Europe's Lost Frontiers

Volume 1

Context and Methodology

edited by

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Cover: Eleanor Ramsey

Landing by Ava Grauls (Duncan of Jordanstone College of Art & Design).
Oil and watercolour on Japanese shōji (障子) paper. 413 x 244cm

Landing is about location, ownership, shifting land and shifting borders. The painting was conceived after talking to academics about the space between Britain and Europe, and asking the question: 'How do you paint a forgotten landscape?' Landing was made to travel and interact with different environments and can be folded up and packed away into four boxes.
Ava Grauls 11/08/2021

Dedicated to our Families
For putting up with Doggerland for longer than any families since the Mesolithic

November 2021

Europe's Lost Frontiers

Europe's Lost Frontiers was funded through a European Research Council Advanced Grant (project number 670518). The European Research Council's mission is to encourage the highest quality research in Europe through competitive funding and to support investigator-driven frontier research across all fields, on the basis of scientific excellence. The European Research Council complements other funding activities in Europe such as those of the national research funding agencies, and is a flagship component of Horizon Europe, the European Union's Research Framework Programme.

Contents

Supplementary Data

List of Figures

List of Tables

General Editor's Preface

Europe's Lost Frontiers was the largest, directed archaeological research project undertaken in Europe to investigate the inundated landscapes of the early Holocene North Sea – the area frequently referred to as 'Doggerland'. Funded through a European Research Council Advanced Grant (project number 670518), the project ran from 2015 to 2021, and straddled both Brexit and the onset of the Covid pandemic. Despite suffering the curse of interesting times, nearly 50 academics collaborated within the project, representing institutions spread geographically from Ireland to China. A vast area of the seabed was mapped, and multiple ship expeditions were launched to retrieve sediment cores from the valleys of the lost prehistoric landscapes of the North Sea. This data has now been analysed to provide evidence of how the land was transformed in the face of climate change and rising sea levels.

This volume is the first in a series of monographs dedicated to the analysis and interpretation of data generated by the project. Here, as a precursor to publication of the detailed results, we present the historical context of the study and method statements. The following volumes will present the mapping, palaeoenvironment, geomorphology and modelling programmes of Europe's Lost Frontiers. Several supplementary volumes based on the works of postgraduate researchers will also be published prior to a final synthetic publication.

The results of *Europe's Lost Frontiers* confirm that these landscapes, long held to be inaccessible to archaeology, can be studied directly. *Europe's Lost Frontiers* will provide benchmark data for future research on the environmental and cultural heritage of Doggerland. Access to such data will become increasingly important. As this volume goes to press it is clear that contemporary climate change, and the rush for green energy, is pushing development within the North Sea at an unprecedented rate. At the point when archaeologists are finally able to access this unique heritage landscape, the opportunities to do so may be significantly limited in the future. In the face of such change, academics, developers and curators must work together to assist green development, and also continue exploration of Europe's largest and best-preserved prehistoric landscape, Doggerland, before that chance is lost.

University of Bradford
November, 2021

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Chapter 1

Europe's Lost Frontiers: context and development

Vincent Gaffney and Simon Fitch

From bank to bank the waterstrife is spread
Strange birds like snow spots o'er the huzzing sea
Hang where the wild duck hurried past and fled
– On roars the flood – all restless to be free
Like trouble wandering to eternity
John Clare, The Flood (1830)

All large research projects have a history, and *Europe's Lost Frontiers* (ELF) is no exception. Funded through a European Research Council (ERC) Advanced Grant between 2015-2021, the project finds its roots within a long tradition of research related to the extensive, previously habitable, yet initially hypothetical archaeological landscapes preserved beneath the North Sea (Coles 1998; Gaffney *et al.* 2009; Walker *et al.* this volume). Setting aside the arcane historiography of marine palaeolandscapes, the previous two decades have witnessed an exponential rise in awareness of the archaeological potential and significance of these areas; essentially following publication of Professor Bryony Coles' seminal Doggerland paper in 1998. Consequently, the specialist literature associated with the subjects is now substantial. Of specific note are the outputs of another European-funded research initiative – 'SplashCOS', the *Submerged Prehistoric Archaeology and Landscapes* of the Continental Shelf network. Alongside an online database of sites (The SPLASHCOS Viewer (http://splashcos.maris2.nl/ or http://splashcos-viewer.eu/), the network provided invaluable syntheses of recent research across Europe and beyond. SPLASHCOS publications also provided important comparative data on the necessary legal frameworks within which work is undertaken on marine palaeolandscapes (Bailey *et al.* 2017, 2020; Fischer *et al.* 2019; Flemming *et al.* 2017; Harff *et al.* 2016). The emergence of a series of research frameworks related to these studies is also noteworthy, and the 2009 and 2019 iterations of the 'North Sea Prehistory Research and Management Framework' (Peeters *et al.* 2019), the CBA's Maritime Research Agenda (Ransley *et al.* 2013) and Historic England's Maritime and Marine Historic Environment Research Framework: Resource Assessment (2011 and updated in 2013) are worth emphasising in this context. However, whilst this increasing corpus of data will be considered in future *Europe's Lost Frontiers* publications, the topic is tangential to this chapter. Here we are concerned with providing a description of how *Europe's Lost Frontiers* was conceived and planned, as well as the changes in direction that occurred during its operation (Gaffney *et al.* 2017).

Against the general backdrop of research and development activity within the UK, it will be apparent that *Europe's Lost Frontiers* essentially sprang from the results of a series of interrelated research projects and one pilot project. The key, underpinning research projects were the *North Sea Palaeolandscapes Project* (NSPP), the *West Coast Palaeolandscapes Survey* (WCPS), the *the Between the salt water and the sea strand* (BSSS) project – funded by the American National Oceanic and Atmospheric Administration (NOAA), and the *Humber Regional Environmental Characterisation* (Humber REC). Aside from the BSSS, all of these projects were supported by the Marine Aggregates Levy Sustainability Fund (MALSF 2010; English Heritage and Atkins Heritage 2009). Two projects, the NSPP and WCPS, were run through the Visual and Spatial Technology Centre (VISTA, Birmingham Archaeology), prior to the dramatic reduction of archaeological staff at the University of Birmingham, and not long before the funding of *Europe's Lost Frontiers* at the University of Bradford (Fitch *et al.* 2011; Gaffney *et al.* 2007; 2009; WCPP 2011A; WCPP 2013; Young 2012). BSSS was funded through NOAA's Office of Ocean Exploration and Research. The Humber REC was one of a number of regional plans funded through the MALSF and DEFRA, led by the British Geological Survey and including a number of NSPP staff (Tappin *et al.* 2011). A pilot project, directly linked to the successful application for Europe's Lost Frontiers, involved the experimental application of emerging sedaDNA technologies to marine sediments (Allaby *et al.* this volume; Smith *et al.* 2015).

An account of the history of some of these earlier projects has been published previously (Gaffney *et al.* 2009). Here it is only important to note that the NSPP, undertaken with Dr Ken Thomson (1966-2007 Underhill nda), pioneered the use of legacy 3D seismic data, and specifically use of the Petroleum Geo-Services (PGS) 'MegaSurveys' to reconstruct the primary topographic features relating to the southern North Sea (Thomson and Gaffney 2007). Prior to the NSPP, much of the North

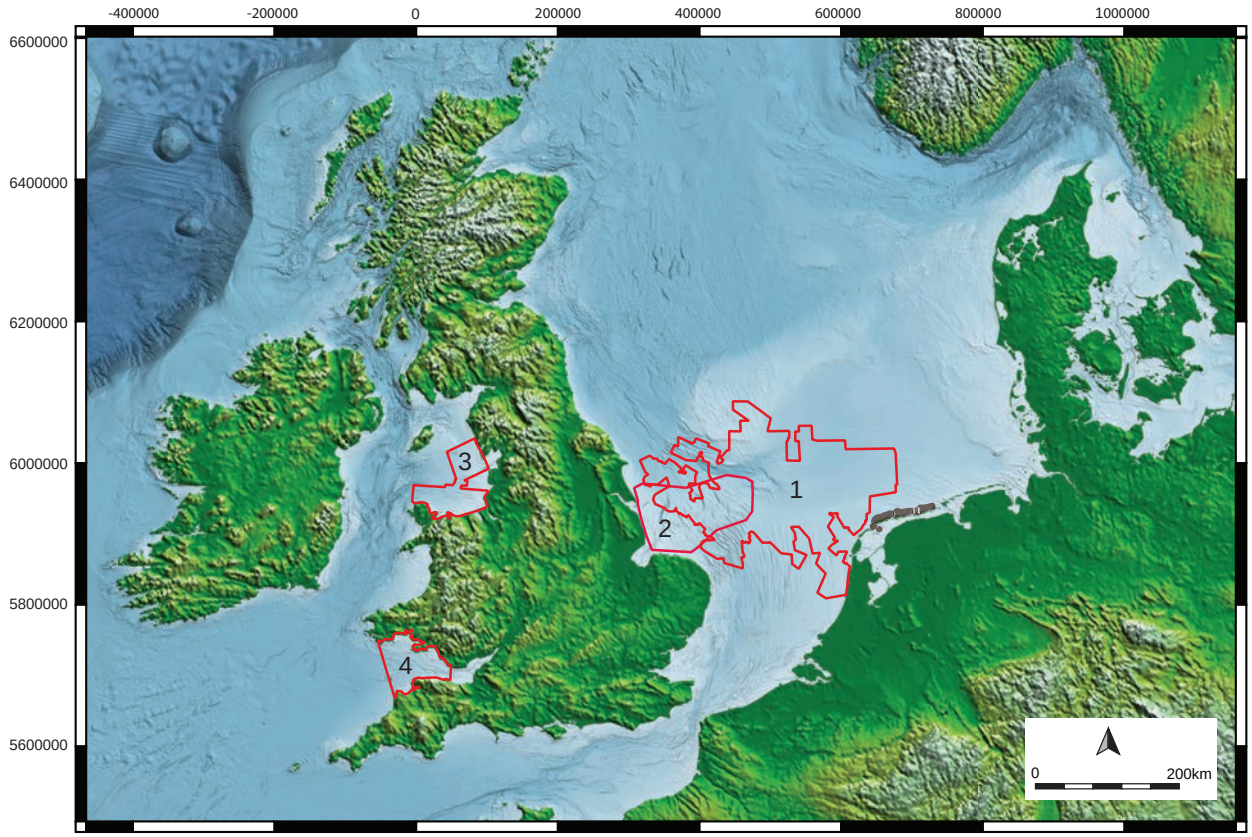

Figure 1.1 Survey areas prior to Europe's Lost Frontiers discussed in this chapter. (1) North Sea Palaeolandscape Project (2) Humber REC (3-4) West Coast Palaeolandscape Project. ASTER DEM is a product of METI and NASA. ETOPO2v2 is the property of the National Geophysical Data Centre, NOAA, US Dept of Commerce.

Sea was effectively a *tabula rasa* in respect of prehistoric archaeology (Amkreutz *et al.* 2018). An original assessment of PGS data, and its use for archaeological purposes, was linked to a doctoral thesis, funded by the Manx Department of Education and undertaken by one of the authors (Fitch 2011).. For this purpose, PGS kindly provided access to the top second of the merged seismic data over an area of *c.* 6000km^2. Exploration of these data suggested that the initial half second of seismic data was likely to include information on surviving, early Holocene landscapes and that this data could be analysed using the technical resources available at the time (Fitch *et al.* 2007). The initial analysis of this data attracted MALSF funding, and the establishment of the NSPP. The final project study area, made possible by further support from PGS, covered approximately 23,000km^2 of the southern North Sea, and stretched from the East Anglian coast to the Dogger Bank and the North Sea median line. At the time, this was the largest contiguous area of geophysical data ever used for archaeological analysis (Gaffney *et al.* 2007). Mapping the upper land-surfaces of these data, combined with supporting seismic sources (Fitch this volume: chapter 4) revealed a wealth of features presumed to relate to the early Holocene of Doggerland, and included estuaries and salt marshes, regions dominated by freshwater river systems and wetlands, through to coastal plains and areas of rolling hills (Figure 1.2).

The value of such an achievement was widely appreciated and attracted several national and international awards (EAA 2013). One aspect of the research which was less valued in some quarters was the historic landscape characterisation mapping and the threat/uncertainty analysis carried out as part of the MALSF contract (Fitch *et al.* 2007a). Essentially a red flag model, this analysis did not simply highlight areas in which important features were located, it also sought to ascertain areas in which the presence or absence of features was uncertain along with the variable level of threat across the mapped area (Figure 1.3).

The response to such imagery was not altogether positive. On March 23rd 2010, Reuters released a news flash entitled 'Stone Age could complicate N. Sea wind farm plans' (https://www.reuters.com/article/energy-wind-idUSLDE62M12020100323). Whilst heritage is frequently a contested area (Flatman 2011; Silverman 2011), the potential of the results of the NSPP to threaten national economic development was never considered

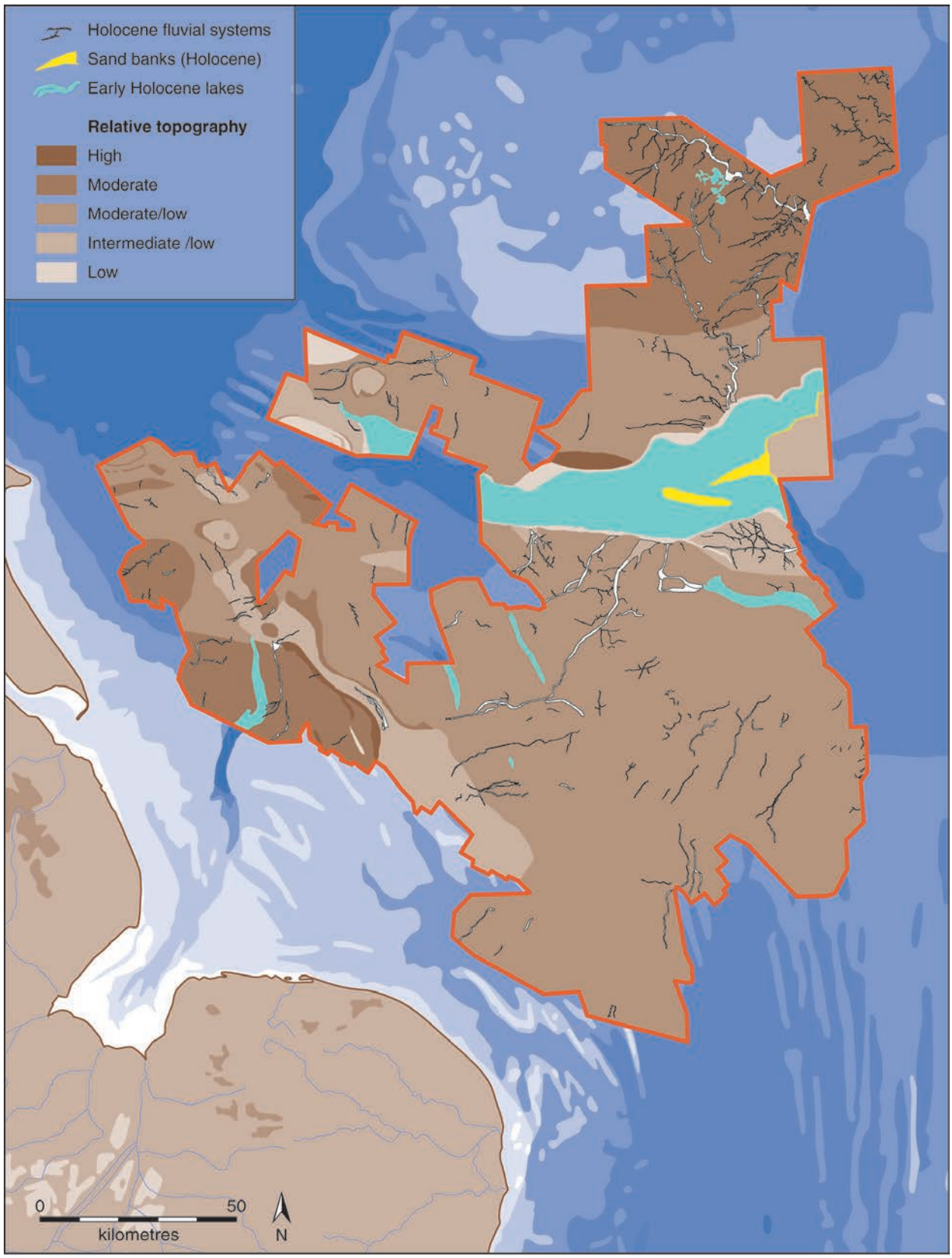

Figure 1.2 Area of Doggerland mapped by the North Sea Palaeolandscape Project (Gaffney *et al.* 2009: Figure 3.23).

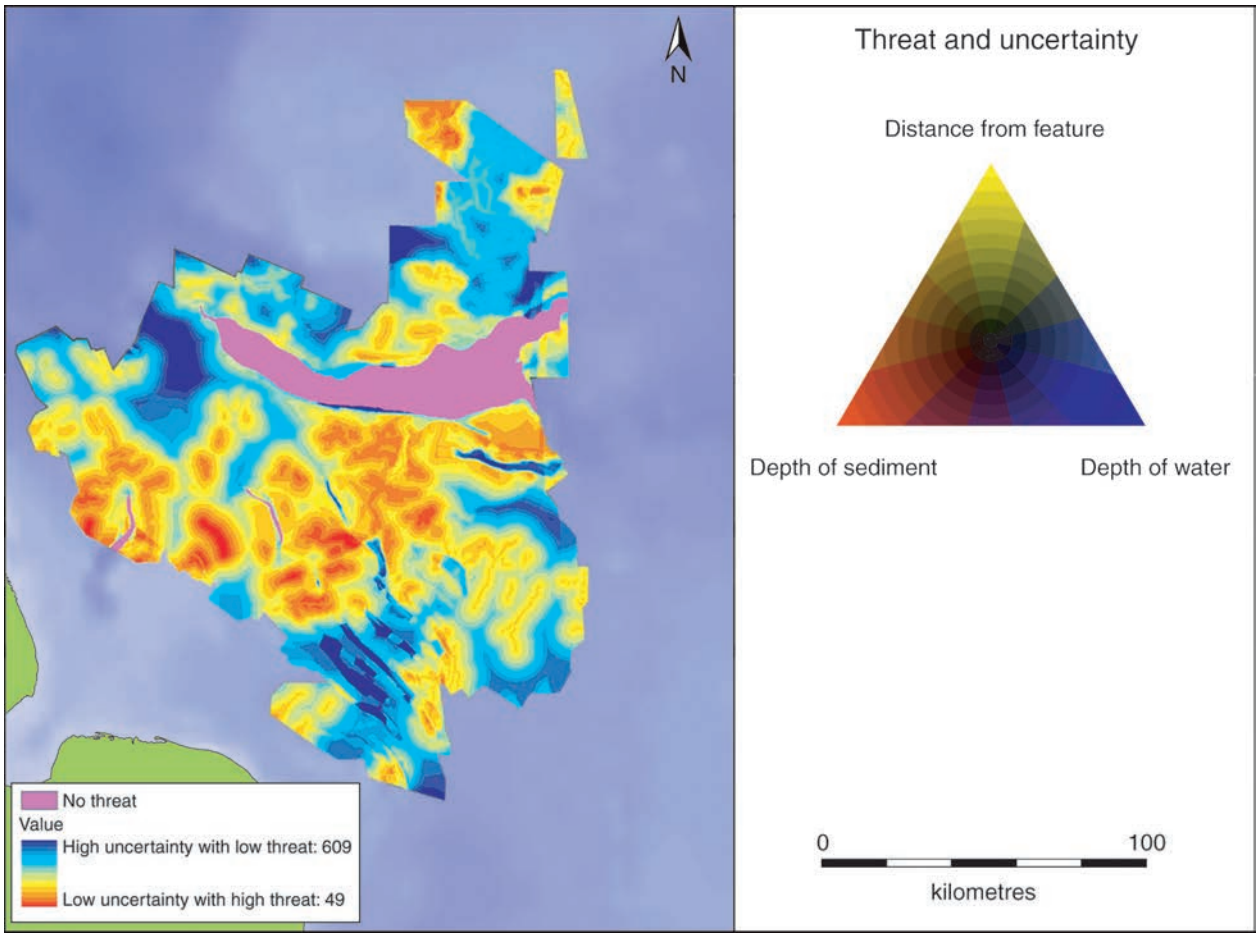

Figure 1.3 Red flag mapping from Gaffney *et al.* (2007: Figure 9.8). This image combines threat and uncertainty data based on distance to feature and depth of overlying sediment. The lack of sediment cover and direct association with identified features with archaeological potential rate as high threats with little uncertainty. Deep overlying deposits lying farther from recorded features rank as low threat areas but with significant levels of uncertainty.

as a likely outcome of the study. This situation changed in 2010 when a national agency contacted the project and asserted that '*the application of your technique is limited to only resolving large scale features which are not obviously related to Mesolithic heritage sensitivity*', and that '*Information in similar adjacent mapped areas suggests that the Birmingham research outcomes may not generally relate to the Holocene and hence not to the Mesolithic or even late Palaeolithic, but potentially earlier events*'. Most telling, perhaps, was the comment that '[we] *believe that there has been a potentially significant mis-interpretation of the late Quaternary geology of the Dogger Bank region by the archaeologists at Birmingham. Ordinarily such differences would not matter unduly, but in this case, there are potentially serious economic consequences for the users of the seabed in the region*' (email to V. Gaffney dated 21/07/2010).

In 2010, a meeting in London was convened with governmental specialists, NSPP researchers and representatives from the British Geological Survey. With the support of English Heritage, as independent chair, the positive role of archaeology in supporting marine development was emphasised strongly, and the validity of the project results asserted. However, it remained true that, whilst there was a technical rationale for the relative dating of the channels mapped by the NSPP, the majority of features remained undated. Moreover, this was a time when the national curator was under considerable stress due to imminent restructuring and, if such assertions had not been successfully challenged, the development of UK marine palaeolandscape research may have been hindered in the short term, at least. If any lesson was to be learned from this fraught exchange, it must have been the importance of working closely with offshore developers and governmental agencies, as well as the dangerous confusion that can emerge if this is not done.

The timing of such a debate was also unfortunate when considered against the attempts by the team to carry out further studies on the UK coastal shelf. The NSPP ran for only 18 months, after which the technical monograph, 'Mapping Doggerland', was published in 2007. A fuller summary of the archaeological

implications of the study was provided at a slightly later date through the semi-popular publication 'Europe's Lost World: the rediscovery of Doggerland' (Gaffney *et al.* 2009). By that time the project team were pursuing funding for further strategic research, and the urgent need to ground truth the results of the NSPP was at the forefront. The first opportunity to undertake such work came through the Humber REC (Tappin *et al.* 2011). Here, the results of the NSPP assisted in planning a vibrocoring programme that provided both dating and paleoenvironmental information from palaeochannels. Survey undertaken as part of the Humber REC '*successfully intersected the feature identified previously by the NSPP and ....it was possible to address the aim of the survey by validating the results of the NSPP by sampling*'. (Tappin *et al.* 2011: 156, Figure 2.5.1 and pages 154-166; Fitch this volume: chapter 4).

A related, important technical issue involved the extent of survey. The utility of 3D seismic data for palaeolandscape mapping was largely proven by the NSPP, but large areas of the United Kingdom seabed have no comparable data coverage. This was most notable off the west and north eastern coasts of Wales and England. Aside from some smaller areas of 3D coverage, as in Liverpool Bay, survey sources were primarily limited to legacy 2D data, such as the UK Coal Board datasets off the Northumbrian coast and other data which is held in the UK's onshore geophysical library (UOKOGL – https://ukogl.org.uk). If the area of study was to be extended to larger sections of the coastal shelf, the project team felt there was a need to assess the potential of 2D seismic data to provide comparable detail to that provided by 3D survey. Funding was provided by the MALSF in 2009 to undertake analysis of collocated 2D and 3D datasets in Liverpool Bay and assess their relative value for palaeolandscape mapping locally and wherever similar data existed around the UK shelf (Fitch *et al.* 2011; Fitch and Gaffney 2011). Finally, as MALSF essentially restricted funding to activities within British waters, separate funding was sought from NOAA and the Qatar Museums Authority to undertake a comparative study of the eastern sector of the PGS Southern North Sea MegaSurvey (*c.* 57,000km^2) and the world's then largest high-definition 3D survey (HD3D) acquired over the Al Shaheen Field, Block 5 (2813km^2, Fitch *et al.* 2011)

The rationale for such international investment in the project in Qatar was made clear by reviewer seven for the NOAA application, who observed that little research of this type had taken place internationally and '*success would have ramifications for study of other shelf areas where these kinds of data may be available or soon will be, such as the US Atlantic coast*'. The study of submerged landscapes across the Americas, whilst advancing rapidly, is still a project in development. A recent publication noted that '*within North America, submerged precontact archaeology is one of the last frontiers in First Americans research, and may rewrite what we think we know about the timing and manner of the peopling of the Americas*' (Gussick *et al.* 2021: 106).

In respect of the North Sea, the completion of these projects brought the team to a significant position. The available mapping was extensive and a vast improvement on previous knowledge, but it was not as such authoritative (Figure 1.4). Fundamentally, there were still large areas in which landscape detail was partial or absent. Although there was confidence that the majority of features might be placed within a broad chronological framework (Table 1), this still represented a palimpsest landscape. The lack of chronological or geomorphological information for most features was a significant issue within an area characterised by inundation and subject to major movements, whether from glacial deformation, salt tectonics or other block movements (Gearey *et al.* 2012; Holford *et al.* 2007; Roberts *et al.* 2018). Another, critical issue lay in an appreciation that, whilst the various programmes of mapping were achievements in themselves, with the exception of the palaeoenvironmental work carried out by the Humber REC, the majority of mapped features existed without any associated environmental or cultural context. Despite this, it was certainly true that our knowledge base was continuously improving. The revived research interest in marine palaeolandscapes in Europe, demonstrated by the work of SPLASHCOS, increasingly provided better access to existing knowledge, and new archaeological and environmental data. The onset of major investment in contractual archaeology in the North Sea also provided access to new data within those areas planned for wind farms and other marine developments (Bailey *et al.* 2020a; Brown *et al.* 2018; Hepp *et al.* 2017; Pater 2020; Peeters and Amkreutz 2020; Prins *et al.* 2019; Sturt *et al.* 2017; Tizzard *et al.* 2014; van Hetern *et al.* 2013). However, the lack of any known early Holocene settlement beyond the intertidal zone was apparent. The absence of extensive, directed archaeo-environmental study across the region necessitated a continuing reliance on chance finds, dredged material or cores acquired for other purposes, for information on landscape use or development across the area (Bailey *et al.* 2020c: 207-8; Peeters *et al.* 2020b: 145, the SPLASHCOS viewer http://splashcos-viewer.eu/). At the onset of this project, Professor Bryony Coles' 1998 observation that we knew almost as little about the early Holocene landscape of the North Sea as Grahame Clark during the 1930s, remained substantively correct (see Walker *et al.* this volume, for a fuller discussion of the archaeological context).

Following the end of the NSPP it was apparent that the provision of a topographic map, whilst not an end in itself, would provide the basis for further exploration. The challenges of working in the deeper marine environments of the North Sea Basin would also require a different approach and substantial funding. The initial

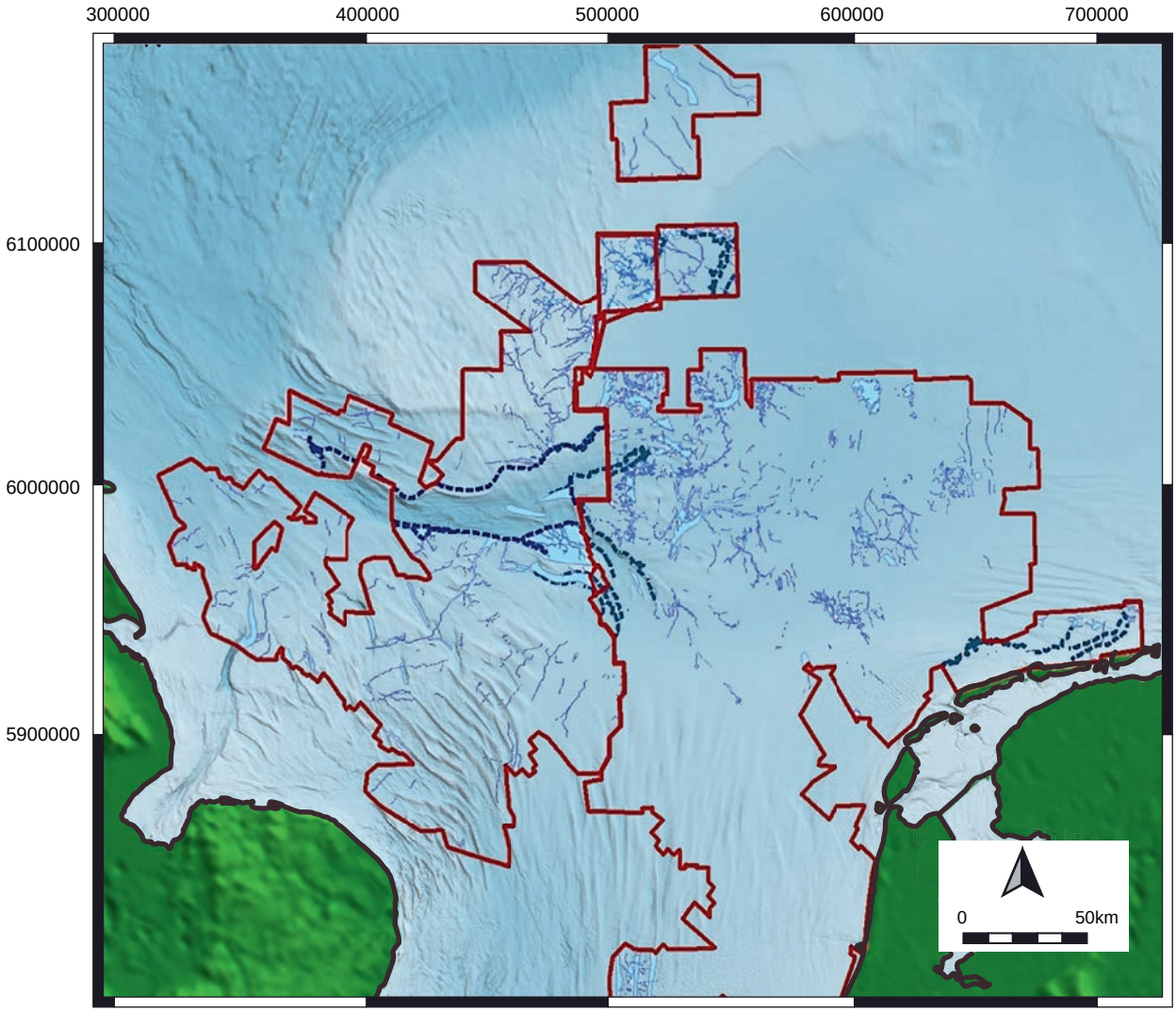

Figure 1.4 Distribution of features located within the southern North Sea during the NSPP and BSSS projects.

development of an ERC Advanced Grant took more than five years and involved three separate applications to the funding agency (in 2010, 2012, 2014). Throughout this period of development, the primary goals of the project were largely consistent. In 2010 these were listed as:

- To produce a near complete topographic map of early Holocene Doggerland using seismic reflection data, fully integrated with other data sources (e.g. sea-level curves, seabed cores)
- To model and simulate, using multi-agent systems inspired by the decentralised, 'bottom up' and emergent phenomenon of nature, possible dynamic scenarios for the geomorphological, ecological and human history of Doggerland
- To use this mapping, modelling and hypothesis generation to inform a programme of seabed coring for palaeoenvironmental and dating evidence which will, along with other proxy data sources, test, or at least constrain, aspects of the models
- To use computer models and simulation-generated data as a basis for real-time, interactive exploration of the virtual landscape, and visualisation of the individual and collective behaviour, and emergent patterns, of the flora, fauna and people affecting the ecosystem
- To provide a robust framework for future research into and management of this extraordinary scientific, heritage and educational resource

Aside from presentational development, between 2010 and 2014 the most significant change within the application was almost certainly the introduction of a major work package related to sedimentary DNA (sedaDNA). This followed an initial meeting with Professor Mark Pallen at the British Association for the Advancement of Science in 2007 which, over time, manifested in a pilot project with Professor Robin

Description	Number	Area in km²
early Holocene basin	1	10
early Holocene channel systems	440	700
early Holocene delta	37	350
early Holocene depression	29	20
early Holocene drier areas within wetlands	20	350
early Holocene high ground	17	200
early Holocene lake	10	150
early Holocene peat beds	8	20
early Holocene sandbank	1	10
EH wetlands	25	550
Last Glacial Maximum channel systems	46	150
Last Glacial Maximum depressions	33	70
Modern sandbanks	26	10
Undated channel systems	36	100
UD depressions	7	30
Undated high ground	3	2
Undated lake	1	20

Table 1.1 Numbers and area of features, excluding coastlines, identified through the NSPP and BSSS projects (2008-2012). After Gaffney *et al.* 2011: Table 5.1

Allaby, analysing sediments from the submarine Mesolithic site at Bouldnor Cliff, off the Isle of Wight in the Western Solent (Momber *et al.* 2011; Momber and Peeters 2017; Smith *et al.* 2015a; 2015b).

The later Mesolithic site at Bouldnor dates between 8030 and 7980 cal BP and is generally considered Britain's best explored, submerged site of Mesolithic date (Momber *et al.* 2021). The results of the sedaDNA pilot study unsurprisingly revealed a wooded landscape that included oak, poplar, apple, and beech, with grasses and a few herbs (Smith *et al.* 2015a). The faunal profile indicated an abundant presence of Canidae and Bovidae (dog or wolf), whilst material interpreted most likely as *Bos* was supported by the find of an auroch bone at the site. The presence of deer, members of the grouse family, and rodents, all compatible with the contents of a Mesolithic diet shared by humans and dogs, was indicative of a later Mesolithic environment. Undoubtedly, the DNA evidence of Triticeae was of considerable surprise and continues to attract discussion (Smith *et al.* 2015b). Neolithic assemblages are not established on the mainland of north west Europe until 7500 BP in the central Rhineland, 7300 BP in the Rhine/Maas delta and adjacent areas, and 7400 BP in western France (Crombé and Vanmontfort 2007; Louwe Koojimans 2007; Marchand 2007; Robb 2013). Consequently, on the presumption that the evidence of DNA is not intrusive, then the source of the *Triticum* signal may come from wheat imported from elsewhere in Europe during the British Mesolithic.

The potential for significant contact between farming and hunter-gatherer communities within the inundated areas of the coastal shelf informed project development. Although the linked issues concerning the final phases of inundation, and the movement of people in relation to the establishment of Neolithic lifestyles, had certainly been of academic interest previously (Coles 1999; Flemming *et al.* 2014; Sturt and Van der Noort 2013), regional investigations of sea-level change had largely been framed in terms of the transition to the current terrestrial context and the impact on the hunter-gatherer environment rather than from hunter-gatherer to farmer societies. This situation existed despite occasional finds of Neolithic artefacts on the seabed, such as the early Neolithic Michelsberg axes from the Brown Banks (Peeters and Amkreutz 2020). These finds had usually been interpreted as votive objects deposited either at sea or at low tide, as gifts to hunter-gatherer ancestors of the inundated plains. However, the position of later prehistoric monuments at the marine interface, such as Seahenge dated at *c.* 2049 BC (Brennand and Taylor 2003), clearly begged the question as to where the earlier Neolithic coastline actually stood and what the implications were in having an enlarged coastal strip during this period (Sturt *et al.* 2017).

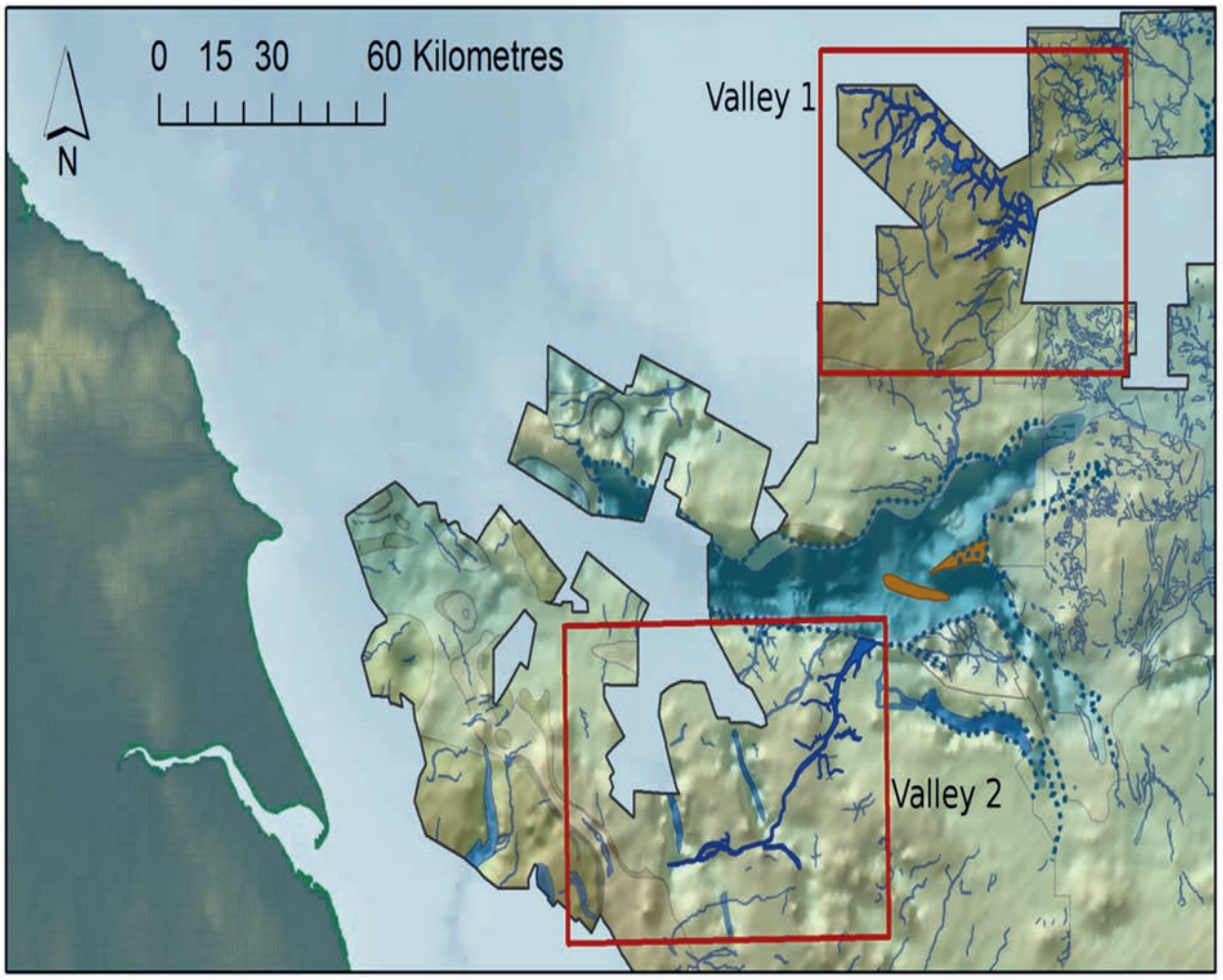

Figure 1.5 Map used in the final ERC application showing course of two submerged river valleys to be targeted for coring by the Lost Frontiers project team, overlaid on NSPP project base map (Gaffney *et al.* 2007).

These results changed aspects of the final, successful ERC Advanced Research Grant that was initiated in December 2015 under the title, *Europe's Lost Frontiers*: *exploring climate change, settlement and colonisation of the submerged landscapes of the North Sea basin using ancient DNA, seismic mapping and complex systems modelling*. The stated goals of the project were:

- How did the early Holocene Doggerland landscape develop in the face of the ameliorating climate and what was the impact of climate-related land loss on the plant, animal and, ultimately, human communities of the North Sea plain?
- At what time did the Mesolithic people of the north west plains make contact with Neolithic technologies and practices, and what form did this contact take?
- Has our view of the Mesolithic – Neolithic transition been drastically skewed by relying predominantly on land-based sites? If so, what changes need to be made to existing theories as a result of the new data?

Alongside these goals were the following primary objectives:

- To produce a near complete topographic map of early Holocene Doggerland, primarily using seismic reflection data fully integrated with other data sources (e.g. sea-level curves, seabed cores).
- To reconstruct the early Holocene environments of Doggerland through conventional means and by using and developing the emerging methodologies for extracting plant and animal DNA directly from sediments cored from the sea-bed
- To explore these data for evidence of the colonisation of plants and animals associated with climatic amelioration, and also for later markers associated with Neolithisation, including non-indigenous flora and fauna

- To model possible dynamic scenarios for the geomorphological, ecological and, by inference, the human history of Doggerland using complex systems simulations.
- To provide a robust, global framework for future research and management of these extraordinary scientific, heritage and educational resource associated with comparable landscapes around the world.

From the onset of the project, the goal to extend the mapping of Doggerland to achieve the maximum coverage possible, and provide a suitable context for simulation studies of environment and, potentially settlement, was clearly a priority. However, a key output from existing mapping was to identify sediment caches with the potential to be cored for palaeoenvironmental data. Aside from simply retrieving environmental samples, the intention was to use such data in support of complex systems modelling to model ecological development.

It is often said that the first casualty of any battle is the plan, and the same might be said when implementing many large archaeological projects. On the basis of earlier mapping, two valleys with incised channels, and therefore the potential to hold accessible sediments, were chosen to act as sampling transects (Figure 1.5). The first valley ran south west to north east out from the Wash and into the Outer Silver Pit Lake and also from the area associated with the Dogger Island into the Outer Silver Pit (Figure 1.5). If correct, coring downstream should have allowed a dating programme to determine the nature and rate of transgression in a consistent manner. A minimum of 100 cores were planned to recover palaeoenvironmental data (sedaDNA, pollen, plant macrofossils, insect remains, ostracods/foraminifera and diatoms) and radiocarbon and OSL samples for 'rangefinder' dates. These data, along with improved, and more extensive seismic mapping, could then be used to build dynamic models of the changing geomorphology and ecology of Doggerland, from the opening of the Holocene around 12,000 BP until its eventual total inundation around 7500 BP (Murgatroyd this volume).

The selection of individual core locations began early in 2016 and was managed by Professor Richard Bates. From the onset, some variation to the proposed programme was required (Figure 1.6). It was apparent that the central section of the longer west to east transect, running from the British mainland, could not be cored in the central section due to the presence of large sandbanks. The core selection was then modified and included a series of transverse core lines in the lower west-east valley draining into the Outer Silver Pit. To the west, a series of cores followed the river channel and a separate transect to the mainland. Individual selection was also guided by the results of survey by the Humber REC. A final transect, intended to follow the path of inundation independent of river channels, was chosen to run from the central section of the main river, south west and towards the East Anglian coast. Individual cores were sited to investigate specific features identified from seismic mapping including one core in the approximate area associated with the findspot of the Leman and Ower point (Clark 1932: 115; Godwin and Godwin 1933).

On the 23rd of June 2016 the United Kingdom voted to leave the European Union. Aside from bequeathing the project with one of the most ironic titles possible, 'Brexit' did cause significant impacts. It was apparent that permissions for licensing in the aftermath of Brexit would present a problem, and that the initial licence would be for a smaller number of cores than planned. A decision was taken to reduce the numbers of cores in the lower courses of the west to east river valley, and to acquire only two cores (ELF019 and 020) from channels south of the river.

The limitation on the numbers of cores that could be taken initially impacted on the overall unit cost of cores across the two planned expeditions, and this led to further changes (Figures 1.7 and 1.8). Although the details of these locations will be provided in a forthcoming volume in the Europe's Lost Frontiers series, here we can note that the second transect running south and west to the coast was abandoned. Further coring on the lower courses of the valley was limited to the Outer Silver Pit estuary. Following discussion with Louise Tizzard and Wessex Archaeology, coring on the Dogger Bank itself was directed to specific channel features: the northern coast and a lake/pingo on the top of the bank. A series of cores were taken on the northern shore of the Outer Silver Pit and opposite the estuary of the main west-east river. However, analysis of the topographic and seismic data south of the main channel, and specifically the data from ELF019, suggested that further coring should include a major transect along a smaller channel which became known as the Southern River. This decision was taken because this channel was accessible and provided the opportunity to sample sediments, from source to estuary, along the whole course of a large river. Whilst the initial coring plan had presumed the acquisition of up to 100 cores, at the end of the project a total of 78 cores from 60 locations were recovered from areas designated as within the original research study area.

Although there were unforeseen variations associated with the two planned coring expeditions, an invaluable characteristic of the ERC Advance Grant is the flexibility such an award offers. The project team were therefore able to follow several research routes that provided additional value to the project (Figure 1.9). One

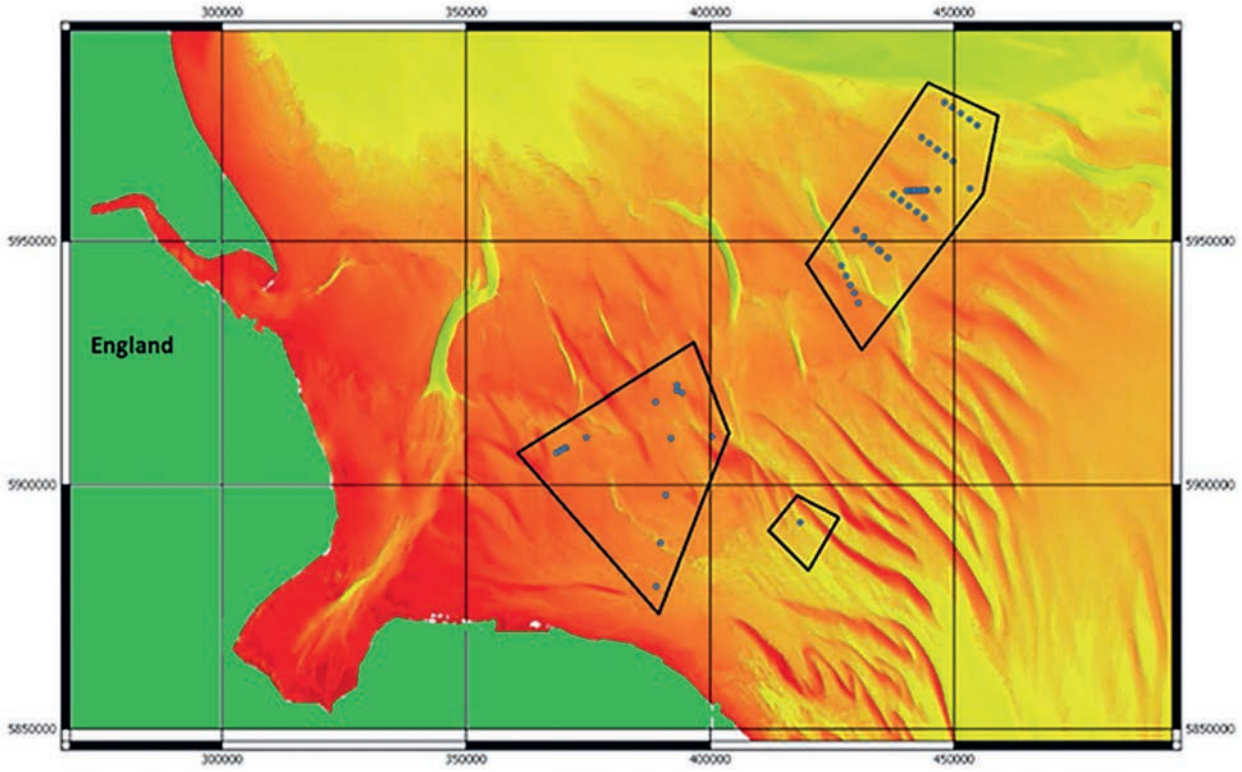

Figure 1.6 Initial modification of the Europe's Lost Frontiers coring programme following funding in 2016.

such opportunity related to the west coast of Wales. Although the North Sea is associated with the largest area of early Holocene, inundated landscape on the European coastal shelf, the archaeological potential of the Irish Sea and the west coast of the United Kingdom is also apparent. Substantive research on intertidal landscapes by Professor Martin Bell (2007) in the Severn Estuary, is of particular note in considering these areas, whilst the evidence for the connectivity of the region both with the adjacent coastlines, the Atlantic shore of Europe and lands beyond has been appreciated for some time (Bradley *et al.* 2016; Brown *et al.* 2018; Cunliffe 2001). However, although the significance of coastlines, in terms of linkage, has been stressed by many (Sheridan 2015: 31; Woodford 2015: 191-205), the literature has tended to concentrate on the evidence for the Neolithic and later periods (Cummings and Fowler 2016). Despite this, the evidence for cross-channel, pre-Neolithic contacts along the southern and western coasts, specifically at the inundated late Mesolithic site at Bouldner Cliff, emphasises the need to provide mapping more broadly along the British coasts (Momber and Peeters 2017; Smith *et al.* 2020).

The initial exploration of the Severn Estuary and Liverpool Bay by the WCPS has been mentioned earlier in this chapter (WCPS 2011; 2013), but further opportunities emerged through a collaborative link with Dr James Bonsall, at the Institute of Technology Sligo, and the Irish Marine Institute. A dedicated survey, using the RV Celtic Voyager, was then planned in Liverpool and Cardigan bays in 2018. Sadly, the appalling weather conditions encountered led to the abandonment of work within Liverpool Bay. Survey of a major river channel in Cardigan Bay was successfully undertaken, although coring proved unsuccessful due to the weather and poor corer penetration. The results of this programme of work will be reported in a forthcoming Europe's Lost Frontiers volume dedicated to remote sensing and landscape reconstruction (Harding *et al.* forthcoming).

2018 also saw the initiation of a collaborative research programme undertaken as part of the 'Deep Sea History' consortium and involving *Europe's Lost Frontiers*, the Flanders Marine Institute (VLIZ), the University of Ghent, the Geological Survey of the Netherlands (TNO), the Deltares Research Institute, Utrecht University and the Royal Netherlands Institute for Sea Research (NIOZ). The initial fieldwork involving *Europe's Lost Frontiers,* was directed at the study of the area known as the Brown Bank. The Brown Bank has long been associated with the recovery of archaeological material; usually found by chance through fishing or dredging and these have included stone, bone and antler artefacts, as well as human remains (Glimmerveen *et al.* 2004; Louwe Kooijmans 1970; Mol *et al.* 2006; Peeters 2011; Peeters and Amkreutz 2020; van der Plicht *et al.* 2016;

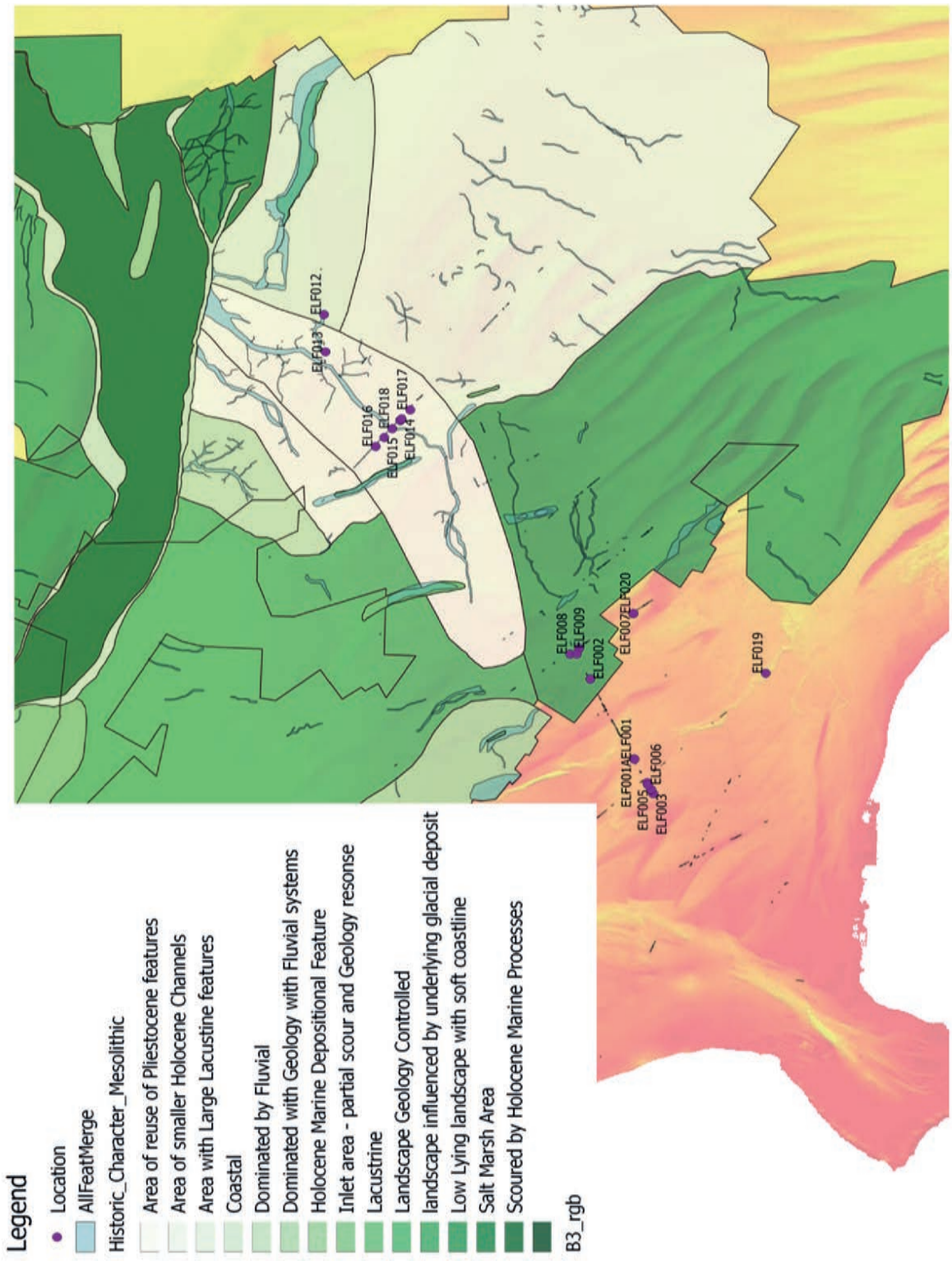

Figure 1.7 Additional modifications to Europe's Lost Frontiers coring programme following BREXIT.

Verhart 2004). Some of the finds are exceptional, such as the find of a cobble mace head, a perforated mattock with remnant of the wooden handle and, unusually, several middle Neolithic polished axes (Peeters and Amkreutz 2020: 160). The concentration, and excellent preservation, of late Pleistocene and early Mesolithic material from several areas across the Bank suggests the material is being eroded from a series of stratified sites or activity zones.

This collaborative programme of work supported three expeditions between 2018 and 2021 and involved research vessels from Belgium (the RV Belgica and RV Simon Stevin) and the Netherlands (the RV Pelagia). The results have provided a significantly enhanced view of the structure of the Banks and indicate areas or eroding peats which may be the source of organic finds (Missiaen *et al.* 2021). The team were also able to mount a short expedition to the Southern River estuary, in support of the mapping undertaken by *Europe's Lost Frontiers.* An area on the estuary was selected for targeted dredging, where it was suspected that erosion might expose archaeological material. Although disrupted by bad weather and poor sea conditions, the few hours of survey available provided the first lithic artefact, a fragment of a hammerstone, found in the deeper areas of the North Sea following directed prospection, rather than as a chance discovery.

As a postscript to this brief description of new surveys undertaken with colleagues in Belgium, Holland and Ireland, it is worth noting that this work was entirely dependent upon the availability of European marine survey vessels and supporting infrastructure. Access to similar resources is simply not available to archaeologists through British research institutions. This situation contrasts strongly with some other North Sea nations. Belgium, for example, provides research vessels to support teams undertaking archaeological exploration, including *Europe's Lost Frontiers*, and will enhance its capacity to undertake such work during 2021 (https://www.eurofleets.eu/vessel/rv-belgica-ii/). If such a situation is maintained this is likely to become problematic for British academics concerned with the cultural heritage of the North Sea. The study of inundated landscapes will become increasingly strategic in respect of our understanding of prehistoric north west Europe, and the requirement to undertake more survey will become urgent if planned marine development across the whole of terrestrial Doggerland takes place (Walker *et al.* this volume).

Aside from new survey programmes it is worth discussing where variation in analytical processes occurred as the project developed. The original ERC application provided for an iterative research methodology with three primary work packages (Figure 1.10). Aside from work package leads, research was supported by specialists contracted through the universities of Bradford and Birmingham, as well as post-doctoral researchers and PhD students based at Bradford and Warwick. The data provided by teams studying seismic mapping, sedimentary DNA and the broader environmental programme was intended to feed into a far-reaching computer simulation exercise. The methodologies associated with specific parts of the analytical programmes are provided in the following chapters, and detailed results of analysis will be reported in forthcoming volumes in the Europe's Lost Frontiers series.

Whilst individual work packages and their components were generally implemented as described in the original ERC application, it is hardly surprising that some variation from the original plan occurred across the five years of research. Most of the individual work packages provide some examples of internal development (Cribdon *et al.* 2020; Missiaen *et al.* 2021; Murgatroyd *et al.* forthcoming). However, it is important to appreciate that disruption and variation to the coring programme impacted upon the project structure and timetable, and the COVID pandemic, significantly delayed analysis and reporting from individual researchers. The extent of these impacts was such that a 12 month 'no-cost' extension was granted to the project by the ERC, extending the project span from its original end date in 2020 through to November 2021.

Undoubtedly, disruption to the project timetable resulted in some negative impacts on the project, and, to a degree, research activity was inevitably more responsive than iterative. However, the addition of Dr Martin Bates to the team, at a relatively early stage, did much to ensure that any variation in the coring plan, and the results of the delayed environmental programme, were supported within an appropriate geomorphological framework, and that the results supported the work of the larger research team (Bates *et al.* this volume). Research methods that were not within the original programme were incorporated as opportunities arose, e.g. palaeomagnetic studies (Harris and Batts this volume). Other techniques, such as the application of geochemistry to the core samples, developed as the project progressed. The addition of Mohammed Bensharada, as a postgraduate student, and Dr Alex Finlay (Chemostrat) to the research team added significantly to the project's analytical capacity (Bensharada *et al.* this volume, Finlay *et al.* this volume). The role of geochemistry as an integrative technology was demonstrated clearly within project's paper on the Storegga tsunami deposit in core ELF01A (Gaffney *et al.* 2020). Alongside the collaborative research links described above, the project attracted external academics to work with Europe's Lost Frontiers researchers. The placement of Dr Merle Muru, through the good offices of Dr Alar Rosenthau (University of

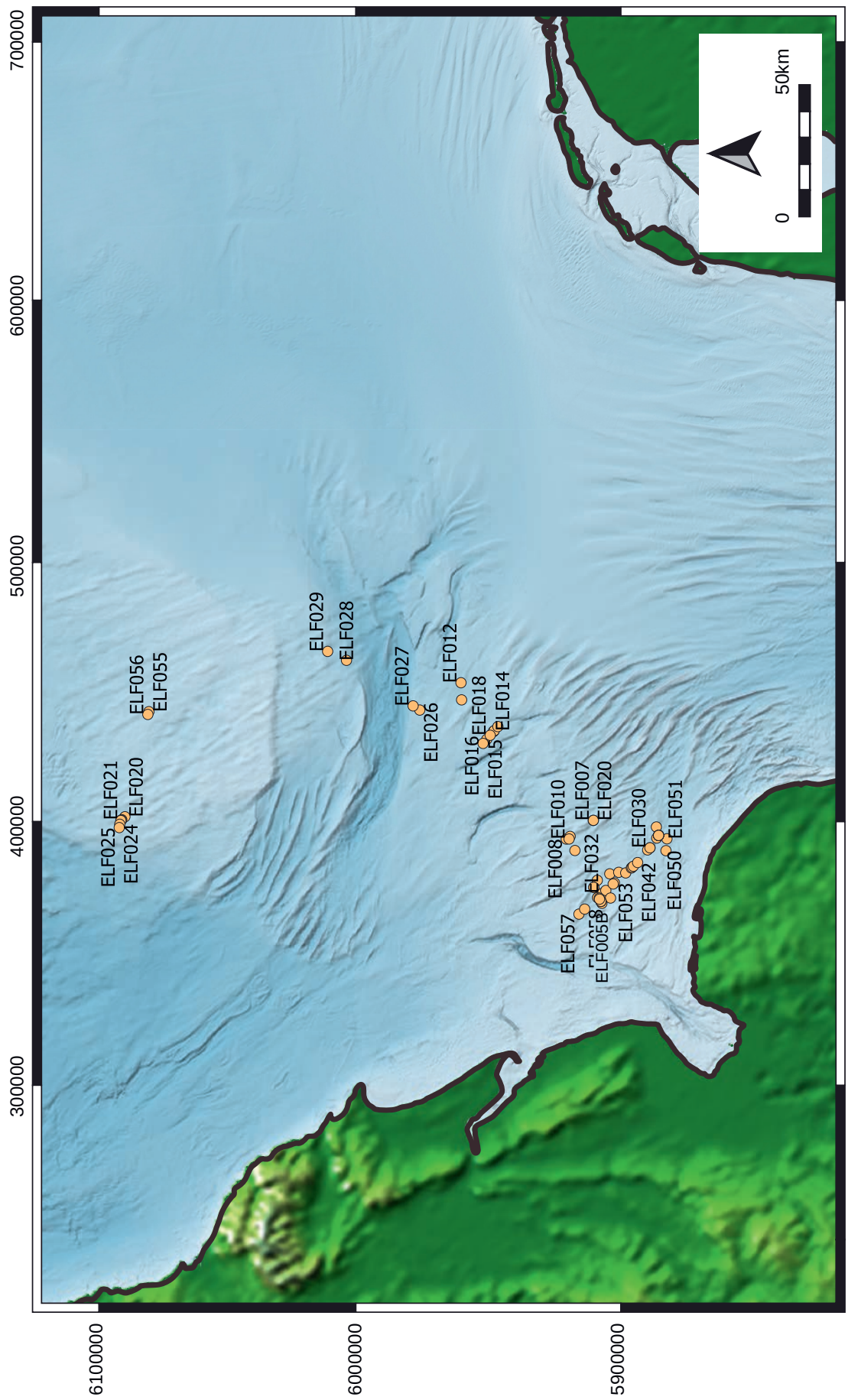

Figure 1.8 Final Europe's Lost Frontiers coring programme.

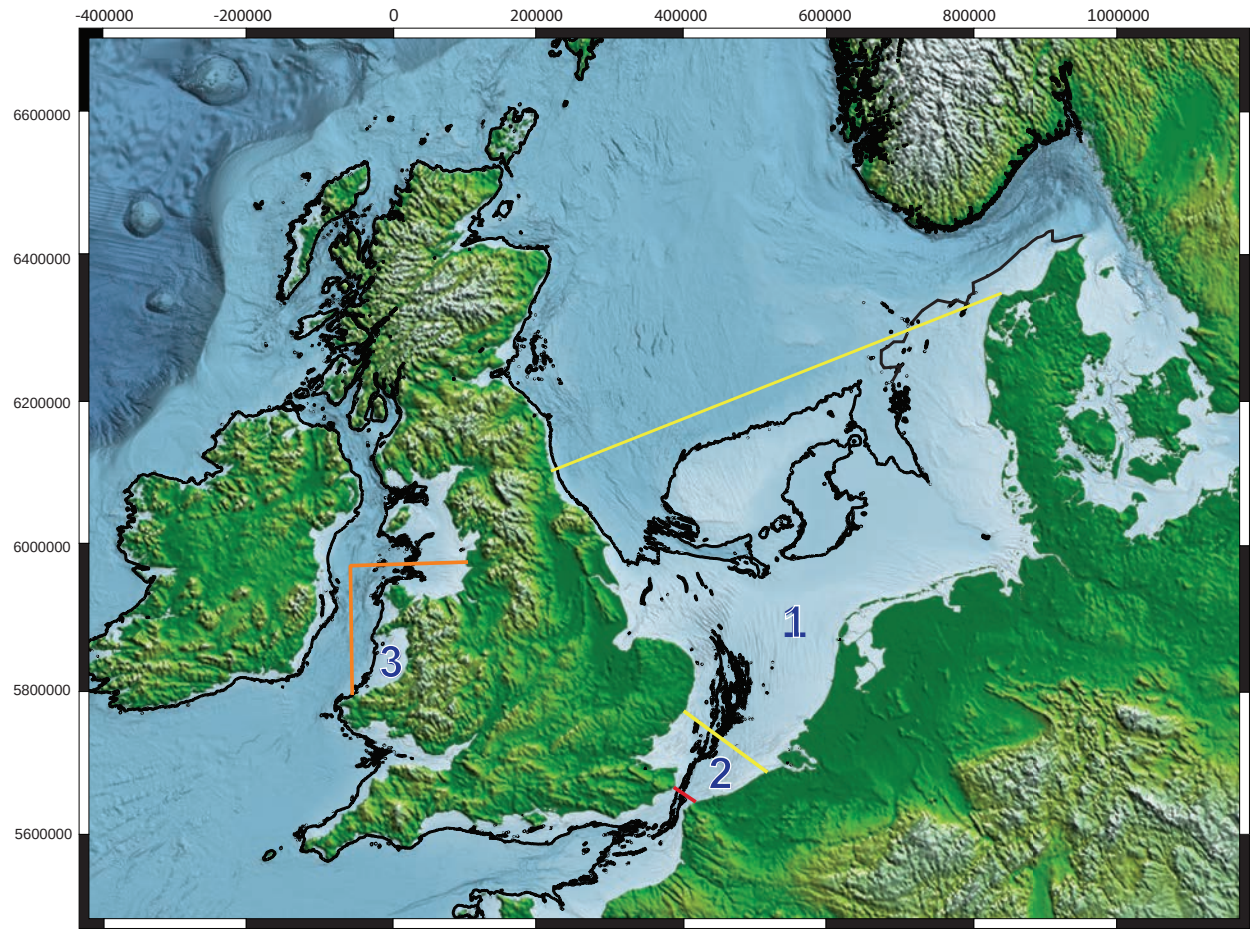

Figure 1.9 Europe's Lost Frontiers core study area (1), Cardigan and Liverpool Bays (3) and area of study added as part of the Brown Bank survey (2).

Tartu), was a significant event. Merle's research on palaeocoastlines, and primary research on the Brown Bank data and the UK Coal Board archive were integral to the project's goals, whilst Dr Muru's considerable expertise in GIS assisted in cartographic development within the project.

The final integrative work package within the project, computer modelling, was managed by Dr Philip Murgatroyd and Professor Eugene Ch'ng. In many respects, this was anticipated to be amongst the most challenging of research themes within the project. The focus of the simulation component as described in the funding application was on agent-based modelling (ABM), a technique ideally suited to examine the actions of individuals within an historic environment. ABM is the most widely used simulation technique within archaeology (Cegielski and Rogers 2016) and it tends to obscure other simulation methods which do not use agents in their design. As the project progressed, it became apparent that there were a series of fundamental questions which were critical to understanding the landscape of Doggerland which were not amenable to ABM. Methods of data downscaling (Contreras *et al.* 2019) became important in providing a basic understanding of how the inundation of the landscape would have looked to the inhabitants of Doggerland (Murgatroyd *et al.* this volume). The taphonomic processes which contributed to the formation of the deposits found within the cores were increasingly understood as vital to our understanding as to how the environmental proxy data within the cores related to the landscape as a whole (Barton *et al.* 2018). These relatively prosaic elements, representing change within the project study area, were examined before widespread, large-scale ABMs were able to be developed. However, ABM development has continued throughout the project and is evidenced by the development of an experimental augmented reality sandbox to simulate response to climate change and sea-level rise (Murgatroyd *et al.* this volume)

This short narrative has outlined the development context of *Europe's Lost Frontiers* and the changes that were imposed upon the project, or occurred through the natural processes of methodological innovation, provision of new data and academic enquiry. Despite such change, researchers within

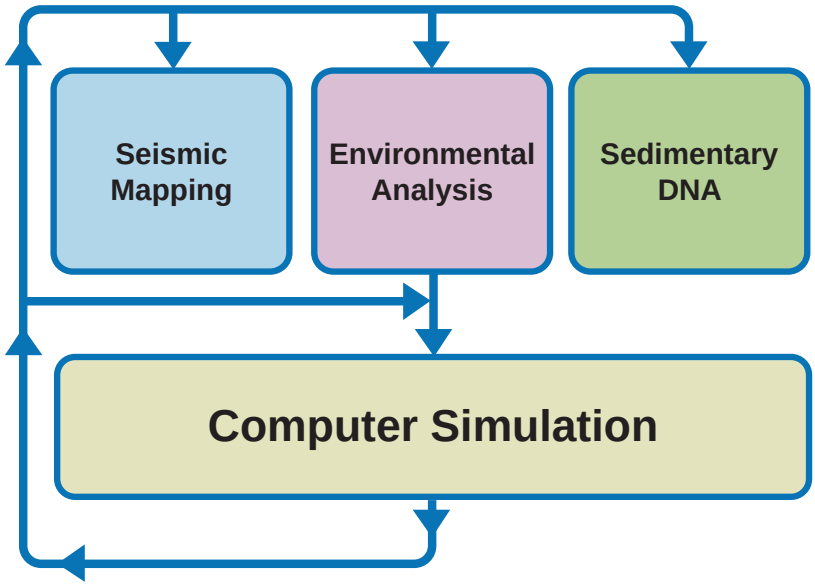

Figure 1.10 Iterative research methodology within Europe's Lost Frontiers.

Europe's Lost Frontiers have pursued key goals relating to the study of the inundated palaeolandscapes of north west Europe, climatic change, sea-level rise and consequent landscape transformation, and these have been achieved on the basis of new geographical and temporal datasets provided through the project and collaborators. The publication of the methodological detail here, and in a series of forthcoming volumes dedicated to the details of mapping, environmental assessment and computer modelling, will support our understanding of how human populations may have reacted to climate change and also the evolving landscape. In the short term, these data will inform our response to current development proposals that will impact much of the area that now constitutes late Pleistocene and early Holocene Doggerland (UK Govt 2020; Fitch *et al.* this volume: chapter 15). Over the longer term, it is hoped that the results of the project will inform the development of research agendas relating to these, increasingly strategic and historic landscapes at a global level.