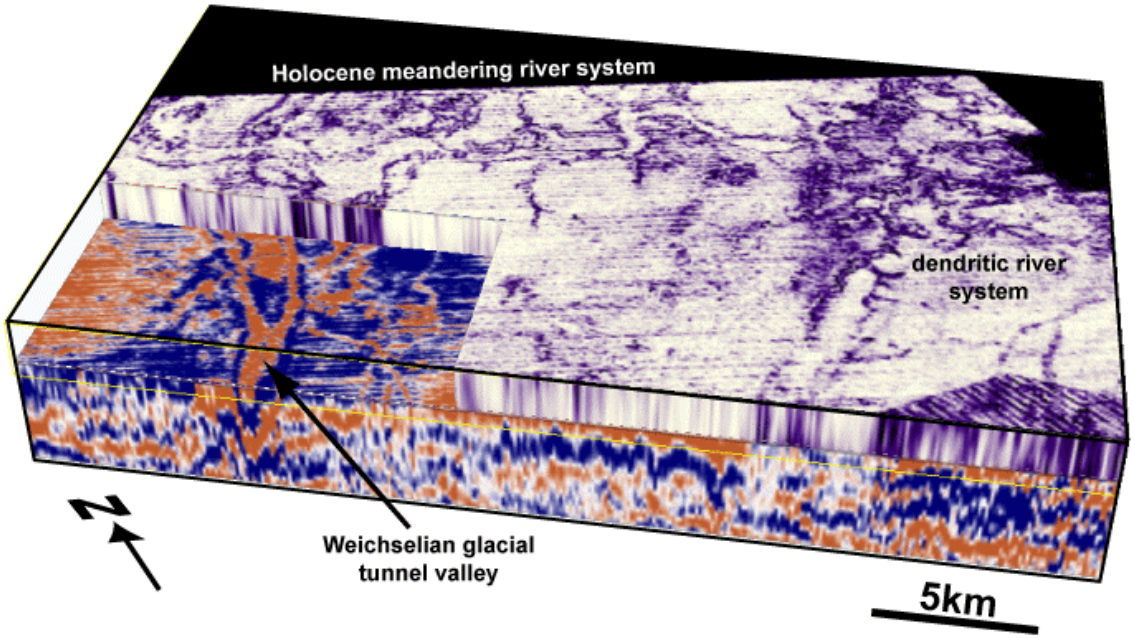
MAPPING DOGGERLAND
The Mesolithic Landscapes of the Southern North Sea



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The Mesolithic Landscapes of the Southern North Sea

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In Memoriam

Dr Kenneth Thomson
(1966-2007)
Pioneer and Explorer of the North Sea

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Foreword

"The middle of the North Sea? Mammoth tusks and flint spears! Looking for Doggerland? All we need is several million dollars worth of your 3D seismic data!"

I am often asked to become part of many research projects, but this phone call from Birmingham was outlining one of the most intriguing. The voice on the phone said "We will come to visit and explain what we want to try to do".

So a few weeks later, we huddled round one of our computer workstations and instead of looking deep down in the seismic data for oil, we applied the latest in petroleum exploration technology to the shallow section. To our amazement, for the first time in thousands of years, the long forgotten surface of Doggerland started to appear. Science does not get more exciting than this and it dawned on us that we were witnessing the start of a new era in marine archaeology.

The project brought together a wide range of people, interests, expertise and technology. The project's achievements, which are of international significance, are a credit to Birmingham University, the team and sponsoring companies for which we are proud to have received a British Archaeological Award. These achievements also stand as a lasting tribute to my friend and colleague Dr Ken Thomson, who tragically died following the project conclusion. His infectious enthusiasm for this project still brings a smile to my face as I remember his phone call to me not so very long ago.

The work will go on in partnership with Birmingham supported by myself, PGS and I hope many other companies.

Huw Edwards (Petroleum Geo Services)
July 2007

Preface

We know that the seas around Britain contain an immense wealth of archaeological sites and remains, potentially without equal elsewhere in the world in terms of their number and diversity. Despite this our detailed knowledge, necessary to promote effective management, is relatively poor and more often than not based on individual sites or find-spots, lacking the opportunity to take a landscape view. Our coasts and seas are also subject to a seemingly ever-increasing rise in development pressure that represents a risk of damage or destruction to the historic environment, which in itself is unique and irreplaceable.

English Heritage is the statutory advisor to the UK Government on England's historic environment, both on land and within the English Territorial Seas and we are committed to:

- helping people develop their understanding of the historic environment;
- working to get the historic environment on to other people's agenda;
- enabling and promoting sustainable change to England's historic environment;
- assisting local communities to care for their historic environment;
- stimulating and harnessing enthusiasm for England's historic environment, land and sea.

The 3D seismics of the Southern North Sea research programme helps us to further these aims through developing new approaches that rely on more partnerships, strategic engagement, speed and flexibility, and clarity and consistency of advice to industry, commercial awareness and customer service. Furthermore, the outcomes of the research described in this volume are of particular benefit to the aggregate extraction industry, clearly justifying our decision to support the programme through the Marine Aggregates Levy Sustainability Fund, of which we are a Distributing Body on behalf of the UK Government.

The research programme is also timely in that we are involved in the intensive development of a new heritage protection regime, introduced by the UK Secretary of State for Culture, Media and Sport in November 2002, that proposes innovative changes to the types of archaeological site that could be protected by legislation to include the evidence of past occupation, or use, by humankind, at a landscape scale (i.e. area designation) regardless of whether the monument lies on land now, or has been subsequently submerged under the Territorial Seas.

The University of Birmingham research also starkly reminds us that, in relation to the latter point, such remains do not in any way respect present-day administrative boundaries, and the submerged prehistory of the North Sea has value for us all. However, the vast subject area (23,000 square kilometres, yet analysed in 18 months) encompasses jurisdictions from Territorial Seas, and Continental Shelves or Controlled Waters, of many countries, with all the complications that brings in relation to legislative powers, management opportunities to further research, amenity and education, for the benefit of all.

The research has been comprehensive: reviewing a range of available methodologies; appraising the geotechnical cores available for ground-truthing; unlocking previously unknown heritage management and research value from legacy commercial seismic data; developing innovative visualisation techniques; integrating marine geological interpretation; incorporating geophysical data, palaeoecological analysis and dating – all at a landscape scale. In total over 690km of palaeo-coastline was observed, together with the interpretation of 10 major estuaries, and extensive areas of salt-marsh, intertidal zone, over 1600km of fluvial systems and 24 lakes/wetlands.

The implications for heritage management are also considered, acknowledging that the data generated are one of the largest samples of a well-preserved submerged Holocene landscape anywhere in Europe, indicating the potential for survival of submerged Early Mesolithic coastal sites (c. 10,000 – 8500 BP) to supplement our sparse terrestrial record. Information on adaptation to coastal change during the later Mesolithic (c. 8500 – 5500 BP) and the increasing insularity of British prehistory can also be obtained.

Finally, this work is more than just of academic interest. Climate change, global warming and sea level rise are all issues in the forefront of everyone's minds now. So as well as exploring and interpreting, in unparalleled detail, one of the most extensive, yet least known, prehistoric landscapes in Europe, this research will lend context and time depth to present day challenges for us all.

Ian Oxley, Head of Maritime Archaeology, English Heritage
July 2007

Acknowledgements

The North Sea Palaeolandscapes Project was a major achievement for all who worked on it but we would like to record here our debt to Dr Kenneth Thomson. Ken was the lecturer in Basin Dynamics at Birmingham, an acknowledged expert on the interpretation and visualisation of seismic data, and a Principal Investigator on the project. Tragically, he died as the project concluded on the 18th of April 2007. To the project staff Ken was a pioneer and an inspiration. To those who knew him beyond the project he remains, in our memories, a great friend and irreplaceable colleague.

Ken, of course, would have recognised that the North Sea Palaeolandscapes Project could not have been attempted without the material and intellectual support of many people and organisations. Our first debt must surely be to PGS Ltd who provided the data used in the original pilot study and the current project study. The kind support provided by Huw Edwards deserves specific mention. The Aggregates Levy Sustainability Fund (managed by English Heritage) provided the financial support without which the project could not have been carried out. Thanks to Kath Buxton, Virginia Dellina-Musgrave and Dr Ingrid Ward for all their help and support over the last two years. Following this, we would acknowledge the work and support of all the members of the project management committee who included; Dr Andrew Bellamy (BMAPA, UMD), Mr Chris Loader (PGS), Dr Virginia Dellino-Mugrave (English Heritage), Mark Dunkley (English Heritage), Mr Huw Edwards (PGS), Dr Joe Holcroft (CEMEX), Dr Justin Dix (University of Southampton), Dr Nic Flemming (University of Southampton), Mr Paul Hatton (Information Services, University of Birmingham), Ms Valerie Scadeng (MCS), Mr Jason Aldridge (MCS), Dr Ingrid Ward (English Heritage).

Professors Geoff Bailey (York) and Martin Bell (Reading) were supportive of the project throughout and assisted greatly in the concluding project seminar when, respectively, they provided the introductory and summary papers.

We would specifically like to thank HP[1] (Dr Martin Walker, Ben Sissons and Nick Hatchard), Mercury Computer Systems[2] (Valerie Scadeng) and Fakespace[3] (Richard Cashmore) for assistance in the launch of this book.

In addition the following provided much needed advice and support:

Mr Graham Tulloch (British Geological Survey), Mr Andy Flaris (BP Exploration Operating Co. Ltd.), Ms Karen Martin (BP Exploration Operating Co. Ltd.), Mr Paul Henni (British Geological Survey), Ms. Lia de Ruyter (Geological Survey of the Netherlands), Dr Ian Selby (Hanson Marine Aggregates), Mr Rob Ingram (Hanson Marine Aggregates), Mr Joe Holcroft (Cemex), Dr Andrew Bellamy (United Marine Dredging Ltd), Dr Ceri James (British Geological Survey), Professor Mike Cowling (The Crown Estate), Dr Mike Howe (British Geological Survey), Dr Colin Graham (British Geological Survey), Miss Claire Pinder (Dorset County Council), Mr Martin Foreman (Hull City Council), Mark Rae (Shell UK Limited), Arthur Credland (Hull City Council), Dr Beryl Lott (Lincolnshire County Council), Eileen Gillespie (British Geological Survey), Rupert Hoare (WesternGeco), Marcia Ritthammer (BP), Mark Bennet (Lincolnshire County Council), Dr Gordon Edge (British Wind Energy Association), Sandra Lane (WesternGeco), Dr Bruno Marsset (IFREMER), Ian Taylor (Boskalis Group), Graham Singleton (CEMEX UK Marine Ltd), Gavin Douglas (Fugro Survey Limited), Ian Wilson (Serica Energy), Dr Chris Pater (English Heritage), Verona Szegedi (ConocoPhillips UK Ltd), Neil Anderton Lynx (Information Systems), Dr Angela Davis (University of Wales, Bangor), John Rowley (British Geological Survey), Carol Thomson (Chevron Upstream Europe), Dr Jim Bennell (University of Wales, Bangor), Mark Martin (Petroleum Geo-Services), Ann Richards (Devon County Council), Georgia Boston (Npower Renewables), Dick Lyons (GEMS-UK), Julie Wallace (Centrica), Matthew Coward (CADW), Katy Whitaker (English Heritage), David Gurney (Norfolk County Council), Serena Cant (English Heritage), Dr Penny Spikins (University of York), Zoe Crutchfield (Joint Nature Conservation Committee), Margaret Stewart (Imperial College, University of London), Professor Greg Tucker (CIRES, University of Colorado, Boulder), Mr Steve Wallis (Dorset County Council), Mr Nick Brown (Norwest Sand and Ballast Co.), Dr Piers Larcombe (CEFAS), John Bingham (TCE/Royal Haskoning UK Ltd), Andy Barwise (Lankelma), Neil Birch (National Wind Power), Brian Ayers (Norfolk County Council), Phil Harrison (DTI), Gwilym Hughes (CADW), Roger Jacobi (British Museum), Malcom Pye (DTI – HSE), Ron Yorston (Tigress), Paul O'Neill (Tigress), Stephen Shorey (Tigress), Dierk Hebbeln (University of Bremen), Tilmann Schwenk (University of Bremen), Hannah Cobb (University of Manchester), Mark Dunkley (English Heritage), Rachel Baines (BGS Digital Licence manager), Joe Bulat (BGS), Paul Henni (BGS), David Long (BGS), Mr Simon Buteux, (University of Birmingham), Professor Geoff Backey (University of Birmingham), Professor Martin Bell (University of Birmingham).

At Birmingham we must record the encouragment provided by the Pro-Vice Chancellor, Professor Geoff Petts, and our respective heads of department, Professor Ken Dowden (IAA) and Professor Paul Smith (GEES). Dr Andy Howard acted

[1] http://welcome.hp.com/country/uk/en/welcome.html
[2] http://www.tgs.com/
[3] http://www.fakespacesystems.com/

as academic reader for the publication. Helen Gaffney formatted the text for publication and also assisted in reading the proofs. Henry Buglass worked assiduously to prepare the illustrations for publication and we thank him for the marvellous job he did. Graham Norrie prepared photographic illustrations for which we thank him. Paul Gaffney and Dr Niall McKeown kindly provided translations for the project abstract. The staff at Birmingham Archaeology were unfailingly supportive throughout the project but we would like to thank Caroline Raynor and Alex Jones specifically. Within the VISTA division we would wish to acknowledge the help and support of our colleagues including Dr Henry Chapman, Keith Challis, Mark Kincey, Steve Wilkes and Meg Watters.

1 Mapping Doggerland

Vincent Gaffney and Kenneth Thomson

Eventually, all things merge into one, and a river runs through it. The river was cut by the world's great flood and runs over rocks from the basement of time. On some of the rocks are timeless raindrops. Under the rocks are the words, and some of the words are theirs. I am haunted by waters.
Norman Maclean (1902-90). A River Runs Through It

1.1 Introduction

The inundated prehistoric terrain of the North Sea basin remains one of the most enigmatic archaeological landscapes in northwestern Europe. This region was lost to the sea over a period of c. 11,000 years following the last glacial maximum and the change in relative sea levels resulted in the loss of an area larger than the United Kingdom (Coles 1998). The region therefore contains one of the most extensive and, presumably, best preserved prehistoric landscapes in Europe (Fitch et al. 2007). Moreover, during the Mesolithic, the period primarily covered by this report, the area was probably an important habitat for hunter-gatherer communities (Morrison 1980, 118). This vast archaeological landscape provides Europe with an immense challenge. How are we to investigate, interpret and manage the heritage of this extraordinary, but largely inaccessible, landscape?

This latter point is of prime importance. Although inaccessible and, in most senses, invisible, the archaeology of the region is as fragile as any terrestrial correlate. In terms of mineral and natural wealth the North Sea basin is a strategic resource for the United Kingdom and all the countries that surround it. Its geographical position ensures that this extensive region also functions as a key infrastructural and communications locus (Fleming 2004, 113 - 117). The area is therefore under intensive developmental pressure from a range of threats including mineral extraction and the direct impact of construction. Specific threats range from the laying of pipelines to, more recently, the development of wind farms, the wider issues of mineral extraction and the extensive, generalised, impact of fishing and commercial trawling (Dix et al. 2004, section 1.4). The implication of such threats, in environmental terms, is probably apparent to most aware individuals and organisations with an interest in the region. However, the significance of the southern North Sea is raised in cultural terms when one considers that whilst the continental shelf retains, arguably, the most comprehensive record of the Late Quaternary and Holocene landscapes in Europe (Fitch et al 2005), this landscape was also extensively populated by humans and at specific periods may well have been a core habitat at a European level (Coles 1998; Flemming 2004).

1.2 The context of study

This potential of the southern North Sea for geological and archaeological research was recognised early, by Sir Clement Reid, in a book on the submerged forests of the United Kingdom published in 1913. Here Reid noted, in a remarkably perceptive paragraph that "*the geologist should be able to study ancient changes of sea-level, under such favourable conditions as to leave no doubt as to the reality and exact amount of these changes. The antiquary should find the remains of ancient races of man, sealed up with his weapons and tools. Here he will be troubled by no complications from rifled tombs, burials in older graves, false inscriptions, or accidental mixture. He ought to here find also implements of wood, basketwork, or objects in leather, such as are so rarely preserved in deposits above the water-level*." (Reid 1913, 9).

Following this promising start, the pioneering work of Sir Harry Godwin on moorlog (peat) deposits associated with the 1931 Colinda harpoon find from the Leman and Ower banks, demonstrated the capacity of these extensive submerged deposits, to provide paleoenvironmental evidence and proved their terrestrial origin, (Burkitt 1932, Godwin and Godwin 1933). Shortly after, Sir Graham Clarke's (1936) seminal work on the "Mesolithic Settlement of Europe" acknowledged the probable settlement potential and the cultural significance of the area. It is notable, however, that these early initiatives were not substantively built upon. Whilst this must have largely been a consequence of inaccessibility of the archaeological deposits Clement Reid (1913, 3) also, presciently, predicted that "*the archaeologist is inclined to say that* [these deposits] *belong to the province of geology, and the geologist remarks that they are too modern to be worth his attention; and both pass on."* The demise of active archaeological research across the North Sea basin from the mid twentieth century was paralleled by the marginalisation of the presumed archaeology of the area. Whilst not denying that some archaeologists were aware of the archaeological potential of the region, the area was increasingly interpreted or represented as a land bridge from mainland Europe to Britain (Coles 1998). The largely unspoken implication was that the inundated area was unimportant in cultural terms (Coles 1999, 51). In many ways it might be said that there was a spiral of indifference towards the archaeology of the region.

Figure 1.1 Hypothetical maximum extent of Doggerland (redrawn from Coles 1998)

Figure 1.2 Early Holocene Doggerland (redrawn from Coles 1998)

More recently, the significance and potential of the archaeological and geomorphological record of the southern North Sea has become an emerging academic interest (Flemming 2004). Within archaeology this phenomenon can be traced directly to the 1998 review article by Professor Bryony Coles, "Doggerland: a speculative survey" (Figure 1.1 and Figure 1.2). After Coles, Dr Nic Flemming has worked unceasingly on promoting the archaeology of the area, most notably through his recent edited volume on the archaeology of the region (Flemming 2004). The ALSF-funded assessment of the archaeological potential of the British continental shelf by Dix et al. (2000) also provided a significant context for further research around the coast of Britain.

However, the fundamental consequence of these publications has actually been an increasing awareness of the deficiencies of our knowledge of the North Sea in terms of the nature or extent of the archaeological deposits of the region. Such sentiments have, more recently, been echoed in the contents of a series of Department of Trade and Industry regional strategic environmental assessments, or "SEA" volumes, for the mainland British marine territories (Flemming 2002, 2003, 2004b, 2005; Wickham-Jones and Dawson 2006).

The lack of knowledge associated with the North Sea Holocene surfaces was so profound that, as recently as 2004, Flemming noted that the inundated landscapes of the Southern North Sea were essentially *terra incognita*. This profound lack of knowledge was maintained despite the results of geological studies that suggested that sediment in the area that might be associated with human occupation achieved depths of 1 to 5m thick and, locally, a maximum thickness of 30-40m (Laraminie, 1989). The potential of these substantial, unexplored deposits has been underscored by the significant number of human artefacts and mammal remains that are often trawled or dredged from the region (e.g. Van Kolfschoten T. and Van Essen 2004). It is usually assumed that such finds originated from eroding or disturbed seabed deposits (Flemming, 2002; Glimmerveen et al. 2004). Flemming (2002) suggested that richer environments for the origin and preservation of archaeological materials could include Holocene fluvial valleys and the Outer Silver Pit, a vast sea inlet which existed to the south of the Dogger Bank from 8,000 - 7,500BP.

These general impressions were supported by the increasing density of sites located around contemporary coasts that, presumably, can be extrapolated onto inundated coastlines beneath the North Sea. This information, clearly suggests that the lack of material associated with deeper waters indicates an absence of evidence rather than evidence of absence (Fischer 2004, figure 3.3; Pedersen et al 1997). The paradox of the North Sea, therefore, is that although the environmental and cultural potential of the region remains largely unknown, it may still be correct to suggest the landscape archaeology of the region is significant at a global level (Mithen 2003, 154-157). Sourcing inundated deposits, and thereby providing an option to protect surviving archaeology, is a key, but problematic goal.

1.3 Previous methodological approaches

If our knowledge of the archaeological deposits of the North Sea is so tenuous, it might be hoped that the larger geomorphological context of the region offers the opportunity to make general observations on the potential nature of preserved archaeological deposits. Unfortunately, although the North Sea has been the subject of extensive exploration for a variety of commercial or academic reasons for decades, this is probably not the case. Our current understanding of the morphology of the Holocene landscape of the southern North Sea is largely based on bathymetric data. This is supported by considerable exploratory activity by the geological services of countries bounding the sea and commercial groups seeking to exploit the area. Work by Jelgersma (1979) produced a series of highly influential maps for the major changes in the coastline from 18,000BP to 8,300BP and, significantly, noted the formation of an island at the Dogger Bank around 8700BP. An attempt was then made to place this landscape within a cultural context by Coles (1998) who dubbed the emergent plain "Doggerland". This work contained hypothetical reconstructions of the coastline from the Weichselian maximum through to 7000BP, but was ultimately based on the earlier study by Jelgersma. Whilst this approach has provided an overview to the area it remains true that the palaeogeography of the region remained lacking in critical detail. Researchers, including Lambeck (1995), Shennan (2000), Shennan and Horton (2002) and Peltier (2004), have used isostatic rebound models to help constrain and improve the present bathymetry-based models. This has resulted in minor modifications to current coastal models but the lack of detail within the landscape (e.g. the location of fluvial systems, details of coastline etc), and the failure to incorporate late Holocene and recent sedimentation, still remain significant issues (Bell et al 2006, Box 1, 14). In so far as these factors have the effect of masking the true relief of the palaeolandscape it is unlikely that an adequate appreciation of the human landscape can be achieved using data provided by previous studies.

In methodological terms, therefore, the investigation of past marine environments has generally been limited by available data that had serious limitations. These have included:

1. Seabed sampling and shallow coring: These provide high quality chronological, sedimentological and environmental data. However, data is widely spaced and provides a poor spatial framework and thus limits its use in assessing the larger landscape and its archaeological significance or potential.
2. High resolution 2D seismic: Traditional shallow seismic techniques (e.g. Stright 1986; Velegrakis et al., 1999) have provided detailed information on the architecture of sedimentary systems but as the data is generally acquired as a series of 2D profiles, a weak three-dimensional framework is created due to the necessary interpolation between the profiles.
3. High resolution 3D seismic: These data represent a significant advance in imaging shallow geology (Bull et al 2005, Gutowski et al. 2005, Muller et al. 2006), but the centimetre-scale resolution of the data dictates that only small areas (<1km^2) can be realistically surveyed.
4. High resolution bathymetry: This may provide excellent images of the seabed topography and is

capable of providing detailed images of Late Pleistocene and Holocene features that have a bathymetric expression. Whilst bathymetry provides a reasonable approximation for the land surface for the area it can rarely consider, or attempt to resolve, burial of features that may have occurred during or after submersion (Cameron et al., 1992). Consequently, the technique is unsuitable for areas including the southern North Sea and the Irish Sea, where deposition has buried most of the Quaternary and Holocene. The scale of this problem was clearly stated by Dix et al. (2004, 89); "*although modern bathymetry can correlate to surfaces relating to earlier periods, in many instance there may be a significant difference (up to c. > 20 m) between them. This can lead to inaccurate representations of shoreline positions (up to 60 km difference) and past topography can be markedly misinterpreted. The bedrock horizon represents a minimum value that could be used in reconstruction. However, modern bathymetry does not represent a maximum value as processes of erosion may have reduced its height over time*".

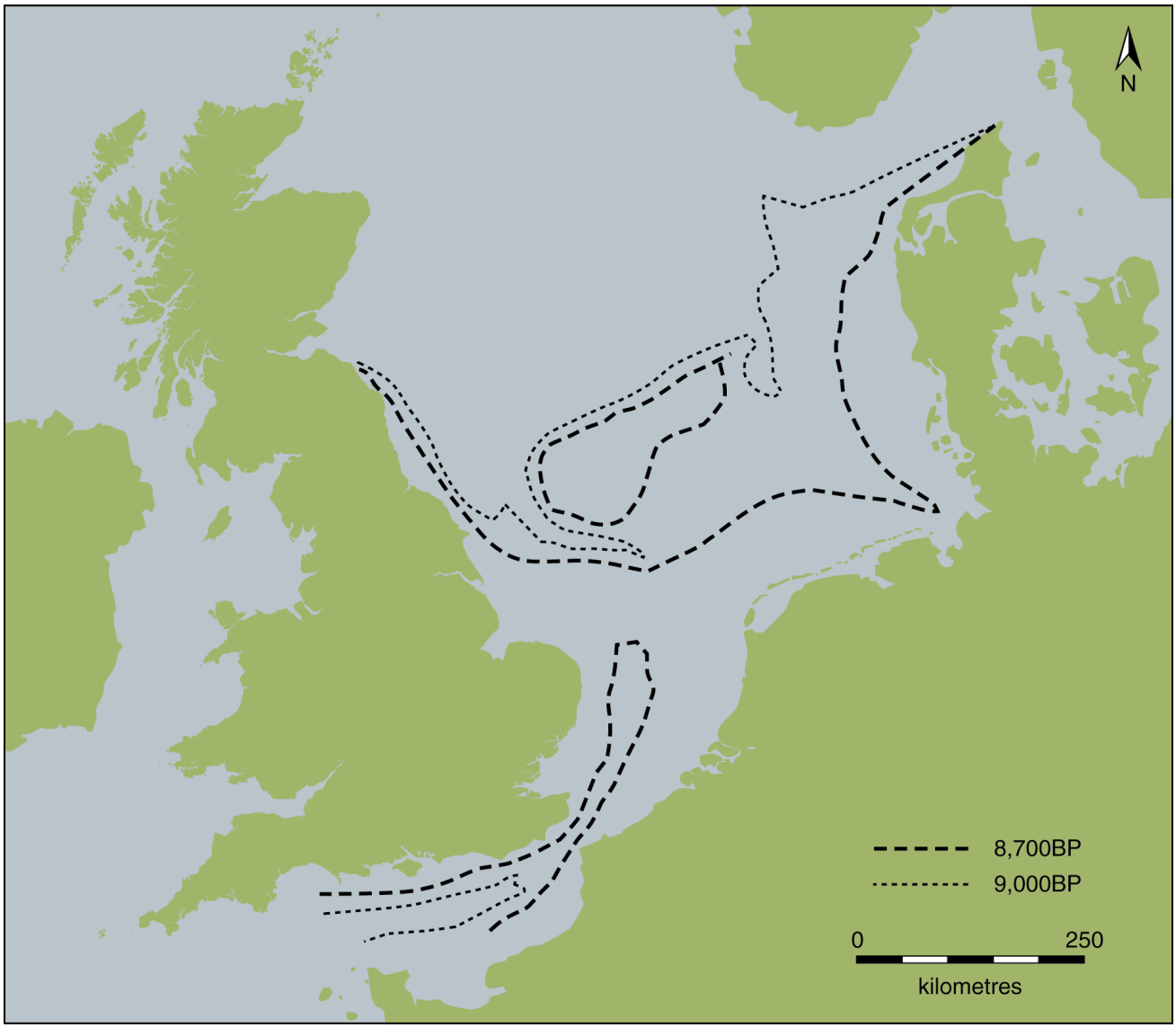

Figure 1.3 Holocene shorelines (after Jelgersma, 1979)

The limitations of these methodologies are also apparent in the archaeological literature. There is considerable interest in the investigation of marine features and the identification of marine landscapes. However, the available technology and scale of archaeological application has tended to restrict studies to the immediate coastal zone and to relatively small, intensively surveyed areas (Mueller et al 2006). Whilst this has been adequate for exploration of

known sites (usually of the historic period, e.g. Paoletti et al. 2005) or micro-regional survey (Pedersen et al 1997), it has largely precluded major landscape exploration. Prior to the current work, therefore, there was no plausible topographic or geomorphological context that could provide a credible proxy indicator for human activity across the former Holocene landscapes of the North Sea.

1.4 Towards an alternative methodology

The impetus and opportunity to develop a methodology using 3D seismic data to deal with this challenging landscape derived from doctoral research carried out at the University of Birmingham by Simon Fitch and under the supervision of the project's principal investigators, Gaffney and Thomson (Fitch et al. 2005). The 3D seismic datasets acquired on the United Kingdom continental shelf for exploring deep geology represent a major resource for understanding Late Pleistocene and Holocene geology. With extensive regional coverage and spatial resolutions of c. 12.5m such datasets provide the opportunity of mapping relatively recent geology at a regional scale and with relative speed. Standard geophysical interpretation techniques usually used on such data to explore deeper features, augmented by volume and opacity rendering, provide significant advantages in reconstructing palaeogeographies and allow the true 3D architecture of Late Pleistocene and Holocene systems to be established (see Thomson and Gaffney, this volume).

The original research at Birmingham coincided happily with an emerging requirement to manage the archaeological heritage in the light of aggregate extraction within the area. Funding for a larger project was made available to the Birmingham team through the Aggregates Levy Sustainability Fund. This fund, administered by English Heritage, seeks to promote best practice in planning aggregate extraction and to provide data to support the protection of our marine heritage that may be impacted by such activities[1]. This serendipitous opportunity permitted the team to develop a methodology centred around the use of extensive 3D seismic data to map Holocene features across a large area of the southern North Sea. A team of three researchers was initially employed to work on this data; Kate Briggs, Simon Fitch and Dr Simon Holford. The papers presented in this volume present the results of this work.

The surfaces investigated as part of this project effectively represents the Holocene landscape inundated between 10,000 and 7,500BP and, in archaeological terms, are associated with the Mesolithic period (Cameron et al. 1992; Jelgersma, 1979; Lambeck, 1995). Given the origin of the data the study area was defined by the extent of available data rather than the probable historic Holocene shorelines (Figure 1.3) or notional areas defined for other purposes (see Cameron et al 1992 for the BGS definition of the Southern North Sea region).

Data for the Southern North Sea is provided through a research agreement between the University of Birmingham and Petroleum Geo-Services[2] (PGS) and we are particularly indebted to Mr Huw Edwards for facilitating access to this information. PGS MegaSurveys are based on seismic data that have been released by oil companies, PGS owned seismic surveys and non-exclusive seismic data made available through other geophysical contractors. Usually these data are available as 3D time migrated seismic surveys. Although quality controlled the different age and data acquisition methods used to collect data demand that the seismics vary in quality[3].

Figure 1.4 illustrates that these data exist as a significant continuous data source across much of the Southern North Sea. Whilst the data does not currently stretch coast-to-coast the total full-fold area of coverage of the Southern North Sea Megasurvey is in excess of 23,000 km² and represents more than 60 original 3D surveys belonging to 20 different data owners. Altogether, this data set represents the largest available data source for the exploration of the palaeogeography of the Southern North Sea region and, in archaeological terms, constitutes the largest contiguous archaeo-geophysical survey programme ever attempted. The work also follows the tradition of seismic study and large-scale archaeological remote sensing projects managed at Birmingham (Gaffney et al. 2000, Thomson 2004, Barratt et al. 2007).

Within this context, the specific aims of the project were:

- To use the existing 3D seismic datasets acquired on the United Kingdom continental shelf for exploring Late Quaternary and Holocene geology over an area of the Southern North Sea.
- To provide maps of the recent geological sequence at a regional scale.
- To provide detailed digital mapping of the topographic features of the region and to use voxel rendering to allow the true 3D architecture of Late Quaternary and Holocene systems to be established.
- To compare the Holocene topographic data with available core and borehole data to ground truth data and calibrate results.
- To provide a model of survival potential for environmental and archaeological deposits within the area of the Southern North Sea to be used by the aggregates industry to plan extraction and mitigation strategies.
- To use data on environmental and archaeological potential to provide an extensive depositional

[1] http://www.english-heritage.org.uk/server/show/nav.1315

[2] : http://www.pgs.com/)

[3] http://www.pgs.com/business/geophysical/research/library/mc3d/dbaFile7567.html?1=1&print=true

map of the Southern North Sea for use for aggregate developmental purposes.

- To utilise seismic attribute analysis to map depositional systems in detail and to make calibrated lithological predictions that may be used in aggregate deposit modelling.
- To provide palaeocoastline data, which may be used in the development and calibration of current sea level and palaeobathymetry models.
- To disseminate knowledge of the methodology and outcomes of the project for the purposes of supporting and developing the aggregate industry and management of the mineral resource.

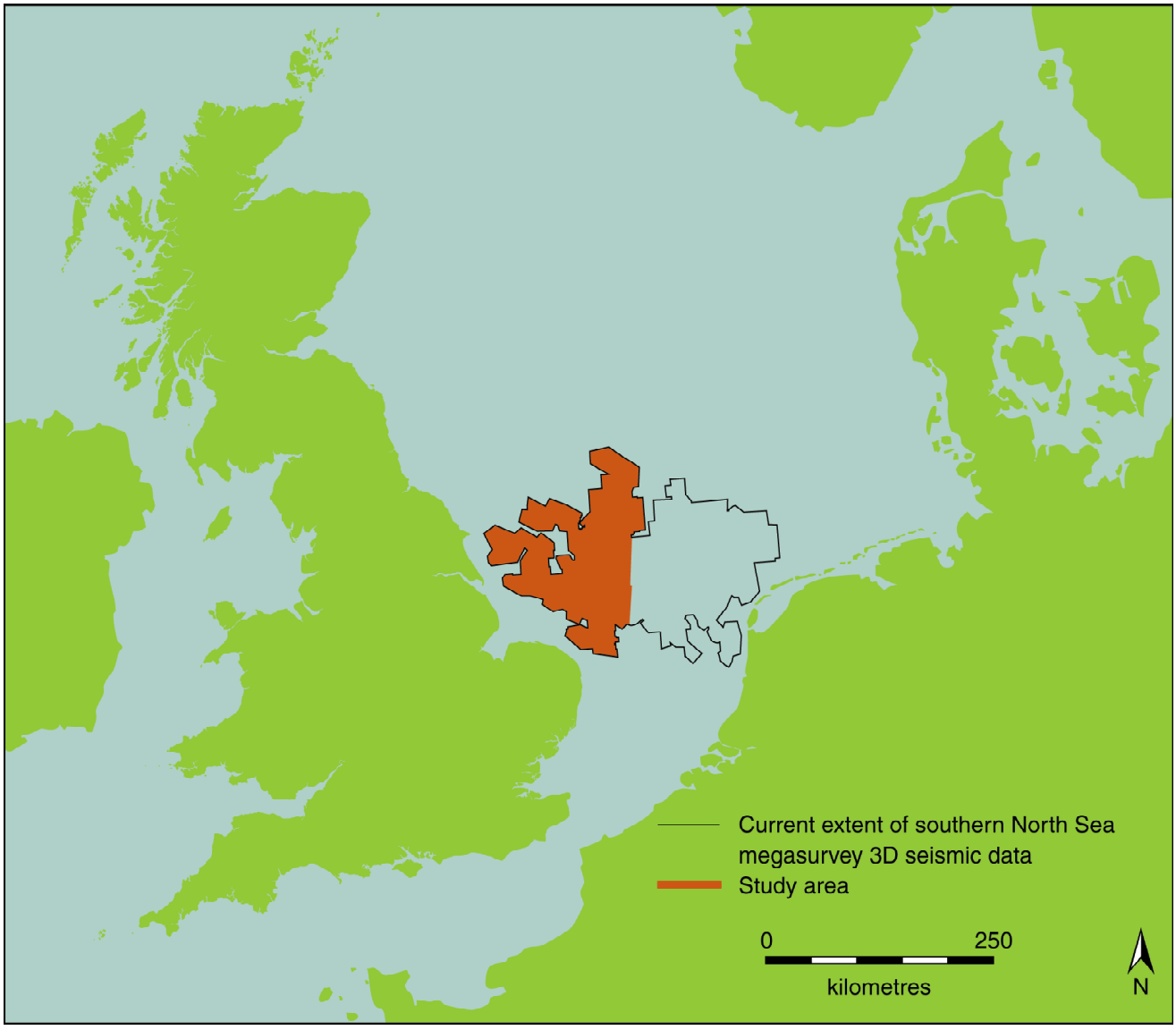

Figure 1.4 Current extent of Southern North Sea Megasurvey 3D seismic data (source PGS http://www.pgs.com/business/products/datalibrary/nweurope/southernnorthsea/snsmegasurvey/)

A full description of the technologies utilised to explore and integrate the available seismic data is provided in the papers by Thomson and Gaffney and Fitch et al. (the atlas, this volume). It is enough to note here that the significance of the first results of this work was rapidly appreciated, and that mapping of the area proceeded apace, as is demonstrated in the atlas paper by Fitch et al. This is complemented by papers from Briggs et al. and Holford et al. (this volume) that demonstrate the detail of specific geomorphological structures, including the nature of internal features identified within the Outer Silver Pit.

It is true, however, that as the project proceeded there was an increasing concern within the team concerning not so much the extent of available supporting data (including 2D seismics lines, cores etc) but the quality, or even availabil-

ity, of some of this information. In particular, spot-checking of cores for environmental potential suggested that the description of core data was, in some cases, misleading and that the environmental potential of some samples might have been compromised by their storage (Smith et al. this volume). Consequently, a project variation was submitted to English Heritage that supported a data audit to assess the extent of available 3D coverages, the availability of other supporting datasets and their potential for research. Dr Mark Bunch was employed for these purposes and the results of this important work are presented in summary within this volume.

In providing this extended introduction it is worth considering the wider significance of this study. Initially, it should be stressed that this volume represents our initial, tentative steps towards providing a robust methodology for the investigation of deeply buried and inundated historic land surfaces. The results of the North Sea Palaeolandscapes Project are, we firmly believe, a major contribution to our understanding of the Holocene land surfaces of the North Sea. From a methodological perspective this is of enormous significance. However, the Holocene landscapes discussed here do not represent the total of available data for the British continental shelf. Comparable areas of submerged, but previously habitable landscapes, can also be found in the Black Sea (Ryan and Pitman 2000; Ballard et al. 2000), the Florida Gulf (Stright 1986; Faught 1988; Marks and Faught 2003; Faught 2004), the Gulf of Arabia (Lambeck 1996) and a number of other regions of the world (e.g. Dortch 1997; Bailey 2004), many of which have also been subject to extensive exploration for mineral extraction. The work presented here is therefore replicable elsewhere and, if implemented, the results for regional research are likely to be as exciting and challenging as those derived for the Southern North Sea.

Of course, there is room for development. This project, which lasted for a mere 18 months, would have benefited from a more substantive integration of supporting information, including high resolution 2D seismic data and further core data. Unfortunately, the audit carried out as part of the study suggests that existing data will not always be available or sufficient for the purposes of refinement or ground truthing of results. There is, therefore, a real need for dedicated, expensive ship time to provide new data to ground truth and extend the results of this study.

Despite these observations, the scale of the work and the fact that the landscape transcends national boundaries ensures that, aside from primary archaeological or geomorphological output, the implications of the results are of international significance in terms of heritage management, at the very least. We have presumed, for nearly a century, that the North Sea contained a significant archaeological record but it has always been a challenge to manage a resource that was largely inaccessible, entirely unpredictable and, essentially, a hypothetical construct. The results presented here suggest that this record may be traced, in part, through the reconstruction of the topographic context of the region. As a consequence, the heritage agencies of countries bounding the North Sea may well have to re-assess their marine management strategies in the light of this information. In this context the steps toward a historic landscape characterisation methodology, as described in the final paper of the volume, are we believe an important contribution towards the management of problematic, marine landscapes.

Ultimately, the principal achievement of the project has been to explore and begin to interpret in unparalleled detail one of the most extensive, yet least known, prehistoric landscapes in Europe. Whilst our knowledge remains imperfect the area is no longer the “terra incognita” pondered upon by Flemming less than 3 years ago (Flemming 2004). Indeed, in the light of our previous lack of knowledge, the scale of the work carried out by this project is truly startling. The analysis of 23,000 square kilometres of seismic data is comparable to carrying out a geophysical survey over a country the size of Wales. It is a cliché to assert that the past is a foreign country. However, in the case of the North Sea Palaeolandscapes Project, it is hardly hyperbole to assert that, along with the outstanding contributions of Coles, Flemming, Dix and others, the project has effectively begun to provide the archaeological outline of a previously undiscovered European realm.

The final point to be made is more emotive. The loss of extensive late Pleistocene and Holocene landscapes, after the last glacial, represents the only previous period during which modern man experienced the impacts of global warming at a scale predicted for the next century. The North Sea Palaeolandscapes Project provides quantitative and visual evidence for the nature and significance of such change. The recreation of the Mesolithic landscape and coastline may, ultimately, be factored into improved coastal models and this is a practical and desirable outcome. We should not forget, however, that this was a populated land. The loss of such extensive areas, insidious and slow overall but terrifyingly fast at times, must have been devastating for the Mesolithic populations of the great northern plains. The coastlines, rivers, marshlands and hills mapped during this project were, for thousand of years, parts of a familiar landscape to the hunter-gatherers of northwestern Europe. The land and its features would have been named; some areas might have been revered and held personal associations or ancestral memories dear to these peoples. It is almost impossible for us now to comprehend the demise of environments and ecologies that supported communities, tribes and entire peoples. Whole territories may have disappeared within the memory of a single generation, and the stress to the indigenous populations is beyond our experience (Mithen 2003). The memories and associations of cultures disappeared, with the landscape itself, as sea levels rose and the land retreated.

As this project concludes, the UN Intergovernmental Panel on Climate Change is finalising its report on the nature, scale and implication of global warming

(http://www.ipcc.ch/). At such a time, and when climate change, global warming and sea level rise are now accepted as amongst the greatest threat to our lifestyles, the fate of the Holocene landscapes and peoples of the North Sea may yet be interpreted, not as an academic curiosity, but a significant warning for our future.