across north-west Europe leading to the onset of a new Ice Age. The principal cause for concern is that a significant decrease in the amount of sea ice formed in the Greenland Sea would lead to a slowdown in the ocean heat conveyor (Wallevik & Sigurjónsson 1998; Toudal 1999). If global warming was sufficiently severe to prevent sea ice forming in the Greenland Sea, no brine expulsion could take place, therefore there would be no mechanism to enable ocean convection to take place. Such a set of processes could conceivably lead to climatic deterioration across north-west Europe at a time when much of the remainder of the world was experiencing accelerated global warming.

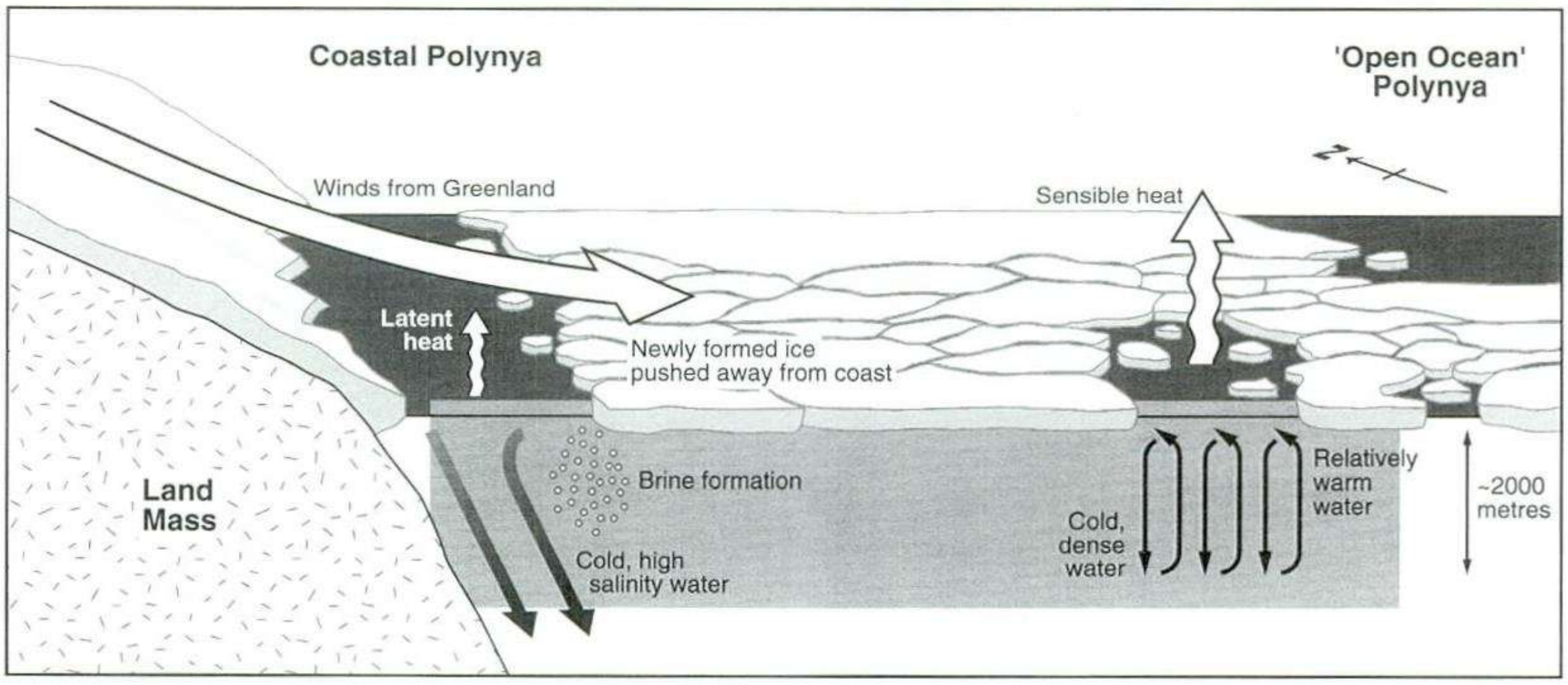

Figure 4.9. Schematic diagram showing links between the North Atlantic Oscillation (NAO) index, sea ice cover in the Greenland Sea and North Atlantic Deep Water Formation (NADW) (convection plumes) and storminess in the North Atlantic region.

Storminess in the North Atlantic region is intimately related to the above processes. Satellite data has identified a significant increase in storminess across the North Atlantic region during the last two decades. Indeed, satellite observations over this time period have identified an average increase in wave height of 2.5–7.5 mm per year (Günther *et al* 1998). A cause for concern has been that this increase in storminess has been accompanied by a corresponding decrease in sea ice cover in the Greenland Sea and prolonged periods of time when the NAO index has been positive, thus raising fears that the North Atlantic Ocean conveyor circulation may be weakening. The recent increase in North Atlantic storminess also coincides with the well-known increase in global air temperatures. These observations are internally consistent and point to the following startling conclusion. We know from analysis of air temperature data for the period AD 1659–1998 that higher than average air temperatures during winter equate to periods when the NAO index is positive. We also know that increased storminess over the last 20 years has coincided with a positive monthly NAO index. Therefore, the inescapable conclusion is that storminess is likely to increase over Scotland in the future as global warming causes air temperatures to rise.

Analysis of historical storm data for Scotland, however, indicates that by far the stormiest periods of the last c 200 years occurred during the decades AD 1810–20 and AD 1880–90. During both of these decades and also at other times during the 19th century, storminess in Scotland was exceptionally severe and certainly storm frequency was greatly in excess of that experienced during the 1980s and 1990s. However, the cause of such exceptional storminess was not due to the disappearance of sea ice. Instead, it was due to the opposite: exceptionally large areas of sea ice that had formed in the Greenland Sea. During 1881, one of the most severe winters, Iceland was almost entirely landlocked. Indeed, the southern limit of sea ice cover during April–June 1881 may have reached to c 200 km north of the Shetland Isles (Figure 4.10) (Gray 1881).

The occurrence of these 'sea ice years' and the exceptional storminess that accompanied them in Scotland may be due to the North Atlantic storm track having been displaced several hundred kilometres farther south than normal. The maximum expansion of sea ice that took place during individual years of the late 19th century generally occurred during spring and early summer. The most immediate consequence of such a change was the southward expansion of the polar anticyclone and the southward displacement of North Atlantic cyclones. The effect of such a change would have been that at this time Scotland would have been subject to exceptional storminess during both spring and summer. Such changes imply that a short-term (several decades) period of climatic deterioration may have taken place during the last three decades of the 19th century. If this is the case, the period of exceptional storminess that affected Scotland at this time may have been due to climate processes quite different from those that characterised the remarkable storminess of last two decades of the 20th century.

It is concluded, therefore, that Scotland's climate future is likely to be characterised by increased storminess set against a background of rising sea levels. An attempt has been made to superimpose the 'best estimate' scenarios of future sea level rise for AD 2050 with a statistical estimate of storm surge elevations (above

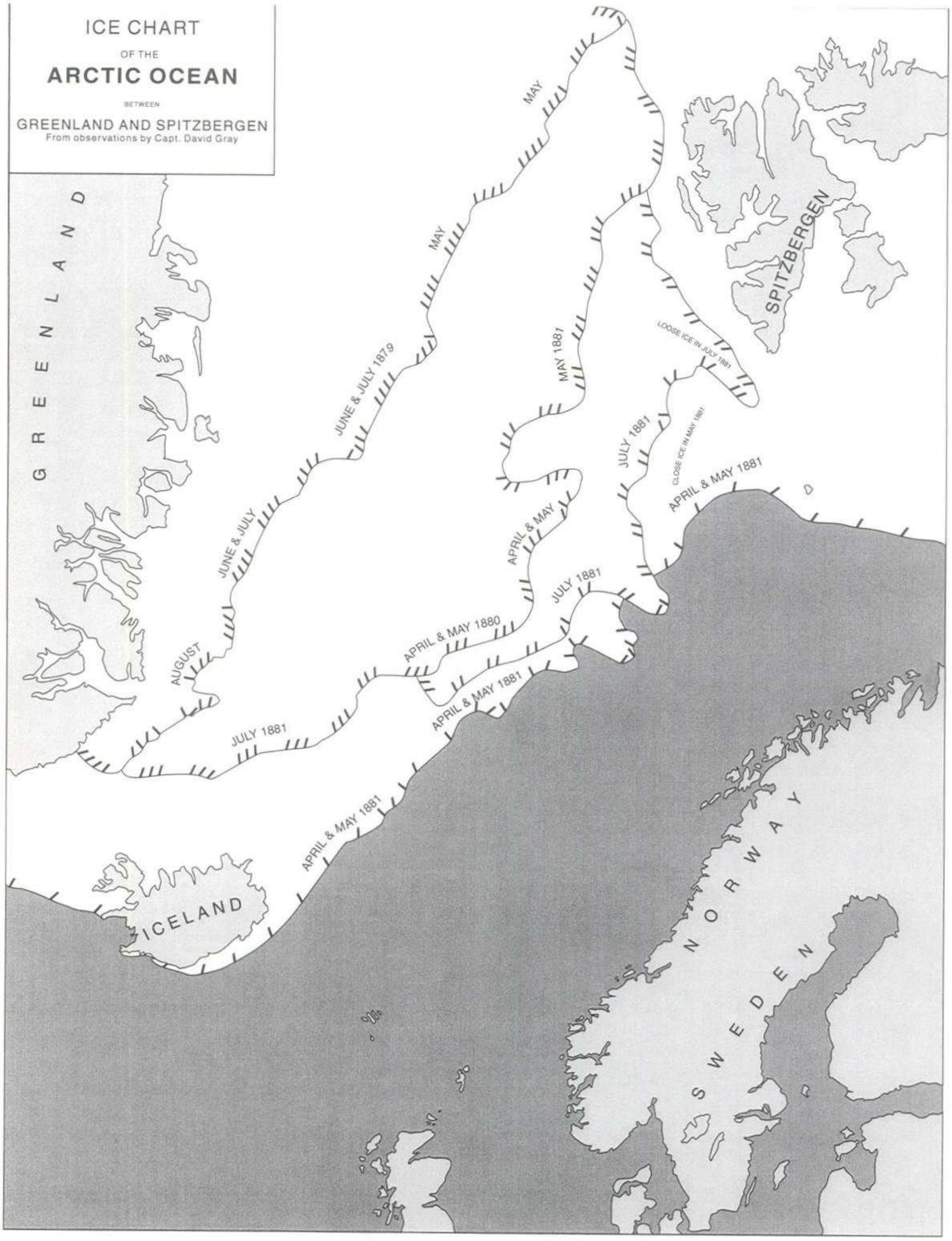

Figure 4.10. Map showing the seasonal changes in the distribution of sea ice during the years 1879, 1880 and 1881. Note the exceptional extent of sea ice during April and May 1881. This particular year was associated with exceptional storminess across Scotland but it had low monthly values for the North Atlantic Oscillation (NAO) index (based on Gray 1881).

mean sea level) based on a return period of 1:50 years (Figure 4.11). This type of calculation, however, does not take into consideration the possibility that the 'best estimate' surge and sea level rise values shown above may be placed within the context of increased storminess in future decades. On this basis, it may be more realistic to consider the maximum marine elevations values shown in Figure 4.11 as related to shorter return periods than 1:50 years.

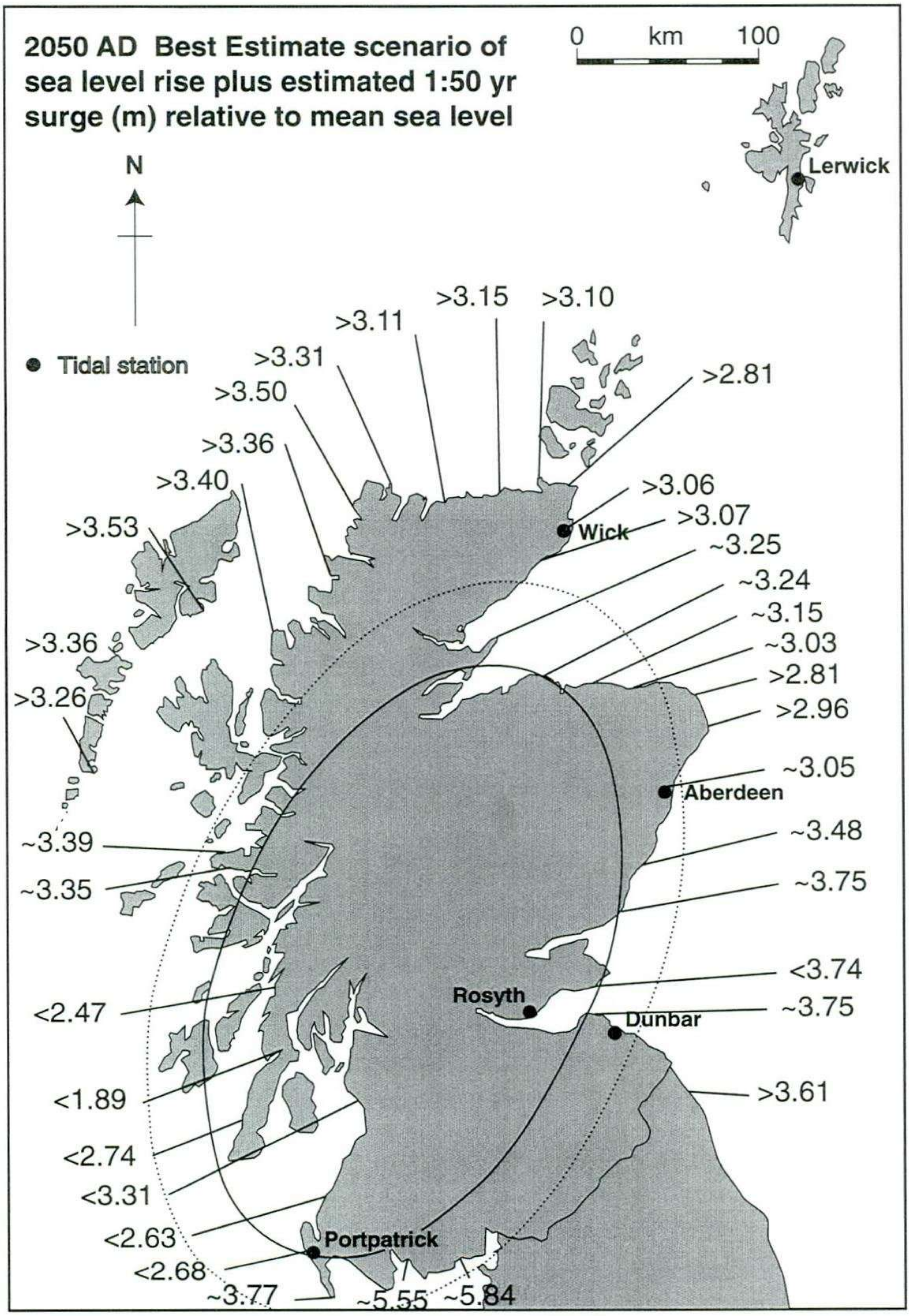

Figure 4.11. Best estimate scenario of sea level rise for 2050 AD to which have been added storm surge elevation values based on a return frequency of 1:50 years (cf modified from Dixon & Tawn 1997). The values shown are derived as relative to mean sea level. The component of sea level rise calculated for each site is based on the pattern of zonation defined by the crustal uplift isobases (Dawson et al 2001).

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(II) ASSESSMENT SURVEYS

5 ASSESSMENT SURVEY: SHETLAND

GRAEME WILSON

Introduction

Coastal zone assessment surveys have been undertaken in Shetland over four seasons by EASE Archaeology. Surveys have been undertaken on Mainland, Westside, Northmavine, Lunna, South Mainland and on the islands of Whalsay, East Burra, West Burra and Trondra (Figure 5.1) (Moore & Wilson 1998a; 1998b; 1999). The areas surveyed were chosen in consultation with the Shetland archaeologist, Val Turner, and the projects were entirely funded by Historic Scotland. The surveys were carried out in accordance with guidelines provided by Historic Scotland (see Ashmore 1994; Historic Scotland 1996). As it is difficult to condense the large body of information generated by these surveys within the space available, this discussion is unavoidably brief.

In general, the Shetland landscape can be characterised as rugged and hilly with small well-defined areas of good land. Within the survey area, the nature of the landscape varies greatly. South Mainland contains much of the richest, low-lying land surveyed and Northmavine much of the poorest, yet each has pockets of land representing all types encountered.

At present, much of the land is given over to sheep. Very little arable was encountered during the course of survey, even in those areas where it was deemed likely that crops could be grown. It was quite common to encounter land which had apparently been cultivated in the recent past but which was now poorly tended and waterlogged and declining into moorland (Stapf in Moore & Wilson 1998a). Habitations have either contracted towards the towns or moved inland towards the modern roads. There are numerous reasons for these recent changes in land use. However, the effect is that the landscape is for the most part deserted and free of modern 'clutter'. This, together with the history of past land use, makes Shetland an ideal place to carry out this kind of fast audit survey.

Previous Work

Previous work in the survey areas, as in Shetland as a whole, has been very limited. South Mainland has perhaps had relatively more attention than Westside and Northmavine has seen the least previous work. Shetland has, perhaps, suffered from its extreme geographical location in relation to the centres of archaeological enquiry further south. Archaeological activity has been intermittent and has had varying aims, from academic enquiry to rescue excavation. It is no surprise, however, that the little work that has been done should have such relevance for the whole of Scotland. The multi-phase settlement site at Jarlshof in South Mainland (outwith the survey area) remains one of the most important type sites in addressing settlement change through time in Atlantic Scotland. Clickhimin (Hamilton 1968) and Scalloway (Sharples 1998) brochs are two of the very few which have been completely excavated and published.

One of the earliest and most important large-scale bodies of work is the Royal Commission Inventory (RCAHMS 1946) which covered the whole of Shetland and has provided a basic data set, against which all subsequent survey can be compared. The next significant phase of activity was carried out by C S T Calder during the 1950s and 1960s. Calder recognised that the 1946 survey was incomplete and attempted to correct this through a combination of excavation and further survey, much of which took place either within the area of this survey or nearby (see Calder 1958; 1963).

Calder's work demonstrated the huge potential of Shetland archaeology, particularly for the study of very early settlement. However, there has, with only one exception (Whittle 1986), been no attempt to expand upon this. The most recent work has tended to be rescue orientated and has, with few exceptions (eg Hedges 1986), lain outwith the area of this survey. The results, however, have informed this work.

Analysis

Introduction

In all, some 846 'sites' were encountered during survey. This does not include the figures for East Burra, West Burra and Trondra (report in preparation). Analysis of this information is not straightforward, partly due to the sheer scale of the information but also because of the nature of the resource and the problems of summarising an extremely heterogeneous data set within tight parameters. The survey results presented here encompass five different areas, each of which, as noted above, has its own character. There are some very interesting trends which will be discussed below after the following provisos.

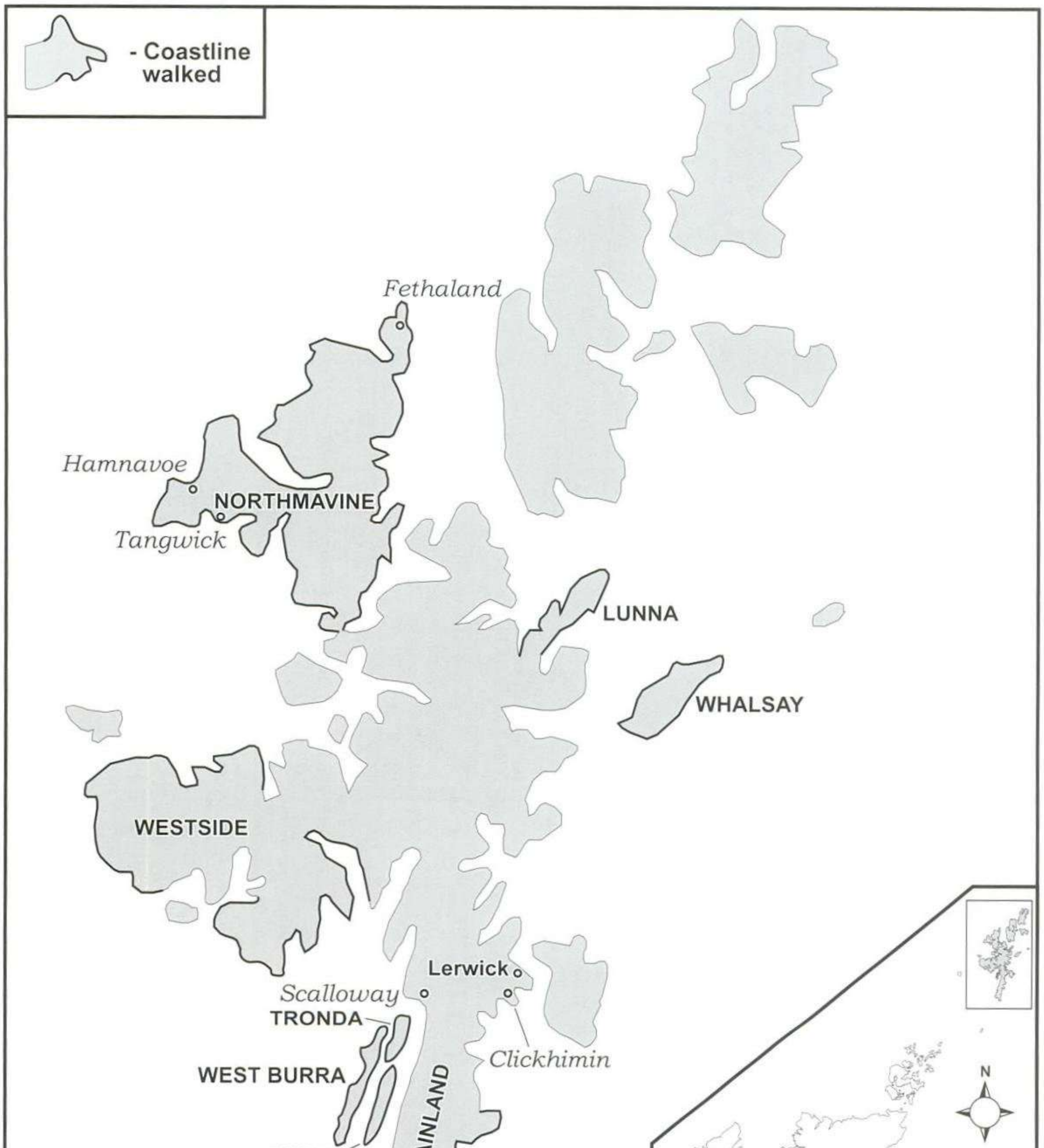

Figure 5.1. Location map showing the areas of survey and places mentioned in the text.

It should be noted that the aims of the fieldwork were to characterise the archaeological resource within the coastal zone. This was achieved by systematic survey and presented in a map-based format. There was no clear requirement to reduce the information to statistics of the kind presented here. Also, although the survey was systematic, it was also subjective, since it reflects the opinions and experience of the fieldworkers. In many cases a site formed the focus for much argument regarding its identity and significance; some interpretations were also changed in the light of new fieldwork, and others will undoubtedly be changed after future investigations. The histograms presented here, then, will give an unjustly objective impression to the casual observer and will be, if anything, more subjective than the survey since sites with long organic development over time must be 'shoe horned' into what are in essence (but unavoidably) arbitrary and modern categories of period and type.

One of the most basic problems encountered during survey was how to define a 'site'. At one level this is simple: a site is any residue of human activity either visible or previously recorded within the survey area. It becomes more troublesome when dealing with large complex sites which span large areas of land and which functioned over a long period of time. It was commonplace to encounter isolated fragments of what were most likely to be much larger residues of past activity. An example of this might be a ruinous dyke, or an outbuilding which functioned only as part of a field system, or a croft lying away from the survey area. Each fragment of dyke or outbuilding would have been recorded as an individual site. Where these elements could be seen to be related to others then the whole was given one site number. In this way, when an abandoned croft could be seen to be related to outbuildings, field systems, etc, then all was counted as a single site and its location and extent recorded.

Where practical, sites of widely different date have been separated, such as where a 19th-century sheep crue clearly overlies a prehistoric house. This was the only practical way that the survey could progress without becoming bogged down, but it has no doubt meant that certain phases of multi-period sites are under-represented. Nevertheless, even taking account of the provisos outlined here, the histograms are useful: they paint a broad picture of the scale of the resource, its strengths and its weaknesses.

Sites by date

The histogram showing sites by date is interesting for several reasons (Figure 5.2). Firstly it highlights the huge number of sites of early prehistoric date (4th–3rd millennium BC and 3rd–1st millennium BC) which are visible in the Shetland landscape. Most of these sites are interpreted as houses, which are more often than not associated with field systems. These structures are not a homogenous group; they survive in such good condition that it is possible to discern several sub-groups of types which can be found in each survey area and throughout Shetland. It is not clear whether they reflect changes through time or differences in function (Figure 5.3). In several cases, groups of houses of varying type were found surviving together in the same location.

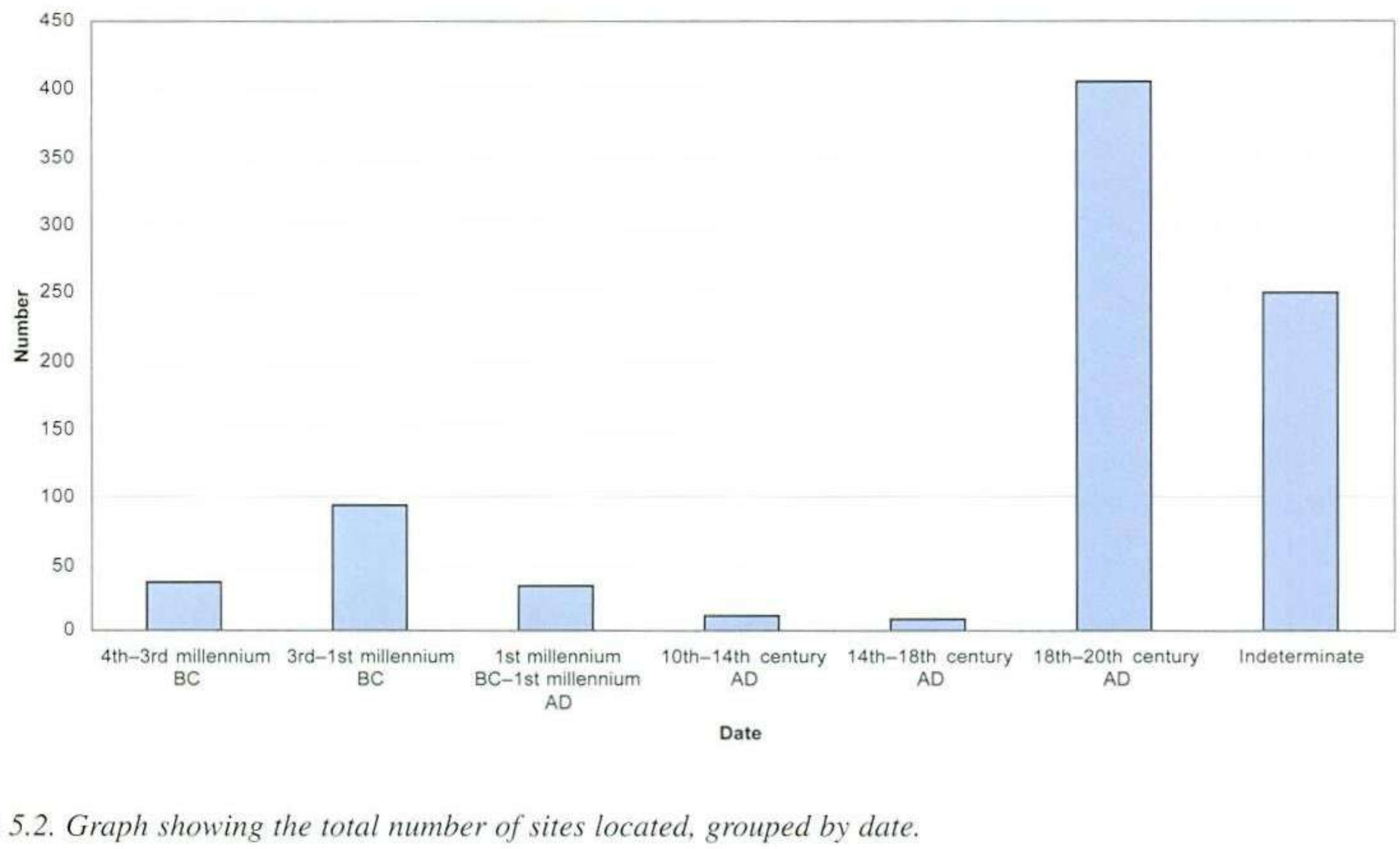

Figure 5.2. Graph showing the total number of sites located, grouped by date.

Figure 5.3. A prehistoric house at Lunna.

The 1st millennium BC – 1st millennium AD category comprises for the most part brochs, together with post-broch settlement, but also includes defended promontories, early church sites, and putative early Christian monastic stack sites. It is more than likely that the large broch mounds conceal other earlier settlement remains (see Carter *et al* 1995). It would not be possible, however, to confirm this without recourse to excavation.

The categories 10th – 14th century AD or 14th – 18th century AD were chosen in order to attempt to define the remaining archaeological resource during an interesting period in Shetland history. It was hoped to detect Norse and then Scottish influence on settlement patterns. In the event this did not prove possible. Very few sites could be confidently assigned to either category. The great majority of sites placed within these date ranges are in fact churches. There are several possible reasons for this gap in the record, some of which are general points applicable to all periods. These include:

- Problems with site recognition – sites of this period may be present but have been attributed to the wrong date range. Sites which are apparently of 18th–20th-century AD date are the most likely candidates here, as well as a percentage of the sites of indeterminate date.
- The nature of settlement, and its economy, may have changed during this period of time and entailed a shift away from the coast and out of the survey area. This would be an attractive theory if some earlier settlement types could be shown to exist within the survey area: Norse influence might then be assumed to be restricted to the outlying, less desirable land. Unfortunately, although there is some evidence in the form of a few putative early Norse structures encountered by the surveyors inland, outside the survey area this does not seem to be the case.
- Earlier sites may be obscured beneath later foundations. In a few cases, such as at Fethaland (Figure 5.4), abandoned structures known to date to the 19th century could be seen to overlie earlier buildings of similar plan. Without recourse to excavation, it is not possible to say more.

Figure 5.4. Fethaland fishing station.

Perhaps the most likely explanation is that the 10th–14th and 14th–18th century date ranges are artificial – historical – constructs which should not have been applied to the archaeological evidence. They were designed to discern patterns in the architecture of settlement which may never have existed beyond a shift from cellular house forms in the later Iron Age towards more rectilinear forms which persist into the present day. It may be that the only way to positively identify sites of this period is via excavation.

Sites by type

The sites have been further divided under eight headings in an attempt to characterise the resource further (Figure 5.5). As some sites come under more than one heading, there would appear to be more sites here than in Figure 5.2: fishing stations, for example, are considered to be both maritime and industrial; a croft and field system is both domestic and agricultural.

There are some interesting points that may be drawn from Figure 5.5. Relatively few of the sites are of indeterminate type. This is due to the excellent preservation of remains in the Shetland landscape where it is easy to identify a field system or a scrap of walling eroding from a section, but less easy to date it since it could conceivably date from any time from the Neolithic onwards.

Sites of every type are represented within the coastal zone, including some which occur nowhere else – noosts, otter traps, fishing stations. Settlement will have been attracted to the coast for ease of transport and access to marine resources. Also, in Shetland, the hinterland is generally hilly and the land of poorer

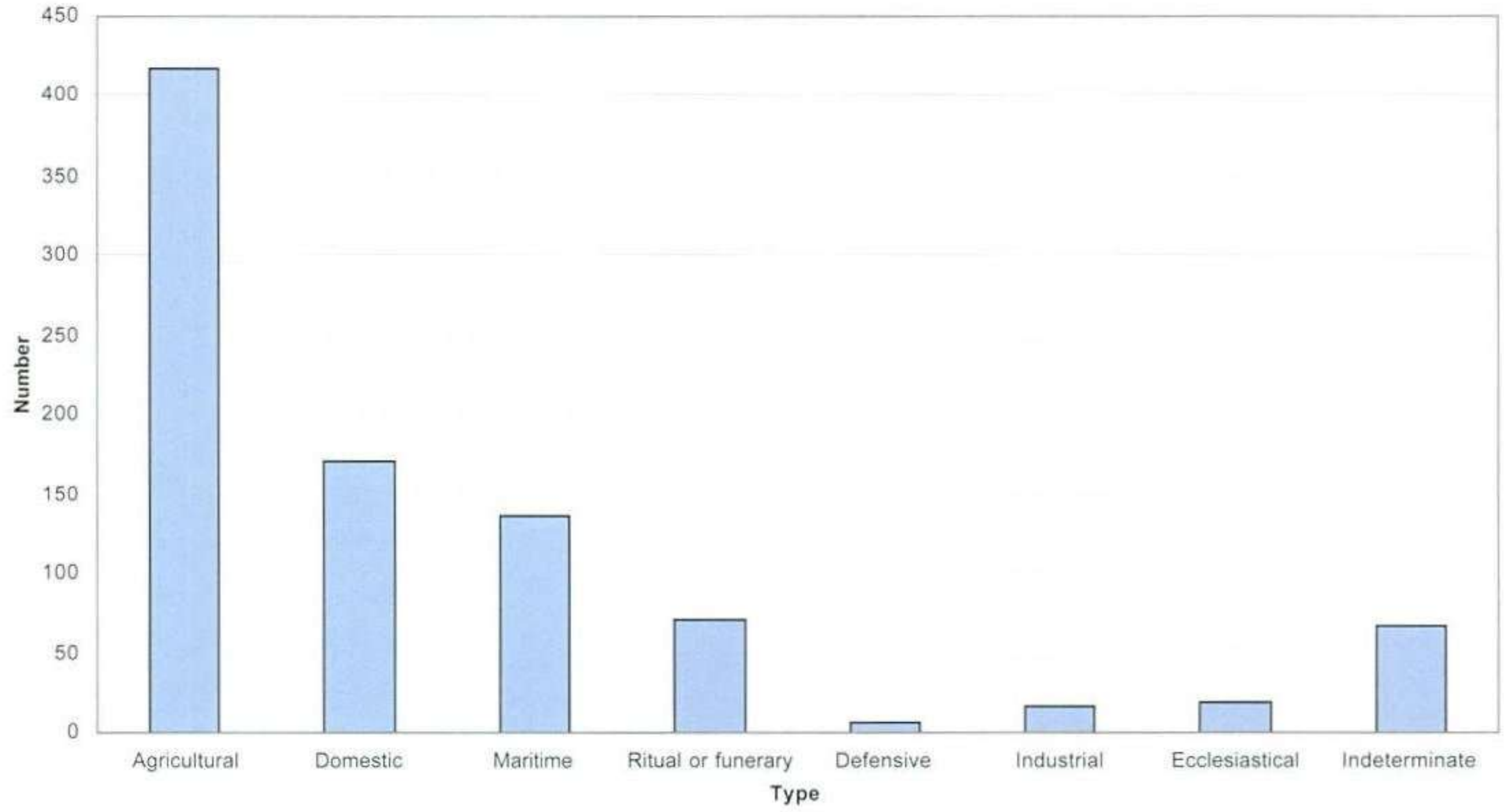

Figure 5.5. Graph showing the number of sites located, grouped by type.

quality than that near the sea. The overriding impression gained from carrying out this work has been that the coastal zone contains the greatest variety and highest potential.

Some of the categories contain very few different types of site: 'defensive' sites are entirely defended promontories, for example. Other categories contain a very wide range of sites: click mills, field systems, clearance cairns, sheep crues, and outbuildings all fall within 'agricultural'; the 'maritime' category includes noosts, fishing stations, whaling stations, wrecks and hulks, yet there seems little gain in creating categories purely for mills or for noosts. Some categories contain sites of widely different date: 'domestic' contains both prehistoric houses and 19th-century crofts, while others, for example 'defensive', contain sites of similar date.

Comparison of site type with site date shows some interesting trends and adds more depth to the picture. It can be seen that certain date ranges are dominated by certain site types. The 1st millennium BC – 1st millennium AD range, for example, is dominated by brochs. The 4th – 3rd millennium BC range is dominated by houses and cairns. The 18th – 20th century category, however, contains a very wide variety of sites. There are several possible explanations for this. On the face of it, it could be expected that there would simply be less variation in the archaeology of the earliest settlers in Shetland. Their society might be expected to have been less complex than modern society and give rise to less variation in the record. This is not, however, borne out by a closer examination of the facts. Brochs, for example, are monumental structures easily identified in the landscape. There have been several excavations of these sites and their date range is not in any serious doubt. It is only when we question the location of the structures which are not brochs that it becomes clear that there may be a bias in the data. The figure of 36 sites in the 1st millennium BC – 1st millennium AD date range does not tell us the whole story.

A similar case holds true for the early prehistoric period, which is dominated by houses and cairns. The cairns are very visible monuments which are relatively difficult to destroy, thus they have survived the passage of time very well and are represented disproportionately in most surveys. The houses are only identified as a result of previous excavation, before which their true age was in doubt.

It is therefore far more likely that this apparent increase in site diversity through time reflects our lack of knowledge concerning early settlement and that our inability to identify site variation is due to a lack of data concerning the true nature of the structures identified by survey. This situation is especially frustrating in Shetland where site preservation is excellent. A limited programme of trial excavation would answer many questions.

As outlined above, the surveys took place over eight separate parts of Shetland and although this is not always illustrated by the histograms, the results would seem to point towards certain patterns. There are, for example, more brochs but fewer prehistoric houses in South Mainland. Fishing stations were found only in Northmavine. Westside contains many more defended promontories than any other area as well as some small square cairns not identified anywhere else.

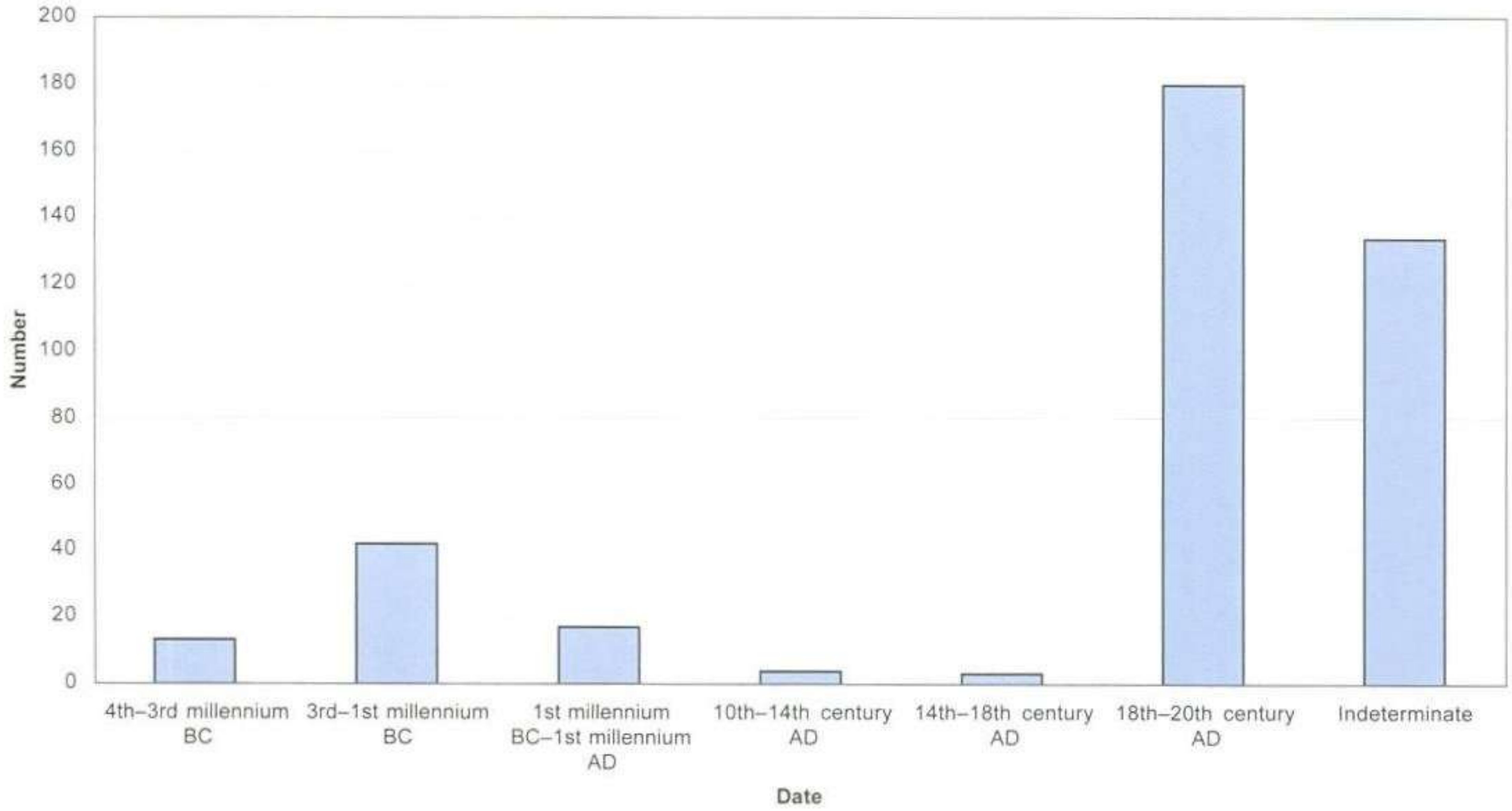

Figure 5.6. Graph showing the number of vulnerable sites, grouped by date.

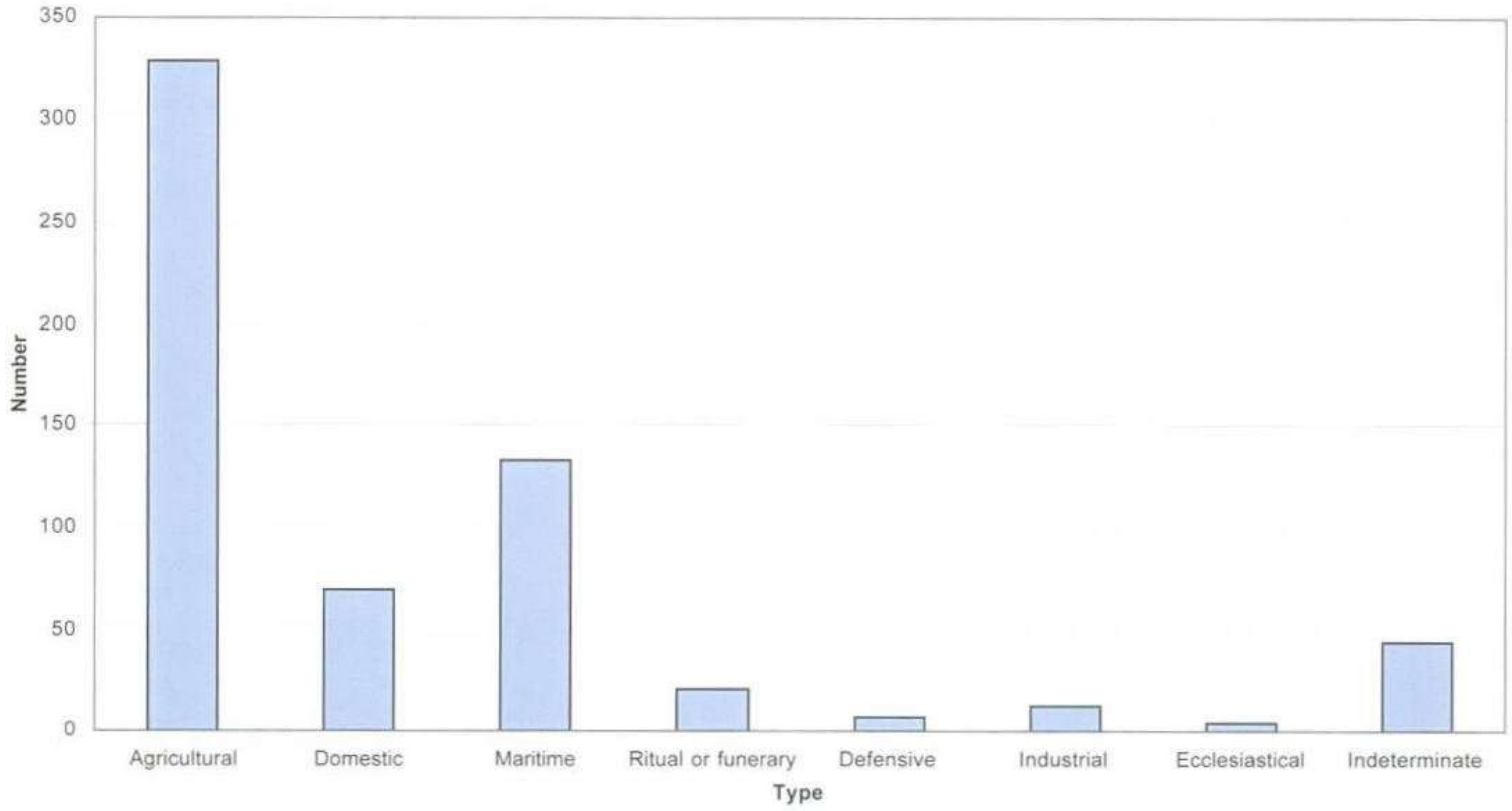

Figure 5.7. Graph showing the number of vulnerable sites, grouped by type.

Vulnerable sites

Figures 5.6 and 5.7 show that all categories of date or type contain some examples which are vulnerable, but there is some variation in the percentages of type which are at risk.

A high proportion of certain types of site are vulnerable due to their nature, since their preferred location would always have been close to the shore. Most 'maritime' sites, for example, lie close to the shore. An obvious example of a vulnerable site type within the maritime category is the boat noost. These will always have been placed above the highest expected tideline to ensure safety during stormy weather, yet not so far that dragging the boat to the sea would have involved a disproportionate effort relative to risk. This is a type of site, incidentally, which is probably one of, if not the most numerous recorded. However, to this author's knowledge, none of the Shetland examples have ever been excavated and they could conceivably be of almost any date.

Many brochs within the coastal zone are vulnerable since they have been sited upon headlands or promontories which appear easy to defend but are also more vulnerable to erosion (Figure 5.8).

Figure 5.8. Burraland Broch, South Mainland.

Geology and erosion

The survey areas were dispersed widely over Shetland, which possesses a very varied geology. Consequently, given the limited space available, it is only possible to summarise very briefly the geology and erosion classes found.

In much of Shetland, the underlying geology is generally 'hard', ie the rock types are igneous or metamorphic. There are some (softer) sandstones in the south and west, but these mostly lie outwith the survey areas. Coast edges are more often than not over 5 m high. The combination of these two factors might be expected to result in less erosion and less vulnerable archaeology, and, as Figure 5.9 illustrates, up to 50 per cent of the coast-edge was classified as stable. Unfortunately, however, the archaeology tends to be found in the lower lying areas, which are more susceptible to the effects of coastal erosion.

Even archaeology situated on a high coastal edge is not always protected. In many places, such as on the west coast of Northmavine, the coast is exposed to the full force of the sea and vegetation can be stripped for hundreds of metres due to wind forcing sea water inland, even over high cliffs.

Erosion was found to be not just a result of rising sea levels and increased storminess, but of a combination of factors. Current land management practices, for example, have a great effect on the stability of the coast-edge. Overgrazing by sheep is common and cattle trampling the ground can easily destabilise fragile deposits. Rabbit infestation is common on archaeological sites since the presence of walls and stonework makes the ground higher and consequently much drier than the surrounding, often poorly drained, landscape.

It is difficult to judge the speed of erosion in most of the areas surveyed since there is no previous information against which to compare the recent findings. Old maps and aerial photographs have been consulted as part of the post-survey analysis, but without much success; there is no substitute for repeated site visits together with basic recording of exposed sections.

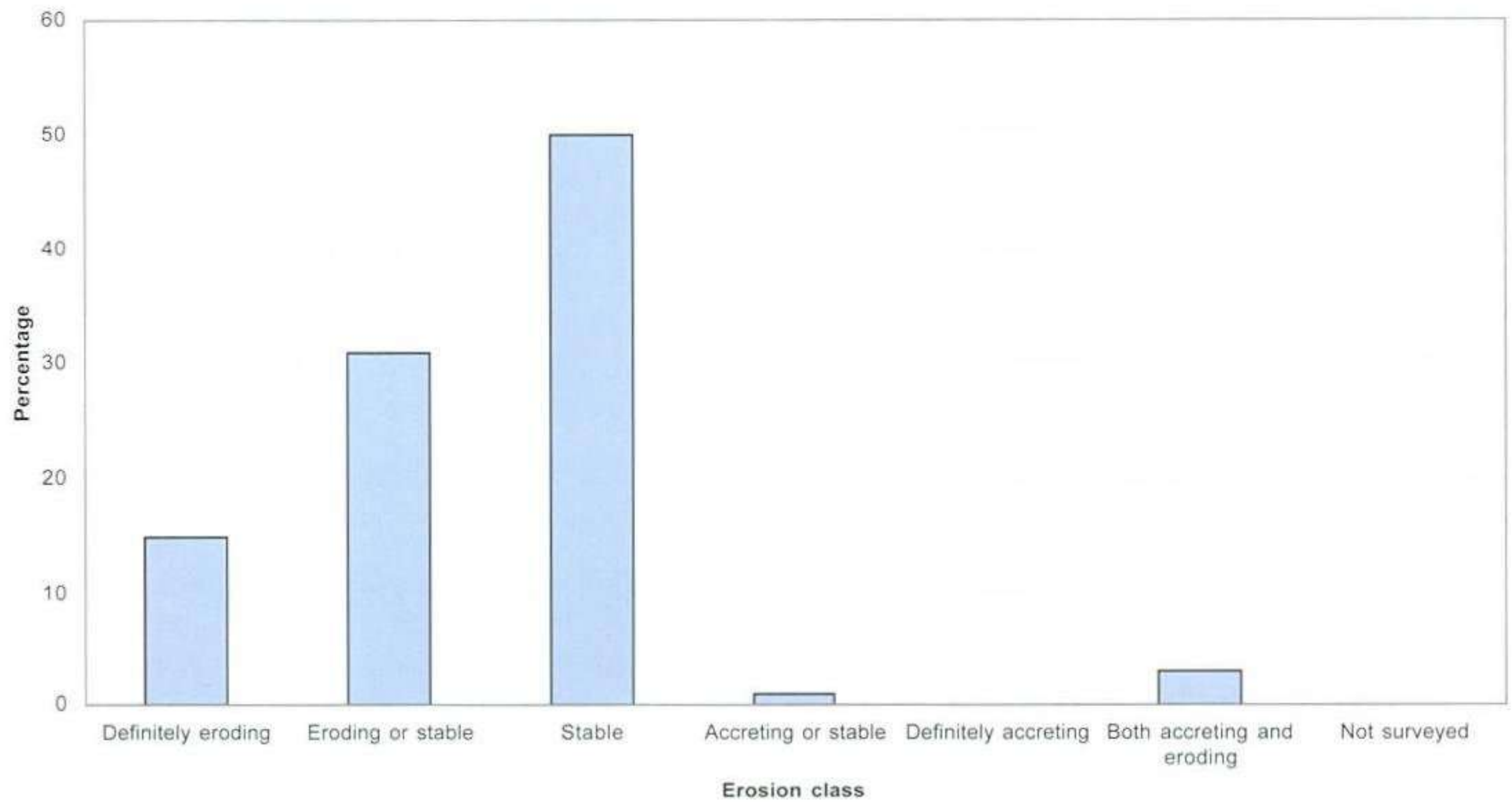

Figure 5.9. Graph showing erosion classes for the coastline surveyed.

Discussion and Recommendations

The surveys have demonstrated the richness of archaeology in Shetland. Sites of all periods survive in abundance, are well preserved and easily detected by survey. The nature of the Shetland landscape, however, means that there is a concentration of sites within the coastal zone and, consequently, a huge proportion of these sites are under direct threat. The implication of this distribution pattern is that if the resource is damaged without any record being made, there will be no second chance: there is no large body of sites lying in the hinterland which may still be present when the coastal sites are lost.

Many of the sites in the coastal zone are specialised and can tell us a great deal about certain facets of past ways of life. This does not mean that they are of limited relevance to wider studies. Nineteenth-century fishing stations, which are still well preserved in Northmavine, are part of a wider phenomenon occurring all around the North Sea. The development of prehistoric settlement in Shetland is of interest in its own right, and it can be seen that there were a great many local adaptations of more widespread house types, yet Shetland is also part of Atlantic Scotland. The large-scale survival in Shetland of prehistoric remains, including entire field systems, makes it one of the best places to study continuity and change through time.

As well as illustrating the potential of the resource within the coastal zone, the surveys have pointed towards gaps in the data and indicated areas which would benefit from further work. There is a great threat to the archaeology of Shetland from coastal erosion, and it goes without saying that the threat is increasing. The onset of global warming, linked with rising sea levels, is set to exacerbate the problem in the short to medium term. There is a need to further define and understand the resource since one of the problems that has been frequently encountered is our basic lack of understanding. In order to formulate strategies to manage the threat, we must have more information. This can only be gained by more fieldwork.

One intriguing type of deposit identified by these surveys is submerged peat. The recognition of old ground surfaces extending offshore opens up the possibility that terrestrial archaeological sites survive under the sea. The existence of such remains and their condition remains uncertain, but is probable. Recent excavations of a burnt mound at Tangwick in Northmavine (Moore & Wilson 2000) recovered the well-preserved remains of a Bronze Age structure together with associated ground surfaces from beneath a storm beach, showing that archaeology can survive in quite unexpected locations.

It is recommended that coastal surveys be repeated, after a suitable interval. This is important in order to gather information on rates of erosion, to record new sites not previously seen, and to reconsider past interpretations in the light of work elsewhere. In the interim, very vulnerable sites should be recorded, others should be monitored, and work should be undertaken to gauge the potential of the many sites which could not be characterised by survey alone.

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6 ASSESSMENT SURVEY: ORKNEY

GRAEME WILSON

Introduction

EASE Archaeology were commissioned by the Orkney Archaeological Trust to carry out three separate seasons of coastal zone assessment survey (Moore & Wilson 1998; 1999; 2000). This work was funded by Historic Scotland and was carried out from 1997 to 1999. In consultation with Julie Gibson, the Orkney Archaeologist, ten areas were chosen for survey. The areas examined were the islands of Graemsay, Burray (including Hunda), Flotta, South Ronaldsay, part of Hoy, North Ronaldsay, Sanday, Westray, Papa Westray (including the Holm of Papa Westray) and part of West Mainland from Waulkmill Bay to Bu Point (Figure 6.1). Fieldwork and the preparation of the reports was carried out in accordance with Historic Scotland guidelines (1996).

As might be expected, the ten areas surveyed vary greatly both in landscape and in archaeological potential. The surveys also generated an enormous body of information. For these reasons it is difficult to summarise the findings in the limited space available and still do justice to the particular riches each area possesses. Much of this discussion revolves around the facts as they are displayed in the form of histograms. These histograms are useful summaries, but do tend to gloss over those sites which are remarkable or unusual. Although necessary for this level of discussion, the histograms are not a substitute for the individual survey reports.

The landscape of Orkney may be generalised as low-lying and fertile. Much of the land within the survey area was fenced up to within a few metres of the coast-edge, and was mostly given over to cattle at the time of survey, although there was some variation: barley was cultivated over much of the south end of South Ronaldsay (surveyed during 1997) and it could be seen that almost all fields had been cultivated in the past. The coastal strip between field and coast-edge was usually left untouched and in consequence was often very overgrown. The combination of flat ploughed fields and overgrown coast-edge undoubtedly adversely affected the results, but it is difficult to see how this could be remedied without recourse to more invasive prospective methods such as trial trenching or large-scale geophysical survey. Both are impractical on the scale of these surveys but have their place within more targeted studies (see Moore, this volume).

Despite the problems encountered, a very large number of sites were detected by this survey – some 843, in fact. Many of these sites are multi-period and the impression gained is of settlement becoming focused, and therefore becoming more detectable, in certain locations, perhaps in an effort to maximise use of the fertile landscape.

Previous Work

An enormous body of previous archaeological work has been carried out in the survey area. A basic survey was carried out over all of Orkney during the 1930s (RCAHMS 1946) which was followed by reassessment in the 1980s (eg Lamb 1983). It should not be surprising that new sites continue to be found in previously surveyed areas. Each survey reflects the differing aims and expectations of the fieldworkers, each successive survey is carried out at different times of the year, and sites are revealed or concealed according to the vagaries of, for example, weather and erosion.

Previous excavations within the survey area include some of the most important in Scotland for the study of prehistory. A few have genuine relevance beyond Scotland and to the whole of north-west Europe. They serve to confirm Orkney's importance as a place where the quality and ubiquity of prehistoric remains is such that they may serve as a 'test bed' for wider theories concerned with prehistory. The sites include Knap of Howar Neolithic farmstead (Ritchie 1983), Isbister chambered tomb (Hedges 1983), Quoyness chambered tomb (Davidson & Henshall 1989), Holm of Papa Westray North (Ritchie 1995) and Holm of Papa Westray South (Davidson & Henshall 1989) chambered tombs, Pool Neolithic and Iron Age settlement (Hunter 1990), Tofts Ness Bronze Age settlement (Hunter & Dockrill 1990), and the Scar boat burial (Owen & Dalland 1999). Most of these excavations took place as a result of the threat from coastal erosion; all lie within the coastal zone.

If there is one drawback to previous work, it is that it has been reactive and site-specific. Excavation has tended to address specific management problems existing at specific locations, but without looking further afield. There has been no attempt to undertake an in-depth landscape study of an *area*, backed up by survey and excavation, and this is reflected in the

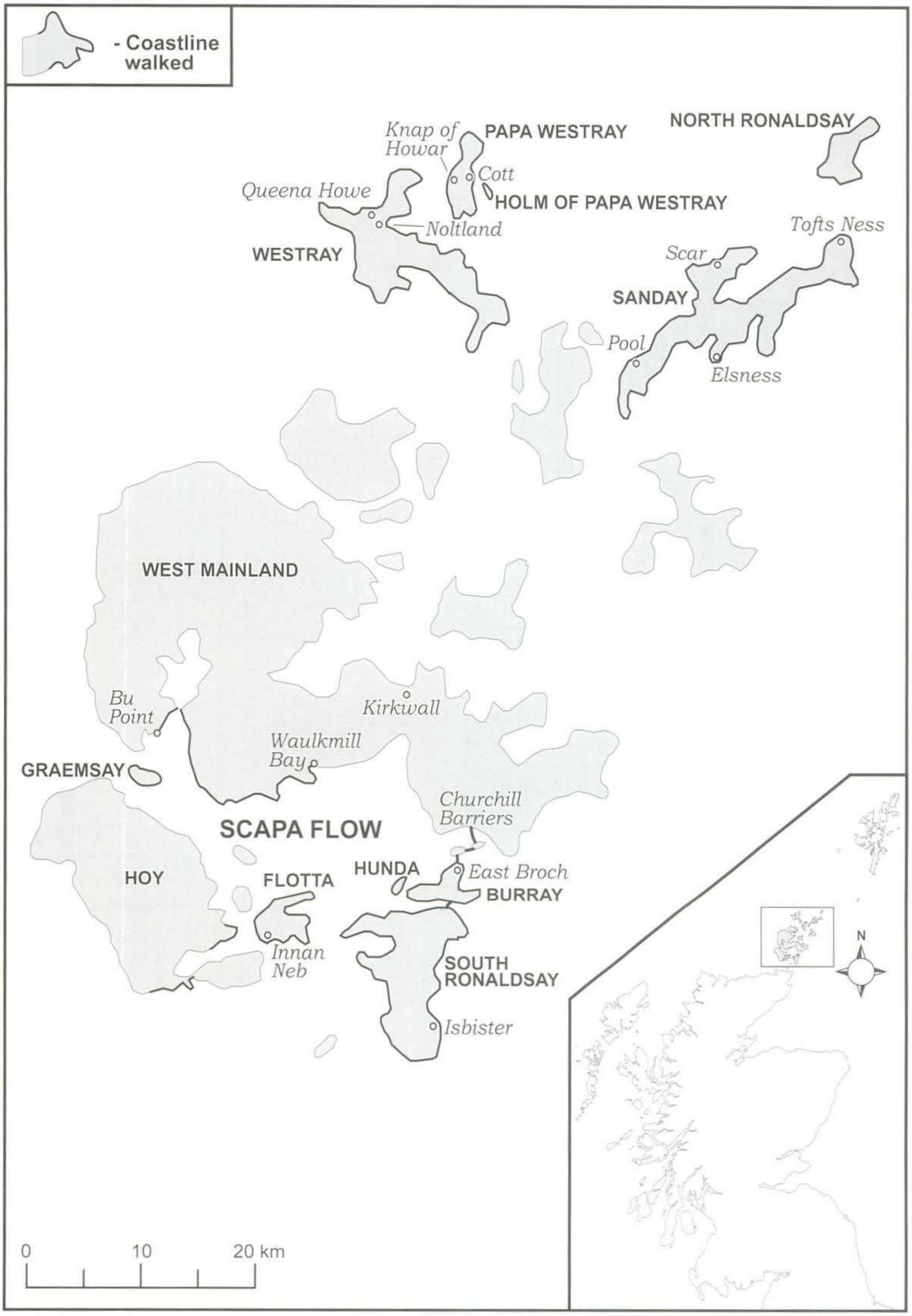

Figure 6.1. Location map showing the areas of survey and places mentioned in the text.

Figure 6.2. Eroding Settlement at Cott, island of Papa Westray.

Figure 6.3. One of the Churchill Barriers blocking entry to Scapa Flow.

results of the excavations to date where it has not been possible to place the sites into their local context.

Analysis

Introduction

As mentioned above, histograms have been chosen as the method of summarising the survey results. It is worth going into some detail concerning how these results have been generated. Firstly, there are problems concerning the definition of what constitutes a 'site'. For the purposes of the survey a site was usually a geographical concentration of the remains of any past human activity. This was further subdivided by date so that, for example, where a World War II coastal battery overlay a broch (eg sites B15, B34, Moore & Wilson 1998), the two were presented as separate entries. Sites of different type but lying close together were also often distinguished, for example a church was distinguished from a prehistoric settlement (eg sites G24, G36, Moore & Wilson 1998) or kelp workings. In this way, some detail could be kept concerning sites presently regarded as unrelated, but it was not always practical to do this. An example of a site recorded as a singular entity even though it contains many different elements is Elsness on Sanday (site SY66, Moore & Wilson 2000). Here, a promontory of land contains a concentration of burial monuments conceivably spanning the Neolithic and Bronze Age.

It was intended to present the results of the surveys primarily in map form (though there was some experimentation with analysis using histograms), therefore it was adequate to represent the 'sites' for the most part as geographical locations containing features of archaeological interest. The accompanying descriptions gave more information on the nature of the site.

There were then, complications when attempts were made to break down every 'site' by type and by date, even where the widely different elements had already been separated. One reason for this is that many sites cannot be easily characterised by just one type (Figure 6.2). Kelp workings, for example, may be maritime, but they are also industrial. Crofts are both domestic and agricultural. Noosts are maritime, but are very likely related to crofts.

The problems of quantification are compounded by the occurrence of very large sites comprising a great number of disparate elements spread over a very wide area. At one end of the scale are the wartime remains which lie around Scapa Flow: these were all built within a very short period of time, with the singular aim of defending the harbourage of the British Home Fleet from attack (Figure 6.3).

There is a case for regarding all of these remains as one site. This was not done (common sense prevailing); instead the separate batteries were identified where possible (sometimes using documentary information) and counted as units since each had its own history and its own purpose (anti-torpedo boat or anti-aircraft for example). Even so, the defensive category is swamped by World War I and World War II ammunition lockers, anti-submarine netting, blockships, gun positions, Churchill Barriers, decoy airfields, telegraph sheds, listening posts, machine gun positions, military bench marks, engine sheds, searchlight positions, camps, and so on (Figure 6.4).

The overall figure of 843 sites is a minimum number since any one site can include many different elements. Boat noosts often occur together in sheltered parts of the coast, but it was not considered practical to count each noost as a separate site, although they are individually described in the survey reports. Multi-period prehistoric sites were frequently encountered, but it would not be possible to chart their development through time without recourse to excavation (Figure 6.5).

Another complication which the histograms gloss over is the variation between islands. Important examples of this include:

- World War I and World War II defensive remains are located almost entirely around Scapa Flow, with only limited remains elsewhere.
- Eighteenth- and nineteenth-century kelp workings are more common in the north isles than around Scapa Flow.
- Very large settlement mounds (also known as 'farm mounds') are concentrated in some of the north isles, particularly Sanday.

The variation in the archaeology sometimes reflects differences in geology or geography. It was relatively difficult to detect new sites on Sanday, for example, probably because the large deposits of sand on the island will have obscured many sites. The sand is also one of the factors giving rise to the large settlement mounds mentioned above. The defensive remains around Scapa Flow are there because of the suitability of that body of water as a sheltered anchorage.

Figure 6.4. Memorial to Squadron Commander Dunning, West Mainland.

Figure 6.5. Queena Howe prehistoric settlement, island of Westray.

Built heritage

The histograms are useful in many ways, even taking account of the provisos noted above (see Wilson, this volume, for similar problems in quantifying Shetland sites). The data has been broken down into seven date ranges, each intended to illuminate one more or less distinct period (Figure 6.6). Where possible, the sites have also been characterised by type (Figure 6.7). The totals for Figures 6.6 and 6.7 are very different. This is because a single site of any one period may be classed as more than one type: blockships are both defensive and maritime; kelp working areas are both maritime and industrial.

The 4th–3rd millennium BC date range contains 34 entries, the majority of which represent sites categorised as ritual/funerary, ie chambered cairns. The exceptions to this are sites such as the Knap of Howar and Pool, proven by excavation to belong within this date range. There are only a few cases where a site which was neither a cairn nor without previous excavation was assigned this date; usually where distinctive artefacts such as struck flints were recovered from an eroding section.

The fact that so few types of site can be assigned to the 4th–3rd millennium BC date range without excavation highlights a general point applicable to most date ranges. Most periods are represented only by a limited range of very distinctive, readily identifiable types: chambered cairns in the Neolithic, burial mounds and burnt mounds in the Bronze Age, brochs in the Iron Age, and so on. In part, this reflects the history of archaeology, where antiquarian interest has been attracted towards the larger and more monumental sites. In Orkney, where the preservation of the remains

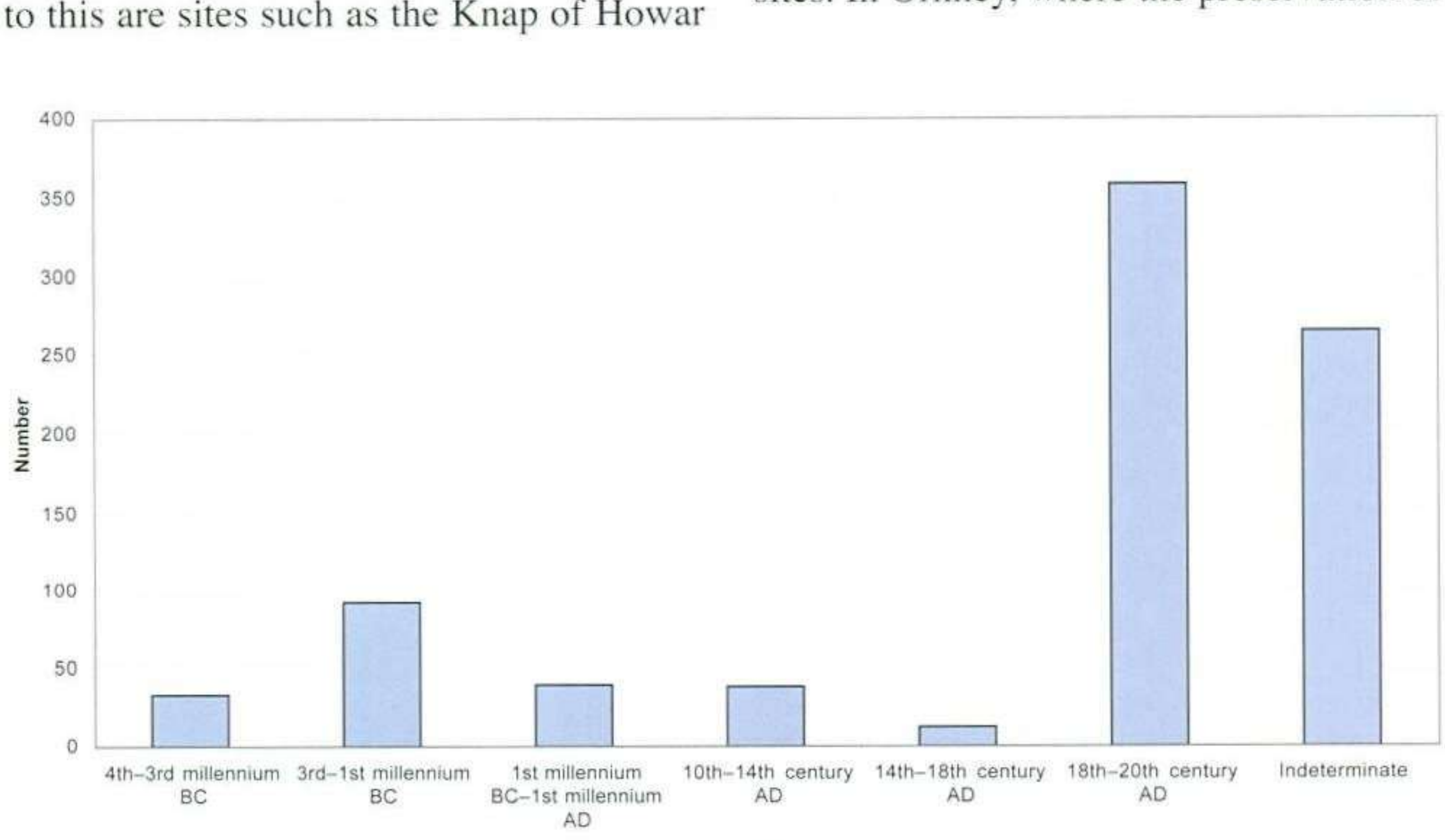

Figure 6.6. Graph showing the total number of sites located, grouped by date.

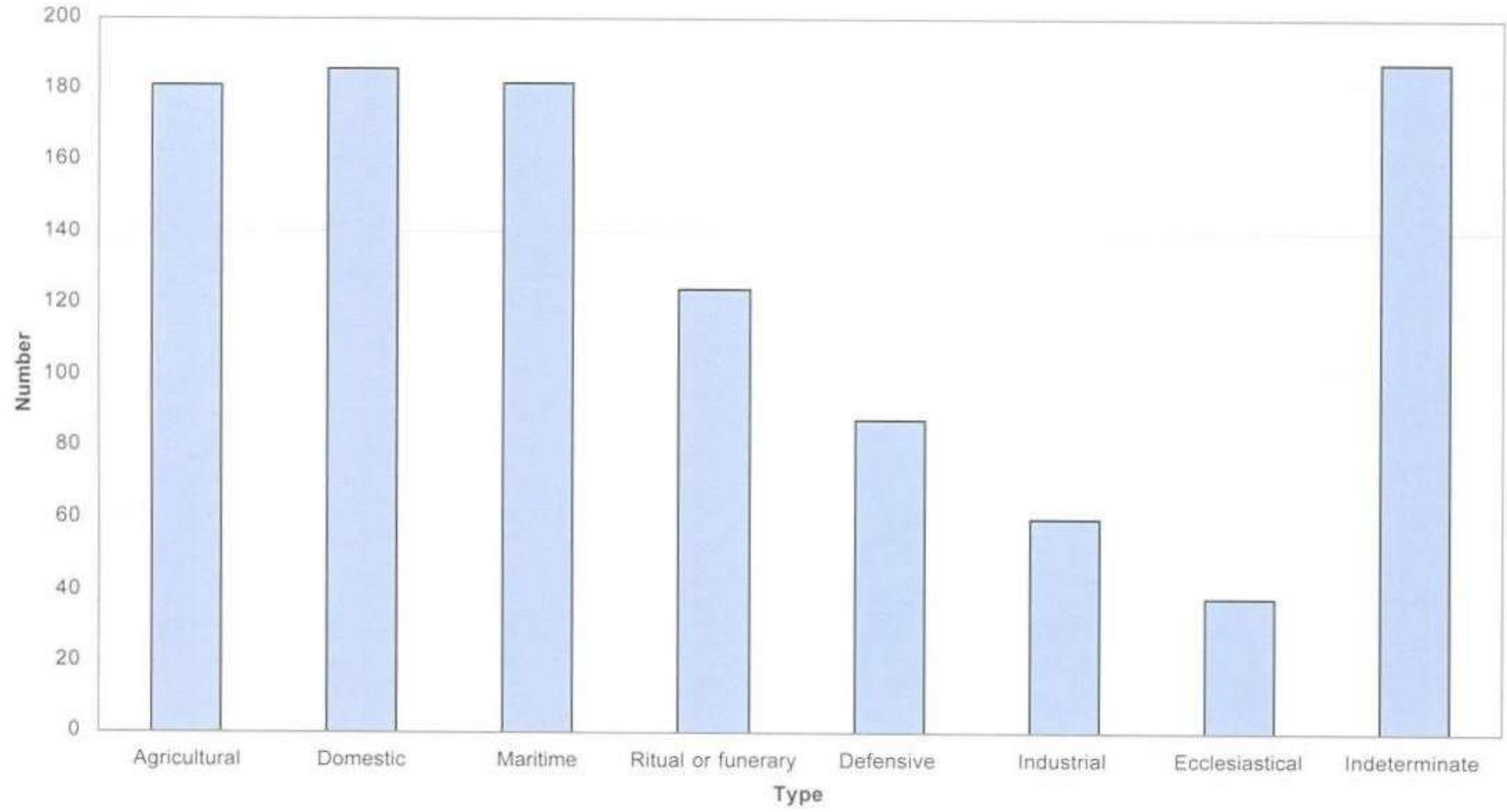

Figure 6.7. Graph showing the number of sites located, grouped by type.

is such that Neolithic houses may stand to roof height, it is difficult to assign a date to a scrap of wall seen eroding from a section. On mainland Scotland, it is most likely that the wall would be medieval or later; in Orkney, it could represent settlement of any date from the Neolithic onwards.

The 3rd–1st millennium date range contains 92 sites. These are almost entirely burial mounds together with a few burnt mounds. The single exception is a settlement site investigated by excavation at Tofts Ness (see site SY193, Moore & Wilson 2000) on Sanday. The number of burial mounds is in fact an underestimate. One of the patterns of distribution of these monuments is the way in which they cluster at what may have been liminal places in the landscape, on promontories and peninsulas. These groups of monuments have been recorded as site complexes since it is difficult to define the resource accurately without recourse to more intensive survey, and additionally they often extend far outwith the survey area.

The identification of any mound as a burial monument belonging to the 3rd–1st millennium BC is fraught with difficulty. Usually, identification is based on a combination of factors: size and shape; whether they occur singly or in groups; association with other monument types; and location within the landscape. Sometimes distinctive elements such as cist burials will be exposed in the body of the mound. Mounds often cluster around very large chambered cairns, and it might be assumed that they post-date the chambered cairn, but this is not necessarily the case. In the first place, recent excavations elsewhere in Orkney have shown how small chambered cairns can appear to be Bronze Age prior to excavation (Downs 1999). Also the sequence of large Neolithic chambered cairn followed by Later Bronze Age burial mounds is perhaps in doubt following the results of excavations at Knowth in Ireland. There, the satellite mounds have turned out to be earlier than the central cairn and the suggestion is that a special central space was surrounded by smaller cairns before a final formalisation/monumentalisation of the space through the construction of the central passage grave (Whittle 1996). This may be a viable model for Orkney.

The 1st millennium BC – 1st millennium AD date range is occupied mostly by brochs together with their associated settlements (Figure 6.8). There are no obvious contenders for non-broch settlement sites except for where they have been uncovered by excavation, as at Pool, Sanday (Hunter 1990; site SY117, Moore & Wilson 2000). Also included within this date range are various structures situated on isolated promontories or stacks. These may be early Christian eremitic sites.

Figure 6.8. East broch of Burray, island of Burray.

The 10th–14th century AD and 14th–18th century AD date ranges are problematic because they are relatively recent yet contain fewer sites than the prehistoric date ranges (a total of 52 sites). This might partly be expected because the prehistoric date ranges encompass a huge period of time – some 4000 years. However, the 10th–18th century AD date range should include better preserved sites, including many for which there is documentary evidence. In effect, church sites make up the majority for this period and these have been dated by reference to documentary evidence. There was no definite sign of domestic settlement belonging to this period (though see Moore, this volume). It is likely that a great deal of the domestic settlement is hidden by modern settlement and some may have been misattributed to a later date range. Almost nothing is known about the nature of settlement between the 10th and 18th centuries AD, particularly towards the end of this date range, and all that can be said is that there is a real need for more work in this area.

The 18th–20th century AD date range contains a large number of sites. Not only are these sites in general better preserved, but they also display a greater spread of site type. It is also relatively easy to characterise a site within this date range from the surface remains alone, although we should not be complacent. The enormous range of defensive sites within the survey area has been mentioned above and this reflects the national importance of Scapa Flow for the study of military remains. Although these remains were abandoned only a very short time ago, it was difficult to characterise them without recourse to documentary information and, despite this, there are sites of which little more could be said than that they are probably related to the defence of Scapa Flow and are of 20th-century date. Most of these sites are in poor condition and deteriorating rapidly: they were built in a hurry and from materials which will not necessarily stand the test of time. Many were purposely built very close to the coast-edge and are now being actively eroded.

Vulnerable sites

The histograms illustrating vulnerable sites by date and by type (Figures 6.9 and 6.10) show how large a proportion of sites belonging to the modern period are vulnerable. In part, this is probably due to a proliferation of sites linked to the exploitation of marine resources – 172 vulnerable sites are maritime in nature. Most of these are of 18th–20th century date and include kelping remains, piers, jetties, noosts and sheds. Not all are maritime in nature, however. The majority of the agricultural sites deemed to be vulnerable are also of 18th–20th century date. The relatively large number of vulnerable sites assigned a 3rd–1st millennium BC date reflects the occurrence of groups of burial monuments in vulnerable locations such as promontories. A very large proportion of defensive sites, of all dates, were deemed vulnerable. This is because the purpose for which they were built tended to determine that they were located in vulnerable areas, ie to provide good views over stretches of water in the case of World War II remains, or to provide a defensible location in the case of brochs or promontory forts.

Geology and Erosion Within the Survey Area

The underlying geology of the survey area is composed almost entirely of Old Red Sandstone. The topography of the survey areas appears generally low-lying and rolling. In part, this is due to the relatively soft sandstones, but it is also due to the deposition of till during the last ice age. The till is, however, generally no more than 1 m thick. In addition, the topography of

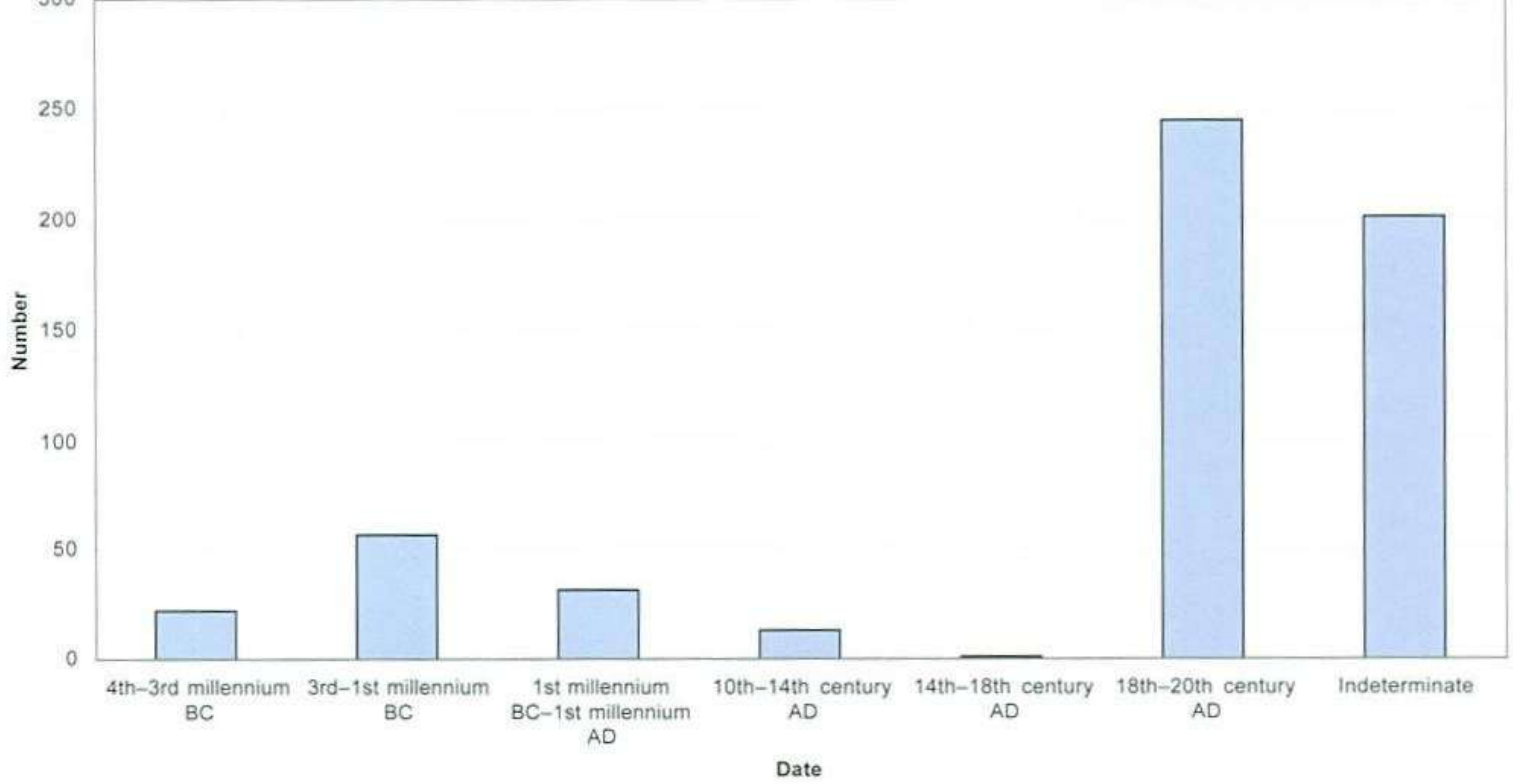

Figure 6.9. Graph showing the number of vulnerable sites, grouped by date.

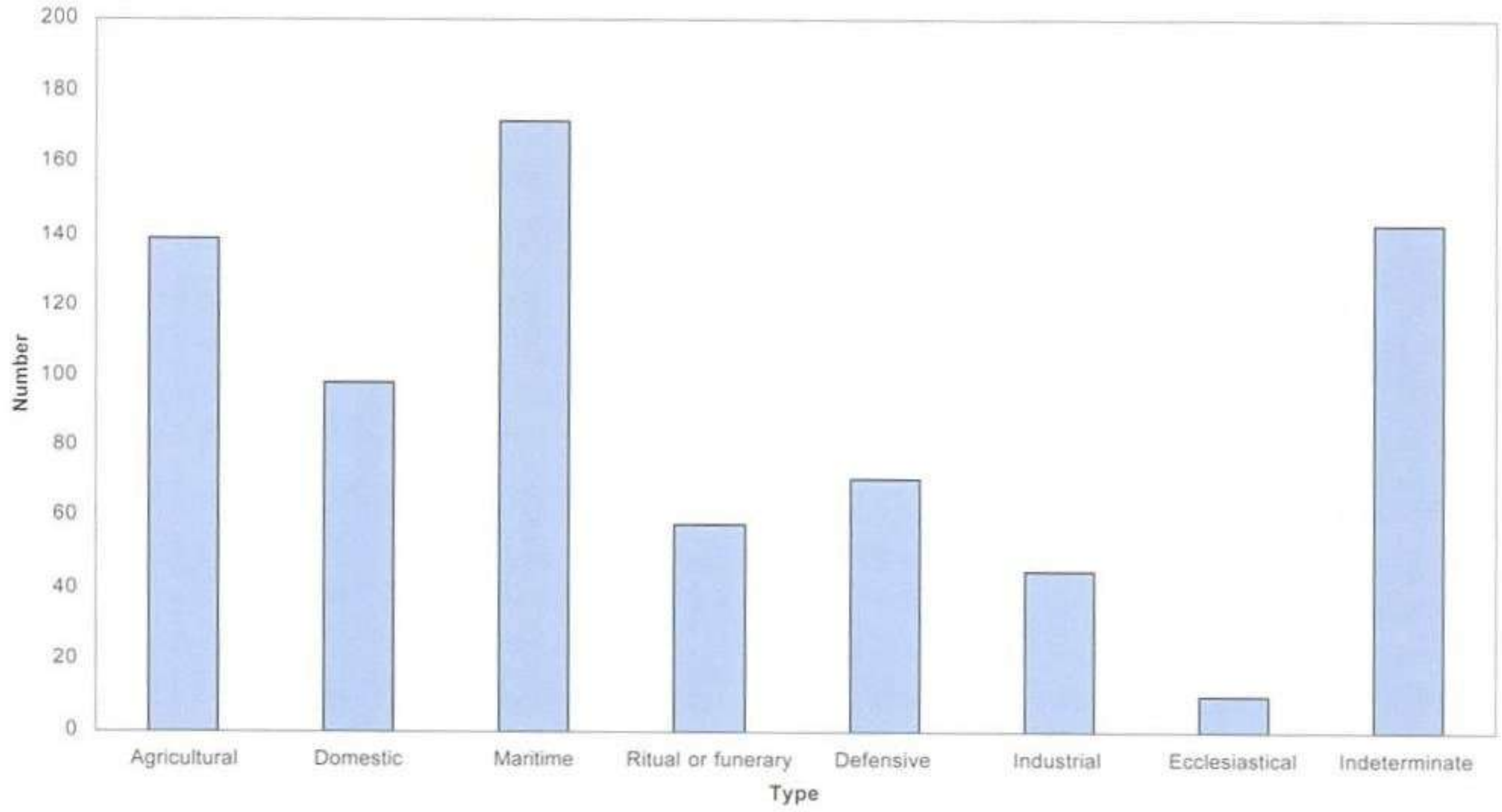

Figure 6.10. Graph showing the number of vulnerable sites, grouped by type.

a large part of the survey area, in particular the islands of Sanday, North Ronaldsay and parts of Westray, is affected by deep deposits of wind-blown sand.

All of the factors mentioned above are relatively vulnerable to erosion (Figure 6.11). Erosion in the survey area has a variety of causes. Marine erosion by a variety of different wave actions is the major cause, but there is also sub-aerial erosion by wind, rain and water. Chemical erosion by salt spray is also a factor. In addition, there are contributing factors which affect rates of erosion.

Farming practices have a direct effect on the susceptibility of the coastal zone to erosion. Overstocking, for example, can damage already vulnerable turf, making it easier for wave action to remove soil. Within the survey area there was, however, only limited evidence for an adverse effect on erosion from land management practices. The single exception to this was on the island of North Ronaldsay, where a large population of sheep, kept on the foreshore, appears to be having a detrimental effect on the vegetation.

The greatest contributing factor affecting erosion is the sinking of the islands, together with changes in sea level since the last glaciation. Already much land has been lost, and this trend is set to continue if predictions of rising sea levels due to global warming are correct.

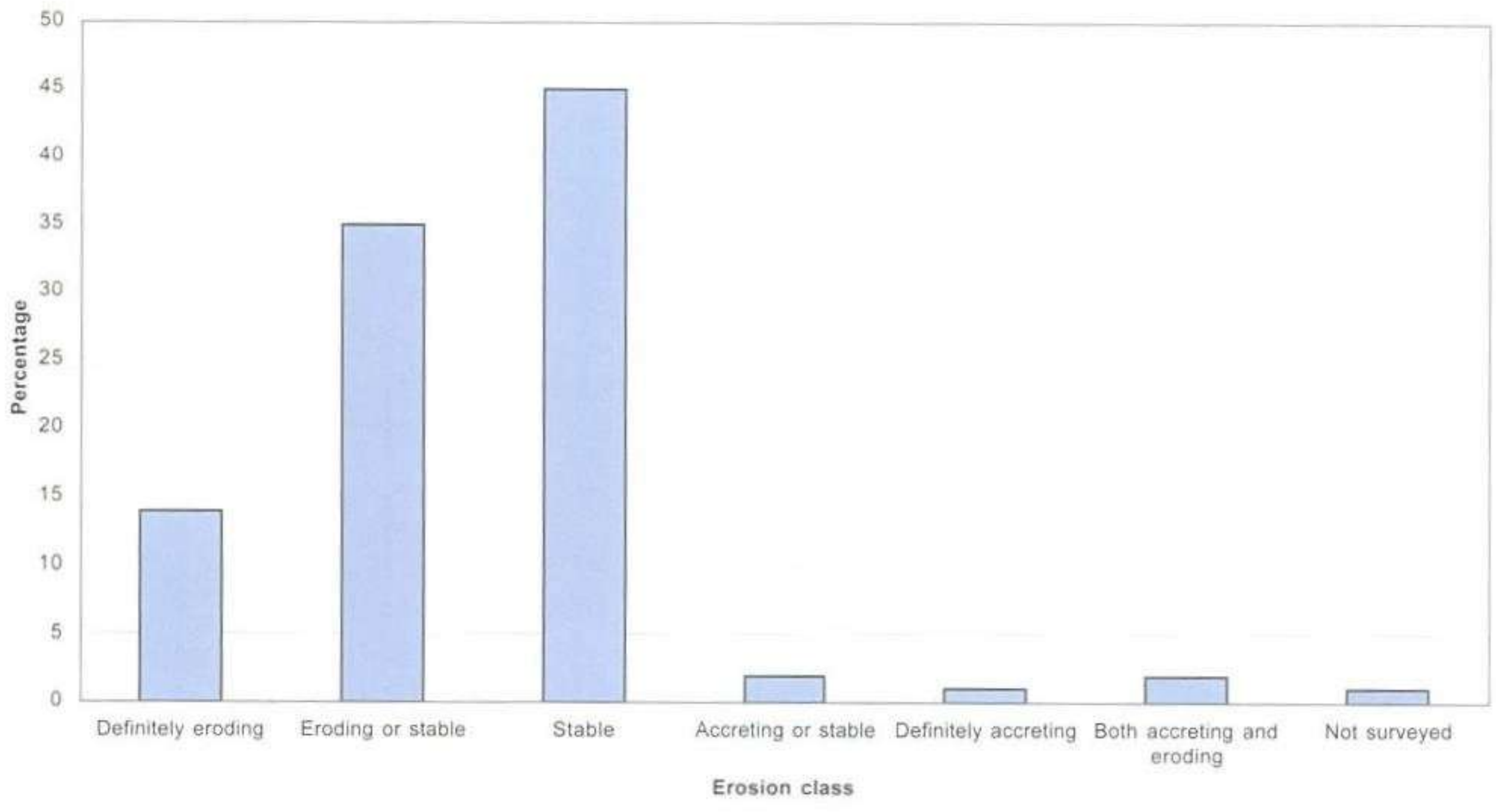

Figure 6.11. Graph showing erosion classes for the coastline surveyed.

Discussion and Recommendations

The impression gained during these surveys is of a coastal zone which is extraordinarily rich in monuments of all periods. Any deficiencies in the record – a lack of medieval settlement or non-broch settlement for example – is likely to be due to a combination of factors. These include the difficulty of assigning dates to sites or characterising them without recourse to excavation. Also, the hinterland of much of the area surveyed had been repeatedly cultivated in the past and was in consequence featureless. This does not mean that the 'missing' sites have been destroyed or that they were never located within the coastal zone. It is to be expected that prospective excavation would rapidly fill any gaps in our knowledge.

One important factor which was brought home to the surveyors again and again was that the group of sites identified is in effect a self-selecting one. This is because identification relies on preconceptions of what the various monuments should look like. It is doubtful, for example, that a Bronze Age burial mound would be correctly identified if it was too big or too small to fit within the expected size range, or if it were in an unexpected location. These surveys thus have the effect of creating an *average* impression of the archaeological potential of the coastal zone. Unusual sites, or site types not previously identified through some other means such as excavation, are in fact less likely to be identified since they fall outwith the 'known universe' of site variation. This tendency is exacerbated when attempts are made to summarise the data. There is a pressure to fit sites into neat categories, which derive from, for example, the results of previous excavation work. These sites, in turn have often been chosen for study due to what it is anticipated will be found during excavation rather than because of the site's unknown potential. It is interesting to note that some of the most informative and useful work has been from rescue excavations where there were no previous expectations or where the expectations were confounded by the results. Pool, Sanday (site SY117, Moore & Wilson 2000) and Knap of Howar, Papa Westray (site PWT1, Moore & Wilson 1999) are two good examples of this.

The areas surveyed consisted of a series of separate islands, each of which varied in the nature of its archaeological potential, as mentioned above. It should be remembered that all of the areas surveyed have suffered greatly through rising sea levels. Distribution maps which use the present-day coastline will be misleading unless they purport to show only modern settlement patterns. The Neolithic landmass of Orkney was very different, to the point where several of the islands surveyed were in all probability joined. This will have obvious implications for interpretation and for predictive modelling of site location. Westray, Papa Westray and the Holm of Papa Westray were probably one island (Ritchie 1985, illus 8). The Holm of Papa Westray is dominated by Neolithic funerary monuments – this may appear an odd place for such monuments but it may have in fact been a promontory or ness of land and as such sits quite happily with other similar locations used for burial during this period. The ways in which the coastlines of Orkney have changed, from the last ice age to the present-day, is an important topic for future research.

Some important recommendations arise from these surveys:

- It is clear that there are a great many sites whose true potential is at present uncertain. Further work is needed to assess these sites in more detail. This information is essential if both local and national priorities are to be formulated, and it is desirable that further work is carried out as soon as possible.
- There is a lack of data concerning the potential of the landscape between the monuments. In Orkney, sites often appear as massive anomalies in what is otherwise a relatively bland landscape. There has been some previous work which has shown that entire prehistoric landscapes can survive buried beneath wind-blown sand (eg Links of Noltland, Westray, and Tofts Ness, Sanday) and more work is needed to investigate the relation Orkney sites have with their hinterland.
- Regardless of any long-term management strategies which may be put in place, there is a large group of sites of all periods which have been identified through these surveys as worthy of further work now (see Recommendations, Moore & Wilson 1998; 1999; 2000). This does not necessarily mean full-scale excavation in every case but a range of options including monitoring and survey.
- These surveys should be repeated after a suitable interval of time, perhaps ten years, in order to assess rates of erosion, for which there is at present very little information. It is not necessary that all the areas are resurveyed; it may be equally useful to sample

those stretches of coastline deemed most at risk.

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7 ASSESSMENT SURVEY: LEWIS

MIKE CHURCH AND CHRIS BURGESS

Introduction

During the months of June, July and August 1996, a team from the Department of Archaeology at the University of Edinburgh undertook an assessment of the erosion of the archaeology and built heritage within the coastal zone of the west, north-west and north-east of Lewis. The results of this 441-km linear survey detail 1825 individual cultural heritage sites, 15 palaeo-environmental sites and 319 geomorphic and erosion cells. Historic Scotland and the Department of Archaeology, University of Edinburgh, sponsored the study.

Aims

The primary aims of the project were to fulfil the requirements of the ongoing programme of coastal erosion assessment defined in Historic Scotland's *Archaeology Procedure Paper 4: Coastal Zone Assessment Survey* (1996). In addition, the results also contributed to ongoing research interests of the wider Calanais Archaeological Research Programme (CARP; Harding 2000). These included:

- the development of computer-aided survey using the software package PenMap (Strata 1996), initiated during previous research projects in Lewis
- provision of a linear survey control along the coasts for the various area survey projects undertaken within the study area
- examination of the coastal strip for potential sites for rescue excavation and selective sampling

The Study Area

This survey comprised the intertidal zone and a 50–200 m strip inland from the Mean High Water Spring (where possible). The survey was executed along a linear transect running from Aird Drollageo in the south-west via the Butt of Lewis to Ranish in the south-east of the study area (Figure 7.1). A wide diversity of coastal forms was covered by this transect, including high cliffs and low rock platform, stretches of raised beach, areas of extended sand dunes and machair, intertidal saltings and isolated areas where alluvial deposition is prevalent.

Lewis is the largest land body in the bow-shaped chain of islands which makes up the Western Isles. The almost exclusive coverage of basement rock of hard metamorphic Lewisian Gneiss is amongst the oldest in Britain, with some formations dating back to 2800 million years. However, the Butt of Lewis and an area north and east of Stornoway are underlain by softer Metasediments and Triassic sediments that affect the long-term erosion of their respective coastlines in relation to the rest of Lewis.

The present Holocene landscape can be broadly separated into two main areas: the 'blacklands' and the coastal strip. The 'blacklands' cover most of the island interior and consist of a treeless subdued topography covered in blanket peat, dotted with hundreds of lochs of varying size and bare outcrops of Lewisian Gneiss. Stretches of the coastal strip consist of land that is agriculturally more viable and on which most of the island's settlement is concentrated. Its form is a function of the development of machair through natural processes (Ritchie 1979; 1985) and anthropogenic intervention (Pankhurst & Mullin 1994; Boyd & Boyd 1990). Pollen diagrams within the survey area indicate that tree cover was greatly reduced by the 1st millennium BC (Bohncke 1988; Birks 1994; Lomax & Edwards 2000).

During the second half of the Holocene the increasingly marginal and forbidding interior has concentrated settlement within the coastal zone. The resulting archaeological remains cover all periods from Neolithic ceremonial remains, through Bronze Age landscapes in both machair and blanket peat, the monumental drystone architecture of later prehistory, medieval ecclesiastical complexes and expanses of abandoned post-medieval settlement. The concentration of this varied and diverse settlement within the coastal zone, coupled with the unique preservation systems of peat and machair and limited intensive agriculture, has created an archaeological resource of great importance.

Previous Work

More than 20 excavations of archaeological sites have taken place within the survey area. These are outlined by Burgess and Church (1997, 29–31). There has also been important research into Quaternary environments and geomorphology, concentrating on Uig Sands and a stretch of relic coastline in the north-west (Sutherland 1993).

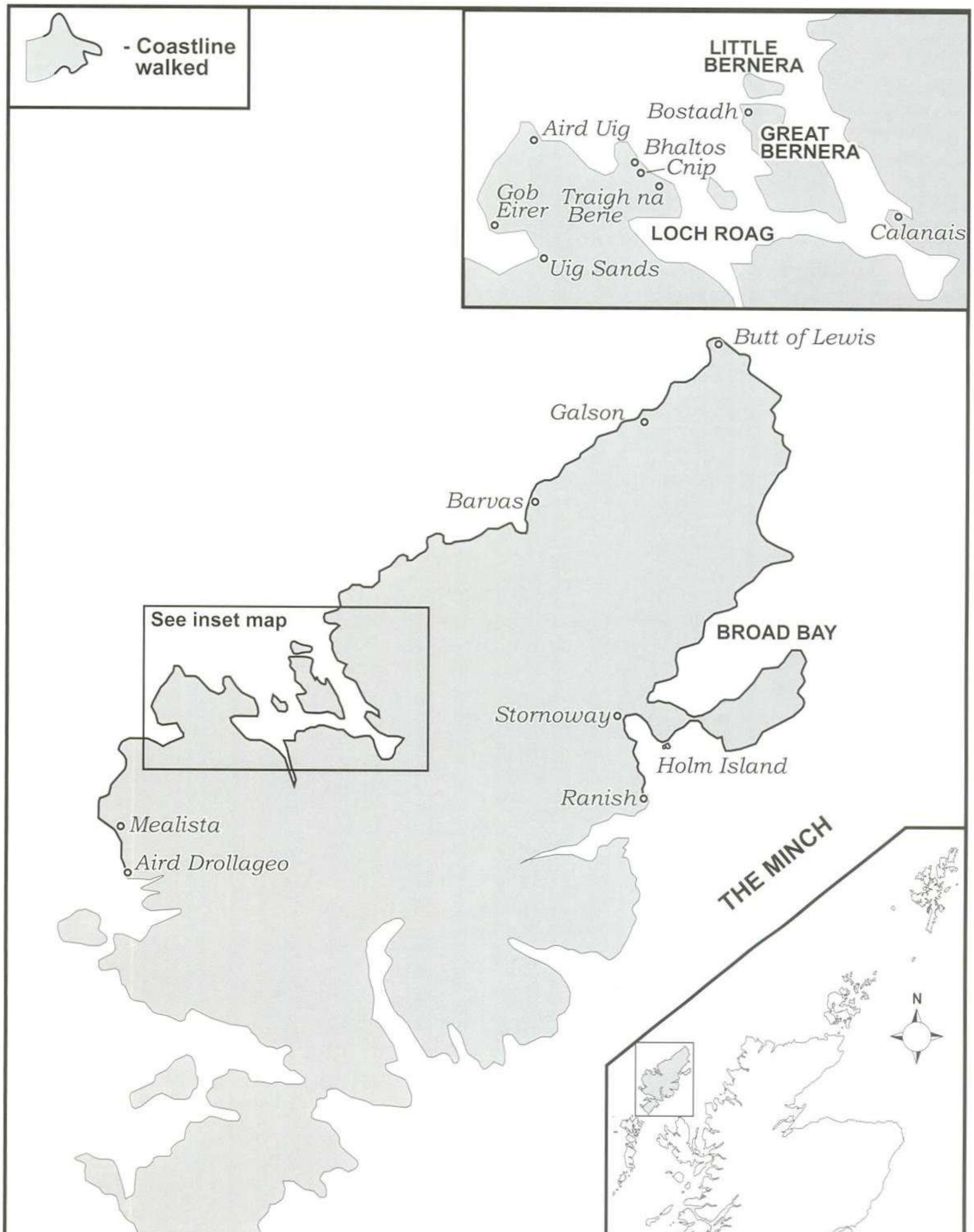

Figure 7.1. Location map showing the area of survey and places mentioned in the text.

Prior to 1985 the main projects were the RCAHMS survey published in 1928 and the coastal erosion assessment undertaken by the National Museums of Scotland (Cowie 1994). The latter involved a detailed survey and site description of selected strips of coastline rich in prehistoric remains.

The initial research of CARP, following the acquisition of Calanais Farm in 1985 (Harding 2000) concentrated on the later prehistoric settlement on the Bhaltos Peninsula. Field survey (Armit 1994) was followed by the excavation of a wheelhouse and cellular complex at Cnip (Harding & Armit 1990), an island dun at Loch Bharabhat (Harding & Dixon 2000), and a broch at Loch na Beirgh (Harding & Gilmour 2000). The island dun and broch have now both been classified as complex Atlantic roundhouses.

In 1993 the West of Lewis Landscape Project (WLLP) started a programme of field survey concentrated around the Loch Roag complex in the west of Lewis (Burgess 2001). Initial work concentrated on the chronology and nature of human settlement from the Neolithic to the post-medieval within an area 4 km by 10 km, stretching from Calanais on the coast into the 'blackland' interior (Coles & Burgess 1995). Further fieldwork within the survey area, investigating the remains of early prehistoric field systems under the peat near the Calanais stones, has been completed recently (Flitcroft *et al* 2000).

The Garenin Landscape Survey (GLS) was set up in 1994 to investigate the late medieval and post-medieval settlement of Garenin through intensive field survey and limited excavation. This led to the trial excavations of features of all periods including blackhouses, illicit stills, a corn kiln, and a promontory enclosure (Burgess & Gilmour 1996; Burgess & Johnson 1999).

The Uig Landscape Survey (ULS) was initiated to investigate the human settlement of Aird Uig, the headland adjacent to the Bhaltos Peninsula. This area was chosen to provide a western comparison for the study of the Loch Roag complex (Burgess 2001). An intensive field survey in the initial season (Burgess & Church 1996a) was followed by selective excavation of certain settlement types in the following seasons (eg Church & Gilmour 1999; Bronk Ramsey *et al* 2000). A component of the initial field survey was a coastal erosion assessment of the archaeology in the 50 m strip around Uig sands (Burgess & Church 1996b) and a reassessment of the coastal erosion sites examined by Armit in the Bhaltos Peninsula (1994).

The survey of the Loch Roag area was completed in 1996 with the detailed survey of the Islands of Great and Little Bernera. Covering an area of more than 900 ha, these two islands lie at the centre of the Loch Roag complex between East and West Loch Roag. The opportunity to study these islands provided a perfect opportunity for linking the surveys on the east (GLS and WLLP) and the west sides (ULS) of the Loch Roag complex (Burgess 2001). Sites of all periods were examined at the same time as the detailed excavation of the late prehistoric and Norse settlement at Bostadh Beach (Neighbour & Burgess 1997).

Methods

The survey adopted a three-phase approach following the standard pattern of linear and area surveys and Historic Scotland's *Archaeology Procedure Paper 4* (1996).

Phase 1: Desk-based assessment

Archaeological, geological and geomorphic material was consulted from the following sources:

- Ordnance Survey record cards, map sheets and the National Monuments Record of Scotland (NMRS) database through the Artemis GIS system – the Artemis data was generated on the basis of a search set to note all sites within 500 m of a centre line path based on the Ordnance Survey 1:25000 survey of the coastline of Lewis
- a selected sample of aerial photographs from the Aerial Photographic Unit at the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS)
- the Historic Scotland Map Room for all relevant Scheduled Ancient Monuments
- the National Map Library for copies of the First Edition 6" Ordnance Survey

Phase 2: Fieldwork

Three field teams, each comprising two people, examined stretches of the coastline divided into arbitrary administrative parcels. Each team covered 5–10 km per day. Each team was equipped with a pen-based portable computer (Compaq Concerto 486SL 33 MHz, 12 Mb RAM) into which details of all cultural heritage, palaeo-environment features and erosion and geomorphology were recorded. PenMap software was used to record the data onto scaled background maps using a GIS system to manage the data. Record forms were programmed for the project by the authors and altered and refined on the basis of the first week's experience in the field. Sites were located to an accuracy of 20 m (a radius of 10 m) by means of either compass resection or hand-held navigational GPS.

The coverage by linear transect included the intertidal zone (where it was deemed safe to examine it) and a 50–200 m strip inland from the Mean High Water Spring. Extensions to the survey strip were made when areas subject to erosion processes directly related to the coastal erosion regime were noted, eg Barvas machair, NGR NB 346 514. Only offshore islands safe to reach by foot were visited, for example Holm Island, NGR NB 450 304. Some stretches of coast were inaccessible due to the presence of crofts running to the foreshore.

Phase 3: Reporting

The use of computers in the field greatly increased the efficiency of transfer, manipulation and analysis of the survey data. A 440-page archive report was lodged with the NMRS (Burgess & Church 1997) and a summary note published in *Discovery and Excavation in Scotland* (Burgess *et al* 1997).

Analysis

Archaeological sites

One thousand eight hundred and twenty-five sites were recorded with a monument density of (on average) more than four sites per kilometre (Table 7.1 and Figure 7.2). This density varies spatially, with areas such as Great Bernera having a high density, and, conversely, some of the more inaccessible cliffs, such as the stretch in the north-east of the survey, having a much lower density. The density from this survey is greater than those of the other surveys completed to date under the wider national strategy being implemented by Historic Scotland. However, rather than simply signifying a higher density of archaeological sites, this may be due to the chronological range of this survey, which included a vast number of post-medieval sites. Also, this may be due to the identification of single 'site elements' in addition to the 'settlement complexes' that are commonly recorded in the other surveys.

Period (field recording)	General period	Number of sites	Percentage of total sites
Prehistoric	Prehistoric	178	9.75
Neolithic	Prehistoric	8	0.44
Bronze Age	Prehistoric	7	0.38
Iron Age	Prehistoric	17	0.93
Pictish	Prehistoric	1	0.05
Norse	Norse/Medieval	4	0.22
Medieval	Norse/Medieval	31	1.70
Pre-clearance	Norse/Medieval	211	11.56
Post-medieval	Post-medieval/Modern	592	32.44
Crofting	Post-medieval/Modern	101	5.53
Modern	Post-medieval/Modern	133	7.29
Multi-period	Prehistoric	1	0.05
Unknown	Unknown	541	29.64
Totals		1825	100.00

Table 7.1. Breakdown of sites by period.

It must be stressed that though some sites can be attributed with confidence to a period, for example complex Atlantic roundhouses are thought to be exclusively Iron Age, many of the period identifications for the sites should be interpreted as

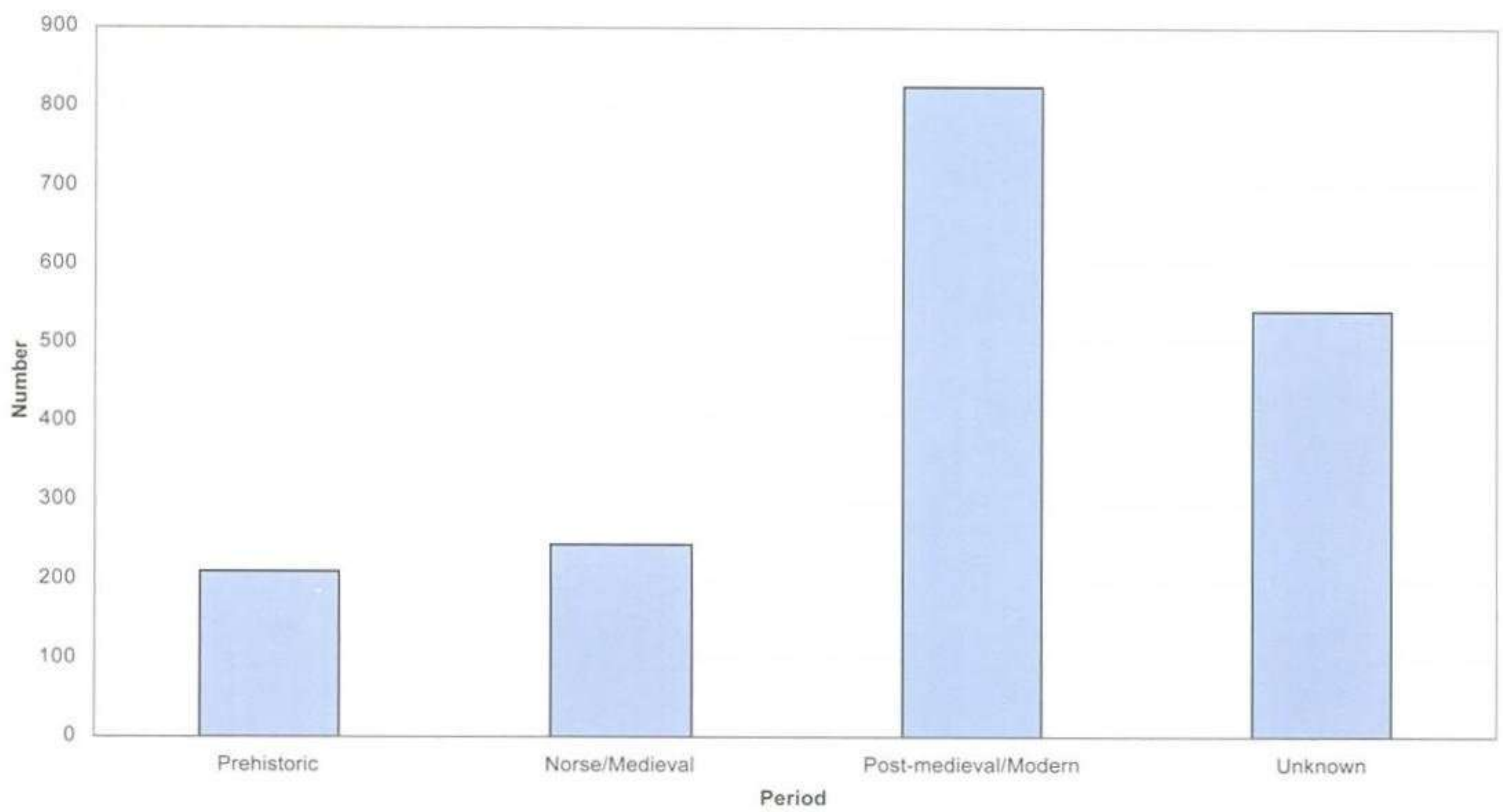

Figure 7.2. Graph showing the total number of sites recorded, grouped by period.

'possible' rather than 'probable' dates. This is especially true of the Norse/Medieval bracket which may include many post-medieval buildings and field systems which were identified in the field as earlier due to variations in the overall form of the rectilinear structures and rigging. Also, many sites, for example Galson (see below), cover more than one period. Past research has shown the dangers of constructing chronologies by survey alone (cf Armit 1996), especially as many Lewisian sites appear as piles of stones obscured by peat and turf. Five hundred and forty-one of the sites (approximately 30 per cent of the total) have therefore been assigned to the 'Unknown' category.

Vulnerable sites

The erosion status of sites by period can be seen in Figure 7.3. This shows that almost 50 per cent of the prehistoric sites are definitely eroding, with a further 15 per cent eroding/stable and only 36 per cent stable. Conversely, the later sites are predominantly stable (66 per cent for Norse/Medieval and 77 per cent for Post-medieval/Modern) and the 'Unknown' sites are subject to slightly more erosion. Clearly, the prehistoric sites are much more likely to be eroding than any other period grouping, primarily as a result of their location and their archaeological visibility within the machair and sand zones. This again has implications for the monitoring and management of the machair zone as many of these sites are considered to be important site types within the Western Isles and beyond.

Erosion cells and geomorphology

The results below were obtained through analysis of the 319 erosion cells, the total length approximately 441 km. The results are presented in three basic groups of data:

- the overall survey (Figure 7.4)
- comparison of the east and west coast data sets

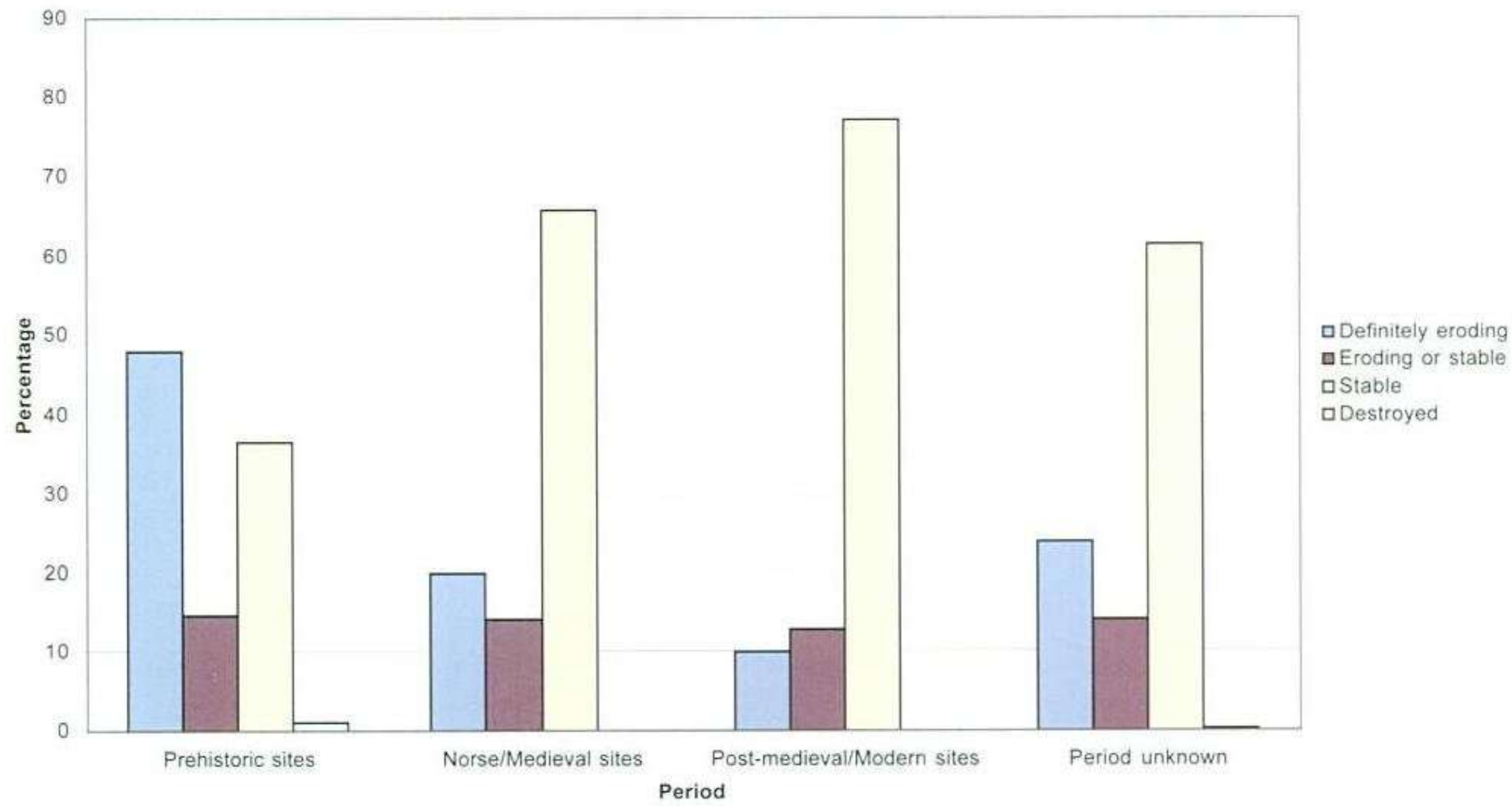

Figure 7.3. Graph showing the erosion state of sites from each period.

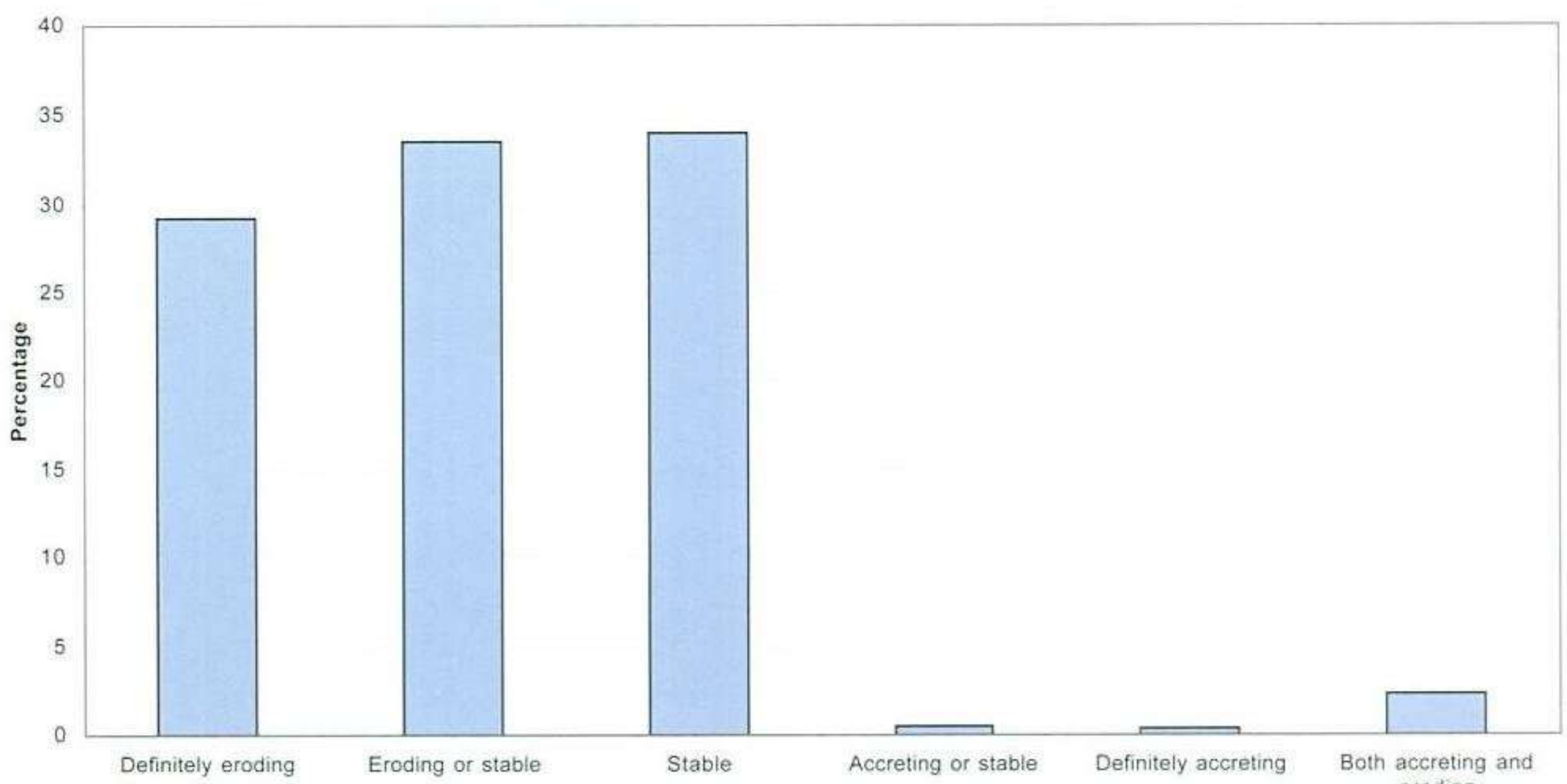

Figure 7.4. Graph showing erosion classes for the coastline surveyed.

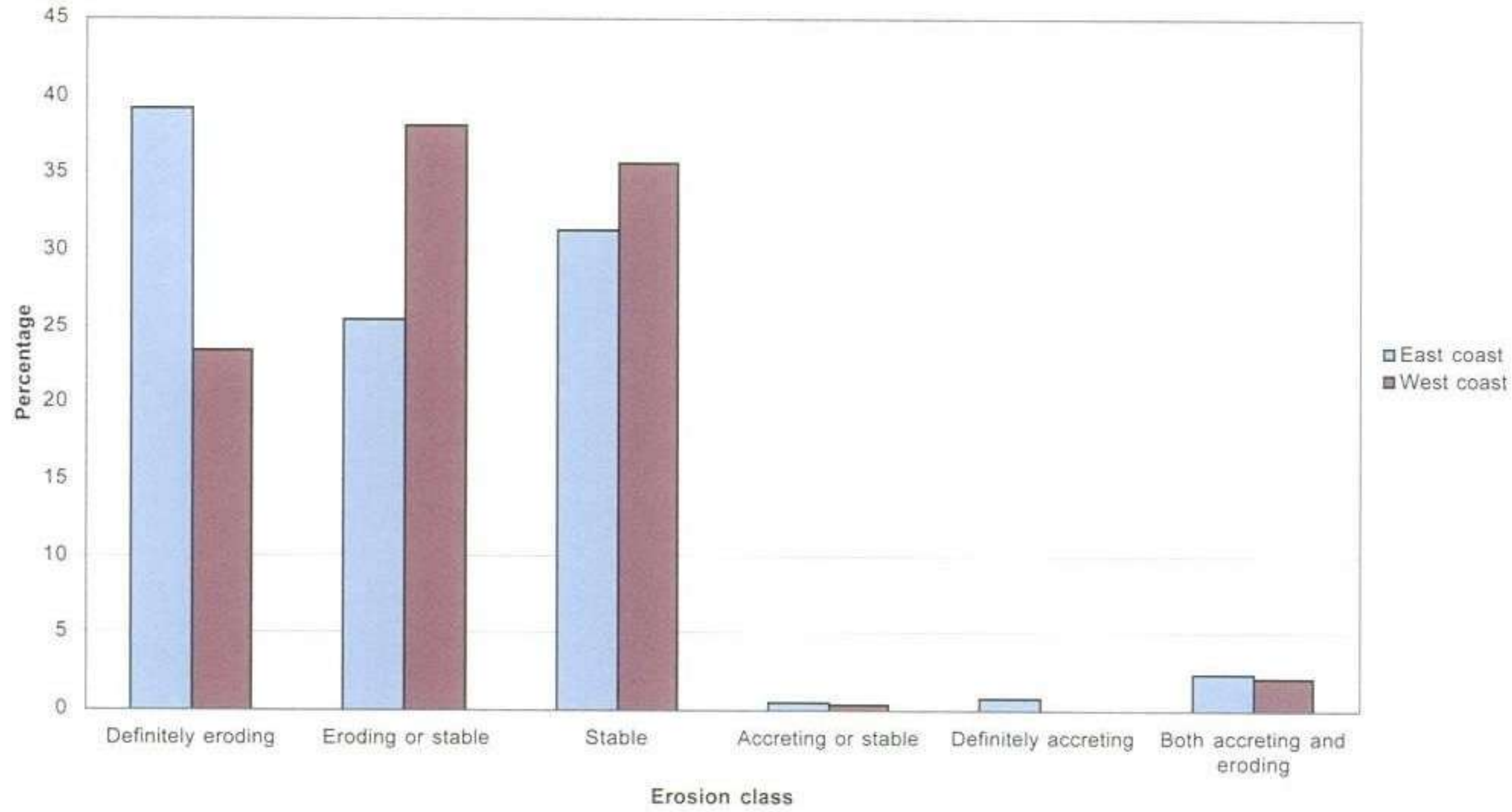

Figure 7.5. Graph comparing erosion classes for the east and west coasts.

(Figure 7.5)

- inspection of the erosion cells within the coastline of sand and machair in more detail (Figure 7.6)

Figure 7.4 shows that the overall regime is characterised by erosion of the coastline, with approximately 29 per cent of the coastline actively eroding and a further 36 per cent of the coast showing some signs of erosion. Only 34 per cent of the coastline was stable and less than 1 per cent of its length displayed a predominantly depositing regime.

Comparison of erosion to the east and west coasts

The hypothesis that the west coast was undergoing more erosion than the east coast was formulated during fieldwork. This was thought to be because the west coast is in the direct line of the severe storms and marine action from the Atlantic whereas the east coast that faces on to The Minch is relatively sheltered. This was an important distinction as approximately 78 per cent of the archaeological sites were located on the west coast. However, when the two data sets are compared (Figure 7.5), it can be seen that the east coast was experiencing the greater erosion, with over 39 per cent of the coast definitely eroding and a further 26 per cent eroding/stable compared to the west coast where 23 per cent was definitely eroding and 38 per cent was eroding/stable.

This apparent negation of the initial hypothesis can be explained through more detailed examination of the geomorphic profiles of the two coasts. For example, though there are large stretches of generally stable high cliff on the east coast, there are also long stretches of eroding sand beaches and machair that are different in character to the generally smaller pocket beaches of the west coast. Also, on the east coast there are long stretches of softer New Red Sandstone cliffs to the north and east of Stornoway. These were generally showing signs of active erosion. Conversely, most of the underlying geology of the west coast is harder Lewisian Gneiss, a sizeable proportion of which consists of stable low rock platforms and cliff within the more sheltered sea lochs of East, West and Little Loch Roag.

Erosion within sand and machair zones

During the fieldwork it was obvious that many of the sand and machair systems encountered were more dynamic in their erosion regimes than the other systems observed. Also, the machair areas have acted as a focus for human settlement from prehistory to the modern day, resulting in numerous rich archaeological sites being recorded. Many of these have been shown through excavation to be unrivalled for their preservation of structural remains, bone and shell, for example Cnip wheelhouse complex (Harding & Armit 1990; Armit 1996) and Bostadh Beach (Neighbour & Burgess 1997).

Previous archaeological and environmental surveys (Ritchie & Mather 1970; Cowie 1994; Ramsay & Brampton 1995; Burgess & Church 1996b) have been biased towards these areas though none has presented comparative data to justify this concentration of research and assessment. All the erosion cells from sandy beaches and machair (approximately 33 km) are presented in Figure 7.6. Fifty per cent was definitely eroding, 26 per cent was eroding/stable and only 4 per cent was stable. This shows that within the wider framework of the generally eroding regime, the sand and machair coastlines act as erosion foci. The low level of stability was particularly marked when compared to the overall stable proportion of the entire study area (approximately 34 per cent). Sand and machair systems also act as deposition foci, with

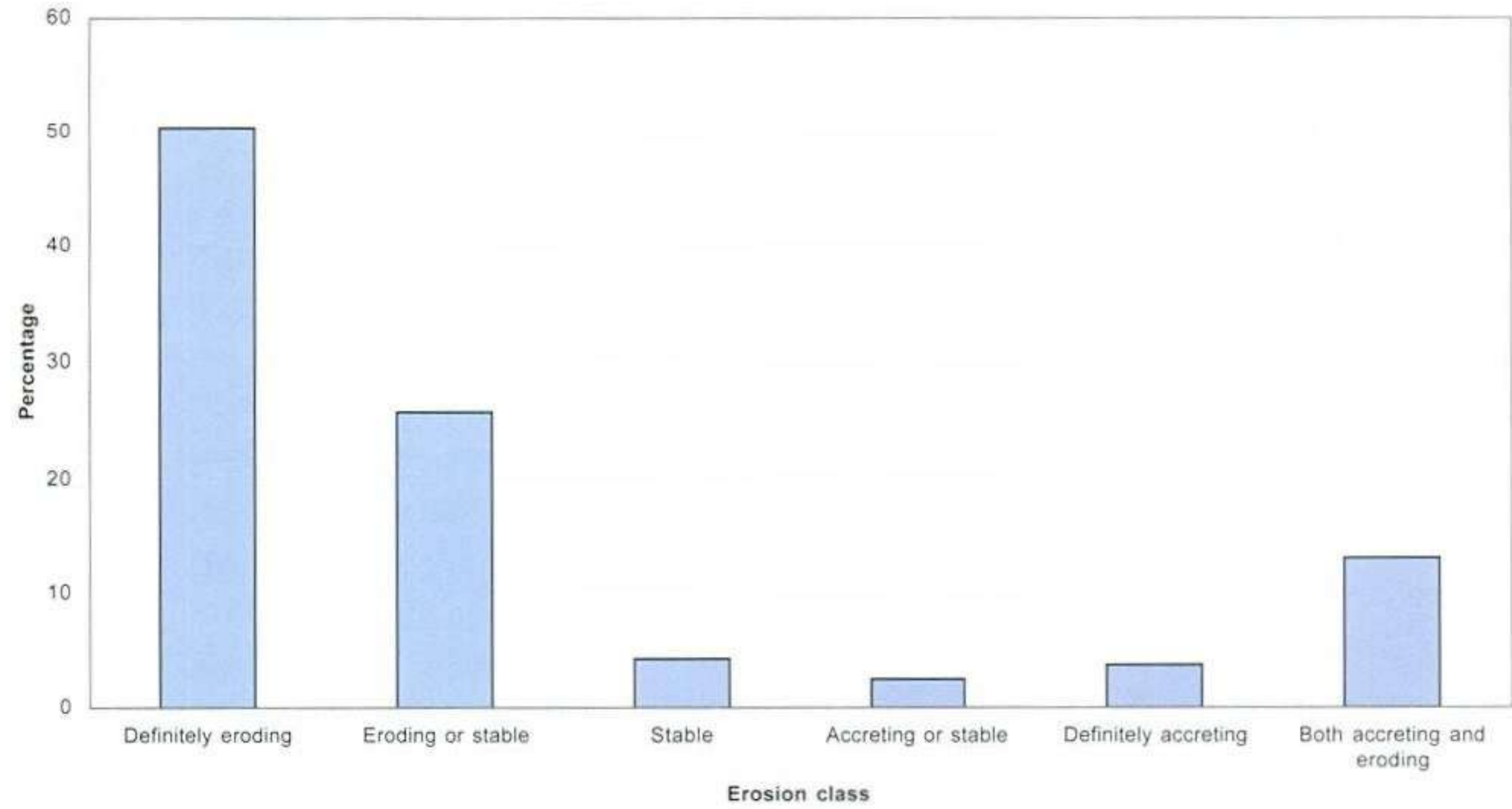

Figure 7.6. Graph showing erosion classes for sand and machair zones.

almost 7 per cent depositing and a further 13 per cent showing signs of erosion and deposition.

The threat to the archaeology within the machair zone is twofold: predominantly from erosion of the archaeological remains but also from the changing 'archaeological visibility' that occurs within the system. For example, the potentially unique Mesolithic stone artefact scatter located by Lacaille at Traigh na Berie (Lacaille 1937) has never been relocated following sand accretion and so has been lost to archaeological research up to this point. The eroding middens within the same zone will also soon be lost forever.

The ease of transport by water and wind action, coupled with the inherent high levels of erodibility of the matrix (Summerfield 1991), mean that machair systems are extremely dynamic, suggesting that the observed results may change from season to season. The results presented here only relate to the erosion regime occurring at the time of fieldwork. Therefore, medium- to long-term predictions for a particular area can only be gained through comparison with further periodic surveys, using a similar methodology. It is obvious, highlighted by all previous surveys and assessments, that the machair should be one of the priority areas for any coordinated and regular monitoring scheme in the future.

Discussion and Recommendations

A more detailed discussion on the types of sites comprising the study is provided in the full archive report (Burgess & Church 1997). The large number of sites and their wide diversity in form and date make it impossible to discuss the archaeological results in any depth within this paper. However, the main threats and erosion foci for the archaeology can be summarised into three general classes which apply for both the west and east coasts within the study area:

- erosion of sites (such as promontory enclosures) located on incised cliffs
- sites of various types and ages within the dynamic erosion/deposition system of machair
- a small number of sites threatened within alluvial systems

Sites on incised cliffs

Sites of this class are typified by promontory enclosures, of which over 60 individual examples have been identified (Burgess 2000). These promontory enclosures are almost exclusively located on incised cliff lines and stacks, and include Gob Eirer (Figure 7.7; Church *et al* 1999). The cliffs are eroding through continuous small-scale slumping and erosion of the soil matrix coupled with low-frequency, high-magnitude cliff slip events which could destroy large portions of a promontory enclosure. Some of these events have reduced many promontory sites to little more than stacks of less than a few metres across.

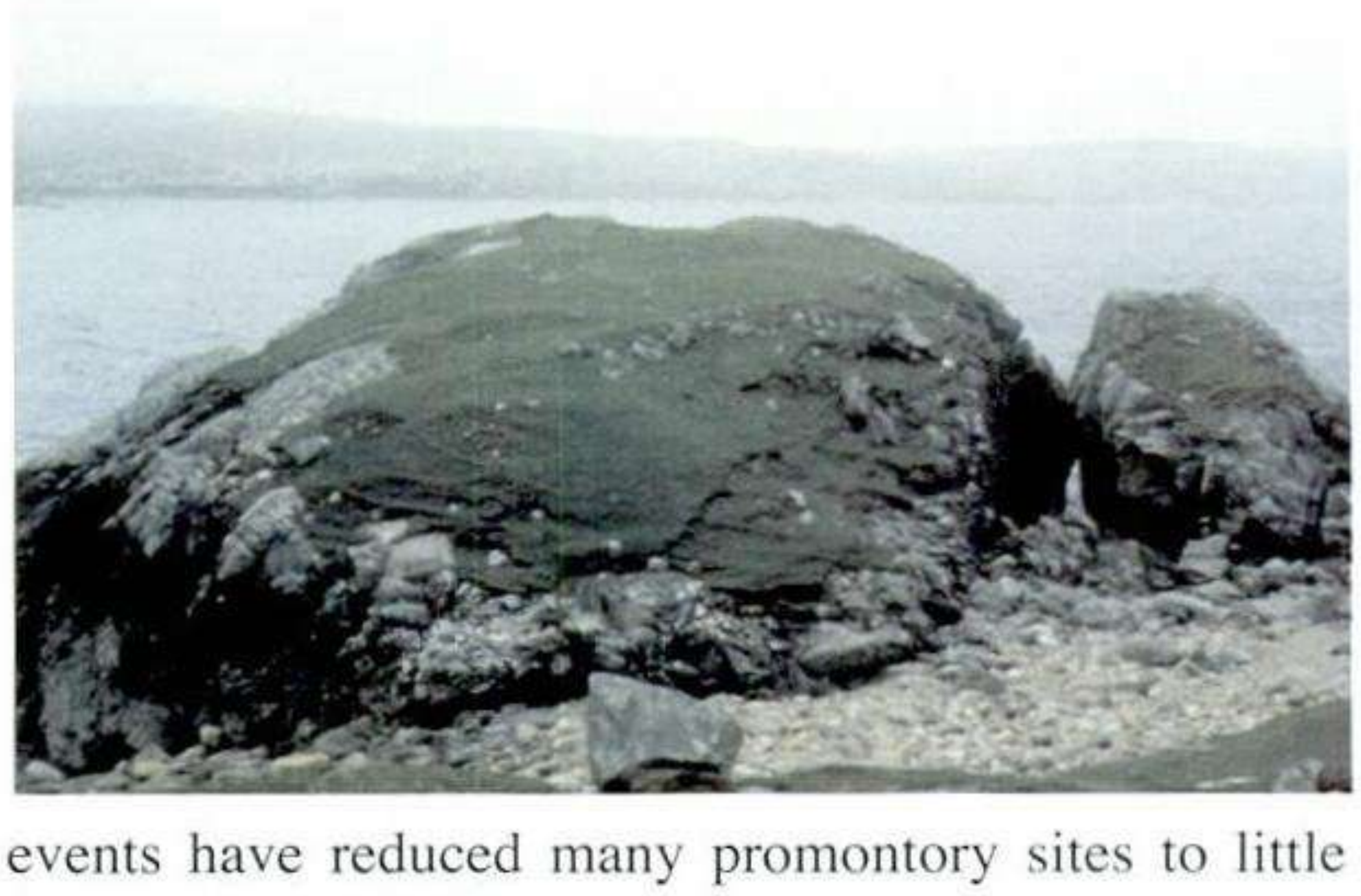

Figure 7.7. The Late Bronze Age / Early Iron Age

promontory enclosure of Gob Eirer.

The actual rate of erosion seems to vary depending on the underlying geology and the depth of substrate on which a site sits. Sites located on the cliffs of Lewisian Gneiss, for example, are generally stable; the threat of erosion increases when sites are situated on deep soft substrates such as glacially-derived sands and gravel. Conversely, sites on the 'till cliffs' overlying Metasediments around north-west Lewis and the conglomerate cliffs of New Red Sandstone on the east coast are at a much greater risk as these areas are experiencing much higher rates of erosion of the relatively soft underlying geology.

Sites within machair zones

Sand and machair zones are experiencing severe erosion and rapid deposition that impacts on the archaeological sites within these dynamic systems. The erosion mechanisms stem from marine, aeolian, livestock and human activity. Marine erosion results in wave undercutting of the sand sections. This can vary in size from the small-scale, as seen in the eroding middens on Cnip headland, to the large continuous eroding sections of up to 5 m in height at Galson. Marine erosion is particularly marked at high spring tides and during high-magnitude, low-frequency storm events such as the storm which revealed archaeological remains at Bostadh during the winter of 1993/4 (Neighbour & Burgess 1997).

Aeolian erosion results in blow-outs and erosion scars which are sometimes very extensive, as at Barvas machair. These basic erosion mechanisms and resulting geomorphic features are exacerbated by animal and livestock grazing. Animals cause direct erosion through their tracks, especially up dune sides, and through extensive burrowing (eg at Mealista, Traigh na Berie and Barvas). Animal activity also impacts on the ability of the machair system to resist erosion by thinning or removing the vegetation that binds the unstable matrix together. Human activity further destabilises the delicate balance between the erosion faces and the erodibility of the machair. This can be the direct impact of human exploitation of the zone, for example through sand extraction and cultivation at Barvas machair, or the more widespread impact of recreational activity. All these erosion mechanisms create material that is consequently deposited further inland by aeolian activity, unless constrained by topography.

Both the erosion and deposition within these zones can be very local and the general regime of an erosion cell may hide the fact that an important site is being eroded or covered up. Also, the dynamic erosion regime that exists in many of these zones can switch from erosion to deposition in a season. Therefore, the high concentration of important prehistoric sites within this zone needs a rigorous monitoring and management scheme.

Sites affected by alluvial action

This class is limited to the points along the coastline where rivers and streams enter the sea or within wider areas of alluvial erosion and deposition, for example at Broad Bay. Generally, the erosion is not too severe because most of the bodies of water are not of the size to cause extensive damage. Along certain stretches of incised coastline, streams are providing a further erosive mechanism at points of weakness that may directly impact upon sites located there. Alluvial action is also one of the few observed mechanisms for deposition within the coastal zone. This is particularly marked at Broad Bay where a number of sites, including a probable Norse settlement, are being both eroded and covered over by sand and mud.

Project evaluation

Further fieldwork, under the wider CARP, has been undertaken on a selection of coastal erosion sites highlighted by the survey. These include a hearth complex of presumed Late Neolithic/Bronze Age date under 1.5 m of eroding peat near Aird Calanais (Figure 7.8; Flitcroft & Heald 1998); a more detailed assessment of the promontory enclosures identified during the coastal erosion assessment of Lewis (Burgess 2000); and work on the multi-period later prehistoric/early historic settlement and cist complex at Galson (Neighbour & Church 2000).

Figure 7.8. Eroding section at Aird Calanais. The hearth complex is eroding from the basal layers of the section and the site is representative of those sites eroding on the low rock platforms of the sea lochs.

At Galson (Figure 7.9), the machair edge has been eroding for decades and has revealed a succession of archaeological remains. These can be broken down into two main groups associated with two major levels in the eroding section. The lower group consists of a number of Iron Age burial cists from an old ground surface that sporadically appear approximately halfway up the section. These were revealed by the progressive erosion of the section (Stevenson 1954; Ponting & Bruce 1990; Neighbour *et al* in press) and form part of an Iron Age cemetery, with the grave goods and radiocarbon dates pointing to the period of burial within a single horizon or old ground surface relating to the first half of the 1st millennium AD. The higher group consists of domestic dwellings with associated palaeosols and middens. This level is less easy to define chronologically, with many finds of Late Iron Age, Norse and medieval date reputedly recovered from the upper horizons. Early excavations (Edwards 1924; Baden-Powell & Elton 1937) identified this upper level as one continuous midden, with the implicit assumption of single-period deposition. However, it is clear from the range of structural forms and artefacts recovered from this layer, which is up to 4 m thick in some areas, that it represents hundreds of years of accumulation.

The Iron Age cemetery is very important archaeologically, not only because of the alkaline properties of the machair that allow excellent preservation of skeletal material, but also due to the rarity of Iron Age burials within Atlantic Scotland and beyond. The archaeological remains within the upper level are also very important as they contain the transitional period from the relatively well-represented Late Iron Age to the Norse and early medieval periods about which very little is known archaeologically within Lewis.

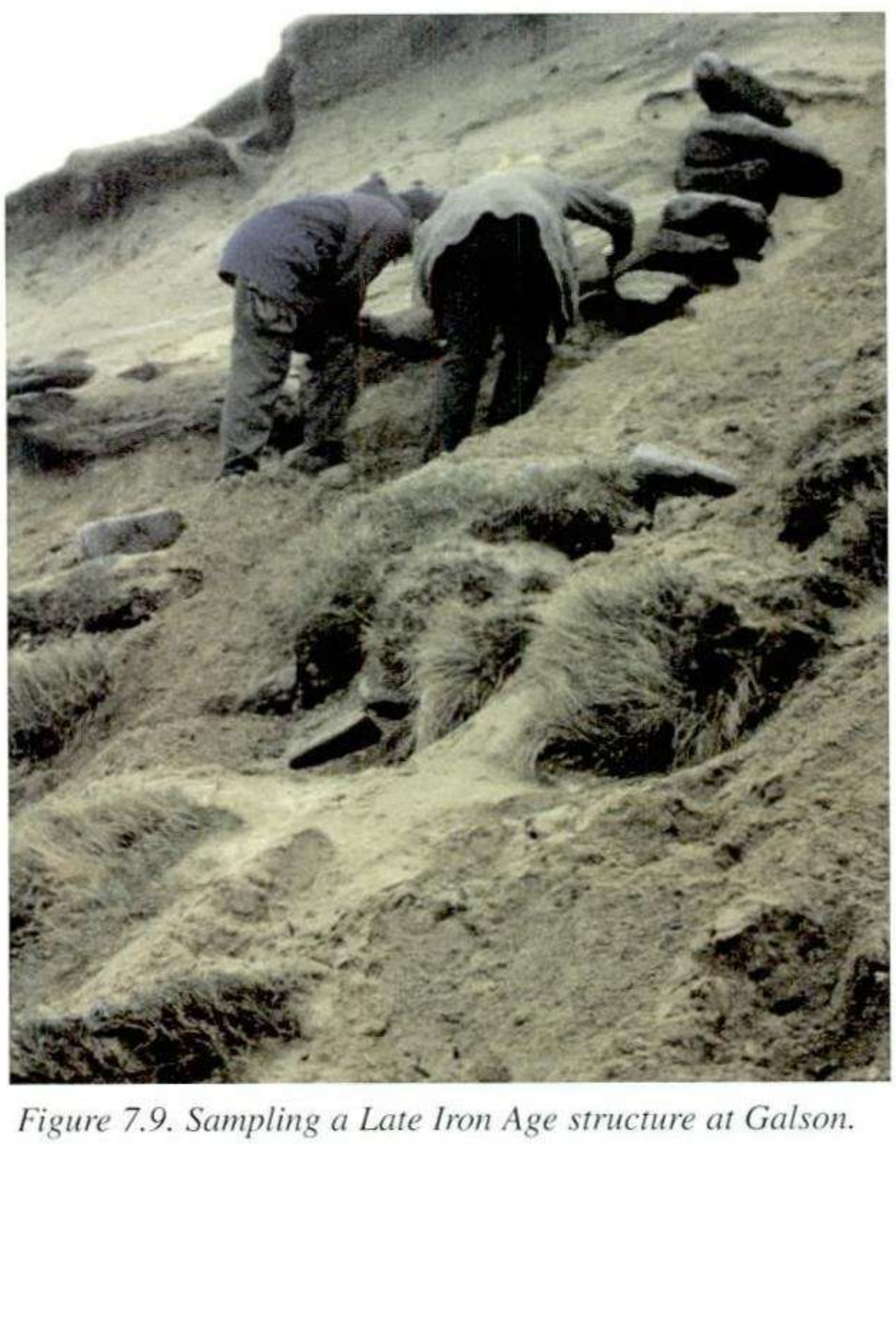

Figure 7.9. Sampling a Late Iron Age structure at Galson.

A programme of monitoring has been underway since 1997 (Church & Neighbour 1998; Neighbour & Church forthcoming). Photographic composites for computer rectification and detailed drawings of the eroding section have been produced at regular intervals. Baseline EDM surveys of the eroding edge have been complemented by geophysical survey in the area immediately behind the erosion face. This has revealed a range of high-resistance anomalies, probably reflecting the presence of buried walls up to 30 m beyond the eroding face. The shapes of the anomalies confirm the presence of both Iron Age cellular structures and Norse or medieval buildings. This research has led to the establishment of a stratigraphic relationship of at least six structures for the upper level, at the time of recording. From initial observation of the pottery, these range in date from Iron Age polycellular forms to rectilinear Norse and medieval structures. Detailed sampling for palaeo-economic data and radiocarbon dating has also been undertaken, establishing the taphonomic pathways for the carbonised material to be used in the dating programme (Peters *et al* 2000). The various classes of environmental remains (plant macrofossils, marine and terrestrial bones and shell) have been incorporated into ongoing PhD research by researchers at the University of Edinburgh.

The initial results of this monitoring have shown that a strip at least 1 m wide has eroded at certain points of the site since 1997. Hence, detailed recording of this type provides a snapshot of the archaeological profile that can change radically over one season, with the concomitant development in interpretation that may occur from the evolving identification of the structural forms of the site. It is hoped that the analysis of the data from the survey and sampling will allow insights into the transitional period between the Late Iron Age and Norse periods. However, it has been argued in the past that a full appreciation of this and other important aspects of such sites is only possible through extensive excavation, as the recording of successive eroding sections can be misleading (O Owen pers comm).

The threat that coastal erosion poses to the archaeological resource in the study area has only been summarised briefly in the space available. The archaeology within the Western Isles in general is of international importance, with a significant proportion of the sites concentrated within the 1 km coastal strip. Many of these sites, especially the prehistoric remains, are actively eroding and some are likely to be lost within the next 10 years.

The three erosion foci outlined above should form the starting point for any monitoring scheme to be developed in the future. Schemes such as Shorewatch, utilising local enthusiasm that is apparent across Lewis, would be the obvious first step. This could be complemented by establishing baseline surveys and detailed and regular monitoring by professionals of especially complex areas such as Galson. Survey and monitoring can be made more effective by backing them up with targeted excavation of sites identified as being of particular importance that would otherwise be lost, unrecorded, to the sea.

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8 ASSESSMENT SURVEY: ISLE OF BARRA

KEITH BRANIGAN

Introduction

Barra is a roughly square island (Figure 8.1), about 8 km north–south and 7 km east–west, with a peninsula (Eoligarry) projecting some 4 km to the north, and projecting headlands in the north-east (Bruernish) and the south-west (Tangaval). The geology is dominated by heavily glaciated gneiss which on some of the high ground is exposed and bare. The highest point of the island is the peak of Heaval at 383 m, and the centre of the island is dominated by peaks at around 200 m. Unlike the Uists, the west coast is not a continuous belt of flat, low-lying land but features a series of steep hillsides and cliff faces, punctuated by small areas of machair. The only extensive area of machair is on the Eoligarry peninsula. The east coast is rocky and generally bleak, but has three deep inlets at the north-east providing harbourage. The interior of the island is dominated by peat bog and moorland covered by heather. Apart from the limited pockets of machair, the only lowland pasture areas are the Borve valley and the area east of Allasdale, both on the west side of the island.

Barra was archaeologically unexplored territory when SEARCH (Sheffield Environmental And Research Campaign in the Hebrides) began work there in 1988. Apart from the excavations by Young (1952; 1955) and the catalogue of 22 sites in the RCAHMS volume (1928), there were no published accounts of the island's archaeology. Between 1988 and 1999 the entire island was surveyed, archaeological survey running in tandem with a survey of coastal erosion.

The survey of coastal erosion was carried out by a team of two, Prof. D Gilbertson and Dr J Grattan, using a modification of the method described by Grainger and Kalaugher (1990). The survey procedure particularly emphasised:

- whether or not a section of shoreline was experiencing negligible erosion in terms of the time frame of the survey
- the character of the sum of the lithologies of the present bedrocks or the superficial deposits and their geomorphic relationships in order to assess their propensity to loss by one or other mechanism
- the nature of the wide range of erosional activities which are active in this geoarchaeological context

The archaeological and erosion surveys were conducted in a zone 50 m from the High Water Mark; where precipitous cliff slopes were encountered, the zone was extended to 100 m. The archaeological survey was conducted by six walkers, a supervisor and a director. The walkers were divided into two teams, each with its own maps and equipment. The zones were walked at approximately 8 m intervals, with the two senior team members walking behind checking results. The coastal zone was surveyed in good weather in late May/early June over a four-year period and visibility was generally excellent. Some sites, however, surely remain unexposed beneath the machair.

Survey Results and Analysis

Two hundred and twenty sites and monuments were recorded in the survey of the 50 m coastal zone on Barra. Sites and monuments judged to be built after 1900, and walls, banks or other linear boundaries the greater part of which extended beyond the coastal zone were excluded from the survey. Of the 220 sites and monuments recorded, 27 were not identified to a functional type (and in some cases were not ascribed to one of our four broad chronological categories). The sites are catalogued and described, and in some cases illustrated, in Branigan and Grattan 1998, where the coastal corridor is divided into five zones with a combined length of 61.7 km.

Ascribing even broad chronological periods to an unexcavated site or monument is particularly difficult in the Western Isles, where some structures, for example the small circular hut, have been in use with little known variation for millennia. In the case of Barra, however, over 30 carefully selected excavations have enabled us to acquire some dating evidence for a wide variety of structures and also to compare in detail structures of broadly the same type but different date. We believe that we can ascribe most sites to one of four broad chronological periods – earlier prehistoric (4th–2nd millennium BC); later prehistoric (1st millennium BC – 8th century AD); medieval (9th–15th century AD); and modern (16th–19th century AD). The least certain of our ascriptions are shieling huts (separating medieval from modern is often difficult), although these are rare or unknown in the coastal zone. The chronological breakdown of the 193 sites to which we have ascribed a date is shown in Table 8.1 and Figure 8.2.

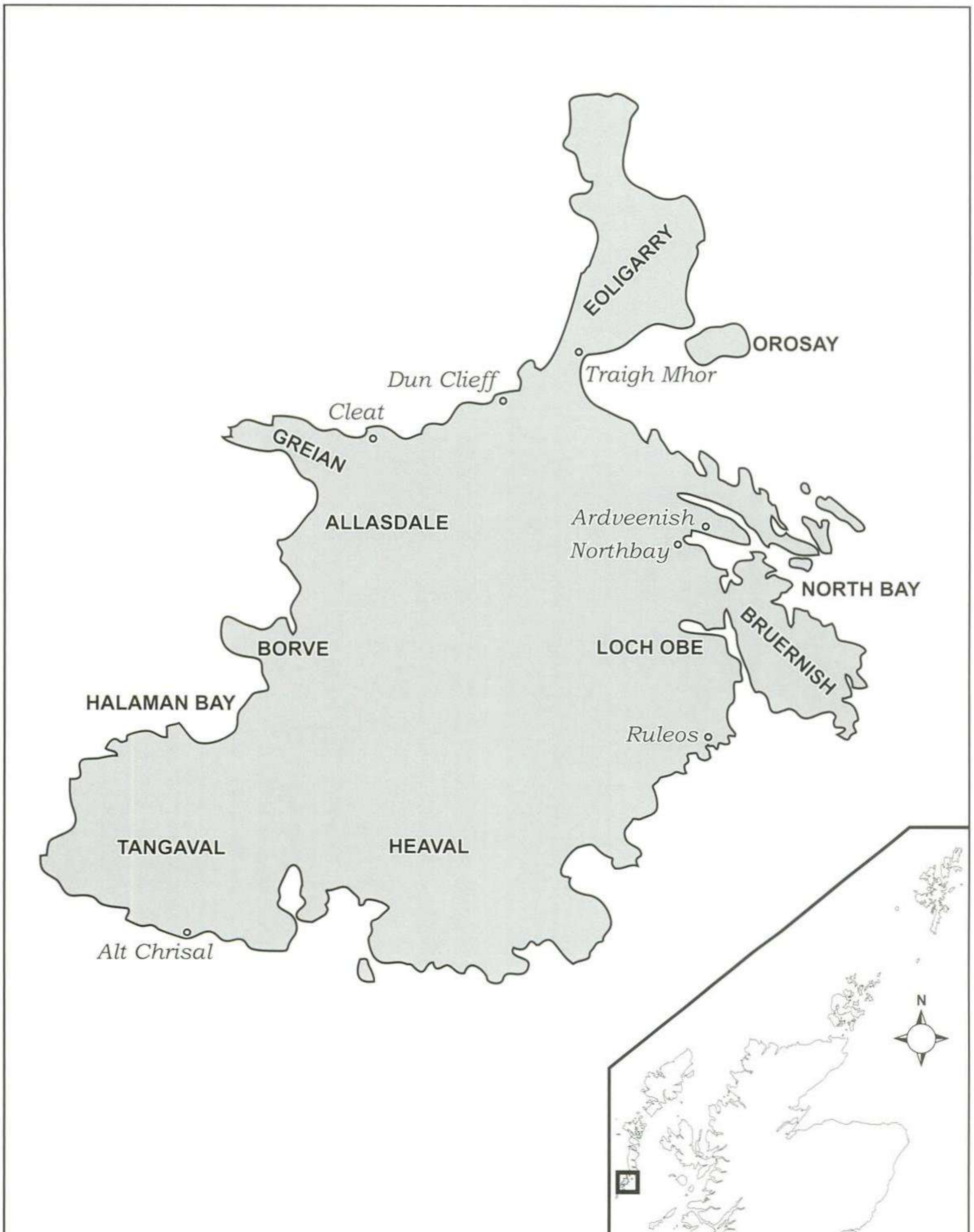

Figure 8.1. Location map showing the places mentioned in the text. Note, the entire coastline of Barra was surveyed.

Period	Number of sites	% of total number of sites
Earlier prehistoric	8	4
Later prehistoric	18	9.5
Medieval	4	2
Modern	163	84.5

Table 8.1. Chronological breakdown of sites.

The dominance of modern period sites is to be expected, as is the small number of medieval sites since these are at present the least diagnostic group of monuments. The earlier prehistoric sites include both Neolithic and Early Bronze Age monuments; most of the later prehistoric sites belong in the Middle Iron Age, but there are a few Late Bronze Age/Early Iron Age examples.

The functional or typological categorisation of sites initially identified no less than 24 types, but for this analysis the number has been reduced to just four. These are: permanent occupation sites (including houses and outbuildings); seasonal, agricultural and 'industrial' activity sites (including shielings, clearance cairns, kelp ovens, etc); burial monuments; and ritual monuments. The breakdown of the 193 classified sites by these functional groups is shown in Table 8.2 and Figure 8.3.

Functional group	Number of sites	% of total number of sites
Permanent occupation sites	103	53.5
Activity sites	83	43
Burial monuments	6	3
Ritual monuments	1	0.5

Table 8.2. Functional breakdown of sites.

The two dominant groups are again not unexpected, since houses/outbuildings and activity sites are far more common in the Hebridean landscape as a whole than burial and ritual monuments (of which see more below). Although the group sizes are small, there may be some significance in the different concentration levels of permanent occupation sites found in the coastal zone in earlier and later prehistory. Only one (12.5 per cent) of the earlier prehistoric sites in the coastal zone is a permanent occupation site, whilst eight (45 per cent) of the later prehistoric sites fall within this category. In contrast, five (83 per cent) of all the burial monuments found within the zone are earlier prehistoric. We will be able to understand better the significance of these variations when we compare the distribution of site types within the coastal zone to their distribution in the island as a whole, in the following section.

Sites have been judged to be 'vulnerable' when they are on either an eroding or an eroding and accreting coastline. The latter category comprises mainly areas of machair and dune systems where material is eroded and may be deposited elsewhere. Given the unpredictability of such erosion and accretion, all sites in such a stretch of coastline must be considered vulnerable to erosion. The breakdown of vulnerable sites by period is shown in Table 8.3, where the number of vulnerable sites is given as a percentage of the total number of sites of that period found within the coastal zone, (see also Figure 8.4).

Period	Number of sites	% of total number of sites for period
Earlier prehistoric	6	75
Later prehistoric	14	78
Medieval	0	0
Modern	96	59

Table 8.3. Breakdown of vulnerable sites by period.

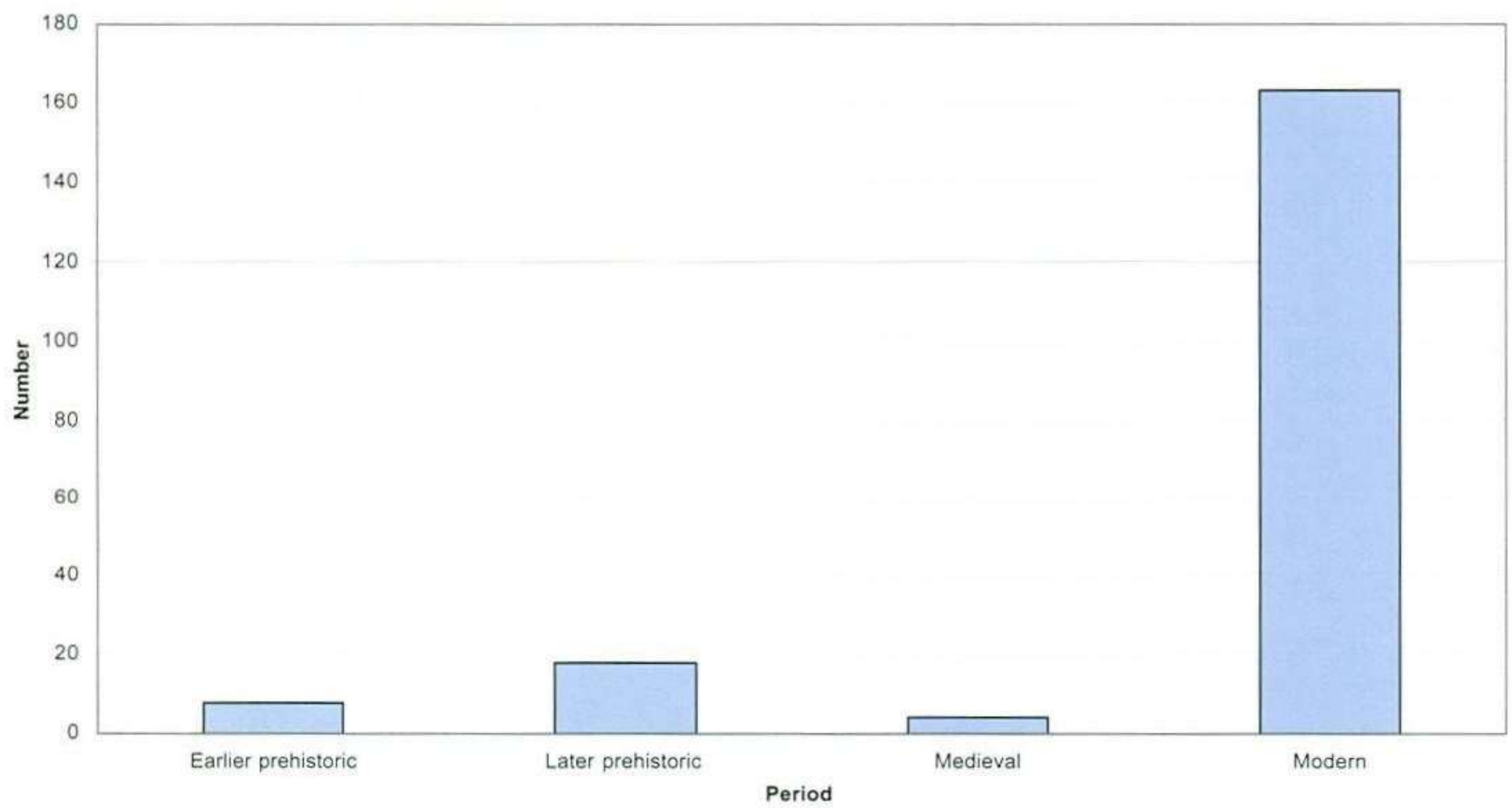

Figure 8.2. Graph showing the number of sites for which a date was ascribed, grouped by period.

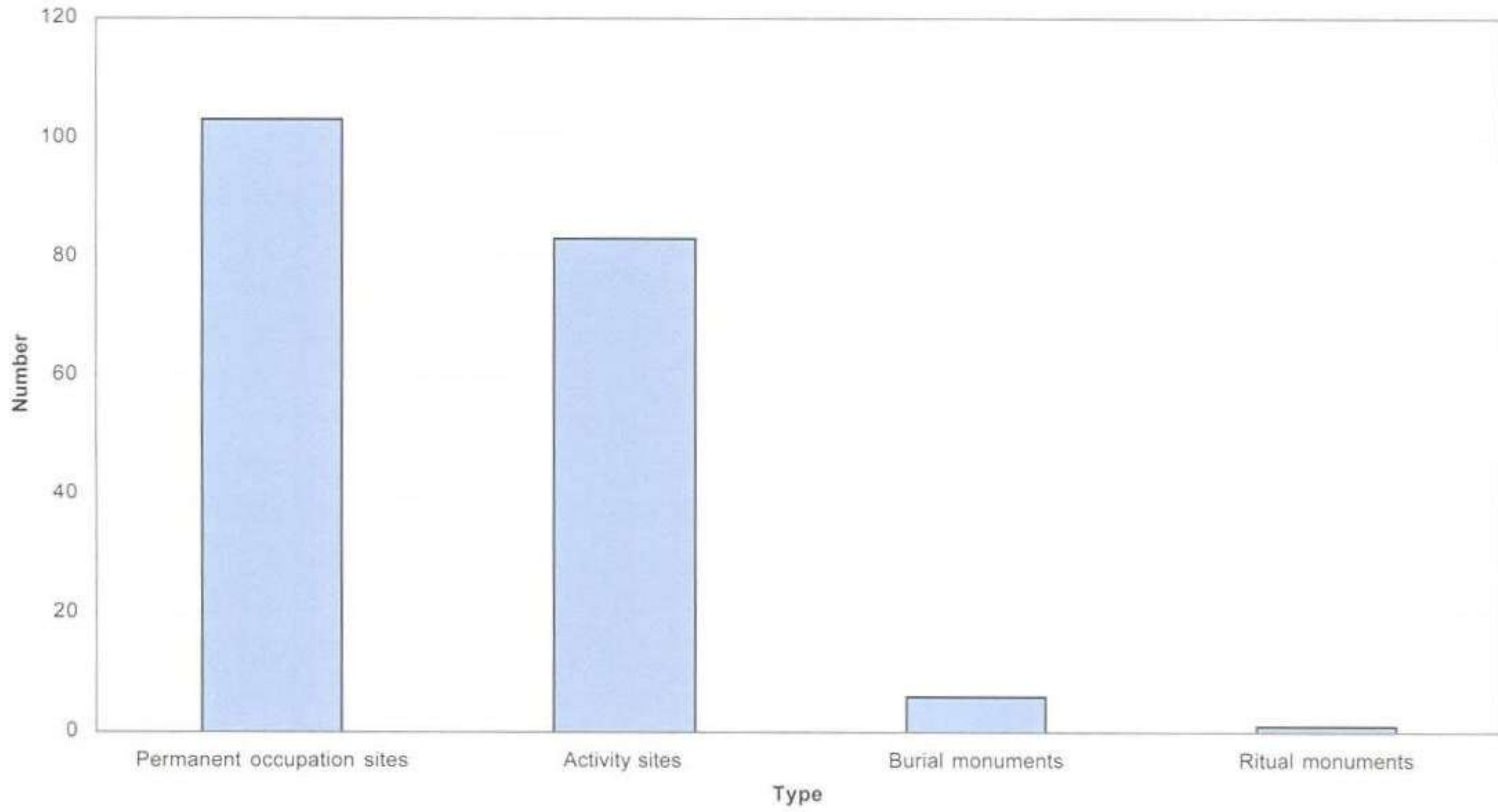

Figure 8.3. Graph showing the number of sites for which a function was ascribed, grouped by site type.

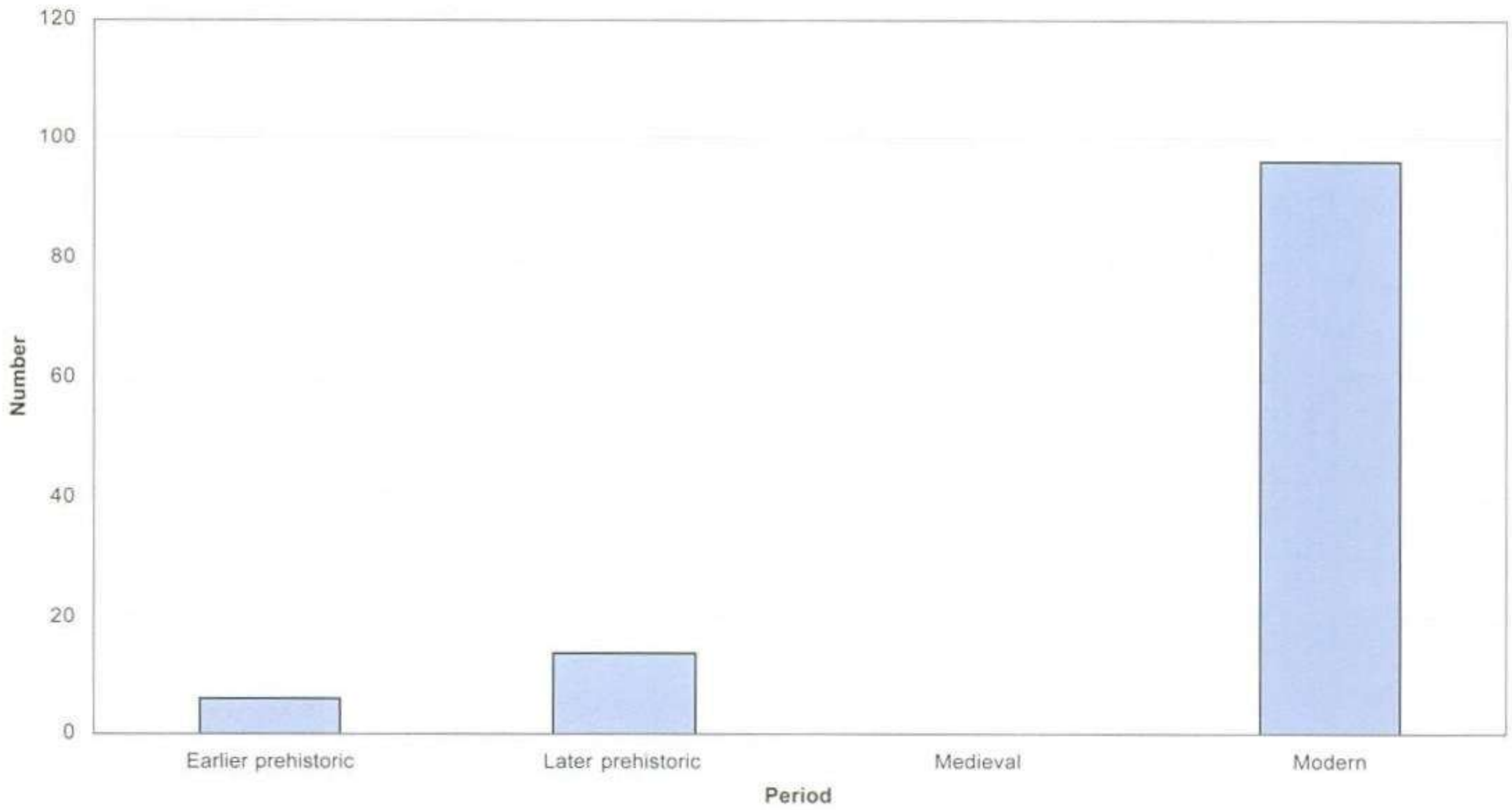

Figure 8.4. Graph showing the number of vulnerable sites, grouped by period.

Prehistoric sites seem to be the most vulnerable, and since they are few in number this must be a matter of concern. However, the threat to each site has to be assessed individually (as was done in the full report, Branigan & Grattan 1998) since highly localised factors often constitute greater risk or offer greater protection to a site than the general state of the coastline suggests.

The breakdown of vulnerable sites by site type or function (Table 8.4 and Figure 8.5) shows that burial monuments and activity sites are the most threatened and since there are so few burial monuments within the coastal zone, they again must be regarded as a cause for concern. The same caveat concerning very localised factors must be borne in mind however.

Function group	Number of sites	% of total number of sites for function group
Permanent occupation sites	53	51
Activity sites	61	73.5
Burial monuments	5	83
Ritual monuments	0	0

Table 8.4. Breakdown of vulnerable sites by function.

An assessment of the overall level of erosion around the coasts of Barra is complicated by the areas of sand and machair where there is both accretion and erosion,

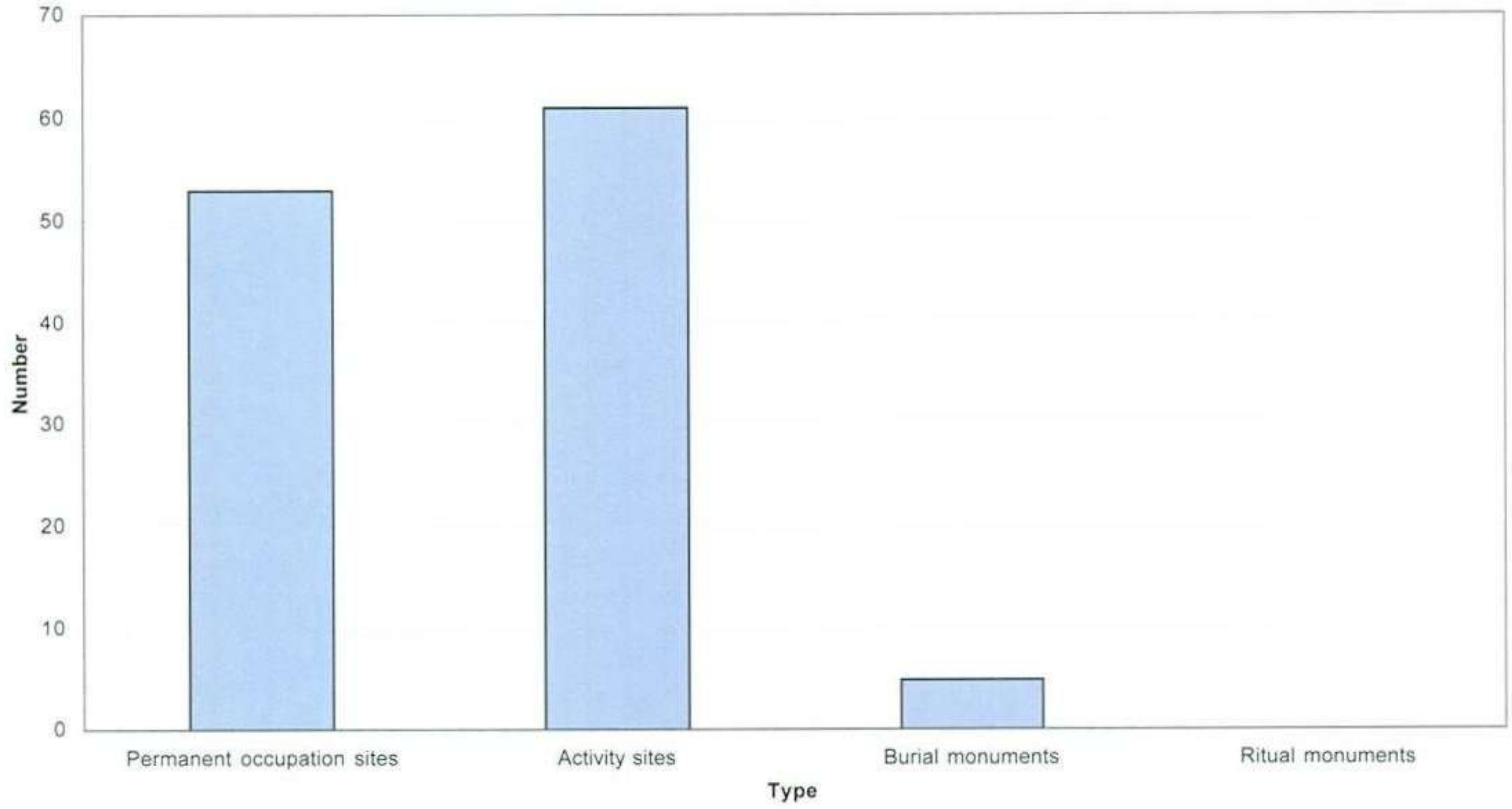

Figure 8.5. Graph showing the number of vulnerable sites, grouped by site type.

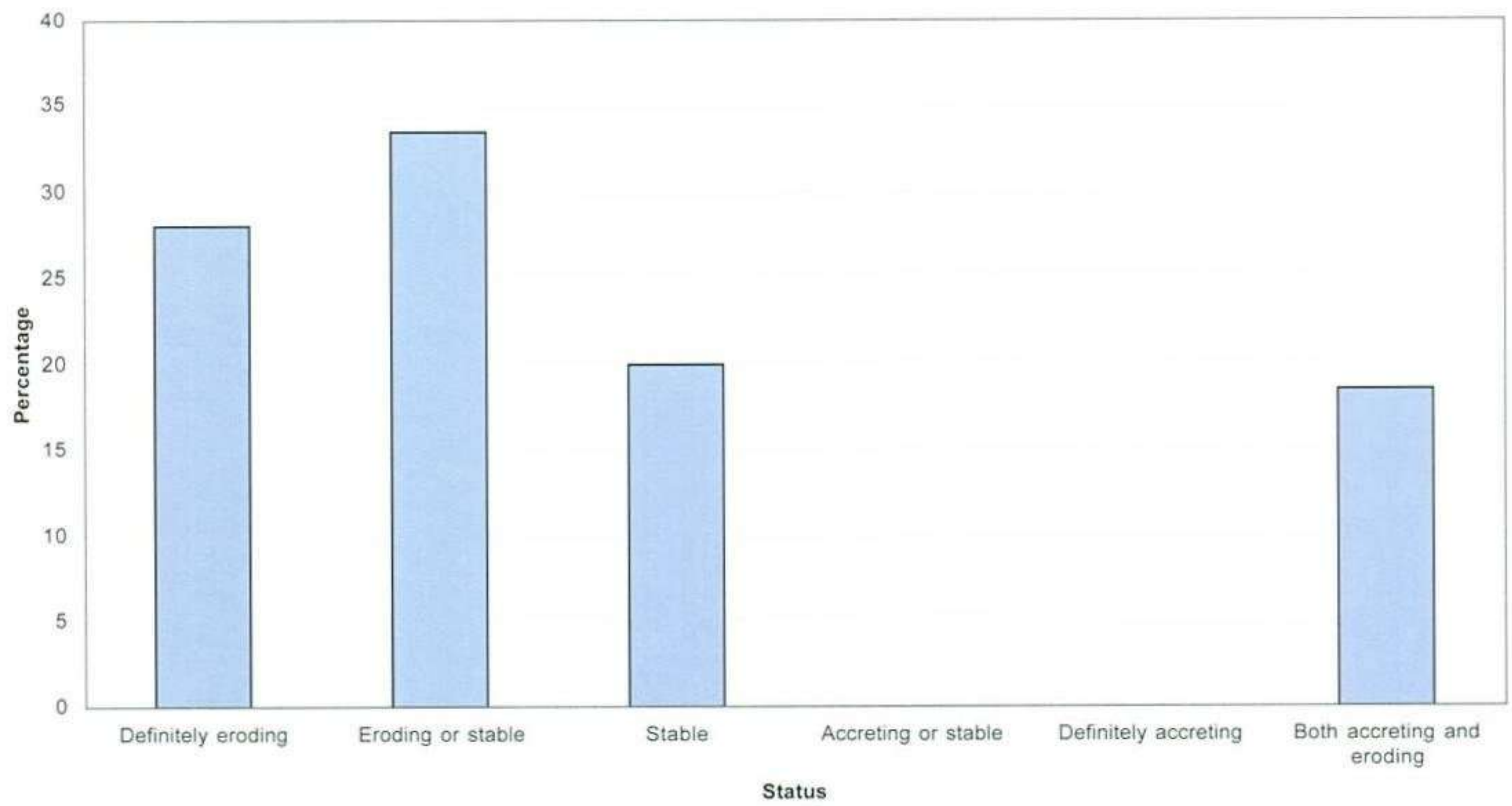

Figure 8.6. Graph showing erosion classes for the coastline surveyed.

but the essentially erosive character of the coastal environment is clear from Table 8.5 and Figure 8.6.

Erosion class	Length in km	% of length of coastline surveyed
Eroding	17.3	28
Eroding or stable	20.6	33.5
Stable	12.5	20
Accreting or stable	0	0
Accreting	0	0
Accreting or eroding	11.3	18.5

Table 8.5. The erosional status of Barra's coastline.

About 20 per cent of Barra's coastline can be said to be stable. These stretches lie mainly in the sheltered sea lochs. The surface lithology and the bedrock erode at very different rates, however, and this is reflected in significant differences in the threat posed to monuments at different points in the coastal zone.

Discussion

What is particularly interesting about the coastal erosion survey of Barra is that the sites and monuments found within the coastal zone can be compared to those on the island as a whole because the entire island has been surveyed. The gazetteer of sites and monuments on Barra (Branigan & Foster 2000, 2–41) lists 960 locations (plus 23 on the offshore islands of Fuday and Fiuay, which are not included here). The coastal zone surveyed represents approximately 4.2 per cent of the total area of the island.

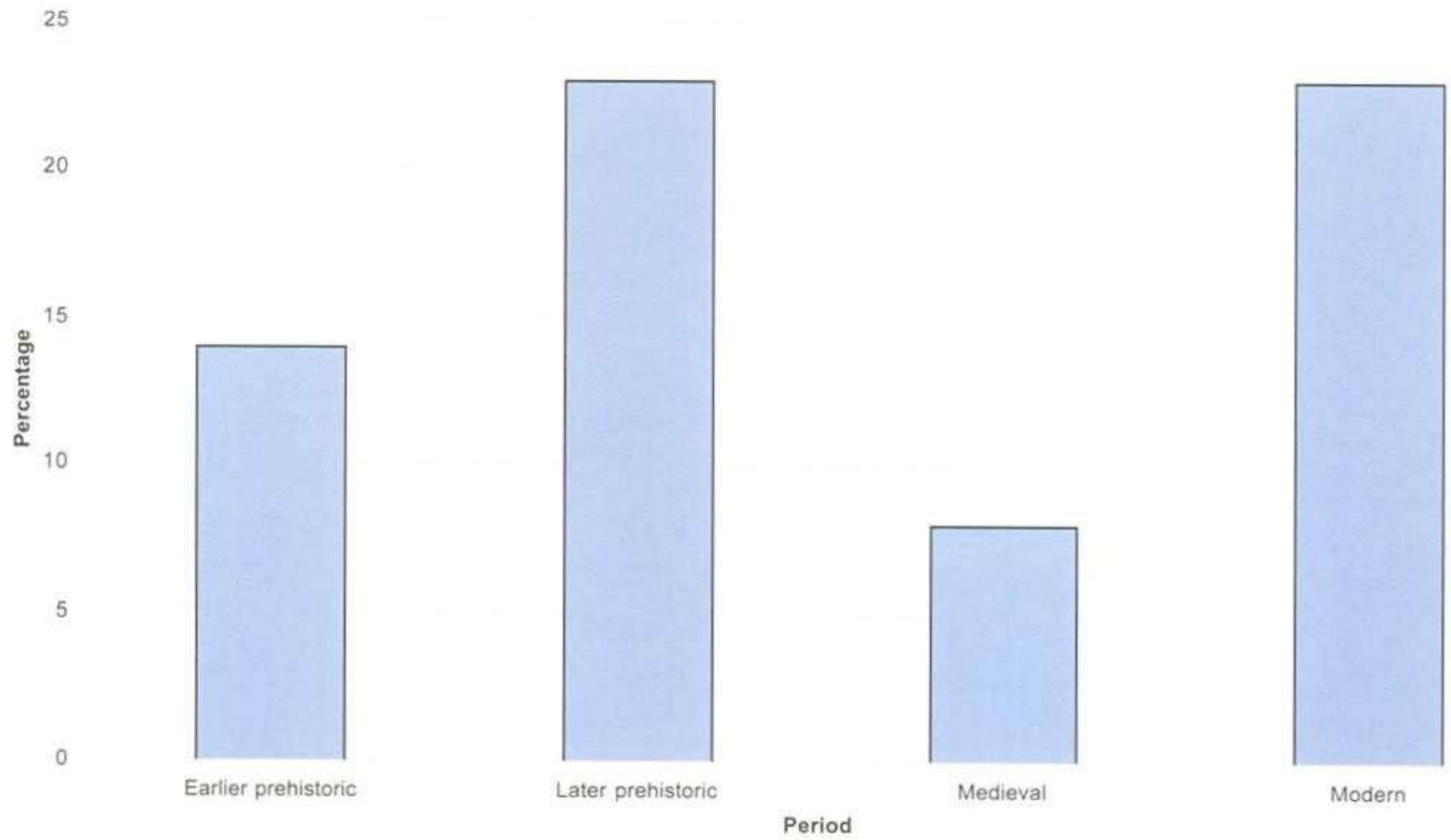

Figure 8.7. Graph showing the number of sites found in the coastal zone as a percentage of the total number located on Barra, grouped by period.

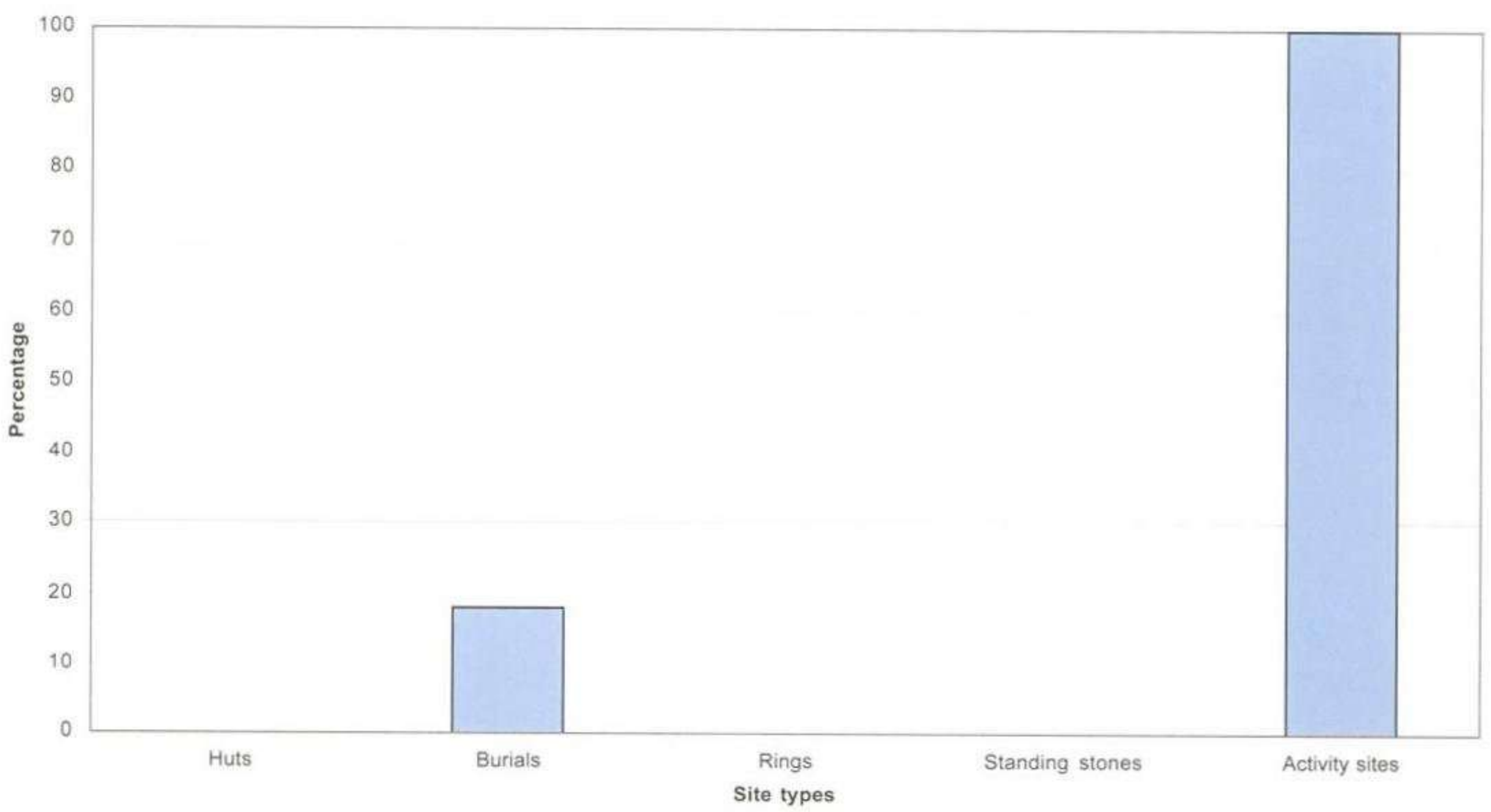

Figure 8.8. Graph showing the number of Neolithic–Late Bronze Age site types found in the coastal zone as a percentage of the total number found on Barra.

In contrast, the 220 sites and monuments recorded in the coastal zone represent 23 per cent of the total number recorded from the entire island. It is true of course that the coastal zone has been surveyed more intensively (the average spacing of surveyors here was 8–10 m, whilst in the interior it was usually 15–30 m). However, given the nature of most sites and monuments on Barra which, except on the machair, are represented by upstanding structural elements, we believe that few sites that are in any way visible on the surface have been missed. Even if we allowed for a 15 per cent rate of omission due to failure to discover inland sites, the number of sites and monuments in the coastal zone would still represent 20 per cent of the total for the entire island. It is reasonable to conclude, therefore, that the coastal zone is archaeologically rich and was a preferred zone for at least some types of human activity in some periods in the past. To clarify this further we can compare the density of sites in the coastal zone at different periods (Figure 8.7).

It can be seen that sites are relatively more frequent in the coastal zone than in the island as a whole during all four of our broad periods of time, and particularly during later prehistory and the modern era. We have to apply a caveat concerning the medieval period, because it is particularly difficult to ascribe unexcavated sites to this period. This is partly because the coastal zone has only a few monuments, such as castles and early churches, which obviously belong to that period and partly because we have tended to ascribe the vast majority of the ubiquitous shielings and shepherds' shelters to the modern period. It does seem to us, however, that taking into account the length of time occupied by each period, the Iron Age and the modern era have been periods of relatively high population on Barra. This may explain the relative density of sites and monuments in the coastal zone in these periods.

However, to better understand the variations in density through time and space we should also compare the density of different types of monuments in the coastal and inland zones.

Figure 8.8 shows the number of each of the five different types of Neolithic–Late Bronze Age monuments found in the coastal zone as a percentage of the total number found on the island as a whole.

It will be seen that although the sample numbers are small, none of the house sites (11), standing stones (5), or stone rings (6) are found within 50 m of the coast. The Neolithic–Late Bronze Age monuments in the coastal zone are burials (6 Early Bronze Age–Late Bronze Age cairns) and 'activity sites' (Figure 8.9). The 'activity sites' comprise three small sub-circular enclosures marked out by stones (eg see Branigan 1995, 170–6) and two midden areas apparently unassociated with structural remains. They seem to be associated in some way with exploitation of marine resources; the middens almost certainly with the cockles from the beaches at the north end of the island.

When we turn to the Iron Age, we have only various settlement sites to look at, but these provide some interesting contrasts (Figure 8.10).

Figure 8.9. Site E11, an oval 'activity enclosure' of possible Late Bronze Age date on the north coast of Barra. The soil has been eroded from the rock up to the edge of the enclosure, which was partially excavated in 1994.

We have identified four different types of roundhouses in Iron Age Barra: small round or oval houses up to 6 m maximum; large roundhouses over 8 m (and up to 12 m) diameter; and large roundhouses with substantial amounts of internal stone debris and evidence for piers or lintels – aisled houses. In addition, there are the brochs and duns, or Atlantic Round Houses. Whilst none of the 23 examples of small roundhouses are found in the coastal zone, 14 per cent of large roundhouses and 9 per cent of aisled houses are found here. Most significantly, no less than 58 per cent of the Atlantic Round Houses (mostly brochs but some variant thick-walled structures usually called duns) are located in the narrow coastal zone.

These are significant variations in distribution, the interpretation of which is complicated and must depend to some extent on our general interpretation of the

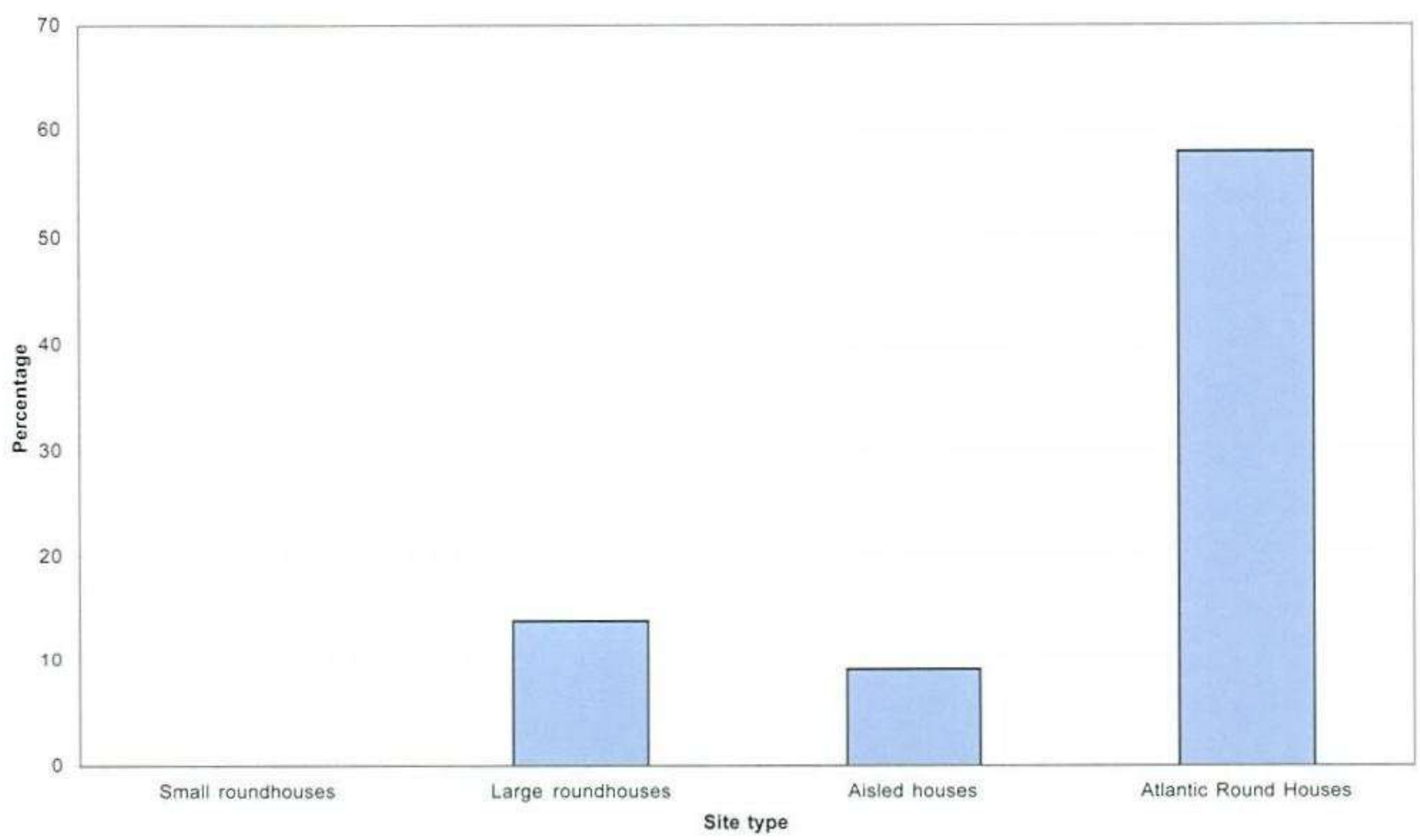

Figure 8.10. Graph showing the number of Iron Age settlements found in the coastal zone as a percentage of the total number found on Barra

social and chronological relationships between the various types of structure. Excavations at two sites on Barra have demonstrated that the small roundhouse appears no later than the Early Iron Age, and that the aisled house in at least one instance replaces a large roundhouse on the same site (Branigan & Foster 2000, 150, 224).

We also note that we have loose clusters which include on the one hand small and large roundhouses, and on the other small, large and aisled roundhouses (Branigan & Foster 2000, 344). It is tempting to suggest that large and small roundhouses were contemporaries in the Early Iron Age, possibly occupied by family groups of either different size or status, and that the larger houses were replaced during the Middle Iron Age by the aisled house. The aisled house is a far more complex structure architecturally, and possibly socially (Parker Pearson & Sharples 1998, 16–21) than the plain roundhouse. The same is true of the Atlantic Round House, which required an even greater input of time and labour to construct, and which seems to be broadly contemporaneous with the aisled house though appearing somewhat earlier in the Middle Iron Age. It appears that it is the larger and probably higher status buildings that appear in the coastal zone during the Iron Age, and that the most complex and prestigious of all, the Atlantic Round House, dominates the Iron Age settlement of the coastal zone for much of the Middle Iron Age.

Having said that, it is notable that the aisled house, found on the machair on the Uists, is found at inland sites on Barra, in some cases at well over 200 m above sea level. These locations require a different construction technique to those on the machair, with thick-walled, free-standing houses like Allasdale and Alt Chrisal replacing the single-skin, lined subterranean structures of the Uist machair.

The dominant site type amongst the 163 modern sites and monuments found in the coastal zone is the blackhouse (64 examples; Figure 8.11). In fact the coastal zone provides 40 per cent of all the blackhouses recorded on Barra. Various interpretations could be offered for this heavy concentration of blackhouses in just 4 per cent of the island's land area. It might suggest that the 18th–19th-century population of Barra was heavily dependent on fishing and kelping for their subsistence and to enable them to pay the rent for their crofts. We know that kelping was certainly a very significant economic activity on Barra from c 1770 to 1835 (Bumsted forthcoming).

But a closer look at the distribution of the 64 blackhouses within the coastal strip on Barra suggests another explanation for this concentration. In fact, 57 (90 per cent) of the coastal blackhouses are found in north-east Barra, which represents just 30 per cent of the entire coastal strip. This area includes the bleak Bruernish peninsula, North Bay and Ardveenish, and

Figure 8.11. Site L7, a blackhouse on the east coast of Barra. The southern wall has been breached by the scouring effect of the tide.

Figure 8.12. Site G9, Dun Clieff, on the west coast of Barra. Exposed to the full force of Atlantic storms, this tidal islet has been stripped of all soil except on the summit, where the walls of a late prehistoric structure cling to an increasingly precarious existence.

Loch Obe and Ruleos. These are areas to which we know crofters and cottars were cleared, initially in small numbers, by General Roderick Macneil around 1830, and then in larger numbers by Colonel Gordon of Cluny in 1848–50. Macneil may well have wanted a landless population clustered around his new 'chemical factory' at Northbay, where many would have been employed in processing the made kelp Macneil imported from the Clanranald estate (Bumsted forthcoming). Gordon shifted people from the machair of Eoligarry, Cleat/Greian and Borve to the east coast, where census data for 1851 demonstrates that the new population there were now fishermen and boat-builders. They replaced the crofters recorded in the 1841 census, who were shipped off to Ontario. In other words, the concentration of blackhouses in the coastal strip of north-east Barra can be directly related to the social and economic disruptions of the period c1830–50.

Recommendations

Six sites were identified to be the subject of a watching brief in our original report (Branigan & Grattan 1998, 92–4). These include features associated with the broch on Borve Headland, which are actively eroding into the sea, and the later prehistoric monument at Dun Clieff, which sits on a small tidal islet and is exposed to Atlantic storms (Figure 8.12). In addition, there is one site (on the tidal islet of Orosay at the north end of Traigh Mhor) for which we have repeatedly urged an assessment excavation. This is an extensive midden with traces of stone structures which forms an eroding mound about 35 m in diameter. It may be Iron Age, but six small and very fragile sherds found in the eroding face have their nearest parallels in the fabric of Beaker sherds from Alt Chrisal on the south coast of the island. This site should be investigated and assessed.

In more general terms, the dune systems at Eoligarry, Allasdale and Halaman Bay should be monitored regularly to identify any exposed archaeology. Eoligarry certainly has several sites currently visible within the dunes, and material has been recorded but is no longer visible at Allasdale. Apart from possible threats of mechanical cockle extraction or airfield runway works at Traigh Mhor, there are no foreseeable threats from human impact on the coastal archaeology at present. In a longer time frame, with the continued subsidence of the west coast of Scotland and the threat of rising sea levels posed by global warming, many of the sites identified in our coastal survey must be threatened with damage or total destruction.

Conclusions

The coastal erosion survey of Barra has revealed that there are areas of rapid erosion and areas of archaeological richness. Fortunately, they rarely coincide. The principal threats to monuments are on the west coast. The particular value of the Barra survey is that it was undertaken alongside a survey of the entire island. It therefore provides an opportunity to arrive at a better understanding of the relationship between the archaeology of the coastal corridor and its hinterland.

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9 ASSESSMENT SURVEY: NORTH SUTHERLAND (KYLE OF DURNESS TO TORRISDALE BAY)

KEVIN BRADY AND CHRISTOPHER D MORRIS WITH DEREK J MCGLASHAN

Introduction

The study area for this survey (Figure 9.1), conducted in autumn 1997, extended from the Cape Wrath peninsula to Torrisdale Bay (approximately 125 km). The mainland coastal strip was limited to the 50–100 m 'corridor' alongside the shoreline, together with the High Water Mark, and – where feasible – the intertidal zone. The difficulties of measuring any given length of coastline are considerable, and have been discussed elsewhere (see Ashmore 1994, 25–7). There is very little doubt that, given the highly indented and fractal coastline involved, the overall distance for the purposes of survey and fieldwork on the ground was considerably greater than that estimated at the desktop stage.

Previous Work

The northern Scottish counties were early recognised as having a rich archaeological and built heritage, as evidenced by the second and third reports of the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) being devoted to the 'Inventory of Monuments and Constructions' in this area (RCAHMS 1911a; 1911b). This was the first systematic ordering and account of the archaeology of this area 'from the earliest times up to 1707' (RCAHMS 1911a, v). These accounts have formed the basis for all subsequent work.

Additions to the record have been largely dependent upon individuals supplying information to the Ordnance Survey (OS), the local Sites and Monuments Record, or RCAHMS either directly to the National Monuments Record of Scotland (NMRS) or through entries in *Discovery and Excavation in Scotland*. Various OS surveyors had been active in the area in 1957, 1959, 1960, 1964, 1971, 1977, 1978, 1980, 1981 and 1983. There have been a number of overview papers (Henshall 1982; Reid *et al* 1982; Omand & Talbot 1982) and a guidebook for the county of Sutherland (Close-Brooks 1986/1995). Understandably, some of the more obvious prehistoric

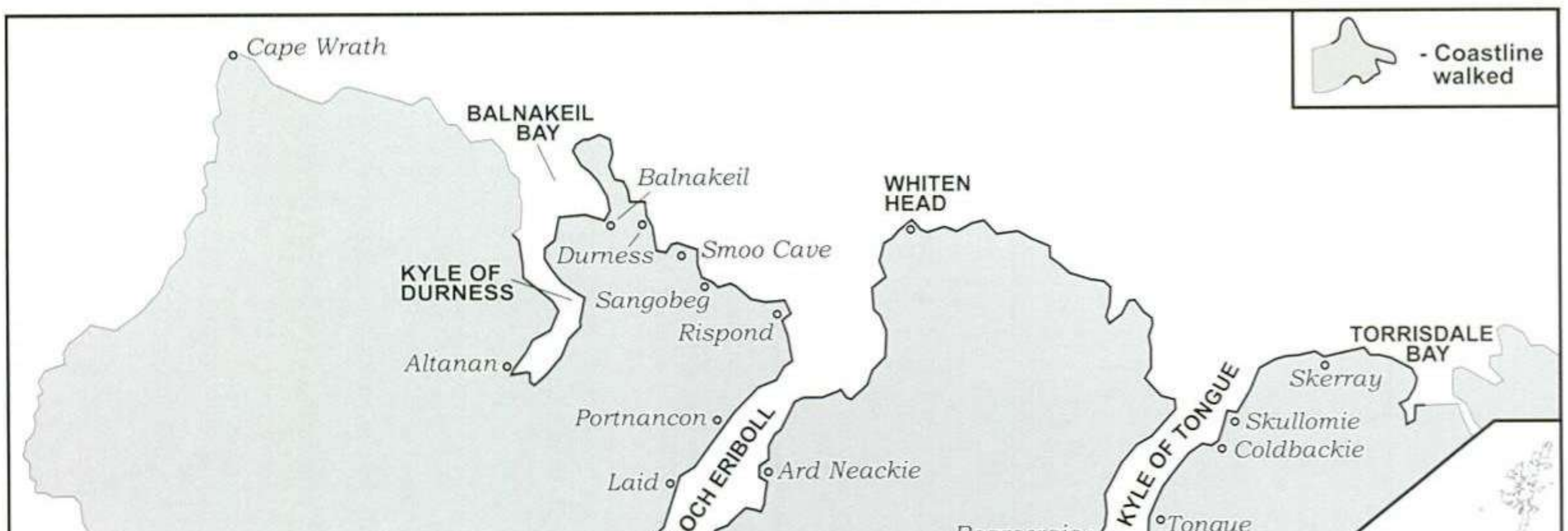

Figure 9.1. Location map showing the area of survey and places mentioned in the text.

monument types have generated specialist studies (eg Armit 1990; MacKie 1994; Henshall & Ritchie 1995). There has been some general interest in the Viking impact on the area (eg Small 1982; Batey 1993, 155–8; Cox 1994; Morris *et al* 1994, 152–3; Fraser 1995; Waugh 2000). Medieval or Later Rural Settlement (or MOLRS) studies have stemmed directly from the pioneering work of Horace Fairhurst (Fairhurst 1964; 1968; Fairhurst & Petrie 1964), and the follow-up to Fairhurst's approach in Strathnaver can be seen in more modern publications (Morrison 1987). Professor John Hume provided a pioneering study of industrial archaeology (1977), and Elizabeth Beaton considered some aspects of the building types and traditions in the area (1987; 1995).

Excavations and intensive survey have been few and far between (for example see Reid *et al* 1967; Pollard 1992; Morrison 2000; Low et al 2000).

Methods

The procedures adopted were standard for this type of survey. A background study complying with the methodology specified in the Historic Scotland *Archaeological Procedure Paper 4* (1996) was conducted, essentially to gather the primary information required prior to undertaking the fieldwork. The fieldwork procedure involved walking parallel transects along the coast, paying particular attention to the High Water Mark and the intertidal zone and the first break of slope inland from, and above, the High Water Mark. During the walk-over phase, the erosion class of the coastline was noted on the maps. The geomorphological information was gathered on-site during the archaeological survey by Derek J McGlashan or in the post-survey phase of the work using secondary sources.

The primary concern of the surveyors was to characterise each site accurately without engaging in elaborate surveying techniques. Essential measurements for dimensions, etc, were taken. Where the sites had been previously characterised, the emphasis was upon checking the earlier records. Within the overall site dimensions, significant details were checked and this was followed up with a brief description of the remains and their current condition. Usually, a sketch plan was added to the recording sheets, and a photographic record made where feasible. The sites were then added to the relevant map sheet copy.

A distinction was made between discrete sites within the coastal zone and broader cultural landscapes which extended beyond the coastal zone. In general, record sheets were completed for both sites and landscapes, although some of the features of the latter were marked upon the 1:10,000 (or 1:10,560) map sheets, and only the dimensions within the coastal zone were measured and recorded.

Analysis

Built heritage

Four hundred and eighty-five sites were recorded by the field survey. Of these, 107 (22 per cent) were already catalogued in the NMRS (September 1997). The remaining 378 sites (78 per cent) are newly recorded.

Twenty-two of the sites recorded fall into more than one period category, firstly, because of demonstrable reuse of an earlier monument, and secondly, because

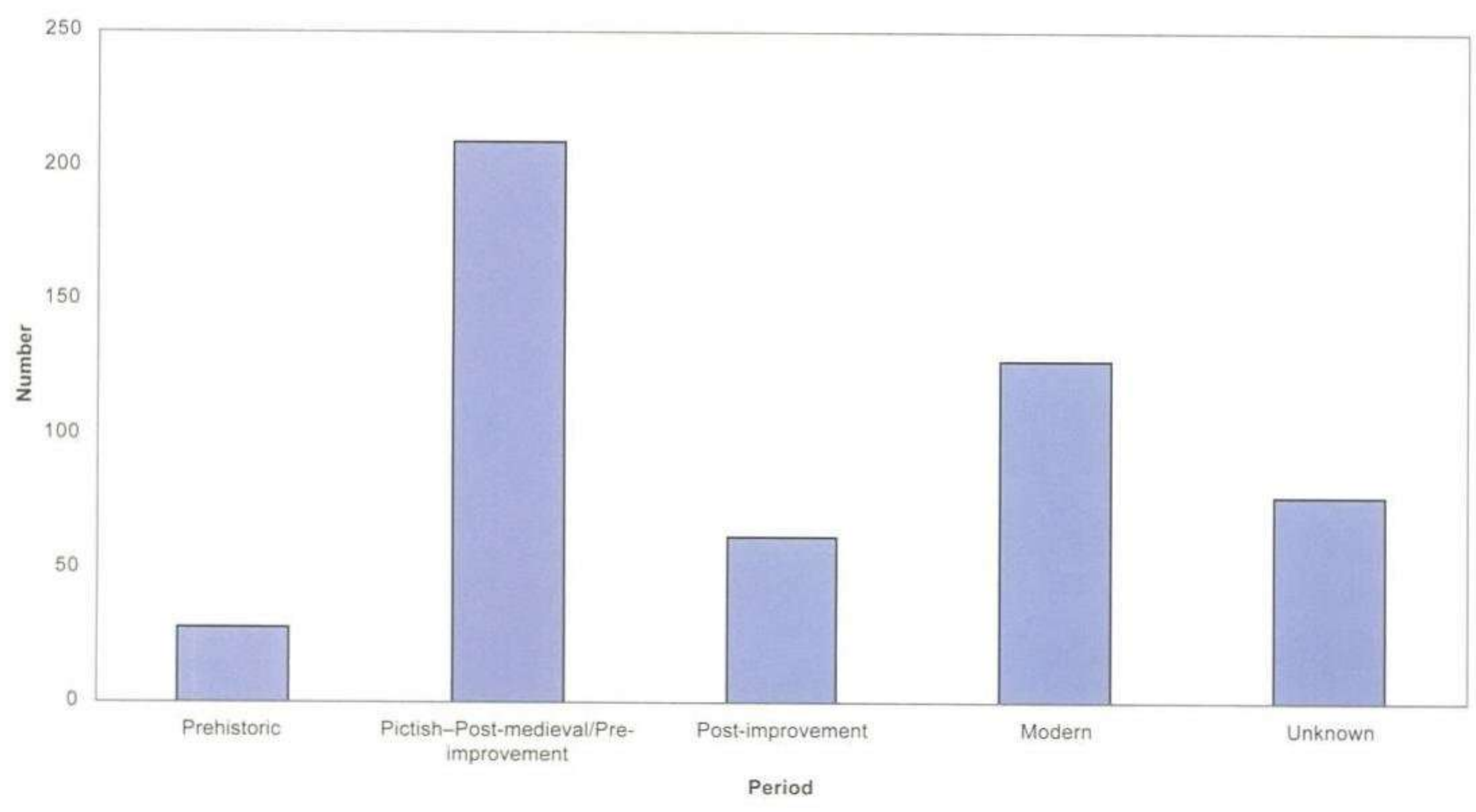

Figure 9.2. Graph showing the total number of sites located, grouped by period.

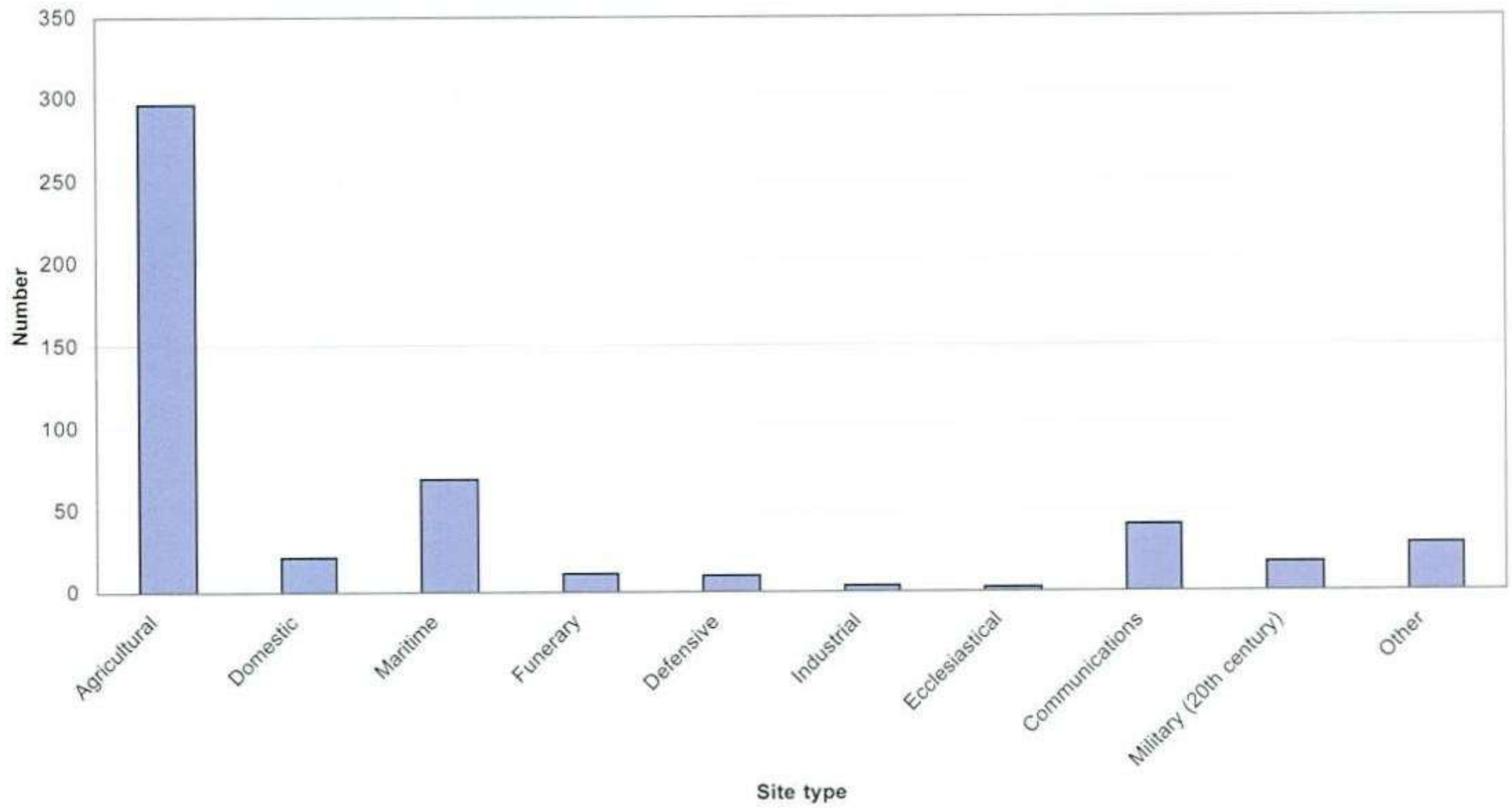

Figure 9.3. Graph showing the number of sites located, grouped by type.

some sites fit comfortably into widely divergent periods of time. In the statistical breakdown, these sites have retained a presence in each period category in which they have appeared. This gives a revised total of 507 sites. All subsequent percentages are taken from this total.

The following categories have been used to separate the sites into a broad temporal framework (Figure 9.2):

- *Prehistoric sites.* The majority of these sites were identified and classified prior to this survey. The term 'Prehistoric' is used to cover a period from the 5th millennium BC to c AD 600 (ie with the historically-attested advent of Christianity in the later Pictish period). Twenty-eight were so categorised (5.6 per cent of the total site population).
- *Pictish, Norse, Medieval and Post-medieval/Pre-improvement sites.* This category covers all sites from c AD 600 to the late 18th century. This is, in effect, most of the medieval period and the post-medieval sites up to, but not including, those sites of a clearly improved nature (see Crawford 1967). Two hundred and nine sites were categorised as consisting of elements considered to be within this broad period (41.6 per cent of the total site population). It is possible that this figure may be misleadingly high: many of the sites recorded in this category may be of later date, but with no characteristically post-improvement elements.
- *Post-improvement sites.* This category catalogues those sites which are 18th–19th century in date and clearly result from the changing practices of land-management brought in as 'improvements' by the Sutherland estate. Sixty-two sites were recorded in this category (12.3 per cent of the total site population).
- *Modern sites.* This category encompasses all 20th-century sites, many of which are at least partially still in use. Special attention was paid to the increasingly ephemeral military sites remaining from World Wars I and II. One hundred and twenty-seven sites were recorded in this category (25.2 per cent of the total site population).
- *Sites of Unknown Date.* Seventy-seven sites which could not be securely fixed to any of the above categories, or that were in any way ambiguous, were not categorised as to period (15.3 per cent of the total site population).

For consistency with other papers in this volume, Figure 9.3 attempts to categorise all sites recorded by type. Whilst certain categories such as 'funerary' are clearly definable, many others are not. There is a considerable degree of overlap between the categories presented here. The largest category is 'agricultural' representing some 59 per cent of the total. 'Domestic' represents only 4.4 per cent of the total. This creates a somewhat confusing picture as many of the elements grouped in the general 'agricultural' category, had domestic elements. Similarly, many of the sites recorded in the 'agricultural' category, for example hollow-ways and possible drove roads, could just as easily have fitted into the 'communications' type. Visibility and clarity of site definition have been a problem for almost all the researchers engaged on these coastal surveys. However, the authors felt that far more intensive fieldwork would be required to examine the use of the landscape through the millennia and thus safely begin to break down those elements into a more

Figure 9.4. Causeway across the Kyle of Tongue.

detailed pattern. As argued in the conclusion to this paper, more concentrated survey outwith the 50–100 m parameter set for this exercise is required in order to understand fully the component parts of the wider agricultural landscapes encountered. The high number within this category simply reflects the fact that the survey was conducted in a rural area (as further evidenced by only 0.8 per cent of the total site population being considered 'industrial') and close to the sea (the second largest category being 'maritime' at 13.5 per cent, representing everything from wrecks to landing places to fishing stations).

Vulnerable sites

The sites most threatened with destruction by coastal erosion processes are the 53 sites (10.5 per cent of the total site population) located either partially or wholly within the intertidal zone, or the 64 sites (12.7 per cent of the total site population) located at the High Water Mark.

Many of the 53 sites within the intertidal zone were built to be within the zone and, as such, their presence there is not taken as a consequence of erosion. However, many of them are seriously deteriorating. The monumental pier at Skullomie provides a graphic illustration of such a site being destroyed by wave and storm action. Many of the sites associated with the, now redundant, ferry-crossing at Tongue are also being destroyed, possibly by the change in tidal pattern brought on by the construction of the vehicular causeway (Figure 9.4). These sites present their own particular problems in that their very nature demanded they be built where they were, yet their location is ultimately leading to their destruction, although not necessarily in an area with a general erosional problem. Other sites located in the intertidal zone clearly signify an area where land has recently been lost to the sea. This is marked along the west shore of Loch Eriboll where dykes are now partially below the High Water Mark. Whether grazing pressure has depleted foreshore vegetation and allowed the sea to break further back on the hinterland at places like Laid is a matter of conjecture and longer-term analysis is required.

Many of the 64 sites located partially or wholly at the High Water Mark are nearer the sea now than when they were constructed and are clearly under threat of at least partial destruction. The potentially very important Late Norse site at Sangobeg is close to total destruction from both marine incursion and hinterland riverine action (Figure 9.5).

The dykes and field-system associated with Boarscaig are now at the High Water Mark and the erosion-scars appear fresh. Whether this is due to saltmarsh depletion brought on by overgrazing is unclear. Again, the construction of the vehicular causeway across the Kyle may have altered the rate at which the sea flows out of the south half of the Kyle of Tongue, thus leading to increased pressures on the shoreline. A long-term study of the effects of the causeway on both tidal patterns and sediment distribution is required and, indeed, eagerly sought by many local residents. The

Figure 9.5. Eroding Norse site at Sangobeg.

patterns of erosion in Loch Eriboll and the Kyle of Tongue are mirrored in the Kyle of Durness where sites like Altanan are now at the High Water Mark and erosion-scars are fresh.

Only 0.8 per cent of sites deemed vulnerable fall within the prehistoric category (Figure 9.6). This probably reflects the low overall percentage of prehistoric sites. Past climatic and coastal changes may be responsible for this low density. Factors such as fluctuating sea levels may have destroyed settlement evidence which had survived in sheltered areas, such as at Smoo Cave. The Pictish through to post-medieval/pre-improvement category has the highest percentage of vulnerable sites (36.8 per cent). Many of these sites represent isolated elements of the general agricultural landscape (eg dykes). Other sites are potentially extremely important. The possible Late Norse midden and structural elements recorded at Sangobeg Sands had badly eroded at the time of the survey and are not expected to last many more winters. Large numbers of the post-improvement and modern category sites (22.2 per cent and 24.8 per cent respectively of the total number of vulnerable sites) are deemed to be in danger from erosion. This may reflect the greater use made of the sea in these periods, with more structures being built at the High Water Mark and in the intertidal zone.

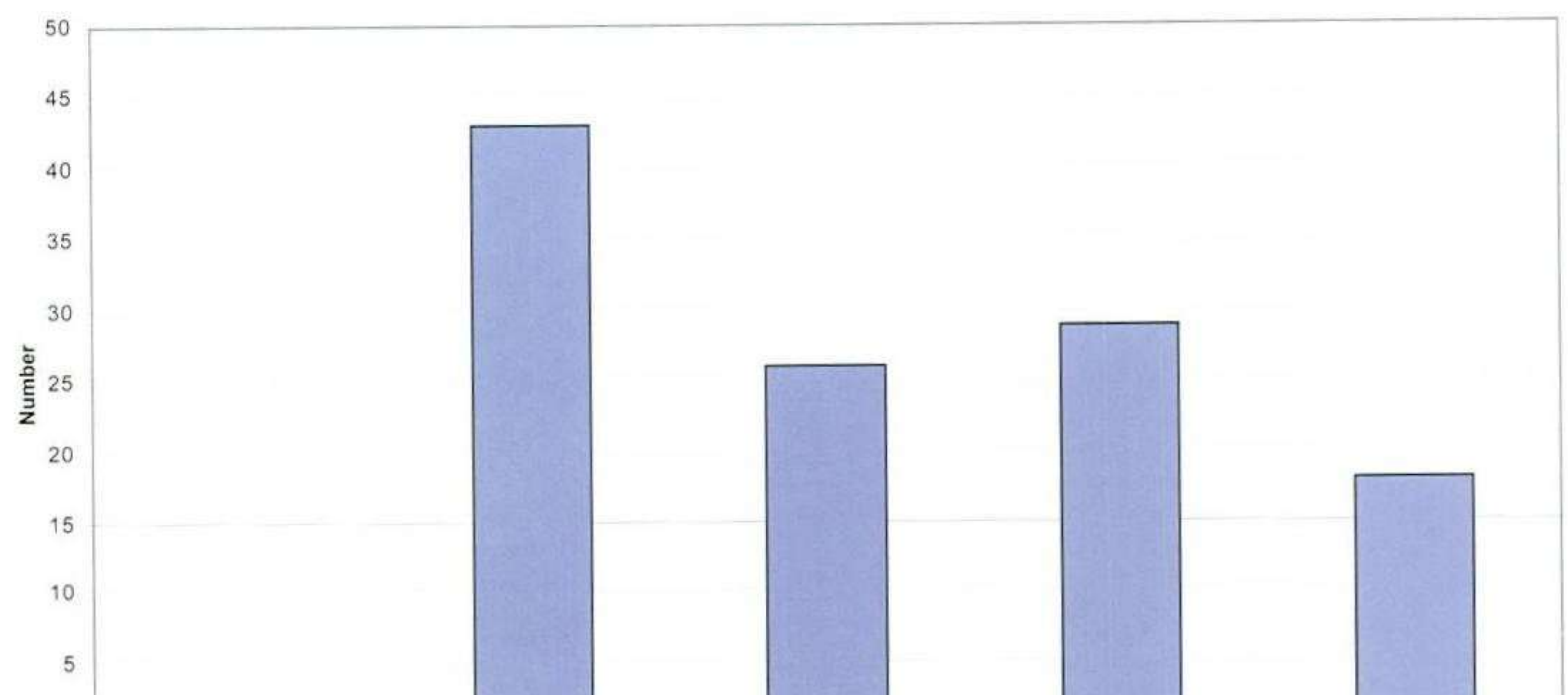

Figure 9.6. Graph showing the number of vulnerable sites, grouped by period.

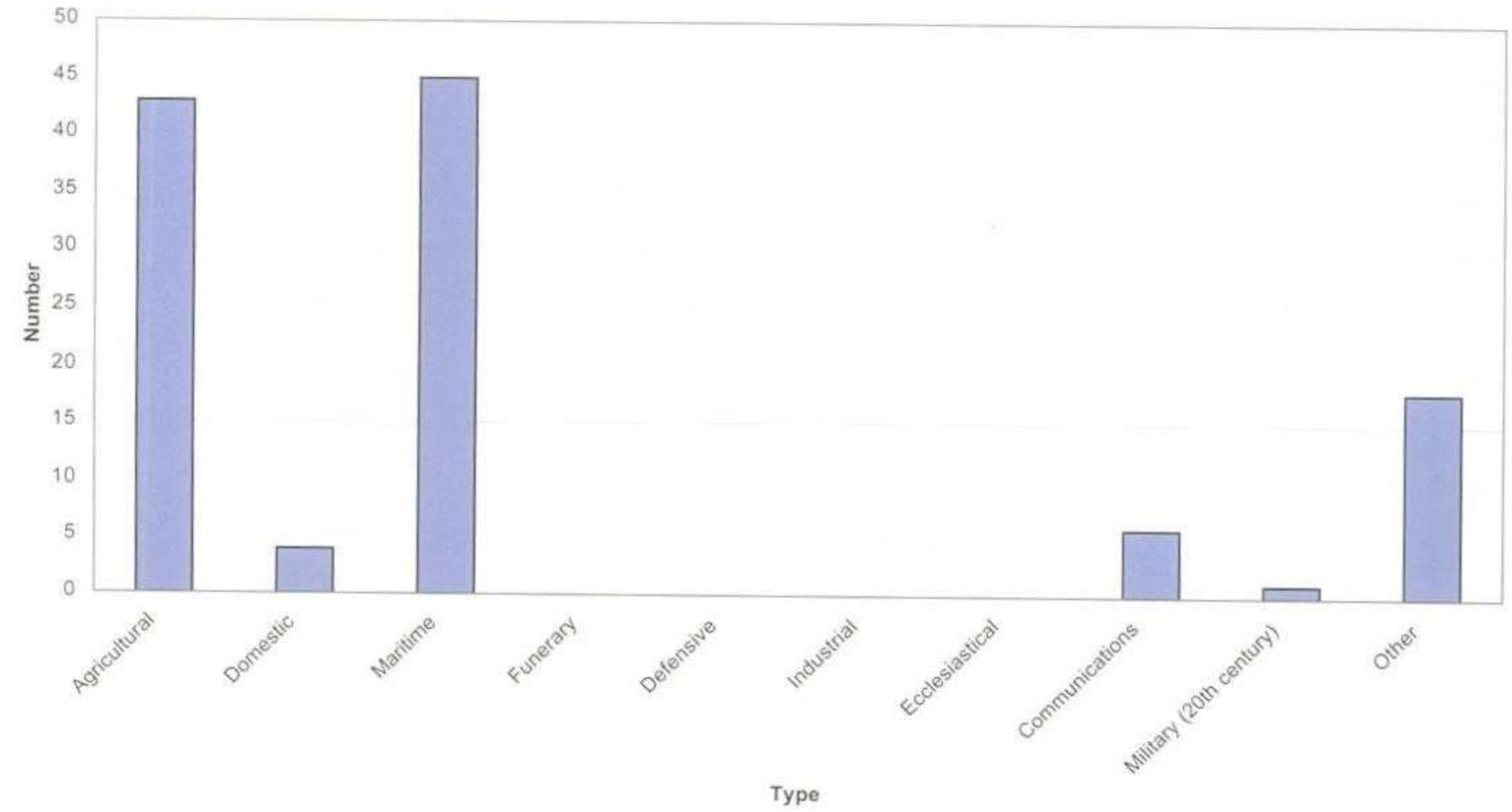

Figure 9.7. Graph showing the number of vulnerable sites, grouped by type.

The vulnerable sites by type category (Figure 9.7) is dominated by maritime sites (38.5 per cent of the total). This is hardly surprising given that such sites are built at the High Water Mark or even within the intertidal zone. However, there is some evidence that modern factors are exacerbating the erosional problem at places such as the Kyle of Tongue (Figure 9.8 and see below). The grandiose estate buildings at the fishing station of Rispond are also deteriorating due to lack of use as the harbour and sea-defences are not maintained sufficiently to stop storm inundation. Again, the agricultural category provides a large number of threatened sites (36.8 per cent of the total). The heterogeneous nature of this category has been explained above and this is reflected in the different elements threatened: limekilns, mills, fields, and indeterminate structures.

Figure 9.8. Eroding foreshore at the west side of the Kyle of Tongue.

Geological and Geomorphological Context of the Northern Sutherland Survey Area

Derek J McGlashan

The North Sutherland area is at the extreme north-west section of the British mainland and has an interesting and varied geology. The different rock types have varying resistance to erosion, and react in different ways to particular processes. In general, the sedimentary rocks suffer more from erosion than the metamorphic rocks. Especially spectacular forms occur in the Durness Limestone, with Smoo Cave being a classic example of a well-developed cave-system. The Durness Limestone also lends itself to the formation of geos, which are common along this coast (Steers 1973). Sandy bays are often found where different rock types meet, one type being more easily eroded than the other: Coldbackie is a classic example of this. The study area crosses the Moine Thrust, an impressive geological feature of Late Ordovician – Mid Silurian age which runs south-south-west from Whiten Head, separating the Hebridean (Foreland) Terrane from the Northern Highlands Terrane. The Hebridean (Foreland) Terrane has a basement of Archean and Early Proterozoic rock which is unconformably overlain by generally undeformed fluvial and lacustrine sediments of mid–late Proterozoic age, again overlain unconformably by early Cambrian-Llanvirn quartz arenites and carbonates. The Northern Highlands Terrane is described as exhibiting 'complex polyphase deformation and metamorphism' in the early Proterozoic (1600–2500 Ma) fluvial-shelf Moine sediments. The Moine Thrust closed orthogonally and had a displacement in excess of 100 km (Dr K Ingham pers comm).

The landscape in this area is dominated by the spectacular scenery inherited from the last (Devensian) glaciation. The result of this is a landscape characterised by glacial overdeepening and watershed breaching (Sutherland 1994). Contrary to popular belief, the mountains of the north-west Highlands were not covered by ice during this period (McCarrol *et al* 1995). In general, for this study area, the movement of ice was in a northerly direction (Sutherland 1994) and exhibits a landscape of glacial scour, creating 'knock and lochan topography' (Linton 1963; Rea & Evans 1996). The current coast was at that stage covered by ice, with the coast during the glacial maximum being many miles to the north (Price 1983; Dawson 1992). The height of relative sea level has fluctuated considerably since the Devensian (Shennan *et al* 1996; Dawson & Smith 1997), which is due to the extent, thickness and form of the ice (Evans 1991). In many areas of the United Kingdom, the land is still reacting to the removal of the last ice-sheet. The mountains of the north-west Highlands, for example, are, in general, rising (relative to the level of the sea), while other areas are sinking, for example, southern England and the Outer Hebrides. Sutherland is outwith the zone of falling sea levels, as depicted in Carter (1988), therefore relative sea level in the study area may be stable, or rising slightly. As yet, there is no accurate data relative to current sea level fluctuations, as the data has not been collected for long enough in an area close enough to yield accurate results.

Erosion

Much of this coast consists of hard rock cliffs, and so is not liable to be eroding at a rapid rate (Figure 9.9). However, a number of areas have a more dynamic nature, for example Balnakeil Bay. These areas require more accurate studies to determine longer-term trends affecting their stability. In general, most of the 'softer' coast exhibited some evidence of erosion, which may either be due to a recent storm event or be part of a longer-term trend. There were few areas where major changes could be identified as readily as at Coldbackie. The changes there are very interesting, and highlight questions regarding sediment movement and the causeway at Tongue. Again, this requires (and deserves) further study. The majority of the sand dunes had areas of recent vegetation colonisation, and some had embryo dunes evident (eg Coldbackie). This would suggest a recent influx of sediment, which again could be due to recent weather conditions as opposed to a longer-term trend in sediment availability. In many areas, erosion appears to be caused, or exaggerated by, grazing or trampling by tourists, and at Skerray the sea wall protection could well be a factor causing, or increasing, the erosion elsewhere in the bay. The results of the field observations of the erosional state of the coastal zone within the survey area are presented in the Figure 9.9.

This was a small, short-term study. More detailed analysis could only be achieved with a longer-term, more accurate study. What must be remembered is that this is an assessment of the coastal stability, it is not an environmental assessment or a rehabilitation guidance note. If further work is to be done at the coast involving protection structures, or the removal or destruction of features, a more detailed assessment and management prescription is likely to be required.

Discussion

The principal aim of this survey was to document the built heritage and archaeology of the coastal zone and to assess the impact of erosional processes upon the cultural heritage. This involved a visual inspection and rapid recording of a coastal strip 50–100 m wide above the High Water Mark and the intertidal zone below. Four hundred and eighty-five sites were recorded, 378

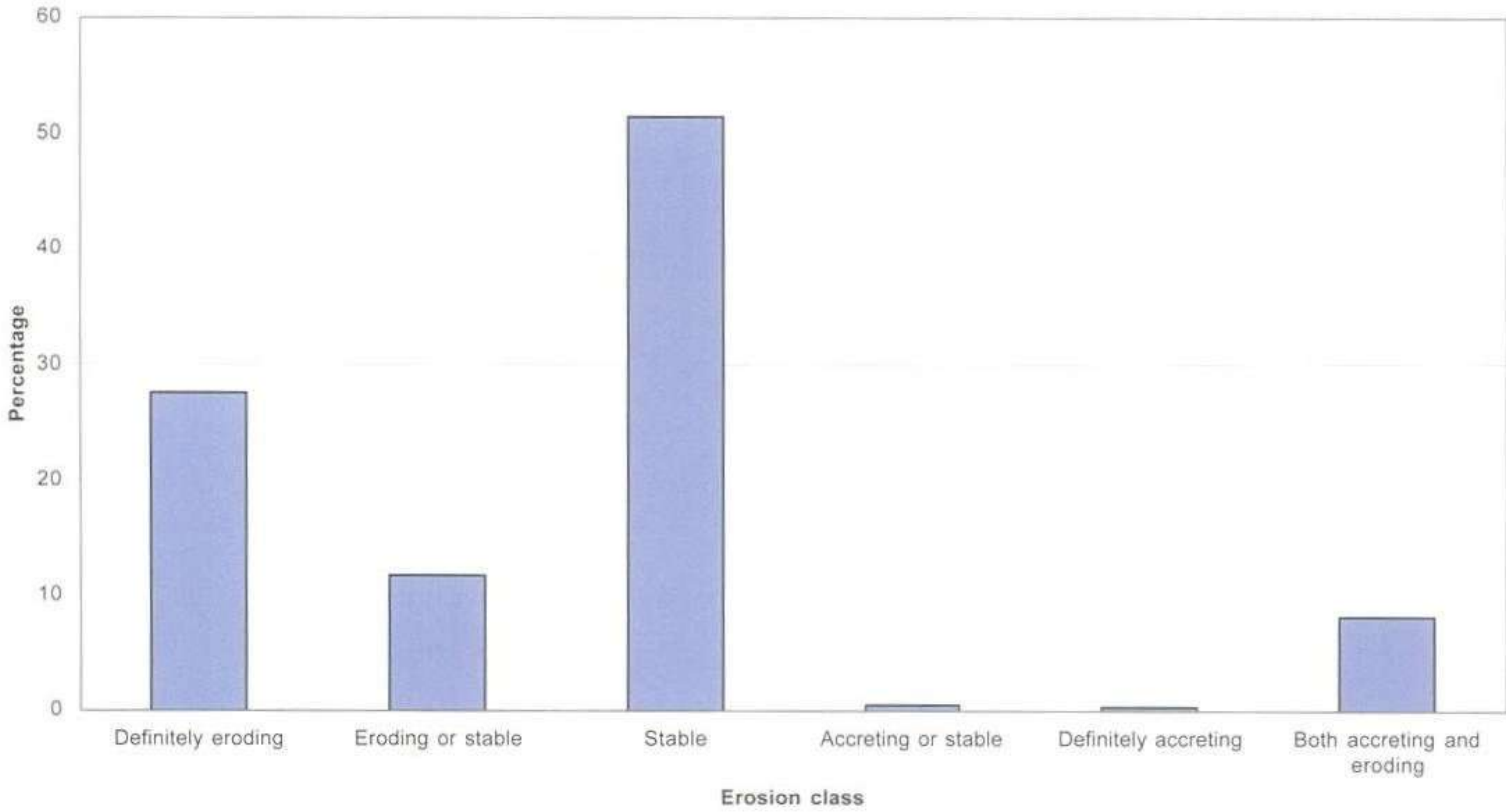

Figure 9.9. Graph showing erosion classes for the coastline surveyed.

(78 per cent) of which were newly added to the overall archive. The range extends from prehistoric sites (up to c AD 600) to those relating to the recent past. The majority of the sites are from the historical periods, especially the post-medieval, post-improvement and modern periods, although there are significant additions to the understanding of earlier periods. Only 22 sites have some degree of 'official' protection at present (4.5 per cent).

The nature of the survey, being necessarily rapid, did not allow for particular areas to be visited more than once or to be visited at different times in the tidal cycle. Multiple visits at different times of the day and in different seasons of the year would be a basic requirement in order to produce a definitive document. It should be borne in mind, therefore, that any conclusions drawn here are tentative and that the true value of this analysis will be as a comparative study for more intensive future work.

Of the 28 sites (5.6 per cent) which appear to be prehistoric, ten are newly recorded. The earliest site recorded was a potentially Mesolithic midden at Smoo Cave, but the range extends through Neolithic/Bronze Age (7 cairns), Bronze Age/Iron Age (6 hut-circles) to Iron Age (4 brochs, 3 promontory forts, and a souterrain). This survey thus complements the detailed survey work and associated excavations undertaken over three decades ago on the prehistoric archaeology of Durness Parish (Reid *et al* 1967).

Two hundred and nine sites (41.6 per cent) have been assigned to a category covering the 7th century to late 18th century, ie medieval and post-medieval (although it is conceivable some may be later). A putative Early Christian monastery (Figure 9.10), a Viking grave, a Viking or late Norse midden, possible Late Norse structures and midden, a medieval tower house and 11 other sites may come from the medieval period. Within their regional context, each of these is extremely important - and the small concentration of Viking and Late Norse sites in the Durness area is particularly significant in providing back-up to the linguistic heritage of the area as reflected in place names (Waugh 2000, 13–23).

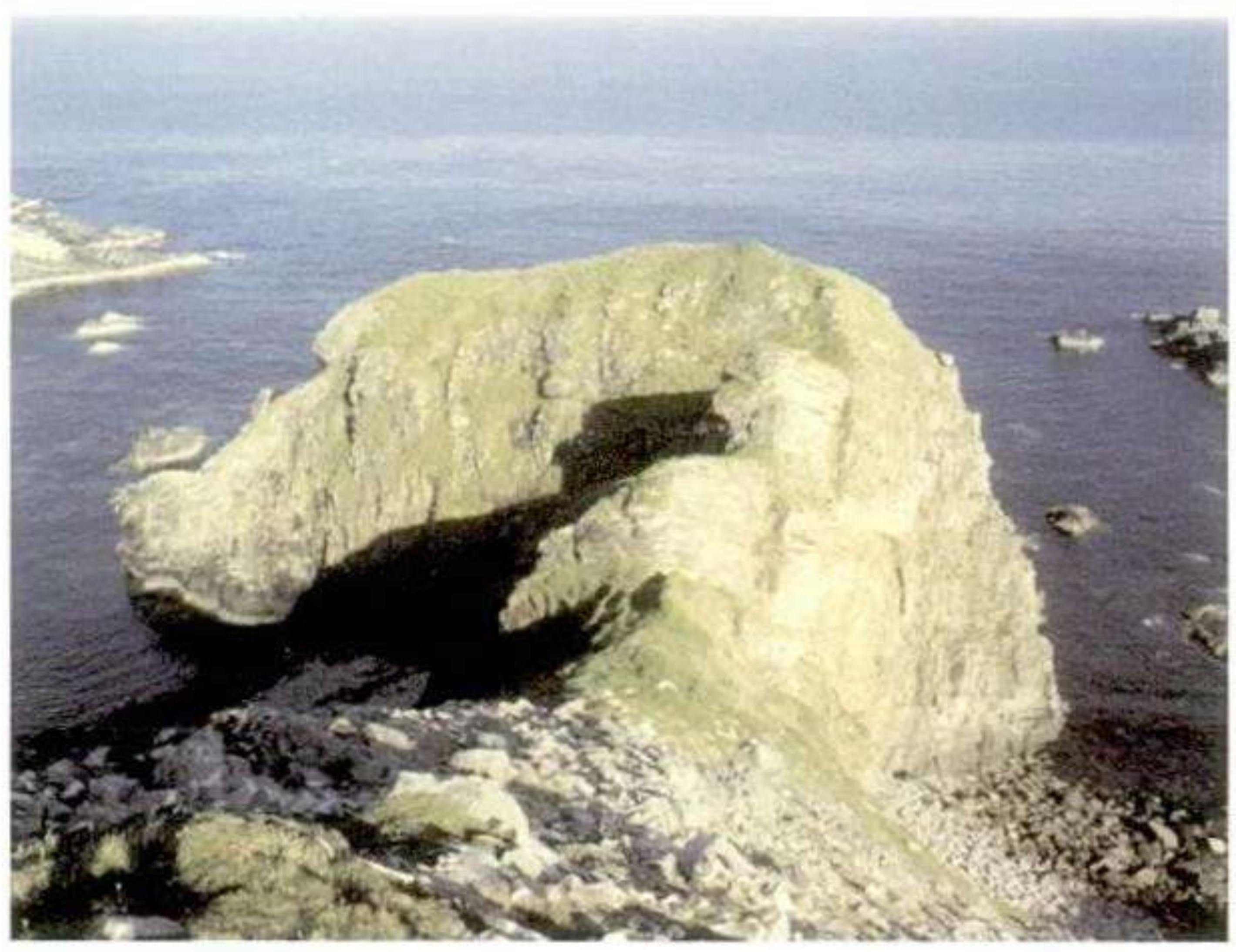

Figure 9.10. Aodhan Mor, a putative early Christian monastic site.

The vast majority of the sites form elements of the general agricultural landscape, sometimes surviving in a remarkable condition from the post-medieval period, although – apart from the deserted settlement at Kinloch – many of the accompanying buildings appear to have disappeared. These are of significance in relation to general discussions about MOLRS (Hingley 1993), and may in several cases mask land-use patterns from an earlier period. Of the higher echelons of society (and their built heritage in the post-medieval period) little is visible, apart from the foundations of Tongue House, Balnakeil Church, and a burial ground at Skerray.

Sixty-two sites (12.3 per cent) are considered to be characteristic of an 18th–19th century post-improvement landscape, associated with the activities of the Sutherland estate. Of particular interest here are the township of Laid, the fishing-stations of Rispond and Portnancon, the industrial site of Ard Neackie, the harbour at Skullomie, 22 other marine sites, and the grand houses at Balnakeil and Tongue.

One hundred and twenty-seven sites (25.2 per cent) are categorised as modern. These include nucleated settlements such as Durness, at the coast, as well as other landscape features and a number of sites associated with the crossing of the Kyle of Tongue. However, the largest sub-group of sites within this category is that associated with military activity, both World War II and more recent. Many of these are in poor condition and merit comprehensive survey in the near future.

Seventy-seven sites (15.3 per cent) were categorised as being of 'Unknown Date', although there is little doubt that over 70 per cent of these relate to the general agricultural landscape. These, and the remaining sites in this category, simply require more comprehensive attention within a broader landscape survey setting.

It is estimated that 52.4 per cent of the coastline examined was currently in a stable condition (or accreting). This undoubtedly reflects the large stretches of coast with high rock cliffs. However, several significant areas of this stretch of coastline are actively eroding (39.4 per cent), especially around low-lying parts of the north–south indented Lochs and Kyles of Durness, Eriboll and Tongue, with particularly vulnerable sand dune areas on the exposed north-facing coast between these Kyles. Indeed, most of the 'softer' coast exhibited some evidence of erosion (the remaining 8.2 per cent was both accreting and eroding). Major problems are clearly experienced at, for instance, Balnakeil Bay, Sangobeg, Coldbackie and Skerray.

A significant number of sites were recorded in low-lying and exposed positions (53 in the intertidal zone and 64 at the High Water Mark: 23.2 per cent of the total), which would be vulnerable to changes in climatic regimes and/or sea level changes. When this is considered in the context of an estimated 39.4 per cent of the coast actively eroding, there is clearly a potential major problem. The dramatic find of a Viking burial in Balnakeil Bay in 1991 (Low *et al* 2000, 24–34) exemplifies the vulnerability of archaeological deposits in such positions and the unpredictability of exposure; less immediately dramatic, but no less important, are the severely eroding deposits at Sangobeg, which appear to contain remnants of Norse settlement. However, although the 'soft' coastline is particularly vulnerable, the deteriorating condition of the later monumental pier-site at Skullomie shows that other areas also have problems. The experience of the impact of changes in tidal pattern at the Kyle of Tongue and the west shore of Loch Eriboll clearly demonstrates the need for vigilance in monitoring the effects of modern 'improvements' at the coast-edge. Other, natural, forces which have not been exacerbated by man-made structures, are clearly also at work. This is demonstrated in the Kyle of Durness where, for instance, the interesting site of Altanan, originally well above the shoreline, is now at the High Water Mark and eroding.

It is evident that this area, with the exception of the Durness Parish sub-area (studied over 30 years ago), has received little attention in the past and that, despite its apparently remote situation on the mainland of Scotland, its archaeology and built heritage are of considerable importance. There is an interesting range of sites of all periods, although the area's greatest contribution in terms of sheer numbers may be in terms of landscape exploitation and settlement evolution in the historic periods: it has an enormous potential for contributing to understanding of MOLRS and the improved landscape. However, the small numbers of early prehistoric and Viking/Late Norse sites have a significance out of proportion to their numbers. Even the World War II sites are of vital significance in the overall picture of 'The Defence of Britain' project.

Recommendations

Sites within the intertidal zone and those at the High Water Mark together represent almost 25 per cent of all the sites recorded by the survey. Individual sites such as Sangobeg require urgent attention in the form of a rescue excavation to salvage what little is left of the cultural landscape (Brady forthcoming). Whilst such drastic action is the exception, there is little doubt that much of the archaeology and built heritage of the Sutherland coastal zone require further attention. Monitoring of many of the sites listed in the gazetteers of the full report (Brady & Morris 1998) is recommended and advisable. This would most sensibly be done against a background of further and more extensive surveys which could fit the coastal elements of extended settlements into their wider geographical and cultural context. The monitoring of the stability of the coastline itself must be ongoing. It is only through regular and systematic observance in the field that trends can be established and satisfactory conclusions drawn. The almost total lack of previous geomorphological work in the survey area has seriously limited the qualitative conclusions which can be drawn from this programme of work. This is also true for the level of previous archaeological work in the area.

The implications are obvious: in general a more detailed survey (outwith the 50–100 m parameters) that puts these coastal sites into their broader topographical and chronological settings is required in purely research terms. This is as true for the World War II material as for the early prehistoric. However, there is an imperative in relation to a number of the sites on this coastline. Unlike the relatively small number of sites under threat in Long's Wester Ross survey (only 5 listed: Long 1996, 118–9), here there are many. Some of these are of major, if not outstanding, importance and should not be left to deteriorate (some at a rapid rate) without at least a more comprehensive record by survey, and in a few cases by excavation. The recommendations for each individual site are given in the relevant gazetteer entry in the full report (Brady & Morris 1998), and in many cases these are of some urgency. But, as is clear from that report, sites within the sub-areas of Balnakeil Bay, Sangobeg, Coldbackie and Skerray, where there is either rapid erosion or particular problems evident, merit (or even demand) immediate attention.

Further, it is clear from both McGlashan's initial geomorphological report (1998), and from the sections excerpted into this paper, that a more comprehensive coastal stability survey is required, against which to place the archaeological and built heritage material and to judge the medium- and longer-term threats to them as well as the immediate short-term problems.

Similarly, this area requires a more intensive examination under less stringent parameters than are delineated by *Coastal Zone Assessment Survey: Archaeological Procedure Paper 4* (Historic Scotland 1996). Inevitably, parameters which emphasise speed of survey, a basic level of recording and maximum coverage present problems in the execution of the work. Both the Wester Ross survey (Long 1996) and, more particularly, this North Sutherland survey, have had to overcome a lack of even basic information since very little work had previously been undertaken in these areas; as a result the surveyors had a far less developed database than would normally be expected, upon which to build. The large number of sites (and the extremely large proportion of newly recorded sites) in North Sutherland stretched resources to the limit within the parameters, a factor which was exacerbated by working in a region of Scotland where terrain and climatic conditions can often be extreme.

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10 ASSESSMENT SURVEY: ULLAPOOL TO LOCHINVER

ANDREW LONG

Introduction

In August 1996, Andrew Long and Associates undertook a systematic coastal assessment survey (henceforth referred to as the ULCAS) of the coastal littoral between the towns of Ullapool and Lochinver, Highland Region. The project was funded by Historic Scotland through Glasgow University Archaeology Department. Consistent with other coastal assessments funded by Historic Scotland at this time, the principal aims of the study were to collect data on the nature, distribution and significance of the built heritage and archaeological record of the coastal zone, and to assess the geomorphological processes likely to affect their future preservation.

A total of 93 km of coastline was surveyed, including the north-western shoreline of Loch Broom, the Coigach Peninsula and the south-eastern fringes of Enard Bay, but excluding the offshore island groups (Figure 10.1).

The coastal topography was dominated by a mountainous backdrop of steep hillslopes and outcrops of highly resistant rock strata, predominantly Torridonian group sediments and Lewisian gneiss, indented by narrow bays and inlets containing raised beaches, storm bars and alluvial fans. The coastline is not significantly developed in modern terms, though the past occupation of the region has clearly focused on the coastal littoral. To date, the ULCAS is the only coastal assessment of the western seaboard of mainland Scotland. This imbues the results with particular value for future management planning in Highland Region in general.

Previous Work

When the study was conceived in 1994, there was no systematic data on the archaeological record of the study region. A small number of sites had been inspected by staff from the Ordnance Survey and Highland Region council. However, by coincidence, the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) undertook an Afforestable Land Survey (ALS) of the Coigach Peninsula in 1994. This included much of the coastline within the ULCAS study area. While on face value this survey appeared to have achieved many of the site recording aims of the ULCAS, the geomorphology and erosional class remained unassessed. Furthermore, the newly acquired ALS data also provided a useful opportunity to compare the results from a general landscape survey with one specifically dedicated to coast-edge assessment, which has demonstrated the significant value of undertaking this form of assessment. It would not have been possible to achieve so much without the generosity of RCAHMS in sharing their unpublished survey data at this time.

Methods

The project methodology was defined in standard guidelines for coastal assessment released by Historic Scotland (1996), and consisted of the systematic field survey of the intertidal zone, coast-edge and a 50 m wide hinterland strip extending inland from the coast-edge. Any specific coastal landforms occurring outside this zone (eg extensive dune systems) were also assessed. The field assessment and recording was undertaken by two teams of two–three fieldworkers, achieving an average of 3–7 km of coastline per day. Owing to the complexity of the built heritage and archaeological record, sites were defined and assessed in terms of both *landscapes and landscape elements*, with only the elements located in the coastal zone being recorded in detail. This was particularly important in order to rationalise the extensive numbers of buildings and landscapes relating to contiguous pre- and post-improvement settlements, which occurred both within and adjacent to the coastal strip. The survey results were documented in a full report to Historic Scotland (Long 1996) and in an abstract published in *Discovery and Excavation in Scotland* (1996).

Analysis

Built heritage

One hundred and seventy-nine individual sites and places were defined, 120 of which were new recordings. It should be noted that the definition of an individual site was highly problematic, and open to variations in interpretation. For the purposes of this review, field boundaries, cultivation strips, clearance cairns, slipways, peat cuttings and other landscape elements were only recorded as separate 'sites' where they were *not* associated with definable buildings or

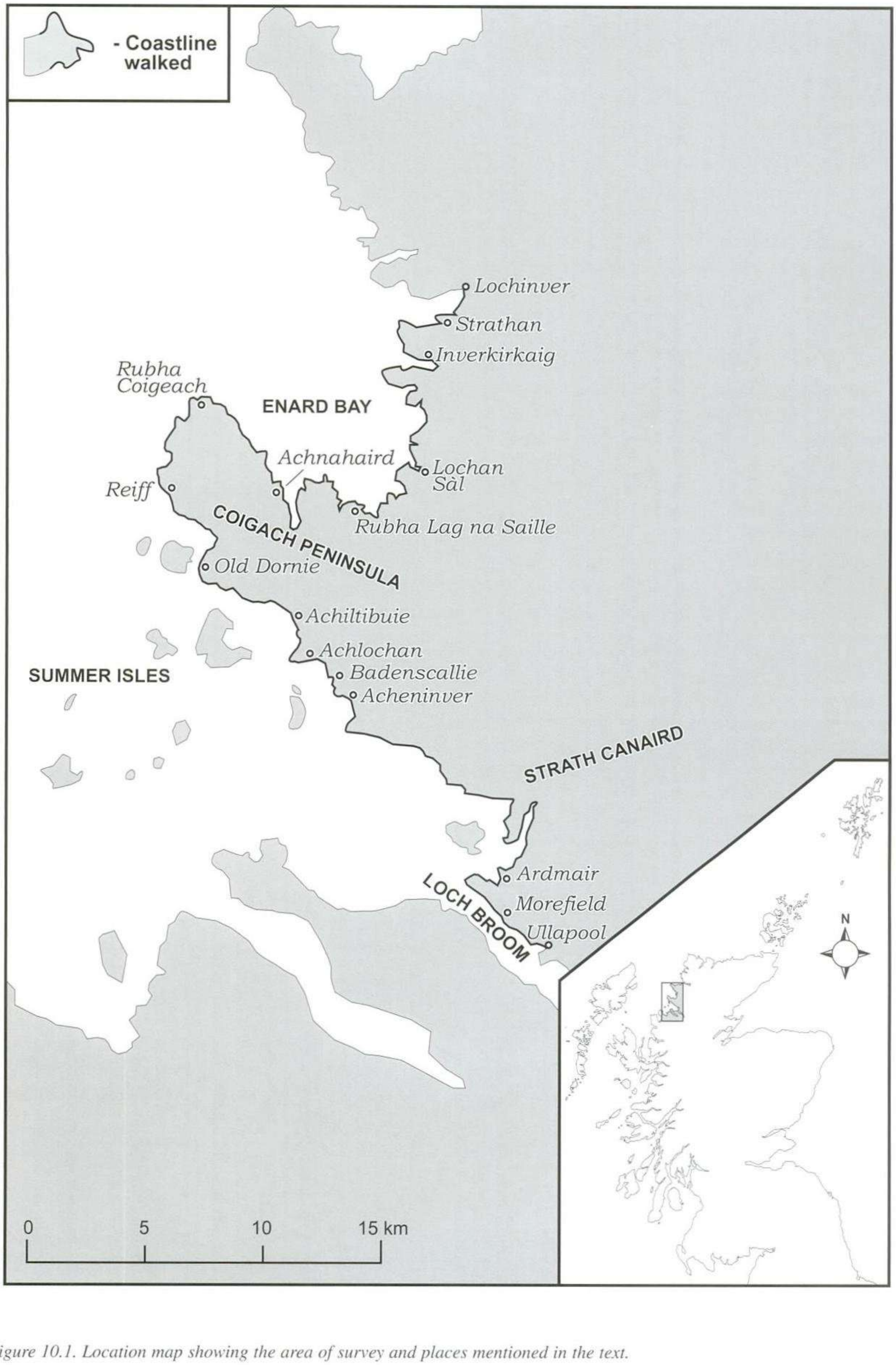

Figure 10.1. Location map showing the area of survey and places mentioned in the text.

Figure 10.2. Loch of Reiff, showing typical elements of the multi-period landscape, including field boundaries, lazy beds and modern houses constructed within the ruins of a pre-improvement township. Partially submerged peat deposits at the shore of the loch are clear evidence for recent marine transgression.

structures in the coastal zone. In some cases, recorded sites comprised new elements of previously recorded site complexes, and as a result the differential between new and previously recorded sites should be considered approximate. Similarly, the RCAHMS First Edition Survey Project (FESP) had previously identified most of the township complexes, though very few had been field inspected.

This problem also applies to the interpretation of age and function. These were frequently not apparent by field assessment alone due to an absence of empirical dating evidence, artefactual material and/or diagnostic architectural traits. Many sites and site complexes apparently relate to occupation over several time periods, though for simplicity each site or place has been categorised by its earliest, diagnostic evidence. As such, the archaeological record and much of the built heritage can essentially be described as a multi-period landscape (Figure 10.2), largely characterised by a range of structures and other features, such as field systems relating to medieval or later rural settlement (MOLRS). Various aspects of these cultural landscapes have been the subject of much theoretical and practical research in recent years (cf Atkinson *et al* 2000).

Problems of definition and interpretation aside, it is clear that the ULCAS has added significantly to our knowledge of past human interaction with the coast-edge. Even within the previous ALS study area, the ULCAS has doubled the number of landscape elements in the coastal strip, in particular documenting several new sites, such as boat nausts, slipways and hulks at the coast-edge, and in the intertidal zone (Figure 10.3).

Figure 10.3. A typical coast edge site at Rubha Lag na Saille, consisting of a drystone building, slipway and naust. The steep hillsides in the background are characteristic of Lewisian gneiss coastal landforms.

The majority of recorded sites and site elements were components of the 14th–20th-century MOLRS landscape (Figure 10.4), relating to either pre- or post-improvement settlements clustered along raised beaches, in the lower reaches of alluvial valleys or bays. These elements have been predominantly defined as agricultural, domestic, or maritime in nature, with frequent evidence of multiplicity of function, as in the case of coastal dwellings with associated field-systems and 'harbour' facilities in the form of boat nausts and slipways (Figure 10.5). Other site types recorded included weirs, fish traps, fords, sheilings, and other miscellaneous drystone constructions.

The number of exclusively maritime site complexes is very low, generally limited to 19th/20th-century structures, such as a lighthouse, a salmon fishing station, and an oyster farm, demonstrating the comparatively low level of coastal development since the abandonment and/or contraction of the townships. Recorded shipwrecks mostly consisted of 19th/20th-century fishing vessels abandoned on the foreshore, often adjacent to boast nausts and slipways. Two reported offshore shipwrecks were also documented, though not inspected, during the field assessment.

The industrial, ecclesiastical and funerary monuments also tended to occur as elements of the townships. Sites of an industrial nature largely consisted of 18th/19th-century kelp kilns, and extensive deposits of 16th/17th-century artefactual and ecofactual debris at Achnahaird Sands (Figure 10.6).

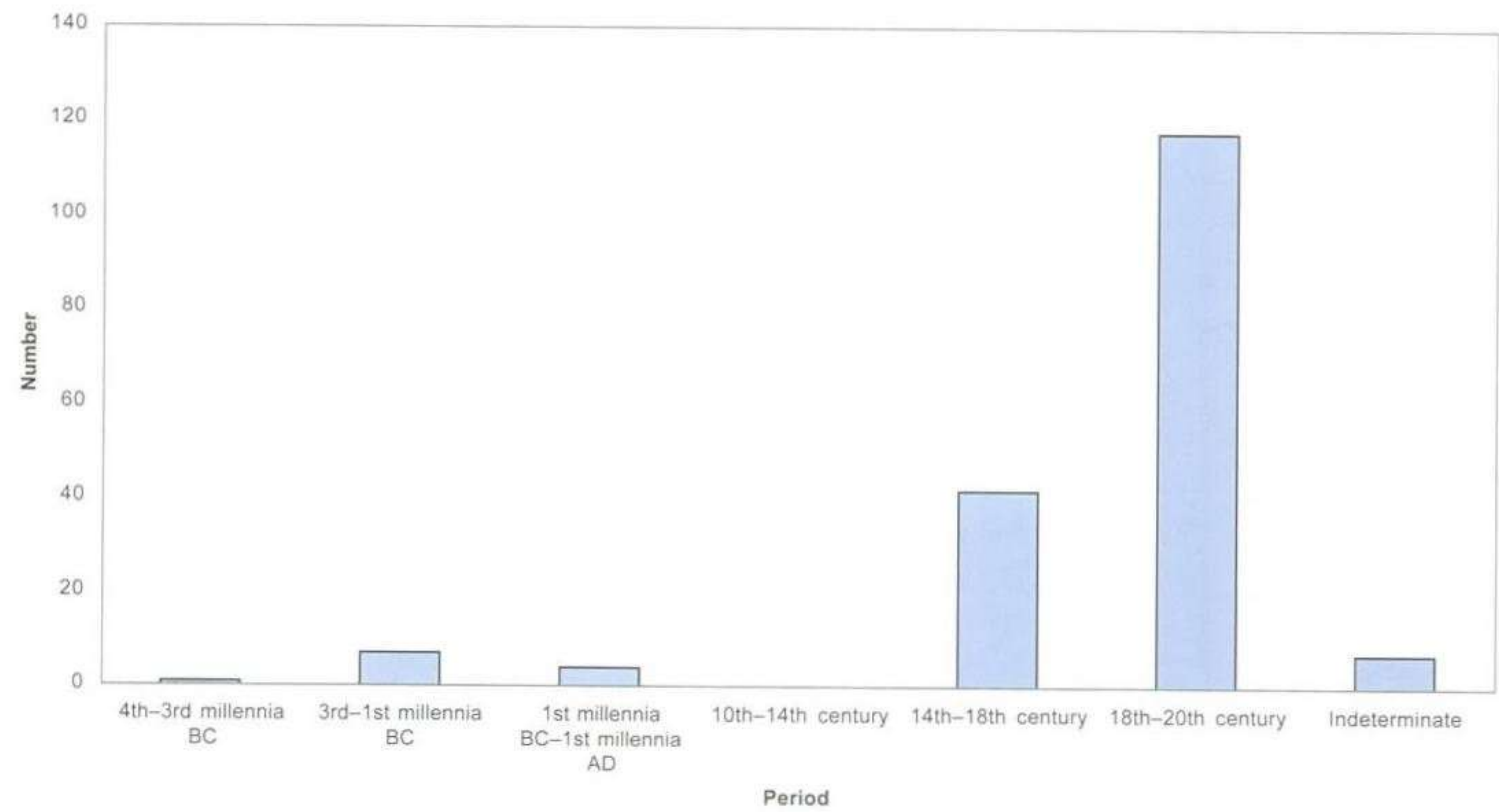

Figure 10.4. Graph showing the total number of sites located, grouped by date.

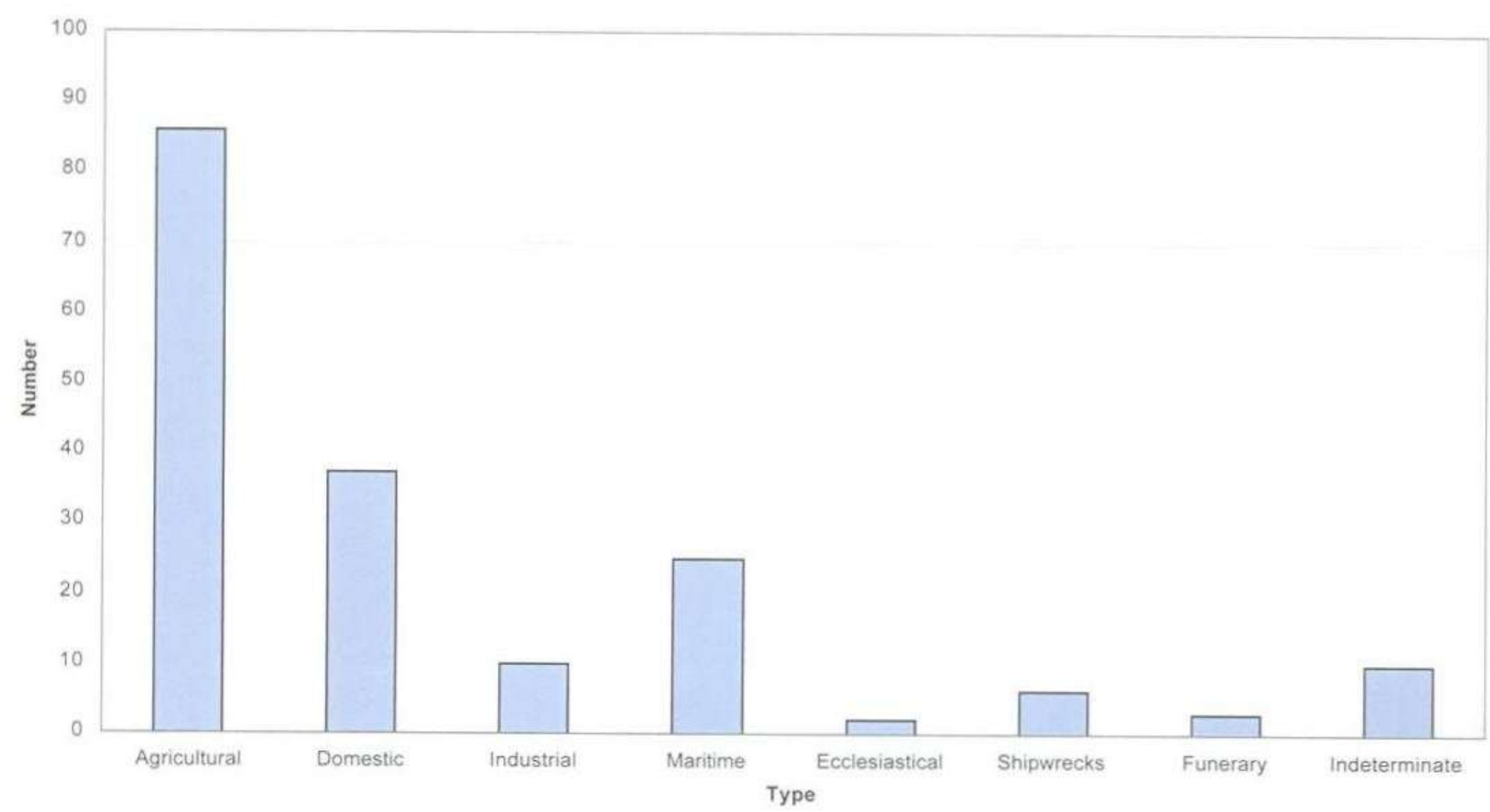

Figure 10.5. Graph showing the total number of sites located, grouped by type.

Figure 10.6. Tidal marshes at the southern end of Achnahaird Bay, looking towards an eroding dune system containing late Medieval and early post-medieval archaeological deposits. Oral and documentary sources suggest that the dune and associated machair system formerly extended across this entire view. Note the submerged peat deposits exposed at low tide.

At this point in time, Achnahaird Sands is arguably unique in the archaeological record of the West Highland seaboard, owing to the circumstances of site exposure and the diversity of stratified structural, artefactual and environmental deposits. The site setting is also unusual in the study area, being located on the margin of a shallow sandy bay surrounded by extensive machair deposits, which offers a sheltered anchorage for large vessels, as well as inland access for smaller boats via an extensive chain of freshwater lochs.

Preliminary analysis of the site context and previously collected material indicates that the remains relate to a significant 16th/17th-century industrial and trading complex, where various materials were worked including stone, iron and non-ferrous metals, such as copper and lead. Livestock, fish and shellfish were potentially being processed on an industrial scale (Long in prep.). Interestingly, the presence of large numbers of low denomination coinage and trading weights suggests the existence of a developed monetary economy, which has not been previously identified in the context of a secular rural site in the Western Highlands. All the evidence points to the site having functioned as a local emporium and/or entrepot, linking communities in the hinterland, the surrounding coast and islands with other political and trading centres in the wider province.

There was very limited evidence of any form of medieval occupation, though it is highly likely that elements of ostensibly post-medieval site complexes originate in this period. A number of sites defined as 'indeterminate' may fit into this category, though there is insufficient evidence to be more certain. Achnahaird Sands, for example, contains traces of medieval artefactual material, though the complex as a whole is dominated by its post-medieval assemblage.

The prehistoric landscape was less apparent, though a number of large, obtrusive structures, including a broch, a vitrified fort and two duns, clearly exploited natural defensive positions provided by the coast-edge. A rock shelter containing shell midden deposits is tentatively interpreted as a Mesolithic site, while various hut-circles, possible burial cairns, and a standing stone were also present in the coastal hinterland. Achnahaird Sands has revealed indications of potential late prehistoric occupation, supported by the close proximity of the Brae of Achnahaird dun, though the artefactual evidence will remain inconclusive until more detailed research is undertaken. The reasons for this overall lack of representation are probably more a factor of the subsequent, extensive use of the landscape and relative absence of ground surface visibility than an absence of occupation or use of the coast-edge.

Geology/geomorphology

The overall geological and geomorphological characteristics of the study area indicate a slowly developing erosional landscape in a relatively early stage of evolution. The process of glaciation has defined the topography and morphology of the region and the subsequent drowning of the landscape in the post-glacial period has emphasised this underlying form, rather than creating a coast edge with an entirely different character. This is a result of the relatively recent occurrence of this marine transgression (c 6000 BP) and the high degree of resistance in the dominant local bedrock, which primarily comprised Torridonian group sedimentary rocks in the central and southern sections (Johnstone & Mykura 1989, 3–41), and Lewisian gneiss in the north of the study area.

These two rock types have created coastlines with a distinctly different character, though both display similarities such as the overall rarity of major coastal cliffs and wide wave-cut platforms, weak wave-notch development and the prevalence of sub-aerial weathering processes actively affecting the underlying glacial landforms. The resulting coast-edge is characterised by glacially smoothed surfaces or scree slopes with low, sloping rock platforms or shelves at sea level. Strong coastal cliff development displaying evidence of bedrock failure is restricted to exposed headlands (eg Rubha Còigeach) and offshore islands, particularly in Torridonian sandstone areas.

The frequent bays and inlets situated around the coast are considered to reflect the underlying topography, as opposed to being the result of the cumulative effects of mechanical wave action on weaknesses in the bedrock. This is supported by the strong correlation between the distribution of these bays and raised beach deposits. On a smaller scale, however, wave action has resulted in the formation of narrow, steep-sided inlets (geos) and caves in exposed areas.

Offshore islands immediately adjacent to the mainland are frequently protected by cobble bars or tombolos (eg Loch of Reiff) formed by longshore drift or under storm conditions. The presence of substantial storm bars composed of massive boulders stands as testimony to the past activity of high-energy waves. While there was little evidence of modern storm bar construction, at Achlochan a broch was constructed onto an existing storm bar, indicating that high-energy waves did play a role in the development of the coastline in the 1st millennium BC or earlier (Long 1996, vol 1, 107).

The influence of isostatic uplift in the area between c 5000 and 2000 BP has resulted in the formation of raised beach deposits along coastal shelves throughout the study area (Price 1983, 182–3). It is also apparent that the process of storm bar formation was either associated with, or immediately post-dated, this period. Storm bars are certainly a feature associated with the modern coast-edge, and have not been observed above raised beach deposits. Active accretion is currently a very rare occurrence in the study area, and has only been observed in estuaries or at the mouths of river valleys; often these deposits have been reworked and sometimes formed into small spits by longshore currents.

Erosion

In general the coastline was considered to be either stable, or, eroding or stable (78.8 per cent) with a negligible rate of regression (Figure 10.7). This state was accentuated by variations in the degree of exposure and bedrock resistance. Definite erosion was noted along 8.6 per cent of the coastline. There was very little evidence of active accretion (1.3 per cent), and this was entirely represented by the development of small spits at river mouths. In certain complex estuarine environments, both accretion and erosion was occurring (11.3 per cent). This effectively amounted to a superficially stable situation, though minor coast-edge erosion was frequently occurring to surrounding drift deposits.

Approximately 4.8 km^2 of the hinterland is situated less than 10 m above sea level, and much of this is located in a few extensive river valleys (eg Strath Canaird). The majority of the hinterland is composed of steep rocky hills and compared to lowland areas is not seriously threatened by the prospect of marine transgression.

The study area contains ample evidence of a post-glacial rise in relative sea level, notably the

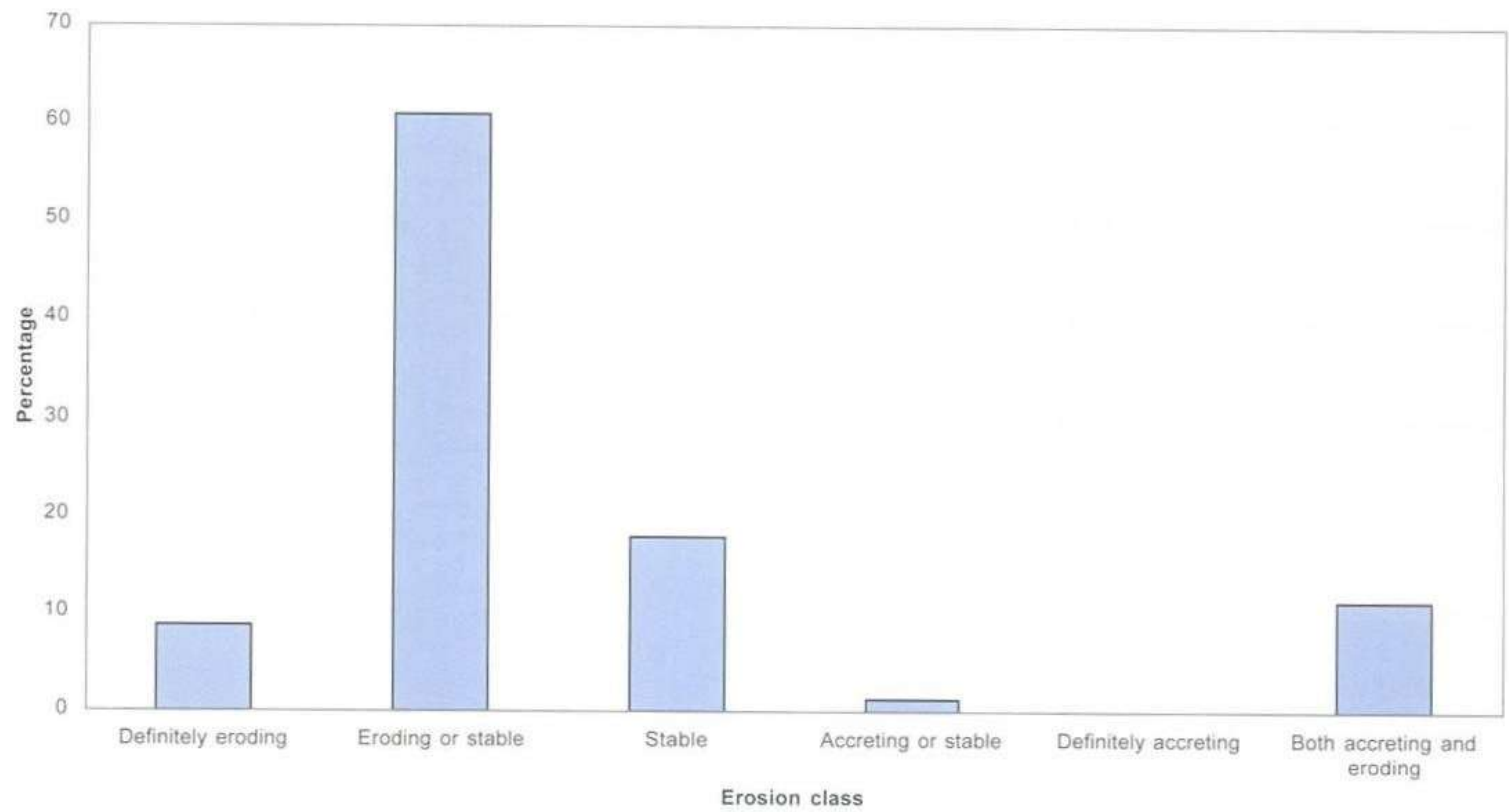

Figure 10.7. Graph showing the erosion classes for the coastline surveyed.

unmistakable underlying form of a drowned, glaciated landscape and various specific locality examples of recent inundation (cf Long 1996, vol 1, 104). It is not clear whether these examples represent regional trends or merely the effects of local factors within estuarine environments. However, they do illustrate the vulnerability of much of the cultural landscape in this region. Approximately 75 per cent of recorded sites and most archaeologically sensitive areas were either wholly or partially located less than 10 m above sea level.

The area has not been the subject of any detailed geomorphological studies, and for this reason it is difficult to determine conclusively the current trend in sea level fluctuation. It is possible that the rate of eustatic sea level rise is either matched or being outstripped by isostatic uplift, as raised beach deposits were generally observed to be intact, with few indications of active erosion or inundation. Therefore, it is probably reasonable to conclude that relative sea level is fairly constant, and that with the exception of certain estuarine situations which characteristically have high tidal ranges, the trend of slow land surface re-emergence is probably continuing.

Much of the coastline is sheltered from the full effects of high-energy wave activity by a group of offshore islands (The Summer Isles), but some exposed headlands do display clear evidence of mechanical erosion. In general, the underlying bedrock is highly resistant to erosion, though substantial raised beach deposits which would be vulnerable to concerted wave activity under adverse conditions are located throughout the study area. These deposits are often located in relatively exposed situations, such as the relatively populous Achiltibuie/Badenscallie area (Figure 10.8).

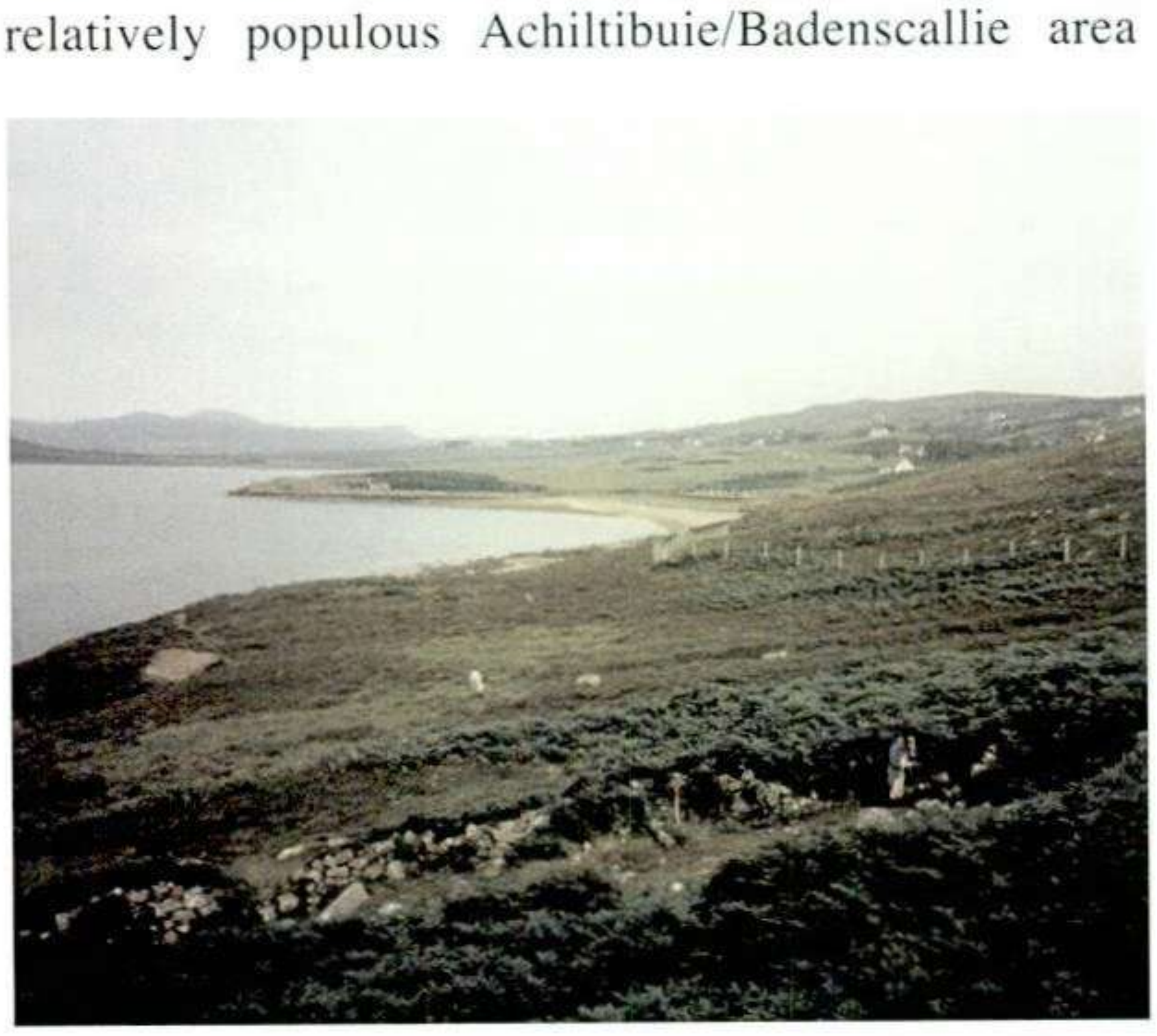

Figure 10.8. Low, peat covered shelves and raised beach deposits characteristic of the relatively fertile coastal landscape of Badenscallie, showing lazybeds and field boundaries extending to the coast edge. Torridonian sandstone is the underlying bedrock.

In this area several archaeological sites are located along the coast-edge. In particular, an 18th/19th-century structure at Port Allt a' Ruisteal, Achiltibuie is currently collapsing as a result of wave erosion (Figure 10.9). Unfortunately, there have been no detailed geomorphological studies into wave or tidal behaviour in this area (Bryan 1994, 3.1–3.5), and so the full extent of this potential problem is difficult to assess. In particular, the normal limit of the wave-affected zone under storm conditions and the documented effects of extreme events on the coast-edge are not known.

Figure 10.9. A structure at Port Allt a' Ruisteal experiencing active coast edge erosion. This was an unusual occurrence in the study area.

In general, the sites inspected during the field survey are not greatly at risk from coastal-related erosion (Figure 10.10), with only limited indications of active erosion, the principal exception being a highly significant structural complex and midden deposits exposed in a degraded sand dune system at Achnahaird Sands. However, owing to the close association between human activities and the sea, 26 per cent of recorded sites are considered vulnerable to future erosion or inundation. This particularly applies to low-lying sites in exposed situations close to the coast-edge (eg Achlochan Broch), which have begun to degrade more significantly in recent years. There is clearly a need for ongoing monitoring of these areas to ensure that management decisions are based on the most up-to-date information on erosional status.

The human impact on the coast-edge from the construction of coastal defences, harbour reconstruction, residential development and other processes is minor at present, though seven locations were identified as having experienced recent developments, having developments in progress, or having further developmental potential. The list below

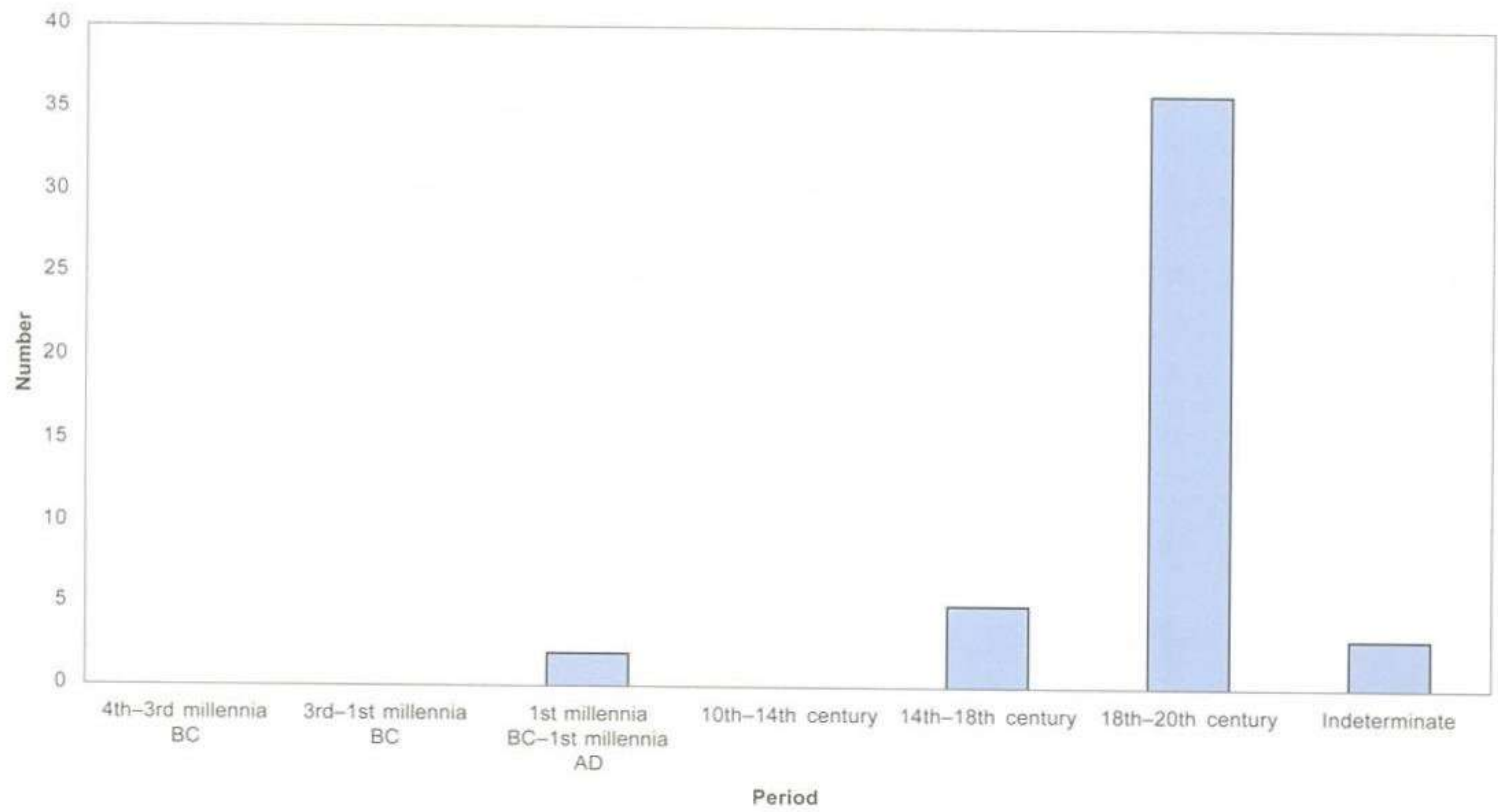

Figure 10.10. Graph showing the number of vulnerable sites, grouped by date.

indicates the nature of coastal developments in the study area and thus provide a basis on which such activities can be monitored.

- *Morefield* – Building site is under construction on the north side of the Ullapool River. This area contains a documented 18th-century settlement.
- *Ardmair Point* – Recent caravan and chalet park constructed on the site of an 18th/19th-century township and fishing depot.
- *Poll a' Chreadha, near Ardmair* – Recent salmon farm depot constructed on the site of lazy bed cultivation plots and a possible structure.
- *Lochan Sàl* – Recent salmon farm complex occupying site of an 18th/19th-century building.
- *Inverkirkaig* – Recent chalet construction in the area of an 18th/19th-century township.
- *Strathan* – Recent chalet construction in the area of an 18th/19th-century township.
- *Lochinver* – Recent construction of new harbour facilities in the town.

Discussion

The study results demonstrate that in general the coastline between Ullapool and Lochinver is slowly eroding, though there are few significant sites under immediate threat from coastal erosion or related processes. The reasons for this are considered to be:

- the sheltered aspect of much of the coastline
- the resistance of the underlying bedrock
- the limited effects of sea level change
- the restricted number of fragile coastal dune systems
- a low level of coastal development in the region.

The built heritage and archaeology of the study area are significantly influenced by the coastal littoral, demonstrating the strongly maritime character of the regional economy. Raised beach deposits and other coastal terraces formed a significant focus for settlement throughout the post-medieval period, with comparatively limited development of the hinterland. Historically, the Coigach Peninsula and other outlying coastal settlements have been dependent on the sea for a range of resources and communications, and this is reflected in the distribution and character of archaeological sites and the built heritage. There is good evidence to suggest that the local townships had considerably greater contact with the offshore islands and adjacent coastal communities than with the rugged and mountainous hinterland, which acted as a considerable impediment to inland communications.

One reflection of this local dependence on the sea is a very high proportion of sites with a coastal-related function (eg boat nausts and kelp kilns), associated with places of an otherwise domestic or agricultural character. The distribution of other activities, such as cultivation and peat cutting, also appears to have been strongly influenced by the sea, partly due to the availability of good soils on raised beach deposits, but also due to the relative ease of access by boat, as attested by the number of tiny, isolated plots of cultivated land nestled in remote inlets around the eastern shore of Enard Bay.

It is consequently unsurprising that many sites are located in highly exposed situations on the coast-edge (eg Achlochan Broch) and may be vulnerable to coastal erosion if there is a general worsening in climatic conditions, a rise in sea level, or during extreme storm events. Approximately 75 per cent of all recorded sites are located in a zone less than 10 m above sea level, including extensive settlements and field-systems occupying low-lying river valleys which extend a considerable distance from the coastline (eg Strath Canaird). Sites in these locations may be at risk from marine transgression. At present, the effects of submergence are localised to certain bays and inlets (eg Loch of Reiff and Achnahaird Bay; Figure 10.11), where existing land surfaces are experiencing increasing tidal inundation and erosion.

Figure 10.11. A former dyke along the western side of Achnahaird Bay, showing the effects of marine transgression.

There was observable evidence of active erosion at various points along the coast, and five sites (2 per cent of site population) are considered to be under threat from coastal erosion or related processes. In general, it is considered that the threats to these sites are minimal, and the generally low significance of the archaeology does not warrant immediate intervention. However, the site of Achnahaird Sands is considered of exceptionally high significance and the threat to the exposed structures and deposits is immediate. The geomorphology and topographic setting of this site are unique throughout the study area, and the exceptional site exposure is providing a remarkable opportunity to study the late prehistoric to post-medieval occupation of the Highlands at a single site. It is probable that sites similar to Achnahaird Sands are situated in positions of similar local importance around the western seaboard, though to date Achnahaird represents the only documented example. This is due to a combination of the exposure conditions, the context provided by this study and the depth of associated research (Long in prep).

In addition, a buried structure at Acheninver has not yet been fully assessed. Sub-surface testing and/or trial trenching is required in order to determine its full significance. It is located in a fragile environment and it is possible that sand quarrying will recommence and further disturb the structural remains.

In general, very few site elements have been directly affected by land development, though that which has occurred has focused on raised beach deposits in the proximity of documented townships and associated field-systems. It is apparent that these areas have acted as a focus for settlement since their formation in the period 5000–2000 BP, and therefore have high archaeological sensitivity.

On a methodological note, the involvement of local groups, such as the Loch Broom Field Club, in an ongoing consultative process has had considerable value in both facilitating the fieldwork and providing support for management recommendations outlined in the report (Long 1996). As a result, the significant multi-period occupation site at Achnahaird Sands is now the subject of a salvage recording and survey project initiated and managed locally through the Coigach Community Council (Farrell & Ross in prep). This local interface has been instrumental in guiding the project through important community issues concerning land access, ownership of information, and publicity releases. This approach may not have been possible through traditional government sponsored or university research programmes.

Recommendations

The extent to which the coastal situation between Ullapool and Lochinver reflects the overall status of the western mainland seaboard is unclear at present, given the absence of comparative research. While the general processes observed in this stretch of coastline will be broadly similar at a regional level, variations in aspect, exposure and geology may significantly affect the local erosional status. If the evidence provided by the ULCAS can be considered representative of the West Highland coast as a whole, it is anticipated that there is considerable unrecorded coastal archaeology. Only a small proportion of this is at risk thanks to a combination of factors, including the resistance of the bedrock, the limited effects of sea level change, and isolation from commercial development. Nevertheless, in localised areas, significant sites will occur in highly fragile landforms which are experiencing erosional threats, in particular coastal machair, dune systems, low-lying raised beaches, and alluvial fans.

In this sense, the erosional status of this region appears to be different from the research presented from the Outer Hebrides, Northern Isles, or the estuarine environments of southern and eastern Scotland, where the erosion of the archaeological record is perhaps more pronounced and less localised. Given the extended length and isolation of the Highland coastline, the priority for future research should arguably be the rapid identification of sensitive locations, perhaps through a thorough desktop assessment, followed by a programme of small pilot surveys, rather than the wholesale survey of arbitrary stretches of coastline. These could be followed by more intensive site recording projects, leading to detailed management planning documents. While the ideal would be to aim for complete coverage of the western seaboard, the practicalities and expense of undertaking field survey in relatively inaccessible parts of the mainland coastline, not to mention offshore islands, would prohibit the effective collection of data within a reasonable time frame, thereby compromising site integrity in the short to medium term.

In future studies of this nature in the Highlands, it is recommended that the survey area be expanded to include all land less than 10 m above sea level. This study has demonstrated the correlation between settlement and the flat, low-lying land suitable for cultivation on raised beaches and in river valleys, and the degree to which this land extends inland from the immediate coastal strip. The potential risk to these sites would be high in the event of marine transgression.

In relation to the specific ULCAS study area, it is recommended that:

- Further work should involve an examination of the marine zone, concentrating on selected slipway and boat naust complexes in the area (eg Old Dornie). There was a high correlation between the occurrence of recent boat remains and these sites, and it may be possible to demonstrate an early phase of use for these features through an examination of the marine zone in conjunction with local oral research and the excavation of selected nausts. This is considered of particular value given that sites on the coast-edge are especially vulnerable to mechanical wave erosion.
- The offshore islands (eg The Summer Isles) require a separate investigation to establish the nature of the archaeology and built environment in these locations, and the effect of coastal processes on the natural and human environment. It is postulated that a greater degree of erosion will be observed due to their increased exposure, particularly on their western coasts. The sheltered nature of much of the mainland coast is due in part to the interruption to longshore wave activity caused by offshore islands. To date, there has been no systematic survey of these islands, though several important chance discoveries have been made, including Early Christian sculpture and a large steatite bowl. As discussed above, the strongly maritime character of the local economy would suggest that the coastal archaeology of these islands is likely to be as rich and diverse as the mainland.
- Any future developments involving extensive ground disturbance to raised beach deposits should be monitored closely given the clear association between these locations and past human activity. This is particularly important given the current poor understanding of human occupation in the Highlands apart from the immediately evident 18th/19th-century settlement pattern.

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11 ASSESSMENT SURVEY: THE INNER MORAY FIRTH

ALEX HALE AND MIKE CRESSEY

Introduction

The Inner Moray Firth Coastal Assessment Survey was undertaken in 1998 by the Centre for Field Archaeology, University of Edinburgh (CFA). CFA also undertook the Coastal Assessment of the Solway North Coast (Finlayson & Cressey this volume). The Inner Moray Firth survey encompassed the 160 km coastal strip from Inverness to Tarbat Ness (Figure 11.1). The area was chosen to encompass a variety of shoreline geology, coastal processes, and archaeological remains.

The project fits into the larger review of coastal archaeology funded by Historic Scotland. It also contributes to the wider regional interest of the management of the Moray Firth. The Moray Firth Partnership (MFP) has generated a management document which considers many topics, including: the landscape and cultural heritage; geology and geomorphology; marine and coastal environments; ecology; social and economic resources; and recreation and tourism. It also looks at coastal protection, planning and management (MFP 1999). The survival, detection and current state of the archaeological resource clearly cross-cuts a number of these subjects.

This paper illustrates the variety of archaeology within the survey area and analyses the survival and destruction of said archaeology with examples. It concludes with recommendations for future research.

Previous Work

Previous archaeological investigations have taken place along the coastal foreshore and the intertidal zone in the area over the past 100 years. In 1908, for example, the Reverend Odo Blundell visited a site in the middle of the Beauly Firth and after a brief investigation declared the site a crannog (Blundell 1909–10). More recent research into two shell middens revealed Mesolithic activity in the Inverness area and lithic scatters associated with one of the middens suggested that the site was used for tool production (Myers & Gourlay 1991). Intertidal research into the Beauly Firth crannogs established a chronological framework for the sites and limited excavations on one of the sites investigated structural and functional attributes of marine crannogs (Hale 2000 and this volume).

Methods

The aims of the survey were to gain baseline information, produce an inventory of the coastal archaeology, and provide a basis for more work including:

- detailed survey of important areas identified by the survey, prior to protection, excavation or abandonment
- monitoring of sites and stretches of coastline by local organisations and people

The methods used to undertake the survey were developed from Historic Scotland policy and procedure papers (Ashmore 1994; Historic Scotland 1996). Prior to the fieldwork, a full desk-based assessment was undertaken. This included:

- identification of a series of zones of accretion, stability or recession which were subsequently ground-truthed to verify the preliminary conclusions on their characteristics
- analysis of the local geological (drift and solid) maps, which provided background information on the types of foreshores and hinterland that would be encountered
- collation of the National Monuments Record of Scotland (NMRS) listings of sites and monuments in the survey area, with information from the Highland Council Sites and Monuments Record (SMR) and information from Historic Scotland on scheduled and listed buildings and designed landscapes

Aerial photographs were studied during the desk-based assessment. There are several series of aerial photographs relevant to the study area, including runs from the immediate post-war period, and surveys from the 1960s and 1970s, undertaken for land-use capability studies. More recent aerial surveys commissioned by Scottish Natural Heritage (SNH) were scrutinised for additional information. Although the Historic Scotland Procedure Paper on coastal zone assessments (Historic Scotland 1996) notes that the examination of several series of photographs and map sources can be expensive, it was considered that the time employed repaid the investment. This was especially true given the importance attached to aerial photographic analysis for the intertidal zone. In addition, it can be difficult in the field to determine

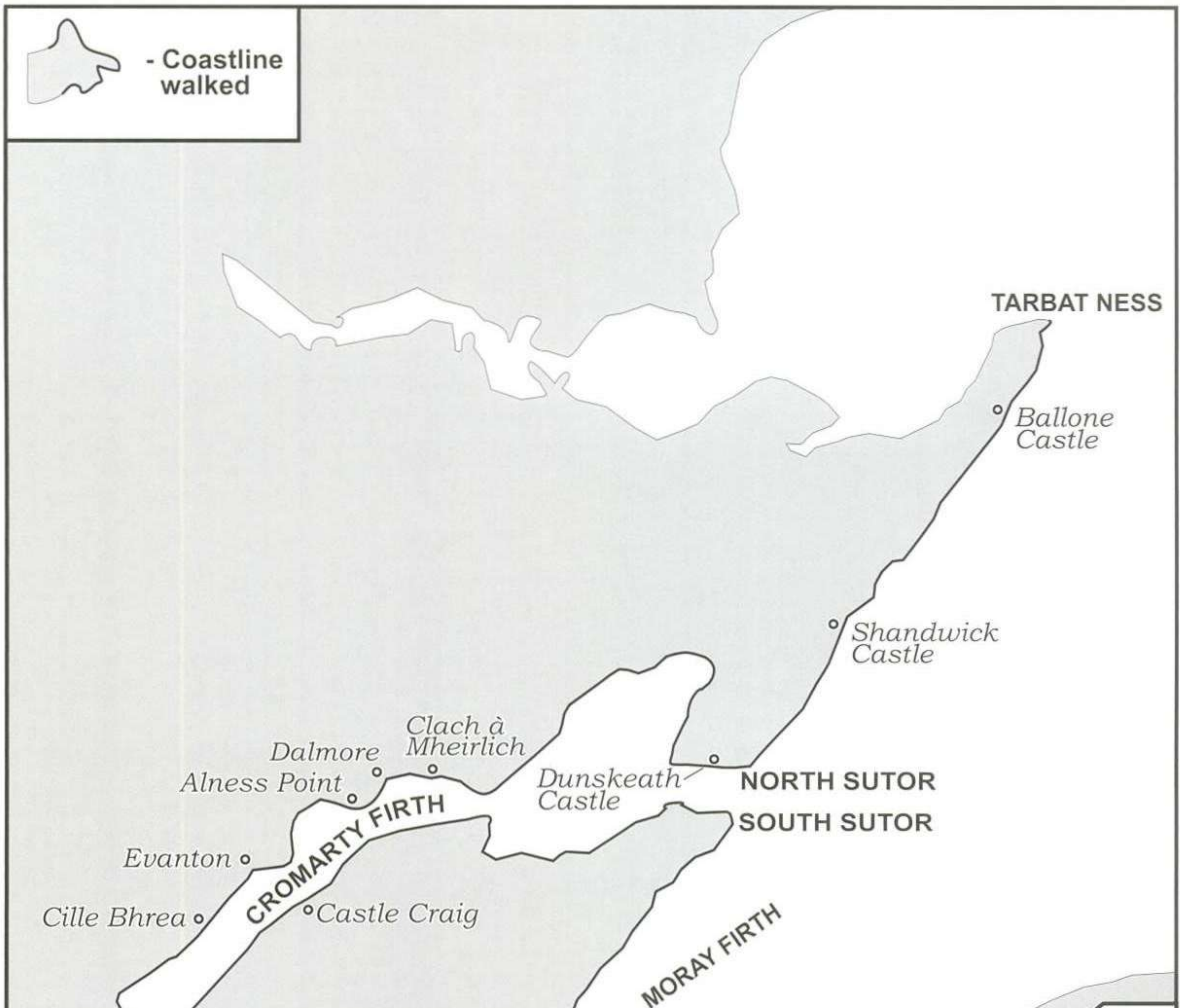

Figure 11.1. Location map showing the area of survey and places mentioned in the text.

whether a given stretch of foreshore is accreting, stable, or eroding; the aerial photographic record spanning over 40 years facilitated this.

Several geomorphological studies of the Inner Moray Firth coast have been undertaken. Recent work by Dr Andrew Haggart of London Guildhall University assessed the previous models of coastal change over the last 10,000 years. Using multi-analysis methods, he has proposed a remodelled sea level curve for the area (Haggart 1987; 1988). Some of the palaeo-environmental data required for the purposes of the project have also been consulted. However, as some of that work has not been directly driven by archaeological research, there are complications with compatibility of information.

Fieldwork

Information obtained during the desk-based stage ensured that the field survey covered a representative sample of the various combinations of environmental settings and monuments. Also, completion of the desk-based study before the fieldwork allowed the field team to be supplied with data assembled from the range of checked sources.

The initial fieldwork was undertaken in September 1998, during which full advantage was taken of the equinoctial tides and no time was lost to inclement weather. Two teams, each comprising two people, conducted an archaeological fieldwalking survey of the 160 km of coastline, during which they recorded the erosion status of sites, assessed vulnerable parts of the landscape, and checked the geomorphological observations. Hand-held Magellan GPS sets were used to generate 8-figure grid references for the location of sites, where local mapped features could not be used to provide a fix. The beaches beneath the North and South Sutor cliffs were not surveyed due to Health and Safety restrictions imposed by the restricted tidal exposure and access limitations.

Analysis

The results of the fieldwork are divided into two parts: the archaeology encountered; and the types of conditions that were affecting the archaeology. An overall view of the archaeology is outlined and is described in broad chronological divisions. The archaeology varied both in condition and period and this diversity is illustrated with two case studies.

Those sites in the NMRS and Highland SMR which are either find-spots or sites identified by aerial photography are not included in the survey data gathered here (Figure 11.2). Some other sites identified in the desktop assessment were not located, and there is a chance that some of these may have been lost due to coastal erosion. If the period of a site was unclear, either from structural form or previous record, it was included in the category 'Uncertain'.

Sites by date

The excavation of two shell middens in Inverness (Myers & Gourlay 1991) confirmed evidence of Mesolithic activity in the study area. The two sites occupy a terrace at about 9 m above current sea level on the delta formed at the mouth of the River Ness. No additional Mesolithic sites were discovered during the survey and the recognition of the above deeply buried sites resulted from development work.

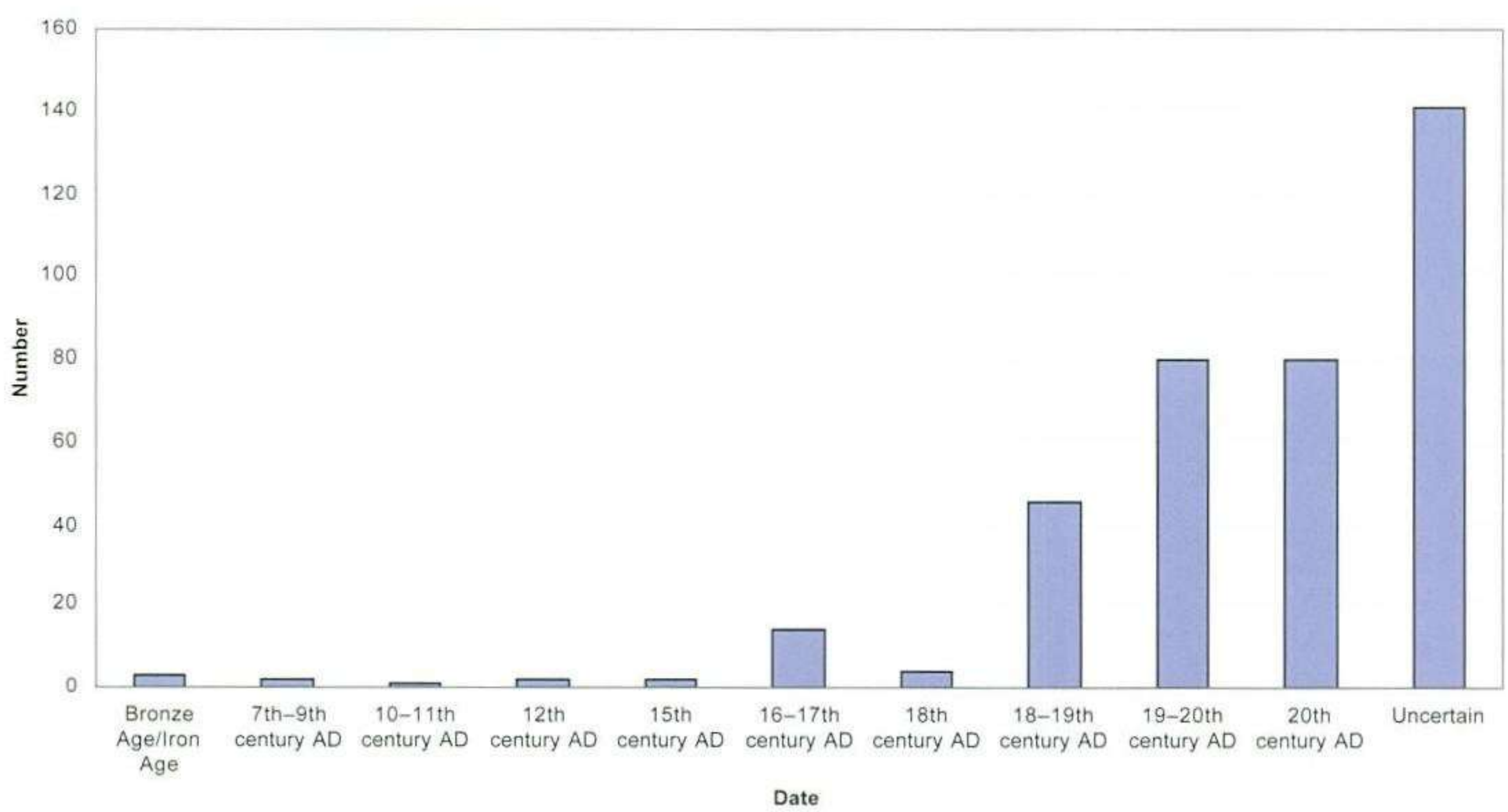

Figure 11.2. Graph showing the total number of sites located, grouped by date.

Despite there being Neolithic monuments in the region – Clava-cairn-type sites to the south and south-east and Orkney-Cromarty-type cairns to the north and west – no such monuments were recorded in the survey area.

There are two Bronze Age cist cemetery sites in close proximity to the survey area. The site at Dalmore on the northern shore of the Cromarty Firth was partially excavated during the latter part of the 19th century (Jolly 1879). The site contained a series of cists containing urns, vessels and burnt bone. The marine crannogs in the Beauly Firth were investigated recently and radiocarbon dates from three of the sites indicate that they were constructed and used in the later Bronze Age and Iron Age (Hale 2000).

There are a large number of Pictish Age symbol stones in or close to the survey area. The Clach A'Mheirlich, for example, which stands on the northern shore of the Cromarty Firth, is a class 1 symbol stone and probably dates to between the 7th and 9th century AD. Other Pictish symbol stones in the region are situated in close proximity to their contemporary coastal margins.

The pre-Reformation chapel, Cille Bhrea (Figure 11.6), is associated with an extensive burial ground. Radiocarbon dating of the skeletal material found there produced dates of the 10th and 11th centuries AD. Dunskeath Castle, standing on the southern edge of the North Sutor, is the only motte site in the survey area. It was fortified by William the Lion in 1179. The remains are now damaged by a military road and from ploughing. There are four other castles in the survey area. Shandwick Castle was built in 1460 and was subsequently completely destroyed; Castle Craig, on the southern shore of the Cromarty Firth, is a fine example of a 16th-century tower house with vaulted main floors. It remains in a poor condition with only the eastern wing standing to its full height. Redcastle, on the northern shore of the Beauly Firth, is reported to be located on the site of Edradour, erected by William the Lion. The castle was modified in the 16th and later centuries and now stands as a roofless shell. Ballone Castle, a late 16th-century, Z-plan tower house, on the southern shores of the Tarbat peninsula has recently been restored and is currently occupied.

Surrounding the Inner Moray Firth and the Cromarty Firth are five 17th-century grain stores known as girnels. These two-storey buildings were built by agricultural estate owners to store grain close to the production zones and also adjacent to the firths. Currently they are in good condition. Four are used as private housing and one, on the north shore of the Cromarty Firth, as a heritage museum.

The Caledonian Canal was one of the largest engineering projects in the early 19th century in Scotland and the sea lock, basin, lockkeepers' cottages, workshops, and hand crane are all included in the survey area. Other industrial archaeological sites include the harbours designed by Thomas Telford at Avoch and Fortrose. Quarries that provided stone for these structures, and the piers along which this stone was transported to awaiting barges, were located around the Beauly Firth and a concentration is found along the southern shore of the Cromarty Firth.

Early 20th-century monuments include World War I and World War II military complexes on the North and South Sutors (Figure 11.3), the remains of an airfield at Evanton and the RAF seaplane base at Alness Point. The heavy military presence attests to the importance of the Cromarty Firth, especially as a naval base, during both wars.

Figure 11.3.Aerial photograph of North Sutor coastal batteries.

Vulnerable sites

Analysis of the sites situated on the foreshore and hinterland (Figure 11.4) shows that within the foreshore category 40 sites were identified to be in a 'Fair' state of preservation, 72 were seen to be in a 'Good' state, and 120 were recorded as 'Poor'. In the hinterland category, 33 sites were found to be in a 'Fair' state, 83 were classified as 'Good' and 64 as 'Poor'. This analysis shows that there is a two-fold increase in the number of sites classified as 'Poor' in the foreshore category. This pattern is not unexpected given the number of sites seen to be undergoing active erosion. However, unlike sites located on the foreshore, archaeology in the hinterland is susceptible to additional forms of attrition, such as quarrying, plough damage, development projects and agricultural practices that may adversely affect the remains.

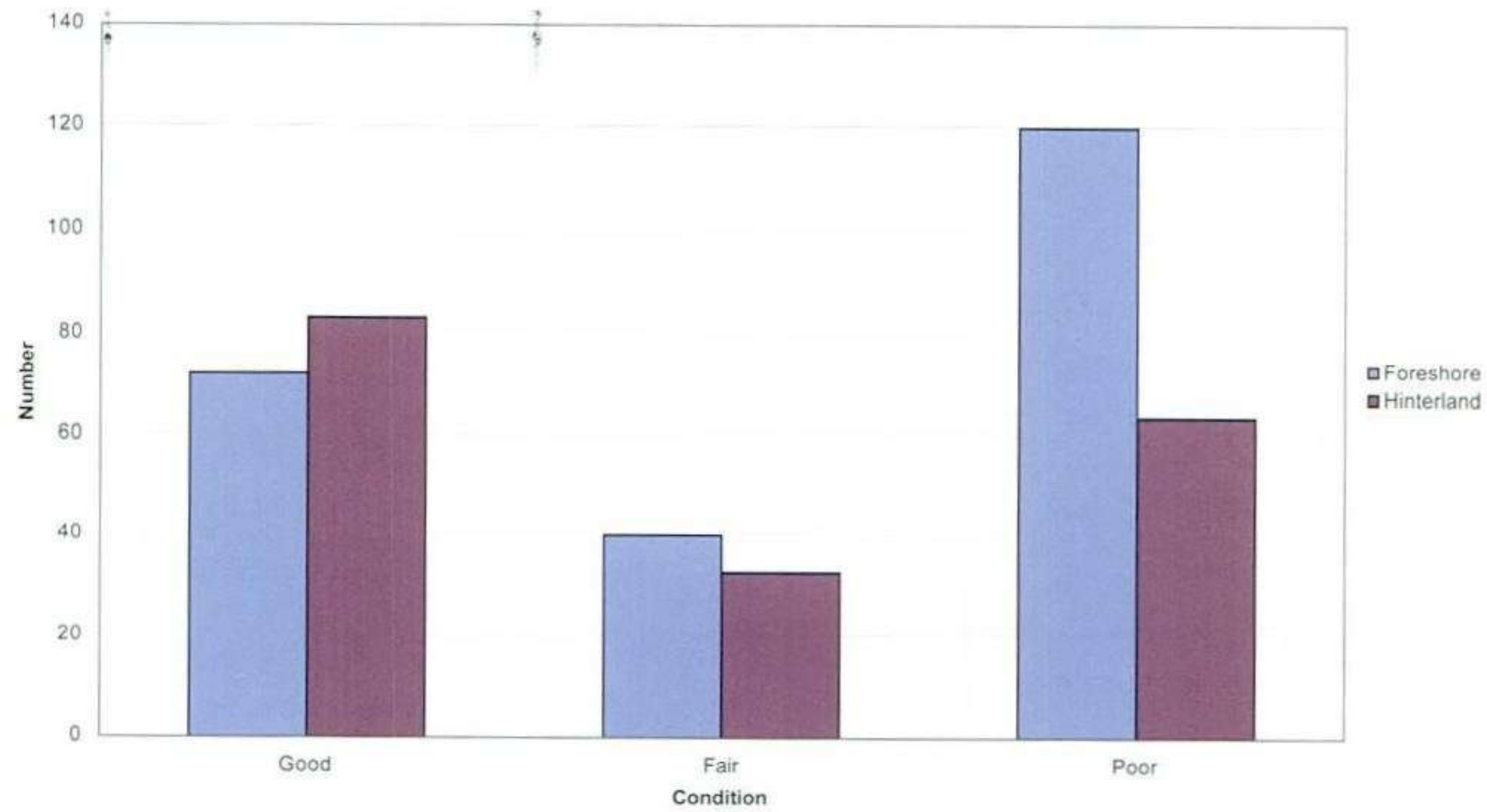

Figure 11.4. Graph showing the condition of sites on the foreshore and in the hinterland.

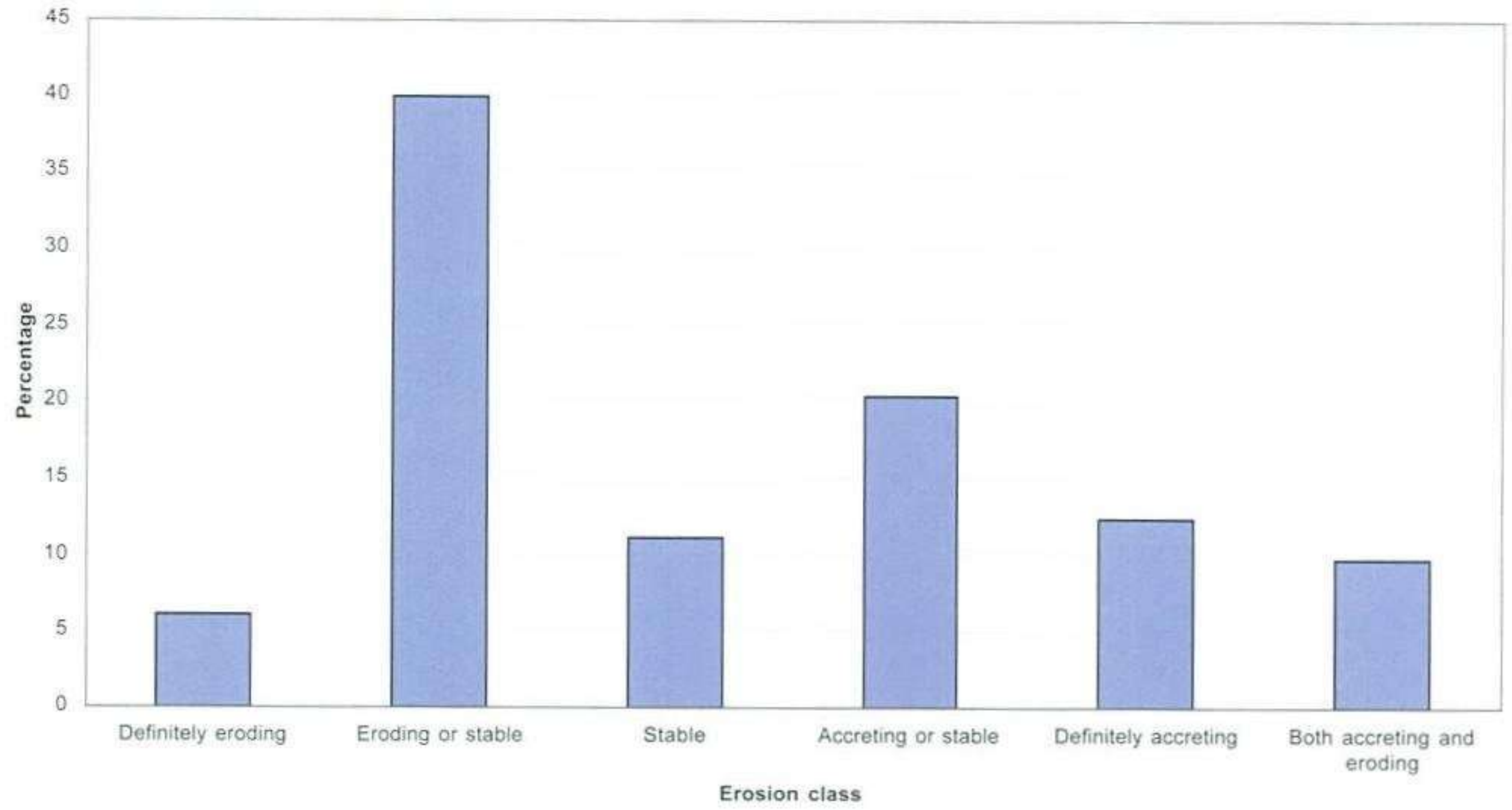

Figure 11.5. Graph showing the erosion classes for the coastline surveyed.

Geology and geomorphology

The study area as defined for the project comprises a wide variety of coastal landforms as a result of both the drift and solid geologies and coastal and terrestrial geomorphological processes. The landforms include precipitous cliffs characterised by the North and South Sutors at the mouth of the Cromarty Firth and north-east of Fortrose to Tarbat Ness. Estuarine environments are predominant within the Beauly and Cromarty Firths and Munlochy Bay, where intertidal mudflats, macro-tidal river channels and salt marsh are common. The geological structure of the Moray Firth has been comprehensively mapped and described by the British Geological Survey in *The Northern Highlands of Scotland* (1989). The dominant basement lithology comprises metamorphosed Moine sediment, unconformably overlain by Old Red Sandstone of Devonian Age. The Old Red Sandstone is locally exposed along much of the coastal sections and is overlain by younger rocks of Permo-Triassic and Jurassic Age. These rocks are derived from mainly non-marine sources such as aeolian dune sand and freshwater/brackish alluvial sediments.

Coastal erosion

The percentage of the total length of coastline cited is based on the straight-line measurement of each unit as mapped on the 1:25,000 map sheets. The combined length of all units is 166.8 km. The figure was used to establish the percentage frequency of each erosion class (Figure 11.5). This figure, however, is an underestimate of the true length of the coastline surveyed, as it does not incorporate the mean length of meandering rivers, deeply incised cliff-edges and other topographical irregularities along the coast. The figure does provide an indication of the relative significance of the results.

The 'Stable' and 'Definitely accreting' classes are more or less equal with 11.2 and 12.4 per cent respectively. The coastal units identified as 'Eroding or stable' achieved the highest frequency with 40 per cent. The 'Definitely eroding' class is represented by 6.1 per cent with a total of 15 individual coastal units. The 'Both accreting and eroding' and 'Accreting or stable' classes are represented by 9.8 per cent and 20.4 per cent respectively.

The results from the 'Definitely eroding' class confirm that only 6 per cent of the total length of coastline examined is being affected by serious erosion. This class includes areas where there are breaches in existing sea-defences or on undefended cliffs such as those below Cille Bhrea chapel. A great majority of the 'Eroding or stable' units are confined to the exposed rocky coastline of the North and South Sutors where erosion is ongoing, albeit slowly. Owing to the slow rate at which the cliffs are eroding, the locality could be classified as relatively stable.

Case Studies

The following case studies were chosen to illustrate the range of coastal erosion or accretion that is affecting some of the archaeology on the Moray Firth coastline. The archaeological importance of the case studies is contrasted with the effects of the various coastal processes.

Case Study 1: Cille Bhrea chapel

Cille Bhrea at Lemlair, on the north shore of the Cromarty Firth, was chosen on the grounds that it provided an excellent example of coastal erosion directly affecting a medieval archaeological monument (Figure 11.6). Recent excavations at the site (Rees 1998) focused on removing skeletal material from an eroding cliff, exposed as the shoreline continues to recede.

Cille Bhrea was reputedly founded in 1198 (Wordsworth 1997, citing Woodham 1956). The chapel was first excavated in 1966 and the excavation revealed a rectangular building with walls less than 1 m in height, a stone font, a possible communion table, and grave slabs. Numerous burials were also recorded (Wordsworth ibid). After 1966, a revetment wall was built at the base of the cliff in an attempt to slow down the rate of erosion, but this was subsequently lost. The site was afforded Scheduled Monument Protection in 1979. Further work was undertaken by Highland Region archaeologist Robert Gourlay in 1983. His sketch of the site denotes that 15 m in length of the 6 m high cliff was actively eroding, with six burials exposed in the cliff section. Based on the findings of the Damage Assessment Report undertaken by Wordsworth in 1997, which noted the exposure of human skeletal remains in the cliff section and scattered on the foreshore, further remedial work was undertaken by AOC in 1998 which aimed to place coconut fibre matting on the upper part of the cliff scarp to encourage vegetation growth and help to stabilise the section.

Figure 11.6. Cille Bhrea chapel under excavation by AOC in 1998.

The AOC excavation recovered valuable information on the density and nature of the burials within the graveyard and chapel. In particular, the presence of deep, complex archaeological deposits beneath the chapel suggest an extended use of the site (Rees 1998). The archaeological deposits were found to be shallow within the exposed cliff section (c 0.9 m) resting on unconsolidated marine sands and gravel.

Assessment of the site and its environs show that the stretch of coastline is affected by predominantly south-easterly winds and high spring tide surges. The site is therefore affected most adversely when these factors occur simultaneously, leading to erosion in what would be considered a relatively sheltered location. Prior to the AOC excavation, the unconsolidated nature of the exposed cliff was estimated to be retreating at about 1 m every 10 years. The archaeological and remedial work aims to reduce the loss of skeletal material from the cliff section for the next 20 years. However, unless the cliff is better protected by effective measures to reduce wave-hammer action and cliff undercutting, erosion will continue to affect the site. The case study demonstrates that the soft character of the underlying geology is a causative factor in coastal erosion at this site.

It can be concluded that erosion has been active over a long period of time and, even after the remedial works were implemented, skeletal remains have been found eroding out of the cliff section and lying on the beach below the site.

Case Study 2: Intertidal fishtraps

Fishtraps were one of the more common monuments recorded along the survey area in the intertidal zone (Figure 11.7). Fishtrap sites have been recorded in English, Welsh and Irish estuaries and further research would aim to complement previously known sites.

The fishtraps recorded during the survey were found in the intertidal zone between Mean High Water Mark (MHWM) and Mean Low Water Mark (MLWM). They are concentrated in two locations: the Beauly Firth and the Cromarty Firth, situated on shallow gradient mud or sand flats. They were built during the 17th–19th centuries to catch fish, especially salmon, that were abundant in the Inner Moray Firth. Seasonal runs of migratory salmon and sea trout swim through marine river channels that, at low water, often act as holding pools. The fish then use the ebb or flood tide to progress further down or upstream. The traps were placed at right-angles or oblique to the channels so that the fish were prevented from continuing their journey. Subsequently, as the tides fell, the fish were forced into the angles of the traps where they were unable to swim upstream or towards MHWM. They could then be caught with hand nets or in static nets.

Figure 11.7. Aerial view of two fishtraps on the southern shore of the Beauly Firth.

Three different types of fishtrap have been identified from documentary evidence: yairs; stake nets; and bag nets. Yairs are curvilinear stone or wooden structures that run perpendicular to the shoreline and curve, usually upstream, to form a bent arc. Wooden stakes interwoven with wattle have been recorded in some yairs, which show complex wattle and stake features at points along their length. Other yairs have been recorded with zigzag plans, designed to trap fish on both the ebb and the flood of the tide. Stake net traps comprise lines of stone mounds into which wooden stakes were driven and between which nets were strung. Bag nets comprise single lines of nets with stakes at either end, usually at MLWM. Evidence of these traps was found as single mounds in the survey area.

Sixty-two fishtraps were recorded in the survey area, compared with over 70 sites marked on cartographic sources dating between 1817 and 1909. Although the variation is not necessarily significant because it does not define the time-depth of individual monuments, it does indicate that the survival of these monuments is dependent on environment and situation. The surviving sites are located in sheltered situations in the Beauly Firth, Munlochy Bay and the Cromarty Firth and there are no remains found on the rocky shorelines between these firths and bay. All of the sites recorded were found to be in poor condition, probably caused by the effects of coastal erosion and/or accretion.

Discussion and Recommendations

Within the limitations of the rapid survey methodology, the results show that post-medieval archaeology is well represented and that many of these sites are located within the foreshore area. The survey also demonstrated that a great number of intertidal archaeological sites are being severely eroded. With reference to the fishtraps, the number of sites has been increased from 31 previously known to 62. Figure 11.4 illustrates the general condition of and disparity between sites and monuments located on the foreshore and those recorded in the hinterland at the time of the survey.

It is recommended that all sites identified as fishtraps that are currently affected by active erosion should be surveyed as soon as possible. The final loss of these remains is imminent and they should be subjected to detailed analysis.

The marine crannogs in the Beauly Firth represent almost 50 per cent of the total number of known crannogs in the intertidal waters of the Scottish coastline and therefore represent an important national resource. Monitoring of this limited resource would enable future management strategies to be developed for intertidal monuments of a similar nature. Additionally, further research into the structural and functional attributes of these sites would enhance the current database.

It is hoped that the results from this survey will contribute to any future policy on Coastal Zone Management and to a Shoreline Management Plan for the area. The results of the survey must be considered only as a snapshot and reflect the observations during the fieldwork season of September 1998. A new programme, including survey, should be undertaken within five years to compare and assess the changes that will have occurred since 1998. This form of medium-term survey project should also be incorporated into a long-term research and management strategy for the archaeology found associated with the coastline of Scotland.

Acknowledgements

The following contributed information and assistance prior to, during and after the Inner Moray Coastal Assessment Survey was undertaken and they are acknowledged with thanks: Rachel Harding-Hill and Heather Corpe at the Moray Firth Partnership; staff at the SNH office in Dingwall; and at the NMRS, RCAHMS, especially for aerial photographic and archive material; John Wood and Dorothy Low at Highland Council Archaeology Service for SMR data; Tom Rees at AOC Scotland Ltd, who provided unpublished archaeological data from the Cille Bhrea chapel excavation; HM Coastguard, Aberdeen, for tide tables and advice on health and safety issues; Mr P W Christie at Highland Council for geomorphology information and sea-defence data; and Annette Jack for information regarding local sites and useful advice for the survey team.

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12 ASSESSMENT SURVEY: FIFE

PHILIP ROBERTSON

Introduction

The coastline of Fife was surveyed on two occasions in 1996 by Maritime Fife, University of St Andrews (Figure 12.1 and Figure 18.1). The first survey (referred to in this report as the south survey) covered the north shore of the Forth Estuary and Firth of Forth from Kincardine to Fife Ness, a section of approximately 107 km in length. Two teams of two archaeologists completed the fieldwork over a period of 12 days in January 1996 (Robertson 1996). The second survey (subsequently referred to as the north survey) extended from Fife Ness to the Fife boundary west of Newburgh, a section of approximately 85 km in length, and was undertaken over a period of 11 days in October 1996 (Robertson & Miller 1997). Due to lessons learned after the completion of the south survey, it was decided to add a geomorphologist to the survey teams.

Previous Work

There have been numerous general works about the Fife coastline (eg Martin 1989), but before Historic Scotland's Coastal Survey initiative (Ashmore 1994; Historic Scotland 1996), only limited survey work had been undertaken on isolated sections of coastline. Attention has been given to particular aspects of importance, such as: the collection of caves around East and West Wemyss (Walker & Ritchie 1987); the Mesolithic site at Morton Farm (Coles 1971); the small harbours of Fife (Graham 1968–9); industrial monuments associated with saltworkings (Ewart 1993); coal workings (Martin 1979); wartime defences (Guy 1994); shipwrecks (Dobson 1996; 1997) and the Tay Estuary salmon industry (Robertson 1998).

Aspects of geomorphology have been examined in some detail by several studies (eg McManus & Wal 1996; Jarvis & Riley 1987). Erosion has also been written about, but from a geomorphological

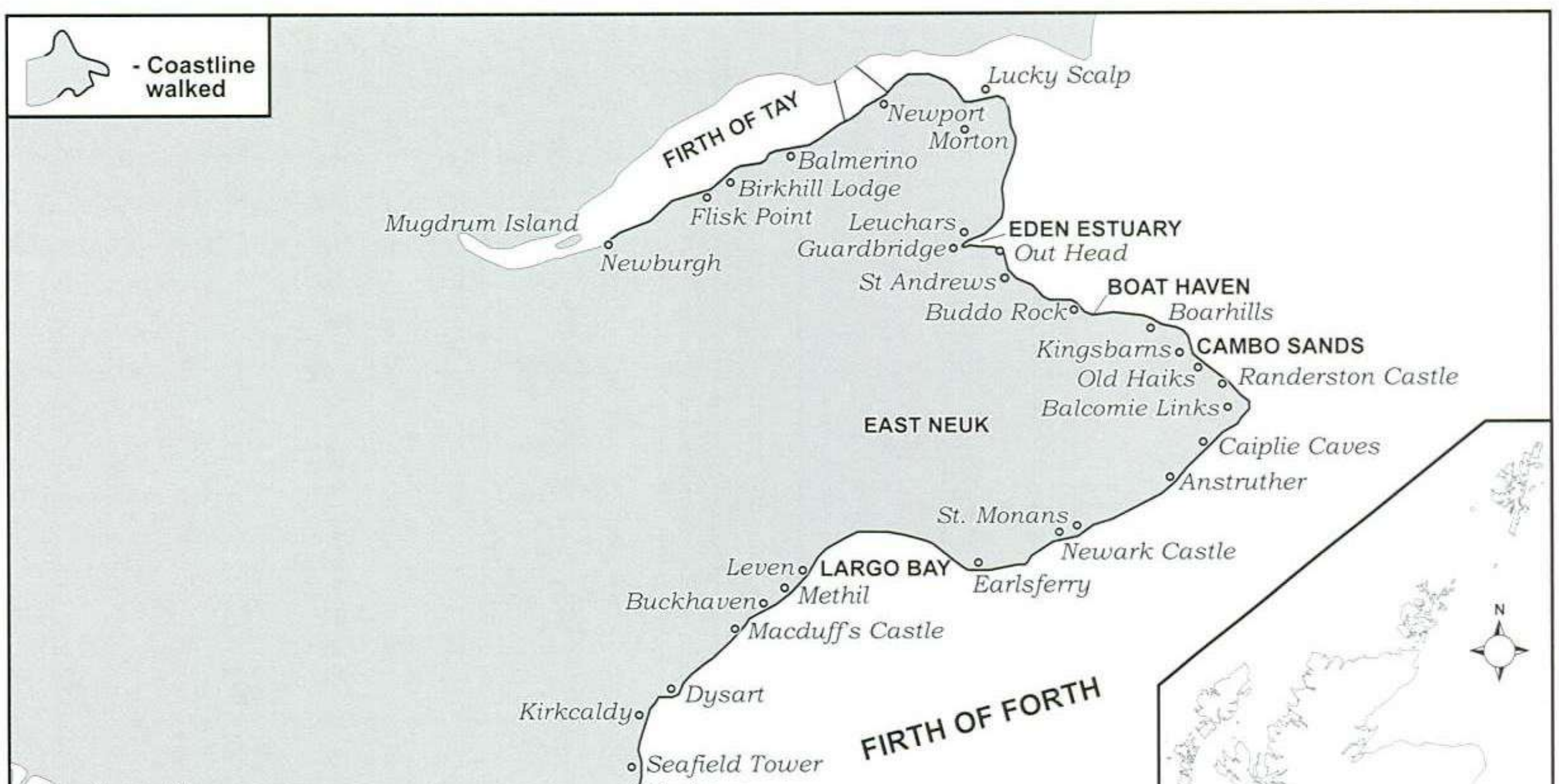

Figure 12.1. Location map showing the area of survey and places mentioned in the text.

perspective, and particularly in relation to known trouble spots such as West and East Wemyss (Miller 1997).

Methods

Research into documentary sources (Fairfax 1996) and aerial photographs preceded the field surveys. The principal objective was to undertake a rapid assessment of the coast edge, intertidal zone, and a 100 m landward strip. Surveys were timed, where possible, to coincide with low water windows and all records were plotted onto Ordnance Survey 1:25,000 Pathfinder maps. Field positions were derived from a hand-held GPS unit to an estimated accuracy of 30–100 m depending on signal strength. However, a number of sites low down on the intertidal zone may have been missed due to tidal height fluctuations. Ministry of Defence restrictions limited recording of the coast-edge adjacent to Leuchars RAF base and Rosyth Naval base.

Analysis

Built heritage

Monument status	Number of sites, south survey	Number of sites, north survey
Protected Ancient Monuments	44	11
Other known monuments	471	6
Monuments formally proposed for designation	3	1
Listed Buildings	14	91
Wrecks	11	5
Designed landscapes	2	0
Sites discovered during survey	179	203
Total	724	317

Table 12.1. Sites according to status, north and south survey.

The south survey identified 724 sites within the target area, 179 of which were not listed in the National Monuments Record of Scotland (NMRS) or the Fife Sites and Monuments Record (SMR). The north survey located a further 317 sites, 203 of which were not previously recorded (Table 12.1; Figure 12.2). The majority of these 'new' sites were identified on the foreshore, where little survey work has been undertaken to date. A smaller number were seen on the eroding face of the coast-edge.

Sites by period

Period	Number of sites, south survey	Number of sites, north survey
Uncertain	78	60
Prehistoric	4	11
Roman to Early Christian	9	2
Medieval	20	20
Post-medieval	516	150
20th-century	97	74
Total	724	317

Table 12.2. Sites by period, north and south survey.

Evidence of a very early environment can be seen in the fossilised trees visible on the shore near Crail. An early land surface was also exposed on the muddy foreshore of the Tay Estuary between Birkhill Lodge and Flisk Point. Here remains can be seen intermittently along a 1.5 km stretch of coast, visible where localised scour has removed the thick alluvial deposits which form the mudflats elsewhere. The land surface is characterised by outcrops of waterlogged organic remains of trees, shrubs, and seeds of other plants in a 17 m wide strip that runs parallel to the shoreline and is exposed only at low water. This land surface, if it is contemporaneous with the peats found

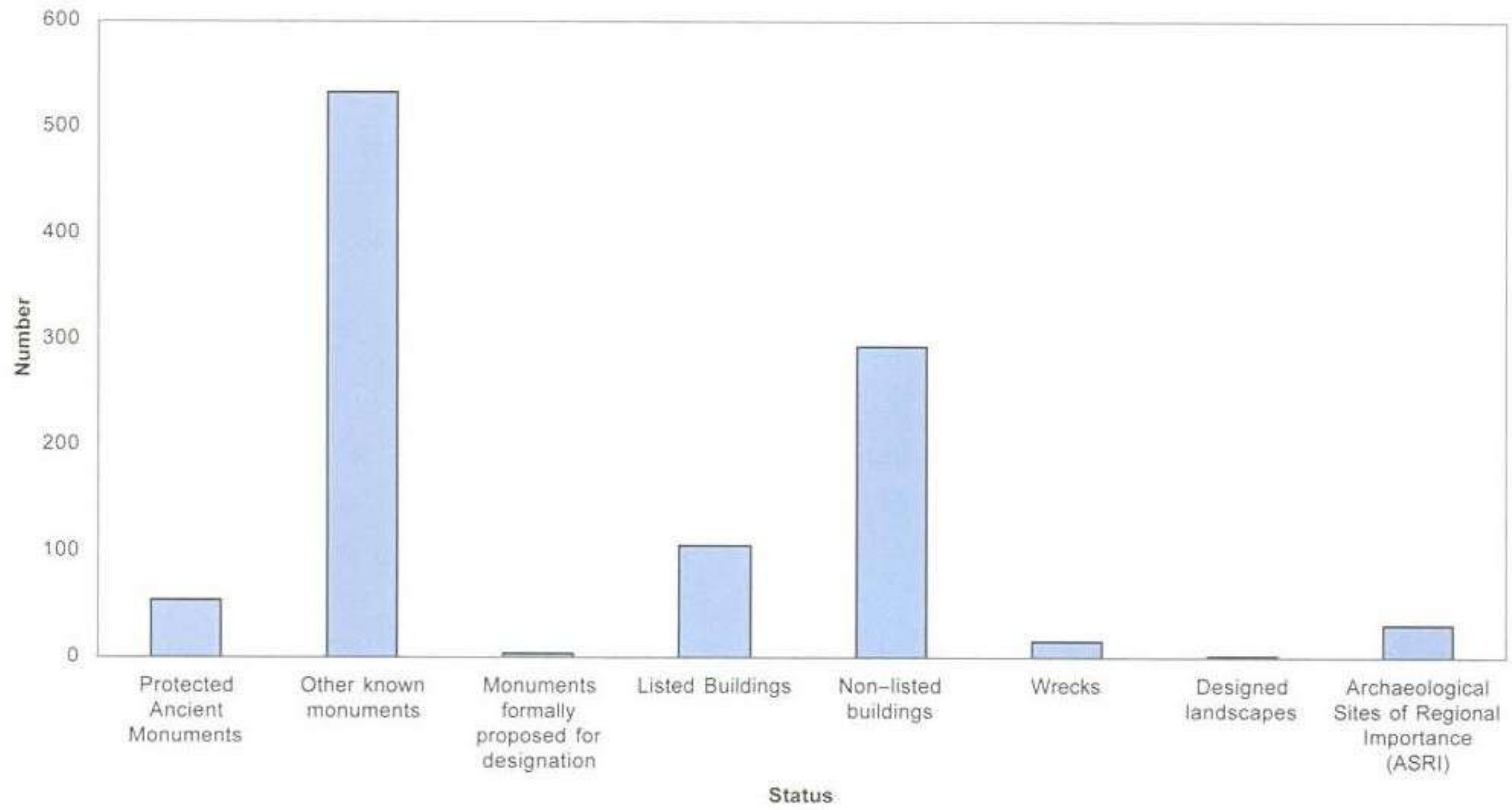

Figure 12.2. Graph showing the total number of sites located, grouped according to status.

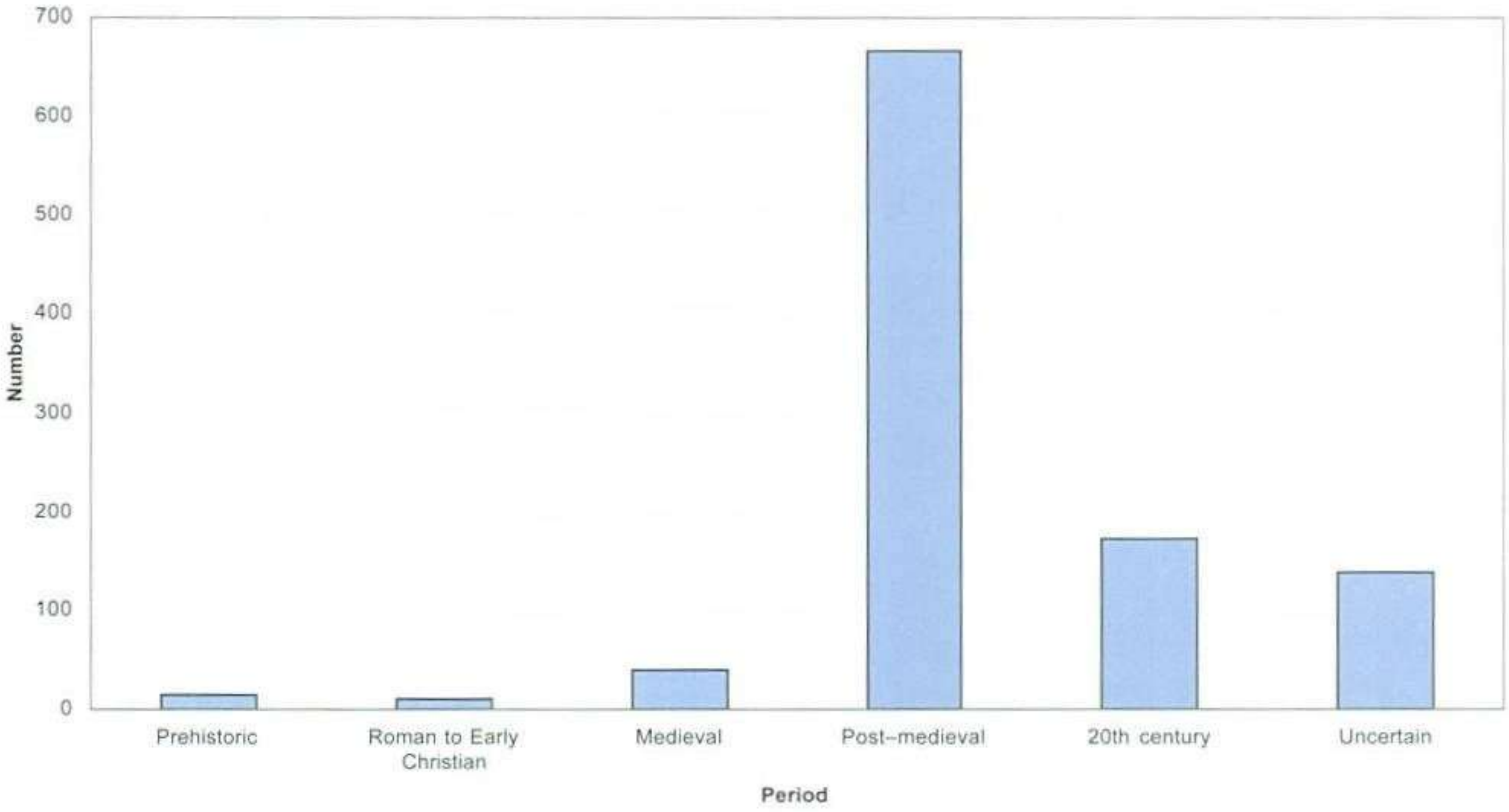

Figure 12.3. Graph showing the total number of sites located, grouped by period.

below the Morton Lochs National Nature Reserve, may date to around 5500 years ago (McManus 1999).

As far as we know, the earliest settlement of the Fife coast took place during the Mesolithic (Figure 12.3), as can be seen in a series of temporary camps discovered, including one at Fife Ness (Wickham Jones & Dalland 1998) and a second at Morton, Tentsmuir (Coles 1971).

The identification of a number of shell and pottery middens along the coast-edge of the East Neuk (Elie; Pittenweem; Crail) may be prehistoric, but could be more recent (Sloan 1984). The same is true of a number of intertidal sites, cautiously identified as fishtraps. Many of these sites may have been in use recently, and have been included in the 'uncertain date' category. The NMRS lists several scattered finds dating from the Bronze Age or earlier. Examples include beaker pottery from St Andrews and a Neolithic flint mace-head found in the banks of the Tay at Newburgh. Mugdrum Island, opposite Newburgh, has yielded some Bronze Age artefacts. Taken together, these finds confirm settlement of the upper Tay Estuary since prehistoric times.

Eleven sites of Roman to Early Christian date were identified. Evidence of Roman activity along the Fife shore is limited to scattered finds (eg Boat Haven pottery and finds from Constantine's Cave), pointing to contacts between Romans and natives of Fife (Hunter 1996).

The Picts have left more of a mark on the Fife coastal landscape with both burial sites (eg Old Haiks Long Cist; Lundin Links) and carvings within cave systems (Constantine's Cave; Randerston Castle Cave; Kinkell Cave) which are found in raised beach deposits to the south-east of St Andrews. Other caves with Early Christian carvings include those at East Wemyss and Caiplie.

The early medieval period saw the development of the feudal state and reorganisation of the Church. Many of the important ecclesiastical monuments and buildings at St Andrews date to this period and a Cistercian monastery was established at Balmerino. As transport by sea was the cheapest form of travel, these ecclesiastical centres also became administrative and trading hubs for produce and minerals from the fertile farmlands and the coastal fringe.

The majority of sites identified during the survey were of post-medieval date. This reflects the considerable development and industrialisation which has taken place since the 19th century. The majority of 20th-century coastal sites are military defences from World War I or II.

Sites of all date by type

Parts of the coast of Fife have been heavily developed in the past, especially the north shore of the Forth. There are also major conurbations at St Andrews, and in the coastal fringe between Tayport and Wormit. This is reflected in the number of buildings and other large built structures noted. A domestic or industrial function can be attributed to the majority of these buildings. In terms of domestic architecture, the town of St Andrews is important for its medieval buildings. The burgh of Culross is also particularly important and has a number of listed building in its coastal zone. Newport and Tayport have significant numbers of listed buildings behind the coast-edge. These mostly date from the 19th century when the area was developed as an attractive suburb of Dundee. The vernacular architecture of some of the East Neuk fishing villages is also worthy of note.

The majority of the industrial structures noted relate to the coal, salt, lime, or shipbuilding trades on which the area thrived following the Industrial Revolution. The

Figure 12.4. Wreck on the foreshore at Wormit with the Tay Railway Bridge behind.

best examples of coal workings, complete with associated structures, can be found at Frances Colliery, north-east of Dysart. Saltpans were established as early as the 16th century at Kirkcaldy, Dysart, Culross and West Wemyss (Ewart 1993), and limekiln working was concentrated in the area around Charlestown and Limekilns. The main shipbuilding centres were at Kincardine, Burntisland, Kinghorn and St Monans (Middlemiss 1995).

The development of quays and wharves at Guardbridge, on the Eden Estuary, is associated largely with the paper mill. The south shore of the Tay also supported several industries, and Newburgh and Tayport were long-time centres of linen manufacture in north Fife. Tayport had a jute and linen spinning mill and two linen factories. Tayport also had a sawmill which supplied shipbuilding concerns elsewhere in Fife.

The coastal location of these industrial centres afforded ease of transport by sea to the market-place. Poor roads made transport by sea desirable (Figure 12.4).

By the 10th century, there were reports of at least ten landing points on the Firth of Forth (Graham 1968–9). St Andrews overlooked a natural harbour at the mouth of the Kinness Burn and this was developed. Increasing trade in and out of the royal burghs saw the development of a string of harbours from the 16th century, and new harbours such as Charlestown, were built in the 18th century to serve new industries. A private landowner built the harbour at Kingsbarns for the export of potatoes. While some of these harbours were of considerable size, there are also numerous rudimentary landing places where natural features have been crudely enhanced These appear to be most common between Elie and Fife Ness and there are examples at Earlsferry and near Randerston Castle.

Fife has several coastal castles, built by prominent medieval families (Fawcett 1992). However, the majority of defensive or military sites are more recent (Guy 1994). The industrial hub and naval bases of the Forth were a target for German attack during the two world wars. Military defences such as anti-aircraft positions and radar posts are scattered along the prominent headlands of the Forth, while tank traps (eg North Queensferry) can be found along sandy beach locations to prevent air or seaborne invasion.

The coastline around Tentsmuir was also considered a potential landing point for seaborne invasion during World War II. The dune systems and sand beaches in the vicinity preserve evidence of a wide range of associated features including tank traps, glider traps, observation posts, command posts, and pillboxes (Figure 12.5).

Marine produce was an important part of the diet of the first inhabitants of Fife as is evident from fish bone finds identified at Morton. A number of fishtraps were found varying from cruive banks (Kincardine), to a possible stone fish trap (Leven), and stake net traps (Leven and Largo Bay). Fishtraps were also recorded in the Eden Estuary and east of Tayport. Many of these traps were used until very recent times. The dating and interpretation of these and other intertidal features, such as a possible crannog discovered near Crombie, requires more study. This ‘crannog’ was interpreted as

Figure 12.5. Collapsed tank traps at Tentsmuir, originally built on dry land.

a temporary boat hard in a subsequent study (Wood 1997b).

Collapsing bothies, fishing platforms, decaying harbours, and salmon cobles associated with the salmon fishing industry are commonplace, particularly on the south shore of the Tay, but isolated examples are found elsewhere (Boarhills; Kingsbarns). Salmon fishing on the Tay has probably taken place since at least Roman times and certainly since the 12th–13th centuries. An industry centred on Newburgh has been in existence for almost 250 years (Robertson 1998; Atkinson 1996).

While harvesting of marine produce has been important since Mesolithic times, farmers working the rich agricultural land on the southern banks of the Tay and along the coastal fringe of the East Neuk also benefited from the sea. Cart tracks cut into the rock platform (eg Pittenweem) allowed access onto the shore for the harvesting of marine produce to fertilise fields. Evidence of the reorganisation of land during the 19th century can be seen in the form of stone dykes marking field boundaries. In places, these extend well down onto the foreshore.

The intertidal muds which dominate the shore west of North Queensferry are very conducive to the preservation of organic remains. At Kincardine, the maritime history of the town is preserved in a collection of 14 foreshore ship hulks, cruive banks, walkways and piers (Wood 1997a). Navigation of the numerous sandbanks, rocks and islands of the Forth caused numerous shipwreck casualties (Dobson 1996). The coastline from Fife Ness to Tentsmuir Point was also treacherous. These hazards in turn brought about the construction of buoys, beacons, lightships and lighthouses around the Fife coast from the 18th century. Notable sites include the Pile Lighthouse, east of Tayport, and the lighthouse construction site at Fife Ness. At Fife Ness, circular indentations have been carved into flat bedrock on the foreshore. A pivot hole, 0.7 m in diameter, can be seen at the centre of one circle. Other indefinite traces of rock cuttings in the rocks can be seen nearby. These features mark the base for construction work carried out in the early 19th century on Robert Stevenson's lighthouse for the North Carr Rocks.

Despite efforts to warn ships of danger, between 1898 and 1908 there were 87 shipping casualties between the Eden Estuary and Anstruther (Dobson 1996). Along exposed sections of coast, such as the East Neuk, the major reminders of such incidents that have survived are the boats that have come to rest in soft sediments. The sandy beach at West Sands has helped to preserve remains of the *Wilhelmina* or the *Jean*. Low down on the foreshore near Cambo Sands can be found the remains of what may be the Torpedo destroyer *HMS Success*. A lone steam boiler, reputed to be from the steam trawler *Gairloch*, lies on the shore near Anstruther. Wrecks were also found in soft seabed sediments at Tayport and near Newport. The latter site is located adjacent to a complex of collapsed wharves connected with the construction of the Tay bridges (Wood 1997d).

The non-local, coarse pebbles and cobbles which comprise the island of Lucky Scalp, east of Tayport, may be ship's ballast. It is suggested that this was transported to Tayport on lighters prior to trans-shipping of cargoes for Perth from larger vessels moored off Tayport (McManus 1999). Salmon fishermen subsequently used ballast piles to create the island of Lucky Scalp as a source of shelter and refuge. The island hosted a stone-built 20 m high structure which combined the functions of salmon fishing station and navigation beacon (McManus 1999). Ballast remains can be found elsewhere on the shores of the Tay. Estimates suggest that between 100,000 and 200,000 tons of material were imported to the Tay Estuary by shipping during a period of at least 100 years (McManus 1999).

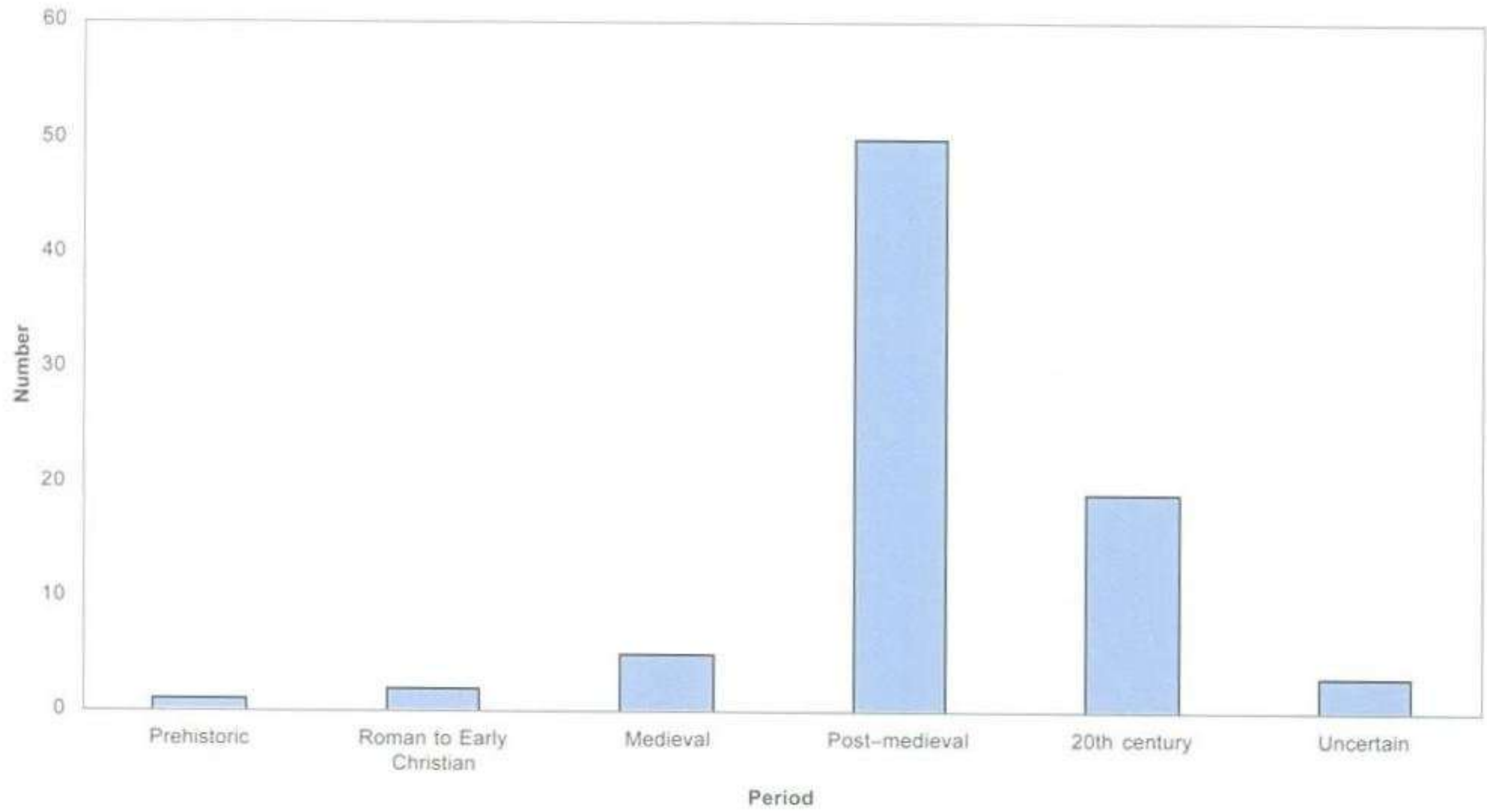

Figure 12.6. Graph showing the total number of vulnerable sites, grouped by period.

Figure 12.7. Aerial view of MacDuff's Castle, East Wemyss, with the caves visible at the base of the cliff.

Vulnerable sites by period

Period	Number of sites, south survey	Number of sites, north survey
Prehistoric	0	1
Roman to Early Christian	2	0
Medieval	5	0
Post medieval	15	35
20th-century	6	13
Uncertain	3	0
Total	31	49

Table 12.3. Vulnerable sites by period, north and south survey.

Potentially the earliest site to be at threat from erosion (Figure 12.6) is the land surface situated between Birkhill Lodge and Flisk Point. At the time of survey, the area may have been undergoing accretion, but localised scour at the visible edge of this mudflat was caused by the flow of the estuary, and hollows in the flat indicate that cyclical erosion has exposed this feature in the past.

Other early sites which appear to be vulnerable include middens and burials found in soft deposits along an eroding face. Middens at Crail and Pittenweem were identified as being at risk. As they are situated above the High Water Mark, the present threat to them is more from wind, frost, and water run-off erosion than from marine action.

The Pictish cist at Lundin Links is also threatened. Three bones were discovered protruding from a topsoil and sand layer which overlies bedrock. These originated from a collection of long cists first identified during quarrying work in the 19th century (Henshall 1956). The cists have eroded due to slumping of the coast-edge deposits, a process which has been continuously observed since their discovery (Maclagan-Wedderburn 1967). Erosion was occurring rapidly during the time of the survey due to strong easterly winds and high spring tides.

The erosion of coastal deposits north-east of Macduff's Castle is of particular importance because the coastline here conceals a string of sandstone caves protected by boulder defences (Figure 12.7).

The Wemyss Caves bear Pictish inscriptions dating broadly to the 1st millennium AD (Walker & Ritchie 1987). It must be stressed that the caves are not imminently threatened by coastal erosion. However, the boulder defences deployed parallel to the caves do not appear to be stable in the long term and the situation needs to be monitored.

Other important caves (Constantine's Cave; Randerston Castle Cave; Kinkell Cave) are not immediately threatened by erosion. They are mostly set back from the coast-edge and the heavy undergrowth obstructing access to them confirms their present stability from coastal erosion. However, the erosion of raised beach deposits at certain locations along the coast between Fife Ness and St Andrews may impact on undiscovered sites such as middens.

A small standing stone identified close to Kinkell Cave requires further attention. No inscriptions were visible on the surface of the stone, which was heavily eroded by calcareous weathering.

Many of the features at threat from erosion are of fairly recent date. The Pile Lighthouse is a Listed Building and although from a distance its structure appears to be sound, its exposed location and disuse mean that it may soon be at risk from damage caused by erosion and lack of maintenance. The lighthouse construction site at Fife Ness is a similar case. Erosion of the stone indentations is occurring due to shingle scouring and other marine action.

The destructive effect of wave action on the site of East Wemyss and Buckhaven Gasworks was clear, with inundation of the building foundations. Comparisons of the present site (Wood 1997c) with builders' plans from the mid-19th century suggest that 30 per cent of this site has already been lost to the sea.

Vulnerable sites by type

A selection of sites has been identified where erosion is not occurring to the monuments themselves but where deterioration of the surrounding environment and deposits suggests that there may be a problem in the future. Examples which fit this category and which may become threatened within five years from the survey date include the following Protected Ancient Monuments: Seafield Tower; Newark Castle; and the Wemyss Caves.

The condition of the small harbours of Fife must be a matter of concern. Recent breaches in the harbour walls at Cellardyke and second-hand reports of erosion to Anstruther Easter and Pittenweem harbours indicate that these important sites may be in a serious state of disrepair. While erosion is undoubtedly a factor in this, the decline in use of these harbours in the last 100 years has been marked by a piecemeal approach to their maintenance (Moore 1992).

Kingsbarns harbour experienced erosion to its harbour walls throughout the short history of its occupation (Figure 12.8) and this has now resulted in the collapse of much of the wall structure.

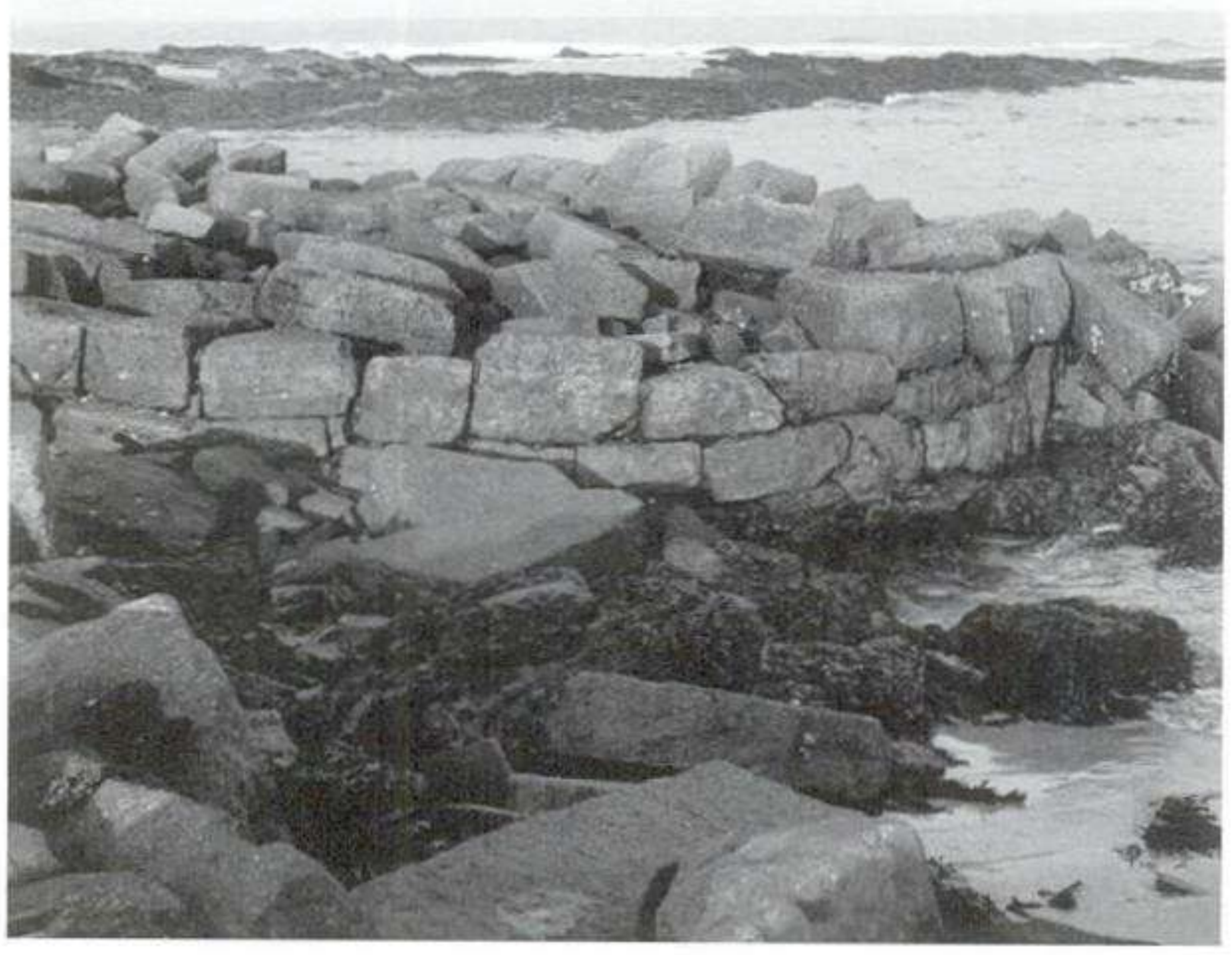

Figure 12.8. Footings of the collapsed north west pier of Kingsbarns Harbour.

Deterioration was noticeable at Fife Ness harbour, the St Andrews Castle piers, Newburgh harbour and Tayport harbour. Despite Tayport harbour being a Listed Building, the sloping cobble wall at the southern end of the main basin is collapsing due to drainage problems, while erosion at the end of the north-west pier has been caused by marine action. Considerable remedial work has been done to St Andrews harbour and the need for periodic refurbishment and maintenance is clear.

The decline of the salmon fishing industry has implications for the conservation of an important part of the Tay industrial landscape. Collapsing bothies, fishing platforms, decaying harbours, salmon cobles and other associated remains are all visible and suffering from neglect, but, in the majority of cases, coastal erosion is not a factor in their decline.

The survey team failed to identify two pillboxes on the coast-edge by Balcomie Links. Both were recorded in 1992 and one of them had been scheduled in 1996. It is feared that they may have been lost to erosion. Concrete debris was noted dumped on the coast-edge nearby. Several other military features may be at risk from erosion. Scouring has exposed some buried features along eroding sections of Tentsmuir beach, while shifting sands have obscured tank traps and other military features close to the coast-edge at the same location.

Geology, geomorphology and land-use

Carboniferous geology dominates the Forth shoreline with coal seams, bedded ironstones and oil-shales a part of the stratigraphic sequence (JNCC 1986). Carboniferous rocks can be seen around Buckhaven and Culross. The coal seams exposed at the coast are intersected by the Forth, which became an estuary following inundation caused by rising sea levels after the last ice age. Glacial till forms in small cliffs and bays where large boulders of glacial origin are sometimes strewn across the shoreline (JNCC 1986).

The net transport of sediment along the Fife coastline is mostly wave induced (H R Wallingford 1997). The prevailing winds in the Forth are westerlies and south-westerlies, but an increase in east and north-east winds has been observed recently. Strong winds from an easterly direction are an important cause of coastal erosion, particularly along the exposed sectors of the East Neuk.

In the Forth, there are two types of wave – those generated by wind (wind waves) and those originating from outside the area (swell waves). Wind waves generate a wide variety of wave patterns, both in terms of height and period, and tend to be generated locally. Wind waves are therefore an important factor in the Forth and Tay Estuaries where there is a limited 'on-shore fetch', or distance over which a wind can blow to generate increasing wave energy. West of the Forth Bridges the 'on-shore fetch' is 0.5–15 km. Swell waves tend to be generated in the North Sea and travel into the Firth of Forth from a northerly or easterly direction.

Estuarine areas such as the section of coastline between Kincardine and Rosyth receive mostly tidal wave energy with wind-generated wave energy restricted to waves created within the estuary itself. Stable mudflats are more common in this more sheltered environment, accumulating in bays and overlying bedrock. In places, the depth of mud exceeds 2 m. The mud probably originated from the River Forth.

East of Dalgety Bay, where the Forth opens out and the coastline is more exposed to wave energy from the North Sea, the coast is characterised by sandy bays interspersed by rocky headlands. In the east, these bays extend up to 5 km in length, but this distance shortens further west until the bays measure less than 1 km across. The coast is heavily developed and sea-wall protection is widespread in this area.

From Elie to Fife Ness, the coastline is exposed to the sea. Being less developed, coastal barriers are not as widespread as on the coastline to the south. The erosive force of the sea, at its worst during periods of easterly gales and spring tides, was evident in damage to the fabric of several small harbours. The coastline here is dominated by a foreshore of igneous intrusions and bare sedimentary rock backed by low cliffs and agricultural land. The lack of sediment lying on the foreshore means that only the most durable archaeological objects have been preserved. Nevertheless, the coast-edge appears to be fairly stable.

From Fife Ness to St Andrews, a platform composed of Carboniferous rocks dominates the foreshore. Fringing sand and shingle beaches exist at points where breaks in the rock platform have allowed sand to accumulate, most notably at Balcomie and Cambo Sands. Behind the isolated sandy beaches, dune ridges can be seen at the coast-edge, while the hinterland consists of blown sand deposits which have built up in low-lying ground between resistant rock headlands. At these points a raised beach rises as a gentle escarpment some distance behind the coast-edge.

Two beaches, East and West Sands, flank the town of St Andrews. The beaches are divided by a rock platform with several fringing beaches. West Sands is a wide sand beach with a low gradient and surplus blown sands nourish the active dune zone which can be seen along the coast-edge. The hinterland comprises an extensive raised beach and links area with blown sand deposits. Relic dunes within the golf course illustrate that West Sands has accreted seawards over time. The northern point of West Sands, Out Head, is a dynamic sand formation which is migrating north-eastwards towards the Eden Estuary. Since the early 1960s, the natural balance between accretion and erosion has been upset by the interference of man. A tip was initiated at the northern margin of Out Head to gain land. Ongoing erosion of this tipped waste means that the sea is now re-establishing a state of equilibrium. West of Out Head, the blown sand at the golf course edge has been eroded and coastal defence measures, such as groynes and gabion baskets, have been deployed to combat this problem.

The inner estuary of the Eden is composed of thick alluvial muds stabilised by marshland. The outer estuary experiences the redistribution of silts and sands by coastal processes and dramatic changes in the position of the main channel have been recorded in the past.

Tentsmuir beach has one of the largest dune systems in Scotland. The extensive dune area is the result of considerable post-glacial sea level fall which left a wide beach zone upon which dunes developed. Blown sand and dunes encroached westwards over low raised beaches. At Tentsmuir Point, a complex interplay of waves and tidal currents occurring at the mouth of the Tay Estuary has developed the spit/bar of Abertay Sands, sheltering Tentsmuir Point and altering the position of the main estuary channel. This has dictated the cycles of accretion and erosion along Tentsmuir Sands.

The Tay Estuary defines the northern coastal boundary of Fife. The heaviest development is in the vicinity of Tayport and the two Tay bridges. At the mouth of the Tay, a low coast-edge of blown sand deposits persists and localised erosion of these deposits can be seen. The intertidal zone east of Tayport is favourable for the preservation of archaeology. West of Tayport, cliffs composed of resistant basaltic and andesitic Devonian rocks reach down to the coast-edge and curved beaches have developed between the igneous rock promontories. As the estuary progresses westwards, the foreshore narrows where deep tidal channels flow close to the coast-edge. West of Balmerino, marshland stabilises the thick alluvial muds which have accumulated on the upper foreshore.

Erosion

Erosion status	Km of coastline, south survey	Km of coastline, north survey
Definitely eroding	3.21 km	9.55 km
Eroding or stable	18.19 km	17.5 km
Stable	31.03 km	31.08 km
Accreting or stable	29.96 km	14.1 km
Definitely accreting	6.42 km	4.3 km
Both accreting and eroding	14.98 km	9.15 km
No information	3.21 km	0 km
Total	107	85.68

Table 12.4. Erosion classes for the north and south surveys.

Although erosion rates were seen to vary substantially, even between adjacent sections of coastline, it is possible to identify the following trends in coastal erosion along the survey section (Figure 12.9).

The coastal stretch between Kincardine and Rosyth is mostly experiencing sediment accretion. Between North Queensferry and Dysart, the coastline is mostly stable with localised accretion or erosion. Between Dysart and Buckhaven, unprotected sections of coast are experiencing erosion, which may be occurring rapidly in places. Between Methil and Earlsferry, erosion of sand along the coast-edge is commonly redeposited on the foreshore. Between Earlsferry and Fife Ness, erosion of the unprotected coast-edge can be seen in many places. Sand is accreting on the foreshore of sheltered bays such as at Earlsferry and Elie.

Along the exposed coastline between Fife Ness and Kingsbarns, the sea is exploiting breaks in the rock-cut platform resulting in localised undercutting of the coast-edge. Erosion of raised beach deposits around Buddo Rock was noted. East Sands, St Andrews, is generally stable despite experiencing temporary changes of up to 1 m in beach height. This results from the complex interplay of tides and currents transporting

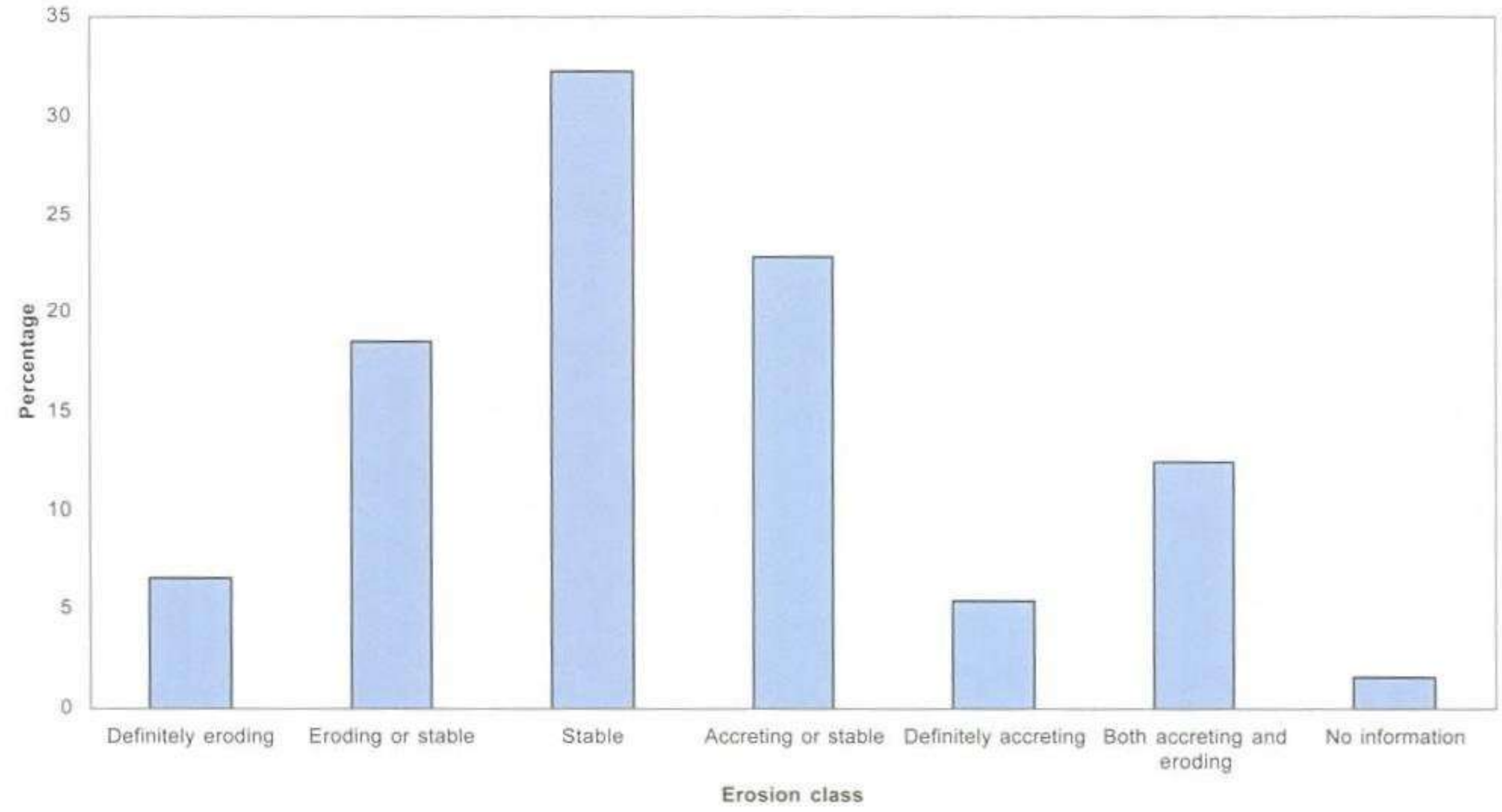

Figure 12.9. Graph showing the erosion classes for the coastline surveyed.

sediment between the beach zone and offshore sinks and bars. West Sands, St Andrews, experiences cycles of erosion and accretion with dune rehabilitation maintaining the stability of this beach zone. In contrast, human interference at Out Head has induced erosion at the northern point. The southern sector of Tentsmuir sands is experiencing accretion, while the northern sector is being eroded. This is the result of natural change due to the complex interplay of tidal currents and waves which occurs at the mouth of the Tay Estuary. The erosion of the northern sector of Tentsmuir has been a matter of recent concern because the High Water Mark is retreating inland at a substantial rate. This situation should be monitored and work might have to be undertaken to stabilise dune vegetation in the area.

The Tay Estuary is generally experiencing accretion of sediments resulting from agricultural run-off from farming and land-use upstream. However, localised erosion is occurring where estuarine currents at high waters flow close to the coast-edge. In built-up areas, erosion is caused by drainage run-off from the land.

Discussion and Recommendations

The surveys achieved their principal objectives, a rapid assessment of the coast-edge, intertidal zone, and 100 m land strip. However, two surveys, lasting 23 days in total, of a coastline 192 km in length with 1041 sites cannot achieve total coverage and further work is required.

The field team located 382 sites which did not appear in NMRS or in the Fife SMR. The majority of these were found on the foreshore where little systematic recording had been done before these surveys. Of these newly identified sites, the intertidal wrecks and associated structures at Kincardine, the wide range of fishtraps identified along the coast, and the coast-edge middens at Elie, Pittenweem and Crail were of particular interest.

Further work is required in identifying some of the intertidal features seen. The range of functions and origins attributed to the site originally called the 'Crombie Crannog' may be a case in point. Here, functions may have been attributed based on the personal specialist knowledge of particular observers rather than on any in-depth examination.

In most cases, these surveys confirmed the existing bibliographic records of the 659 sites already noted in the NMRS or Fife SMR. But, in some cases, changes had occurred, mostly due to coastal erosion. The value of ongoing monitoring became clear because rapid changes set off by some environmental or man-made trigger were seen to be occurring to coastal sites. Without periodic monitoring, it would be impossible to identify sites under threat or to react to any threat posed.

Conclusions

Several conclusions can usefully be drawn. The factors perceived to play a major part in controlling erosion rates along the coastal edge include the deployment of coastal defence measures, the local geology, and the degree of shoreline exposure. Coastal defences were seen to be effective in limiting erosion along protected stretches, such as at St Andrews Castle, but the resulting effects on unprotected sections of coastline, while difficult to quantify, need to be considered.

Erosion rates varied between a coast-edge comprising resistant bedrock geology and that comprising raised beach and marine deposits, blown sand or landfill. For instance, the unprotected coastline between West Wemyss, East Wemyss and Buckhaven, which comprises drift clay or landfill deposits, is experiencing rapid erosion, whereas the unprotected bedrock promontories between North Queensferry and Kinghorn appear stable.

The coast between Fife Ness and the Forth Road Bridge is fully exposed to the open sea, with the effects of erosion seen to be particularly destructive during prolonged periods of easterly gales and spring tides. In contrast, the sheltered estuarine area to the west of the Forth Road Bridge displays an altogether different picture, with sediment accretion along the foreshore, comprising mostly mud originating from the upper reaches of the River Forth. There is similar accretion in the Tay Estuary.

Erosion may be having a detrimental effect on 80 sites within the survey area. The Pictish cist at Lundin Links was the site thought to be most under threat. Considerable deterioration was identified at the site of the East Wemyss Gas Works, and more gradual deterioration at Crail and Pittenweem midden sites. The condition of the small harbours of the Firth of Forth, with anecdotal evidence of recent damage to Cellardyke, Pittenweem and Anstruther Easter, and the loss of the two World War II pillboxes, must also give cause for concern.

There is a need to carry out more detailed recording of many of the sites identified because, as time passes, certain material will be lost. For instance, evidence for rudimentary landing places along the Fife coast exists in the worked rock of the foreshore. While this evidence may last for years, information on the enhancement of these natural harbours by, for example, iron fittings will be lost due to corrosion of iron in sea water.

Not unsurprisingly, coastal erosion is not a new problem in Fife with records from the 18th century detailing spectacular flooding events. In the future, it is likely that coastal erosion of archaeological sites will continue to occur. Any prediction for global sea level rise for the 21st century is complicated by regional and climatic variables.

Changes in sea level complicate the task of tracing coastal communities into prehistory. It is therefore important to remember in the future that, just as traces of coastal activity can be found inland on the raised beaches of the Forth (Price 1982), we may also find submerged coastal evidence buried deep in estuarial mud deposits.

The following recommendations (Table 12.5) concern both previously unrecorded sites where there is further need for investigatory fieldwork, and recorded sites where the survey team recommended that further work should be carried out because the site appeared to be in poor condition or because erosion represented a threat to its fabric.

Action	Number of sites, south survey	Number of sites, north survey
Survey	86	44
Monitor	21	10
Survey and monitor	22	4
Nil -no action required	595	259
Total	724	317

Table 12.5. Recommendations for further work.

In response to these recommendations, Maritime Fife has undertaken some follow-up survey work as part of the Historic Scotland focal study initiative (Wood 1997 a, b, c, d; Oxley this volume). In addition, site visits were made to record the loss of archaeological deposits from the Pictish cist at Lundin Links (Will 1996). By the time of this second visit, the deposits identified during the coastal survey project had disappeared.

Acknowledgements

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13 ASSESSMENT SURVEY: THE FIRTH OF FORTH (DUNBAR TO THE BORDER OF FIFE)

HEATHER F JAMES

Introduction

A rapid coastal survey was undertaken by Glasgow University Archaeological Research Division (GUARD) of the south shore of the Firth of Forth from Dunbar to Stirling and along the north shore to the Fife border, a distance of 170 km (Figures 13.1 and 13.2). A brief assessment was also made of a number of sites between Dunbar and the English border. The survey took place in February and March 1996 and reported in April 1996. The Firth of Forth is located on the east coast of Scotland and starts as a narrow meandering river at Stirling, widening out to c 2.5 km at Grangemouth and 15 km at North Berwick. There was a lack of previous archaeological survey, but three geomorphological studies (Firth *et al* 1995; Halliwell 1995; H R Wallingford 1995) had been undertaken.

Methods

The aim of the survey was to assess the effects of erosion on the archaeology and built environment within the coastal strip and highlight sites under direct threat of destruction. For the purposes of this survey the coastal strip was defined by Historic Scotland (1996) as the area between Low Water Mark and 50 m inland, thus including the intertidal zone. Sites between 50 m and 100 m inland were included in the gazetteer but not visited. An attempt was made to locate all the known sites included in the National Monuments Record of Scotland (NMRS) and those depicted on the first edition Ordnance Survey (OS) maps. Any new sites or features of archaeological interest discovered during the fieldwork were recorded. The condition of each site was assessed. Based on this assessment, a subsequent recommendation was made to survey, monitor or 'do nothing'.

Listed buildings, designed landscapes, scheduled and unscheduled monuments were all included in the survey. Due to a lack of time, the possible sites identified from an inspection of oblique and vertical aerial photographs in the NMRS could not be checked in the field and so their inclusion as archaeological sites remains unverified.

The fieldwork was undertaken simultaneously by two teams, each of two archaeologists, over a period of 10 days. One team studied the coastal strip east of Cramond (approximately halfway) and the other worked to the west. The teams generally walked each section of coast once, in whichever direction was most convenient. The ideal methodology would have been to walk the coastline at different states of the tide and in different directions as this would have greatly increased the chances of finding new sites, but unfortunately the time-scale did not allow this.

The survey included an assessment of the hinterland geology, coastal geomorphology and current rates of erosion. This assessment was undertaken by archaeologists at the request of Historic Scotland, but it is now recognised that a long-term assessment by professional geomorphologists would be more appropriate and exact. The assessment observed the coastal conditions and grouped lengths of coast which had similar properties. In this way the coast was divided into 53 'units' of varying length. The location, length, foreshore type, coast-edge and hinterland type of each unit was recorded. Also recorded was the condition of each unit, ie eroding, accreting or stable, the condition of sea walls, the presence of other coastal works, and any relevant local knowledge.

Analysis

Built heritage

Prior to the survey, about 210 archaeological sites or find-spots were recorded in the NMRS (including six designed landscapes). The fieldwalking and examination of documentary sources identified 82 new sites and consultation of the aerial photographs detected 134 possible or potential sites which require verification. Therefore the total number of archaeological sites in the survey report (including the *possible* sites) was 423. Twenty-six of the known archaeological sites are Scheduled and eight are in the care of the Secretary of State for Scotland (in Guardianship). In addition, about 229 listed buildings were recorded within the coastal strip.

As this was one of the first coastal surveys undertaken, no statistical analysis of the sites by date, function or character was carried out. It has only been possible to undertake a brief overview of the results for this report.

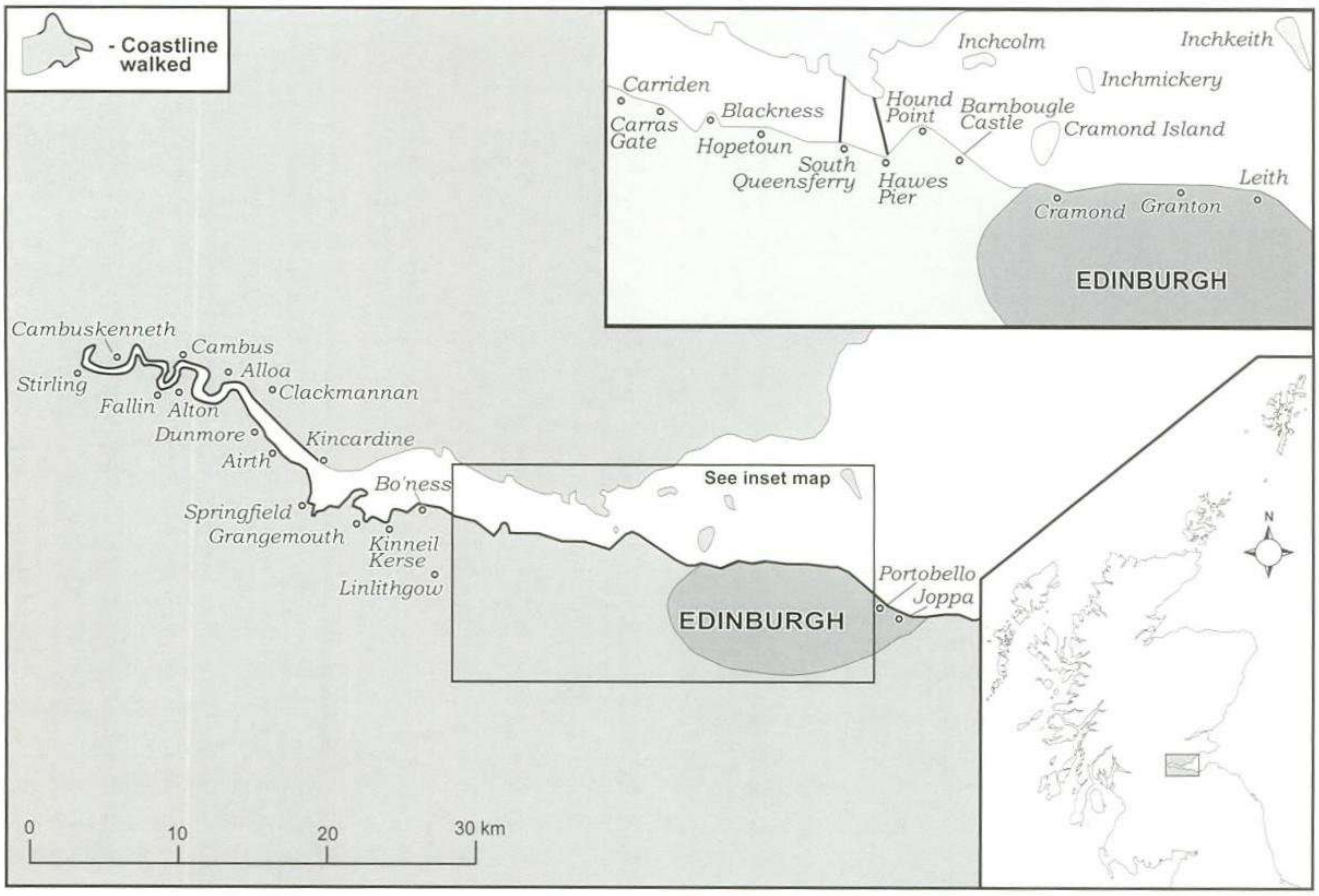

Figure 13.1. Location map showing the western half of the survey and places mentioned in the text.

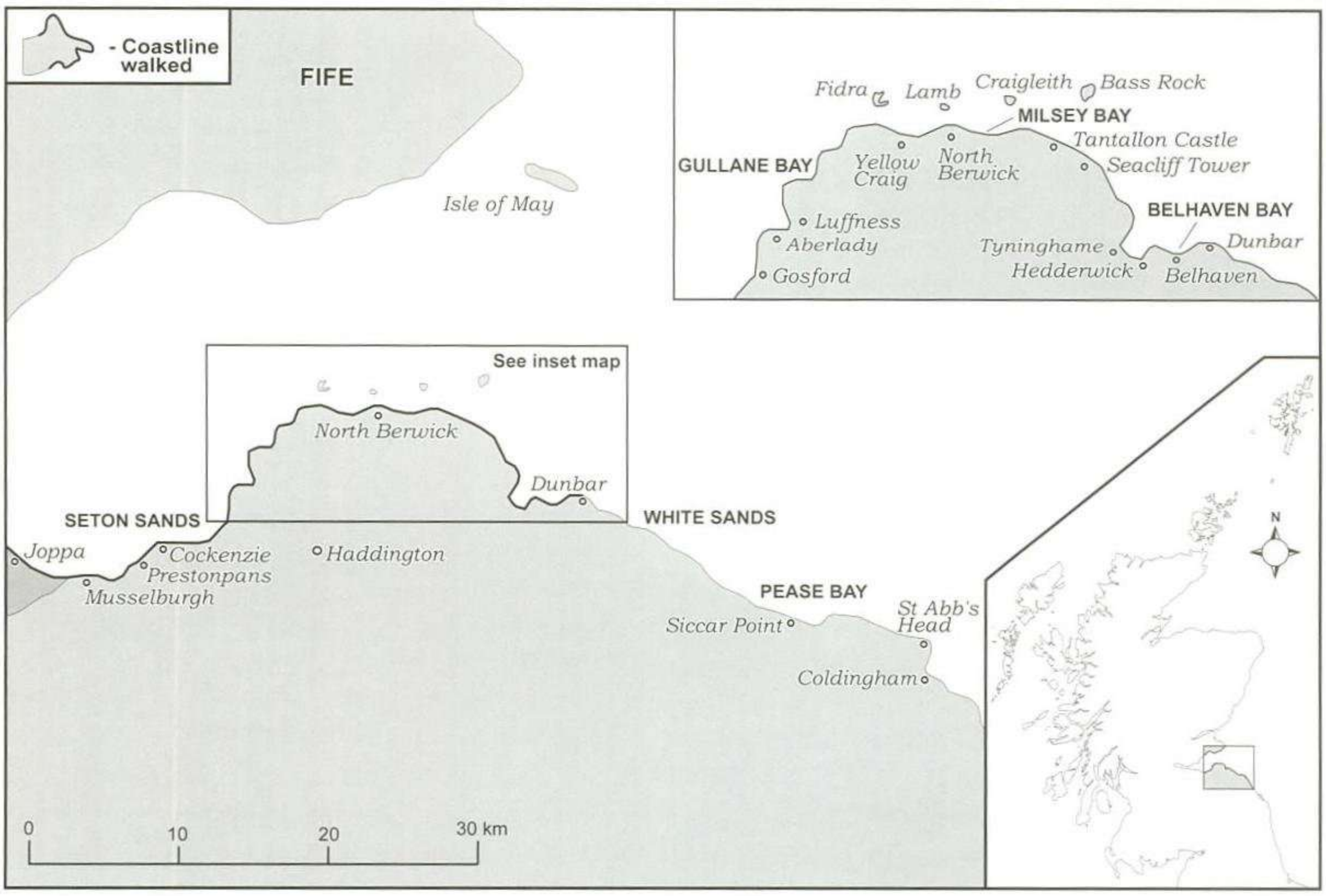

Figure 13.2. Location map showing the eastern half of the survey and places mentioned in the text.

Sites by date

The prehistoric period is clearly under-represented in the archaeological record. The attribution of date in this report is as given by NMRS and has not been reconsidered in the light of recent archaeological knowledge. A single shell midden (Kinneil Kerse) and an antler implement are the only indications of two possible Mesolithic sites. Similarly, the Neolithic period is represented by two find-spots, Hedderwick, which has produced Neolithic pottery, and a single stone axe found elsewhere in the coastal strip. The Bronze Age is slightly better represented with seven sites. These consist of six short cists or groups of short cists, and a single Late Bronze Age sword. Eleven sites are thought to date to the Iron Age. These include two promontory forts (Carras Gate and Siccar Point), two caves, a 'building' which has been associated with Iron Age midden material, two groups of cists, an Iron Age 'burial', a brooch, a small group of Iron Age rings and a copper cauldron.

Nineteen sites of uncertain date are also considered to be prehistoric. These include nine 'forts', enclosures or earthworks, one barrow with associated cists, five other groups of undated cists, one midden, and one site which revealed human remains. The only potentially *new* prehistoric sites were two crop mark enclosures detected on aerial photographs.

The Roman period is represented by ten sites, consisting of three forts (Cramond, Blackness and Carriden), a promontory fort, a possible temporary camp, a watching tower, an altar, a possible breakwater, a trumpet brooch, and a Roman coin.

The Early Historic (or Early Christian) period in this area is represented by 18 sites. These comprise 14 long cist cemeteries (two are *possible* sites), a chapel, and three monastic settlements (all at St Abb's Head). There are also two Anglo-Saxon sites consisting of a cairn and a timber hall (Dunbar).

Fifty-four sites are attributed to the medieval period. These include six castles (Figure 13.3), one abbey, five churches, one nunnery, two battle sites, four chapels, two wharves or harbours, and two deserted medieval settlements.

Eight areas of rig and furrow (evidence for earlier cultivation) seen from aerial photographs could be medieval or later in date. The remaining 300 sites are attributed to the post-medieval period. These include industrial, commercial and domestic buildings, harbours, docks, piers, wartime defences, designed landscapes, wooden structures, wrecks, sea-wall defences, and outdoor swimming pools.

Figure 13.3 View of the covered passage leading from Dunbar Castle to the blockhouse.

Listed Buildings

One hundred and fifty-five Listed Buildings (of medieval and post-medieval date) lie within 50 m of the coast-edge. These buildings are concentrated in South Queensferry, Musselburgh, Prestonpans, North Berwick, Belhaven and Dunbar. The majority were domestic houses of the 18th and 19th centuries and are often still inhabited; however, many of them have been converted for other uses, such as shops. There are five listed churches, in North Berwick, South Queensferry and Preston Pans. Two castles are listed, Tantallon Castle (Figure 13.4), and Barnbougle Castle.

Figure 13.4.Tantallon Castle, built in about 1360.

Listed harbours include Bo'ness, Queensferry, Hawes Pier (and lighthouse), Fisherrow Harbour (Musselburgh), Cockenzie, and Dunbar (including the

Battery). Listed industrial buildings include the glass cone at Alloa Glassworks (Figure 13.5), the Thistle Pottery at Portobello, and four maltings or warehouses in Dunbar. More unusual listed structures include the drinking fountain at Bayswell Park, Dunbar, Luffness dovecot, and the 18th-century gatepiers at the old burial ground, South Queensferry.

Figure 13.5. Alloa Glassworks.

The fabric of these structures is adversely affected by the salty environment, but the fact that they are used and maintained by their owners has ensured their survival. They are not particularly suffering from erosion of the coast-edge because of the presence of sea walls.

Vulnerable sites

There are several upstanding structures which are neither listed nor scheduled, nor are they protected or maintained. They are therefore vulnerable to erosion. These include the medieval Seacliff Tower (Figure 13.6) which is actively eroding into the sea, the post-medieval limekiln at Fallin, mine workings at Musselburgh, rock-cut salt pans at Joppa, and the possible remains of a pan house at Cockenzie. The industrial remains within the Firth of Forth are generally vulnerable because they have not been recognised and valued as part of the national heritage.

One of the most vulnerable types of site consists of unconsolidated midden deposits. The archaeological record includes 10 sites where midden material has been exposed in the past, such as Hedderwick, where a short cist containing a human skeleton was found along with hundreds of pottery sherds, flints and stone axes. The site is located on a rapidly eroding plateau 6 m above the shore which indicates that it has already been partly destroyed. No newly exposed or eroding midden was found here or elsewhere during the survey, perhaps partly because slumping of the sandy coast-edge has masked the midden deposits, or perhaps because of the susceptibility of midden deposits to complete and rapid removal by the effects of tides, wind and erosion of the coast-edge. Some sites may not have been discovered because of their inaccessibility, because they were hidden by the high tide at the time of the visit, or because they were located on steep gradients which were unsafe to scramble over.

Figure 13.6. Seacliff Tower, East Lothian.

Also vulnerable to the effects of erosion are sites constructed of wood, such as old piers, sea defences, bank revetments, glider traps, fish weirs and fishtraps. There are 20 sites which consist of wooden piles or posts located within the eroding or stable shoreline. Only one possible fishtrap was noted during this survey but others may still await identification. Wooden hulled shipwrecks within the intertidal zone are also highly sensitive to erosion; two in particular were noted in Aberlady Bay.

The survey recorded many previously unrecorded World War II defences such as lines of anti-tank traps consisting of either concrete cubes or cones, gun batteries, pill boxes, gun emplacements, and a searchlight base (Figure 13.7). Despite being built of concrete and brick, these are threatened because of their proximity to the coast (and exposure to coastal erosion) and because they have not generally been appreciated as part of the historic environment. Many have been actively destroyed, sometimes blown up by the landowner. Slit trenches were also seen, but can be easily overlooked in thick undergrowth or sand dunes, as they are merely cut into the ground surface.

Figure 13.7. A World War II brick searchlight base.

Geology and geomorphology

The underlying geology of the study area includes the basaltic rocks of the North Berwick coast and limestone to the east, which are resistant to erosion and form the higher cliffs. The sedimentary rocks of the western section are less resistant to erosion and form gently rolling lowlands. The overlying glacial sediments were deposited during the Late Devensian glaciation. These deposits have been reworked by the processes of coastal erosion, which has moved material along the coast and added to it by the deposition of river alluvium and by sand blown from intertidal sand banks.

Post-glacial changes in sea level have also affected the coast-edge and have influenced the location and visibility of prehistoric sites. A combination of isostatic rebound and rising sea levels resulted in a series of raised beaches extending from Stirling to Dunbar (Sissons *et al* 1966). Lambeck has predicted that the maximum sea level occurred about 6000 years BP, which corresponds with the Main Post-glacial Shoreline seen in eastern Scotland (Lambeck 1995, 447). The present shoreline was therefore submerged for some periods during the post-glacial period, which may explain the absence of prehistoric sites.

The nature of the coast-edge is quite varied along its length. The western section of the estuary from Stirling to Grangemouth consists of a meandering tidal river with a low coast-edge that has been defended with revetments in several places. Mudflats are exposed at low tide and many tidal reed beds fringe the shoreline. The mudflats continue east of Grangemouth while the coast-edge consists of reclaimed land protected by sea walls. Between the rocky headland at Blackness and Hound Point the low coast-edge continues and raised beach deposits and occasional rocky outcrops are found. From Hound Point to Granton there are extensive sandflats.

From Granton eastwards to Seton Sands are the built-up areas of Edinburgh, Musselburgh, Preston Pans and Cockenzie. Here the coast-edge consists of sea walls which front a rocky or sandy foreshore.

From Seton Sands to North Berwick the coast consists of wide sandy bays, such as the Gosford Sands, between rocky promontories; Aberlady Bay and Gullane Bay are also backed by extensive sand dunes. In the vicinity of Tantallon Castle the coast-edge rises to form cliffs over 20 m high. From here the Forth becomes more exposed as it faces the North Sea, but the coast is still varied.

The estuary of the River Tyne opens out into Belhaven Bay where extensive sand spits have built up across its mouth, allowing mud and sand flats to form. From Belhaven to Dunbar the coast-edge is increasingly dramatic with cliffs up to 100 m high. The upper edges of the cliffs consist of steeply sloping overburden which is gradually slumping into the sea. Along this stretch are a few small sandy bays such as White Sands and Pease Bay.

Some of the small rocky offshore islands within the Firth of Forth were considered by the survey but (with the exception of Cramond) could not be visited in the time available. These include Inchkeith, Inchmickery, Fidra, the Lamb, Craigleath, and the Bass Rock. Other islands further from shore not included in the survey include Inchcolm, and the Isle of May.

Erosion

The above factors have combined to create a complex pattern of erosion along the coastline. This pattern has been affected (probably far more so than any other area under study in Scotland) by human interference as the intensity of settlement, industry, reclamation and agricultural activity has resulted in the construction of protective sea walls and earthen banks. These have generally slowed the recession of the coastline in particularly sensitive areas, but this has often resulted in greater erosion in unprotected areas.

The study concluded that about 16 per cent of the coast-edge was actively eroding, 55 per cent was eroding or stable, about 15 per cent was stable and the remaining 14 per cent was classified as either stable or accreting (Figure 13.8).

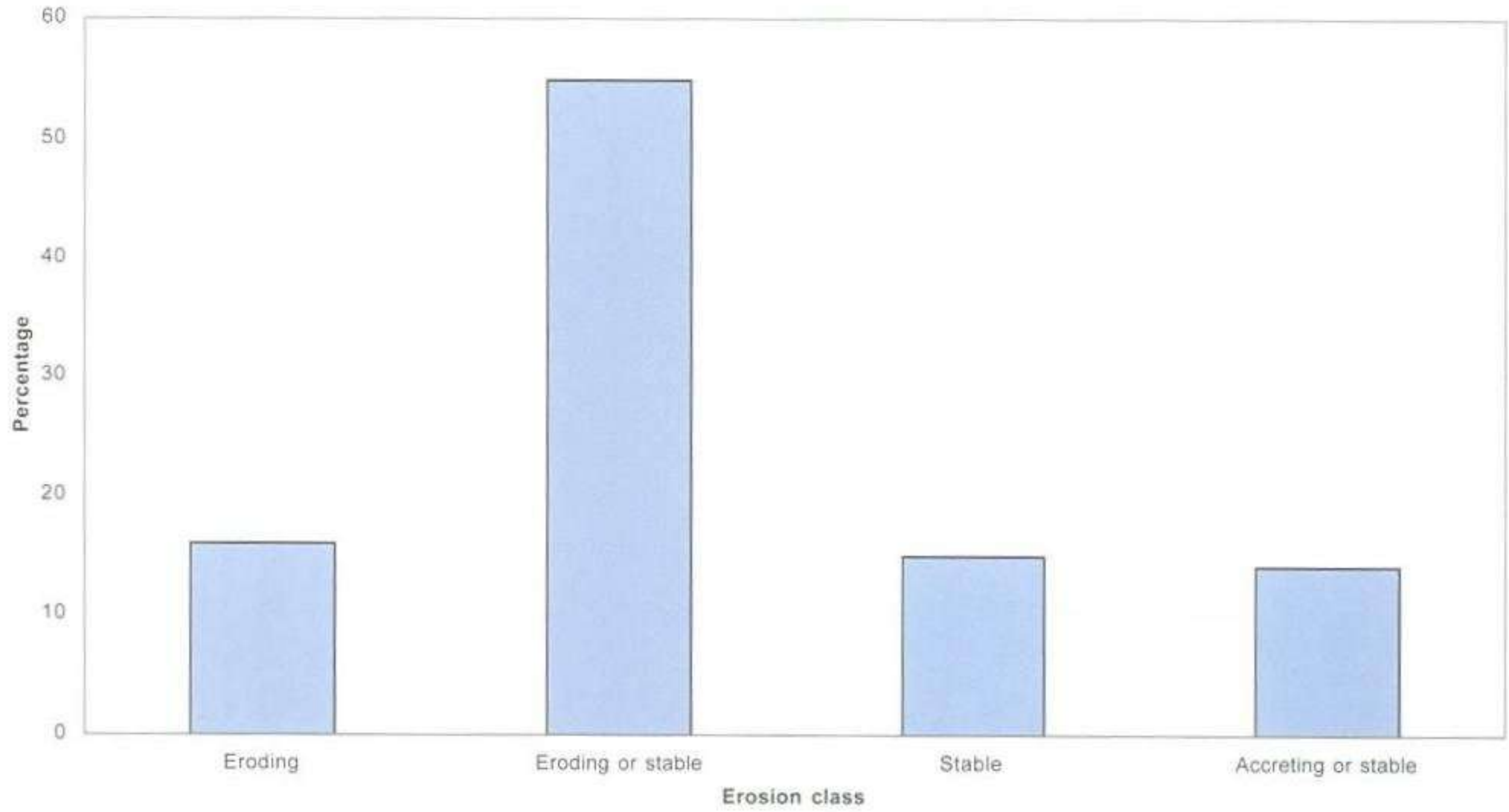

Figure 13.8. Graph showing the erosion classes for the coastline surveyed.

The most serious erosion was thought to be taking place from Bo'ness to just west of Blackness Castle, from Hound Point to Cramond, in Gullane Bay, from North Berwick to Belhaven Bay, the southern part of Belhaven Bay, and from Dunbar towards St Abb's Head. Only those areas which were protected by sea walls were classified as stable, yet they too were showing signs of the destructive effects of the waves. Accretion was noticeably taking place in limited areas such as Aberlady Bay, Milsey Bay, and Belhaven Bay.

In the absence of scientific measurement, there was scant evidence for the actual speed of erosion. At Gosford and Tyninghame the presence of ruined sea walls shows that in the past 100 years the coastline has receded between 5 m and 7 m. At Hedderwick Sands the eroding coast-edge forms sand and mud cliffs up to 3 m high and the local Scottish Natural Heritage (SNH) warden suggested that 0.3–0.4 m was being lost every year. There is therefore much work that should be done in measuring the rates and nature of erosion in the Firth of Forth.

Discussion

The interaction of the coastal region with its hinterland and the sea, islands and land beyond is complex and varies along the length of the coast. Changing social and economic conditions have resulted in changing foci for this interaction and differing survival of earlier patterns, some of which have been incorporated into the landscape and some destroyed. It is difficult also to consider the importance of sites without consideration of the wider landscape, as coastal sites did not function in isolation from their hinterland. This, however, was beyond the scope of the rapid survey.

There is evidence for prehistoric settlement in the Lothians dating from at least 4500 BC (Ashmore 1996), yet there is a general paucity of sites within the coast-edge. There are at least three possible reasons for this under-representation:

- The sea level was formerly higher than at present, creating the raised beaches; the present coast-edge would have been submerged and therefore unavailable for settlement.
- Many prehistoric sites have been masked or obliterated by later occupation or cultivation which in the case of this area of study has been intense.
- Little work has been done in this area to look specifically for prehistoric sites within the intertidal zone or beneath deep deposits of wind-blown sand.

This dearth of prehistoric sites contrasts with the relatively large number of long cist cemeteries within the archaeological record. Long cist cemeteries generally date from the 5th century to the 11th century (Henshall 1956; Dalland 1992). They are found in coastal locations, often in sand dunes, specifically in south-east Scotland. No cemeteries appear to be exposed in the coastal strip at present, though some are within actively eroding zones. It is well-known in Scotland that this situation can change very rapidly as previously unknown cists are often exposed after storms.

The area around Cambuskenneth Abbey produced a previously unrecognised crop mark feature. This was subsequently investigated by a team from GUARD and the associated geophysical and topographical surveys have shown the area to be under-researched and well worth further study and possibly more extensive statutory protection (Etheridge 2000).

Graham (1969), in his study of the harbours of the Firth of Forth, has highlighted the connection between the inland royal burghs such as Haddington and Linlithgow with their coastal harbours Aberlady and Blackness. These harbours were also important for fishing, particularly for herring, in the 18th and 19th centuries. Other known medieval harbours are located at Belhaven, Queensferry, North Berwick, Leith, Cramond, and Stirling. Some of these medieval harbours, such as Queensferry, Leith and Cramond, would have been incorporated into the later harbour fabric, leaving little or nothing visible. Lack of detailed analysis of the harbours and unmonitored development may result in the destruction of the medieval remains. Belhaven harbour, founded in the middle of the 12th century and used by the Isle of May Priory, now lies within reclaimed ground behind a sea-wall. Parts of masonry were still visible in 1841 and in 1966 other masonry was discovered (Graham 1969, 216).

In between the official harbours, the surviving stone-built piers, ports and jetties are remnants of post-medieval industry and are reminders of the importance that the water used to have for transport up the Forth and across to Fife. This survey has shown that several of these features shown on the first edition OS map still survive, although in a much decayed state, such as at Cambuskenneth and Dunmore. Further work on these features could assess their rate of decay by comparison with Graham's photographs.

The islands of the Forth were not included in the survey but are clearly also affected by coastal erosion and are an important part of the archaeological landscape. In the past, the sea has been a conduit rather than a barrier for contact between settlements in the Lothians, Fife, the rest of Scotland, and with the continent. These islands have evidence of settlement (some dating from the prehistoric period), and medieval castles. The presence of Early Christian and medieval monastic retreats and prisons shows that their relative isolation was also a factor in their settlement.

Several stretches of the coast-edge are included within 18th- and 19th-century designed landscapes associated with large estates. Many features such as areas of woodland and rides survive, while others have been lost due to changes in fashion and a decline in the maintenance of grounds as the priorities of the landowners changed. At Hopetoun House, crop marks show the location of old gardens beneath the turf (Cruft 1981). Although the coast-edge is not generally the focal point of an estate or designed landscape, it does form an integral part and because of this, has been protected by the construction of sea-walls, as at Gosford and Tyninghame.

There are several areas of the upper Forth where much of the coast-edge has been reclaimed by farmers wishing to improve their properties. At Airth, successive embankments since the 18th century have reclaimed large areas of the flood plain (Driscoll 1994). Reclamation has also taken place at Clackmannan, Cambus and Alloa Inch, south of Kincardine Bridge to Bo'ness, east of Cramond to Leith, and at Musselburgh. The implication of this reclamation is that these areas can be considered archaeologically sterile except for those features belonging to the post-medieval period.

Recommendations

- All the sites identified from aerial photographs should be checked in the field and further aerial surveys in the vicinity should be planned. Aerial photographs also indicate that there are potentially some very interesting sites, the most exciting of which is a possible new long cist cemetery site near Gosford. Several areas of rig and furrow and many World War II sites were also recorded. Crop mark enclosures were seen at Taylorton Piggery, (near Stirling), Alton, Yellow Craig, the Lamb, and Seacliff. A possible promontory fort was noted at Coldingham. Other crop marks which may be of archaeological interest were seen at Dunmore and Springfield. All of these should be further investigated.
- The coastline should be monitored regularly in order to detect sites exposed by episodes of coastal erosion caused by storms, extreme high tides, or the slumping of overburden or sand dunes.
- Scientific measurement of coastal retreat should take place where erosion is most severe. Carter (1990) has attempted to measure the rate of recession of the Northern Irish coast by comparing maps, charts, documents and photographs of the past 150 years. He suggests that this method, supplemented with field surveys, can produce a reasonably accurate picture of the coastal changes.
- Future survey teams should include a geologist/geomorphologist.
- Specific examination of the intertidal zone should be organised. This would enable the detection of any of these particularly vulnerable, but as yet under-researched, sites.
- There should be further research into specific themes associated with the coastal strip, for example fish weirs and traps, harbours, river transport, and salt panning. Research into related themes not specific to the coast-edge should also be undertaken, for example prehistoric settlement, medieval deserted villages, and a detailed study of Cambuskenneth Abbey.

- There should be consideration of the known sites within the wider landscape, especially of how the sites inter-reacted with their hinterland.
- Surveys of the islands of the Firth of Forth, with the exception of the Isle of May which has already been looked at in detail (James & Yeoman forthcoming), should be undertaken as they were excluded from this survey.
- It is suggested that Listed Buildings should be dealt with separately from the other archaeological sites. The work involved in gathering data about them proved time-consuming and, considering the 'rapidity' of this survey, perhaps was not time well spent.

Acknowledgements

The author would like to acknowledge the work of the survey teams: Susan Bain, Alan Radley, Mairi Logie and Stuart Halliday. Catriona Leask provided a summary of the Statistical Accounts. Dave Etheridge undertook the other documentary research and consultation of aerial photographs. The author would like to thank Tessa Poller for her very helpful comments on the text.

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14 ASSESSMENT SURVEY: SOLWAY FIRTH (MULL OF GALLOWAY TO SARK BRIDGE, GRETNA GREEN)

BILL FINLAYSON AND MIKE CRESSEY

Introduction

The Centre for Field Archaeology (CFA) carried out a rapid Coastal Assessment on behalf of Historic Scotland during the autumn and winter of 1996 (Cressey & Toolis 1997). The survey followed the guidelines and procedures outlined in *Coastal Assessment Survey: Archaeological Procedure Paper 4* (Historic Scotland 1996). The survey area extended from the Mull of Galloway to Sark Bridge near Gretna Green (Figure 14.1) and included a coastal corridor approximately 50 m wide and covering a combined map unit length of 318 km. The primary objectives were to establish which areas of the Solway Firth coastline were eroding and to what extent this was having an effect on the archaeological record. A series of case studies was carried out to compare and contrast the differing rates of erosion and accretion at selected representative environments within the study area.

Environmental Setting

The Scottish part of the Solway Firth included within the study comprises a wide variety of coastal settings that include precipitous cliffs and a variety of depositional areas, such as sand dunes, intertidal mud flats, estuaries, lagoon complexes, and salt and freshwater marsh. The total length of coast in Dumfries and Galloway is estimated at 447 km (Ritchie & Mather 1984), and the Solway Coast study area comprises a significant proportion of this area. Within the coastal region of Dumfries and Galloway, there are an estimated 35.4 km of beach formations. The total area of sand in Dumfries and Galloway, including beaches, dunes and links is 2368 ha, representing 4.7 per cent of the Scottish total, but, at least in 1984, there were no beaches with high perceived erosion damage. Seventy-eight per cent of the beaches have raised beaches in their hinterland, representing an important resource for early prehistory in the area.

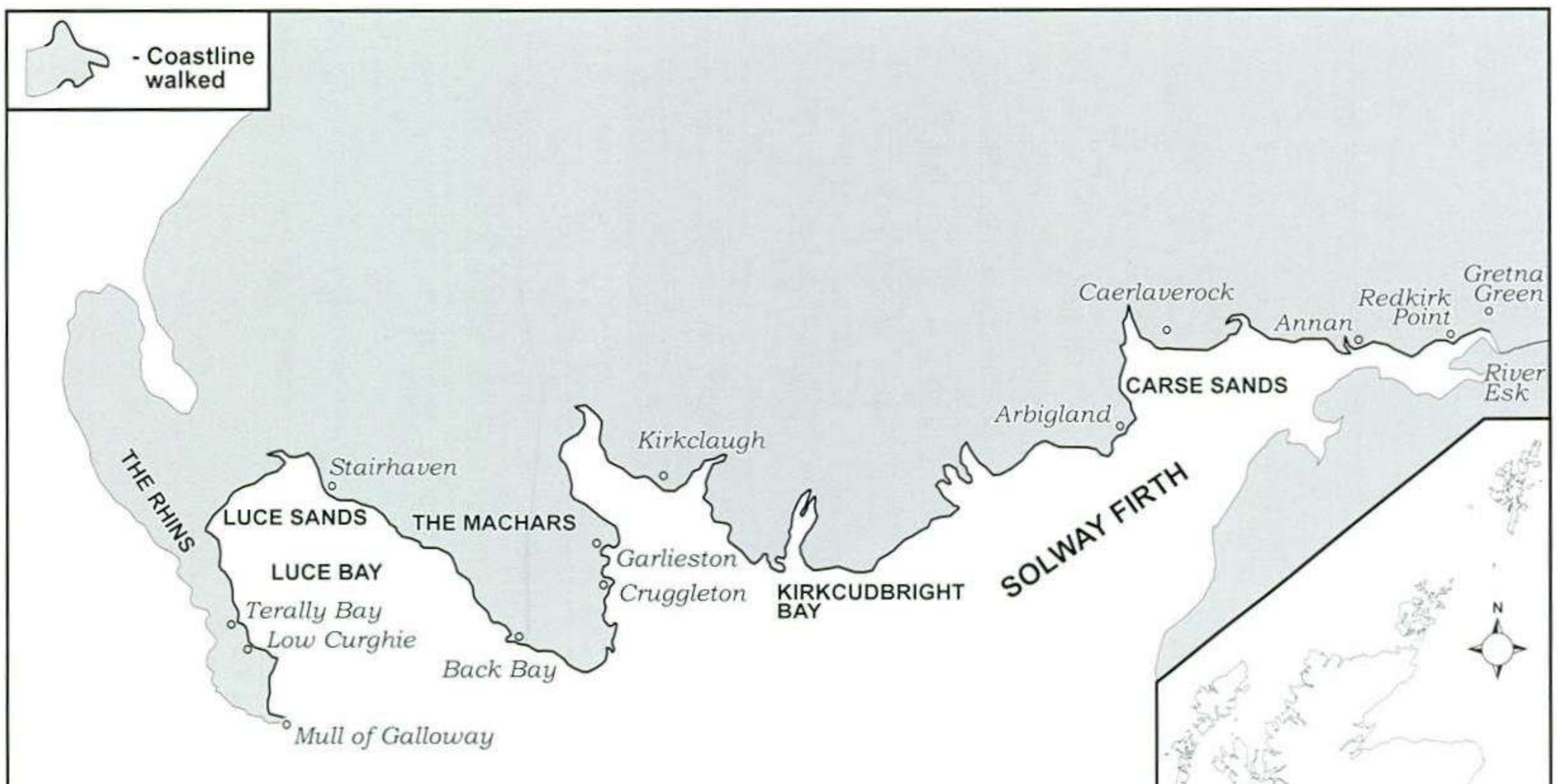

Figure 14.1. Location map showing the area of survey and places mentioned in the text.

Previous Work

Relative sea level changes make the coastal environment both complex and rewarding to study. As early as 1856, coastal erosion led to the discovery of Bronze Age cist burials and intertidal sub-fossil timbers in the Annan region. In recent times there has been a considerable amount of archaeological research in the study area. Much of this research has been prompted by coastal erosion, for example the work at Cruggleton Castle (Ewart, 1985) and Luce Sands (Cowie 1996). Local researchers such as Cormack and others have made a substantial contribution to our knowledge of this shore (Cormack & Coles 1968). A great deal of palaeo-environmental research has been conducted on intertidal areas such as the extensive tidal flats towards the head of the Solway Firth (Jardine 1980; Wells 1999; Dawson *et al* 1999). These researchers have clearly demonstrated the wealth and diversity of the archaeological potential within this area of south-west Scotland.

Methods

In accordance with the framework devised by Historic Scotland (1996), CFA adopted a four-phase approach that included the following elements:

- base-map preparation
- full desk-based survey
- field survey
- case studies and reporting

Phase 1 – Preliminary base-map preparation

Preliminary base-map preparation was undertaken for archaeological, geological and geomorphological aspects of the survey and included a rapid scan of the whole study area. During this initial start-up period, contact was made with the Scottish Wildlife Trust, Scottish Natural Heritage, the Ministry of Defence and other relevant landowners to arrange access.

Phase 2 – Desk-based survey

The results of the rapid scan assessment formed the necessary framework to undertake the full desk-based study. In addition to heritage information, this research identified a series of coastal zones characterised by respective accretion, stability and recession. CFA was allowed access to new aerial survey data housed at Scottish Natural Heritage, Dumfries, that provided invaluable support to the geomorphology database. The desk-based study was completed before fieldwork commenced, allowing the field teams to be supplied with 1:25,000 scale map sheets with colour-coded baseline information on geology, shoreline geomorphology, built heritage and archaeology.

Phase 3 – Archaeological, geological and geomorphological survey

The archaeological survey was systematic and conducted in all relevant land parcels (with the exception of areas thought to be unsafe, see below). Two teams of archaeologists working in close liaison with the geomorphology team carried out the survey. In essence, the fieldwork comprised standard archaeological field survey combined with the recording of the erosion status of sites. The assessment of vulnerable parts of the landscape, and the addition of new information was plotted onto the archaeological map sheets along with erosion classification. In areas with no accurate control points, hand-held GPS sets were used to assist in locating sites for mapping as required in the Historic Scotland procedure.

Survey conditions were not always ideal and extensive areas of dense vegetation cover above the High Water Mark, potentially masking small-scale archaeological features, proved to be a problem. Although the survey was conducted in the autumn and early winter, few problems were encountered with weather conditions. There were sections which could not be walked for safety reasons. These included some areas of cliffs and, most significantly along the Solway coast, areas of intertidal mudflats that could not be traversed on foot.

The geological and geomorphological features identified by the desk-based survey were ground-truthed by a team of geomorphologists to verify the preliminary results of the desk-based study. Ground-truthing was conducted at 50 sample locations, as opposed to examination of continuous lengths of coastline. An important aspect of this work was to assess the reliability of available geological maps within the study area.

Phase 4 – Case studies and reporting

The final survey report (Cressey & Toolis 1997) contained 168 colour-coded maps. It also included four case studies of archaeological remains, illustrating in greater detail the effects of coastal erosion. The archaeological importance of the sites was presented and the effects of localised and more massive coastal erosion were brought into focus. The first study assessed the upstanding remains of Stairhaven Harbour and the subsequent recession of the cliffs and the loss of the harbour. The second study examined the effects of erosion on a later prehistoric promontory fort at Back Bay. The third study examined the loss of intertidal peat and archaeological remains at Redkirk Point. The fourth case study was presented as a contrast to the other aforementioned case studies and reviewed the effect of both accretion and erosion over the last 140 years at Caerlaverock Merse, a large area of salt marsh landscape that has shifted its position many times over this period.

Analysis

Built heritage

In accordance with the guidelines set down in *Coastal Assessment Survey: Archaeology Procedure Paper 4* (Historic Scotland 1996) the archaeological sites were separated into broad chronological groups: early prehistoric; later prehistoric and early medieval; medieval; post-medieval; early 20th century.

Early prehistoric sites (8000–1000 BC)

A small, scattered distribution of early prehistoric sites is affected by coastal erosion. They comprise a flint scatter at Terally Bay in The Rhins, a find-spot of a hammer stone at Kirkcudbright Bay, and the Mesolithic occupation site and associated finds at Redkirk Point. Localised coastal erosion and instability of the foreshore account for the erosion at the first two sites, while massive coastal erosion affects the last-named site. That so few early prehistoric sites were located is probably a result of geomorphological processes. A variety of effects will have taken place over the long period covered by this chronological class. Many of the earliest sites known in the area, dating to the Mesolithic, are on raised beaches which are outwith the coastal survey zone. Other sites are almost certainly buried within river sediment, or lie in the tidal mudflat zone. These sites are not readily visible to conventional fieldwalking. This means that these locations, therefore, will be severely under-represented. Unfortunately, the fact that these locations are formed of soft sediments means that they are potentially at serious threat from rapid erosion. When seen, their appearance may be temporary and brief, following localised storm events and before being reburied or destroyed.

Later prehistoric and early medieval sites (1000 BC – AD 1000)

A larger, scattered distribution of later prehistoric and early medieval sites, dominated by the cluster of promontory forts around the southern tip of The Machars, are adversely affected by coastal erosion. They consist mainly of promontory and cliff forts, but also include 'homesteads', a possible galleried dun, a broch (Figure 14.2), and some less strictly defined settlements. The known sites appear overwhelmingly to indicate places of settlement which are located on the limits of the land.

This offers a marked contrast with the settlement record of the early medieval period, during which this geographical setting seems to have been much less favoured.

Medieval sites (AD 1000 – AD 1700)

A small, scattered distribution of medieval sites is suffering from coastal erosion. Localised coastal

Figure 14.2. Stairhaven broch.

erosion affects Kirkclaugh Motte and Cruggleton Castle (Figure 14.3), while massive erosion has obliterated the remains of the church and related medieval remains at Redkirk Point. These sites should be monitored on a frequent basis, although, given the severity of erosion in the intertidal area compounded by incisions caused by channels of the River Esk, it is unlikely that medieval structural remains now survive at Redkirk Point. However, isolated finds may continue to be revealed by the erosion of the foreshore.

Figure 14.3. Cruggleton Castle.

Post-medieval sites (AD 1700 – AD 1900)

Constituting by far the largest group of archaeological sites on the Solway Coast, the extensive but generally scattered distribution of more recent sites is nevertheless dominated by clusters of monuments and remains, particularly within the numerous bays and inlets of the coastline. The group as a whole differs markedly in nature from the preceding groups and includes piers, harbours, shipwrecks and fisheries. Predominantly maritime and industrial in character, the majority of sites are located on the foreshore and are particularly vulnerable to violent wave action. Although monitoring was recommended, detailed survey of a representative sample may be the best response to the erosion affecting this class.

Early 20th century (1900–1945)

A small distribution of monuments, mainly comprising World War II defences, designed landscapes, coastal defences and fishtraps (Figure 14.4), and largely clustered at Garlieston Bay, Carse Sands, and Arbigland, are affected by severe coastal erosion processes.

Figure 14.4. Fishtraps, Monreith Bay.

The gardens of Galloway House border on a severely eroding coastline at Cruggleton Bay, south of Garlieston, while on the foreshore of Garlieston Bay itself, the rusting hulk of a Mulberry harbour, used in training exercises during World War II, is vulnerable to violent wave action. The general dilapidated condition of many of the World War II defences was recorded during the field survey (Figure 14.5). A general monitoring and surveying programme may represent the best response for this group of sites.

Erosion and affected sites

Three hundred and thirty-four archaeological sites were recorded in the assessment survey. Of these 118 sites or 35.3 per cent of the population were identified as eroding. These eroding sites were further separated into two groups, one where the erosion was generally *Fair* (ie moderate erosion), the other *Poor* (ie severe erosion). The results show that moderate coastal erosion affected 16.2 per cent and severe coastal erosion was recognisable at 19.1 per cent of the total population of known archaeological sites (Figure 14.6).

The extent of coastal erosion affecting each chronological group can be gauged from Figure 14.7, where the number of sites in a group is expressed as a percentage of the total population of eroding sites. As can be seen, most of the eroding sites are from the post-medieval period. There are, however, a worryingly large number of later prehistoric and early medieval sites affected.

For interpretative purposes the sites were also split into eight classes of archaeological site type (Figure 14.8). As can be seen, erosion is affecting all types of site, with structures associated with World War II being the most vulnerable.

Figure 14.5. An eroding pillbox, one of many severely threatened sites from this period recorded during the survey.

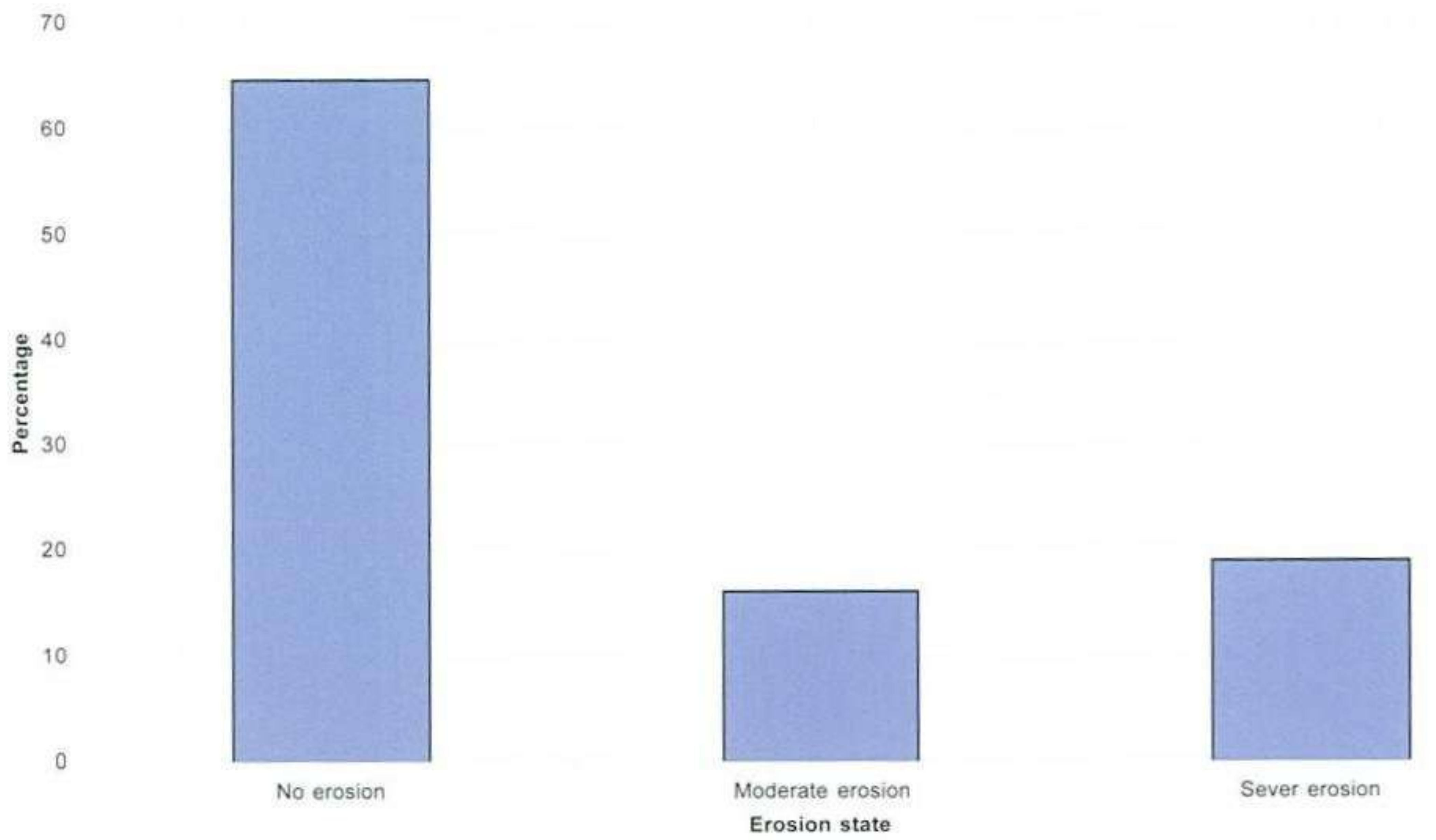

Figure 14.6. Graph showing the erosion state of all archaeological sites located during the survey.

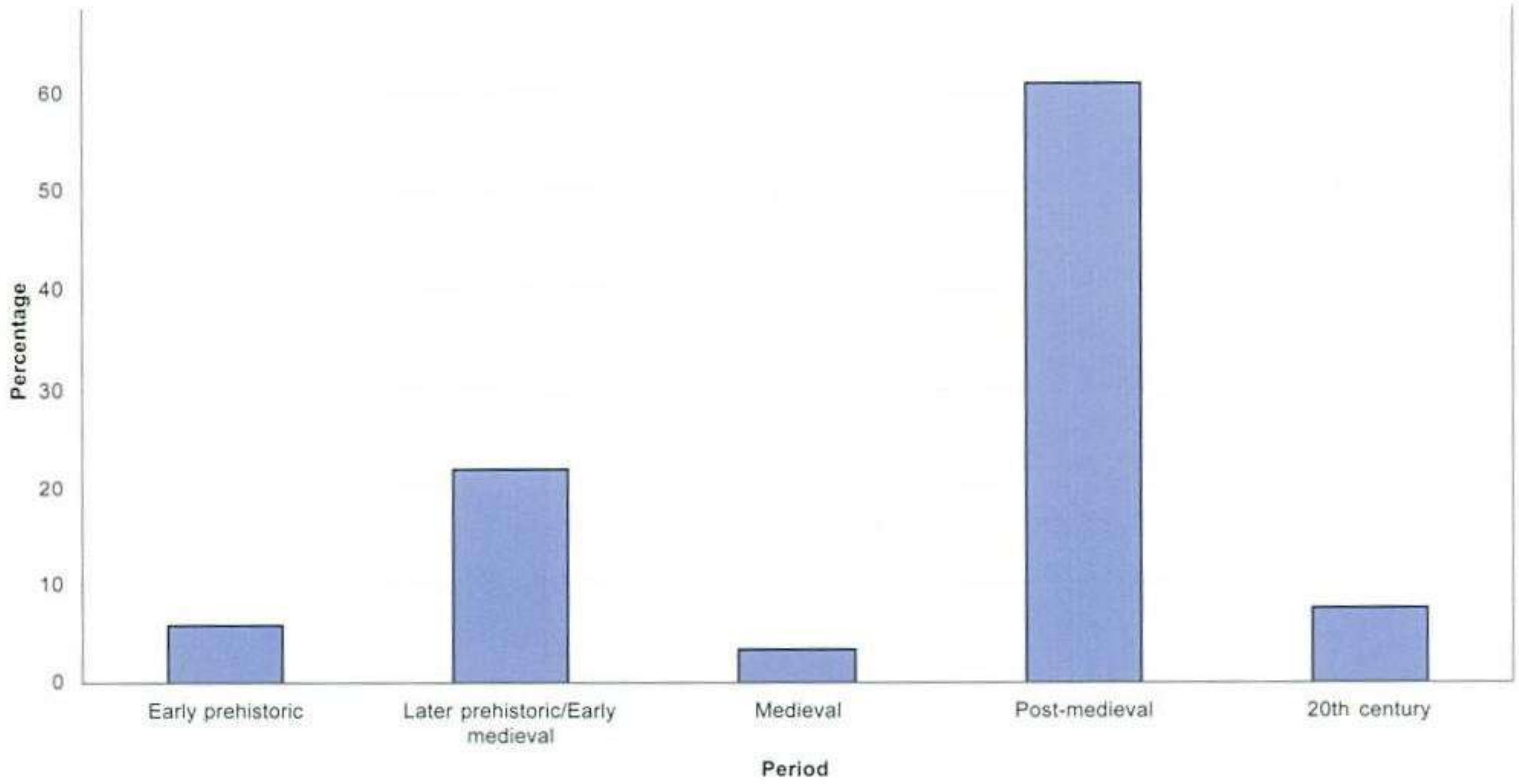

Figure 14.7. Graph showing the number of eroding sites from each period, expressed as a percentage of the total population of eroding sites.

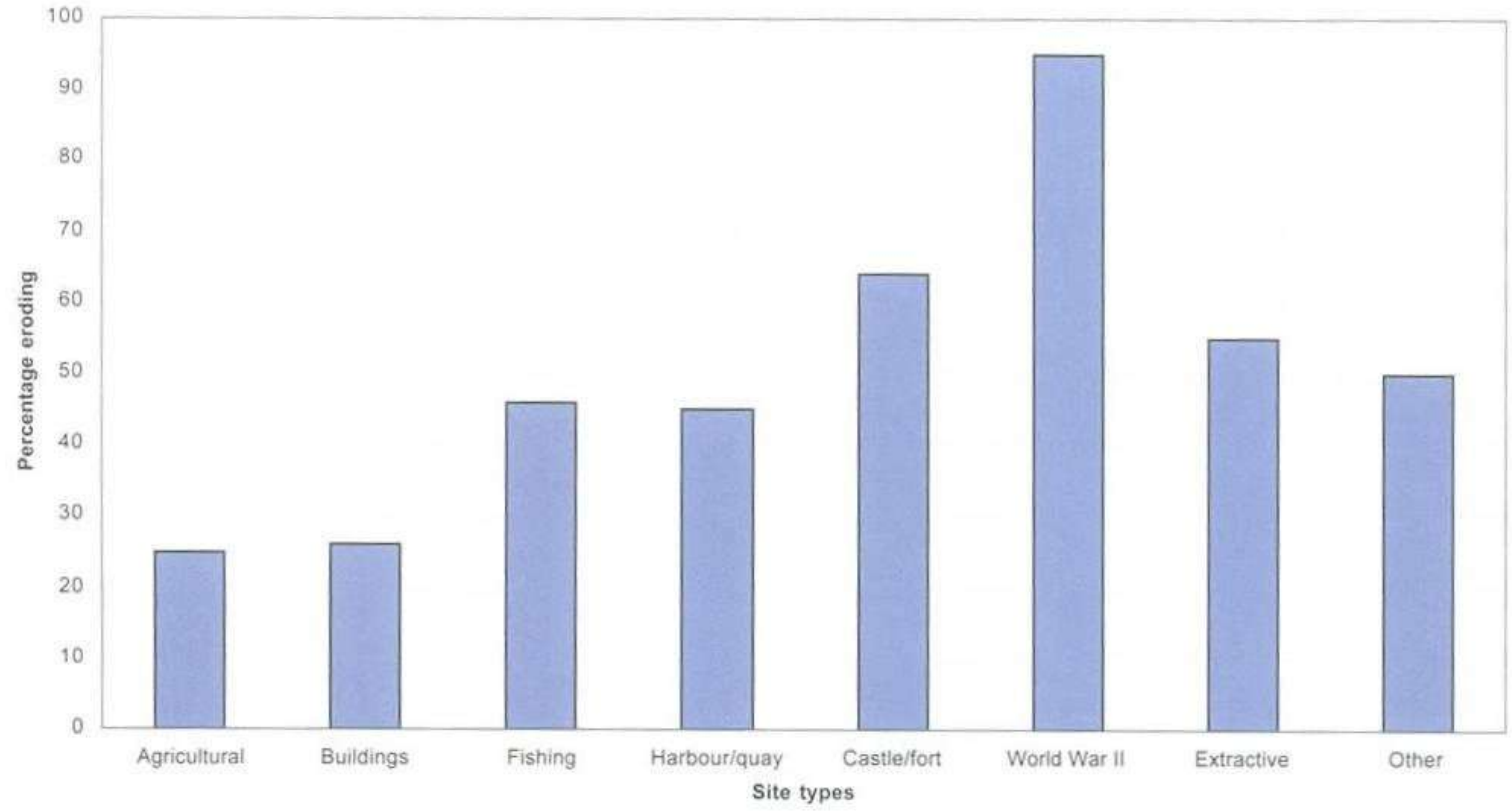

Figure 14.8. Graph showing the percentage of eroding sites from each site type class.

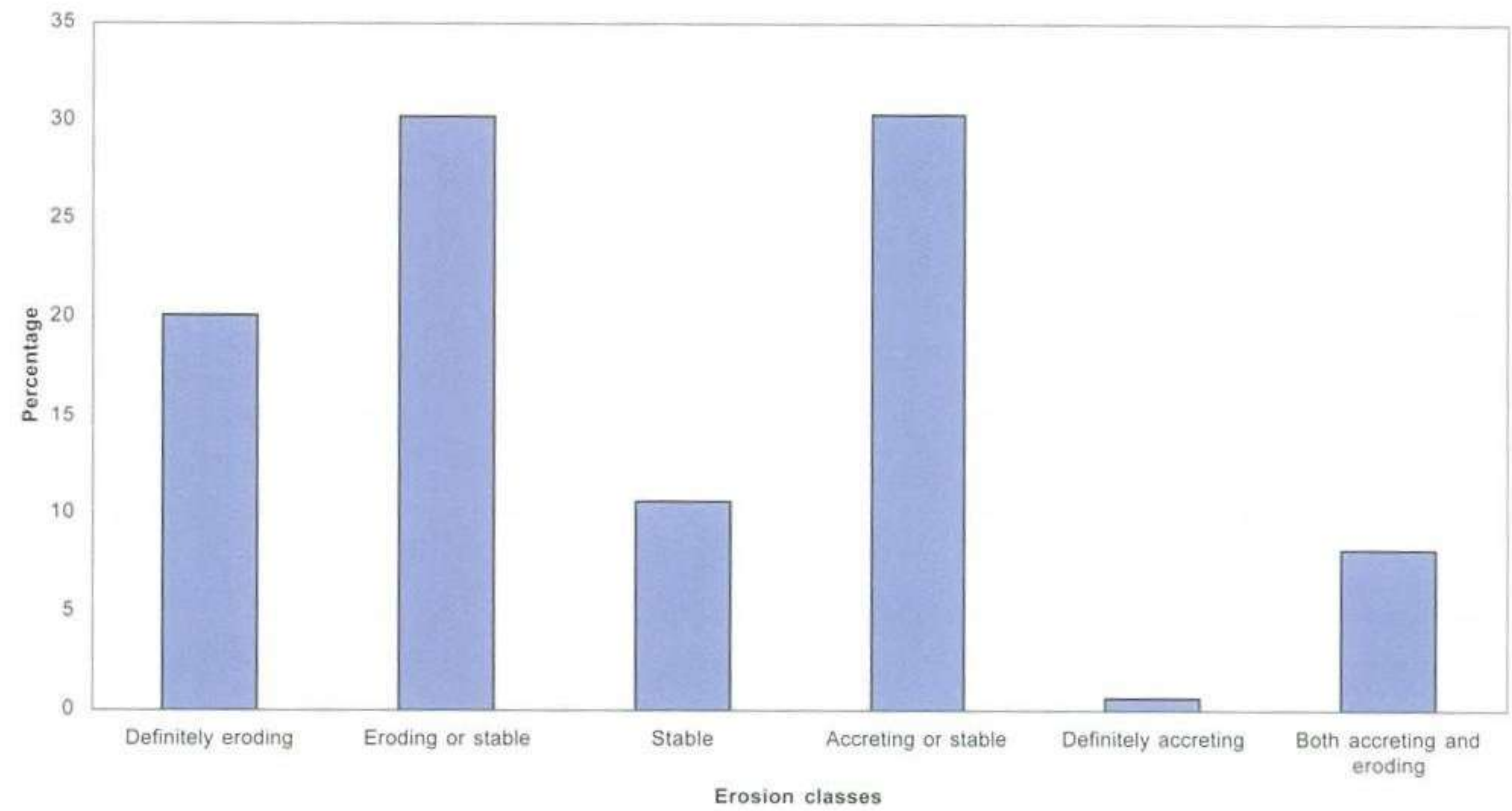

Figure 14.8. Graph showing the percentage of eroding sites from each site type class.

Coastal erosion

The percentage of the total length of coastline cited is based on the linear measurement of each unit as mapped on the 1:25,000 map sheets within the report. The combined length is 318 km. This figure was used to establish the percentage frequency of each erosion class (Figure 14.9). 318 km is acknowledged to be an underestimate of the true length of the coastline surveyed, as it does not incorporate the mean length of meandering rivers or deeply incised regions of cliff-edge and indeed other topographical irregularities along this coast.

The *Accreting or stable* and the *Eroding or stable* classes have the same percentage frequency of 30 per cent. The units identified as *Definitely eroding* were found to comprise 20 per cent of the total length of the survey. *The Stable, Definitely accreting* and the *Both accreting and eroding* erosion classes are much lower in frequency with 10.6 per cent, 0.6 per cent and 8.2 per cent respectively.

The results from the *Definitely eroding* class confirm that a substantial portion (20 per cent) of the Solway coast is being affected by serious erosion. This class includes areas where there is a direct failure of existing sea defences such as at Low Curghie, Stairhaven Bay, and south of Garlieston pier. The greater majority of units in this class occur on the eastern Solway coast towards Annan, where the coast-edge is generally soft.

Discussion

This survey represents a snapshot of the condition of the archaeological remains that were visible in late 1996 and as stated above, a broad range of archaeological sites on the Solway Coast were seen to be affected by a series of erosion processes. These can be seen generally to correspond to different groups of chronologically distinct archaeological monuments and remains, reflecting the varying topographical locations and building techniques of the relevant sites. Briefly, the results of the survey have revealed the following general trends affecting vulnerable sites on the Solway Coast:

- A small number of early prehistoric settlement sites are vulnerable to localised or more massive coastal erosion.
- A larger number of later prehistoric and early medieval settlement sites are again affected by localised coastal erosion, often exacerbated by agricultural pressure and erosion from grazing animals. These factors contribute to the occurrence of specific erosion processes, and can form an integral part of the general erosion pattern. Therefore, it is fundamental when drawing up measures to alleviate erosion of coastal archaeological sites to take into account the erosion dynamics in their entirety.
- A small number of medieval settlement sites share the same trend as the early prehistoric sites.
- The largest groups of sites, comprising monuments and remains of an industrial and maritime nature from the post-medieval period, is adversely affected primarily by violent wave action.
- The range of monuments of the early 20th century exhibit severe vulnerability to coastal erosion.

Following on from the publication of the Rapid Coastal Assessment, Historic Scotland and Scottish Natural Heritage, with support from Society of Antiquaries of Scotland, funded some further research in the Upper Solway Firth (see Focal Study, Cressey, this volume).

Recommendations

A number of recommendations were proposed based on the survey results:

- to establish a local network of interested parties to undertake regular monitoring of areas of soft sediments, in order to assess the rates of erosion and the appearance of new archaeological sites
- to conduct more detailed geomorphological studies and provide a more detailed chronology for coastal sediments, allowing inferences to be made regarding the likely presence and period of buried archaeological remains
- to conduct more detailed survey of a number of specific, representative sites
- to ensure that a systematic programme of monitoring of known threatened sites is established
- to maintain good communications with other agencies interested in the management of the coast

We consider that these recommendations can only be achieved by a combination of joint initiatives. Some of the work might be achieved directly by Historic Scotland through the Monument Wardens, or indirectly by the award of grants for specific pieces of research. Wider (and more frequent) monitoring will require additional efforts and must include the Local Authority Archaeologist, Museum Officers, and the participation of local groups. The Council for Scottish Archaeology and SCAPE may have a role to play in coordinating local society efforts. Such locally-based monitoring is probably the only way that sites located in soft sediments will be observed as mudflats and river banks move during the course of the year.

Acknowledgements

The authors wish to express thanks to the field archaeologists who carried out the survey under the supervision of Kirsty Cameron. They are also grateful to Ronan Toolis who assembled most of the archaeological field monument data and assisted in researching the case studies. Kevin Hicks and George Mudey are thanked for their assistance with the illustrations in the report. All the landowners are thanked for their kind permission and co-operation in conducting this survey, and the local people who shared their knowledge with us. Finally, Patrick Ashmore is thanked for overseeing the project on behalf of Historic Scotland, who funded this project.

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(III) FOCAL STUDIES

15 FOCAL STUDY: PALAEO-ENVIRONMENTAL INVESTIGATIONS AND COASTAL ZONE MANAGEMENT, INNER SOLWAY FIRTH

MIKE CRESSEY

Introduction

Largely based on the findings of a rapid coastal assessment of the entire Scottish side of the Solway Firth (see Finlayson & Cressey, this volume and Cressey & Toolis, 1997), Historic Scotland commissioned further work on a section of eroding coastline close to the town of Annan, East Dumfriesshire (Figure 15.1). A range of palaeo-environmental techniques, including fossil diatom and pollen analyses, wood identifications and stratigraphical recording supported by Accelerated Mass Spectrometry (AMS) radiocarbon dating, were undertaken to establish the nature and quality of information preserved within cliff deposits. The work was carried out as a collaborative project by the Universities of Stirling, Coventry and Edinburgh in 1997 (Cressey *et al* 1998; Dawson *et al* 1999; Cressey *et al* 2001).

The objectives for the 1997 Phase 2 palaeo-environmental investigations included:

- a review of previous work on peri-marine wetlands and sedimentological history in the Solway Lowlands
- a study to assess whether successive layers of exposed sediment are likely to preserve organic materials relating to human activity

As an adjunct to this work, a further phase of research was undertaken during 1999 (Phase 3) to recover sub-fossil wood from an eroding cliff at Broom Knowes to the west of Newbie Cottages.

The Newbie Cottages shoreline is classified by Scottish Natural Heritage (SNH) as a Geological Conservation Review (GCR) site and is also part of a much larger Site of Special Scientific Interest (SSSI), namely the Upper Solway Flats and Marshes. The Phase 3 study included an assessment undertaken on behalf of SNH to examine a series of management options for the conservation of this section of coastline (Cressey *et al* 2000). Management options for the GCR site were suggested and the wider implications of these suggestions were explored (see below).

Location and Environmental Setting

The eroding cliffs at Newbie Cottages are located 1 km west of Annan Water and 1.5 km east of the village of Powfoot. Jardine (1975) initially described the

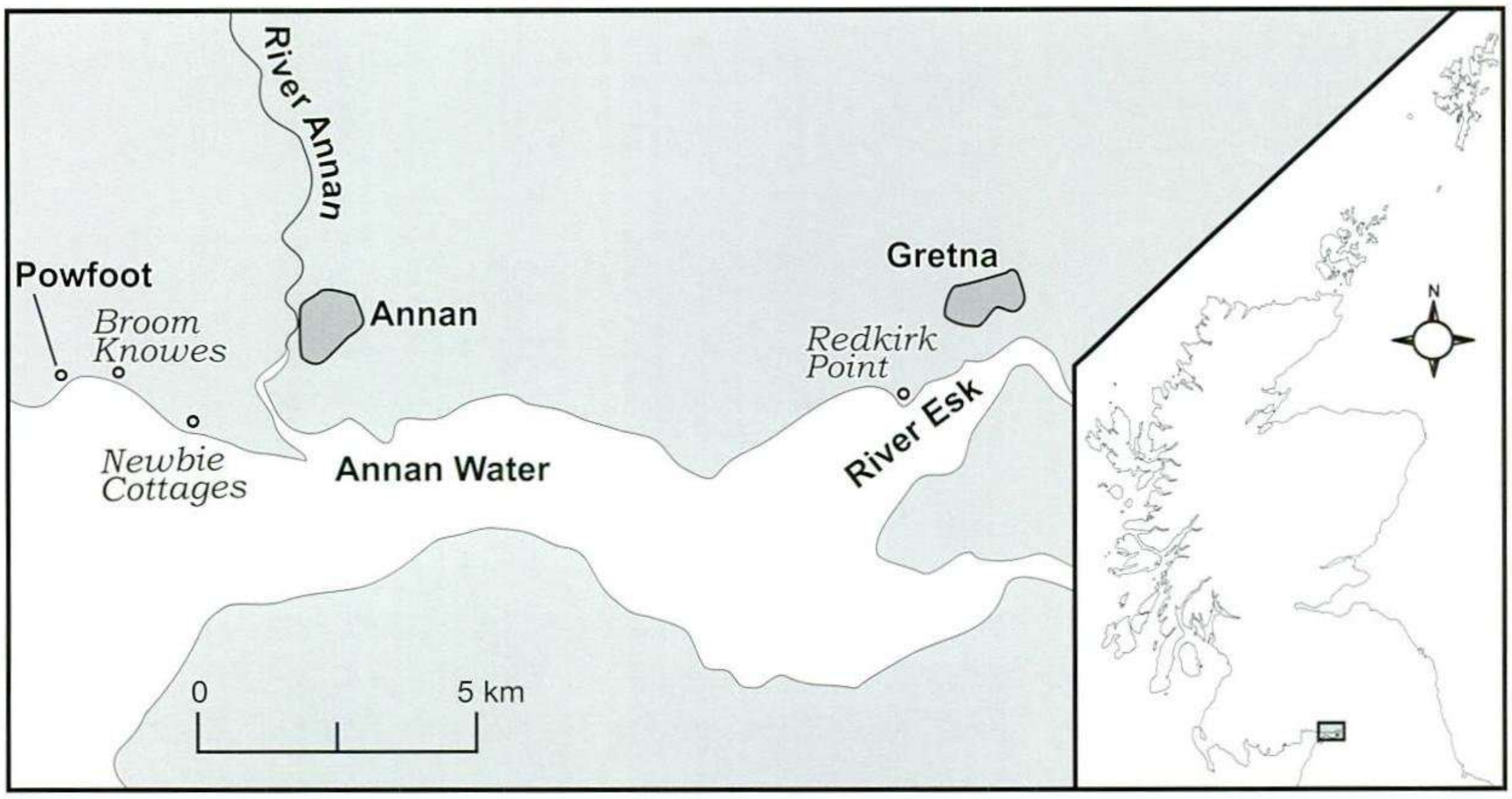

Figure 15. 1. Location map showing places mentioned in the text.

coastline west of Newbie Cottages during his research on relative sea level changes in south-west Scotland. The Newbie Cottages area is one of the few parts of the Solway coastline where Holocene coastal sediment exposures are well displayed. The coastal zone between Powfoot and Redkirk Point (including the Newbie area) is characterised by some of the fastest rates of cliff recession throughout the Solway Firth. A winter storm in 1998 accounted for the loss of 0.3 m of cliff when spring tides backed by onshore winds played a critical role in loss of sediment.

This report gives details of two of three recorded sections in the study area: a cliff section recorded at Newbie Cottages (Site A) and a section situated c 200 m west of Newbie Cottages (Site B). The other site (Site C), further west at Broom Knowes, has been discussed in detail elsewhere (Cressey *et al* 2000). A radiocarbon date from one of five exposed oaks at Broom Knowes has been included in Table 15.2 below.

Newbie Cottages: Lithostratigraphy and Environment

Sites A and B share a similar stratigraphy (Figure 15.3), although the dune sand and palaeosol sequence at Site B is heavily disturbed by rabbit infestation and could not be recorded in detail. At Site A (Table 15.1), samples were obtained from the organic horizons (Units 2, 4, 6, 10, 12, and 14) using monolith tins. Contiguous pollen and diatom samples were extracted from these samples. Radiocarbon samples were obtained from critical contact zones and on the outer-ring sections of fossil wood.

Units in Fig 15.3	Description	Troels-Smith (1955) notation
16	Root mat	
15	Sand	Ga4
14	Humic palaeosol C	Sh3 ga1 Dh+ Th+
13	Sand	Ga4
12	Humic palaeosol B	Sh3 ga1 Dh+ Th+
11	Sand	Ga4
10	Humic palaeosol A	Sh3 ga1 Dh+ Th+
9	Sand	Ga4
8	Peat and woody fragments	Sh4 Dh+ Th+
7	Sand	Ga4
6	Peat and wood	Sh4 Ga+ Dh+ Th+
5	Grey carse clay	As4 D1 Dh+ Th+
4	Carse peat	As4 Sh+ Dh+ TH+
3	Grey carse clay	As4 D1 Dh+ Th+
2	Intertidal woody peat	Sh4 D1+ Dh+ Th+
1	Boulder clay/sand/gravel	As1 Ag1 Ga1 Gs1 Gg (min)+ Gg (maj)+

Table 15.1. Summary table of lithostratigraphic units, sediment type with Troels-Smith notation recorded in the cliffs at Newbie Cottages (Site A). The position of the units is shown in Figure 15.3.

Jardine (1975) earlier described the lithostratigraphy exposed in the cliff, but until the recent investigations the intertidal peat remained unrecorded. The intertidal peat (Unit 2) is visible about 20 m out from the base of the cliff and sub-fossil tree stumps and the eroded

Figure 15.2. The ramping effect caused by sediment loss at the base of an eroding cliff at Newbie Cottages.

surface of the peat are well exposed at low tide. Towards the base of the cliff, the peat is masked by recent beach deposits and up to 5 m of carse clay (Units 3 and 5). The carse clay commences at 2.5 m above sea level and is very compact. It remains uniform until 6 m above sea level, where an organic peat layer is present (Unit 4). Carse clay continues above this layer until 7.5 m above sea level, where a well-humified woody peat (Unit 6) commences and extends to 8.6 m above sea level. The basal and upper contact boundaries of this unit are sharp. Above this layer, dune sand is interbanded with three palaeosol horizons (Units 10, 12 and 14) that vary in thickness.

Radiocarbon Dating Results

Ten samples were submitted to the Scottish Universities Research and Reactor Centre, East Kilbride, and AMS dates were obtained from the humic acid fraction on 5 mm sections of sediment recovered from specific contact zones (see Table 15.2). These results also include a single date obtained from a stratified oak stump at Broom Knowes (Site C) and a sub-fossil oak stump recovered from an intertidal peat deposit at Redkirk Point. In the case of the samples from Newbie Cottages, the results show good linearity in terms of chronological integrity. The date-range attained from the stumps recovered at Broom Knowes

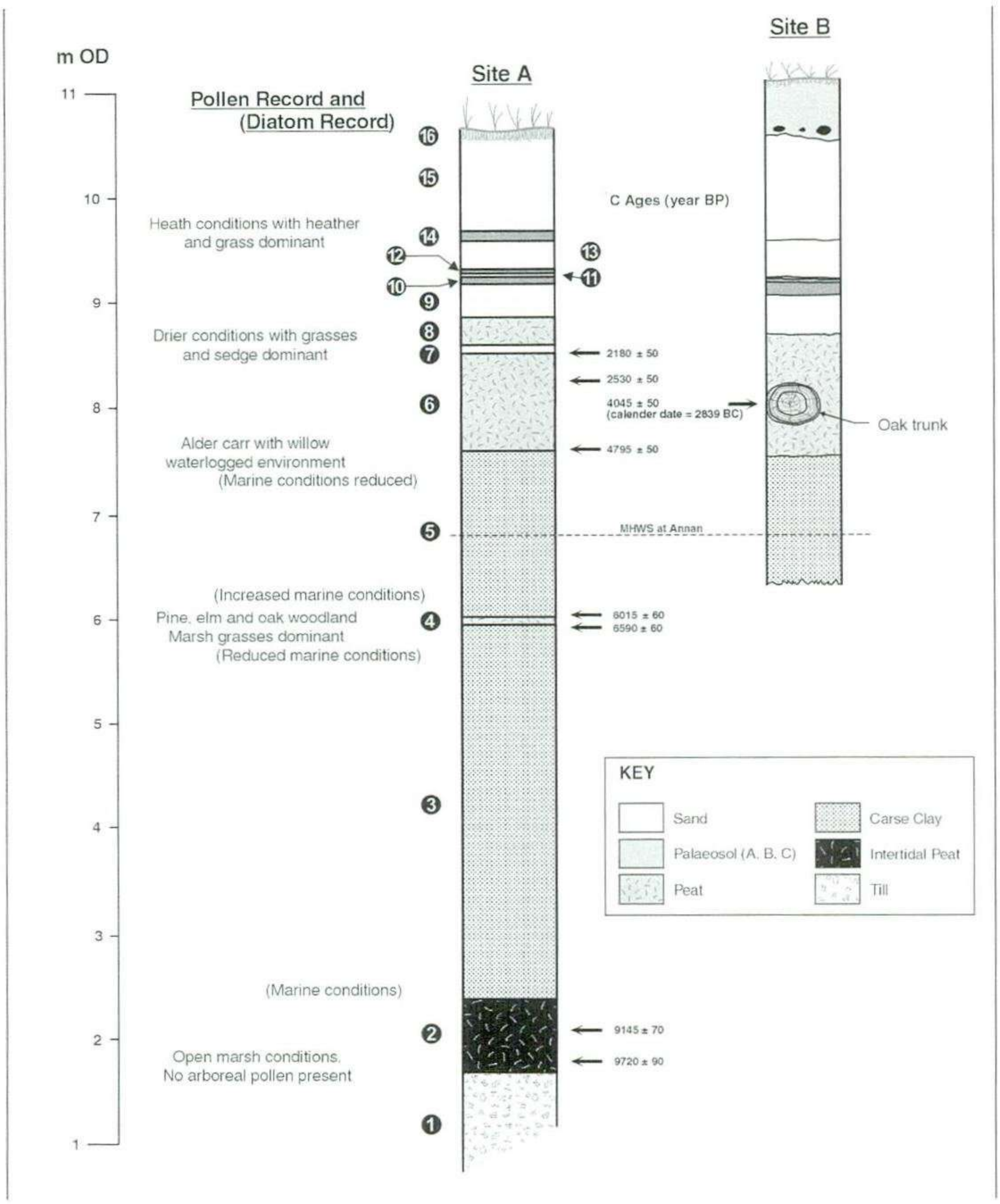

Figure 15.3. Stratigraphic profiles of cliff sections at Sites A and B near Newbie cottages.

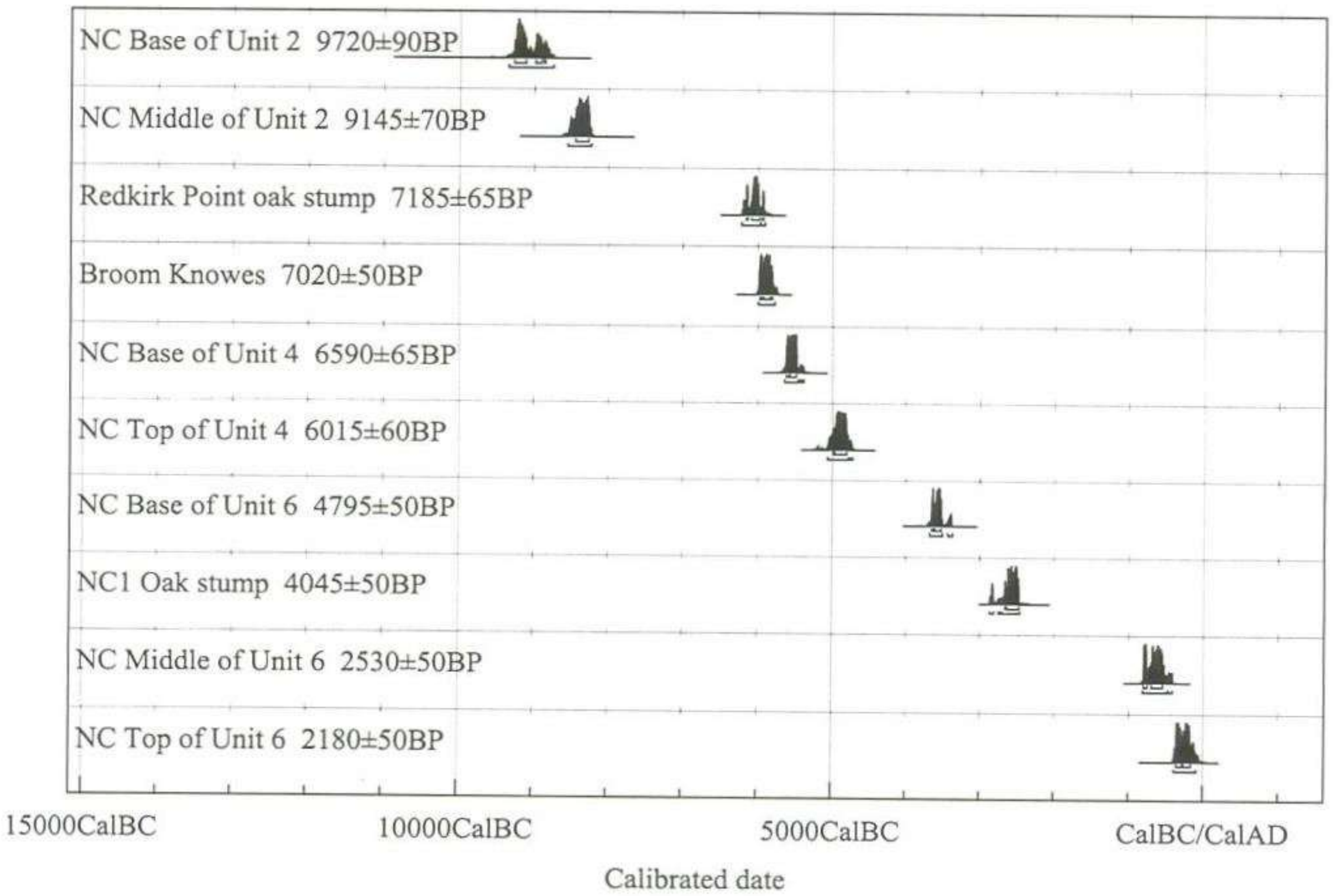

Table 15.2. Radiocarbon dating results.

and Redkirk Point shows that both sites were colonised by oak trees in more or less the same period. In the case of the oak stump recovered from the middle of Unit 6 at Site B, the sample for AMS dating was obtained on the bark and cambium layer interface, the latter representing the outermost tree-ring.

Results from Dendrochronological Dating from Site B

Four oak stumps were recorded close to Site B. From samples obtained from each of these, individual tree-ring sequences were run against a series of master chronologies from England and Ireland. Only the largest tree stump (sample NC1 near Site B) produced significant correlation with these master chronologies, dating the 264 tree-ring sequence to 3112–2849 BC (Crone 1998). The addition of a minimum of 10 rings to account for the missing sapwood (Hillam *et al* 1987) provides a calendar date of 2839 BC. NC1, therefore, stopped growing late in the second half of the 3rd millennium BC. This result is currently the second earliest dendrochronologically dated timber in Scotland (Crone 1998).

Local Sediment-forming Site Dynamics Based on Pollen and Diatom Analyses: Newbie Cottages Site A

The results of pollen and diatom analyses are summarised below and in Figure 15.3. A more detailed account of the use of a local contemporary diatom taxa in relation to the palaeo-diatom record at Newbie Cottages is provided in Dawson *et al* (1999).

The pollen and radiocarbon dating evidence both correlate well with continuous palaeo-ecological records from nearby peat deposits (Lloyd 1999; Wells 1999). Treeless environments persisted into the early Holocene in the coastal area around the Solway, and the development of extensive woodland occurred locally after c 9000 BP. By 6500 BP, mixed deciduous woodland was established and was still present shortly after the elm decline (c 4800 BP). This record gives no insight into the timing or causes of woodland decline, but anthropogenic influences are considered to be important within the upland areas in south-west Scotland (Tipping 1999). By 2200 BP the landscape was predominantly open, although some surviving woodland fragments are inferred. The results obtained from the Newbie Cottages section (Units 2, 4 and 6) are summarised below.

The intertidal peat, Unit 2 (9700–9150 BP) Mesolithic

Pollen analysis of the basal sediments from this unit suggests that it was deposited in a fresh-water, sedge-dominated marsh community. Fossil wood fragments are dominated by birch (*Betula* sp). Diatom analyses from the boundary between this unit and the overlying carse clay suggest that these sediments were deposited in a lower intertidal environment with increasing marine influence across the transition. This suggests marine encroachment onto a freshwater marsh in the early Holocene.

The carse peat, Unit 4 (6600–6000 BP) Late Mesolithic–Early Neolithic

Diatom analysis across the lower boundary of this unit suggests that this transition represents a regressive sea level index point, with a reduction in salinity and marine influence as the peat developed. Pollen analysis from the centre of this unit implies it was deposited under open, marshy vegetation, with a fluctuating water table. Diatom analysis from the upper edge of the peat suggests deposition just above Mean High Water Springs (MHWS). Samples from the overlying carse clay show increasing marine influence with renewed marine transgression.

The overlying peat, Unit 6 (4800–2200 BP) Neolithic–Iron Age

Diatom analysis across the lower transition shows a reduction in marine influence as the peat unit is approached, demonstrating that the boundary is a regressive sea level index point. The pollen assemblage from the base of the peat suggests that alder carr was locally present, which implies low to non-existent marine influence. A mixed oak–birch woodland co-existed alongside an alder carr environment. The pollen results are corroborated by the sub-fossil remains of oak and birch stumps, which are locally exposed towards the base of Unit 6 at Site B. Pollen analysis suggests that the upper boundary of the unit, dated to 2200 BP, was deposited under a more open vegetation community, dominated by graminoids but possibly with some heaths. More detailed study would be needed to investigate the cause of this change. Above Unit 6, a series of organic palaeosols (Units 10, 12 and 14) interspersed with sands suggests an active coastal environment and a complex history of dune evolution in the last two millennia. Pollen assemblages from single samples within the palaeosols suggest that they developed in an open environment, either heath or grassland, which was possibly grazed.

Discussion of the Wider Implications

The diatom assemblages determined primarily from the lithostratigraphical boundaries suggest that the sediment sequences are transitional between increasing and decreasing amounts of marine influence to the Newbie area throughout the Holocene. The beginning of a widespread marine inundation is confirmed at the base of the sequence (start of Unit 3) and can be correlated with the rise of the main postglacial transgression of the early Holocene. It has been demonstrated that the thin deposit of carse peat (Unit 4) formed *in situ*, with a graded transition from and to carse sediments above and below the unit. These findings are in accord with the available dates from Jardine (1982). They suggest that the grey carse clay (Unit 5) above the carse peat (Unit 4) represents a late Holocene marine transgression which culminated at c 4500 BP (uncal). This is in accord with recent data from elsewhere in Scotland (Dawson &Smith 1997).

The radiocarbon dates obtained on both recumbent and upstanding waterlogged oak stumps recovered from Broom Knowes and at Redkirk Point (Table 15.2) attest that they are remnants of a contemporary climax forest close to the River Esk at a time when sea level was much lower than today. Routine pollen analyses were carried out on sediment above and below five oak stumps at Broom Knowes, but on the basis of the pollen work alone there is no conclusive evidence that Mesolithic communities impacted on this woodland.

The skeleton pollen diagram constructed for Newbie Cottages (not depicted) shows good correlation with other regional pollen diagrams, and highlights the successive vegetation changes and the effects of marine inundation. These results suggest that during the early part of the Neolithic, the landscape close to the main channel of the River Esk was well-wooded with local patches of oak and birch. Alder and willow thrived close to freshwater streams. During the Late Neolithic–Early Bronze Age (4500 cal BP), dense oak forest, fringed with stands of birch, became more established in areas less prone to waterlogging. The remains of oak and birch exposed in the cliff section at Site B were found as recumbent trunks with no evidence to suggest they had been felled. Others were in an upright position, as they would have grown. This seems to suggest that the trees died of natural causes, perhaps as a result of the growth of blanket peat which continued to develop as a result of wetter conditions augmented by fluctuations in climate, and perhaps more importantly, increased surface run-off from the surrounding catchment. It is not until the later prehistoric period that local woodland diminished significantly and that the local soils became more suitable for agriculture, as is evidenced by the presence of palaeosols which occur extensively between Site A and Site B.

The pollen record suggests that these sediments accumulated over most of the Holocene, albeit not continuously. The record clearly extends into the later prehistoric and has considerable potential for the archaeological and the palaeo-ecological record of the region. The progressive lowering of relative sea levels during the Bronze Age is coincident with dune formation. These are well illustrated in the Newbie Cottages area with palaeosol formation. Bronze Age cists are known to have eroded from the upper section of the cliff during the 19th century. The palaeosols studied may possibly indicate different grazing regimes associated with successive soil layers, suggesting changing patterns of human impact on the landscape over time.

The focal study undertaken at Newbie Cottages has shown that palaeo-environmental evidence, such as palaeo-channels, buried and intertidal peat deposits, fossil wood, vegetation layers, and coarse and fine sediment deposited between major sea level changes are all well preserved. These remains also have important potential to provide robust radiocarbon chronologies as demonstrated in Table 15.2. Moving away from the coast-edge and further inland, the potential for deposits formed in mire situations is equally great. These deposits are at risk from commercial peat extraction and agricultural drainage. In addition, the continued rapid erosion of the Solway coast means that the threat to these inland sites will increase over time.

Management Options for the GCR site

It was during the final phase (Phase 3) of research at Newbie Cottages that SNH initiated further research to investigate appropriate management options for this scientifically important section of the Inner Solway Firth. The work included mapping the extent of exposed intertidal peat and recording additional sections of the cliff in order to update the scientific importance of the GCR site in the light of continual coastal erosion.

The principal management issue at the site is the rate of erosion. Cliff sections are being eroded through natural agencies and there is progressive loss of scientific interest. The difficulty is to achieve an appropriate balance between protection and cost. A secondary management issue is the use of inappropriate defences constructed in the past. Waste material has been used, including demolition waste from a munitions factory behind the Broom Knowes site and concrete waste indiscriminately dumped in the Newbie Cottages area. This material is now being dispersed and concentrated by longshore drift. In severe conditions this material is thrown against the base of the cliffs, causing scouring.

Several management options to address the issue of erosion were considered in discussions with SNH staff:

- *Bioengineering*. Bioengineering combines mechanical, biological and ecological principles (eg planting appropriate plants that deflect wave energy) to construct protective systems to prevent slope failure and erosion. This option was rejected on the grounds that the Newbie cliffs are affected by high wave energy, thus making the bioengineering method unfeasible, and because such approaches might obscure the scientific interest.
- *Rock armouring/hard sea defence measures*. This option would include some form of groyne or boulder dump defensive works. Given the length of coastline involved at the survey area, the cost of such works would be considerable. Other factors such as the impact on the SSSI were also taken into account. This option was therefore rejected.
- *Allow the cliff to recede* ('monitor and resurvey'). This option might include the following elements:
  1. Allow the cliff to retreat until landowners and the local authorities have to take remedial action to defend a given portion of the cliff. In such circumstances, the defence measures most likely to be used would obscure some or all of the site's interest. If this situation arises, SNH might consider recommending alternative less damaging options, such as foreshore revetment or the establishment of strong points.
  2. Establish a programme to monitor the annual rate of cliff recession and to carry out systematic recording of new exposures at such time as specific thresholds of cliff recession are exceeded, for example at 5 m intervals. New exposures should be logged and palaeo-environmental material such as intertidal peat or sub-fossil wood remains should be recorded and their palaeo-environmental significance assessed.
  3. Set up fixed control points tied into the existing survey grid at Newbie Cottages so that future recording work can be undertaken within an already established survey framework.
  4. Undertake a survey to establish the landward extent of the key deposits. This would allow the acceptable limits of coastal erosion to be set for the protection of the scientific interest.

Preferred Option

From the review of the management options for the Newbie and Broom Knowes cliffs, it was concluded that the only viable option was a 'monitor and resurvey' approach for the short term. The cost of defending the site would be too expensive and might obscure its scientific interest. The work already undertaken provides a good framework with which to progress to more detailed recording.

Conclusions

The complexity of former sea level changes in this area highlights the fact that not only are uplifted and submerged relict coastal sediments well preserved, but also that the coastal sediment sequences are locally interrupted by terrestrial sediments.

The focal study has demonstrated that the Newbie Cottages sedimentary sequence holds considerable palaeo-environmental potential:

- The use of altitudinal-based diatom assemblages for palaeo-sea level reconstruction provides a more accurate determination of the movement of palaeo-MHWS. This study has demonstrated the potential for using diatom assemblages (see also Dawson *et al* 1999) alongside the palynological record.
- The pollen sequence at Site A appears to cover the majority of the Holocene, starting with an early Holocene spectrum reflecting an open pre-woodland environment and developing into full woodland cover in the later Holocene. Disturbance of the later Holocene wooded environment increased, leaving an open environment where grazing pressure appears to have had a recognised impact during soil-building phases.
- The use of AMS radiocarbon dating on appropriate contact zones, in combination with dendrochronology, has been successful between Site A and Site B. The results of this work have led to a reappraisal of the previous radiocarbon chronologies that were based on 'bulk' radiocarbon samples. The calendar year date obtained on the NC1 oak stump is the second earliest date established using dendrochronology in Scotland.

The management options examined during the final phase of the study have shown that there is no single clear-cut method for the management of such an important section of coastline. The 'monitor and resurvey' option was the only viable option given the harmful and expensive option of hard coastal defence works. A balance has been struck which amounts to a form of *managed retreat* whereby the cliffs will be allowed to erode and will be monitored for any significant scientific data at intervals in the future. The importance of the GCR site lies in the fact that it can be seen in its entirety, both in relation to the offshore peats and to the stratigraphy exposed within the cliff sections.

Acknowledgements

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16 FOCAL STUDY: COASTAL SITE ASSESSMENT IN ORKNEY

HAZEL MOORE

Introduction

Rising sea levels and increasingly erratic weather conditions, linked to global warming, appear set to exacerbate coastal erosion well into the next century (Bell & Walker 1992, 219–20). One outcome will be an acceleration in the rate at which coastal archaeological remains are threatened. In some cases, little or nothing is known of the sites which are being destroyed and a non-renewable resource is being lost forever. In Orkney and Shetland, where sea levels are still rising, almost 1000 sites have been identified by audit survey as being at risk from coastal erosion (Wilson, this volume).

Given the scale of the problem, it is likely that very few coastal sites in the Northern Isles can be safeguarded from erosion in the longer term and that many will be lost to the sea in the short to medium term. In the belief that we should not adopt a policy of passive surrender, but also accepting that we cannot hope to save every site, this paper examines how a 'managed retreat' might be effected in archaeological terms, with reference to approaches tested recently on coastal sites in Orkney (Figure 16.1).

Managed Retreat

In archaeological terms, a policy of managed retreat accepts that the majority of sites will eventually be destroyed by coastal erosion, but seeks, as far as possible, to discover and record the remains before this happens.

This work can only realistically be carried out as an ongoing coastal archaeology programme since many sites are already known to be vulnerable, and many more are likely to be affected in the future. The sites are not equally at risk or of the same archaeological potential, however, thus it is necessary to prioritise them so that the response can be structured to provide for present and future circumstances. In practical terms, this means that several stages of archaeological work, ranging from non-invasive survey to site evaluation and full excavation, may be required.

The alternative strategy of attempting to preserve sites *in-situ* through physical protection in the form of coastal defences of various types, is unrealistic in the majority of cases and is only an effective solution in the short to medium term. The problems involved in constructing and maintaining coastal defences rule out this option at all but a few sites which have already been shown, usually through excavation, to be of exceptional importance. For the majority of threatened sites, some form of archaeological intervention is likely to offer a more useful and cost-effective approach.

Coastal Zone Assessment Survey and Beyond

As we have seen, the recent campaign of audit survey funded by Historic Scotland has been successful in rapidly covering extensive areas of coastline, identifying new sites and areas under threat and in reporting back quickly. The challenge is to build on this.

One recommendation arising from the first series of audit surveys in the Northern Isles is the need for repeat surveys. In the first place, this would build in a time dimension to observations on erosion and secondly, it would identify new archaeological exposures. The survey results also clearly indicate that the number and type of sites and their vulnerability to erosion varies considerably from area to area. It is not possible, therefore, to estimate in any but the most general of terms, what might be at risk in unsurveyed areas. From this, it could be argued that those areas at risk, but which have not so far been surveyed, require further work.

The most important recommendation to arise from audit survey is the necessity for a further level of qualitative assessment: to investigate the relative rarity and importance of individual sites and to determine if they are of local, national or, in some cases, international importance.

One of the shortcomings of audit survey is that site records are limited to a brief description of the visible components, with interpretation based largely on untested assumption. In practice, it proved difficult, if not impossible, to characterise or date a large number of the sites found through audit survey in Orkney and Shetland; in many instances, very little information beyond a grid reference could be supplied.

The data provided by audit survey is not a good source of the type of information required when considering priorities for excavation or safeguarding. Working from surface clues alone may also introduce a bias in

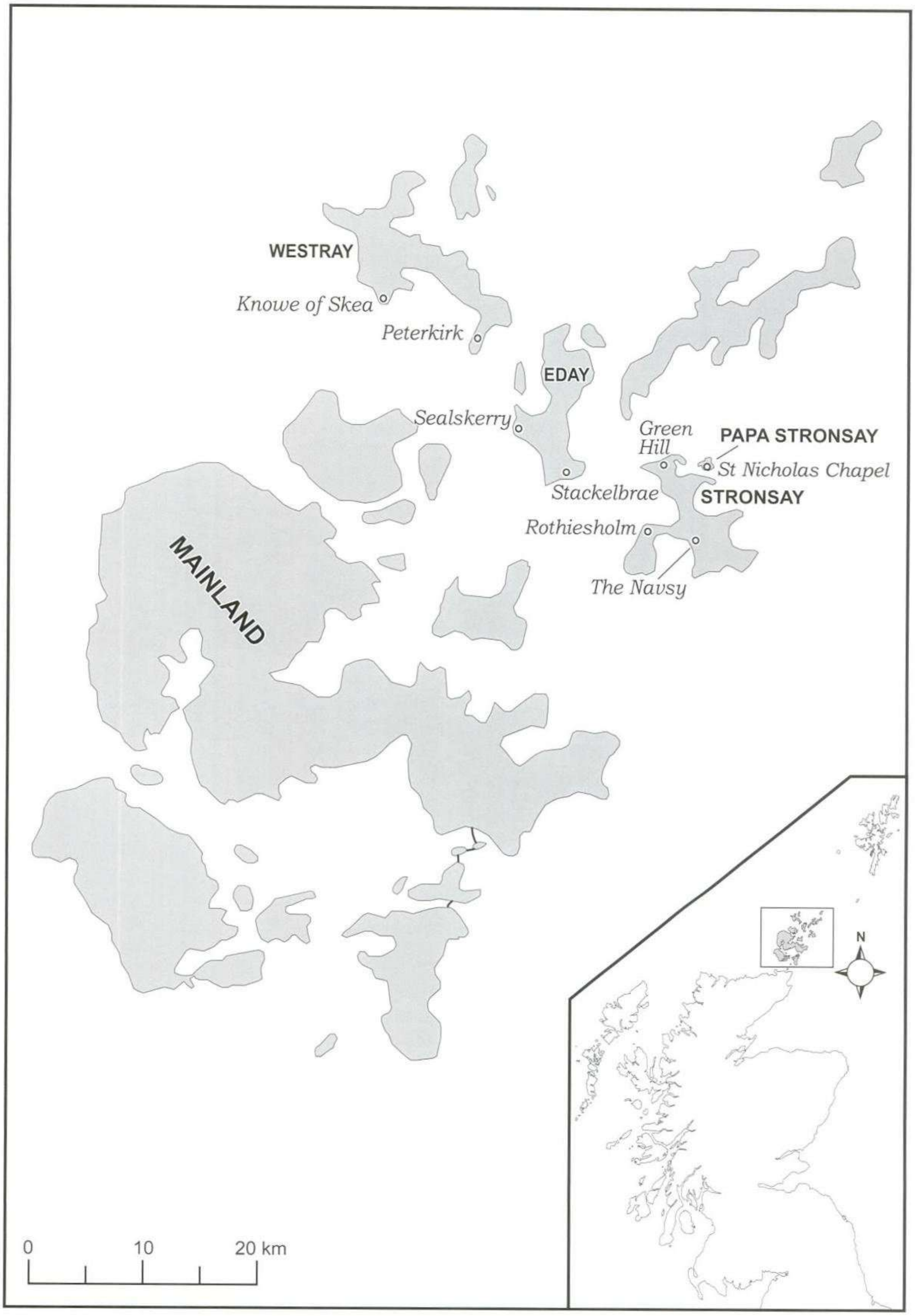

Figure 16.1. Location map showing places mentioned in the text.

favour of the more visually interesting or readily interpreted remains. When the surveyor has difficulty in characterising a site, it is less likely that researchers at a later date will be able to appreciate the potential of the site and it may become overlooked. In contrast, the more visible and readily identifiable sites, which may not necessarily hold the greatest archaeological potential or constitute the best areas for further investigation, are likely to make a strong impression on the surveyor and will also be more likely to command the interest of those who later make use of the survey data.

Ultimately, some form of excavation is likely to represent the most decisive approach to the problem of sites at risk from coastal erosion. Where remains cannot be preserved *in situ*, excavation can provide a detailed record of what was present. It is unlikely, however, that resources will be found to excavate more than a small proportion of the sites at risk. It is also the case that site vulnerability is not, in itself, sufficient reason to justify large-scale investment. The archaeological potential of a site and its value within a wider research agenda are at least as important; excavation may not be justifiable at some sites.

Towards an Integrated Coastal Policy

Ideally, audit survey should act as a first step in an integrated, rolling programme, to be followed up with repeat survey, site assessment, excavation and protection. It might be envisaged that a proportion of sites found by audit survey would require further assessment to better characterise the nature of the archaeological remains present. The criteria for selection for assessment, and later for excavation or protection, might be broadly similar to the considerations which guide site scheduling decisions (including condition, rarity, group value, situation). In this case, however, vulnerability to destruction might be given more emphasis and particular note should be taken of the sites about which least is known.

This process of prioritisation requires that many different and competing criteria be evaluated for individual sites and that large numbers of sites be weighed up against each other. It may well be recognised that the best, and indeed possibly, only way to make sense of such large amounts of data is to develop some form of structured decision-making process (Startin 1993). In any event, to derive maximum use from the results of audit survey, the results must be evaluated in a systematic manner.

The methodology used in site assessment could be standardised to some degree, but an overly rigid system is unlikely to make the best use of time and resources at every site. The basic questions to be answered by assessment will, as on non-coastal sites, relate to nature, extent, date and condition. On coastal sites, some of which may already have been damaged by erosion, there is the added need to assess the integrity of the surviving remains and to provide an indication of vulnerability to destruction.

Many coastal sites display erosion faces where sections of stratigraphy can be readily seen and recorded. As an assessment method, this approach offers a relatively cost-effective assessment solution, with the added advantage that it demands little in the way of post-excavation commitment and can therefore provide results quickly.

Non-invasive techniques may be suitable for the assessment of some types of site, but there are some serious drawbacks. One disadvantage is that it can be difficult to ascertain the extent of the remains or to procure suitable material for dating without recourse to excavation (see Case Study 1). Site characterisation can be largely based on guesswork or abstracted from what may be an unrepresentative exposure. The results of non-invasive assessment may usefully serve to inform strategies for future work, but will not substantially lessen the amount of work still to be done.

A preferable option, in most cases, is invasive assessment using trial trenching or small-scale open area excavation (see Case Study 2). The advantage of this approach is that it deals directly with the archaeology, providing an insight into the actual remains. In many cases, this level of effort may be an adequate response in itself, negating the need for any further work. On sites where a further stage of excavation is required, this preliminary invasive assessment can both substantially lessen the scale of future work and provide for a more closely targeted research design.

Site Assessment

EASE have conducted a number of different types of site assessment on coastal sites under threat from erosion in both Orkney and Shetland. In each case, the work was geared to answer a specific set of questions about the site, as well as more generally exploring the effectiveness of different assessment methodologies. This work can be seen as a second stage in a structured managed retreat response, and in some cases, as a final stage. Two programmes of work, representing the very first (Case Study 1) and the most recent (Case Study 2), of these assessments are summarised below to illustrate the results provided by different approaches.

Case Study 1: Pilot programme of non-invasive recording in Orkney

In 1996 EASE carried out a pilot programme, funded by Historic Scotland, to investigate the feasibility of one type of rapid assessment. The aim of this work was to provide an enhanced site record and, at the same time, to investigate the level of information with regard to nature, extent, date, complexity and condition, which could be obtained without recourse to excavation. It was hoped that the information gained would be of assistance in defining local priorities and be sufficiently detailed to inform estimates of the costs, benefits and relative merits of a range of management options.

Six eroding sites, on the islands of Eday, Stronsay and Papa Stronsay, were selected for assessment because each was considered to be of high archaeological potential. Prior to assessment, the sites had been visited on several occasions by Raymond Lamb, Orkney Archaeologist (Lamb 1984). On the basis of recovered artefacts and visual inspection, the sites were adjudged to represent:

- a broch and associated settlement (Green Hill, Stronsay)
- a possible Viking settlement (The Navsy, Stronsay)
- a Norse period farmstead (Rothiesholm, Stronsay; Figure 16.2)
- a chapel (St Nicholas' Chapel, Papa Stronsay)
- a substantial medieval house (Castle of Stackelbrae, Eday; Figure 16.3)
- a possible medieval settlement (Sealskerry, Eday)

Work was carried out over a month in January–February 1996 by a team of four. A limited set of recording methods, devised at the outset in consultation with Historic Scotland, was strictly

Figure 16.2. Rothiesholm settlement and farm mound, site prior to section cleaning.

Figure 16.3. Castle of Stackelbrae medieval settlement, site prior to section cleaning.

Figure 16.4. Rothiesholm settlement and farm mound, prepared section.

adhered to. At each site, the erosion face was cleaned and made vertical before being drawn in its entirety (Figure 16.4); exceptions were made only where there was a risk of large-scale collapse.

The sections were deepened only where archaeological deposits could be seen to extend below the level of the beach. Topographical survey was carried out and extended into the site hinterland, beyond all visible site components. At five of the sites a set of permanent markers was put in place to provide a baseline from which to measure future losses to erosion. Soil samples were collected from the sections for the recovery of dating material, with processing being carried out on site. Artefact recovery was limited to objects dislodged during section cleaning.

The condition of each of the sites was considered under two headings: the scale of past losses, and the stability of the surviving remains. The interrogation of first edition maps and aerial photographs provided broad background information on coastal changes. They were rarely detailed enough to be capable of being securely related to either previous archaeological findings or to the remains visible during the course of this work.

In all cases, archaeological remains were found to be actively eroding. The condition of the remains was found to be as much influenced by the type of deposits present as by the various natural processes. Stone structures built on sand, for example, are particularly prone to collapse, and fine layers of peat ash may erode more quickly than either peat or clay. Damage at this level may not be perceptible from geomorphological studies of coastline change, which emphasises the need for specific site monitoring. In many cases, once a major collapse has occurred, the stratigraphic integrity of a site may be lost to an extent that renders it no longer worthy of further consideration.

Results

The results indicated that the level of information which could be retrieved through this type of rapid evaluation varied according to individual site circumstances. The most rewarding sites were those which exhibited long, continuous exposures of well-stratified deposits and contained readily identifiable elements or substantial upstanding remains.

At five of the six sites investigated, it was found that the remains could be characterised with some degree of detail from the visible elements alone. Equally, site complexity could, albeit somewhat coarsely, be estimated from the number of discrete stratigraphic elements visible in the sections and from topographic features. The extent of remains behind the coast-edge was frequently harder to gauge, however. Many of the sites were wholly or partially covered with blown sand and without recourse to invasive trenching, it was not possible to determine with certainty the inland extent of four of the sites.

Records made during earlier monitoring visits proved more useful. The enclosure wall seen at St Nicholas' Chapel, for example, would not have been identified so readily in the recorded section had it not been noted

Figure 16.5. Peterkirk Broch and settlement, under assessment.

Figure 16.6. Bakie settlement, doorway in section.

previously when a more substantial part of it survived. In a number of cases, comparison of the surviving remains with those noted in previous records suggested that entire structures had been removed: a clay-bonded structure at Rothiesholm was no longer in evidence, nor was a massively built wall at the Castle of Stackelbrae.

At each site the integrity of the surviving remains was assessed and examined to determine if they were stable, undermined, or collapsed. Consideration was given to the likelihood of future damage from erosion caused by sea, wind, animals and humans, the extent of current vegetation coverage, and the nature of deposits both above and below the archaeological remains. The survival of organic materials, such as shell and bone, and of artefacts was also noted.

It did not prove possible to procure enough suitable material for dating from any of the sites. In two cases, no suitable sampling deposits were located, while samples from the remaining four sites contained either insufficient amounts of identifiable materials or none at all.

Conclusions

This work provided a detailed snapshot of six important and vulnerable sites at a level which could be used to estimate costs and strategy for a range of future management approaches.

The lack of surface features at some sites made it difficult to gauge how far archaeological remains extended inland, and thus, in three cases, topographic survey was not useful. Furthermore, while it was known from previous records that some sites had been more extensive, the lack of accurate measurements hampered any appraisal of original site extent. In this regard, it is to be hoped that the permanent baseline markers inserted at five of the sites will remedy this for the future.

The most serious drawback with this type of evaluation was the failure to recover suitable dating material. While all but one of the sites are broadly classifiable on topological evidence (the exception being Sealskerry), it is of great concern that early or unusual deposits might not be identified. Even if suitable material had been found, it would be questionable how representative a single date or small set of dates obtained in such a manner would be, given the difficulties inherent in assessing taphonomy from limited section exposures.

It was concluded that the methods employed in this assessment were likely to represent the minimum level of work required for eroding coastal sites. For extremely badly damaged sites, where the aim of archaeological intervention is to provide an enhanced record prior to total destruction, this type of work may prove to be an adequate substitute to invasive techniques, although salvage excavation would probably provide better results for a similar cost.

The assessment method could be improved by a more targeted approach: in some instances topographic survey could have been abandoned; elsewhere section recording could have been less extensive while remaining representative. It is difficult to see how the failures of this assessment could be remedied without recourse to additional techniques, such as trial trenching and/or geophysical, coring or probing surveys.

Case Study 2: Project Westray 2000

This programme was funded by Historic Scotland and aimed to assess three foci of eroding archaeological remains on the island of Westray. The methodology employed was adapted to suit requirements at the individual sites and included geophysical survey, topographical survey, section recording, trial trenching, and open area excavation. The objectives were to recover information about the nature, extent, date, condition and complexity of individual sites, and to determine the relationship between sites. It was hoped that the level of information gained would be sufficient to characterise the sites in some detail.

This assessment was designed from the outset to act specifically as a follow-on from audit survey. The sites were selected on the basis of recommendations made in the audit survey report (Moore & Wilson 1999, 28–31). Three large sites and eight associated smaller sites were selected. Each had already been damaged by coastal erosion, was unlikely to be suitable for protection, and appeared to be of high but unproven archaeological potential. The sites were:

- a large artificial mound known as Knowe of Skea and four structures and a field system on the adjacent promontory of Berst Ness
- a large artificial mound at Peterkirk (Figure 16.5)
- a nearby site at Bakie, possibly a Norse/Medieval settlement (Figure 16.6)

Work was carried out in two seasons over two months with a team of ten. The first season, April 2000, saw the completion of geophysical (resistivity) survey and topographical survey on all of the sites. The results of this work were analysed to determine the optimum locations for assessment trenching. During the second season, July–August 2000, two large open area trenches were excavated at the mounds at Knowe of Skea and Peterkirk. Eight smaller trial trenches investigated additional sites and features recorded by the geophysical and topographical surveys. At Bakie, six trenches were opened and the continuous

Figure 16.7. Peterkirk Broch and settlement, excavating the defences.

Figure 16.8. Bakie settlement, trench with corn drying kiln.

Figure 16.9. Knowe of Skea, Late Iron Age building partially uncovered.

archaeological exposure was recorded in full.

While budgetary constraints meant that the pace of excavation was necessarily swift, deposits were removed in plan and full, excavation-standard, recording was employed. Artefacts were collected by context and soil samples were recovered and processed on site.

Results

At the time of writing, the results were at a preliminary stage, with specialist analyses not yet completed. It is clear, however, that these assessments have been successful in gathering a large amount of information about the sites and their hinterland.

A wealth of evidence was collected on the extent, condition and complexity of the sites, and in all cases securely sealed samples for dating were recovered. It also proved possible to characterise the remains at each site more fully. The mound at Peterkirk was revealed as the remains of a broch with extramural settlement and substantial defences (Figure 16.7); at Bakie, a range of farm buildings, including a corn drying kiln of probable late medieval date, was uncovered (Figure 16.8). The Knowe of Skea has been revealed as a very well preserved Late Iron Age building; the adjacent structures have been shown to represent smaller cairns and funerary remains (Figure 16.9).

At Peterkirk and Bakie, since the results of assessment are sufficiently detailed and probably representative of the sites as a whole, further work is likely to provide diminishing returns and is therefore not recommended. Further work may be desirable at Knowe of Skea, however, given that it is a rare site type which is at once well-preserved but also threatened by erosion.

Conclusions

The success of this work results from two main factors: a wide range of assessment techniques were available and could be employed in a flexible manner; the sites examined preserved a high degree of stratigraphic integrity, making for relatively straightforward excavation. A further consideration is that the team comprised experienced fieldworkers, capable of working quickly under minimal supervision.

This assessment method could usefully be employed on almost any site. A potential drawback, however, is that it is destructive, although this is unlikely to be problematic on sites which are already threatened. Of more concern may be the possibility that invasive trenching may weaken the site and destabilise the surrounding area, rendering it more vulnerable to erosion.

Comparison of assessment methods

While the projects outlined in each of the case studies is not directly comparable, it is clear that the invasive methods employed in Case Study 2 delivered the objectives of site assessment more successfully. The Westray 2000 project cost just over twice as much as the Pilot Programme, but it could be argued that the work has provided more conclusive answers and a more permanent solution in that at least two of the sites will not require further excavation.

The overall cost of the Westray 2000 project is comparable to a medium-sized excavation project. While the results of assessment at each site are less comprehensive than would be generated by a full-scale excavation, it has been possible to investigate three large sites and eight smaller ones to a reasonable level for the same cost. Considering the large number of sites which potentially require assessment, this approach can be recommended.

Conclusions

Coastal erosion has been acknowledged as a major threat to archaeology and the first stages of an archaeological coastal zone policy are now in place. Audit survey will provide the basic background information to assist with appraisal of the situation at a national level. A further level of site assessment will be required before decisions can be taken to protect, excavate, or abandon sites. If a managed retreat is to be effected, evaluation work must be synchronised with audit survey within a rolling programme. Many sites are already eroding and decisions on their future must be made swiftly. The value of audit surveys will only be as good as the systems in place for receiving and responding to them.

Experimentation with different types of assessment methodology in Orkney has shown that there is no substitute for invasive excavation. It has also demonstrated that limited excavation can be carried out rapidly and to a tight budget. A single programme of work can achieve a great deal in a short amount of time and take advantage of economies of scale if one can employ a variety of techniques in a flexible manner and work with a professional team.

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17 FOCAL STUDY: SEEING THE UNSEEN: LOCATING MARINE CRANNOGS

ALEX HALE

Introduction

Within the intertidal zone of the Scottish coastline are a number of archaeological sites that are representative of an under-researched environment. This paper focuses on one particular type of site: marine crannogs. The known number of marine crannogs is very small (Figure 17.1) and only 9 out of 11 documented sites survive. However, by analysing the coastal environments, the site remains, and the types of coastal processes that affect the sites, we can attempt to predict where further sites could be located. To this end, we should assess the history of investigation behind the known sites and highlight to what extent that history has biased our current research approaches. We should then be able to develop research strategies to locate and begin to analyse the unknown marine crannogs.

Background

Crannog research in Scotland began as part of a Europe-wide interest in wetland sites, particularly lake-dwellings (Keller 1878; Munro 1890). Robert Munro was the pioneer of crannog research in Scotland and his investigation of sites was concentrated, although not exclusively, in the south-west of Scotland. However, others also took part in early investigations of crannogs, such as John Stuart (1864–6) and the Reverend R J Mapleton (1870), to name but two. Munro was joined in the 20th century by the Reverend Odo Blundell. Blundell used early diving equipment to investigate Highland crannogs and was thus able to examine sites in a way that Munro had been unable to manage (Blundell 1909–10).

Reports by other early crannog researchers include a small number of references to the investigation of crannogs in marine locations and Munro remarked in *The Lake-Dwellings of Europe*:

'The question of submarine crannogs is still obscure, and the few facts that have come to light leave the matter in doubt as to whether the structures were originally constructed in the water or on a dry land and subsequently submerged, in consequence of changes in the relative levels of sea and land.' (Munro 1890, 443)

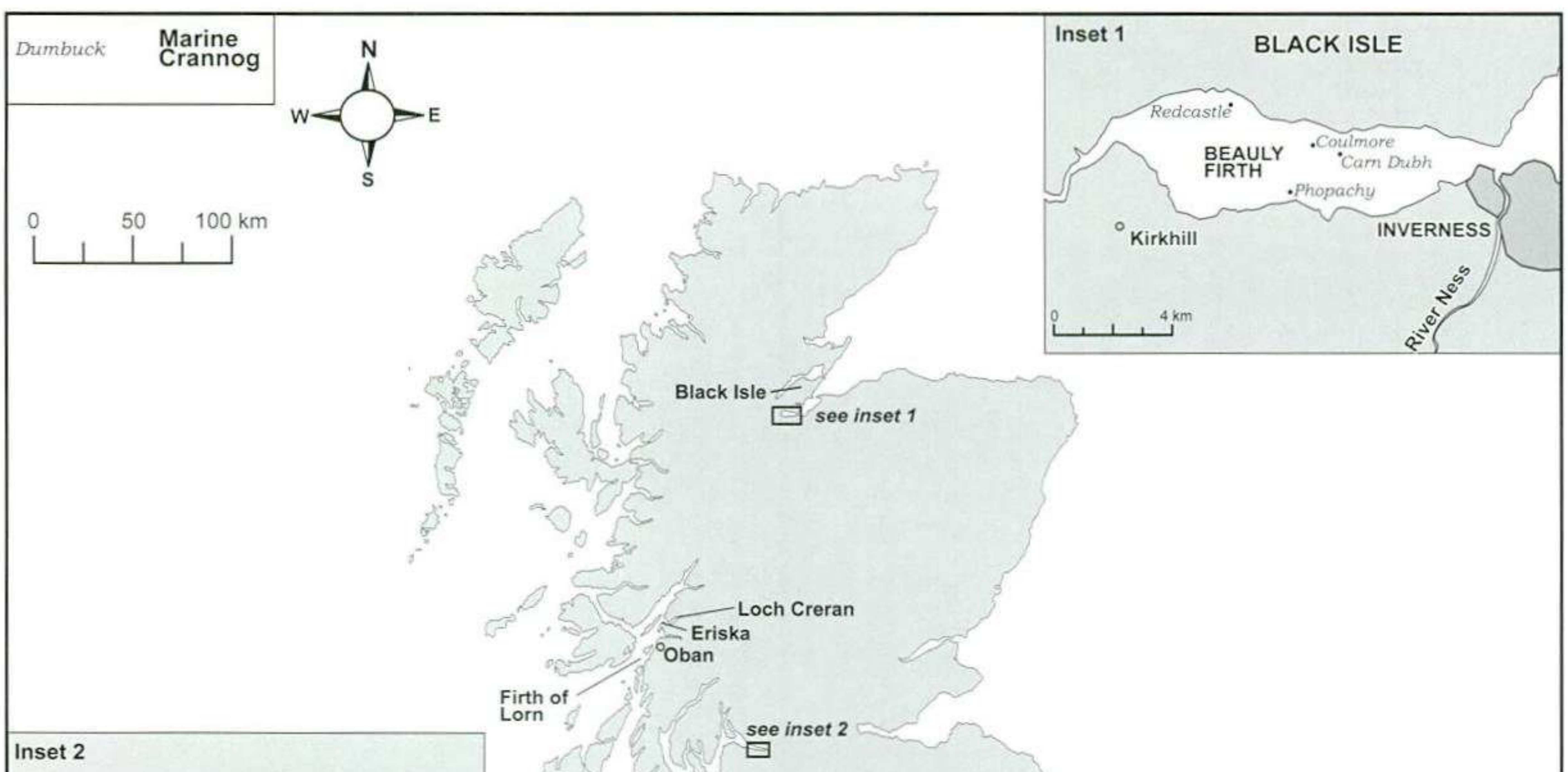

Figure 17.1. Map showing the location of known marine crannogs and places mentioned in the text.

Munro's recognition of the problems of interpretation, and, indeed, investigation of marine crannogs may be a contributory factor to the marginalisation of marine sites in this period of crannog research and a factor in there being so few sites of this sort documented. By 1900, only two marine crannogs had been investigated in comparison with over 50 freshwater sites (Munro 1884–5; Bruce 1899–1900).

Evidence from the records of early notices of marine crannogs indicate that two groups of sites were known: one in the Beauly Firth and the other in the Firth of Clyde, and a further single site north of Oban, near the Isle of Eriska. These early reports are useful when determining whether intertidal remains are marine crannogs, rather than naturally-occurring geological features or other types of remains. For example, some of the reports include evidence of the variety of materials and structures found on these sites and lists of the small finds that were recovered. Aspects of environmental evidence were also recorded, albeit, by modern archaeological standards, somewhat crudely.

Records of past investigations sometimes include the condition of the different remains when first uncovered. By re-examining the evidence of structures excavated in the past and comparing them with the current remains, any alterations that have occurred may be recognised and related to factors such as erosion. Comparisons between the records of previous investigations and the current research may enable the rates of loss over a known period to be calculated. This could also help to quantify and identify the agents of destruction that may threaten these sites.

Accounts of organic remains recovered during the original investigations may be used to suggest characteristics of the environment when sites were built. Organic and inorganic deposits may also indicate palaeo-environmental conditions and variations on or near the site. Any records of the sediments or deposits overlying the sites may contribute to an environmental history and be used as an indicator of post-depositional change, which has resulted in the current position of these sites in the intertidal zone.

Previous Investigations

The following extracts and accounts illustrate the early references to marine crannogs and demonstrate the variety of interpretations of their origins and possible uses. They include examples of evidence of both structural and artefactual information and demonstrate the different approaches taken to investigate such sites.

Beauly Firth

In 1699, James Fraser, Minister of Kirkhill parish, near Inverness, described three marine crannogs in the Beauly Firth:

'There are three great Heaps of Stones in this Lake, at considerable distance one from the other, these we call cairns in the Irish. One of a huge bigness, (in the middle of the Frith [sic]) at low water, is accessible; and we find it has been a Burial place by the Urns which are some times discovered. As the Sea encroaches and wears the Banks upwards, there are long oaken Beams of 20 or 30 Foot long found; some of these 8, some 12 or 14 feet under Ground. I see one of them 14 feet long, that carried the mark of the Ax on it, and had several Wimble bores in it.' (Lowther 1699, 538)

One of the most detailed accounts of the marine crannogs in the Beauly Firth, published in 1808, describes the sites, some of their characteristics, and their locations and possible uses. Discussion regarding the water levels that affected the sites is particularly interesting:

'The cairns in the Beauly Firth are very singular, and merit a place among the antiquities of the county of Inverness. Two are much larger than the rest; one of these is opposite to Redcastle, and the other about two miles above the ferry of Kessack, and are said to be distinctly seen above the surface of the sea, during low water neap tides. In some of these, which are accessible, beams of wood have been found; in other, graves and human bones have been discovered occasionally; which leaves no doubt of their having been in former ages used as habitations both for the living and the dead; and consequently, of their being at that period dry ground. The most material circumstance, worthy of investigation is, why the good people of that country made choice in those days, of such inconvenient dwellings for themselves, or of such repositories to contain the bones of their departed friends? and why the sea covers this burying ground at present, which we may presume was not the case at the time, owing to the reluctance of all men at a watery grave?' (Robertson 1808, 430)

Evidence of the names and classifications given to marine crannogs demonstrates that authors had recognised the sites and that they were regarded as objects of antiquarian importance, even though their origins and uses were not necessarily known. The following record, taken from the *Statistical Account* of 1791–9, mentions a fourth site in the Beauly Firth near the confluence of the River Ness and the Firth:

'There is, at some distance from the mouth of the river Ness, a considerable way within the flood mark, a large cairn of stones, the origin of which is of very remote antiquity. It is called Cairnairc, that is the cairn of the sea.' (Sinclair 1981, 631)

This is the first recorded use of a name for one of the sites in the Beauly Firth and translation from the Gaelic suggests that the term 'airc' implies 'difficulty', rather than the explanation given in the account (Maclennan 1979). Perhaps the site was used as a warning of the tidal streams at the confluence of the River Ness and the Beauly Firth (Watson 1993). Cairnairc was also called a cairn, which today implies a number of particular functional and structural characteristics. Later references to the same site indicate that it was a large mound covered by stones, situated above Mean Low Water Mark (MLWM) at the mouth of the River Ness. It was also described as a navigation aid with a beacon situated on top of it (Maclagan 1875, 89).

In the 1870s, Christian Maclagan visited all of the sites in the Beauly Firth and described them in some detail (Maclagan 1875). She believed that one of the sites was similar to a crannog in the nearby Loch of the Clans. The loch had been drained and consequently revealed two possible crannogs (Grigor 1862–3). She described some of the remains in the Beauly Firth thus:

'Crannog in the Beauly Firth, ...in the centre of the Beauly loch, stands the remains of the "Black Cairn", now only visible at low tide. We visited it at low-water of the lowest tide of the year, and believe it to be a crannog greatly resembling one in the neighbouring "Loch of the Clans", but resting on larger stronger piles. Our boatmen declared they had often drawn out of it beams 9 or 10 feet long and 3 feet broad, fresh and fit for use. They had great difficulty in pulling them out, which they did by fixing their anchors in a log or pile.' (Maclagan 1875, 89)

This account reveals the position of the site, its relationship with sea level, and describes some of the structural remains. It may have been as a result of this account and the description of extensive structures that the site became the focus of two early 20th century investigations.

In the summer of 1909, as part of his investigation of Highland crannogs, Odo Blundell visited Carn Dubh (the Black Cairn) with the intention of diving to inspect the site (Blundell 1909–10, 12). However, he discovered that the site was above Low Water Mark and that he could get to it by boat and walk across the site. He described the site as standing approximately 1 m above the surrounding sandbank and measuring 80 m east to west and 60 m north to south. He suggested that the surface stones weighed approximately 50 kg each and he noticed some smaller stones beneath the surface. A number of stones were different from the surface cover and were explained as dumps from vessels that had run aground on the site (Blundell 1909–10, 17). He also found a number of horizontal timbers beneath the surface stones and believed them to be wedged in by the overlying stones.

It should be noted that Carn Dubh was designated a Scheduled Ancient Monument in 1971, classed as a 'crannog or beacon-stance (possible)'. Despite this measure to protect the site, little was known, at the time of scheduling, about the origins, period of construction and use of Carn Dubh, or why it was built in such a location. Additionally, the destructive agencies that may affect a site in such a location are still unknown.

A survey of the archaeological remains of the Black Isle, Easter Ross, was carried out in the early 1950s and includes the marine crannog near Redcastle (Figure 17.2) in a gazetteer of sites:

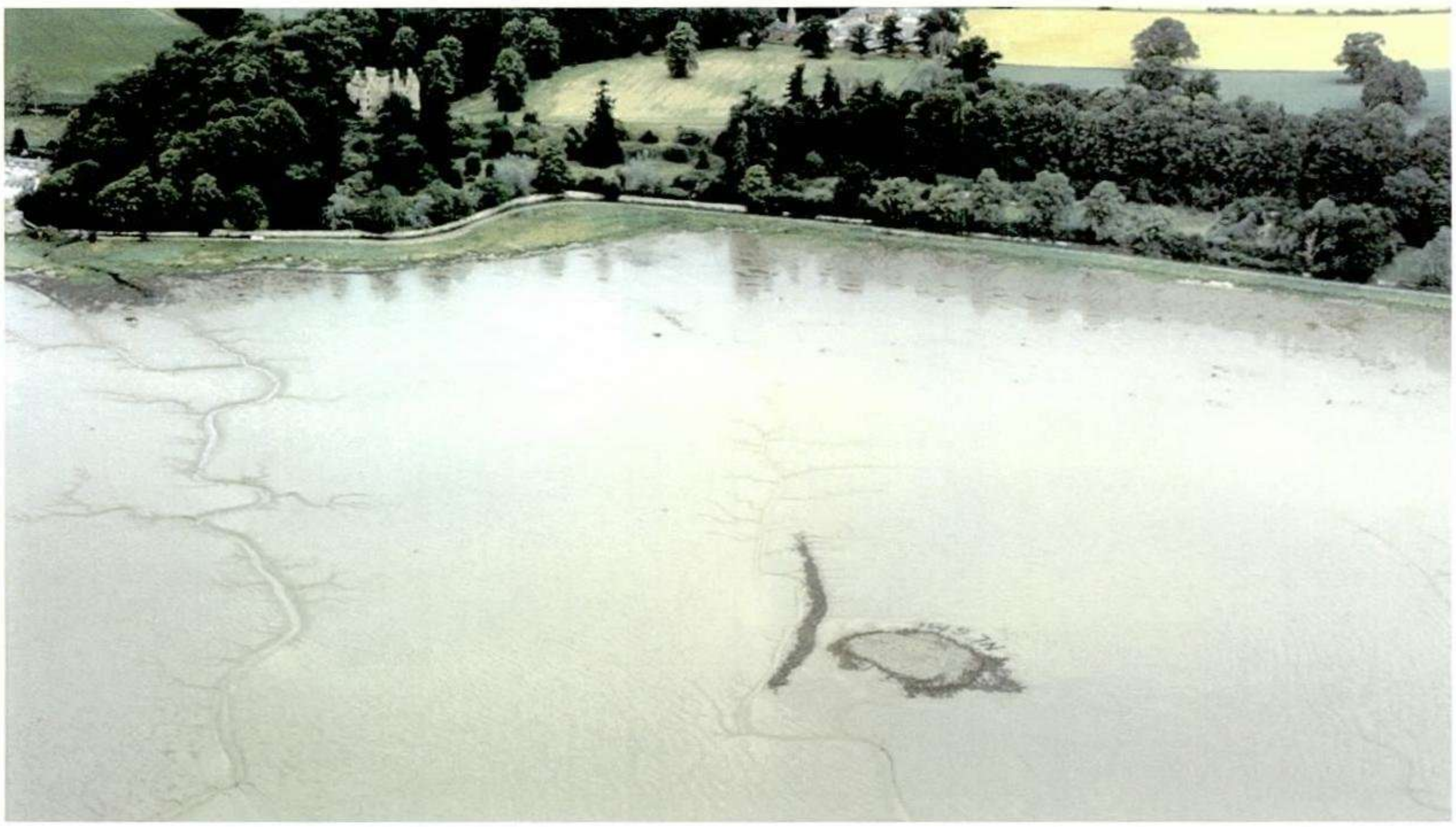

Figure 17.2. Aerial photograph of Redcastle crannog taken by the late GDB Jones, Manchester University.

'About 400 yds below high-water mark on the mud-flats to the S. E. of Milton village is a low cairn of stones of considerable size. Its position and the faint but quite definite remnants of a causeway leading to it, leave little doubt of this being a crannog.' (Woodham 1953–5, 85)

This account marks a departure from those above because it associates the site with a causeway feature and because Woodham classified the site as a 'crannog'. Milton Loch crannog, which possessed both a stone mound and causeway leading to the shore, was being excavated at the same time. In the year before Woodham's survey, C M Piggott had completed her excavation of Milton Loch crannog 1 (Piggott 1952–3), and the publication of her report may have influenced Woodham's interpretation of the linear feature adjacent to Redcastle. Current research has shown that the line of stones was built as a breakwater to prevent the Redcastle Burn from encroaching on to the site.

Firth of Clyde

The group of marine crannogs in the Firth of Clyde was the focus for investigations at the end of the 19th century and beginning of the 20th century. Dumbuck was one of the first marine crannogs in Scotland to be investigated extensively. The various records of the investigations contain details of the location of the site, many of the structural features, and suggestions as to the possible functions of various structures and small finds.

Dumbuck was discovered in 1898 by William Donnelly, a local artist from Dumbarton, who produced a large number of watercolours of the excavations (Figures 17.3 and 17.4). Excavations of the site took place between July and October 1898 and were supervised by John Bruce, who later became President of the Society of Antiquaries of Scotland. At the time, the excavation was a very public event, which led to numerous articles being written about the site. The excavations revealed a central circular, timber platform, approximately 15 m in diameter. This timber 'flooring' was covered by 30–45 cm of estuarine sands and silts (Bruce 1899–1900, 437). According to Bruce, the flooring consisted of three layers of horizontal timbers, the upper and lower layers had been laid radially from a central point, whereas the middle layer had been laid across those above and below it. In the middle of the circular structure was a wattle-lined pit 2 m in diameter.

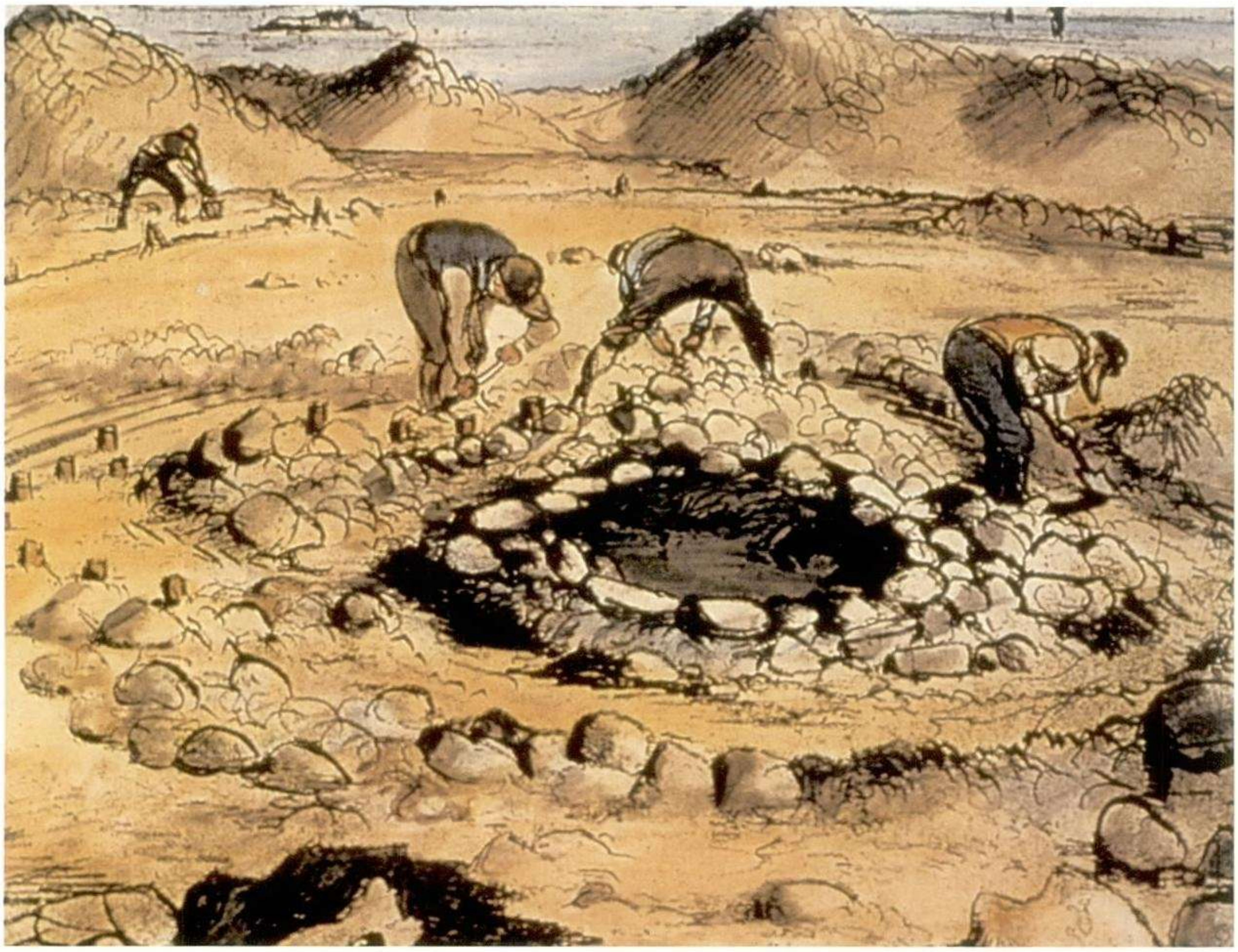

Figure 17.3. Watercolour by William Donnelly of the excavation of Dumbuck crannog.

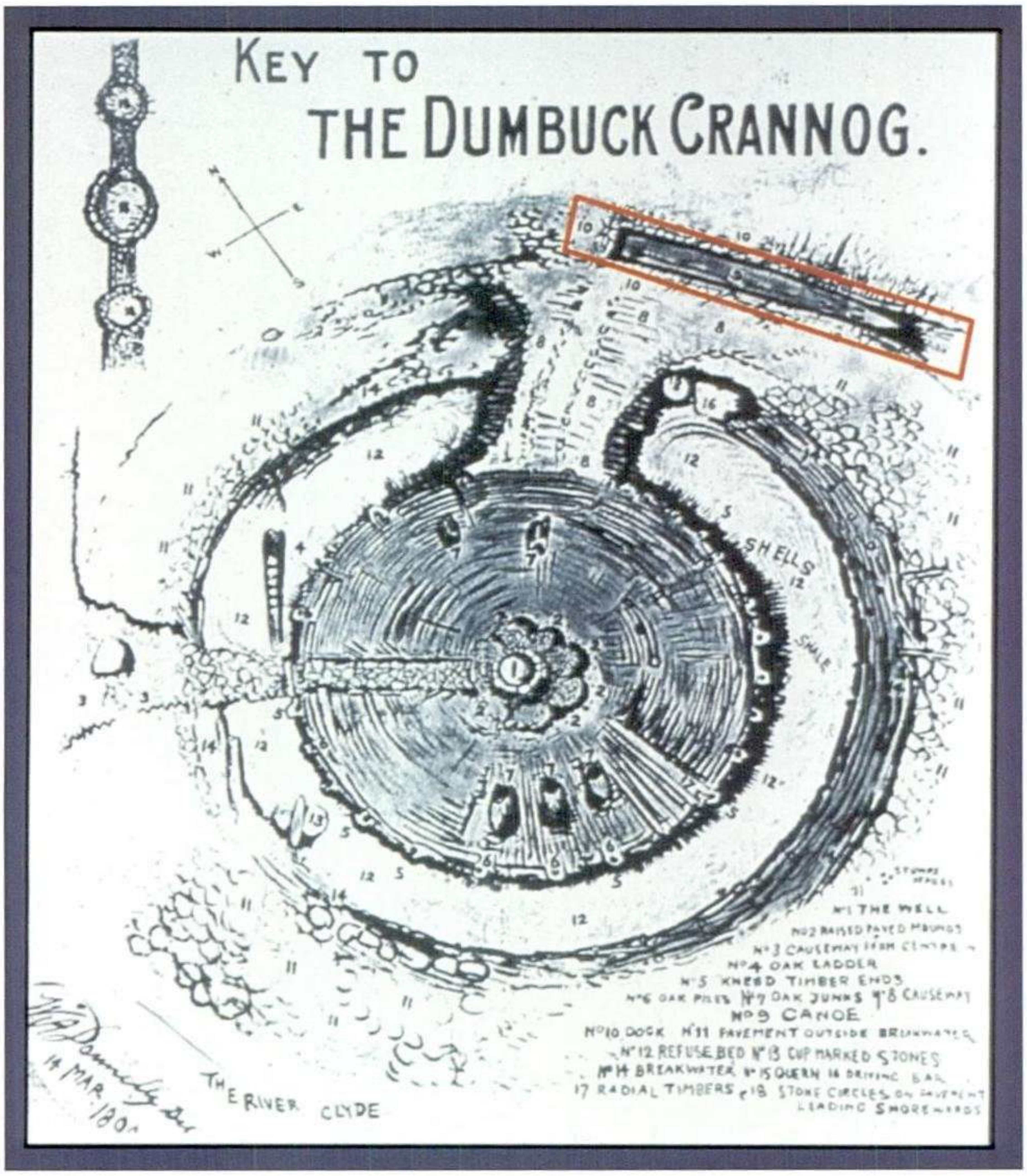

Figure 17.4. Watercolour by William Donnelly of the dock and boat, Dumbuck crannog.

Surrounding the timber platform was a ring of 27 oak piles spaced 2–3 m apart, and 4–5 m beyond the circular timber structure was a stone and timber 'breakwater', which surrounded the site except on the north side. From the centre of the site, leading westwards, was a 2 m wide linear stone feature, possibly a causeway, laid on top of the horizontal platform timbers. A second all-timber causeway was described as having been positioned between the centre of the site and a dock feature.

The dock, in which a log boat was found *in situ*, was approximately 15 m north-east of the centre of the site (Figure 17.4). The dock comprised an open-ended linear structure constructed of piles and horizontal timbers that formed shuttered sides that opened towards the main channel of the Firth. The dock was 15 m long and 2 m wide (Neilson 1905, 283) and accommodated an 11 m long oak log boat (Mowat 1996, 26). Some of the descriptions of Dumbuck and its surroundings include records of two streams on either side of the site. Drawings by Donnelly effectively show the site on the end of a short promontory formed by the two streams (Neilson 1905).

The position of two sites, Langbank East and Langbank West, on the southern shore of the Firth of Clyde appears to have been confused since the excavation of one of them (Langbank East) at the beginning of this century. Recent analysis of aerial photographs and fieldwalking has relocated both of the sites and identified the site excavated by Bruce (Hale 2000). Bruce's account of the investigation and records of later work by John Hunter of Paisley Museum in 1977 have enabled the following description of the remains of the site to be compiled.

Excavation of Langbank East took place over two fieldwork seasons, starting in October 1901 and continuing between September and October 1902 (Bruce 1908). Bruce recorded that the site was located on an island, known as the Baby Island, which was severely eroded and where only the remnants of turf were found. Records of Bruce's excavation reveal that he found an oval structure of horizontal timbers surrounded by a ring of piles, spaced approximately 1–1.5 m apart and similar to that of Dumbuck. The only diagnostic finds, an inscribed bone comb and a bronze penannular brooch, were found in the 'refuse mound'. The comb has been compared with a similar comb found at Ghegan Rock near Seacliff, East Lothian, which was dated in association with late Roman objects (Bruce 1908, 46). More recently, the Langbank comb has been dated on stylistic grounds to the 1st century AD and classed as a single-sided A1 design, after MacGregor (Foster 1990). The brooch was dated to the Early Roman period by C M Piggott (1952–3, 150) and the design is similar to Fowler's type A, Aa or A1, also attributed to the 1st or 2nd century AD (Fowler 1960).

A fourth site in the Firth of Clyde was discovered on the northern shore close to Old Kilpatrick. Excavation of the site occurred prior to the construction of Napier and Miller's shipyard, in 1906. No written records exist of the excavation, but a number of photographs are held by RCAHMS in the National Monuments Record of Scotland and the Glasgow City archive library holds a series of maps and plans of the site.

From analysis of these plans, the site was calculated to be approximately 25 m long and 20 m at the widest points. The site was roughly oval in plan with the long axis aligned north to south and parallel with the flow of the river. A plan dated 1840 indicated that although the site was within the flood plain of the River Clyde, it was approximately 15 m inland from the MHWM and approximately 40 m from the MLWM. The large-scale plan shows the site situated between the 1 and 2 m contours, the southern edge sloping to below 1 m above sea level.

The remains appear to form a curvilinear structure with parallel rows of vertical piles between worked horizontal timbers, branches and trunks. Occasionally, a timber was located lying between the parallel rows; these may have acted as bracing timbers. There was an accumulation of brushwood towards the north-west of the site. The plan of the site was incomplete because a number of areas have been disrupted by dredging, to the extent that some timbers were removed.

A recent investigation of the Erskine site focused on assessing whether it was associated with the end of the Antonine Wall and the Roman presence in the area (Hanson & Macdonald 1985). The site is situated 150 m north of MHWM, adjacent to MLWM on the edge of the main river channel. The investigations consisted of clearing surface stones and sediments to expose the upper timber components of the site. These were planned using photogrammetry and the resultant plan reflects a number of structures.

The site is oval in plan and approximately 40 m long and 27 m wide. The long axis is aligned east–west, parallel to the river flow. The site is covered with stones overlying smaller pebbles and cobbles. Among the stones are both horizontal and vertical timbers. The site comprises timbers surrounding the south, east and northern peripheries with a concentration of radially-aligned timbers in the north and east. The radial timbers were laid horizontally and some of the external piles are tilted with their tops towards the centre of the site. Perpendicular timbers were recorded between a few of the radials. Some of these showed signs of working; two had been cut into half-checks and two had been cut with mortise holes at their ends, with a vertical post through the hole. The only artefact recovered was a fragment of a rotary quern found on the surface of the site. The wooden remains at Erskine were sampled during the 1985 survey to apply both dendrochronology and radiocarbon dating techniques (Hanson, W, pers comm). However, although species identification of the samples was carried out by Dr Anne Crone, the samples proved to be unsuccessful for dendrochronological analysis (Crone, A, pers comm). Four samples were submitted for radiocarbon dating to the Scottish Universities Radiocarbon Research Centre and the results were: 1950 ± 50 BP (GU–2328), 1970 ± 50 BP (GU–2187), 2170 ± 60 BP (GU–2383) and 2210 ± 50 BP (GU–2186) (Barber & Crone 1993; Hanson, W, pers comm). Despite the lack of suitable material for dendrochronology, it is interesting to note that all of the horizontal timbers sampled were identified as alder and the five piles sampled were identified as oak (Crone, A, pers comm).

Other marine crannogs

An Dòirlinn is the earliest marine crannog to have been excavated in Scotland. In September 1884, Robert Munro visited Eriska, 20 miles north of Oban, with the intention of assessing whether the site was an artificial island (Munro 1884–5). He had been alerted to the presence of the site by J Meliss Stuart, who was about to build a bridge on to the Isle of Eriska and had dug some small trenches into the site and recovered burnt bones, charcoal and large timbers (Munro 1884–5, 192).

The site lies on a sandflat in a sheltered bay on the north shore of the narrow firth called An Dòirlinn, which separates Loch Creran from the Firth of Lorn. The surface morphology of the site is similar to some of the other known marine crannogs described above and consists of an oval mound covered by stones and estuarine sediments. Records of the first excavation describe worked and unworked structural timbers positioned towards the centre and around the edge of the site. When Munro visited the site, the trench edges had been eroded by tidal action but the same trench was re-excavated and continued through the site from one side to the other.

In the centre of the site were layers of timber mixed with brushwood and the margin timbers were sometimes laid in pairs. The timber remains in the centre were approximately 1 m below the surface estuarine sediments and stones, and overlying fragments of timber and brushwood. The timbers on the margin were only one layer deep and Munro noted cut-marks on some of the pieces and what appeared to be a saw-cut on one. Munro's succinct description of the site reflects the brevity of the investigation and the inferences that can be drawn are, as a result, limited. Further investigations would be necessary to develop Munro's interpretation that:

'A stagnant marsh existed here in former times, sufficient to afford protection for a fort or crannog, before the sea encroached upon it to the extent it now does.' (Munro 1884–5, 195)

Conclusions

The impression from the early and even the more recent investigations into marine crannogs is that the researchers have concentrated on individual sites rather than taking a more overall view of the monuments within their landscapes. The landscapes in which these sites are located have particular attributes that can be identified and may be found in conjunction elsewhere, which may prove fruitful in the identification of further sites. The landscape attributes that are common to the Firth of Clyde and Beauly Firth groups of marine crannogs may be obvious but nevertheless benefit from reiteration:

- shallow gradient shorelines
- sheltered heads of firths
- extensive mud or sandflat intertidal bodies
- sandy sedimentary regimes
- shoreline marshland
- palaeo-shorelines and low promontories

From the above criteria a number of focus areas could be identified and future research should aim to target those locations, primarily with aerial photography, during low-water periods. For example, the heads of the Firth of Forth, Tay and Solway estuarine systems could be target areas for future surveys designed to locate marine crannogs. Despite the fact that all three of the aforementioned Firths were surveyed as part of Historic Scotland's coastal assessment programme, no further crannog sites were found. This may have been a result of the nature of these rapid assessment surveys, which had health and safety restrictions imposed due to the problems of working in the intertidal zone. The areas in question may benefit from site-specific survey and particularly from a programme of aerial photography, carried out over successive seasons in order that varying light levels and seasonal changes can be recorded and the optimum conditions utilised. The aerial photographic programme should be complemented by intensive fieldwalking, which should involve both shoreline and intertidal survey transects. This form of survey could be used in conjunction with the coastal assessment surveys in order to monitor coastal erosion and to locate further marine crannogs, or other types of intertidal archaeology.

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18 FOCAL STUDY: ARCHAEOLOGICAL WORK IN ADVANCE OF THE FIFE COUNCIL SHORELINE MANAGEMENT PLAN

IAN OXLEY

Introduction

During late 1997, Fife Council appointed the environmental consultants Posford Duvivier to develop the region's Shoreline Management Plan (SMP) which was part-sponsored by Historic Scotland. In addition, Historic Scotland grant-aided the Maritime Fife project to investigate the concept of targeted assessments in the SMP tradition for a selection of archaeological areas situated in the coastal zone of Fife.

This paper summarises the results of the study (Oxley 1998a) which tested the utility of applying the SMP process to selected coastal archaeological sites, with particular emphasis on archaeological areas and sites which are either of special interest or at risk (see Figure 18.1).

The subject areas chosen differed widely in character and included:

- a section of river bank alongside a harbour at Kincardine
- a dynamic foreshore containing World War II defences at Tentsmuir
- the surviving archaeology of the threatened occupation of salmon fishing on the River Tay
- a selection of the known coastal caves of Fife
- the St Andrews foreshore
- a Pictish cemetery at Lundin Links
- midden deposits at Elie and Crail
- a shipwreck and other foreshore structures at Woodhaven

In addition, grading exercises for all the coastal archaeological sites, and shipwrecks located within Fife's waters, were included in the report; they are also summarised here. Comment is also made on the coverage given to archaeological issues in the published SMP that resulted from Fife Council's initiative.

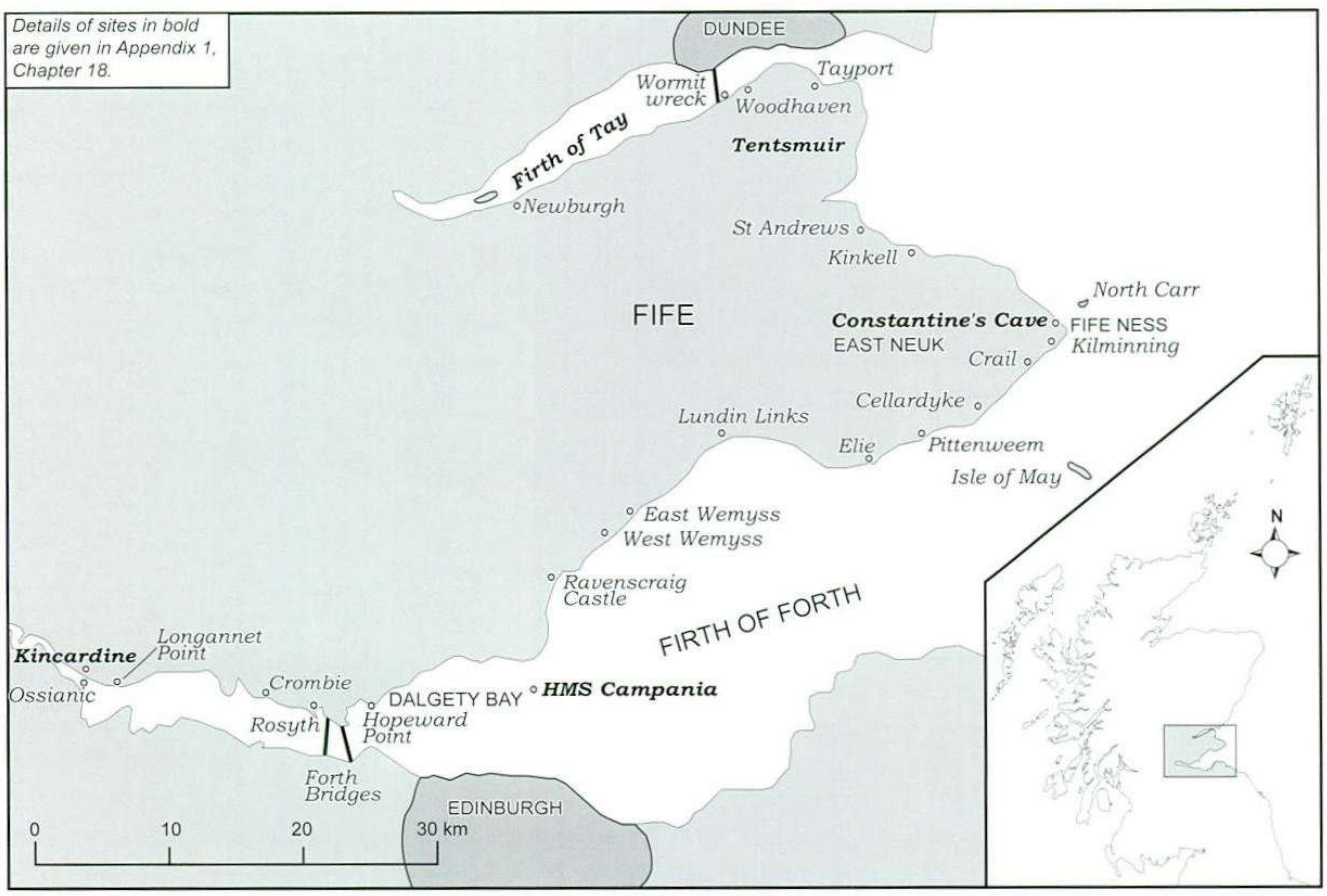

Figure 18.1. Location map showing places mentioned in the text.

Background

Mainland Fife is a peninsula situated between two major estuaries (the Firths of Forth and Tay), with a third border on the North Sea. Throughout its history, maritime influences have spread far inland. The coastline itself varies from dynamic dune systems to eroding sea cliffs, from heavily industrialised seaports and defence establishments to local nature reserves, and from salt marshes to historic harbours.

The archaeological heritage of Fife is rich and varied, not least in the maritime and coastal areas and their immediate hinterland. A number of summaries of the maritime archaeological record have been published which indicate that this invaluable cultural resource is under severe pressure from human and natural processes (BAHTG 1997; Gale & Fenwick 1997; Ashmore & Oxley 1998). Archaeological remains are vulnerable, within the medium and long term, to threats such as erosion and coastal development. In order to mitigate against these threats, high-quality data is required, together with appropriate decision-making by responsible organisations. SMPs are one of the many mechanisms by which this can be achieved.

Philosophical Approach

An underlying factor behind the Focal Study project was that the full potential of the maritime heritage, which is uniquely rich in Fife, had not been fully appreciated in the past (Oxley 2000). It is recognised that in coastal and maritime archaeology there are usually no hard boundaries. The archaeological remains around our coast often belong to seamless 'landscapes' which extend from dry land, through the intertidal zone, and onto the seabed. Despite occasional difficulties of access to marine and intertidal archaeological remains, and differences in the arrangements by which the sea and land are managed, such remains are no less important than those situated on dry land. Therefore, they should be considered in accordance with the principles which apply to land-based archaeological remains.

The approach to the coastal and marine archaeological heritage should also be inter-disciplinary as the existence of evidence is not restricted to present-day geographical boundaries such as the Low Water Mark (LWM). Boundaries or distinctions, such as inland, coastal, foreshore, intertidal, and marine, are all artificial devices which do not necessarily have any relevance to the extent of archaeological or historical sources of information. All evidence of the archaeological environment – terrestrial and marine, from whatever period and irrespective of present-day administrative boundaries – must be considered in an integrated way before they are considered as independent components.

Maritime Fife Surveys

During 1996, Historic Scotland grant-aided Maritime Fife to carry out two Coastal Zone Assessment Surveys covering the entire Fife coast (see Robertson, this volume). The aim was to create a 'snapshot' view of coastal erosion and sites affected. The definition of the area to be assessed was a 50–100 m wide strip encompassing the coast-edge and the intertidal zone. The audit was to include not only archaeological remains, but listed buildings. In the winter of 1996/97, Maritime Fife carried out a series of pre-disturbance surveys of foreshore sites identified in the Historic Scotland coastal surveys as being either of special archaeological interest or at particular risk due to coastal erosion. These sites included:

- an area of foreshore at Kincardine, less than 750 m in length, containing a complex of abandoned hulks, timber piles, stone banks, and structures which may represent fishtraps (Wood 1997a)
- a complex of the remains of stone-built structures on the foreshore at Crombie, possibly relating to boat-building or cargo handling (Wood 1997b)
- an early 19th-century gasworks at Wemyss suffering active erosion by the sea (Wood 1997c)
- a collection of wharf structures, and a substantial intertidal wreck situated on the eastern side of the Tay Rail Bridge and thought to have been involved in the repair of the Tay Railway Bridge after its tragic collapse in 1879 (Wood 1997d)

Further work on the shipwreck heritage of Fife described the known resource in relation to the reasons for the casualties and the nature of past maritime activity (Cunningham-Dobson 1997). Case studies investigated six local shipwreck sites or areas, including representatives of coast-edge small boat wrecks, intertidal hulks and completely submerged vessels. This initiative illustrated the rich diversity of the shipwreck heritage located in the waters around Fife.

Coastal Planning

Development control

To landward of LWM, archaeology is considered within the unified system of development control provided by the planning system, and National Planning Policy Guidance 5 (Scottish Office 1994a) explains the regard which should be accorded to archaeological remains. In essence, there is a presumption in favour of preservation *in situ* wherever possible. Stress is laid on early consultation between planning authorities and developers in order to reconcile the needs of archaeology and development.

Where preservation *in situ* is not justified, procedures should be in place to ensure proper recording before destruction, subsequent analysis, and full publication.

To seaward of LWM there is a sectoral approach to development control. Regulation, including the need for environmental assessment, is divided among a range of government departments and agencies. Consideration of archaeology is often hampered by a lack of information on the extent of the resource and by the absence of a comprehensive management structure in the submerged zone. However, growing awareness of marine archaeology and the development of the maritime database, NMRS – Maritime, at the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS), should encourage more detailed consideration of the marine cultural heritage. Moreover, seabed developers can now be guided by a *Code of Practice for Sea Bed Developers* that promotes early consultation with archaeologists (JNAPC 1995).

Coastal issues in Scotland have gathered momentum since the publication of coastal planning guidance which encouraged planning authorities to:

- identify in their structure and local plans areas at risk from coastal erosion
- set out the policies which will be applied to the location of new development in areas at risk
- refuse planning permission for development in areas at risk, particularly where expensive engineering works would be required to protect that investment (Scottish Office 1997)

The archaeological resource does not consist of entirely discrete sites contained by well-defined environmental zones. Palaeo-environmental deposits, for example, can extend from dry land across the intertidal area and on to the seabed. The need to consider the archaeological resource during the planning stage of land developments has long been recognised (Fife Regional Council 1994). Yet archaeological sites and landscapes in the intertidal and subtidal zones are similarly vulnerable to destructive impacts. Examples of destructive impacts include engineering works such as coast defences, sewage outfalls and pipe and cable-laying, and the construction of harbour works and of new maritime facilities (eg marinas). In sponsoring the Maritime Fife project from 1995 to 1998, Fife Council (and the earlier District Councils) recognised the fact that their interests and activities were likely to affect coastal and submerged archaeological sites.

The Shoreline Management Plan (SMP) process

An SMP is a document that sets out a strategy for coastal defence for a specified length of coast, taking account of natural coastal processes and human and other environmental influences (MAFF 1995). Coastal planning guidance in Scotland recommends the production of SMPs in consultation with adjoining authorities (Scottish Office 1997). These plans should:

- demonstrate an understanding of the processes of coastal erosion and deposition
- consider the implications of alternative means of dealing with coastal erosion
- outline a strategy for coastal defence
- identify the implications for development plan policies and development control decisions
- highlight opportunities for maintaining and enhancing the natural environment
- set out arrangements for monitoring the natural processes at work and the effect of coastal defence strategy

The definition of the parameters of an SMP is given in the 1993 Ministry of Agriculture, Fisheries and Food (MAFF) publication *Coastal Defence and the Environment: A Guide to Good Practice*. It states that SMPs:

- have their extent and boundaries set by the sediment cell or sub-cell, with a normal inland boundary of 1 km depending upon circumstances and extent of coastal processes
- are subject to extensive consultation of interested parties
- encourage collation and interpretation of existing information plus new coastal process data
- take account of natural coastal processes and human and other environmental influences
- set clear objectives to guide coastal defence options and agree a preferred approach
- address issues of sustainability in environmental and economic frameworks
- set objectives for future management

Scottish Natural Heritage (SNH) reviewed the potential application of SMPs to Scotland, concluding that it is uncertain whether the concept is applicable to the majority of regions in Scotland because of the predominantly fjordic coastline (Hansom *et al* 2000). The current approach was regarded as lacking a strategic approach and no single organisation was providing a coordinating point for coastal management.

The historic environment and SMPs

MAFF has recently commissioned research to evaluate a sample of SMPs carried out in England and Wales, and to make recommendations for future practice

(MAFF 2000). Some plans gave a brief discussion of the historic development of the human and built environment, but archaeological and historical features were considered to be included more effectively in areas covered by existing dedicated databases. Resources were generally identified from existing Scheduled Ancient Monuments Lists and County SMRs. Relatively few clients/consultants (involved in the plan production) entered into specific discussions during plan preparation with relevant bodies (eg the statutory heritage organisation) other than through consultation. In some cases, key information was incomplete or insufficiently detailed. In particular, it was noted that the inclusion of marine archaeological information depended largely upon the availability of existing compilations or databases and ranged from negligible to detailed summaries developed from various shipwreck databases or contact with marine archaeological trusts or societies. Lessons to be learned from this exercise included the fact that schedules of archaeological and historical sites are not necessarily complete or reliable, and that the historic and archaeological environment has been tackled in an inconsistent manner in the past.

Further research, commissioned by English Heritage, stated that the treatment of the historic environment in English SMPs (which exist for the entire length of the coastline) has been inconsistent, and that there are significant gains to be made from integrating it more fully in all types of environmental management processes (Wessex Archaeology 1999). The comprehensive series of recommendations in this report included:

- clients should seek the advice of curators in preparing and monitoring the specification of each SMP
- curators should be represented on SMP steering groups
- 'Historic Environment' should become a principal heading, equivalent to 'Natural Environment' and 'Current Land Use and Human Environment'
- 'Historic Environment' should be a distinct heading on the standard forms used in describing each Management Unit, and on the standard forms used to appraise strategic defence options

The improvements should not just be one-way, as the assessment of coastal processes, coastal defences and natural environment would be enhanced by information drawn from the appraisal of the historic environment. Furthermore, SMPs should recognise the contribution of the historic environment to landscape character, amenity and recreation. SMPs must be informed by quantitative data and qualitative assessment – an aim severely affected by the scope and quality of archaeological databases, particularly for maritime archaeology.

Clients should be encouraged to use specialist archaeological consultants in collating and assessing data relating to the historic environment. In considering tenders for SMP preparation, clients should recognise that the employment of specialist archaeological consultants provides value for money in assessing the relationship between SMPs and the historic environment.

As it happened, the Fife Focal Study satisfied some of these recommendations, but it was also viewed as an opportunity to test a framework in which archaeology is given equal consideration to that afforded to the normal concerns of SMPs: damage to property; natural environment considerations; and possible threat to human life in coastal protection work scenarios.

Coastal processes and impacts on archaeological sites

Coastal processes are essentially natural phenomena. Erosion, for example, involves the movement of sediment from one area to another within a defined area known as a 'coastal cell' (HR Wallingford 1997).

The effects of coastal erosion processes cannot be entirely prevented. Moreover, the seascape and coastal forms we see and want to conserve today are the result of these processes at work in the past. The process normally occurs slowly, but extreme tides, storm surges, exceptional waves, or a combination of these, can result in spectacular losses of land in a short period of time, for example at Lundin Links (Will 1996). Global warming is predicted to increase the incidence of flooding due to rises in sea levels and the increased frequency and severity of storms (Dawson, this volume). The result will be the erosion of natural defences such as sand dunes and shingle ridges, exposing the land behind. With its generally harder rock formation and indented coastline, Scotland has not experienced the same drastic losses as the east coast of England, but there are areas with specific problems.

Fife may be considered to be such an area because of the complex interplay of isostatic recovery, sea level change and historical shoreline defence strategies which are often difficult to disentangle and interpret (Firth *et al* 1997). Other factors include the sediment budget, energy input from solar and wave action, and changes in storm activity. Sediment budget will have been influenced by past agricultural activity, especially in the late post-medieval period.

Threats

Currently the three main threats, which are often interrelated, to the historic environment of the Fife coast are modern development, neglect, and coastal erosion.

Modern development

Development during the 20th century, and particularly since World War II, has already dramatically changed the appearance of some parts of the Fife coast and continues to be the main threat. It consists of infixing and reclamation of intertidal areas and the insensitive conversion of historic structures (or their complete or partial demolition) to make way for new buildings and waterfront facilities (jetties, slipways, docks and roads). These buildings could be associated with traditional industries, for example the new fishmarket at Pittenweem, but in many cases they are retail outlets or new upmarket housing. Urban expansion has meant that a greater proportion of the shore is now built upon than at the end of the 19th century.

In the past, the implications for maritime archaeological remains have not necessarily been extensively considered in the formal planning process. However, a few pre-impact studies have been carried out, targeted at specific problems such as the proposals for marine outfalls at Kinkell and Kilminning (Oxley *et al* 1995). Nowadays, conventional archaeological development control processes, such as watching briefs and desk-based assessments, are more common.

Neglect

When waterside structures and buildings go out of use, there is usually no longer an economic reason to maintain them. The condition of the small harbours of Fife must be a matter of grave concern (Robertson 1996; 1997). Recent breaches in the harbour walls at Cellardyke and a major repair project at St Andrews, for example, are both indications that the fabric of these important harbours may be in a serious state of disrepair. While erosion is a factor, the decline in the use of the harbours in the last 100 years has been marked by a piecemeal approach to their maintenance (Moore 1992).

Coastal erosion

Erosion, resulting from processes such as ongoing post-glacial rise in sea level, has been identified by Historic Scotland as a long-term serious threat to Scottish archaeological sites (Ashmore 1994). The degree to which coastal erosion is currently affecting archaeological sites in Fife is difficult to quantify. There are the 'spectacular' examples, where a single event brings to light a find such as at Lundin Links (Will 1996).

Sites on the foreshore or below High Water Mark are vulnerable by virtue of their location and some sites show obvious signs of the effects of erosion (eg the ongoing dispersal of the structural elements of hulks in the intertidal zone at Kincardine, Newburgh and St Andrews harbours).

Coastal defences may be effective in limiting erosion along protected stretches, but the resulting collateral effects to unprotected sections of coastline, while difficult to quantify, need to be considered. Erosion rates vary with the nature of the coast-edge, whether it is bedrock geology, raised beach, marine deposits, or landfill. The coastline east of the Forth Bridge is fully exposed to the open sea which is particularly destructive during prolonged periods of easterly gales and spring tides. In contrast, the sheltered estuarine area west of the Forth Bridge and west of Tayport on the Tay displays sediment accretion along the foreshore comprising mud originating from the upper reaches.

The Relative Costs of Protection and Excavation

The installation, monitoring and maintenance of physical coastal protection works are expensive. However, on balance such options are likely to be cheaper than full-scale archaeological intervention involving excavation, post-excavation analysis, full publication, and curation of the complete archive in perpetuity. The early stabilisation of the foreshore at East Wemyss cost around £100000, but in that case total excavation of the cave sites may have amounted to over £500000. Ashmore (1994) estimates the provision of a stable defence of a 50–100 m strip of coast to cost around £10–40000, with regular inspection, maintenance and repair over 20 years. When compared to the cost of a full-scale excavation, which might be in the order of £200000, the financial advantage of coastal defences is clear, although over a 100–200 year time-span the costs may become roughly equal.

Therefore the costs of implementing a stable defence to a large archaeological site might be a fraction (perhaps 10–20 per cent) of the expense of a rescue excavation sufficient to record the archaeology thought to be vulnerable to destruction in the next 20 years. Such estimates should be viewed with caution and when calculating for longer periods (eg 100 or 200 years), they will become increasingly unreliable because of uncertainty about all the variables.

The value of recording receding or eroding sections of archaeological features being actively exposed will be minimal because of the difficulties of associating these recording events to each other and the site as a whole (Church, this volume). This highlights the need for research into effective monitoring strategies.

The above comments relate principally to coast-edge sites that, in most circumstances, remain dry. Full consideration of the costs and implications of the protection of submerged sites has not been carried out although some attention has been paid to shipwrecks (Oxley 1998b).

Objectives of the Fife Focal Study

The overall objective of the Fife Focal Study was to provide additional information to aid the achievement of the Archaeology and Built Environment Management Objective of Fife's Shoreline Management Plan (Fife Council 1999), which itself has two aims:

- to conserve the archaeological and built heritage resource
- to conserve the archaeology of the estuaries and of the seabed and to maintain the diversity of wreck sites for future generations

Archaeological Management Options

A primary step in considering the historic environment is to compile the records from existing databases, usually the NMR and the local SMR. Known sites can then be ranked according to different levels of significance. Finally, the options for management of a particularly site can be assessed, including:

- justified abandonment
- defence of the coast involving high or low cost systems
- excavation before the site is destroyed and preservation by record
- routine recording and monitoring as the site is destroyed

For the purposes of the Focal Study project these strategies were equated to the coastal defence options used in the SMP process. However, the latter do not normally have the flexibility to focus on the problems or potential of individual archaeological sites. Therefore, in the Focal Study case, the proposal was amended to selecting sites based upon prior knowledge, summarising the contexts in which they are located (the natural and human environments), considering all future management options and, finally, suggesting a preferred option.

The following four options were defined:

Intervention Level I

This level advises the most thorough level of action, including those headings included in Intervention Level III such as monitoring, and survey.

Archaeological recording and excavation: either for the purposes of rescue or to obtain further data to inform management proposals. It ranges from complete excavation (and therefore destruction of deposits), to small-scale work on specific, targeted sites.

Stabilisation of site: intervention to assess and design remedial action to halt deterioration of site.

Heritage interpretation plan: includes public access management, and the provision of interpretation material, ranging from small-scale (leaflets and boards) to purpose-built visitor centres.

Intervention Level II

This is a step down from the detailed and comprehensive level described above where the site is excavated, interpreted, monitored, and presented to the public in some form, but involves many, if not most, of the headings above. The emphasis here is on baseline survey, basic recording, some action to improve public awareness of and access to the site, and periodic review.

Intervention Level III

This is a level of minimum intervention. The areas of intervention described above may feature here in a much reduced form, but the emphasis is primarily on monitoring the site. Some level of recording may be included here (such as a photographic record) and the site should be under periodic review to consider whether its management under this heading is most appropriate. In terms of heritage interpretation, the site should be included, for example, in coastal walk initiatives by mapping it and including some information on its background.

Do Nothing

No intervention, no action.

Focal Study Site Selection

The sites selected for the case studies highlight the rich and varied nature of Fife's maritime archaeological heritage and its susceptibility to impacts of different forms. The Historic Scotland coastal surveys (Robertson 1996; 1997), and the more detailed pre-disturbance surveys carried out by Maritime Fife that followed them (Wood 1997a–d), identified a number of sites which were at particular risk and/or were of particular significance. These sites were selected to be the subject areas of this present study of archaeological shoreline management, rather than relying on the traditional SMP mechanisms of 'management units' or categorisation based on coastal cells. Attention was paid to the factors – human or natural – that cause change to the sites. The assessments also looked at additional topics which might inform the development of individual management and interpretation strategies for each site, and the coastal archaeology of Fife as a whole.

The subject areas were categorised into two levels, according to their relative importance or perceived degree of threat:

- Level 1: Fife's Coastal Caves, Newburgh and archaeology of salmon fishing on the Tay, Tentsmuir, Kincardine
- Level 2: St Andrews foreshore, Lundin Links, Elie and Crail shell middens, Woodhaven and the Wormit wreck

Fife's coast-edge sites

In addition to paying specific attention to selected sites, the Fife Focal Studies project carried out a review of the existing information about all the coast-edge archaeological sites located in Fife recorded by the Historic Scotland Coastal Surveys (Robertson 1996; 1997). Data was entered into the Maritime Fife database and the sites were then graded according to the Non-Statutory Listing (NSL) criteria supplied by Fife Archaeology Service. Two hundred and seventy sites were included in the exercise. Not surprisingly, sites later selected for the Focal Study were highly rated for further attention.

Fife's shipwrecks

A further analysis was undertaken of the known shipwreck sites situated in Fife's waters in order to emphasise the wide variety of coastal archaeological sites, and to stress that it is only recently that this type of site has been considered on an equal basis to other sites. Information on the sites was derived from the Maritime Fife database. The sites were then graded according to the NSL criteria (supplied by Fife Archaeology Service), together with specialist knowledge of the overall UK shipwreck resource.

Fife's shipwreck heritage is a unique resource covering vessels lost at sea, and those wrecked and abandoned on the shore which are now located in the intertidal zone. Shipwrecks form a large, but probably least-known, part of the archaeological heritage of Fife. The majority are late 19th- and 20th century wrecks of many types, including fishing vessels (both sail and power), fishery protection vessels, steam packets, passenger vessels, leisure craft, dredgers, tugs, lighters, barges, general cargo vessels (sail and power), warships, submarines, and minesweepers.

In terms of archaeological heritage management in Scotland, the treatment of shipwrecks is relatively new. They have never before been considered as a separate category in regional or management assessment exercises, although some local authorities have followed Fife's lead in incorporating wreck sites into their SMRs.

Although the Maritime Fife project has raised awareness of Fife's overall maritime heritage in recent years and a number of new sites associated with maritime themes have been discovered, most of the site types are familiar, for example foreshore features such as slipways, fishtraps, and military defences. Such foreshore sites can be assessed for the NSL in the same way as all the other terrestrial sites of Fife.

Shipwreck sites are significantly different from other archaeological sites and so require careful consideration as to whether existing ranking systems and procedures are relevant. Such sites principally represent the remains of vessels that are themselves archaeological objects with particular characteristics and value. The concept of time capsules has been widely promoted, but, in reality, shipwrecks are a series of time capsules, none of which have been completely sealed. From the point of deposition on the seabed, shipwreck sites (with all their constituent structures, objects, features and deposits) are subject to a range of impacts and influences (Oxley 1998c).

The National Historic Ships Project undertook an international review of evaluation systems being applied to shipwrecks and preserved historic vessels (Groom 1996) and the criteria that were shown to be consistently applied are the following:

Integral to the vessel

- **Technical** – demonstrate a high degree of technical or creative achievement for the period in question; significant in demonstrating a particular stage in the type's seminal or optimal development
- **Aesthetic** – significant to art history or popular perception
- **Historical association** – important in relation to a figure, event, or phase of historical influence
- **Social/economic association** – significant in the evolution and pattern of maritime history

Modifiers

- **Originality** – taken to represent the percentage of original fabric from the vessel's normal working life. Whilst important to the consideration of a restored museum exhibit, shipwrecks can be considered to be catastrophic events in the working life of the vessel, and as such what remains on the seabed is all that remains of the vessel's working life.
- **Condition** – a scale of possibilities
- **Scarcity** – an established scarcity either as a result of a process which produced few such items or as the result of decay or destruction
- **Age** – may or may not have a considerable effect on the survival or remains on the seabed, environmental constraints often having more importance

At the present time, it is difficult to apply such criteria consistently to Fife's shipwrecks because of the lack of baseline information. The overwhelming majority of records are documentary references to ship losses for which fieldwork is required to confirm the actual existence of remains. There are also a large percentage of 'Unknowns' that have been recorded from hydrographic survey work. These anomalies have yet to be closely inspected by a competent authority. Moreover, with the work of NMRS – Maritime still being in its infancy, the broader picture of Scotland's total potential resource remains unclear, and as such it is hard to apply some of the criteria (eg 'scarcity').

However, as suspected, Fife's 'accident black spots' became apparent during the study. Areas such as the North Carr rocks, Fife Ness, and the Isle of May show large concentrations of sites. Marine environmental conditions around these navigation hazards indicate that they are likely to be extremely rich in archaeological evidence from a wide range of historical periods. It would not be unreasonable to suggest that similar causes of shipwrecks, and the consequent preservation of remains, would also relate to much earlier time periods.

The criteria used for the selection of Archaeological Sites of Regional Importance (ASRI) were also applied to the shipwreck dataset. 'Degree of preservation' and 'relating the site type to its setting and environment' are important factors in ASRI selection. A total of 269 wrecks were listed on the Maritime Fife database and, in general, the sites which were of particular importance reflected those wrecks which have been identified in previous work of Maritime Fife, for example the *Campania*, the possible *Ossianic*, and the Wormit wreck. Summary sheets for all of these sites were included in the Focal Study exercise (see example in Appendix I).

Conclusions

Fife

Some coastal and maritime archaeological sites in Fife are under threat and the most appropriate way of mitigating these, and future, threats is to acquire high-quality information through comprehensively researched assessment and monitoring procedures that are currently lacking. Regular monitoring of the coastal archaeological resource of Fife is required to a repeatable standard to prevent unnecessary damage and loss. Increased background knowledge about the coastal and maritime archaeology of Fife is necessary in order to enhance the effectiveness of decision-making relating to the whole range of archaeological evidence in the region, regardless of the present-day environment in which it happens to lie. Opportunities for interpreting the whole range of the maritime and coastal archaeological sites of Fife are considerable, and currently underdeveloped. There is also a need for a well-resourced capability, local or otherwise, to react promptly to any unexpected exposure events.

Although the interests of the historic environment have been included to a certain extent in the SMP process for Fife, clearly the shortage of resources meant that only a limited (and desk-based) assessment of the historic environment was achieved. The work was also heavily based on existing inventories (well-known to be not always accurate, complete or accessible), such as the NMRS, Fife's SMR and the Maritime Fife database. Finally, it is clear that the traditional SMP evaluation of environmental resources does not sit easily with the requirements of the historic environment. Fife Council in the final SMP (Fife Council 1999) recognised that the preparation of the SMP indicated that further research into the archaeological value of the coast of Fife (which is difficult to quantify) would benefit the future decision-making process.

General

The relative success in getting coastal archaeological interests incorporated in the SMP process in Fife highlights the poor situation in the rest of Scotland. The activity over the last five years of specific maritime archaeological projects such as Maritime Fife has raised the profile and enhanced the overall knowledge of the coastal archaeological heritage in that region. This is not the case in the other regional and island areas of Scotland. Overall there is a general lack of information and where sites are known, the quality of the data is often poor. This problem is compounded by a widespread lack of awareness, and low level of appreciation, of the coastal and marine archaeological resource both locally and nationally. Although Historic Scotland is working to redress this situation with the publication of the *Conserving the*

Underwater Heritage Operational Policy Paper (Historic Scotland 1999), it is clear that the interests of the coastal and submerged archaeological heritage are usually seen in the commercial world as an impediment to development and progress, rather than as a positive asset with a multiplicity of benefits.

Recommendations

Many of the recommendations generated by the English Heritage study of the historic environment in SMPs (Wessex Archaeology 1999), referred to above, can be echoed following the Focal Study exercise. All future coastal and marine management plan initiatives in Scotland, including SMPs, should consider greatly increasing the attention paid to coastal and marine archaeology from that which was possible in the Fife Focal Studies project. The project has demonstrated that there is real value to be gained from including archaeological issues in all coastal and marine planning initiatives.

Efforts should be made to minimise the difficulties that occur due to the division of responsibilities on the basis of environment (ie coastal or marine), whether administrative or for planning purposes. SNH recommended that ideally SMPs should be viewed within the context of wider Coastal Zone Management Plans (CZMPs) and that the Scottish Executive should recommend that such CZMPs are produced as a priority for all of the Scottish coastline (Hansom *et al* 2000). Historic Scotland is considered to be a significant potential partner in all Scottish SMPs, benefiting from the clarification of a strategic policy position on issues of coastal erosion and the historic environment, leading to a more targeted funding requirement for site protection and possibly rescue archaeology. Similar benefits should accrue to local authority archaeological curatorial interests, but, as the Fife Focal Study has shown, despite the vigorous efforts of Historic Scotland and the Fife Archaeology Service, much more input is required by the archaeological community throughout all stages of the SMP process. Such input will be required in any other coastal planning initiatives that may replace or absorb SMPs.

Finally, it may be useful to broaden the approach even further and consider recent European guidance on Integrated Coastal Zone Management (ICZM)(Commission of the European Communities 2000) which suggested the following eight principles as a basis for successful ICZM:

- a broad 'holistic' perspective (thematic and geographic)
- a long-term perspective
- adaptive management during a gradual (planning and management) process
- reflect local specificity
- work with natural processes
- participatory planning
- support and involvement of all relevant administrative bodies
- use of a combination of instruments

It would be nice to see ICZM planning for Scotland, on a national, regional and local scale, which included comprehensive treatment of the coastal and marine heritage.

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APPENDIX I: SAMPLE FOCAL STUDY RECOMMENDATIONS

ARCHAEOLOGICAL FOCAL STUDY UNIT: CONSTANTINE'S CAVE

Location:

NMRS NO61SW6 NGR NO633 101
North of Fife Ness adjacent to Balcomie Golf Course.

Characteristics:

Cave (c 6 m deep) in isolated sandstone outcrop. Many incised and pounded crosses in groups and singly. Two primitive carvings of animals. History of the name linked to King Constantine I and King Constantine II. Floor excavated in the early part of this century with the results indicating human use of the cave from the Roman period up to the 17th century, including an iron smelting furnace. Documentary evidence reports the discovery of 18 burials in 'stone coffins' adjacent to the cave.

Natural environment:

Wind erosion, damp interior with lichen and moss growth overlying some carvings.

Human environment:

Used as lavatory, probably by golfers, making visiting the cave unpleasant and having possible detrimental effects. Some modern graffiti.

PREFERRED OPTION:
Intervention Level I

Do Nothing:

This option is not appropriate due to the perceived impacts, the acknowledged historic importance of the site, and the potential for heritage interpretation.

Intervention Level I:

Already a Scheduled Ancient Monument, this site requires urgent attention due to the impact of the inappropriate human use of the cave and the possible biological risk to the inscriptions. Options should also include research into future impacts, possibilities of heritage interpretation (eg incorporating the cave in the scope of the Fife Coastal Walk initiative), and full recording of the inscriptions. Further excavation of the cave may produce additional information but would involve complete destruction of the deposits. Considerable benefits would be derived from considering heritage interpretation options for this site.

Action Plan

Year 1: Baseline survey. Develop management and heritage interpretation plans.

Year 2: Implement plans.

Year 3: Monitor.

Year 4: Review.

ARCHAEOLOGICAL FOCAL STUDY UNIT: TAY FISHING ARCHAEOLOGY

Location:

NGR NO213 184 – NO 492 285
The south shore of the River Tay, the northern edge of Fife Region.

Characteristics:

The archaeological evidence of the recently abandoned Tay salmon fishing industry. Bothies, ice houses, platforms, slipways, boats, and the remains of equipment such as nets and winches. Some of these may date back to the early medieval period and be associated with local religious foundations of Lindores and Balmerino. Potential for existence of submerged archaeological and palaeo-environmental remains.

Natural environment:

The natural features of this area are complex and range from steep shingle beaches, sandstone cliffs and rock platforms to estuarine muds. The river edge is generally stable with localised erosion (including sub-alluvial peat exposures). Thick vegetation growth is helping to stabilise the foreshore. However, uncontrolled plant growth is having a severely detrimental effect on the built heritage.

Human environment:

Some structures are severely degraded. Absence of adequate maintenance. Complex issues of ownership and responsibility. Wash from river traffic may be a significant threat to the stability of the foreshore.

PREFERRED OPTION:
Intervention Level II

Do Nothing:

This option is inappropriate due to the extent and importance of the remains and features, their generally dilapidated condition, and the unrealised potential for benefits from appropriate interpretation.

Intervention Level II:

Many individual structures and features require recording. Some also require stabilisation and management. There is significant potential for heritage interpretation to raise awareness of an important local industry in an area of great natural beauty.

Action Plan

Year 1: Baseline survey of individual features. Develop heritage interpretation plan.

Year 2: Implement plan.

Year 3: Monitor.

Year 4: Review.

ARCHAEOLOGICAL FOCAL STUDY UNIT: TENTSMUIR

Location:

NGR NO 492 285 – NO 478 199
Between the Eden and the Tay estuaries in north-east Fife.

Characteristics:

Large back dune system backed by extensive forest plantation. National Nature Reserve. Coast-edge (World War II defences and fishing-related sites), intertidal and submerged (wrecks) archaeological features. Long period of occupation and maritime use, from Mesolithic sites to the present. Other archaeological sites often without secure context and affected by dynamic geomorphological processes.

Natural environment:

Area of national nature conservation interest. Large area of wind-blown sand; the dune system at Tentsmuir is one of the largest in Scotland. Dynamic geomorphological processes have been recorded as affecting the area since 1812.

Human environment:

Highly significant as amenity area. Complex ownership and responsibilities. Some evidence of human impact (eg damage from mountain bikers and local development). Poor integration of archaeological interests in interpretation strategies.

PREFERRED OPTION:
Intervention Level II

Do Nothing:

This option is inappropriate due to the importance of the natural and archaeological features, the dynamic nature of the environmental and geomorphological processes which affect the area, and the high amenity value of the area.

Intervention Level II:

The complexity of the area means that large-scale, wide-ranging excavation projects would be costly. Coastal defence strategies to mitigate the occasional impacts to individual archaeological sites may be necessary. Baseline surveys of visible remains in vulnerable parts of the areas would provide a database that would inform future initiatives. Effective monitoring of the area required, with adequate contingency plans to ensure that new exposures of archaeological remains are dealt with promptly. Many constituencies, including the general public, have an interest in Tentsmuir. Heritage interpretation strategies, raising awareness and encouraging controlled access, should prove beneficial.

Action Plan
Year 1: Develop local monitoring, management and heritage interpretation plan.
Year 2: Implement plans.
Year 3: Monitor.
Year 4: Review.

ARCHAEOLOGICAL FOCAL STUDY UNIT: KINCARDINE FORESHORE

Location:

NGR NS 928 872, Northern shore of the Inner Forth Estuary, adjacent to Kincardine town.

Characteristics:

Complex of archaeological sites and features. Abandoned hulks, remains of fishing station, redundant river bank revetments and walkways, piers and harbours – situated on the river side of embankment built in the 19th century. Potential for the presence of sub-alluvial deposits.

Natural environment:

Foreshore intertidal muds.

Human environment:

No evidence of vandalism. Possibility of impact due to pollution. Implications of the planned improvements to the Kincardine Bridge.

PREFERRED OPTION:
Intervention Level II

Do Nothing:

This option is inappropriate due to the extent and importance of the remains and features, their generally dilapidated condition, and the unrealised potential for benefits from appropriate interpretation.

Intervention Level II:

Many individual structures and features require further recording. Some also require stabilisation and management. There is significant potential for heritage interpretation to raise awareness of evidence of important local industries situated in an area at risk of development.

Action Plan
Year 1: Assess structures for stabilisation. Develop heritage interpretation plan.
Year 2: Implement plan.
Year 3: Monitor.
Year 4: Review.

ARCHAEOLOGICAL FOCAL STUDY UNIT: HMS Campania

Location:

NGR NT 2395 8368 Lat 56° 2'.43 N Long 03° 13'.33 W
Off Burntisland.

Characteristics:

Built 1893. First Cunard liner not to use sail power. Short period as world's largest and fastest ship. Early 'mother ship' for seaplanes. Broke adrift in a storm in 1918. Sank after collision. Extensive post-wrecking salvage and disturbance. Large spread of wreckage with two distinct concentrations. Assessed as possible Designated Historic Wreck Site but not progressed because of lack of data about current condition.

Natural environment:

Generally soft substrate. 20 –30 m depth

Human environment:

Adjacent to major shipping channels. Some recreational diving occurs in the vicinity but not on this site because of difficult environmental conditions.

PREFERRED OPTION:
Intervention Level II

Do Nothing:

This option is not appropriate given the historical importance of the wreck together with the lack of knowledge about its current condition.

Intervention Level II:

Major programmes of excavation on this site would be prohibitively expensive. Objects and structures recovered in such an initiative may not prove suitable for museum display. Baseline recording is required in order to help identify future impacts and to inform a management plan. Benefit would be derived from integrating the site into local heritage interpretation initiatives (eg the coastal path).

Action Plan

Year 1: Baseline recording. Develop management and heritage interpretation plan.

Year 2: Implement plan.

Year 3: Monitor.

Year 4: Review.

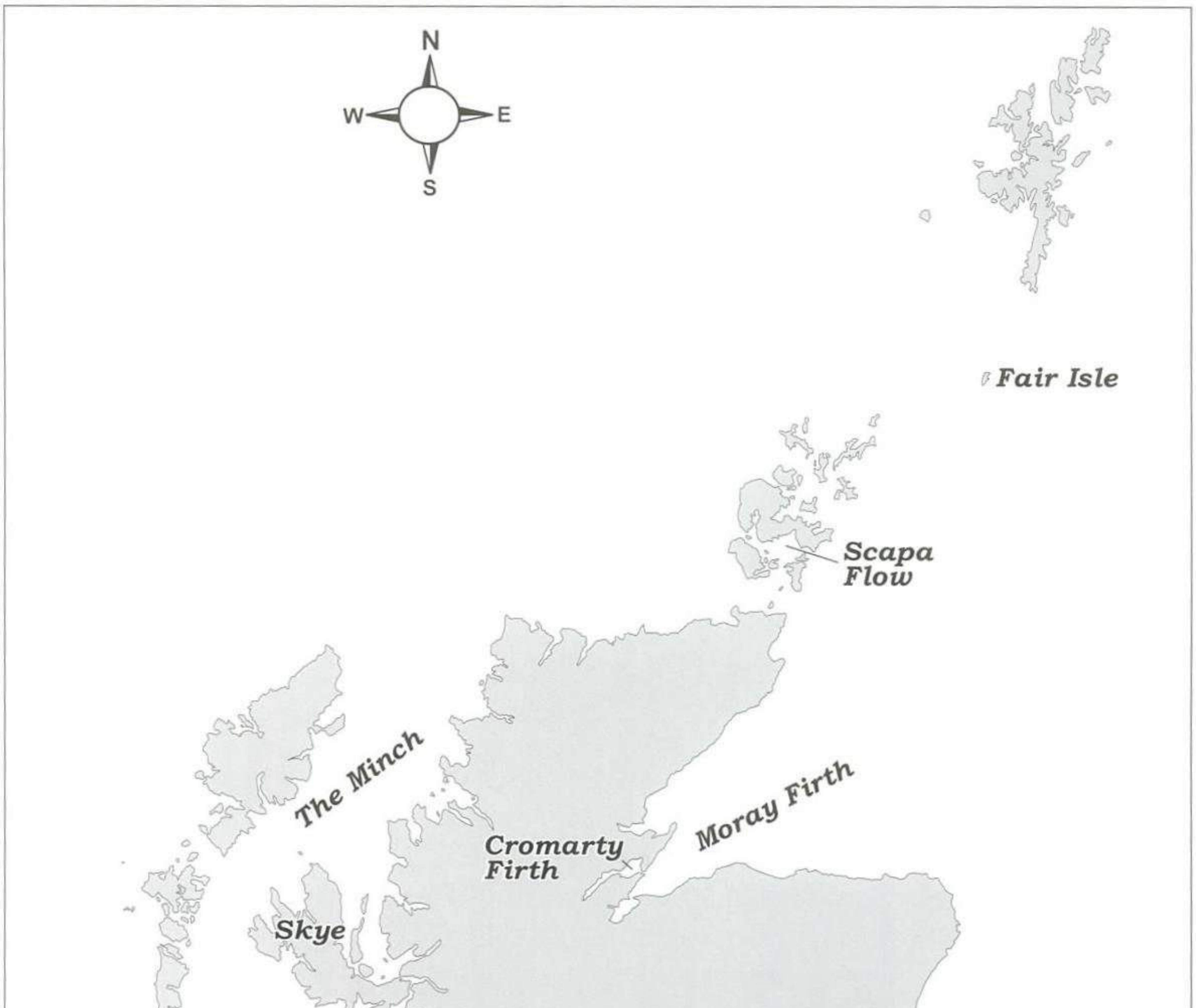

Figure 19.1. Location map showing places mentioned in the text.

(IV) MANAGEMENT AND MONITORING

19 COASTAL ZONE MANAGEMENT IN SCOTLAND FROM THE PERSPECTIVE OF THE FIRTHS INITIATIVE

ALEXANDER J DOWNIE

Introduction

Since 1990, growth in establishing Integrated Coastal Zone Management (ICZM) programmes in the UK has been extremely fast, most taking place in the early part of the decade. All the major firths of Scotland – Moray, Tay, Forth, Solway and Clyde – are covered by coastal management partnerships under the banner of Scottish Natural Heritage's (SNH) Firths Initiative (Figure 19.1). Any future initiatives will expand into more open coastal areas. Work has begun, through the Scottish Coastal Forum (SCF), to tackle the remainder of the coastline. Some of the projects have now produced management strategies and entered the implementation phase, others are just starting. But what has been achieved to date and what are the lessons learned? This paper reviews the work of the Firths Initiative, assesses the role of SNH in the ICZM process and discusses possible future ways forward in extending the voluntary principle to other parts of Scotland. New ICZM partnerships are likely to: cover smaller lengths of coastline, follow the voluntary approach as promoted by current Scottish Executive coastal planning guidance, and look to the SCF for future national guidance relating to the coast and the dissemination of good practice. Finally, it is recognised that in order to be secure and effective, firth projects and other ICZM partnerships must deliver products and services which satisfy the objectives of a wide range of partners.

In 1979, the Nature Conservancy Council (NCC), predecessor of SNH, published a report on marine wildlife conservation (NCC 1979) which recognised that in law there was no area designated as the 'coastal zone'. The report acknowledged that there were a number of impacts, resulting from human activities, on marine ecosystems that fall within the four elements normally considered to be part of the coastal zone:

- sea and seabed below median Low Water Mark
- foreshore between mean Low and High Water Marks
- beach above mean High Water Mark and adjacent land
- estuaries and tidal rivers

A later report commissioned by the Department of the Environment (Lee 1993) found that in terms of the coastal zone there could be no single definition for many stretches of the coast, a feature already supported by others such as Gubbay (1991) who concluded that for practical reasons it was unrealistic and inappropriate to have a standard definition of the coastal zone suitable for all Coastal Zone Management (CZM) programmes.

The law and the effectiveness of administrative frameworks relating to the coastal zone have been found to be very complex (NCC 1979; Bell & McCall 1993; Lee 1993) and that as new uses rapidly develop, new regulatory arrangements were, and to a certain extent still are, developed in a largely *ad hoc* manner. Jurisdictional difficulties have been reported as being experienced by interests operating in the coastal zone and rather haphazard procedures had been developed for consulting interested parties. The NCC (1979) report highlighted the absence of the following:

- an integrated policy of the users of the coastal zone as a whole based upon an overall plan for the entire zone
- a single ministry or public authority with overall or even primary responsibility
- uniform mechanisms whereby claims for new uses could be evaluated or priorities between different uses determined
- certainty as to who has authority in any particular area, in particular a straightforward means of discovering who has ownership or lessee rights

Fourteen years later Bell & McCall (1993) were still highlighting similar problems:

- lack of a strategic approach to the use and management of the Scottish coastal and marine resource
- lack of an environmentally sensitive and sustainable approach to the use and management of the Scottish coastal zone
- discontinuity in planning and management for activities which span the land–sea divide
- the role of the Crown Estate Commissioners
- the large number of organisations involved in the management of marine activities and the lack of integration among them

So the finding by the NCC in the late 1970s that the regulatory legislation tended to deal with the control of individual uses and to apply to different strips of the zone and not necessarily involve a satisfactory balance of competing uses was still being raised as an issue of concern in the early part of the 1990s. But what about now? Ten years further on and some 24 years after that NCC report, what has happened in Scotland to try to help sort out this confusion? Has management of the coastal zone finally come of age?

Contextual Background to Coastal Planning

In the years since 1979, a lot of development work on CZM has been undertaken in the UK. Some of the important milestones include: the Government White Paper *This Common Inheritance* (HMSO 1990), the Environment Committee report on coastal zone protection and planning (House of Commons Environment Committee 1992), the Government White Paper *Scotland and the Union* (HMSO 1993), and government participation at the UN Conference on Environment and Development in Rio de Janeiro in June 1992 – the 'Earth Summit' – at which world leaders agreed an action programme to promote sustainable development: Agenda 21.

In particular, the 1992 House of Commons Environment Committee report included recommendations that:

- a pragmatic approach should be taken to defining the coastal zone at the appropriate national, regional or local level
- a CZM approach should be adopted as the framework for all coastal zone planning and management practices in the UK
- there should be a hierarchy of CZM plans from national to regional and local levels
- CZM plans, despite being non-statutory documents, should have their policies incorporated in relevant Development Plans
- the grant-aid policies of organisations concerned with the coast should be linked to the strategic framework laid out by CZM plans
- the government should consider how best to establish, resource and empower regional CZM groups based on natural coastal 'cells' as the lynchpin of integrated protection and planning of the coastal zone

Subsequently, coastal policy in Scotland has been more clearly defined through a series of papers: *Review of Scottish Coastal Issues* (Scottish Office 1994); *Scotland's Coasts* – A discussion paper (Scottish Office 1996); NPPG 13: *Coastal Planning* (Scottish Office 1997). In addition, the establishment of the SCF in late 1996 provided a national context for the work of local groups, as well as a national focus for coastal issues.

The strategy preparation phase

In 1993, 14 years after NCC's marine wildlife conservation report, SNH established the Focus on Firths (FoF) Project. The FoF Project was developed as a Scotland-wide initiative to promote the integrated management of the natural resources of Scotland's firths, and to help try to address the concerns highlighted for the coast, not only from the NCC's 1979 study but also those raised before and since. These included concerns identified as the result of such projects as the Estuaries Review (Davidson *et al* 1991), various academic reviews of the conservation importance of/threats to the British North Sea (Davidson 1990) and more particularly Scottish estuaries (Raffaelli 1992), and the conservation directions identified under the UK Biodiversity Action Plan (BAP) estuaries habitat statement (DoE 1995).

The FoF Project Plan (Atkins 1994) had two main aims:

- to secure integrated management strategies for the Solway, Forth and Moray Firths and other significant firths by facilitating consensus and cooperation among all users and statutory authorities, having regard to the UK BAP
- to increase appreciation and understanding of the vital importance of the natural heritage significance of Scotland's firths through information collation and dissemination, the production of educational and interpretative materials and promotion of community involvement and local ownership.

The project was designed to cover all the firths of Scotland, but in the first instance it concentrated on the Solway, Forth and Moray. It has since encapsulated further work on the Cromarty, Clyde and Tay. The FoF Project had an initial time-scale set to meet the 1998 BAP estuaries targets deadline. However, following organisational development within SNH and the passing of that deadline, the project was redefined and ICZM work now continues within SNH, principally under the auspices of the Firths Initiative. This redefinition into an Initiative rather than continuation as a Project is also in line with the ideal of seeking to make CZM part of SNH's core work in the wider coastal and marine environment, as defined in the ICZM Policy Guidance Note (SNH in prep). This is also recognition that CZM is a facilitation process by which we can seek to achieve some of SNH's strategic priorities. Promoting sustainable use is one of the three themes highlighted in SNH's corporate strategy (SNH 2000). The corporate strategy further defines a series of priorities under four main headings: land and freshwater use; built development; rural development and tourism; and use of the sea. In particular, SNH priorities for use of the sea are to:

- substantially raise awareness of the diversity and quality of the marine natural heritage of Scotland
- develop effective mechanisms for management of special areas
- secure a precautionary approach in the harvesting of fish and fisheries management which does not damage other features of the natural heritage
- achieve integrated management in key marine areas, so as not to exceed carrying capacity, and to deliver multiple benefits
- encourage uptake of standards and procedures to minimise the environmental consequences of shipping movements and oil and gas extraction in Scottish waters

CZM projects in Scotland

Currently there are six firths management projects in place around Scotland, namely:

- Cromarty Firth Liaison Group (CFLG) – www.morayfirth-partnership.org/CROM3.html
- Moray Firth Partnership (MFP) – www.morayfirth-partnership.org/TOP.html
- Tay Estuary Forum (TEF) – www.dundee.ac.uk/crsem/Tef.htm
- Forth Estuary Forum (FEF) – www.forthestuaryforum.co.uk
- Solway Firth Partnership (SFP) – www.abdn.ac.uk/sfp
- Firth of Clyde Forum (FOCF) – www.clydeforum.org

These projects have all tackled things slightly differently but have followed the lead as described in the House of Commons Environment Committee report (1992). They have taken a pragmatic approach to defining the coastal zone at their appropriate local level to be covered within their management area. However, these are not the only CZM projects that have been, and in most cases still are, in operation. Additional projects have included: the Fair Isle Marine Environment & Tourism Initiative (Riddiford 1998); the Orkney Islands CZM study (Kerr 1999); the Loch Ryan Advisory Management Forum (Dumfries and Galloway Council 1999); the Skye CZM experiment (Highland Council 1997); and the Minch Project (Tyler & McHattie 1999). In total, around half of Scotland's coastline has been covered with a CZM plan of some sort. Yet it would be wrong to assume that the gaps between these projects have no management plans which involve a coastal element. The SCF has undertaken an audit of Scottish coastal plans and areas covered, with the aim of compiling a register of all plans and eventually a database of plans for use in future coastal planning work (SCF 1999).

SNH's practical support for CZM was not the first of its kind in either Scotland or the UK: English Nature's Estuaries Initiative pre-dates the work done in Scotland (English Nature 1992) and in Scotland itself the Orkney Islands Council commissioned a Management Strategy study for Scapa Flow in 1989. In fact, the Orkney study is considered to be one of the first CZM studies in the UK to consider the conflicting demands placed on coastal resources (Kerr 1999): for example, Scapa Flow is obviously well-known for its wrecks, and the strategy looked at these cultural heritage relics as well as considering the natural environment and conservation importance of the area. The wrecks were principally considered from two viewpoints, recreation (sport diving) and archaeology, and recommendations were made to exploit the general tourism potential of both.

Again, even when considering just the Scottish firths, SNH cannot take all the credit; the work of the CFLG was already underway before the launch of the FoF Project in 1993, although it subsequently adopted the FoF concept of working. The CFLG was set up in 1992 to provide a forum for the discussion of issues affecting the quality of the coastal environment of the Cromarty Firth area and to encourage those whose actions affect the coastal environment to be aware of such influences and to adopt best practice in minimising adverse impacts.

So what has the Firths CZM work achieved?

The three priority firths targeted as part of Scotland's input to work under the UK BAP, the Solway, Forth and Moray, had completed management strategies by the end of 1999 (SFP 1998; FEF 1999; MFP 1999). The SFP launched its strategy in July 1998 but was beaten to the title of being the first firth to publish by the CFLG which had already published a Management Strategy and Action Plan in March of the same year (CFLG 1998). Additionally, the Clyde launched its Management Strategy in July 2000 (FoCF 2000) and early developmental work is also underway on the Tay through the work of the TEF.

The firths fora are supported by representatives of all key agencies in the firths in question. It is acknowledged, however, by these fora that SNH funding has been crucial to establish the partnerships and in particular has supported Project Officer posts. This crucial role of SNH was further demonstrated by the response to a questionnaire which formed part of an internal review process undertaken by SNH in 1998. The questionnaire was sent to the Chairs of the Forth, Solway, Clyde, Cromarty and Moray partnerships, asking them to consider a series of issues in relation to their own. In response, they paid tribute to the SNH financial and in-kind support and stressed that a major success was commitment to partnership working.

SNH is now moving from being the main funder of the work in the three main firths in the early years towards becoming a more equal funding partner. Substantial investment by SNH has given individual projects a measure of security and consequently allowed bids for external funding to be sought, using SNH money as guarantees, for example it has been used by the FEF and the MFP as the major source of collateral in successful bids to secure EU LIFE money. Additionally, the FoCF (originally operating as the CEF — Clyde Estuary Forum) also secured LIFE funds for work under the ESTURIALES network mainly through the participation of the former Strathclyde Regional Council. The FEF participated in the EU ICZM Demonstration Programme on the Integrated Management of the Coast; its two-year project came to an end in late 1999. The MFP began a three-year implementation project on ICZM at the end of 1998.

Perhaps most importantly, the secure funding has generally allowed the Project Officers concerned to concentrate on developing strategies rather than on having to seek finance to fund their own posts.

In addition to direct financial input, SNH has also provided substantial in-kind investment, principally in terms of staff time. More generally, other partners have supported individual projects or sponsored publications. SNH has also financed GIS development work, the establishment of the Sea Chests (an educational resource), and the geomorphology and landscape assessment research projects.

Participation by the FEF in the EC ICZM Demonstration Programme

The FEF was the first of the firths projects to get underway in 1993. The management area covered by the FEF has long been recognised as a valuable national and international resource with a diverse range of habitats and wildlife, but it is also home to 25 per cent of Scotland's human population. From the tidal water limit at Stirling to the Isle of May at its North Sea entrance, the Forth is 96 km long, has a coastline of 273 km and covers an area of some 1670 km2.

The Forum participated in the EC's Demonstration Programme ICZM as one of the 35 demonstration projects. Four aims were identified to the EC:

- assessment of the effectiveness of a non-statutory voluntary partnership approach
- increased cooperation between all interests concerned
- improvement of environmental protection
- preparation of an integrated management strategy for the Estuary and Firth of Forth

However, it should be noted that the SCF, in its response to the EC's consultation on the proposal for an European ICZM strategy, highlighted the fact that the Forth as the sole demonstration project in Scotland did not represent all the issues and problems being experienced on the Scottish coast. The SCF, therefore, considered that due weight should be given to responses from individual Scottish fora.

Some examples of work undertaken by the FEF over the period of the programme include:

- Conflict resolution and issues tackled – the FEF was involved in discussions relating to building a new Forth Road Bridge and a new bridge at Kincardine; consulted over *NPPG13*; and consulted over a proposal to extract marine aggregate from the Middle Bank area in the Forth.
- Natural heritage benefits and wider environmental improvements – all firths partnerships have been working to raise awareness of the importance of the local environment and its need for sustainable management. In particular, the FEF had input to the proposed designation of the Forth as a Special Protection Area (SPA) under the Birds Directive, to discussions on the preparation of an updated Oil Spill Management Plan, and to research into areas within the Forth where managed retreat might be feasible to tackle perceived sea level rise.
- Influence on the planning process – the FEF influenced the Local Authority planning process through recognition of the Forum and its aims within Local Plans. It is acknowledged as having increased awareness, improved relations between partners, and instigated changes in some management practices, as well as developing joint working procedures. The economic development topic group commissioned an appraisal which resulted in the publication of *An Economic Appraisal of the Forth Estuary and the Firth of Forth* (Firn Crichton Roberts 1998). This included a study of the planning and development framework, the development potential and priorities, and the production of a framework economic development strategy for the Forum.

Although the FEF began the process of developing a management strategy in 1994, it was during the EC Demonstration Programme project that it launched its integrated management strategy in 1999 (FEF 1999). This aims to improve the way the Forth is managed by:

- promoting integrated management by encouraging bodies to work together and to consider new management of the Forth as a whole

- promoting a new approach to management that will bring users and regulators together to discuss and resolve issues at a local level

Since publication of its management strategy, the FEF has continued work on a number of areas, including sustainable economic development, flood risk and managed retreat, the Forth Estuary Modelling System (FEMS) and the Forth SPA and its implications.

The work on flood risk and managed retreat in particular, which included research commissioned on behalf of the FEF by SNH, stems from the issue of predicted sea level rise, highlighted by the FEF in its management strategy. Results indicate that in the last 150 years, 33 per cent of intertidal land in the Forth Estuary has been lost and some 43 per cent of the coastline of the Firth of Forth is defended against attack from the sea. Additionally, a limited number of potential sites for coastal managed realignment were identified in the Upper Estuary. A recent article in *Forth Sight* (FEF 2000), the magazine of the FEF, has highlighted that predictions of rising sea levels and greater storminess are fuelling fears about the possible loss of beach/dune systems in general and are generating demands for increased or improved coastal protection. Current guidance prepared for SNH (HR Wallingford 2000) indicates that in some situations, when considering coastal defence, it can be more viable both from an environmental and economic perspective to relocate threatened assets further inland. However, it should, of course, be remembered that some things, such as archaeological sites, cannot be relocated, and further it is almost impossible to put a monetary value on them. The question of economics has been shown to be a very important feature of the coastal erosion/coastal defence issue. The EC's Demonstration Programme report (European Commission 1999a) stresses that economics are at the heart of the coastal erosion issue and that damage from erosion is costly, but so also is its prevention, whether through removal of the causes or through defence.

The implementation phase

It can now be said that the implementation phase proper has started on those Scottish firths with published management strategies. Already conflict resolution has taken place over some issues, and some natural heritage benefits are being delivered. The following are some illustrative examples in addition to those already supplied for the Forth.

Conflict resolution and issues being tackled:

- SFP has had input to cockle fishery issues on the Solway.
- MFP has been involved in landscape assessment work and consulted on bird disturbance.

Natural heritage benefits and wider environmental improvements:

All partnerships have been working to raise awareness of the importance of the local environment and the necessity for sustainable management.

- SFP has had input to: Wigton Bay Local Nature Reserve; goose management scheme; merse management scheme; and the European Marine Site (under the UK Marine Special Areas of Conservation LIFE Project).
- MFP has been involved in development of the Dolphin Space Programme and discussions on the European Marine Sites proposed within the area of the partnership.

Firths Strategies influence on the planning process:

- The SFP Steering Group includes key individuals within the planning process of all the local authorities and so has direct links with the planning process. The SFP is acknowledged in the Dumfries & Galloway Structure Plan.
- MFP is referenced in the current Moray structure and local plans. It has raised awareness of links between MFP work and local authorities through a planners' workshop.

Since 1993 further examples of key achievements from the Firths work has been reported on a regular basis within SNH Annual Reports and in various external papers, eg Atkins (1996; 1999). The various projects have produced some novel and diverse products covering a range of areas and media. The FoCF has participated in the ESTURIALES LIFE Project: Cybestuaries through the now defunct Strathclyde Regional Council, a partner of the original CEF. This project helped develop a package comprising a multimedia CD-ROM and a support manual for those interested in promoting the sustainable management of European estuaries (Cybestuaries 1998). Various educational packages have also been produced, such as the MFP's slide pack or SNH's Sea Chests. More local progress has also been reported in the newsletters of the various fora (*Tidelines, Cromarty Firth Currents, Moray Firth Matters, Forth Sight*) and now the SCF (*Coastline Scotland*). Further information is also available from the web-sites of these various groups.

International perspective

Scotland has not been working on CZM in isolation; as mentioned earlier, the EC has been running a Demonstration Programme since 1996 and in April 1999 issued two documents prepared by the thematic experts of the Programme. The first report presented the lessons learned (European Commission 1999a); the second was a consultation document concerning the principles and conditions that need to be met to ensure a European ICZM strategy (European Commission 1999b). Of the 171 responses received by the EC, 43 were from the UK and 11 of those were from Scotland. Almost all respondents were in favour of a European strategy for ICZM, although views differed as to the type of policy instrument to be used to support it: some favoured a Directive, others did not. The EC has now published a proposed strategy on ICZM (European Commission 2000a), including a draft Recommendation to Member States offering guidance on how ICZM should be advanced at Member State level (European Commission 2000b).

Conclusions

The core aims and objectives of the Firths work are being achieved with the successful publication of management strategies for the Cromarty, Solway, Forth, Moray and Clyde Firths. The Firths work has demonstrated that CZM partnerships can function effectively to produce genuinely integrated management strategies and has started to resolve difficult issues which could cause significant conflict. Public awareness, understanding, and ownership of coastal natural heritage issues has been raised through publication of a wide range of materials, and through meetings and community involvement events. The work to date has also had an important influence on internal SNH policies and programmes and external policies at Scottish, UK and EU level.

Atkins (1999) suggested a range of products which the Firths Initiative work could deliver for partners during implementation, ranging from contributions to Agenda 21 and Biodiversity Action Plan objectives to supporting the management of designated sites such as those under Natura 2000. He highlighted the fact that in order to be secure and effective, firth projects must deliver products and services which satisfy the objectives of a wide range of partners. More recently, a role has been suggested under the implementation of the EC Water Framework Directive (WFD) in Scotland through involvement in the proposed catchment management planning system that is likely to be introduced (Council of the European Communities 2000). The Scottish Executive has trialed a WFD implementation project by commissioning research to establish a shadow River Basin Management Committee to cover a proposed west of Scotland River Basin District. This work in turn provided text and information for a proposed shadow River Basin Management Plan (RBMP) to address pressures upon groundwaters, wetlands, rivers, lochs, estuaries and coastal waters (Babtie Group 2002a). Part of the work was an assessment of how the RBMP process would interact with existing planning mechanisms and whether improvements could be achieved by following a different approach or by introducing legislation or national guidance (Babtie Group 2002b). This project encompassed an area covered by two firths projects (Clyde and Solway) and two additional projects in Loch Ryan and Loch Fyne.

ICZM is now promoted by the Scottish Executive as an important approach to complex issues of coastal management, eg *NPPG 13* (Scottish Office 1997) and the establishment of the SCF. Additionally, Local Authority participation in integrated coastal management is now a fact of life within Scotland where additional projects such as the Minch Project have tackled large areas of coast and included the relevant Local Authorities within the area of the project. Although the Minch Project ended in June 1999, elements of a draft business plan developed by the Minch Forum have been taken forward by some partners. Other CZM projects/experiments have been driven much more by Local Authorities taking the lead and have tackled more localised areas such as: the work by Highland Council on the Isle of Skye where a proposed zoning system was developed; Dumfries and Galloway Council's lead in Loch Ryan; and the work commissioned at Scapa Flow by Orkney Islands Council. However, Local Authorities are not the only drivers; the Fair Isle Initiative is an example of a community-led proposal for the sustainable development/use of the marine resource of Fair Isle.

Currently, there is strong commitment from partners to continuing firths projects into implementation of the management strategies. Although many valuable products and outcomes have already been generated, the real return on investment in coastal management planning will be obtained when management strategies are implemented. However, the question of future resourcing remains to be addressed not only within the Firths Initiative projects but more widely across the other Scottish and UK projects. The recent change in the membership fees structure of the FEF, which involved a significant increase, is being watched closely by the other fora.

In future, SNH will seek to ensure that support and involvement in any ICZM project will be linked to the adoption of protection of the natural heritage as a central management objective (SNH in prep), through caring for the natural world, enriching people's lives, and promoting sustainable use. The aim will be to achieve integrated management in marine areas, so as not to exceed carrying capacity, and to deliver multiple benefits. The work of CZM planning has largely covered the major Scottish firths and it is now up to the SCF to take the lead in providing advice and guidance to develop projects in other parts of Scotland. The SCF has already begun this by forming a steering/project group to investigate the possibility of producing a Scottish coastal strategy (Downie 2000). In turn, such a national coastal strategy should provide the link between local strategies and EC recommendations.

Earlier, I asked the question, 'Has management of the coastal zone finally come of age?' My answer would have to be yes. The EC's Demonstration Programme has produced a simple and pragmatic definition of the coastal zone: a strip of land and sea of varying width depending on the nature of the environment and management needs. But, more importantly, the production of the Communication (European Commission 2000a) has highlighted the need for integrated management of planning in the coastal zone at a European level and has proposed a strategy for Europe. The accompanying non-binding Recommendation (European Commission 2000b) invites Member States to:

- adopt a common vision for the future of coastal zones, based on eight principles
- undertake a national stocktaking exercise to identify which actors, laws, and institutions influence the planning and management of their coastal zones
- develop a national strategy to implement the principles for ICZM
- cooperate with neighbouring countries and work actively with EU institutions and other coastal stakeholders
- report back to the EC on their experiences in implementing this Recommendation

Finally, McGlashan (2000) suggested that we are only at the third stage of O'Riordan & Vellinga's (1993, cited in McGlashan 2000) four-stage evolution of coastal management. That is, we have sustainable development, comprehensive environmental management and habitat restoration, and emphasis on participation, but we have yet to reach the fourth stage which concerns the future and which focuses on shared governance, the precautionary principle, and ecological empathy. However, I would suggest that we have now reached a situation from which we could move on to that fourth stage.

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20 COASTAL ARCHAEOLOGY IN THE CONTEXT OF THE FIFE SHORELINE MANAGEMENT PLAN

NOEL BEECH AND PETER THORNTON

Introduction

'Coastal defence' is the general name given to two kinds of measures that serve to protect people, property and other assets from the action of the sea. These measures are 'coast protection' – protection against the action of land erosion; and 'flood defence' – protection to avoid inundation of the land. Inundation, or the risk of it, prevails when the land level is below sea level.

The earliest human influences by man on Britain's beaches occurred long before the Victorian era. However, it has been mainly since that time that shoreline management, whether deliberate or inadvertent, has taken place. Coastal defence schemes, often in response to uncontrolled developments close to the shore, continued to be installed throughout the first half of the 20th century. A key event in the progression of coastal defence in Britain was the 1953 North Sea surge event which, sadly, resulted in the loss of over 300 lives in Britain (many more on the Continent). Following this disastrous event, public awareness of the effects of flooding increased dramatically. This led rapidly to local authorities, and those empowered to carry out coast defence works, implementing schemes to avoid inundation. However, given the understandable urgency to provide protection, the works thus carried out probably hindered progress towards a more strategic and economic approach. A fuller description of the history of coastal defence in Britain is given in the *Beach Management Manual* (Simm *et al* 1996).

Increasingly from the 1980s, there was a growing recognition of the need to plan coastal defences more strategically, to take proper account of the natural physical processes, to cater for the broad range of issues concerning their construction, and to promote sustainability. The strategic process and the associated document became known as a Shoreline Management Plan (SMP).

A coastal cell is a length of coast that is relatively self-contained in terms of the movement of sand or shingle in the nearshore zone; thus, these cells form logical natural boundaries within which to contain one or (more usually) several SMPs.

In June 1995, the Ministry of Agriculture, Fisheries and Food (MAFF) published guidance notes on the preparation of SMPs. These notes defined the geographical boundaries for coastal cells around the coast of England and Wales. Scottish Natural Heritage, the Scottish Office of Agriculture, the Environment and Fisheries Department and Historic Scotland extended the earlier work (see Figure 3.2). This resulted in the definition of a further 11 coastal cells around the coastline of mainland Scotland, the Orkney and Shetland Islands and the Western Isles (HR Wallingford 1997).

What is a Shoreline Management Plan?

A Shoreline Management Plan (SMP) is a document that sets out a strategy for coastal defence for a specified length of coast. The strategy takes into account the natural coastal processes, human influences, land use and other environmental matters. SMPs have generally been prepared on behalf of the authorities responsible for coastal defence, it being understood that a given plan may cross administrative boundaries and therefore would need to advise several authorities including councils and the flood defence authority (eg the Environment Agency in England and Wales). The same councils will be empowered to undertake and/or sanction works for flood defence and control of coastal erosion.

SMPs have been prepared for almost the entire coastline of England and Wales. The Fife SMP was one of the first of such undertakings in Scotland (see Figure 18.1 for map). The primary functions of the Fife SMP were twofold:

- to provide the basis for sustainable coastal defence policies for the coastline between Kincardine and Newburgh
- to set objectives for the future management of the coastline

The aims of the completed Fife SMP were:

- to assess the options, and to agree a preferred approach to coastal defence
- to define future requirements for monitoring defences, management of data, and research related to the shoreline
- to identify opportunities for maintaining and enhancing the natural coastal environment, taking account of any specific targets set locally or by legislation

- to set out a framework for continued consultation with interested parties

For these objectives to be achieved, the SMP had to address the following issues:

- coastal processes
- coastal defences
- natural environment
- land use
- human and built environment

The Context of Archaeology

Archaeology constitutes a valuable, if not invaluable, part of our built environment. Whereas modern development can be copied or rebuilt elsewhere (at a price), the same is rarely true for sites and monuments of historic origin. In particular, the coastline accommodates a diverse archaeological resource that is vital for an understanding of Britain's heritage and relationship with the sea.

Of course, coastal defence works, such as might be derived from an SMP, can have significant influences on shoreline features. These influences might be direct (eg as a result of the construction obscuring the feature), or indirect (eg as a result of changes to the sediment drift or supply). Indirect influences are often more serious because they can be far reaching, both geographically and chronologically. This means that works constructed at a given site could have remote influences by way of accretion or erosion. All this points to the importance of correctly planning defences at the conceptual level implicit in an SMP.

It is crucially important, therefore, to take account of coastal archaeology in the process of evaluating alternative coastal defence strategies for an SMP. The SMP is probably the only planning vehicle in which the impact of coastal defence on archaeology, and a wide range of other coastal attributes, can be considered in a true spatial and temporal context.

Archaeology of the Fife Coast

It is not the purpose of this paper to describe the archaeology of the Fife coast. This is documented elsewhere, including in the Shoreline Management Plan of Fife (Posford Duvivier 1998). The coastline is rich in archaeology, which is very relevant to coastal defence issues; therefore it is useful to be reminded of some of the important archaeological features. The following overview of the archaeology of the Fife coastal zone is taken from the SMP:

'Fife's coastal zone has a unique cultural heritage, ranging from the camps of the earliest Mesolithic inhabitants of around 9000 years ago, to the modern naval facilities at Rosyth. This heritage is made up of thousands of archaeological sites and historic buildings and forms an irreplaceable resource of national importance.

Figure 20.1. Photograph of Crail harbour, typical of the East Neuk villages.

The breadth and depth of the archaeological and cultural heritage of Fife is signified by a wide range of sites from single finds such as the Neolithic flint macehead near Newburgh, to the religious and secular buildings of Medieval St Andrews.

Fife's maritime heritage is characterised by harbours (Figure 20.1), ports and fishing villages all along the coast.

The northern coastline is characterised by fishing lodges and towns arising from the salmon fishery within the River Tay.

Very few early settlements have as yet been identified but this may be because modern settlements overlay them. However, standing structures such as Early Medieval churches and chapels provide some of the earliest indication of settlement in many of the coastal towns; some date back as far as the 10th century, such as Longannet Point church. Medieval castles sometimes provide further indication of a concentration of settlement, many located in what became modern settlements such as Rosyth Castle, Ravenscraig Castle (Figure 20.2), Crail Castle, and St Andrews Castle.

Figure 20.2. Ravenscraig Castle, Kirkcaldy.

Pillboxes and other coastal fortifications are evident adjacent to Crail airfield and Tentsmuir Sands (Figure 20.3) and form the most recent layer in a coastal heritage stretching back over thousands of years.

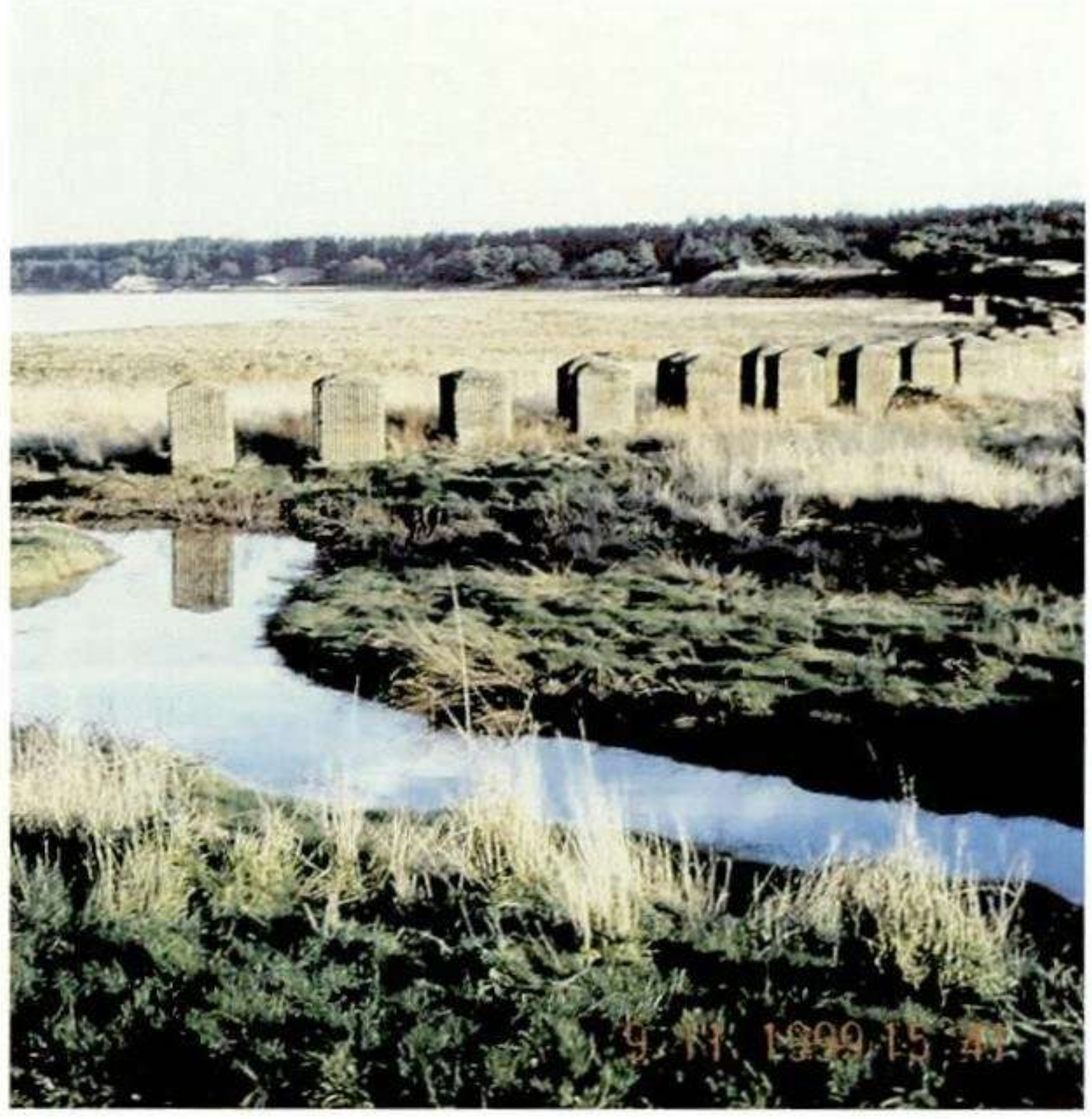

Figure 20.3. Tanktraps at Tentsmuir.

Some archaeological sites are protected, whilst many buildings in coastal settlements have been statutorily 'listed'; other sites have been designated as being of regional importance (Archaeological Sites of Regional Importance). It is, however, the full spectrum of sites, settlements and landscapes – both designated and undesignated – which gives the Fife coastal zone its unique character and significance'.

Examples

This section outlines the findings of the SMP for two sections of the Fife coast in which archaeology was a significant determinant in the decision-making process.

Wemyss

This section of coast extends between the villages of West Wemyss and East Wemyss. Prime quality agricultural land and woodland separate the two settlements. There is a small harbour at West Wemyss and a sewage outfall at East Wemyss. The many important archaeological sites include a number of prehistoric cave sites to the north of East Wemyss. These contain evidence of early settlements and include a wealth of Pictish rock art. There are nine Scheduled Ancient Monuments (including the East Wemyss caves, West Wemyss Tollbooth, MacDuff's Castle and Dovecote) and a further eight Archaeological Sites and Areas of Regional Importance.

The recommended strategic option at this site was to 'selectively hold the defence line'. This would involve the continuing maintenance of the existing man-made defences and the strengthening of other lengths of defence. Although this option could lead to the loss of some of the areas of prime agricultural land, it would, however, offer protection to the built frontages in the area and the sites of archaeological importance. The caves were considered to be suitably important in that they added weight alongside other assets to the decision to selectively hold the line, even though intervention could potentially affect the shoreline habitats and exposed geology.

Dalgety Bay

This section of coast extends from Hopeward Point to Dalgety Bay. The area includes the entire frontage of the town of Dalgety Bay, which has been subject to significant expansion following industrial and residential development and includes a small sailing club. The area is important archaeologically: there are two Scheduled Ancient Monuments – the 12th century St Bridget's Kirk (which lies close to the coast), and Aberdour Lodge Standing Stone (inland). There are two further Archaeological Sites and Areas of Regional Importance.

The recommended strategic option at this site was to 'do nothing'; ie to withdraw from maintenance and reinstatement of any coastal defence. In this case the assets at risk were such that continued defence would be uneconomic; this was because the costs of providing defence exceeded the benefits that would be derived from it (ie the monetary value of the speculated losses due to land loss). However, the indications are that the actual risk to properties in the hinterland would be very low. The adoption of this option could eventually lead to some loss of the archaeological features. This decision highlights, to some extent, the difficulty in weighing up all factors strategically. Although both recreational and archaeological assets would be at risk in the future, the economic benefits were insufficient to warrant intervention.

Conclusions

As with all other valued assets, the loss or preservation of an archaeological resource from flooding or coastal erosion must be balanced against the cost of providing defence to preserve that asset – and, indeed, all the other factors affecting the decision to defend or not defend (eg sustainability). Whilst it might seem attractive, from certain viewpoints, to extend blanket protection to all such assets (eg archaeology), in practice this is not going to be the case, as evidenced by the example of Dalgety Bay, above. What is important is that archaeology is now recognised in the coastal defence equation and can influence the decision-making process. In this respect, there is useful work to be done in the future to extend our means of evaluating this important asset in quantitative terms, and thus enable its value to be gauged alongside conventional defence benefits.

During preparation of the Fife SMP, the economic valuation of archaeological sites was considered in order to assist the defence option decision-making process. However, the methodologies currently available were not considered appropriate, were proving contentious in peer debate, and were therefore discarded. Although designations provide a form of valuation, it is concluded that until alternative forms of valuation methodology are introduced or peer acceptance becomes more widespread, archaeology is best represented by linking sites to other assets; generally, recreational assets are more suited to this, eg footpaths and car parks that may be there to access the site. Furthermore, recreational assets are more easily valued, and such values are considered more acceptable to mainstream decision-makers; an example of this would be the revenue generated from car parking.

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(V) DISCUSSION

21 SHOREWATCH: MONITORING SCOTLAND'S COASTAL ARCHAEOLOGY

SHANNON M FRASER WITH SIMON GILMOUR AND TOM DAWSON

Monitoring the Coastal Resource: the Concept of Stewardship and the Role of Volunteers

The Scottish Coastal Zone Assessment Surveys of Fife, the Isle of Lewis, the Solway Firth and the Ullapool coastline, undertaken in the 1990s and described elsewhere in this volume, illustrated the potential for the recognition of a very large number of archaeological sites at the coastal margin. The significant number of sites identified during the surveys as being under threat from coastal erosion or accretion demonstrated the desirability of monitoring sample stretches of coastline over a period of time, in order to begin to quantify the coastal archaeological resource with more precision. At the same time, the refinement of our understanding of the progress of various types of coastal erosion, achieved by such a monitoring exercise, would inform our research and management strategies with regard to the coastal historic environment.

The idea of establishing a framework for local volunteer monitoring of the coastal archaeological resource in areas covered by the rapid assessment surveys was developed in the late 1990s as one means of addressing the issues arising from the survey programme. Historic Scotland initiated the concept of a pilot monitoring scheme and approached the Council for Scottish Archaeology (CSA) - an independent, national voluntary-sector body - to implement the project.

Given the sheer scale of the Scottish coastline, and the consequent potential for archaeological conservation management in such an active environment to consume considerable financial resources, we should be thinking in terms of raising awareness and understanding of the issues among Scotland's communities to enable us to address some of the problems posed by coastal erosion in a meaningful way, over the long term. The concept of stewardship of the environment in its broadest sense is important in this regard, as it can motivate people to take an active interest in the care of their natural and cultural heritage. In the shorter term, this might result in a fruitful partnership between archaeological professionals and locally-based volunteers which would broaden the extent and achievements of archaeological research in the coastal context. In the longer term, increased local understanding and appreciation of, and involvement with, Scotland's coastal archaeological heritage has the potential to generate a key voice in support of endeavours to press for greater investment in its conservation and management.

CSA's involvement in this initiative, entitled *Shorewatch: monitoring Scotland's coastal archaeology*, stemmed from its long-held remit to foster enhanced understanding of the importance of the nation's cultural heritage, and to facilitate participation in archaeology at a local level. CSA's role was initially to undertake a feasibility study for *Shorewatch* (Phase I, 1997–8), followed by pilot initiatives (Phases II–III, 1999–2001), all grant-aided by Historic Scotland. It has examined the viability of the involvement in such a project of local individuals and organisations, including, for example, local history and archaeological societies, amateur archaeological groups, schools and branches of the Young Archaeologists' Club (YAC) Scottish Network for 8–16-year-olds.

The *Shorewatch* Initiative: Concepts and Framework

The overall aim of the *Shorewatch* initiative is to encompass a flow of *ambition*, through *endeavour* to *reward*. *Shorewatch* aims to draw upon the strong interest in local history held by many individuals and groups and their desire to become actively involved in finding out about it; to guide that enthusiasm and capitalise on the skills many of these people already have; and ultimately to give people a sense of having participated in something worthwhile and rewarding, allowing recognition of their contribution to the body of archaeological knowledge.

For the purposes of the Phase I feasibility study, the core geographical area for potential coverage in the *Shorewatch* initiative was delimited as being from 50 m above High Water Mark to below Low Water Mark (LWM), being the zone recommended for survey within the Coastal Zone Assessment Surveys. As monitoring of sites below LWM is of considerable complexity, particularly in terms of access and health and safety, it was decided to eliminate detailed consideration of such projects from the initial study. The issue of sub-LWM monitoring is currently being explored.

Each project carried out by an individual or group taking part in the *Shorewatch* initiative is based on a framework of four distinct stages.

Stage 1: Identifying a possible site or sites along a stretch of coastline

Sites can be chosen by the participating group or individual by contacting the relevant Local Authority archaeological service for advice, consulting the local Sites and Monuments Record (SMR), and/or by accessing the National Monuments Record of Scotland (NMRS) in order to identify sites located by the Coastal Zone Assessment Surveys. This research stage of the project may also turn up survey data and information on the history of the sites, from which the *Shorewatch* project may be taken forward. In practice, many groups already have local knowledge of sites and stretches of coastline which would be relevant to a *Shorewatch* project.

Stage 2: Initial site survey to establish a monitoring baseline

The initial site visit – the foundation of the monitoring project – aims to record the condition of the chosen site or sites and any areas within them that may be under threat from coastal or other erosion.

Stage 3: Monitoring specific sites for signs of coastal erosion or accretion

Once initial recording has taken place along the selected stretch of coastline, monitoring methods are discussed within the group to determine the most suitable method for the chosen site or sites and for the group's aims. The monitoring projects may take the form of active or passive survey. Active monitoring may involve, for example, the insertion of erosion posts to be checked consistently at intervals, or tape measurement and resurvey of specific areas of the site. Passive monitoring techniques entail photographic or sketch surveys to record any changes; these can also be compared with previous graphic evidence which may be lodged in SMRs.

Stage 4: Data dissemination

Once data have been collected through the monitoring process, there are a number of complementary mechanisms for their dissemination which can address various constituencies. The exploration of appropriate standards for monitoring data and means of making them available to a variety of interested parties was addressed in Phases I and III of the *Shorewatch* pilot study. With regard to the archaeological community:

i. data may be deposited in the local SMR, thereby incorporating progress reports on coastal archaeological retreat and beginning the process of quantifying the threat. Where no SMR is in place, a local museum or archaeological society may be the appropriate local repository;

ii. data may be lodged with the NMRS, both in hard copy and in electronic form to allow remote access;

iii. brief notices of discoveries should be published in CSA's journal, *Discovery and Excavation in Scotland*, which provides summary reports of all archaeological fieldwork carried out in Scotland each year.

The Phase I feasibility study highlighted the importance of a 'final product' for project participants which would allow them to appreciate their contribution in a wider context. Each project should therefore have an achievable goal. This may be realised by various means of disseminating monitoring data to a broader audience. For example:

iv. reports of the activities of various *Shorewatch* groups around the country may be advertised in more general publications such as *Scottish Archaeological News*. Published by CSA three times a year, this membership newsletter reaches a wide and varied readership, comprising not only members of the archaeological community but also the interested public. Such a strategy can also serve to inform different participating groups of their colleagues' activities in other parts of the country, enabling them to make contact with each other;

v. a participating group might produce a simple leaflet explaining the need to monitor coastal archaeology, describing the aims of a specific project and setting out its results. Such a leaflet could be placed in local museums and libraries to inform the local community, perhaps attracting further participants;

vi. a dedicated *Shorewatch* web-site would allow the various participants to see what is happening in other parts of Scotland and to advertise their activities to a world audience. It would also promote communication among different groups.

The Phase I Feasibility Study: Key Issues and Initial Responses to the Shorewatch Initiative

Initial responses to the concept of a *Shorewatch* initiative were very positive. Consultation with Local Authorities and their archaeological services indicated a general willingness to support such a scheme, while discussion with the Royal Commission on the Ancient and Historical Monuments of Scotland resulted in the formulation of a recording form for monitoring projects compatible with the requirements of the NMRS.

Figure 21.1. Members of the Shetland branch of the Young Archaeologists' Club survey the eroding remains of a broch on the island of Bressay.

Figure 21.2. Members of the University of St Andrews Student Archaeology Society recording erosion at the St Monans saltpans, Fife.

CSA contacted a number of target groups to ascertain whether they would be interested in participating in a coastal initiative. The response from YAC Scottish Network branches was particularly encouraging. Local history and archaeological societies were enthusiastic, but noted that a common dearth of younger members constrained their ability to undertake fieldwork. However, their participation could usefully comprise the initial research stage of a project. Indeed, some of the interested YAC branches felt they would benefit more if they participated in a *Shorewatch* project in collaboration with a local society.

Most groups consulted expressed the need for professional advice and guidance in the unfamiliar coastal context, while discussions with project leaders of previous volunteer schemes stressed the importance of maintaining a local focus. A priority would therefore be to identify local or regional volunteer coordinators with archaeological expertise.

As with all activities or projects based on fieldwork in the coastal environment, the health and safety of individuals taking part is of primary importance. The Phase I feasibility study recommended that the safety precautions promoted by the Coastguard should be used as general guidelines. However, it further recommended specific safety measures to be undertaken. Guidelines for risk assessments for shoreline environments and activities were prepared, designed to help participants ensure that potential threats to individuals involved are recognised, that the level of danger is estimated, and that, if it is decided that fieldwork is viable, plans are made to reduce the potential risks as far as possible.

Participation in coastal activities also has insurance implications, related primarily to the affiliation and composition of volunteer groups. Considerations include age range, ratio of adults to children and experience of participants. All groups involved in any project taking place under the *Shorewatch* banner require appropriate insurance cover and participants must sign indemnity forms.

The Phase II Pilot Initiative

Facilitated by a central *Shorewatch* coordinator, the Phase II pilot involved the participation of the Isle of Lewis YAC Branch in collaboration with a local amateur archaeological group, and the Fife YAC Branch. This permitted an assessment of variations of geography, coastal environment and local community response. Both projects contributed to our knowledge of the state of the archaeological resource. Considerable levels of erosion were noted at the chosen site in Lewis, while the selected coastline in Fife provided information on several new features and recovered a number of artefacts from an area already intensively studied by professional archaeologists. These *Shorewatch* projects also provided the basis for other activities on the coast that both educated and entertained.

A key issue which emerged from the Phase II study was that coastal stretches undergoing less active erosion, as in the Fife project, may be less capable of sustaining long-term volunteer interest as little change is observed from one monitoring visit to the next. Where young people are involved, the provision of auxiliary activities for education and recreation assumes particular importance in this more static context, as they have the potential to add variety and interest to the more routine processes of data collection.

The Phase III Pilot Initiative

The restricted time-scale of the Phase II study meant subsequent visits to the sites after the winter – when erosion is likely to peak – were not possible. Run over the course of a year from March 2000, *Shorewatch* Pilot Phase III expanded the project both geographically and in duration, allowing people from all over Scotland to monitor sites over a complete seasonal cycle. A broad spectrum of groups and individuals took part in this pilot, including the YAC Branch in Shetland (Figure 21.1), the University of St Andrews Student Archaeology Society (Figure 21.2), the Edinburgh Archaeological Field Society, and individuals in Dumfries and Galloway under the guidance of Mr Ronan Toolis. Further work continued in the Outer Hebrides under the supervision of Mrs Carol Knott, including the activities of the Lewis YAC Branch and some of the cast of the television programme *Castaway 2000* on the island of Taransay.

Both of these group coordinators are professional archaeologists working in a voluntary capacity; it is hoped that their recognition as potential regional *Shorewatch* coordinators will be mirrored in other areas, particularly the more remote north and west. This was one aspect that the Phase III initiative was particularly keen to promote, as it is a strong mechanism for implementing strategies identified as important in the Phase I feasibility study, including the maintenance of a local focus and the desire of non-specialist groups for professional guidance. These are likely to be achieved more effectively at the level of regional rather than national coordination.

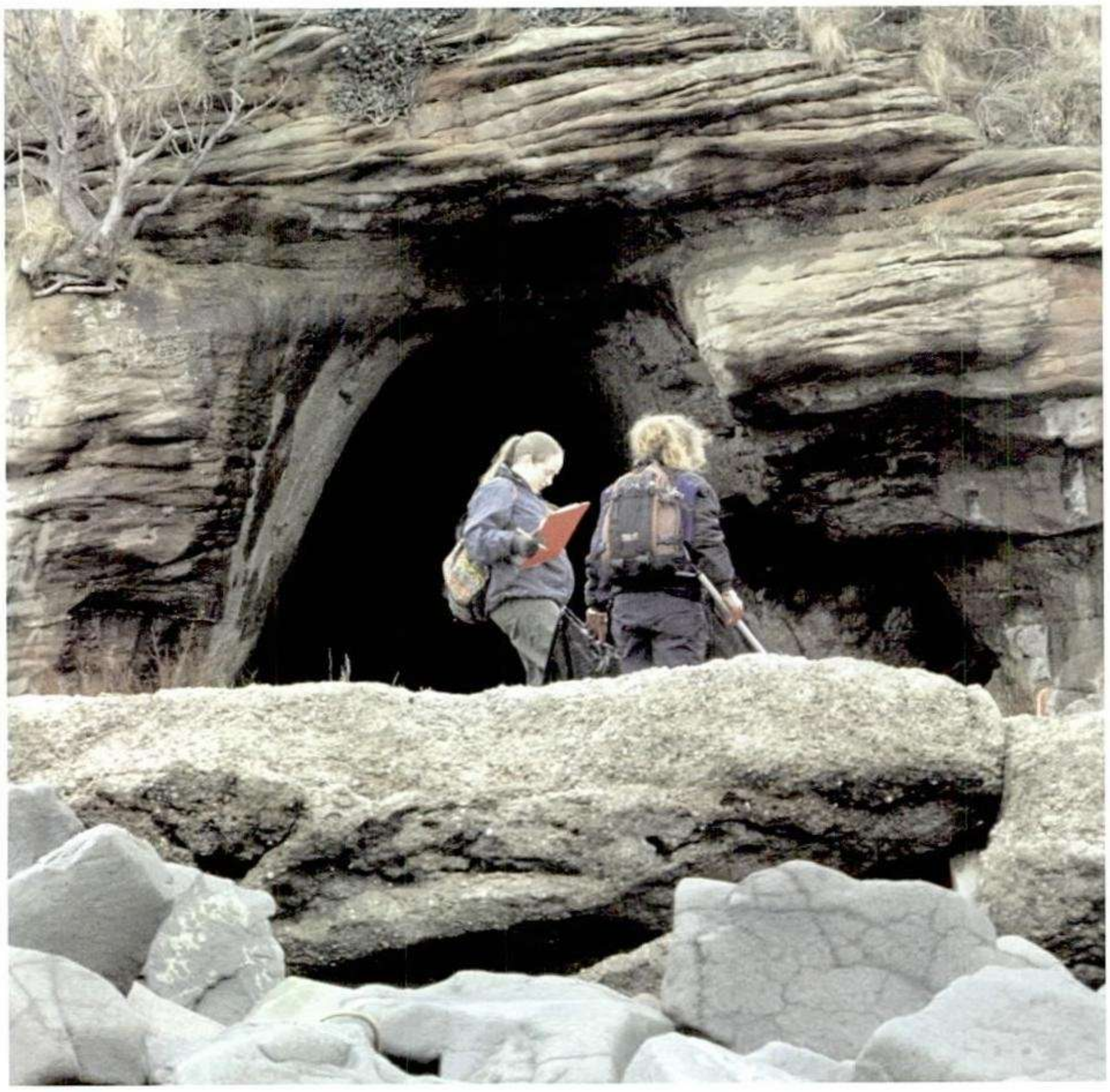

Figure 21.3. Local group undertaking a beach clean in front of the caves at East Wemyss, prior to recording the archaeology. The group are members of a linked project combining the Marine Conservation Society's Adopt–a–Beach campaign and Shorewatch monitoring.

Figure 21.4. Local community group recording rock-cut features on the island of Foula, part of the Shetland's Past project.

Figure 21.5. Members of the North of Scotland Archaeological Society survey part of the remote coast of Loch Hourn. The remains of numerous structures associated with the herring fishing industry are visible in the field around the tent.

Shorewatch: A Prototype National Programme

Since the completion of the Phase III pilot initiative, the Scottish Coastal Archaeology and Palaeo-Environmental Trust (SCAPE) has been working closely with CSA on the development and administration of the project. SCAPE has a remit to promote activity and study of the history, archaeology and past environments of Scotland's coastal zone.

SCAPE has forged links with many other organisations, and has established a Shorewatch project in Fife linked to the Marine Conservation Society's *Adopt-a-Beach* campaign. *Adopt-a-Beach* encourages local community groups to remove litter from a chosen stretch of coast, visiting between one and four times a year. Information is recorded about the type and volume of litter collected, and the data are sent to the Marine Conservation Society for analysis. In the linked project, a local group has adopted the beach at East Wemyss (Figure 21.3) and is combining beach cleans with *Shorewatch* monitoring of erosion close to the Wemyss caves. This has helped to address the problem of sustaining interest in the *Shorewatch* project along stretches of coast undergoing slower rates of erosion.

Shorewatch has also been drawn into the Shetland Amenity Trust's new community archaeology project, *Shetland's Past*, in which a number of local history groups are being helped to record all the archaeological remains in their area. The Shorewatch initiative is particularly appropriate to Shetland as over 92 per cent of the population lives within a kilometre of the sea. Five groups, each based on a different island, are collecting information through *Shorewatch* in addition to undertaking other recording projects (Figure 21.4). A wide variety of local inhabitants participate in these groups, united by their strong common interest in the history and archaeology of their individual islands.

Another joint venture has been the survey of the north coast of Loch Hourn by the North of Scotland Archaeological Society (Figure 21.5). Members of the Society came from across Highland Region to spend ten days carrying out an intensive survey of the coastal archaeology of this remote area. Despite the difficult weather and terrain, they managed to locate and record hundreds of previously unknown sites. They are currently preparing to publish the results of their survey and to send copies of the collected data to the local SMR.

CSA too continues to play an active role in the refinement of the *Shorewatch* initiative. The various pilot projects demonstrated the potential of *Shorewatch* as a valuable medium for teaching children many new skills; CSA is currently exploring applications within the school curriculum and is developing an 'education pack' for the *Shorewatch* programme.

With so many varying participants and different shorelines, a current task of *Shorewatch* is to examine and assess the reports from and responses to the programme to allow ease of transmission of the results to the archive and the archaeologically-aware audience. A major aim is to provide professional feedback to the participants to demonstrate the value of their contribution and thus to encourage continued support for *Shorewatch*. The overriding importance of this monitoring initiative lies in its 'bottom-up' approach, whereby local people themselves set up, run and develop the *Shorewatch* projects, albeit initially with some help where necessary from the central coordinator. If the exercise is seen by participants – and local communities – as both beneficial and rewarding, it should help to foster a sense of stewardship of the coastal archaeological resource. It should also enable *Shorewatch* to continue with minimal input from regional or national bodies, such as Local Authority archaeological services and Historic Scotland. However, developments concomitant upon the *Shorewatch* scheme will almost certainly involve these and other organisations, together with the local communities themselves, since encouraging a sense of stewardship will inevitably lead to an increased sense of ownership and a desire for further work on – and indeed protection of – certain threatened archaeological resources. There must be a commitment from the various bodies implicated to discuss and evaluate at regular intervals the information resulting from *Shorewatch* monitoring with the local groups involved, to achieve an appropriate balance between local and national aspirations.

Future Directions

The research undertaken to date suggests that an initiative which aims, through the work of volunteers, to identify, survey and monitor archaeological remains which may be under threat from coastal erosion is both worthwhile and feasible. Local coordinators have been identified, communication links established among participants, advisory bodies and other specialists, and 'resource packs' produced to provide procedural guidance and background information. Promotion of *Shorewatch* as part of other initiatives such as *Adopt-a-Beach* and *Shetland's Past* is also seen as a positive way forward, encouraging partnership among different bodies and broadening awareness of archaeological issues. Similarly, the development of *Shorewatch* within the school curriculum is a theme worthy of elaboration. A dedicated web-site should also be considered seriously, as this would be the perfect medium to advertise the various groups' activities, allow communication between the groups, and portray the visual changes on sites over time.

Further developments should include the cementing of the central coordinator's role as a necessary part of the overall *Shorewatch* programme. Although local groups initiate and run the projects themselves, central coordination remains important for advocacy and promotion, for monitoring the various groups' progress and identifying training needs, for assessing the quality and quantity of material being produced, and, indeed, for actually evaluating the data in terms of the original concept – quantifying and qualifying the threat to the national coastal archaeological resource. Mechanisms for extending the *Shorewatch* initiative into a much longer-term endeavour are currently being explored, including the potential for Heritage Lottery Fund support. Certainly, *Shorewatch* would appear to have the potential to produce results which are valuable both to local communities and to the wider interested public, as well as to a more specialist, archaeological audience.

Acknowledgements

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22 COASTAL EROSION OF ARCHAEOLOGICAL SITES: ISSUES AND RECOMMENDATIONS ARISING FROM THE SEMINAR PAPERS

PATRICK ASHMORE

Introduction

This paper starts with a summary of and generalisation from the preceding papers, followed by a combination of the recommendations made in the papers and in the discussion at the seminar of 11 November 1998. These are salted with the experience of running coastal projects over the last few years and an examination of the recommendations made in England, Wales and Northern Ireland. I hope they will stimulate further discussion on the best ways to deal with the threat to coastal archaeology from marine erosion.

The Background Processes: Land, Sea and Storm

Hansom identifies Caithness, Orkney, Shetland, north-west Skye, western Sutherland and the Western Isles as the most vulnerable areas, because of greater storminess and subsidence than in other parts of Scotland. Lees, from a slightly different perspective, suggests that Dumfries and Galloway, Orkney, Shetland and the Western Isles are the areas most prone to erosion. Dawson predicts that Scotland's climate future is likely to be characterised by increased storminess set against a background of rising sea levels, and that the effects will be worst in the north-east tip of Aberdeenshire, Caithness, Orkney, Shetland, Skye, western Sutherland and the Western Isles. The most vulnerable places common to all of these studies are the northern and western archipelagos.

These studies also describe how, throughout Scotland, and since about 5500 cal BC, more sediment has been leaving beaches than has reached them. New marine and coastal sediment sources have largely been consumed, so sediment movements, except in inner estuaries, are now largely recycling from a limited reserve. That means that an increased protective cover on one part of the coast corresponds to loss at another. Further, even those areas which are still emerging, and which lie on the somewhat less stormy east side of Scotland, are parts of dynamic systems sensitive to local landforms and currents.

The coastline is changing rapidly. The nature of the bedrock or overlying sediment, exposure to wave attack, change in relative sea level, offshore sediment supplies, increased storminess and changes in wind strength and direction have important effects on sites. Lees suggests that at least 15 factors should be taken into account. Hansom points out that local erosion and sedimentation patterns are complex and cyclical. Thus there will be a large contingency element in survival of sites. More geomorphological analysis of coastlines is crucial to understanding the likelihood of damage to known and unknown archaeological sites.

Dawson shows that scientists cannot safely predict whether storms, the major agent of destruction, will increase overall or decrease. Nor can they safely say much about changes in wind direction patterns which can lead to accelerated erosion on parts of the coast where erosion has not been very active in recent years. More research on Atlantic marine and atmospheric systems is required.

The Surveys and Focal Studies

This preliminary analysis of the information from the coastal zone assessment surveys and focal studies is based largely on the summaries in this volume. It is planned to re-analyse the full survey data to create and populate standard categories and produce firmer figures. From that it should be possible to start to assess the relative importance of the archaeology in various areas.

The current analysis incorporates points made during the discussion at the seminar of 11 November 1998. The most general point, made again and again in both the papers and the discussion, is that a greater depth of information is desirable if priorities are to be formulated at local and national levels, but that important sites should not be left to erode until such time as a much improved understanding has been reached.

Cover

The coastal zone assessment surveys covered about 2350 km, or around 20 per cent of Scotland's coastline (see Appendix for details of how the length is measured). About 6646 sites were recorded. Some 2727 sites, or 37 per cent, were to some degree vulnerable to coastal erosion. As Wilson (above) and others have noted, defining what constitutes a site can be difficult, so these results must be treated as indicative rather than definitive. Extended to Scotland as a whole, they suggest that there may be about 34000 sites close to the coast, of which around 12400 are vulnerable.

However, the spreads around these estimates of the total numbers of coastal monuments in Scotland are very high. The variations in numbers of all sites per kilometre (Table 22.1) may partly be due to the different widths of the coastal strip in different surveys. Clearly the numbers are not normally distributed, so an average and variance cannot be calculated.

The figures for vulnerable sites, although also very variable, do have an approximately normal distribution even though it is skewed to the right. The average of one vulnerable site per kilometre has a large error. If the aberrant figure for Fife is ignored, a new average of 0.85 vulnerable sites per kilometre has a standard deviation of slightly over 0.5. It would probably be sensible to say, pending the more detailed analysis planned, that there will most commonly be about ten vulnerable site on any ten given kilometre stretch of Scotland's coast and that in 95 cases out of 100 there will not be less than one nor more than twenty. That said, there is likely to be clumping of sites in favourable areas and any further analysis should attempt to explore this aspect of the data.

Survey	Sites per kilometre All	Vulnerable
Barra	3.57	1.88
Fife	5.40	0.42
Lewis	4.14	1.39
Moray	2.34	1.00
N Highland	4.01	0.93
NW Highland	1.92	0.49
Orkney	2.49	1.68
Shetland	1.92	0.89
Solway	1.05	0.37
S Forth	2.49	0.24
Average	2.9	0.93
Standard Deviation	1.4	0.7

Table 22.1. The numbers of sites per kilometre in the surveys.

The time distribution of sites visible on the coast

The surveyors tailored their period classifications to the types of site which they encountered. The figures and percentages in Tables 22.2 and 22.3 below have been amalgamated from those various period classifications. No synthesised figures are available for the South Forth survey. During the next analysis it is planned to reassign all sites to a more detailed set of period categories.

Survey	Length (km)	Sites	Period Uncertain	Pre-medieval	Medieval to Modern
Barra	61.7	220	27	26	167
Fife	192.7	1041	138	26	877
Lewis	441.0	1825	542	211	1072
Moray	160.0	375	141	6	228
N Highland	125.3	503	77	28	398
NW Highland	93.0	179	7	12	160
Orkney	339.0	843	266	166	411
Shetland	441.0	846	251	169	426
Solway	318.1	334	68	76	190
Totals	2171.8	6166	1517	720	3929

Table 22.2. The numbers of sites of the prehistoric and historic periods in the coastal assessment surveys.

Survey	Period Uncertain	Pre-medieval	Medieval to Modern
Barra	8%	16%	76%
Fife	13%	3%	84%
Lewis	30%	11%	59%
Moray	37%	2%	61%
N Highland	15%	6%	79%
NW Highland	4%	7%	89%
Orkney	31%	20%	49%
Shetland	30%	20%	50%
Solway	21%	22%	57%
Average	21%	12%	67%

Table 22.3. The percentages of sites of the prehistoric and historic periods based on Table 22.2.

On average one in eight of the sites was pre-medieval and two-thirds were medieval to modern. One-fifth could not be assigned even to these very broad periods. The spread attached to these figures cannot be expressed as an average and variance because the figures are not normally distributed. But they are probably, like those for vulnerable sites per kilometre, large. Fife and Moray had noticeably few visible (or recognisable) pre-medieval monuments; and although figures are not available for South Forth, the same was true there, apart from the fairly abundant long cist cemeteries. Highland had few pre-medieval sites, but the particular classification used here is awkward because Norse sites could be assigned to either category. Strikingly, Shetland, Orkney and Solway seem to be particularly rich, in percentage terms, in visible early coastal sites, with Barra somewhat less rich.

One important question is whether there are many more pre-medieval sites in the lowland coastal areas than are visible or recognisable, surviving beneath superficial deposits. A complementary important question is whether the surveys will, using a more systematic classification of the site types and their periods, provide a quantifiable form of the evidence for broad regional differences.

The uniqueness of the coastal heritage

In general, it seems that many of the monuments directly under threat have some specialised marine-related functions or are directly dependent on marine resources.

In Shetland the surveys showed that many coastal sites, such as fishing stations, are readily identifiable as specialised; thus their loss to erosion cannot be compensated for by study of inland sites. On Barra the coastal zone represents about 1/25th of the total area of the island but it contains nearly 1/4 of the sites and monuments, a difference between the inland and coastal area which is particularly strong during later prehistory and the modern era. A significant proportion of all known sites in Lewis is concentrated in a 1 km wide strip by the coast. In north-west Sutherland there seems to have been a high dependence on marine resources and there appears to be a correlation between raised beaches and human activity.

The differences in site distribution densities between coastal and inland areas, and the demonstrable dependence on marine resources in many parts of Scotland, show that coastal sites represent a unique resource vital to our understanding of the whole of Scotland's past.

Area studies behind the coast

Neither coastal nor inland sites can be properly understood if explanations take no account of links between them. For some kinds of site, and the rig and furrow field systems of Sutherland are but one example, survey and documentary work must cover a considerable inland area if the coastal exposures are to be understood. Some focal studies have taken this into account: the study of the marine crannogs of the Beauly Firth took place in the context of the surrounding landscapes because of the dependence of the crannogs on their hinterland. Although general research into topics such as prehistoric settlement and medieval deserted villages will be valuable to an understanding of what related material might be expressed on the coast, a greater priority should be given to studies directly related to sites on the eroding coastline.

Areas between monuments

Several surveyors suggested that any impression of isolated sites separated by comparatively large archaeology-free stretches of coastline is misleading. Entire prehistoric landscapes can survive under soil, sand or peat. It is undoubtedly true of all lowland coastal areas that many sites originally built of wood, or low earth banks and shallow ditches, will be invisible during rapid surveys.

One way of addressing the lack of information about the landscapes between prominent monuments is considered under **Monitoring** below.

Intertidal zones

Examination of the intertidal zone should be encouraged. In Shetland, Orkney, the Western Isles, parts of western Highland and the Solway, offshore submerged peat and sites below storm beaches show that archaeological sites that were originally on dry-land can survive in unexpected localities. The Moray and Fife surveys in particular showed, despite the difficulties in examining the mudflats fully, that many sites originally built in the intertidal area survive, from glider traps to marine crannogs.

The difficulties of working in the intertidal zone are great. Local enthusiasts are particularly well-placed to explore the potential of this zone since intensive long-term intertidal walking is required. Aerial photography should also be fruitful. Particular types of site, such as marine crannogs, can be targeted on the basis of geomorphological and geographical characteristics.

Underwater archaeology

Just as the archaeology and palaeo-environment of the coast relates to the hinterland, so ancient landscapes and other remains survive on the seabed below low water in some parts of Scotland. As with much dry-land archaeology, the primary requirement is to know the shape and nature of the resource. Submerged archaeology of dry-land type and peatlands are known from Shetland and the Western Isles, and peatlands survive in the intertidal zone and probably undersea in those areas and in Orkney and the Solway. However, the extent of submerged post-glacial landscapes has not been adequately mapped. The situation for wrecks is only a little better, for as Oxley (above) points out, despite real progress by RCAHMS in developing a maritime database over the last few years, that database is highly incomplete.

In *Conserving the Underwater Heritage*, Historic Scotland sets out four aims which can be summarised as:

- develop a protection regime
- pursue beneficial management of key underwater sites
- record sites which cannot be saved
- encourage publication about these activities

The operational policy of Historic Scotland, in essence, is to afford the same status to underwater sites as to those on dry land and to encourage others to do the same (Historic Scotland 1999). Although Historic Scotland has no specific legal responsibility to survey or assess the resource, it is responsible for the protection of nationally important archaeological remains and wrecks in such areas, and it needs to inform itself and others (including other government departments) so that it can advise on protection and priorities. Local authorities have no responsibility for the archaeology of areas below the Low Water Mark.

Site and small area-based Focal Studies

The conference indicated that detailed studies of the geomorphology and archaeology of small lengths of vulnerable coastline and their immediate hinterlands is highly desirable. The threat to each site has to be assessed individually because highly localised factors often offer greater risk or greater protection to a site than the general state of the coastline suggests. There is a requirement for more geomorphological studies related to the soft estuarine sediments, particularly in estuaries.

Further work is needed to assess the true potential of a great many sites. One of the main problems facing surveyors was site type recognition. Wilson points out (above) that where remains are not as distinctive as, for instance, World War defences, preconceptions of what various monuments should look like may give the record a spurious air of uniformity. Often, little is known about the nature and duration of visible settlements and burial places, and many sites are multi-period and may have had different functions at different times.

Thematic Studies

Many surveyors argued that there should be further research into specific themes associated with the coastal strip, and also broader research themes, to increase understanding of the resource and its potential to answer large questions.

The broad themes to which coastal sites are relevant are almost uncountable. Wilson noted that social factors can be very important in determining distributions of sites. For instance, World War I and II defensive remains in Orkney are located almost entirely around Scapa Flow with only limited remains elsewhere. In this case, favourable geographic features were utilised due to social factors originating well beyond the coastline of the islands. There are also many poorly understood variations between the Orkney islands, perhaps sometimes because of differences in superficial geology; for example, very large 'farm mounds' are concentrated mainly in Sanday where the build-up of sand may be partly responsible. Some more recent aspects of society, such as the early industrial remains by the Firth of Forth, are generally vulnerable to loss without record because their value as part of the national heritage has not percolated into all parts of society.

Further thematic research into industries and remains associated with the coastal strip, including fish weirs and traps, harbours, river transport, and salt panning, will undoubtedly produce more discoveries. The Moray survey has doubled the number of known fishtraps in the area and these sites are both part of the important Scottish fishing heritage and particularly vulnerable. The focal study at Newbie Cottages at the east end of the Solway added detail to the already complex model of coastal change in this area and showed that the local sediments have considerable palaeo-environmental value, covering much of the Holocene period. Several attributes which are common to the two main known concentrations of marine crannogs in the Beauly and Clyde firths, including shallow gradient shorelines and shelter at the head of firths, can be found elsewhere in Scotland. Thematic studies including aerial photography and intensive field walking may lead to a much better understanding of their distribution and use.

Visibility

Visibility is a major issue. As the surveys in Orkney in particular showed, our assumptions about the nature of many prominent sites are untested. In addition, the presence of prominent sites may lead us to neglect the areas between them. The seemingly obvious thus hides the truth in two ways.

In many areas, remains of the prehistoric era are probably present but invisible. There are, for instance, relatively few known prehistoric sites near the coastal edge of the southern shores of the Forth, in contrast with the relatively large number of long cist cemeteries. This may be mainly because many prehistoric sites were made of wood and earth and will have been masked or obliterated by later occupation or cultivation, which in this area has been intense. Sometimes, of course, the contrast has been created recently. In several areas of the upper Forth, much of the coast-edge has been reclaimed and these areas can be considered archaeologically sterile except for those features belonging to the post-medieval period.

Concentration on known sites is not the best way forward in some areas, where it seems important to monitor areas of coastline after storms to catch previously invisible evidence.

Monitoring

Sites in some areas are disappearing very rapidly. Several surveys and focal studies showed this dramatically. The dramatic find of a Viking burial in Balnakeil Bay, Sutherland, in 1991 exemplifies unpredictability of exposure. In Fife, rapid changes which had been set off by some environmental or artificial trigger were seen to be occurring to coastal sites. Only frequent monitoring will reveal sites in soft sediments.

Infrequent recording of the eroding sides of sites is less cost-effective than a combination of frequent monitoring and focal studies, which should probably be a priority. Without regular monitoring, it would be difficult to identify threatened sites, react to threats, or develop management strategies. In some areas it may be more useful to monitor small areas rather than long stretches of coastline. The main requirements include creation of networks of local people, and one promising way forward is the fostering of Shorewatch groups.

Repeat Surveys

Several surveyors suggested that their surveys should be repeated after a suitable interval of time, perhaps between five and ten years, in order to assess rates of erosion, for which there is at present very little information. It will not always be necessary to resurvey all parts of an area; it may be equally useful to sample those stretches of coastline deemed most at risk.

Managed Retreat and Prioritising Now

Archaeologists must embrace the concept of managed retreat, albeit in a rather different sense from that used in natural heritage studies. Regardless of any long-term mitigation strategies which may be put in place, many sites have been identified as worthy of action now. Protective measures such as walls, bunds and beach rebuilding all have problems, the most acute of which are the effects on nearby coasts and the cost of maintenance. It seems increasingly unlikely that protective measures will be seen as appropriate responses to coastal erosion of the archaeological and palaeo-environmental resource except at a few sites of unusual excellence. The thrust of the recommendations made by surveyors is that excavation should be planned well in advance with priorities based on research criteria, often after or along with study of the areas around the foci of excavation.

The focal studies in Orkney suggest that invasive work is more cost-effective than mere recording of eroding faces, and that it may not be the best strategy to invest very large amounts in individual sites; it may be possible to gain a considerable amount of information from limited excavation. On the other hand, it seems that at Galson on Lewis frequent visits, recording and sampling between 1997 and 2000, during which a strip 1 m wide has eroded, did allow a three-dimensional picture to be drawn up. In general, the best way of managing important stretches of coastline is monitoring by local people and focal studies of individual sites by experts as new evidence appears.

It would, however, be rash to dismiss all salvage work, in the sense of speedy reaction to damage to sites. After storm damage, large archaeology-rich standing sections will slump, destroying more evidence. Some sites such as the Scar boat burial (Owen & Dalland 1999) obviously merit emergency excavation. The trick is to recognise when a speedy reaction is required, and monitoring networks appear again to be the best way forward.

Overall, the message appears to be that individual stretches of coastline require tailored solutions which in many cases will involve geomorphological work, monitoring, survey, and at least small to medium-scale excavation.

Auditing

There was discussion at the 1998 seminar about putting a valuation on sites during rapid surveys. Perhaps the importance of sites can be measured by some parameter with a roughly normal distribution. If so, then comparing the worst with all the rest and then comparing the best with all the rest, 5 per cent can be seen as of hardly any significance, and 5 per cent as of exceptional potential. If that is a sensible way to define how many of a large number of sites are very important, it suggests that, at any given time and despite changing perceptions of exactly which sites to include in that category, around 600 of the roughly 12000 sites and clusters of sites vulnerable to erosion are very important.

If the relative potential and priority of sites are to be categorised, standards and criteria must be agreed. There are two promising approaches, not truly independent of each other, and possibly complementary. One is to identify important research themes and then to give sites (or areas) scores according to how relevant they appear to those research themes. That has been the traditional method of selecting sites for excavation and areas for detailed survey, although explicit scoring has not been used. The other is to score sites (and possibly stretches of coastline) according to the quality, amount and variety of evidence surviving in them. This approach rests on the assumption that most evidence about the past is of interest, but that information which can be related to other evidence is of more value than isolated pieces of data. It is probably more technically viable for production of national statistics than an approach based on research themes. But its difficulties are obvious, given how many sites reveal at most their surfaces. Whether or not it will be possible to use either of these methods during rapid surveys is a moot question, as the discussions of **Site and Small Area-based Focal Studies** and of **Visibility** above make plain.

Erosion

The classifications used in the various surveys are fairly consistent. The minor variations are probably negligible if it is accepted that the categories blur into their neighbours rather than being sharply distinct. Distance measurements are broadly comparable between surveys but, as discussed in the Appendix, not completely so.

Two broad zones (not covering the whole of Scotland) are identified for the purposes of this analysis: Zone 1 is a zone of general land subsidence and high storminess; it comprises the northern and western archipelagos. Zone 2 is a zone of general land rise and somewhat lesser storminess; it comprises the survey areas south of Sutherland. The north and north-west Highland survey areas do not seem to fall comfortably into either zone.

Lengths in km to nearest 100 m (but see Appendix)

Zone		Survey	Eroding	Eroding or Stable	Stable	Accreting or Stable	Accreting	Both Accreting and Eroding	Both Info.
1	Barra	61.7	17.3	20.6	12.5	0.0	0.0	11.3	0.0
1	Lewis	441.0	128.8	148.0	150.5	2.1	1.4	10.2	0.0
1	Orkney	339.0	47.5	118.6	152.5	6.8	3.4	6.8	3.4
1	Shetland	441.0	66.2	136.7	220.5	4.4	0.0	13.2	0.0
2	Fife	192.7	12.8	35.7	62.1	44.1	10.7	24.1	3.2
2	Moray	160.0	9.8	64.2	17.9	32.6	19.8	15.7	0.0
2	Solway	318.1	63.8	96.0	33.8	96.6	1.9	26.0	0.0
2	S Forth	170.0	27.2	93.5	25.5	23.8	0	0	0
	N Highland	125.3	34.6	14.7	64.6	0.6	0.5	10.3	0.0
	NW Highland	93.0	8.0	56.7	16.6	1.2	0.0	10.5	0.0
	Total of surveys	2341.8	416.0	784.7	756.5	212.2	37.7	128.1	6.6
1	Zone 1	1282.7	259.8	423.9	536	13.3	4.8	41.5	3.4
2	Zone 2	840.8	113.6	289.4	139.3	197.1	32.4	65.8	3.2
	Scotland (inferred)	12000.0	1997	3543	3747	962	193	655	34

Table 22.4. Erosion status lengths in km to nearest 100 m (but see Appendix). The zonation used in this table reflects general subsidence and storminess.

	Eroding	Eroding or Stable	Stable	Accreting or Stable	Accreting	Both Accreting and Eroding	No Info.
Scotland	17.8%	33.5%	32.3%	9.0%	1.6%	5.5%	0.3%
Zone 1	20%	33%	42%	1%	0%	3%	0%
Zone 2	14%	34%	17%	23%	4%	8%	0%
N Highland	28%	12%	52%	0%	0%	8%	0%
NW Highland	9%	61%	18%	1%	0%	11%	0%

Table 22.5. Erosion status percentages to nearest percent (but see Appendix). The zonation used in this table reflects general subsidence and storminess.

Each underlying record represents observation on a single day. It is not possible to know how far the results represent longer periods of time. Further, without analysis of the overall distribution of different types of coast and their circumstances it is not clear whether this c 20 per cent sample of coastal erosion is representative of the whole of Scotland. Nevertheless, in the storm-ridden and mainly subsiding far northern and western islands of Scotland, this rapid pilot shows that 53 per cent of the coast was either 'eroding' or 'eroding or stable' and 1 per cent was 'accreting' or 'accreting or stable' when the areas were surveyed. In the more southerly and easterly zone 48 per cent was either 'eroding' or 'eroding or stable' and 27 per cent was 'accreting' or 'accreting or stable'. The main difference between the zones seems to be in the amount of accretion rather than the amount of active erosion. In the islands, although there is much movement of sand from one spot to another on the land, it seems that eroded sediment is not currently being redeposited locally once it has entered the sea. Thus, where in the southern and eastern areas erosion may be attacking either the land or relatively freshly deposited 'protective' sediments, in the subsiding northern and western parts very little protection is provided by freshly deposited 'protective' sediments.

In north Highland much of the coastline is apparently stable, but as in Zone 1, there is hardly any accretion. In some ways erosion is more extreme in north-west Highland (Ullapool to Lochinver) than in either Zone 1 or 2, even though the percentage of actively eroding areas was somewhat lower. It is not known whether this was due to a different discrimination between the two classes 'eroding' or 'eroding or stable' from that made by other surveyors, but the north-west Highland surveyor considered it to reflect the sheltered aspect of much of the coastline, the resistance of the underlying bedrock, the limited effects of sea level change, the restricted number of fragile coastal dune systems, and a low level of coastal development in the region.

In Shetland, Orkney and the Western Isles, erosion of archaeological sites was found to be not just a result of high sea levels and storminess. Current land management practices, for example, have a great effect on the stability of the coast-edge. Overgrazing by sheep is common in Shetland, and in Orkney, in particular, cattle trampling can easily destabilise fragile deposits. Rabbits are rife in Orkney and the machair of the Western Isles, partly because agriculture on the flatter surrounding areas dissuades rabbits from creating burrows there. In Shetland, rabbits are attracted to archaeological sites because the presence of walls and stonework makes the ground higher and consequently drier than the surrounding, often poorly drained landscape.

In Fife, erosion rates varied depending on geology; areas of drift clay or landfill deposits often experienced rapid erosion, whereas bedrock promontories often appeared stable. Other factors perceived to play a major part in controlling erosion rates along the coast-edge included coastal defences and the degree of shoreline exposure. Well-maintained coastal defences were seen to be effective in limiting erosion, as at St Andrews Castle, but the consequences for neighbouring unprotected sections of coastline need to be considered.

In Lewis, many sites are eroding and are likely to be lost or significantly damaged in the next decade. Three main concerns are:

- erosion of sites such as promontory enclosures on incised cliffs, where the rate of erosion seems to be dependent on underlying geology
- sites in the highly dynamic machair environments where marine, aeolian, livestock and human agencies combine to create very local areas of erosion
- a small number of sites threatened by stream erosion near the coast

On the Solway shore prehistoric and medieval sites seem to be suffering mainly from localised erosion. This is exacerbated by grazing animals. Any management strategies must take all sources of erosion into account. Post-medieval sites are mostly threatened by violent wave action.

One fairly general conclusion from these surveys is that in order to assess the medium- and longer-term threats to the archaeological and built heritage properly, there will need to be more comprehensive coastal stability surveys.

National Perspectives and Local Actions in Scotland

Scottish coastal archaeology does not exist in a vacuum. The Scottish Coastal Forum (SCF) is an overarching advisory body for all coastal matters in Scotland. It exemplifies the socially inclusive approach in Scotland, emphasising regional and local initiatives to suit local circumstances (The Scottish Office 1996) and is working on developing a national coastal strategy. Centrally-based legislators, administrators and academics can provide vision, frameworks, expertise, and in some cases resources, but local authorities are at the forefront of coastal protection and there are many local groups and individuals who have a variety of strong interests and their own visions of what could or should be done.

Shoreline Management Plans

Shoreline Management Plans (SMPs) have been created for several areas. Beech and Thornton describe above how Fife has prepared an exemplary plan based on the guidance published by the Ministry of Agriculture Food and Fisheries (MAFF) (1995). There has been a high archaeological input into preparation of the Fife SMP. Focal studies in Fife tested the possibility of targeted assessments as part of its development. Eight different types of study were undertaken, ranging from the salmon fishing industry of the Tay to a section of river bank containing ship-hulks near Kincardine. One of the conclusions of the Fife SMP is that currently available methodologies for giving archaeological sites an economic value which will influence decision makers are contentious, and probably inadequate, while Oxley (above) concludes that SMP evaluation of environmental resources sits uncomfortably with the needs of the historic environment.

Oxley suggests that there is a general lack of appreciation of the value of coastal and maritime archaeology and argues that in Fife the vigorous efforts of the local authority archaeology service and Historic Scotland have not been matched by input from others, to the detriment of the SMP process. He notes that there are many opportunities for interpretation, and in harmony with the conclusions of the authors of the Fife SMP, that the economic benefits of archaeology can at present best be asserted through related economic activities.

The almost total lack of reports on previous coastal work in some other parts of Scotland has seriously limited the conclusions which can be drawn from the rapid assessment surveys.

The Firths Initiative

The Firths Initiative of Scottish Natural Heritage (SNH) has focused on partnerships bringing together the interests of groups from local authority planning, natural and cultural heritage management, industry, education, tourism, and so on. It has from the first taken the cultural heritage into account. Management strategies and consultation networks have been developed for six large areas. This initiative has had a strong European component. Downie (above) concludes that although sustainable development, comprehensive environmental management, habitat restoration and emphasis on participation are now in place, the next challenge is to achieve shared governance, adoption of the precautionary principle, and ecological empathy.

Archaeological initiatives and partnerships

Partnerships will be essential to success. Although Historic Scotland is a key player in dealing with the consequences of both coastal erosion and of present coastal management practices and developments, it does not have a statutory remit for coastal protection, and cannot take this area of conservation forward on its own. It does have a role in setting up meetings to foster discussion and understanding of the problems, and contributing to discussions initiated by others, so that, amongst other things, it can provide advice to the Scottish Ministers.

The three main current Scotland-wide coastal archaeology initiatives are Shorewatch, the University Coastal Archaeology Research Group (UCARG), and The Scottish Coastal Archaeology and Palaeo-Environmental Trust (SCAPE).

Long-term monitoring is essential to a more rounded picture than can be provided by rapid surveys. Shorewatch is a framework intended to support local groups and individuals in monitoring and recording discoveries in such a way both that the results are fed into the archaeological record and that the work of the groups and individuals is given the recognition it deserves. The archaeology of intertidal areas and of lowland coastal landscapes can be approached in no better way than constant surveillance by local people. Local groups initiate and run individual Shorewatch projects themselves, but central coordination remains important if results from individual groups are to help understanding of the threat to the national coastal archaeological resource. The pilot Shorewatch project, managed by the Council for Scottish Archaeology (CSA), and SCAPE's progress in setting up groups, suggests that Shorewatch has the potential to produce results valuable both to local communities and the wider interested public, as well as to the more specialist, archaeological audience.

Support frameworks must take account of the interests of coastal communities, local cultural resource managers and local interest groups, as well as academics and centrally-based archaeological organisations. Historic Scotland has grant-aided the Centre for Environmental History and Policy, at the University of Stirling and the University of St Andrews, in setting up SCAPE. SCAPE is intended to provide a forum to take forward the coastal aspirations of all those with an interest in coastal archaeology, and is inclusive rather than exclusive. The Shetland Amenity Trust has been an active partner. SCAPE will provide a strategic framework for archaeological work, bid for funds for mitigation projects, and educate people in the problems and opportunities presented by coastal archaeology. Aided by a generous grant from the Carnegie Trust, it has been carrying out the detailed analysis of existing coastal assessment surveys. In addition, it will manage coastal assessment surveys and Shorewatch projects on Coll, Tiree and Islay over the next three years with funding from a project set up by the Royal Society for the Protection of Birds (RSPB) and grant-aided by the Heritage Lottery Fund (HLF).

UCARG plans to create research frameworks and to bid for funds from bodies which provide academic research funding. It has, for example, developed an interdisciplinary project looking at long-term settlement sustainability and stresses in coastal communities on the Scottish Atlantic margin. The proposed project builds largely on existing research activities of the partners, and is designed to obtain data on resource availability and environmental stresses, settlement continuity and resource use and consumption, all within a framework of ecosystem change. Strategic academic projects like this are a major component in any scheme for managing the coastal archaeological resource.

Local actions and sustainability

The coastal heritage belongs as much to local communities as to regional organisations such as local authorities and to the nation. There is a requirement for broadly based educational initiatives and support frameworks for locally-based mitigation of the threat to coastal sites. Shorewatch is designed to fit in easily with schemes related to the natural heritage and to local amenity. It should help both to enrich a sense of local community and to foster local conservation of the built heritage. The information provided by these groups will be an important source of information for setting priorities.

Monitoring need not be the only role of local groups. The planned involvement of local people in the rapid survey phase of the SCAPE project in Coll, Tiree and Islay points to one possible way forward; and, if a sustainable approach to dealing with the problems of erosion is to be developed, it should perhaps include the local initiation of excavation projects.

Sustainability may not seem relevant to an inexorably diminishing resource. However, even if sites cannot be preserved for ever, the information and artefacts from them can be rescued in advance of the sea. A sustainable approach should seek to integrate active archaeological work, education and tourism. Mitigation can be designed to ensure that excavation projects have a positive long-term effect on local economic and social well-being. The fieldwork elements of major excavations are already of considerable economic benefit to isolated communities, generating both direct income and increased visits by tourists, albeit for a few years at most. By contrast, most post-excavation work – often costing more than the fieldwork – is done in cities in southern Scotland, England and Wales. An approach emphasising the sustainability of local communities would, for instance, seek ways in which as much paid post-excavation work as possible could be done locally. Some sites will turn out to have a long-term visitor potential, and their protection by sea walls may be justified. However, well-designed excavation projects, like that at Scatness in southern Shetland (Nicholson & Dockrill 1998), now in its sixth year, themselves provide a truly local experience with the potential to attract a growing number of visitors. The Achnahaird project in north-west Sutherland, initiated locally and funded by regional and national bodies, points to another way forward.

Fresh thinking is needed. Coastal sites are being destroyed by the sea without record. Some of the concerns that professional archaeologists have about excavation by voluntary groups can be addressed in this context, particularly if partnerships between voluntary groups and professionals can be set up on an equal footing. The resource is disappearing: the approach to its recording before destruction should be predicated on 'use it or lose it'.

Conclusions and Recommendations

In what follows, for the sake of brevity, 'archaeology' is taken to include the archaeology of buildings, wrecks and also palaeo-environmental evidence, while 'site' refers both to discrete structures and to large areas containing archaeological evidence. Where appropriate, I have taken account of recommendations contained in:

- *England's Coastal Heritage* (English Heritage & RCHME 1996) which summarises a desk-based study of the English coastline by the Universities of Reading and Southampton (Fulford et al 1997)
- *Caring for Coastal Heritage* (Cadw 1999)
- *A Review of the Archaeological Resources of the Northern Ireland Coastline* (McErlean et al 1998)

1 Conclusion: Many important coastal archaeological sites are vulnerable to coastal erosion.

Very roughly, 12000 coastal sites are currently threatened by erosion in Scotland, of which, again very broadly, 600 will be of exceptional importance. In general, they are no more or less threatened by development than other Scottish sites.

Aim: To mitigate the threat.

Recommendation:

i) Encourage policies and frameworks for mitigation of sites threatened by coastal erosion.

2 Conclusion: Important sites continue to be destroyed while wider research goes on.

Aim: To ensure that spending on further surveys, focal studies, research and other frameworks and policy developments does not exclude work on sites currently suffering from severe erosion.

Recommendation:

i) Some patently high-potential sites suffering from active erosion should be excavated now, with concurrent associated survey and focal studies.

3 Conclusion: Documentary research can illuminate coastal issues.

Aim: To gain a better understanding of what questions coastal archaeology can answer by studying existing data.

Recommendations:

i) Completed surveys should be re-analysed using standardised categories to produce standardised quantitative data for the various areas and to reduce uncertainties in global figures.

ii) Coastal survey results should be compared with the records in the RCAHMS database, CANMORE.

iii) Groups of excavation results should be analysed to draw out their overall significance.

iv) Maritime Record enhancement should focus first on increasing the breadth of the record.

v) A list of thesis topics should be sent to universities to encourage academic desk-based research.

4 Conclusion: Coastal sites and landscapes are too little understood for the development of comprehensive research proposals.

Aim: To carry out surveys, focal studies and excavations to provide a better understanding of what questions the coastal resource can answer.

Recommendations:

i) Focal studies of eroding sites and groups of sites should normally include invasive fieldwork, because sites often cannot be identified to period and function from surface remains alone.

ii) Cleaning and recording of eroding faces on its own will not usually be cost effective, and a combination of topographic, and in some areas geophysical, survey with small scale excavation will often be preferable.

iii) Further archaeological survey and focal studies are required behind the shoreline to establish the archaeological and palaeo-environmental context of sites and the areas between upstanding sites.

iv) In all focal studies, attention must be paid to the environmental, geological and topographical context in which archaeological material occurs.

v) All those involved in coastal archaeology should encourage local volunteers to:

- a) find, identify and survey coastal sites
- b) monitor known sites and their environs
- c) report their results to local and national archaeological bodies

vi) Intertidal areas should be investigated and monitored for old land surfaces and archaeological and palaeo-environmental evidence. The work:

- a) can probably be done best by locally-based enthusiasts in loose partnership with academic institutions, because these areas cannot be investigated adequately through rapid or sporadic surveys
- b) should include a comprehensive analysis of existing aerial photographs and the commissioning of new ones
- c) should aim for integration with survey of adjacent dry land
- d) should target zones of high potential
- e) should include collection of local oral information
- f) should include a programme of new excavations

vii) Ground-truthing of maritime geophysical survey and net fastening data, mainly in areas of high potential.

viii) The maritime archaeological community should invest in or gain access to side scan sonar, a sub-bottom profiler and a proton recession magnetometer which could produce not only better information on wrecks but also an assessment of the potential of underwater landscapes in the northern and western archipelagos.

ix) There should be encouragement for more wreck surveys.

5 Conclusion: Not enough is known about how to assign values to sites.

Aim: To develop value categories for sites and areas.

Recommendations:

i) Values of sites which appear to be of well-known types should be based on the potential of sites and surrounding areas to contribute to knowledge at a broad range of scales, and to education and to enhancing the economy.

ii) Values should be assigned to completely unexcavated sites on the basis of their apparent richness in stratigraphic detail, well-defined contexts, and evidence such as bone and other organic materials.

iii) The collective significance of numerous slight sites must be taken into account.

iv) Funding organisations should devote part of their funds to supporting groups of projects relating to pre-announced themes rather than considering projects in isolation.

6 Conclusion: Priorities must be established.

Aim: To establish how to prioritise areas and sites for surveys, focal studies and excavations.

Recommendations:

i) Priorities must be developed for survey, focal studies, excavation, and in a few instances protection.

ii) The first priority must be to ensure that there are resources (the time of researchers and others as well as money) for completion of publication, archiving and finds disposal of fieldwork already done before devoting resources to new fieldwork projects.

iii) In Scotland as a whole we need to establish a sensible balance between assessment surveys (including repeat surveys), focal studies and excavations.

iv) There must be further analysis of how values and priorities for archaeological sites and landscapes can be made commensurable with values and priorities based on economic factors.

v) In the short term, while these prioritisation methods are being established, the archaeological priorities of active researchers with a good publication and public involvement record should continue to determine which sites are excavated on a large scale.

7 Conclusion: It is essential to gain a better understanding of the environmental factors which control erosion.

Aim: To obtain a better understanding of the roles of past, present and future variations in sea level and storminess, and of local geographical, geomorphological, and hydrological factors, in controlling erosion.

Recommendations:

i) More research is required into long-term climate change and the marine environment of the north Atlantic and North Sea. In particular, more data from the medieval period is currently needed.

ii) More geomorphological survey (probably including excavation) and analysis is required to elucidate how the particular geography, geomorphology, aspect and other characteristics of each site determines whether it will survive for many decades or be destroyed rapidly by erosion.

8 Conclusion: Existing arrangements are in principle adequate for protecting coastal and sites from development but there should be further consideration of arrangements for protecting maritime sites.

Aim: To continue to protect sites threatened by development.

Recommendations:

i) The principles of NPPG5 and PAN42 should apply not only on land but also to the territorial sea by Scotland.

ii) There should be consultation about sectoral consents and about consents and licences outwith the territorial sea.

iii) Planners should pay special regard to the precautionary principle in considering the impact of development on archaeology.

iv) Existing partnerships such as the Scottish Coastal Forum and the Estuary Forums should be encouraged to continue to take archaeology into account in encouraging holistic approaches to all issues.

9 Conclusion: No one existing body can currently afford to provide all of the resources needed if the sites threatened by coastal erosion are to be protected or excavated in advance of destruction.

Aim: To obtain the resources required to protect or excavate sites threatened by coastal erosion.

Recommendations:

i) Partnerships should be formed to seek funding from diverse sources for major, long-term research, including surveys, focal studies and excavation programmes, to mitigate the threat from coastal erosion to archaeological sites.

ii) Funding bodies should give support to formulation of research proposals for applications for major funding.

10 Conclusion: The management of the coastal archaeological resource should take account of other coastal issues.

Aim: To ensure an holistic approach to coastal archaeology management.

Recommendations:

i) Archaeology should, where possible, be integrated into Coastal Zone Management (CZM) initiatives.

ii) Shoreline Management Plans (SMPs) created by local authorities should balance the preservation of our cultural heritage against the potential damage that ill-conceived defences can cause to the natural heritage.

iii) The most important sites should be preserved in situ.

iv) Historic Scotland should advise management agencies directly and through the Scottish Coastal Forum.

v) Management of intertidal sites should accord with the principles applying to dry-land sites.

vi) Management of coastal historic landscapes should include consideration of landscapes below the low water mark.

vii) Intertidal archaeology should be integrated with other CZM.

11 Conclusion: Coastal archaeology must take account of the needs and values of local communities.

Aims:

i) To increase accessibility of information.

ii) To empower communities to mitigate the threats to their local coastal heritage.

Recommendations

i) To increase access to information:

a) The dissemination of coastal and maritime information by NMRS and local SMRs is a crucial aspect of informing local communities.

b) Historic Scotland coastal surveys should be disseminated on the internet.

ii) Communities, if supported with lottery or other funding, should invite in archaeologists and specialists to help rescue (or in a few cases preserve and display) their local coastal heritage and in so doing contribute to local education, jobs and tourism over a significantly long period.

iii) Training is required to help local communities take such ideas forward.

iv) Because post-excavation work following large coastal excavations can be a very lengthy process, during which no benefits accrue to local communities, ways of having some or even most of this work carried out locally must be sought.

v) New ways of providing feedback to professionals, the public and the local community must be explored.

12 Conclusion: If many sites are to be excavated, the number of records and artefacts requiring storage will increase.

Aim: To preserve original material resulting from excavations and surveys.

Recommendations:

i) The local and national implications for publication, museum storage and archiving and maintenance of monument records must be considered.

ii) The findings of the current Scottish Museums Council audit of museums must be considered before planning any project likely to produce many finds and associated records.

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APPENDIX: THE LENGTH OF THE COASTLINE OF MAINLAND SCOTLAND, AND APPROXIMATIONS IN STATISTICS QUOTED ABOVE

The table below provides the results of measuring the length of the coastline of mainland Scotland with a pair of compasses on maps at successively larger scales, and then using a power law derived from these figures (cf Peitgen *et al* 1992) to estimate what the length would be at still larger scales. The power law underlying these figures appears to be roughly:

log length = 7.82 - 0.195 log scale

using natural logarithms (ie to the base e (2.71828182845904 ...)).

Compasses setting	**Measured length (nearest 10 km)**	**Projected length (nearest 100 km)**
100 km	1020 km	
50 km	1170 km	
20 km	1390 km	
10 km	1590 km	
5 km	1820 km	
1 km		2500 km
100 m		3900 km
10 m		6000 km

Table 22.6. Measured and projected lengths of the Scottish coastline (see text for details)

Because the length of the coastline depends on the scale at which it is measured, one can in a sense state the length of the coast to be what one wants it to be. The length one would in theory get, if one could literally walk a pair of huge compasses set at 10 m along the coastline, is 6000 km (to the nearest 100 km). The length of the coastline of the islands of Scotland is about the same as the length of the mainland coast. So a reasonable estimate of the length of the whole Scottish coastline is 12000 km.

The lengths quoted for each survey above have been assessed using an interval of nearer 10 m than 100 m. By and large, the length assessments will be the same or smaller than those which would have been obtained using compasses set at 10 m. So the estimate of a 19.6 per cent sample of the whole coast is an underestimate. Measurements have been consistent within each survey, so percentages for each survey are valid measures. Because of the differences between surveys, however, their combination to produce Scotland-wide figures is an approximation.

The survey reports allow re-measurement of all the survey lengths on a completely consistent scale, and this will be undertaken soon as part of a fuller synthesis of the results, supported by a Carnegie Trust award to SCAPE.

CONTRIBUTORS

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Noel Beech is a Director of consultants Posford Duvivier, responsible for coastal and river engineering on a world-wide basis. His international work has included erosion/siltation studies of the entire Red Sea coast of Yemen, coastal zone management studies on the Caribbean, and institutional strengthening in Eastern Europe. As one of the authors of the CIRIA *Beach Management Manual*, he is well-known for his commitment to coastal management.

Whilst recognised as an expert in coastal physical process, Dr Beech is known throughout the coastal engineering community for his professional contribution to a vast range of marine-related projects ranging from the design of breakwaters to the strategic management of estuaries and coastal zones.

During the 1990s Noel Beech managed, directed and was expert advisor on nine Shoreline Management Plans in the UK, totalling some 1500 km of coastline and estuary frontages. Amongst these was direction of the Fife Shoreline Management Plan, the subject of his paper in this volume.

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Kevin Joseph Brady MA (Hons) FSA (Scot) graduated from the Department of Archaeology at the University of Glasgow in 1994. After graduation he worked as a research assistant with the Viking and Early Settlement Archaeological Research Project (VESARP). His research involvement includes excavations at the Early Medieval settlement at Tintagel, Cornwall and the Pictish/Late Norse site at Sangobeg. Kevin Brady directed the Coastal Zone Assessment Survey in North Sutherland in 1997. He has also been a leading partner in the Shetland Chapel-site Survey since 1997, and has led major survey seasons in Unst and excavations on the possible monastic site on the sea-stack of Brei Holm off Papa Stour. He is currently undertaking the Bachelor of Law at the University of Glasgow.

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Keith Branigan is Professor of Prehistory and Archaeology at the University of Sheffield. He graduated in Archaeology and Ancient History at the University of Birmingham in 1963, where he became a Research Fellow in 1965 and took a PhD in 1966. In 1966, he was appointed to a lectureship in archaeology at the University of Bristol. When a new Department of Prehistory and Archaeology was established at the University of Sheffield in 1976, he was appointed as its first professor and head of department. For many years he led a double-life in archaeology, researching and publishing many books and papers on both Romano-British archaeology and Aegean prehistory. In 1988, however, he and a group of colleagues from Sheffield began a five-year programme of research in the Outer Hebrides. SEARCH (Sheffield Environmental and Archaeological Research Campaign in the Hebrides) is now in its 14th year and has already published four of a planned series of six volumes reporting on the project's results.

CHRISTOPHER BURGESS

Christopher Burgess has been a professional archaeologist for 12 years. For eight of these years he worked as a self-employed surveyor and project manager on projects primarily for the University of Edinburgh and Historic Scotland. His research interests lie in the settlement and landscape history of the Western Isles of Scotland, and landscape archaeology in general, and he has recently completed his PhD for the University of Edinburgh based on these themes. Since 1998 he has been the Senior Archaeologist for Northamptonshire County Council's archaeological contracting unit, Northamptonshire Archaeology.

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Alastair is a graduate in Geography from the University of Aberdeen. After completing an MSc in Louisiana State University, as a Rotary Scholar he completed a PhD at the University of Edinburgh on the 'Raised shorelines of Jura, Scarba and NE Islay'. He was appointed Professor of Quaternary Science at Coventry University in 1998. He has published extensively in the fields of geomorphology and climate change. In particular he has published many papers on Quaternary sea level changes in Scotland and on tsunamis. His present research interests are concerned with historical climate changes in the North Atlantic region and, in particular, historical archives of Scotland's climate and weather.

TOM DAWSON

Since graduating in 1984, Tom Dawson has worked on a variety of urban, rural and underwater archaeological sites. He spent several years with the Museum of London and has worked on other major projects in Britain. However, his interest in travelling has also led him to excavations abroad, and he has worked in Japan, Italy and France. For two years he worked on the UNESCO excavations at the World Heritage Site of Anuradhapura, Sri Lanka, and spent a further year helping to establish the Sri Lankan National Monuments Record.

He is currently working at the University of St Andrews, where he is making a detailed study of the state of coastal archaeology in Scotland. He has overseen the establishment of The SCAPE Trust, is helping to coordinate Shorewatch and is initiating a variety of projects concerned with eroding archaeological sites.

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Dr Downie holds a fisheries/pollution-oriented marine biology PhD from the University of London (studied at the University Marine Biological Station, Millport, Isle of Cumbrae) and an Honours Zoology Degree, marine biology-oriented, from the University of Aberdeen.

BILL FINLAYSON

After completing his PhD in 1989, Dr Bill Finlayson worked for Edinburgh University's Centre for Field Archaeology (CFA) between 1990 and 1999, latterly as the Centre's manager. During this period he was one of the founder members of the working group based in Scottish Universities looking at coastal archaeology. This reflected his long-term interest in coastal archaeology, particularly in the Mesolithic, where he conducted research on the west coast and in the Hebrides on a number of projects. He is currently the Director of the Council for British Research in the Levant based in Amman, where he is pursuing other aspects of his interest in hunter-gatherers and the transition to agriculture.

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Shannon M. Fraser MA, Dip Post-Ex, PhD, MIFA, FSA Scot, FFCS, was until December 2000 Director of the Council for Scottish Archaeology, a voluntary-sector organisation which aims to promote public awareness of and interest in Scotland's historic environment, and to facilitate participation in Scottish archaeology by a broad range of volunteer groups and individuals. She is currently the Archaeologist for the North-east Region of the National Trust for Scotland, a body which specialises in integrated conservation management of the natural and cultural heritage.

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Alex Hale has been involved in Scottish coastal archaeological research since 1991. He completed a PhD on Scottish marine crannogs at the University of Edinburgh in 1999. He has been involved in two Historic Scotland supported coastal surveys and other coastal environment survey projects. His interests lie in the peri-marine landscape and the evidence of human occupation and use of that environment. He is currently employed as an Archaeological Investigator at the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS).

JIM HANSOM

Dr Jim Hansom resides in Balfron, is married to a secondary school teacher and has three sons, two of whom attend Balfron High School. Jim is a Reader in Geography at the University of Glasgow and describes himself as a coastal geomorphologist with research and consultancy interests in coastal process, erosion, flooding and sea level change issues. He is interested in the environment and environmental education is also an interest. Dr Hansom sits on both the West Areas Board of Scottish Natural Heritage and on its Scientific Advisory Committee.

HEATHER JAMES

Heather F James is currently working part-time for Glasgow University Archaeology Research Division (GUARD) as a Project Manager and is studying for an MPhil in the medieval settlement and landscape of the Kilmartin Glen, Argyll. She took her first degree in Archaeology and Geography at Exeter University and since then has gained many years' experience excavating on a great variety of sites in Scotland, Northern Ireland and England. In particular, she co-directed the excavations of the medieval priory on the Isle of May. She has also worked for the curatorial departments of Dumfries & Galloway and Strathclyde. In addition to the coastal survey discussed in this volume, Heather James has also undertaken a survey of the Northumbrian coast for the County Council. To avoid confusion, she would like to state that she has never excavated in Wales.

GEORGE LEES

George Lees trained in Geology at the University of St Andrews and gained a PhD from Manchester University in 1990 for research into trace fossils. Previously, he was employed as a sedimentologist with the Ministry of Agriculture Fisheries and Food (MAFF) in England, investigating the impacts of dredged spoil disposal at sea and of marine aggregate extraction.

He is currently employed by Scottish Natural Heritage as a coastal advisor with a focus on coastal landforms and processes. He advises, and commissions research, on a range of issues relevant to the natural heritage of Scotland's coastline, including coastal erosion and defence, coastal and marine aggregate extraction, impacts of climate change upon the coastline, and shoreline and coastal management. He is also closely involved with the preparation of interpretive material for coastal sites and with the promotion through various media of Scotland's magnificent coastline.

ANDREW LONG

Andrew Long graduated from Durham University with a BA Hons degree in Archaeology in 1986, and spent the next five years as a freelance archaeologist in London and Scotland. In 1991 he established an archaeological business in Melbourne, Australia, which has grown into one of the key archaeological and heritage consultancy companies in the State of Victoria.

In 1996 he returned to Scotland to undertake the Ullapool to Lochinver Coastal Assessment Survey on behalf of Historic Scotland, and used the opportunity to begin post-graduate research at Glasgow University on the history and archaeology of Achnahaird Sands, which he is presently finalising. His current research interests cover a wide range of topics, including coastal erosion research, the medieval and post-medieval periods in the Scottish Highlands, the archaeological evidence for Scottish culture in Australia, the archaeology of Australian towns, and the use of bark and other arboreal resources in Aboriginal and colonial society in Australia.

Andrew Long is arguably the world's leading (and only) authority on scarred trees as cultural landscape markers.

HAZEL MOORE

Hazel Moore is a partner in EASE Archaeological Consultants based in Edinburgh. A graduate of Trinity College, Dublin, she has worked for the past 15 years as a field archaeologist in Ireland and throughout Scotland. Her work has included extensive coastal survey in the Northern Isles for Historic Scotland and numerous excavations on sites threatened by coastal erosion, ranging from burnt mounds with complex internal structures to multi-period settlement sites in Orkney and Shetland. She has published numerous articles on Scottish prehistory. Her current interests include later prehistoric settlement and society in northern Scotland with emphasis on late Iron Age/Early Medieval land use.

CHRIS MORRIS

A graduate of Durham University, specialising in Anglo-Saxon and Viking History and Archaeology, Christopher Morris began his career as Assistant Lecturer in History and Archaeology at Hockerill College of Education in 1968. He was appointed to a lectureship in Archaeology at Durham University in 1972, and was promoted to Senior Lecturer in 1981. In 1988 he became Reader in Viking Archaeology. He left Durham in 1990 to take up the Appointed Chair of Archaeology at Glasgow University, where he was Head of Department from 1990 until 1999, Convenor of the Faculty of Arts Research Committee from 1992 until 1998, and Senate Assessor on the University Court from 1995 until 1999. He is currently Vice-Principal for Staffing and the Arts-side Faculties. His archaeological fieldwork has been undertaken in northern England, the Isle of Man, Cornwall, Caithness, Sutherland, Orkney and Shetland, and his publications include three monographs on surveys and excavations at Birsay Bay, Orkney and Freswick Links, Caithness, and two edited volumes on Viking and Late Norse archaeology in Northern Scotland and the North Atlantic region. In the 1970s he founded the Viking and Early Settlement Archaeological Research Project (VESARP); the most recent work of this group has been in North Sutherland (including the survey reported upon in this volume) and on chapel-sites in Shetland.

IAN OXLEY

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PHILIP ROBERTSON

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GRAEME WILSON

Graeme Wilson is a partner in EASE Archaeological Consultants based in Edinburgh. He has published numerous articles on Scottish prehistory and has contributed specialist articles on worked bone artefacts. A graduate of Southampton University, he has worked as a field archaeologist throughout the British Isles and abroad for more than 15 years. In recent times he has carried out coastal survey in the Northern Isles and has led excavations in both Orkney and Shetland. He is currently excavating an early prehistoric funerary complex at Berst Ness on Westray. His interests include the Neolithic period in the Northern Isles and the archaeology of play in the Iron Age and later times.